VAPOR INTRUSION AND AMBIENT AIR STUDY
FINAL RESULTS REPORT
ARMEN CLEANERS
ANN ARBOR, MICHIGAN

Prepared for:

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Foreword

This document is one in a series of work products and case studies designed to provide information on the performance of innovative tools that support less costly and more representative site characterization. This series of documents includes reports on new technologies as well as novel applications of familiar tools or processes. They are prepared to offer operational experience and to further disseminate information about ways to improve the cleanup process at hazardous waste sites.

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ACRONYMS AND ABBREVIATIONS

µg/L	microgram per liter
µg/kg	micrograms per kilogram
$\mu g/m^3$	microgram per cubic meter *
µL	microliter
µ-TCD	chip thermal conductivity detectors
1,1,1-TCA	1,1,1-trichloroethane
1,1,2,-TCA	1,1,2-trichloroethane
1,1-DCE	1,1-dichloroethylene
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
°C	degrees Celsius
CH_4	methane
cis-1,2-DCE	cis-1,2-dichloroethene
CO	carbon monoxide
CO_2	carbon dioxide
COC	chemical of concern
COPC	chemical of potential concern
CSM	conceptual site model
DC1	data category 1
DCE	dichloroethene
DET	Detroit City Airport
DNAPL	dense nonaqueous phase liquid
DTW	Detroit Metro Airport
DWS	Dynamic Work Strategy
ECD	electron capture detector
EPA	U.S. Environmental Protection Agency
ERB	EPA Superfund Division, Emergency Response Branch
ERT	EPA Environmental Response Team
FID	flame ionization detector
FIELDS	Field Environmental Decision Support
FLUTe	Flexible Liner Underground Technologies Everting
GAC	granular activated carbon
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometry
GIS	geographic information system
g/mole	grams per mole
ITRC	Interstate Technology Regulatory Council
MDCH	Michigan Department of Community Health

ACRONYMS AND ABBREVIATIONS (Continued)

MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
Micro GC	Micro Gas Chromatograph
MIP	Membrane Interface Probe
mL	milliliter
mL/min	milliliter per minute
mL/sec	milliliter per second
MNA	monitored natural attenuation
MRL	minimal risk level
MS/MS	mass spectrometer/mass spectrometer
msl	mean sea level
MW	monitoring wells
N_2	nitrogen
ng	nanogram
O_2	oxygen
OSRTI	Office of Superfund Remediation and Technology Innovation
PCE	tetrachloroethene
PID	photoionization detector
ppbv	parts per billion by volume *
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
REAC	Response Engineering and Analytical Contract
RI	remedial investigation
SOP	standard operating procedure
SSI	screening site inspection
START	EPA Superfund Technical Assessment and Response Team
STSC	Superfund Triad Support Center
TAGA	Trace Atmospheric Gas Analyzer
TCE	trichloroethylene
TCL	target compound list
trans-1,2-DCE	trans-1,2-dichloroethene
% v/v	percent by volume
VC	vinyl chloride
VOCs	volatile organic chemicals [#]

* Vapor concentrations of chemicals can be reported in units of micrograms per cubic meter ($\mu g/m^3$) or parts per billion by volume (ppbv). Vapor and air screening concentrations established by MDEQ are in units of $\mu g/m^3$, but many of the analytical methods discussed in this report yield concentrations in units of ppbv. Concentrations of a chemical in $\mu g/m^3$ at 25 degrees C can be converted to ppbv by using the equation ppbv = ($\mu g/m^3$)(24.466/mol wt), where "mol wt" is the molecular weight of the chemical in grams per mole (g/mole). Using this equation and the molecular weight for PCE (165.83 g/mole), the MDEQ residential inhalation criterion of 42 $\mu g/m^3$ for PCE converts to 6.20 ppbv.

[#] In this report, PCE is considered a VOC, as are the other chlorinated chemicals in this acronym list. In addition to these volatile chlorinated solvents and related chemicals, VOCs include other classes of chemicals, such as volatile aromatic and aliphatic hydrocarbons (for example, BTEX). In this report, the acronym "VOC" can encompass any of the chemicals on EPA's Superfund TCL, viewable at http://www.epa.gov/superfund/programs/clp/vtarget.htm. An equivalent common definition of VOC is volatile organic compound..

EXECUTIVE SUMMARY

The Armen Cleaners site is an active dry cleaning business. The site is located within a densely populated residential area in Ann Arbor, Michigan. It has been in operation since 1950 and has used the cleaning solvent tetrachloroethene, which is also called perchloroethylene (PCE). In 1985, neighbors complained about solvent odors coming from the facility and surrounding soil. The Michigan Department of Natural Resources (MDNR) investigated the site and concluded that waste from the dry cleaning process had been illegally stored and that routine spillage had occurred. In response to MDNR's findings, the site owner removed soil in the northwestern corner of the cleaner's property. MDNR believed that additional soil should be removed and initiated subsequent investigations of soil, groundwater, soil vapor, and residential indoor air surrounding the site. These investigations implied that transport of PCE via the vapor intrusion pathway to surrounding residences was a primary exposure pathway of concern for the site. However, these investigations left data gaps in understanding this pathway and its associated risks compared with other potential sources of PCE in indoor air, such as background concentrations in outdoor (ambient) air and residential indoor air.

In September 2002, the Michigan Department of Environmental Quality (MDEQ) and the Michigan Department of Community Health (MDCH) requested the assistance of the U.S. Environmental Protection Agency's (EPA's) Region 5 Emergency Response Branch (EPA ERB) to better assess the relative contributions of the multiple potential vapor pathways from the site to inhalation risk in the surrounding residences. To fulfill this request, EPA ERB asked the EPA Region 5 Superfund Technical Assessment and Response Team (EPA START) for technical support, which in turn contacted EPA's national Environmental Response Team (EPA ERT) and the EPA Superfund Triad Support Center (EPA STSC) for additional assistance. In spring and summer 2003, these organizations collaborated in implementing a new investigation to further delineate source areas of PCE beneath the site and evaluate the vapor intrusion and ambient air pathways. The investigation featured aspects of EPA's Triad approach to site restoration that promotes systematic planning, dynamic work strategies, and real-time measurement technologies to expedite cleanup. Initial systematic planning included stakeholder meetings, public outreach through fact sheets and websites, and coordination with residents in homes to be sampled.

Source evaluation included the use of a Membrane Interface Probe (MIP) to delineate areas of high PCE concentration and potential dense nonaqueous-phase liquid (DNAPL), also termed "free product," in the subsurface. The presence of DNAPL was further assessed using a ribbon

NAPL sampler, also known as a "Flexliner" or a Flexible Liner Underground Technologies everting (FLUTe) membrane. The MIP data delineated two highly contaminated zones at the north-central boundary and the southwestern corner of the site. The MIP data also revealed clay zones south and southwest of the site that appear to affect contaminant migration in these areas. The MIP did not clearly bound the lateral extent of the potential contamination to the east and south of the site, nor did it clearly define the vertical extent of the primary source area beneath the northern boundary of the property. Based on the MIP data, the potential for vapor intrusion appeared greatest at residences at 628 South Ashley Street, 635 South First Street, and possibly 631 South First Street. The Flexliner data agreed with the MIP data in identifying the major zones of potential free product and high concentrations, but provided no additional delineation.

Vapor probes were installed at 34 locations near the site to evaluate vapor transport pathways. Soil vapor samples collected using Teflon Tedlar sample bags were analyzed by EPA ERT's mobile laboratory for PCE and related compounds by gas chromatography/mass spectrometry (GC/MS) methods. Sub-slab vapor points were also installed in the basements of 15 residences north and west of the site. In addition, indoor and outdoor air samples were collected from entryways of the residences that had been subjected to sub-slab sampling. These samples were collected using individually cleaned Summa canisters and 24-hour integrated air samplers for analysis by EPA Method TO-15 at an off-site laboratory. Prior to the indoor air investigation, the project team surveyed and assisted residents in removing or managing potential background sources of PCE and other volatile organic compounds (VOCs).

Although a range of VOCs was detected during the vapor intrusion study (such as benzene, toluene, ethylbenzene, and xylene [BTEX], plus acetone, ethanol, and chloromethane), PCE was identified as the predominant site-related chemical of potential concern (COPC). Moreover, the study indicated that only two properties immediately adjacent to the site were of potential concern from intrusion of PCE vapors. These properties were 628 South Ashley Street (immediately north of the site) and 635 South First Street (immediately west of the site). Eleven of the 14 detections of PCE reported in Summa canisters, and all detections greater than the acceptable indoor air concentration of 6.20 parts per billion by volume (ppbv), were from canisters collected at these two properties. Canister concentrations measured at 628 South Ashley Street ranged from 0.68 ppbv to 25 ppbv, with the highest concentrations measured in the basement samples. These concentrations correlated with surrounding data from vapor probes and sub-slab vapor points on the property; the sub-slab concentration at 628 South Ashley Street was 2,600 ppbv,

and adjacent vapor probe concentrations (near the principal source area at the site) were as high as 550,000 ppbv. These data indicated that attenuation was significant even though the vapor intrusion pathway appeared complete at this property. (A vapor remediation system, installed after MDEQ's earlier investigations, was operating in this residence at the time of EPA's vapor intrusion study and may have contributed to the observed attenuation.)

In comparison to 628 South Ashley Street north of the site, indoor air concentrations at the 635 South First Street property west of the site appeared to show greater correlation to surrounding outdoor air than to soil vapor. Summa canister concentrations ranged from 5.9 to 70 ppbv, with the highest concentrations measured on the first-floor entryways, and not the basement. Surrounding concentrations in soil vapor were much lower than at 628 South Ashley Street, with a sub-slab concentration of 37 ppbv and vapor probe concentrations ranging from 6.6 to 690 ppbv. These data agreed with the MIP data that showed that clay zones in this area may affect vapor migration.

Monitoring data for ambient and indoor air for comparison to the Summa canister and soil vapor data were reported from EPA's Trace Atmospheric Gas Analyzer (TAGA) IIe mobile monitoring unit. The TAGA IIe used triple quadrupole mass spectrometry to sample and measure VOC concentrations in air in real time. The TAGA investigation paralleled the vapor intrusion sampling program in that all properties that were accessed for vapor point, sub-slab, or Summa indoor air sampling were also included in the TAGA air monitoring. The TAGA data concurred with the soil vapor and Summa canister data in identifying 628 South Ashley Street and 635 South First Street as the residences of concern. The TAGA data further confirmed that transport of ambient air from the site may be a significant pathway relative to vapor intrusion at 635 South First Street. TAGA indoor air measurements (with the highest concentrations on the first floor, ranging up to 29 ppbv) appeared to correlate with wind direction at 635 South First Street. The significance of ambient air transport compared with vapor intrusion was less certain at 628 South Ashley Street; lower TAGA concentrations ranging up to 3.7 ppbv were measured indoors, with lower correlation to wind direction or outdoor air.

Overall, the study conducted by EPA START and EPA ERB of the Armen Cleaners site succeeded in combining a number of investigative technologies and real-time analytical tools to build a large, comparative data set to assess vapor transport of PCE and other VOCs. This data set created multiple lines of confirmatory evidence to clarify the chemicals, pathways, and residential receptors of concern surrounding the site. The study indicated that vapor intrusion and

ambient air impacts from the site declined quickly with distance, affecting indoor air at only two properties immediately adjacent to the site. The study also indicated variable relative contributions of the vapor intrusion and ambient air pathways, with vapor intrusion appearing to predominate at 628 South Ashley Street but with a more significant ambient air pathway possible at 635 South First Street based on the meteorological conditions at the time of the study. Uncertainty remains in the assessment of these pathways based on differences between the investigative tools used (such as the comparability of 24-hour integrated Summa canister samples to real-time TAGA measurements) as well as site operations and ambient conditions. Concentrations in outdoor air and contaminant transport are expected to be highly variable, subject to batch processing and ventilation at the site as well as meteorological conditions.

When evaluated against the tenets of EPA's Triad approach, however, the vapor pathway study made effective use of a variety of field-based and real-time tools to generate a reliable, consistent set of "collaborative" data. "Collaborative data sets" are used to control different aspects of uncertainty so that the data can be used to build an accurate conceptual site model (CSM). In its simplest form, rapid high-density data from one technique are used to control sampling uncertainty stemming from spatial or temporal heterogeneity, while another technique (such as an off-site laboratory) is used to control the greater analytical uncertainty inherent in these rapid analytical techniques.

The study suggested that MIP, vapor probe, sub-slab probe, and Summa canisters (indoor and outdoor) provided a good basic toolset to characterize the vapor pathways. The TAGA provided a collaborative data set that corroborated the findings of the MIP, vapor probe, sub-slab probe, and Summa canister sampling for both the ambient and subsurface vapor pathways from the site. The TAGA provided the added benefit of a more complete, continuous picture (that is, a vapor transport "movie") of potential impacts surrounding the site in real-time on a given day. The TAGA further demonstrated the uncertainties associated with such a picture (for example, as a result of changing ambient conditions), and the challenges associated with assessing the significance of vapor pathways and exposure.

Over and above the real-time technologies used, the EPA project team effectively implemented the Triad concept of "systematic planning" in working with stakeholders and residents to plan and carry out the investigation. However, the team was working under time, budget, and sampling access constraints that limited the extent a Triad-based "dynamic work strategy" could be used to adjust and refine the sampling approach in the field, leaving some data gaps unfilled at the end of

the investigation. For example, although redundant data were collected well north and west of the site that indicated no impacts to soil vapor or ambient air, data gaps were left in other areas east and south of the site. More delineation of the source area is also necessary to assess remedial options, particularly in regard to vertical extent of high concentrations of PCE in soil and potential DNAPL. Thus, fewer project constraints and a more adaptable dynamic work strategy could have allowed more real-time decisions in the field, continuous refinement and review of the CSM, and further adjustments to the investigation strategy (sampling locations and data density) while the field team was mobilized to further advance the site in the remedial process. Additional real-time data management and assessment tools would have been needed to maximize efficiency and minimize project cost under a more dynamic approach. Although a more dynamic work strategy would have increased the budget and prolonged the schedule of this investigation, it is likely that both the overall cost and time required to clean up the site would have been reduced.

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) Superfund Triad Support Center (STSC) Team prepared this report to summarize data collection and results from an investigation at the Armen Cleaners site in Ann Arbor, Michigan. This report was prepared and the investigation conducted in cooperation with the U.S. EPA Superfund Division, Emergency Response Branch (EPA ERB), and the Region 5 Superfund Technical Assessment and Response Team (EPA START). The primary focus of the investigation was to identify issues related to vapor intrusion. This report further provides suggestions and information on data utility, additional data needs, risk assessment, and remedial action for the site. The evaluations and suggestions presented in this report have been developed in accordance with the Triad approach to site characterization and remediation that EPA is promoting. The Triad approach stresses the use of systematic planning, real-time measurement technologies, and dynamic work strategies in the field to expedite environmental data collection and increase the weight of evidence generated to support environmental decision-making throughout the project or site life cycle.

The Triad is being promoted by OSRTI as a means of streamlining site characterization and remediation at Superfund, Resource Conservation and Recovery Act (RCRA), Brownfields, and other revitalization sites. The Triad approach is becoming more widely accepted and used by many EPA regions, states, and local governments. The principles and tools used with the Triad have been demonstrated to reduce schedules and budgets required to reach project milestones at many sites across the country. OSTRI has forged partnerships with the U.S. Department of Energy, the U.S. Army Corps of Engineers, the U.S. Navy, the Interstate Technology Regulatory Council (ITRC), and other organizations to develop more examples of how the Triad can be applied.

Working with the EPA Environmental Response Team (EPA ERT) and its Region 5 START contractor, EPA ERB recently completed a Triad-based investigation at the site that used dynamic sampling designs and multiple real-time methods to characterize the potential sources and extent of concentrations of volatile organic chemicals (VOCs) in soil vapor, outdoor (ambient) air, and indoor air at and around the site. Additional real-time methods were used to delineate potential zones of free-phase solvent surrounding the site that could continue to pose threats to nearby receptors. EPA ERB requested assistance from OSRTI in reducing and interpreting the data collected and in developing suggestions for further action at the site that could be communicated to the Michigan Department of Community Health (MDCH) and the Michigan Department of Environmental Quality (MDEQ).

The suggestions provided in this report were prepared based on information obtained from the EPA START project team, EPA ERT's data reports (EPA 2003a-d), and data provided by Columbia Technologies, Inc., the vendor of two real-time measurement technologies that were employed at the site. Additional information is included and further assessed from reports prepared for MDEQ, including the "*Final Remedial Investigation Report"* (DLZ 2001a), the "*Additional Groundwater Investigation Letter Report"* (DLZ 2001b), and the *"Draft Supplemental Investigation Letter Report"* (DLZ 2002). EPA Region 5 START also provided raw data summaries and other files required to prepare these suggestions.

The Superfund Triad Support Team became involved with the site only recently. Therefore, its understanding of the site and the issues it presents may be limited. The data evaluations and suggestions provided are intended to help the project team assess the data collected and plan future investigations with similar challenges.

1.1 PURPOSE OF THE RESULTS REPORT

In responding to EPA ERB's request for assistance, OSRTI and the Superfund Triad Support Team agreed to provide the following support based on review of the data collected by EPA START and previously by MDEQ at the site:

- Summarize the nature and extent of site-related VOCs in air and vapor surrounding the site.
- Assist in compiling a conceptual site model (CSM) based on the data gathered so that stakeholders can more clearly identify critical decisions that may be needed to assure the protection of human health and the environment at the site.
- Identify potential receptors on a preliminary basis.
- Assess the potential presence and extent of free-phase solvent or highly contaminated subsurface soil or groundwater that could act as a continuing source.
- Assess the overall quality of the collaborative data set that was compiled for the site using different characterization approaches and tools and assess the utility and contributions of the different tools to the CSM.
- Provide suggestions on additional data collection that might be needed to support mitigation at the site.

An integral part of the data review effort was compiling data from various investigations at the site into a project database and developing a companion geographic information system (GIS) for data plotting and visualization.

1.2 OBJECTIVES AND SCOPE OF THE VAPOR INTRUSION STUDY

The Superfund Triad Support Team's review focused primarily on the data collected during the vapor intrusion study conducted by EPA's START in conjunction with the EPA ERT. This study marshaled a range of innovative sampling and analytical tools to assess potential risk from exposure of surrounding residents to vapors emanating from the site. Until the late 1990s, the perceived health risks associated from releases of VOCs were thought to be mainly from direct contact or ingestion of contaminated soil or groundwater. Since the neighborhood used city water for drinking, it was believed that risks from exposure and human health effects from contaminated groundwater at the site were minimal. Detailed assessment of the air quality in the residences near the site was required in light of the increased knowledge of the potential hazard to public health from VOCs intruding into residences via subsurface gases (EPA 2002).

At the request of MDCH, EPA ERB agreed to assist in assessing the vapor intrusion pathways at the site. Recent data collected by MDEQ suggested that a health risk from vapor intrusion may be present in the residences immediately surrounding the site. Accordingly, EPA conducted a multimedia study of the site and surrounding area in spring and summer 2003 to evaluate the potential impacts from indoor air to residences surrounding the site and investigate the source and extent of the vapors. The study used real-time analytical and direct-push techniques to assess the presence and extent of source zones in the subsurface below the site and the surrounding area. Soil vapor was sampled in the area surrounding the site, including sub-slab vapor samples of select residences. Data for indoor and outdoor air were also collected around the site, as well as within and surrounding nearby residences, to further assess the relative contributions from the ambient air versus the vapor intrusion pathway to surrounding residences.

1.3 SITE DESCRIPTION AND HISTORY

The Armen Cleaners site is an active dry cleaning facility. The site consists of approximately 1/4 acre of land within the City of Ann Arbor, Washtenaw County, Michigan (Figure 1). The Armen Cleaners building, the only structure on the site, has operated as a dry cleaning establishment since approximately 1950. Currently, the site is used as the main Armen Cleaners facility for dry cleaning operations, processing items from other branches of Armen Cleaners as well as items brought in directly by the public for dry cleaning. The facility uses a closed-loop dry cleaning system, which utilizes a VOC solvent, tetrachloroethene (PCE). This process generates waste residue (sludge) that contains PCE (approximately 40 to 60 gallons per month).

The address of the site is 630-632 South Ashley Street, and it is bordered on the east by Ashley Street and on the south by Mosley Street. Pertinent site features are illustrated on Figure 2. It is located within a densely populated residential neighborhood; homes and apartments are located north and west of the site, with the closest residence approximately 10 feet north of the site boundary at 628 South Ashley Street. Commercial and light industrial properties are also located north, east, and south of the site. A paved driveway used by delivery trucks is located along the north side of the building. A gravel-covered parking lot for a neighboring residence (635 South First Street) abuts the site to the west.

In 1985, after complaints from a neighbor of solvent odors coming from the dry cleaning facility and surrounding soil, the Michigan Department of Natural Resources (MDNR) investigated the site. MDNR concluded that the waste residue from the dry cleaning process was being illegally stored in 16- and 20-gallon drums in the alley adjacent to the facility, where routine spillage had allegedly occurred. As mandated by MDNR, the initial remediation by the owner was excavation of contaminated soil adjacent to the northwestern corner of the building. Soil from an area approximately 27 feet by 27 feet was removed to a depth of 6 feet and transported to a licensed landfill. (Refer to the maps in Enclosure A for the location and boundaries of the excavated area.) MDNR believed that additional soil removal was necessary based on results for confirmation soil samples. However, excavation was terminated for structural reasons, specifically the proximity of the excavation to the Armen Cleaners building. The excavated area was backfilled with clean soil.

1.4 ENVIRONMENTAL SETTING

The following section describes the regional and site-specific geology, hydrogeology, structural geology, glacial geology, and prevailing wind directions associated with the site.

1.4.1 Geology and Hydrogeology

The site is located in the east-central part of Washtenaw County. Glacial features and deposits shape the topography of the county. Ann Arbor ranges in elevation from 800 to 900 feet above sea level. The Huron River bisects the northeastern part of Ann Arbor.

Regional Structural Geology

Washtenaw County is located on the southeast margin of the Michigan Basin. The Lucas – Monroe anticline trends northwest to southeast though the western part of Washtenaw County (Figure 3). East of the Lucas – Monroe anticline, a minor anticline trends northwest to southeast through Ann Arbor to the

west of the site. The beds below the site, which are the eastern limb of the anticline, gradually dip to the northeast. These anticlines are attributed to fault blocks of Precambrian basement rocks. The faulting occurred during the early Paleozoic and ended at the end of the Mississippian Period.

The Mississippian-age Coldwater Shale, which is relatively impermeable, is the underlying bedrock at the site. The Coldwater is approximately 600 feet thick at the site area. Underlying the Coldwater, sedimentary units of Devonian, Silurian, Ordovician, and Cambrian age are present. These Paleozoic sedimentary units range in thickness from approximately 4,000 to 7,000 feet. Precambrian granitic gneisses and schists are at an approximate depth of 5,000 feet below sea level.

Regional Glacial Geology

Glacial features and deposits shape the topography of Washtenaw County. The glacial geology of the Ann Arbor region consists of unconsolidated and intermixed sands, gravels, and boulders; and fluvolacustrine deposited clays, shales, silts, sands and gravels of most likely glacial outwash origin. These Quaternary glacial deposits with interbedded sands and gravels are consistent to a depth of approximately 200 feet below ground surface. Individual clay-rich layers range in thickness from approximately 4 to 100 feet. The sand and gravel layers range from approximately 3 to 90 feet. The extended cross-sections shown in Figures 4 and 5 are an encompassing, generalized representation of the varying depositional environments that are observed in the geology of the Ann Arbor area. The northern cross-section, A-A' (Figure 5), shows a series of interbedded and most likely horizontally continuous silts, sands, and gravels with occasionally interbedded clay and sand lenses in the near surface. As seen on all well logs, thick horizontally continuous packages of clay and silt are seen throughout the region beginning at approximately 775 feet above mean sea level (msl). Laterally continuous sands and channelized gravel packages are occasionally interbedded within these clays and silts, indicating fluvolacustrine depositional systems. At a depth of approximately 650 feet below msl, the thick Coldwater Shale unit is seen on two well-logs, MD-102D and 29-5, which were drilled deep enough to intercept bedrock. This unit is understood to underlie all near-subsurface geology throughout the region, and is also seen on the B-B' cross-section that is depicted through the Armen Cleaners site (Figure 5).

Cross-section B-B' shows geology similar to cross-section A-A'. Near-surface geology overlying the Coldwater Shale, along the western and central lengths of the cross-section, appears almost entirely composed of predominantly silty material with occasional interbeds of channelized to horizontally continuous silty sand packages, as seen in well-logs Private Well and 29-1. Along the eastern length of cross-section A-A', as seen in well-log 28-1(Enclosure B), the surface unit appears to be a predominantly

sandy package that overlies the same silt unit as was previously mentioned in the two well logs to the west.

Site-Specific Geology

Soils at the site are described as composed of fill material that consists of brown fine to medium sand with trace gravel mixed with brick fragments to a maximum of 6.5 feet below ground surface (bgs). The fill material is underlain by interbedded brown clayey and silty sand to a maximum of 18 feet bgs (DLZ 2001a). The permeability of the soils at the site is considered intermediate. Infiltration rates range from 0.8 to 2.5 inches per hour. Approximately 20 percent (6 inches) of the annual precipitation in Washtenaw County infiltrates glacial deposits and recharges aquifers (Veatch and others 1930).

Beneath this soil zone is an approximately 15- to 20-foot-thick silty sand with occasional clay lenses that may be laterally and vertically interconnected. (These relationships are seen in cross-sections completed from the 2003 Membrane Interface Probe [MIP] investigation later discussed in Section 3.3.) Beneath this silty sand is an approximately 90-foot-thick silt with occasional sand and gravel lenses that may be horizontally and vertically interconnected. A potentially laterally continuous sand and gravel package approximately 10 feet thick is at approximately 110 feet below the surface. Beneath this sand and gravel deposit is the Coldwater Shale, which continues for as much as 600 feet into the subsurface, as previously discussed.

Hydrogeology

The water table through Ann Arbor is highest in the western and southern parts of the county and lowest in the southeastern parts. Regionally, groundwater flows towards the Huron River (Figure 6). Regional groundwater flow is expected to be toward the northeast from the site. According to groundwater levels measured in July 2002 (DLZ 2002), the top of the water table at the site is 7.43 feet below the surface on the north side of the Armen Cleaners building and as deep as 12.97 feet bgs on the south side. There appeared to be a groundwater divide or mound running southwest to northeast, directly below the Armen Cleaners building, based on measurements of static water levels in 2001 and 2002 (Enclosure A). Groundwater flow was assessed to be to the northwest and southeast of this divide; however, this data set was limited and has not been confirmed over time.

Sand and gravel aquifers are present at depths ranging from 80 to 200 feet in the area. The clay-rich till does not appear to be continuous over a 3-mile radius from the site. Ann Arbor uses both surface water

and groundwater as sources of drinking water, but the majority of the wells are located more than 3 miles away from the site. One municipal well that draws water from the sand and gravel aquifer is located 0.8 mile southwest (upgradient) of the site. In the past, water from this well has been mixed with other well and surface water during the winter. The closest private well is 2 miles southwest of the site. Well logs from this and other residences in the area indicate that these wells draw water from sand and gravel aquifers at depths ranging from 100 to 200 feet. The Huron River, 1.2 miles northwest of the site, is the source of the surface water.

1.4.2 Prevailing Winds

The regional prevailing winds for the Ann Arbor area were assessed from wind rose data reported from the Detroit Metro Airport (DTW) and the Detroit City Airport (DET) in Detroit, Michigan. These data are presented in Figure 7. The wind rose from the monitoring station at DTW represent data from 1987 through 1991. The station is 26 miles southeast of the site, with an anemometer height of 33 feet above ground surface. The primary wind direction at DTW was from the southwest (11 percent) followed by west-southwest (10 percent), south-southwest (8 percent), south (8 percent), and west-northwest (8 percent). The average wind speed was 11 knots. Understanding prevailing wind directions is considered essential in defining the potential influences from contaminated outdoor air from the site to nearby residences.

The wind rose from the monitoring station at DET represents data from 1989 through 1991. The station is 36 miles northeast of the site, with an anemometer height of 33 feet above ground surface. The primary wind direction at DET was from the southwest (10 percent) followed by west-southwest (9 percent), west (8 percent), south-southwest (7 percent), west-northwest (7 percent), and north (7 percent). The average wind speed was 11 knots.

1.5 PREVIOUS INVESTIGATIONS

The following paragraphs summarize the field activities conducted at the Armen Cleaners site by MDNR and MDEQ from initial soil sampling in 1985 through the supplemental investigation in July 2002. Field activities during this time include sampling soil, groundwater, basement water sump, indoor air, and soil gas; soil was also sampled with a Geoprobe and grab groundwater samples were collected.

1.5.1 INVESTIGATIONS BEFORE 1990

Soil samples collected by MDNR in association with excavation at the site identified PCE at concentrations as high as 580,000 micrograms per kilogram (µg/kg), and another VOC solvent, 1,1,1-trichloroethane (1,1,1-TCA), as high as 9,900 µg/kg. Later in 1985, MDNR installed four monitoring wells (MW-1 through MW-4) at the site (see Enclosure A for monitoring well locations). Subsequent groundwater sampling in September and November 1985 reported maximum concentrations in groundwater of 8,100 and 9,100 µg/L for PCE (Well MW-3).

In 1989, EPA conducted a screening site inspection (SSI) at the site (EPA 1990). The SSI included an interview with the site owner, a reconnaissance inspection of the site, and collection of six surface soil samples and groundwater samples from three of the existing monitoring wells (MW-1 through MW-3). Analytical results from this SSI identified PCE in soil at up to 400 µg/kg and in groundwater at up to 2,200 µg/L.

1.5.2 Remedial Investigation, Summer 2000

A remedial investigation (RI) was performed at the site by DLZ Michigan, Inc., for MDEQ, as documented in the "*Final Remedial Investigation Report"* (DLZ 2001a). Figures from this report that summarize the data collected have been attached in Enclosure A for later comparison to the EPA data. The RI focused on defining the extent of contaminated soil and groundwater near the area of the 1985 soil excavation. Soil and groundwater samples were collected to define the vertical and horizontal extent of VOCs near the site. Monitoring wells were installed to assess the condition of groundwater, currently and over time.

Soil Investigation

Soil samples were collected from 20 Geoprobe borings during the RI. Four additional hand auger soil samples were taken as a result of access issues with the Geoprobe rig. The soil from each sample location was logged and screened for total VOCs using a photoionization detector (PID). Soil samples were collected at 2-foot intervals from the surface and analyzed for halogenated VOCs using a field gas chromatograph (GC) according to the heated headspace method (EPA Method 5021). A split portion of the samples was sent to a laboratory for analysis of VOCs using EPA Method 8260. Six compounds were detected in soil samples: PCE, trichloroethylene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and methylene chloride.

The data obtained using EPA Method 8260 from the RI are summarized in Enclosure A. Soil that exhibited PCE at concentrations greater than the MDEQ soil saturation concentration screening level (88,000 µg/kg) was reported in three on-site borings (GP-5, GP-5A, and GP-5B) at a depth of 0 to 2 feet bgs, which indicated that free-phase liquids may be present below the Armen Cleaners building. The exact source of the liquid was not identified in the RI report, however. The detected concentrations of PCE in these borings ranged from 75,000 to 510,000 µg/kg. Potentially applicable MDEQ screening criteria are summarized in Table 1 (MDEQ 2002).

In addition to the GP-5 borings, concentrations of PCE exceeded 10,000 µg/kg at other areas surrounding the building (GP-1, GP-12, and GP-13; Enclosure A). The concentration of PCE also exceeded drinking water protection criteria (Table 1) in at least one of the soil samples collected from each soil boring, with the exceptions of the hand auger samples HA-1 and HA-2. PCE-contaminated soil extended to the depth of the water table (approximately 7 feet) on the north side of the Armen Cleaners building at borings GP-1, GP-3, GP-5, GP-5A, GP-5B, and GP-7.

Grab Groundwater Sampling

After the Geoprobe soil samples had been collected above the water table, the Geoprobe was further advanced into the saturated zone at each boring location. Two direct-push grab groundwater samples were collected at each boring location, the first from the interface of the soil and water table (approximately 7.5 feet bgs to 12 feet bgs), and the second from approximately 10 feet below the water table. Each sample was submitted to a field mobile laboratory and analyzed for the presence of VOCs by EPA Method 5021 (headspace); a split sample was taken for laboratory confirmation testing using EPA Method 8260 (purge and trap). Six solvent-related VOCs were detected in the grab groundwater samples: PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and methylene chloride. Additional compounds that the RI report noted as "not typically associated with dry cleaning activities" were also detected. These compounds included toluene, ethylbenzene, xylene, isopropylbenzene, 1,3,5-trimethylbenzene, and 1,2,4-trimethylbenzene. The potential for anthropogenic background levels or other sources of these additional chemicals were not explored.

The data obtained using EPA Method 8260 for the RI grab groundwater samples are summarized in Enclosure A. Potentially applicable risk screening criteria established by MDEQ (2002) for PCE are presented in the Table 1. PCE exceeded the drinking water criterion in at least one of the groundwater samples collected from each on-site soil boring location. PCE was also detected at concentrations greater than the groundwater contact criterion in three borings along the north side of the Armen Cleaners

building (GP-3, GP-5, and GP-5A), with laboratory concentrations ranging from 45,000 micrograms per liter (µg/L) to 160,000 µg/L. Free-phase liquid was reportedly observed in the purge water during sample collection at boring GP-5 (8 to 12 feet bgs). No concentrations of PCE exceeded the industrial and commercial groundwater volatilization to indoor air criterion, but one sample collected on the residential property north of the site (boring GP-6, 8 to 12 feet bgs) exceeded the residential and commercial groundwater volatilization to indoor air criterion.

Monitoring Well and Residential Sump Water Sampling

The RI included sampling of five existing monitoring wells, all located off site. Six compounds were detected, including PCE, TCE, cis-1,2,-DCE, trans-1,2-DCE, 1,1,1-TCA, and 1,1,2-trichloroethane (1,1,2-TCA). PCE was detected in groundwater samples collected from wells MW-3, MW-5, and MW-7 at 180 µg/L, 28,000 µg/L, and 45 µg/L. These concentrations are above the residential and commercial drinking water criterion (5 µg/L), and the concentration measured in the sample collected at well MW-5, located just north of the Armen Cleaners building, is also above the groundwater direct contact criterion (12,000 µg/L) and the residential and commercial groundwater volatilization to indoor air criterion (25,000 µg/L). In addition to the monitoring well samples, one water sample was collected from a basement sump at 628 South Ashley Street, the residence immediately north of the property. This sump sample contained PCE at a concentration of 28 µg/L.

The RI concluded that the horizontal extent of contaminated groundwater was defined to the east and west, but remained unknown to the north (beneath 628 South Ashley Street) and south (beneath the Armen Cleaners building). Thus, an additional groundwater investigation was performed in March 2001 (DLZ 2001b) that involved collection of two groundwater samples from each of four new Geoprobe borings (GP-19 through GP-22) installed on the 628 South Ashley Street property (Enclosure A). PCE was detected in only one of these borings (GP-19), at a concentration of 45 µg/L (exceeding the MDEQ drinking water criterion). Based on the additional groundwater investigation, DLZ concluded that the horizontal extent of groundwater contaminated by PCE had been adequately defined north of the site in terms of the applicable MDEQ criteria. Moreover, the vertical extent of groundwater contamination appeared to be limited to 18 feet bgs based on the Geoprobe data collected during the RI and the additional groundwater investigation.

1.5.3 Supplemental Investigation, July 2002

DLZ conducted a supplemental investigation focusing on indoor air, soil gas, and groundwater for MDEQ between February 2001 and July 2002 (DLZ 2002). Seven indoor air sampling events were conducted over this time at the residences of 622 South Ashley, 628 South Ashley, 635 South First, and 631 South First. Most were 24-hour integrated samples collected in Summa canisters and analyzed for VOCs using EPA Method TO-14/TO-14A. Potential background and household sources of VOCs were not accounted for or removed during this sampling program, however, so potential biases in the data from non-site sources could not be assessed. The apartment building at 628 South Ashley Street was the only property where PCE concentrations exceeded the MDEQ acceptable indoor air concentration of 6.20 parts per billion by volume (ppbv), with detected concentrations ranging from 1.1 to 31 ppbv in the basement and first-floor apartments. Detections below the indoor air criterion at less than 2 ppbv were measured at 622 South Ashley Street and 635 South First Street. Based on the indoor sampling results, air purifiers using granular activated carbon (GAC) filters were installed in each of the four apartments and the basement of 628 South Ashley on June 5, 2002.

Twelve EMFLUX passive soil-gas samplers were set in and around the perimeter of 628 South Ashley Street on June 21, 2002, and were recovered on June 25, 2002. The samples were analyzed for VOCs in accordance with EPA Method 8021. PCE was detected in each of the 12 samplers, with total recovered masses ranging from 91 to 1,500 nanograms (ng). A broader soil-gas survey consisting of 16 additional locations was conducted in July 2002. Most of the additional sample locations were around the perimeter of the Armen Cleaners building, with other locations at 622 South Ashley and 631 South First. PCE masses measured in the samples recovered from the second soil gas survey ranged from less than the reporting limit (25 ng) to 770 ng. Although PCE was the dominant contaminant detected in the passive soil gas surveys, TCE, toluene, and xylenes were reported in one or more of the samples. The soil gas data collected by DLZ provided an initial understanding of vapor extent at the site. These data outline potential source zones of interest at the north-central boundary of the Armen Cleaners property (in the driveway between the rear wall of the cleaners building and the 628 South Ashley Street property) and in the southwestern corner of the property. However, these data could not be readily correlated to the applicable risk-based concentrations or to the data collected in other media, and the possibility of other VOC sources or ambient background levels that could affect the results of the study was not assessed.

Groundwater samples were collected from wells MW-1, MW-3, MW-5, MW-6, MW-7, and MW-8 on July 1, 2002. Static water level measurements recorded in each well before sampling confirmed a groundwater divide beneath the site near wells MW- 3 and MW-5, and groundwater samples were

analyzed for VOCs in accordance with EPA Method 8260 (Enclosure A). PCE concentrations from wells MW-3 (210 µg/L), MW-5 (5,100 µg/L), and MW-7 (240 µg/L) exceeded the MDEQ drinking water criterion of 5 µg/L. Vinyl chloride (VC), cis-1,2-DCE, and TCE detected in samples from well MW-7 also exceeded the MDEQ drinking water criteria.

1.6 REQUEST FOR EMERGENCY RESPONSE BRANCH ASSISTANCE

After review, MDEQ and MDCH identified uncertainties in the data sets collected during the RI and supplemental investigations. The uncertainties of greatest concern related to the relative contributions of the vapor intrusion and ambient air pathways from the site to inhalation risk in the surrounding residences. There was speculation that basements were acting as groundwater divides or barriers, and that built-up contaminants were degrading basement walls, because groundwater was shallow in the area. Reviewers were also concerned that the indoor air data collection during the supplemental investigation did not address potential outdoor and household background levels of PCE and other detected chemicals, which contributed an unquantified level of uncertainty to the results and their evaluation. In September 2002, therefore, MDEQ and MDCH requested the assistance of EPA ERB in designing and conducting additional investigations at the site that managed and reduced these uncertainties. The focus of these investigations was to verify whether the ambient air and vapor intrusion pathways are complete and significant. The EPA START in turn contacted the EPA ERT and the EPA STSC for additional technical expertise on vapor intrusion and ambient air monitoring to assist in designing and implementing a data collection strategy. EPA STSC provided additional technical assistance under contract to both the EPA START and the EPA OSRTI.

2.0 EPA DATA COLLECTION ACTIVITIES

In spring and summer 2003, EPA START implemented a new investigation at the site to assist MDCH in further evaluating the magnitude of any potential issues related to indoor air. EPA's data collection brought a range of field-based and other investigative tools to bear. Activities were targeted to:

(1) Further assess the extent of free product or highly contaminated media in the subsurface that could continue to act as sources of PCE or other VOCs to groundwater and indoor air

(2) Further resolve the completeness of the vapor intrusion pathway to surrounding residences

(3) Assess the ambient air pathway from the site to surrounding receptors for comparison to the vapor intrusion pathway

The investigation in the support of these objectives is summarized below.

2.1 SYSTEMATIC PLANNING

Project planning began through a task force that included project stakeholders and decision makers from MDCH, MDEQ, EPA, Washtenaw County, and Ann Arbor. Based on site issues and project objectives outlined by the task force, EPA ERB, EPA START, and MDEQ held several planning meetings to clarify the primary data gaps and develop a scope of activities to be performed. The EPA START and the EPA ERT were to provide technical support, including activities related to sampling design, chemistry, analytical methods, quality assurance/quality control (QA/QC), and geosciences. The planning process relied on a preliminary CSM that was built from the historical data sets and site knowledge. The planning process established the study area of interest, the media of concern for sampling the vapor intrusion and ambient air pathways, and the analytical tools and sampling strategies that would be applied.

As the technical approach was being developed, several meetings were held to inform and obtain feedback from members of the task force. The city council was also briefed and a public participation component was initiated, which featured a new web page about the site at the city website. EPA START also developed a web-based fact sheet about background sources of PCE. After a scope for the investigation had been outlined, a public meeting was held to present the project objectives and the proposed investigation strategy. The public meeting also addressed questions from the public and provided access agreements to residents to gain approval for sampling on residential properties in the study area of interest. A residential survey form was created, and the city began meeting with residents in the study area to interview them and help them temporarily minimize or remove potential background sources of VOCs during the investigation.

2.2 SOURCE EVALUATION

In late May 2003, the EPA ERB asked the EPA START to begin the investigation at the site using a MIP to delineate areas of high concentration in the subsurface. MIP is a direct-push technique that uses a downhole tool to heat adjacent soils and groundwater to 120 degrees Celsius (°C). The heating increases the volatility of any VOCs present in the subsurface, and the resulting vapors diffuse across a semi-permeable membrane located in the tip of the tool. Once inside the tool, a closed inert gas loop carries the vapors to a series of detectors housed at the ground surface. Continuous chemical logs or profiles are generated from each hole. Soil conductivity and other parameters are also measured, and these logs can be compared with the chemical logs to better understand where the VOCs occur.

EPA START subcontracted Columbia Technologies, Inc. (www.columbiadata.com), for the MIP survey at the site. The detectors for Columbia's MIP unit consisted of an electron capture detector (ECD), which has a high sensitivity to PCE and other halogenated solvents, working in tandem with a PID and a flame ionization detector (FID), which have more universal responses to VOCs, particularly hydrocarbon compounds. Additional sensors for conductivity, temperature, and tip speed in the drive tip were used to map more permeable (sand) and less permeable (clay) zones in the subsurface, since permeability affects migration of VOCs.

The MIP survey involved 63 borings pushed to depths of between 14 and 54 feet bgs. Sample locations are shown on Figure 8. Sample locations were initially selected based on a 50-by-50 foot unaligned sampling grid, designed with the assistance of the FIELDS software package developed by EPA Region 5 (www.epa.gov/region5/fields/), that began at the site and progressed north and west to the downgradient residential properties. The grid was expanded in this manner to assess the presence of high-concentration zones and preferred pathways for contaminants leading away from the site. A few other grid elements were positioned in other downgradient and crossgradient areas south and east of the site. The sample location within each MIP grid element was selected randomly and adjusted in the field as necessary based on underground utilities, structures, and access.

The presence of dense nonaqueous phase liquid (DNAPL) beneath the site was also assessed using a ribbon NAPL sampler, also called a "Flexliner," or a Flexible Liner Underground Technologies Everting (FLUTe) membrane, also provided through Columbia Technologies. The ribbon sampler consists of an inflatable tubular ribbon made of hydrophobic absorbent material that is forced against the side of a borehole or direct-push hole in zones of suspected DNAPL contamination. If DNAPLs are present, they will wick into the ribbon, creating a stain. The device is deflated and retracted from the borehole using a

tether connected to the deepest portion of the liner, and then the ribbon is visually inspected and possibly analyzed. Ribbon samplers were deployed in six direct-push holes surrounding the Armen Cleaners building to depths ranging from 17.5 to 20 feet bgs. Ribbon sampler locations are included on Figure 8.

2.3 VAPOR INTRUSION PATHWAY EVALUATION

After source evaluation activities were completed, the EPA START conducted a detailed investigation of the vapor intrusion and ambient air pathways surrounding the site. This investigation was completed between May 27 and June 10, 2003, and involved installation of soil vapor probes and sub-slab vapor points, followed by real-time analysis of samples using multiple field-based laboratory analytical methods. The evaluation also included collection of air samples from residences, including indoor air from various rooms and living spaces as well as outdoor air samples near exterior doorways. These indoor and outdoor air samples were collected in Summa canisters for analysis at an off-site laboratory.

Soil Vapor

After the source evaluation, the EPA START evaluated the potential migratory pathways for vapor from the apparent source areas to the residences. Vapor migration is a complex process that is affected by a variety of factors including, but not limited to, barometric pressure, precipitation, temperature, vapor pressure of the chemicals of concern, permeability, and the presence of man-made pathways. EPA installed 34 active soil vapor sampling probes surrounding the site in the study area to evaluate the unsaturated zone beneath the site for the presence of PCE and other VOCs. Probe locations were selected judgmentally based on the MIP survey, property access, and historical data. The probe locations are shown in Figure 9. The purpose of the soil vapor probe installation program was to: (1) evaluate where soil vapor conditions in the subsurface could result in impacts to indoor air, (2) evaluate potential impacts from contaminated groundwater to soil vapor and indoor air, and (3) collect data that could be used to estimate attenuation factors for the groundwater to indoor air pathway.

Vapor probes were installed just above the water table at depths ranging between 4 and 7 feet bgs. Vapor points were installed using a Geoprobe rod to manually advance dedicated drivable stainless steel points attached to stainless steel vapor screens and 0.17-inch polyethylene tubing. The annular space surrounding the screen was filled with clean #1 sand. Approximately 1 foot of hydrated granular bentonite was poured above the sand. The remaining annular space was filled with grout slurry. A female Swagelok fitting was installed in the end of the tubing, and the surface of the vapor point was

finished using bolt-down manhole covers set in a concrete pad. A diagram that illustrates vapor probe construction at each location is presented in Figure 10.

Soil vapor samples were collected in single-use Teflon Tedlar sample bags supplied by EPA ERT for analysis on site. Samples were collected using a "vacuum box" and personal sampling pump. After they were collected, samples were immediately transported to the EPA ERT's Trace Atmospheric Gas Analyzer (TAGA) unit for analysis by GC and GC/MS (see Section 2.5). The TAGA unit was stationed on the site during the week of June 3 through June 10, 2003.

EPA START also installed sub-slab vapor points in the basements of residences located within the area of interest to gain additional information on the potential for vapor intrusion in homes. Sub-slab vapor points were installed to allow a detailed "Tier 3" evaluation of the vapor intrusion pathway to indoor air, as outlined in draft EPA guidance (EPA 2002). Sub-slab samples were installed at depths of 6 to 12 inches below the basement slabs of residences. Three-quarter-inch holes were drilled through the basement floor using a rotary hammer drill. Sample locations were positioned in the approximate center of the basement. The drill was advanced through the concrete slab and into the underlying granular material. Once the hole was made, a piece of 3/8-inch copper tubing with female compression fittings at the top was inserted. Several inches of #1 sand was placed at the bottom of the hole, covering the bottom tip of the copper tube. The remainder of the hole was filled with grout to the top of the copper tube, which was approximately 1 inch below floor grade. Threaded male fittings were installed in the female fittings at the top of the copper tube to seal the vapor point. Fifteen sub-slab probes were installed in residences downgradient and northwest of the site, as shown on Figure 9. Residential sampling locations for sub-slab samples were selected based on MDEQ historical data, MIP data, vapor probe data, and property access.

Indoor and Ambient Air (Summa)

Indoor and outdoor (ambient) air samples were collected from each of the residences where sub-slab samples were collected. Indoor air was sampled after the sub-slab samples had been collected using laboratory-cleaned Summa canisters and 24-hour integrated air samplers. The Summa canister samples were collected simultaneously from the basement and the first floor. Samples were also collected simultaneously at the entrance to the residence (the front or back porch, whichever was nearest the site) for comparative outdoor air data. Figure 9 illustrates the residences where the Summa canister sampling occurred, along with the specific location of each sample at each residence. A total of 45 locations were

sampled, which amounted to between three and four locations per residence. Samples from the interior of the residences were collected several feet above the floor level to target the breathing zone.

The two residences nearest the site, at 628 South Ashley Street and 635 South First Street, were each sampled on two different dates during the Summa canister sampling program. Specifically, three locations (basement, kitchen, and front porch) were sampled at 628 South Ashley Street on both June 6 and June 10, 2003. The three locations established at 635 South First Street were sampled on June 4 and June 6, 2003.

2.4 AMBIENT AIR AND INDOOR AIR MONITORING USING TAGA

The EPA ERT also conducted target compound monitoring using the TAGA to assist the EPA ERB in its investigation of air quality issues at the site. The TAGA air monitoring program paralleled the vapor intrusion pathway sampling program in that all properties that were accessed for vapor point, sub-slab, or Summa indoor air sampling were also subjected to TAGA air monitoring. The TAGA sampling locations are shown on Figure 11.

The TAGA air monitoring events were conducted June 2 through 5, 2003. Indoor air was pumped continuously from each residence into the TAGA and analyzed in real time (Section 2.5). Although the whole house was scanned using the TAGA, continuous air sampling and analysis with the TAGA focused on locations near other sampling points (Summa canister locations) and potential preferred pathways (such as floor drains) to improve the pathway analysis and promote data comparisons. Ambient air was also analyzed at entry points to the buildings on each property and at potential release points (vents and windows) from the Armen Cleaners building itself. In addition, the TAGA was used in mobile monitoring mode, collecting and analyzing samples continuously as the TAGA was driven and parked along streets surrounding the site. The field program for TAGA sampling and analysis is described in the *Final Analytical TAGA Report, Armen Cleaners Site, Ann Arbor, Michigan, July 2003*, prepared by Lockheed Martin/REAC for EPA ERT (EPA 2003a).

2.5 COORDINATION WITH RESIDENTS AND IDENTIFICATION OF BACKGROUND SOURCES

Before the indoor air sampling programs (Summa and TAGA), EPA START worked in cooperation with the City of Ann Arbor to interview the residents of houses to be sampled. The information was recorded on standard forms modeled from EPA indoor air guidance (EPA 2002) and the State of Massachusetts (http://www.mass.gov/dep/ors/files/indair.pdf). Information recorded on the forms included occupant ages, occupations, lifestyle information, and structural information for the dwelling (for example, age, and building materials). In addition, possible sources of background VOCs were discussed with the residents. Each resident was requested to identify and list potential sources of VOCs in the residence, and then to remove them at least 48 hours before the indoor air characterization portion of the project. The City of Ann Arbor also assisted residents who requested help in identifying and removing or securing potential background sources of VOC contaminants of interest.

2.6 ANALYTICAL METHODS FOR EPA DATA COLLECTION ACTIVITIES

This section provides further information on the specific sampling and analytical methods that were applied during the EPA vapor intrusion and ambient air sampling programs.

2.6.1 Soil Vapor Analysis from Vapor and Sub-slab Probes

Soil vapor samples were collected from vapor probes and sub-slab probes in 1-liter Tedlar bags (Teflon) supplied by EPA ERT. New sample bags were connected to the inside of a negative-air chamber, and the lid was closed. One end of the negative-air chamber was connected to the Swagelock fitting on the end of the soil vapor probe or the female compression fitting on the sub-slab probe. Initially, Tygon tubing was used to connect the sub-slab fittings to the negative air chamber. The Tygon was later replaced with Teflon tubing, however. The tubing was changed after low levels of chemicals of concern (COCs) began to appear consistently in several field blank samples. In addition, the tubing and sample train was replaced after each sample to further minimize the potential for cross-contamination.

Samples were collected through the sample train by connecting a personal sample pump to the other end of the fitting on the negative air chamber to create a vacuum within the box. This procedure allowed the sample to be collected at a low flow rate with reduced potential for cross contamination. Soil vapor samples from vapor point and sub-slab sample locations were analyzed during the field program using GC and GC/MS methods, as described in the following sections. These analyses occurred between June 2 and June 5, 2003.

Micro GC

An Agilent 3000A Micro Gas Chromatograph (Micro GC) was used to perform fixed-gas analysis of the soil vapor samples. The primary compounds of interest were oxygen (O_2), nitrogen (N_2), methane (CH_4), carbon monoxide (CO), and carbon dioxide (CO_2). The 34 soil vapor and 15 sub-slab samples collected by EPA START personnel were analyzed on site. The purpose of these samples was to verify that soil vapor was being collected and that surface or ambient air was not being drawn in. Samples were analyzed in accordance with REAC SOP #1725, *Micro Gas Chromatograph Analysis of Fixed/Permanent Gases.* All analytical data were verified per data category 1 (DC1) requirements (EPA 1991). The Micro GC analytical report provides the details of the GC data collection program (EPA 2003b).

The Agilent 3000A Micro GC used dual capillary columns (columns A and B) and dual micro-chip thermal conductivity detectors (μ-TCD). Air samples were injected into the GC by an internal sampling pump that drew the vapor-phase sample through individual fixed volume sampling loops for a programmed period. Once injected, the dual column, dual μ-TCD system allowed independent detection and identification of compounds. The results from column A were used for oxygen, nitrogen, methane, and carbon monoxide. The results from column B were reported for carbon dioxide. Limits of quantitation were in the 4 to 5 percent per volume range for the target atmospheric gases.

Hapsite GC/MS

The EPA ERT used an Inficon Hapsite portable GC/MS to perform initial screening analysis of the 49 soil vapor samples collected at the Armen Cleaners site. The samples were analyzed for PCE and its breakdown products, TCE, trans-1,2-DCE, and VC. Samples were analyzed on site in accordance with REAC SOP #1726, *Field Analysis of VOCs in Air Using the Hapsite GC/MS (Draft SOP)*. All analytical data were verified per DC1 requirements. The Hapsite GC/MS analytical report provides additional details on the portable GC/MS data collection program (EPA 2003c). The Hapsite analyses were used to obtain fast screening-level data on the ranges of VOC concentrations found in the samples. These concentration range data were used to assess the "presence or absence" of significant VOC levels in the samples. The concentration range data were also used to estimate the optimal sample aliquot size for more definitive and sensitive analysis of the samples using the Agilent GC/MS.

An aliquot from the Tedlar bag was introduced via a fixed-volume sampling loop into the Hapsite GC/MS to begin the analysis. While the sample loop was purged and loaded, internal standards were mixed with the gas stream. When this operation was complete, the sample (250 microliter [μL]) was injected onto the

GC column to begin the analysis. All samples were diluted in Tedlar bags. Limits of quantitation for undiluted samples ranged from 90 to 100 ppbv.

Agilent GC/MS

In addition to the Hapsite screening-level GC/MS, a laboratory grade, bench-top Agilent 6890 gas chromatograph and 5973N mass spectrometer housed in the TAGA bus were used for low-level quantitative analysis of VOCs in the soil vapor samples in the field. Fifty-five compounds made up the target compound list (TCL), which included PCE, TCE, 1,1-DCE, trans-1,2-DCE, cis-1,2-DCE, and VC.

All 49 vapor samples were analyzed on site in accordance with *REAC Standard Operating Procedure (SOP) #1701, Field Analysis of VOCs in Tedlar® Bag Air Samples by GC/MS*. Analytical data were validated per DC1 requirements. The GC/MS analysis employed a pre-concentrator trap in a manner similar to EPA Method TO-14. An aliquot of each sample (ranging from 1 milliliter [mL] to 1,000 mL) was withdrawn from the Tedlar bag and trapped in an OI Analytical 4560 sample concentrator along with 10 mL of a three-component internal standard mixture. Subsequently, the sample was thermally desorbed to the GC/MS system for analysis. Minimum limits of quantitation were in the range of 4 to 10 ppbv. The GC/MS analytical report provides additional details of the Agilent transportable GC/MS data collection program (EPA 2003d).

2.6.2 Indoor Air Summa Canister Analysis Program

Integrated 24-hour indoor air samples were collected in homes surrounding the site to assess whether the exposure pathway was complete from the site to potential residential receptors. Six-liter Summa canisters were installed for sample collection in multiple rooms within each residence (Figure 9). Samples were collected after the house had been screened with the TAGA. Canisters were analyzed for a comprehensive list of 60 halogenated and nonhalogenated VOCs according to Modified EPA Method TO-15 (http://www.epa.gov/ttn/amtic/airtox.html) by Air Toxics, Ltd., of Folsom, California (http://www.airtoxics.com/). Limits of quantitation for undiluted samples ranged from 0.5 to 1 ppbv.

2.6.3 TAGA Indoor Air and Ambient Air Analysis

Indoor and outdoor air monitoring for PCE, TCE, trans-1,2-DCE, and VC using the TAGA was performed in accordance with the Response Engineering and Analytical Contract (*REAC) Draft Standard Operating Procedure (SOP) # 1711, Draft Trace Atmospheric Gas Analyzer (TAGA) IIe SOP*. The TAGA method is based on the Perkin-Elmer API 365 mass spectrometer/mass spectrometer (MS/MS), a

direct-monitoring instrument capable of detecting, in real time, trace levels of many organic compounds in ambient air. The technique of triple-quadrupole MS/MS is used to differentiate and quantitate compounds using a selected-ion technique.

The TAGA monitored indoor air using a 200-foot length of corrugated Teflon sampling hose to draw samples into the MS/MS. A 6-foot length of corrugated Teflon sampling hose was used to collect samples for stationary and mobile ambient air monitoring and was connected to a glass transfer tube that passed through the wall of the TAGA bus to the MS/MS. Air was continuously drawn through the Teflon sampling hoses at a flow rate of approximately 1,500 milliliters per second (mL/sec). The air then passed through a glass splitter, where the pressure gradient between the MS/MS core and the atmosphere caused a sample flow of approximately 10 milliliters per minute (mL/min) and through a heated transfer line into the ionization source. The flow into the MS/MS was controlled so that the ionization source pressure was maintained at an optimum value of approximately 2.6 torr. The remaining airflow was drawn through the air pump and vented from the TAGA. The result was taken as the average after 1 minute of continuous readings at each sampling location for indoor air samples collected within buildings.

During TAGA air monitoring, a parent/daughter ion pair was monitored for each target compound. The operator used letter keys (flags) sequentially to denote events or sampling locations as the air monitoring proceeded. This information was also recorded on the operator's log sheet. The intensity of each parent ion/daughter ion monitored by the TAGA, in turn, was recorded by the computer for that location in a file on the hard disk. One set of measurements of all of the ions was called a sequence.

A 1-minute pre-entry outdoor data segment was collected at the beginning of each residence survey. The sampler then entered the unit at the operator’s signal while the distal end of the hose was held at breathing height. The sampler proceeded to each room in the unit, where a 1-minute data segment was collected. After the rooms in the residence were sampled, each survey or investigation was concluded by collecting a 1-minute post-entry outdoor data segment. The calibration system was used at the end of the survey or investigation file to introduce a flow of calibration standard gas sufficient to produce a concentration of approximately 2 ppbv of PCE, TCE, trans-1,2-DCE, and VC.

3.0 SUMMARY OF RESULTS FROM EPA INVESTIGATIONS

Results from the EPA investigation were reported in a variety of formats. Results from the MIP survey were presented as MIP boring logs and 2-dimensional and 3-dimensional plume maps posted to the vendor's website. Data from the Flexliner investigation were presented as photographs of the liners after they had been installed and removed from the borings. Soil vapor data from EPA ERT's GC, HAPSITE, and Agilent GC/MS analytical programs were presented in separate data summary reports that also discussed field sampling activities and QA/QC findings (EPA 2003b, 2003c, 2003d). The results from the TAGA monitoring were provided in another report (EPA 2003a). The data from the EPA data collection activities are interpreted and discussed in this section.

3.1 SOURCE EVALUATION

Lateral contaminant plumes, as delineated and modeled from the MIP logs, are shown in Figure 12. The MIP data are further summarized on 3-dimensional oblique representations in Figures 13 and 14. These representations were modeled from the responses of the ECD and PID detectors by the vendor, Columbia Technologies, Inc. (www.columbiadata.com), using its SMARTDATA kriging software. The software further modeled high or variable conductivity that indicates potential low-permeability zones (such as clay zones), which are also included on Figures 13 and 14. Cross sections generated from the MIP logs, which display clay zones as well as contaminant zones, are presented in Enclosure C.

Figure 12 shows that the highest overall ECD responses were observed at on-site boring ACMB-045, located adjacent to and north of the Armen Cleaners building. This boring was located in the vicinity of earlier MDEQ sampling that noted very high soil concentrations of PCE and soil that was apparently saturated with free-phase solvent (Section 1.5.2). The MIP log of boring ACMB-045 is presented in Figure 15. Inspection of the MIP log indicates that the ECD begins to saturate at a depth of approximately 5 feet bgs, which is interpreted as indicating significant concentrations of PCE vapor. Significant response or saturation of the PID and FID is also observed at approximately 10 feet, accompanied by inflections in the temperature, conductivity, and speed sensors. The MIP vendor interpreted these observations as indicating the presence of a saturated zone with potential DNAPL (where concentrations of PCE exceeded soil saturation and groundwater solubility levels). The PID and FID signals abruptly declined at about 15 feet bgs, again accompanied by inflections in the temperature, speed, and conductivity sensors. This

abrupt decline implied that the bottom of the saturated zone had been reached and that the MIP had passed into a dryer, lower-permeability zone. However, this observation could not be verified in the ECD response because the high levels of PCE encountered had apparently contaminated and compromised the performance of this sensitive detector for the remainder of the boring. Thus, the MIP log for ACMB-045 indicated that the interval between 10 and 15 feet bgs was of greatest concern in this area of the site as a source and preferred pathway for PCE. This interval began about 3 feet below the top of the water table.

Attempts to further delineate and confirm the vertical extent of PCE in this area by pushing a boring adjacent to ACMB-045, called ACMB-045B, were inconclusive. As indicated from the MIP log presented in Figure 15, no useful information was obtained at this boring from the ECD; apparently, this detector had remained contaminated from the high concentrations observed at boring ACMB-045. Inflections in the PID response were observed in boring ACMB-045B at between 10 and 30 feet bgs, but were not accompanied by inflections in other sensors. Despite attempts to refine MIP settings and push speeds to improve detector response, the data from boring ACMB-045B could not definitively confirm the vertical source zone of concern on the north side of the Armen Cleaners building that had been indicated by data from boring ACMB-045.

The lateral extent of apparent source material was further resolved west of borings ACMB-045 and ACMB-045B at borings ACMB-044 and ACMB-044A. These MIP logs are also shown on Figure 15. Inflections in the ECD at these borings began at approximately 7 feet bgs, reaching saturation at 10 to 12 feet bgs. Slow declines in ECD response were observed to where these two borings were terminated at around 20 feet bgs. The zones of ECD saturation also showed corresponding, although slight, inflections in the PID response. The lack of significant PID response implied that a significant saturated zone of PCE was not present, however, and that the primary source zone north of the building had been laterally delineated to the west.

The lateral extent of contaminants north of boring ACMB-045 also appeared to be limited, given that much lower responses was observed in the three surrounding borings, ACMB-055 through ACMB-057 (Figure 12). However, significant responses were observed in two borings located south and west of the site, ACMB-033 and ACMB-043. Significant PID response and saturated ECD response were observed between 15 and 25 feet bgs at boring ACMB-043, located on the property at 635 South First Street. These zones were much shallower at boring ACMB-033 (3 to 12 feet bgs), located at the end of the driveway from the site onto West Mosley Street. Together,

the data from these borings indicate other potential source zones beneath and west and southwest of the Armen Cleaners building. The complete MIP logs for borings ACMB-033 and ACMB-043 are shown in Figure 16. There is a 4- to 5-foot decline in ground elevation between these borings south and west of the site and boring ACMB-045 on the northern boundary of the site.

Low levels of contamination, as indicated by the ECD response, were also observed east of the site in borings ACMB-035, ACMB-047, ACMB-058, and ACMB-112 (Figure 12). The level of contaminants appeared greatest at boring ACMB-047, directly across Ashley Street from the site, where high ECD response was noted beginning at 7 feet bgs and was not yet clearly delineated when the boring was terminated at 14 feet bgs. The MIP logs for these borings appear on cross sections B-B', C-C', and H-H' in Enclosure C. Because of property access restrictions and the presence of utility corridors, no MIP borings could be drilled east of borings ACMB-047 or ACMB-112 to further delineate contamination in this area.

In general, the MIP data set appeared to delineate highly contaminated zones north, west, and south of the site. The oblique maps in Figures 13 and 14 further show that clay zones may affect contaminant migration south and southwest of the site. However, the MIP data set did not clearly delineate the lateral extent of potential contamination east of the site or the vertical extent of contamination beneath the eastern portion of the site (borings ACMB-045/045B and ACMB-047). Further delineation to the east of the site would require permission for access to the commercial properties in this area and intensive utility clearance. Moreover, the lack of residential receptors in this area implies that it is of lower concern from a vapor intrusion perspective and is of interest only if downgradient groundwater quality is of concern to the site stakeholders. Based on the MIP data, the surrounding properties of greatest interest from a vapor intrusion perspective appeared to be 628 South Ashley Street (due north of the site), 635 South First Street (due west of the site), and possibly 631 South First Street (immediately northwest of the site).

The Flexliner data agreed with the MIP data in identifying zones of potential free product. Flexliner boring ACFB-002, installed near boring ACMB-045 that had exhibited the highest MIP response, showed staining at a depth of between 11 and 12 feet bgs, further implying the presence of DNAPL in this area just north of the Armen Cleaners building. This Flexliner is shown in Figure 17, which compares it with surrounding Flexliner borings ACFB-001 and ACFB-003. Although the figure shows that the liner from boring ACFB-003 was heavily stained, indicating potential impacts from saturated soil, no overt staining was observed in either boring ACFB-001

or ACFB-003. Heavy soiling was also observed in a similar depth range at borings ACFB-005 and ACFB-006, southwest of the cleaners building. These borings were near ACMB-033, another boring that showed high response during the MIP survey, further implying another zone of significant contamination in this area. A segment of liner from boring ACFB-005 that shows the degree of soiling, along with some small potential stains from free product, is included in Figure 17.

3.2 SOIL VAPOR AND AMBIENT AIR PATHWAY EVALUATION

The following paragraphs describe the results obtained during sampling associated with vapor intrusion, vapor probe data for soil vapor and sub-slab vapor points, bulk gases for vapor sub-slab probes, indoor and outdoor (ambient) air from Summa canister data, and the ambient air pathway data set. The data are then further discussed as they relate to the site and associated residential properties.

3.2.1 Vapor Intrusion Pathway Data Set

Table 2 presents descriptive statistics for the results reported from the vapor probe, sub-slab, and Summa canister indoor air sampling events. The table presents summary statistics for the VOCs that were detected in at least 15 percent of the samples collected from each of the three media. Non-detected results were included in the calculation of the summary statistics at a value of one-half the reporting limit. Table 2 summarizes results from the analysis using the Agilent bench top GC/MS for the vapor probe and sub-slab samples. Additional data reported from the portable Hapsite GC/MS data were not used because they essentially duplicated the Agilent GC/MS data for the vapor probe and sub-slab samples, but with higher reporting limits. (The comparability of the Agilent and Hapsite GC/MS data is further discussed in the EPA ERT's Hapsite GC/MS report [EPA 2003c]. This report is included in Enclosure D.)

Table 2 shows that of the six halogenated VOCs (PCE and five daughter products) reported from the Agilent GC/MS, PCE was the only compound detected at a frequency greater than 15 percent in the vapor probe or sub-slab samples. Mean concentrations for PCE in these two sets of samples are skewed by extreme values near the site, such that the median or geometric mean may constitute more appropriate measures of central tendency. In comparison to the vapor probe and sub-slab data sets, a broader range of VOC analytes was reported from the Summa canister analysis of indoor and outdoor (entryway) air, as reflected in a larger number of analytes with

detection frequencies of greater than 15 percent. Chemicals detected in addition to PCE included constituents of benzene, toluene, ethylbenzene, and xylene (BTEX), acetone, ethanol, and chloromethane. Elevated background concentrations for these common chemicals are possible in residential air for (EPA 2002), and their broad distribution across the study area and lack of correlation with source area data from the site suggest that they are not site-related. The GIS data posting tool for the site, attached to this report on CD-ROM as Enclosure D, provides further information on the distribution of these analytes. Thus, PCE appeared to be the primary chemical of potential concern (COPC) from a vapor intrusion perspective based on vapor probe, sub-slab, and indoor air data. As such, subsequent discussion focuses on PCE. The PCE results for all the vapor probe and sub-slab samples collected during EPA's investigation are presented in Table 3.

VOC Data for Vapor Probes

Overall, PCE was detected at 60 percent of the vapor probe locations installed across the study area. A contoured map of the general distribution of PCE in soil vapor is shown in Figure 18. As shown, two samples with concentrations that exceeded 300,000 ppbv were reported. One was at vapor probe location ACVP-006, at the southwestern edge of the Armen Cleaners property. The other was at vapor probe location ACVP-012, just north of the boundary between the Armen Cleaners property and the property at 628 South Ashley Street. These data correlate well to the extreme MIP readings at borings ACMB-033 and ACMB-045 (Figure 12), not only in terms of location, but also in terms of depth. (Vapor probes were installed at depths of 4 to 7 feet, where high MIP response was also observed.) The vapor plumes depicted on Figure 18 also indicate that potential threats to residences are greatest due north and due west of the site (that is, to the properties at 628 South Ashley Street and 635 South First Street).

As indicated by the vapor probe data, the plume of PCE in soil vapor appears to be delineated to non-detect (that is, to less than the reporting limit of 4 ppbv) approximately 100 feet north of the site by borings ACVP-021 and ACVP-022 (associated with the property at 618 South Ashley Street). Borings ACVP-008, ACVP-009, and ACVP-017 similarly delineate the plume to non-detect west of the site, along South First Street. However, detections in borings ACVP-002 through ACVP 004 and ACVP-014 indicate that the plume is not delineated by the current sampling program south and east of the site. PCE concentrations in the southern- and eastern-most vapor points sampled (ACVP-002 and ACVP-003) ranged from 6.1 to 21 ppbv. As a whole, the vapor point data set concurs with the MIP data set: both portray the plume from the site as limited in size and well delineated to the north and west, with the potential for impacts

greatest at the residences close to the Armen Cleaner facility. Both data sets also show that the extent of the plume has not been well defined east and south of the site.

A secondary PCE plume was partially delineated by the vapor sampling at the extreme northern end of the study area. The highest concentration measured in this plume was 82 ppbv at ACVP-036, at the corner of South Ashley Street and West Madison Street. This plume appears to be disconnected from the main PCE plume and may or may not be site-related. The PCE detections in this area are further discussed in Section 3.2.3, below. This plume was not detected during the MIP survey.

VOC Data for Sub-slab Probes

The overall distribution of PCE in the sub-slab samples correlates with the soil vapor plumes delineated by the vapor probes. The maximum sub-slab concentration of 2,600 ppbv was reported at 628 South Ashley Street, just north of the site near the area of high subsurface concentrations identified in the MIP, Flexliner, and vapor probe studies as well as in the historical MDEQ investigations. Three of the other four detections, ranging from 6 to 37 ppbv, were at other properties near the site: 635 South First Street, 631 South First Street, and 622 South Ashley Street. The remaining detection of 40 ppbv was measured well north of the site at 213 West Madison Street, near the northern plume delineated by the vapor probe study (see Section 3.2.3).

As mentioned in Section 2.6.1, carryover contamination was detected in a sampling train blank during the field program for vapor probes and sub-slab probes. Specifically, 5.1 ppbv of PCE was detected in the sampling train blank analyzed on June 4, 2003. Corrective actions for this potential sample cross-contamination problem consisted of switching from Tygon to Teflon tubing and using dedicated tubing for each sample. Multiple samples collected on the previous day (June 3, 2003) contained concentrations in the range of (less than 10 times) the contaminated sampling blank. Based on the blank results, a potential for high bias exists in these samples, which include the isolated sub-slab sample result of 40 ppbv noted above at 213 West Madison Street. However, a similar sub-slab result of 37 ppbv reported at 635 South First Street on June 3, 2003, showed the same result during a resampling event on June 5, 2003, implying that the cross-contamination had not affected the June 3 result. Vapor probe and sub-slab data that may be affected by the contaminated "old" sampling train are further discussed on a per-property basis in Section 3.2.3.

Bulk Gas Data for Vapor and Sub-slab Probes

Bulk atmospheric gas data (oxygen, nitrogen, carbon dioxide, carbon monoxide, and methane) were collected for each vapor and sub-slab probe point to assess the extent the soil vapor collected by the probes resembled atmospheric air. In some (but not all) cases, these data may indicate leakage of atmospheric air into the probes during sampling. The bulk gas data are included with the rest of the analytical data for the site on CD-ROM in Enclosure D.

Results from the bulk gas sampling indicated that concentrations of nitrogen and oxygen were near atmospheric levels in almost all of the probe samples collected. Oxygen ranged from 19 to 20 percent in 14 of the 16 samples collected for sub-slab probes, and nitrogen ranged between 75 and 78 percent in all 16 samples. The ranges of oxygen (15 to 20 percent) and nitrogen (76 to 83 percent) in the vapor probe samples were broader, but still approached atmospheric levels. Among other bulk gases analyzed, no detections were observed for carbon monoxide or methane, save one high detection of methane at 82 percent at vapor point ACVP-030 (609 South First Street) that was ascribed to a natural gas leak (EPA 2003b). Carbon dioxide levels were generally consistent with background concentrations in the sub-slab samples (0.5 to 1 percent). Carbon dioxide levels were higher in the vapor probes, ranging from 1 to 5 percent for most samples, and as high as 13 percent in a few samples.

Some general trends observed in the bulk gas data included slightly lower levels of oxygen and higher levels of carbon dioxide in the vapor probes than in the sub-slab samples, perhaps because the vapor probes were installed at greater depths (4 to 7 feet bgs) than the sub-slab samples (0.5 to 1 foot). No other trends (such as correlation with VOC levels or with distance from the site) could be discerned in the bulk gas data, however. The overall uniformity of the bulk gas levels across the study area indicates that comparable data were collected at the different vapor monitoring points and may reflect the natural conditions of the subsurface rather than atmospheric contamination of the samples. The observations of a conductive shallow aquifer zone with a high water table and consistent recharge, along with the limited degradation products observed for PCE, are consistent with the bulk gas data in implying aerobic conditions in the aquifer. These data are not further discussed in this report because the probe data sets are self-consistent and can be compared and correlated to the other EPA data sets without the bulk gas data.

Indoor and Outdoor Air Summa Canister Data

PCE was detected in 14 of the 54 Summa canister samples at a mean concentration of 4 ppbv, much lower than the means calculated for vapor probe or sub-slab samples. Table 4 presents the Summa canister results for PCE. Detected concentrations ranged from 0.68 to 70 ppbv. Eleven of the 14 detections, and all detections greater than 5 ppbv, were reported in canisters collected at the adjacent properties due north (628 South Ashley Street) and due west (635 South First Street) of the site. This finding is reasonable given that these two properties are located closest to the zones of high subsurface concentrations delineated by both the MIP and soil vapor surveys (see Figures 12 and 18). The 11 detections at these two properties also encompass both Summa canister air sampling events at each of these properties. (The property at 635 South First Street was sampled on June 4 and June 6, 2003 while 628 South Ashley Street was sampled on June 6 and June 10, 2003.)

Of the 14 detections measured in the Summa canisters, six were reported in basement samples (ranging from 3.3 to 25 ppbv), four were reported in first-floor indoor samples (ranging from 0.68 to 5.9 ppbv), and four were reported in outdoor entryway samples (ranging from 1.1 to 70 ppbv). The highest basement concentrations were measured at 628 South Ashley Street, whereas the highest first-floor and entryway concentrations were measured at 635 South First Street. This observation implies that the relative contributions of the vapor intrusion and ambient air pathways may differ at these two properties. More detailed discussions of the Summa and other data sets for each individual property are presented in Section 3.2.3.

3.2.2 Ambient Air Pathway Data Set

TAGA monitoring of outdoor and indoor air included PCE and three potential daughter products from the decomposition of PCE (TCE, trans-1,2-DCE, and VC). Summary statistics are provided for these data in Table 5. Whereas all four target analytes were detected in outdoor air surrounding the site at a detection frequency of 25 percent or more, only PCE was detected during indoor air monitoring at nearby residences. The mean concentration calculated for PCE in outdoor air was biased high by concentrations reported from vents and windows on the Armen Cleaners building. Of the 20 air monitoring points around the building, concentrations at 12 were greater than 1,000 ppbv, ranging as high as 50,000 ppbv at Vent #11. Emissions from the building are anticipated to fluctuate because cleaning operations are performed in batches. The project team also noted that emissions cycled with operation of the building's cooling fans, with

increased emissions associated with operation of the cooling fans. Further evaluation of the building as a source of emissions to ambient air was beyond the scope of this study, requiring additional information such as indoor air conditions in the building, the features and performance of the ventilation system, and assessments of mean mass flux rates for the contaminants.

The TAGA data for PCE collected at the cleaners building are summarized on Figure 19, along with indoor and outdoor TAGA samples collected at the adjacent property of 635 South First Street on the same day (June 3, 2003). June 3 was the only TAGA sampling day when concentrations were detected above the MDEQ acceptable indoor air concentration of 6.20 ppbv in indoor or outdoor air surrounding the cleaners site. As Figure 19 indicates, the 635 South First Street property was downwind of the cleaners on this day.

In addition to PCE, the detections of TCE and trans-1,2-DCE also appeared to be primarily associated with the site, with all detections greater than 1 ppbv (ranging as high as 120 ppbv TCE and 88 ppbv 1,2-DCE) reported from on-site monitoring points near vents and windows. However, detections of VC were widely distributed over the study area, with the highest concentrations in the range of 10 ppbv, and did not appear to be as strongly associated with the site. Low concentrations of all four target analytes (in the range of 1 ppbv or less) were detected at most of the mobile monitoring points.

As indicated in Table 5, PCE was detected at 23 percent of the 166 TAGA monitoring points established in residences surrounding the site. Thirty-three of the 38 total detections, and all concentrations greater than 1 ppbv, were measured in the two residences adjacent to the site at 628 South Ashley Street and 635 South First Street. The mean concentration in indoor air across the study area, as measured by the TAGA, was approximately 2 ppbv with a median of 0.4 ppbv. The complete set of PCE data collected during the TAGA monitoring program is presented in Table 6.

3.2.3 Impacts to Residences as Indicated by Vapor Pathway and Ambient Air Pathway Data

The vapor intrusion pathway and ambient air pathway (TAGA) data collection further established the site as a significant source of ambient and subsurface vapors and further confirmed that the properties due north and due west of the site were of greatest concern for residential exposure to these vapors. The data sets identified potential downgradient impacts of the site and other areas of interest that may require additional investigation. The complete data sets compiled by EPA

START and EPA ERT for each of these properties is further summarized and discussed in this section. All properties where one or more soil vapor, sub-slab, indoor air, or outdoor air samples exceeded MDEQ inhalation criteria are summarized on Figure 20.

Armen Cleaners

The soil vapor data and air monitoring data collected from potential source areas on the Armen Cleaners property are summarized together on Table 7. The TAGA sample locations on the exterior of the cleaners building are also illustrated on Figure 21. As discussed previously, soil vapor hot spots indicated by PCE concentrations that exceed 300,000 ppbv correlate with potential source zones identified by the MIP and Flexliner surveys at vapor probes ACVP-006 and ACVP-012 (located just off the Armen Cleaners property at 628 South Ashley Street; see Table 8). These hot spots are located just southwest and north of the cleaners building.

In addition to the subsurface hot spots, Vent #11 on the roof of the building is indicated as a significant source of PCE, with a measured TAGA concentration of 50,000 ppbv. As shown in Table 7, a Tedlar bag sample was also collected from this vent and analyzed by the Agilent GC/MS, with a reported concentration of 18,000 ppbv. (This sample was identified as "Stack 11.") Vapors emitted from other vents and windows on the building were measured by the TAGA as 1,000 to 3,000 ppbv PCE. Vent #11 and the other vents with the highest TAGA concentrations appeared to be associated with the building cooling and ventilation system rather than with the clothes processing equipment (which is a "closed-loop" system). The TAGA and Tedlar bag sampling at the building vents and windows began at 4:00 p.m. on June 3, 2003. The field team noted that clothes processing at the cleaners appeared to be ending for the day at the time of sampling.

628 South Ashley Street

An extreme soil vapor concentration of 550,000 ppbv PCE was reported at vapor point ACVP-012, upgradient of the residence and associated with the hot spot north of the Armen Cleaners building (Figure 18). The complete set of discrete air and vapor sample data and TAGA real-time monitoring data for the residence at 628 South Ashley Street is presented in Table 8. Sample locations within the residence are illustrated on Figure 22. Another high vapor concentration of 6,700 ppbv was reported at vapor point ACVP-016 at the southwestern corner of the property, also near the boundary with the site. This probe location is near the former soil excavation, where the owner had removed source material in 1985. Soil vapor concentrations of PCE decline to 20 ppbv at vapor point ACVP-019 on the northern property line.

A concentration of 2,600 ppbv was reported in the sub-slab sample collected beneath the residence, compared with concentrations of 25 ppbv measured in collocated Summa canister samples collected in the basement near the sub-slab sample point. A ratio of these concentrations produces an attenuation factor between the sub-slab and indoor concentrations of approximately 0.01, which is an order of magnitude below the default attenuation factor of 0.1 for sub-slab and shallow soil gas recommended in EPA guidance (EPA 2002). The indoor air concentrations reported from the basement samples collected on June 6, 2003, exceed the MDEQ acceptable indoor air concentration of 6.20 ppbv. However, Table 8 shows that two additional Summa canister samples collected in the first-floor kitchen and on the front porch of the residence were non-detect for PCE.

As described in Section 1.5.3, GAC air purifying systems had been installed in the basement and apartments of 628 Ashley Street after MDEQ's supplemental investigation in June 2002. At the time of the Summa and TAGA screening events, the EPA field team noted that the two GAC purifiers in the basement were still active and had not been turned off. Therefore, the Summa and TAGA results are considered concentrations attained with the purifying system in place. Concentrations would be anticipated to be higher if the air purifiers were turned off or removed, possibly producing a sub-slab-to-indoor air attenuation factor closer to the EPA indoor air guidance value of 0.1. The project team could not determine whether the GAC filters had been changed regularly to maintain optimum PCE removal.

As discussed previously, a second Summa sampling event was performed at 628 Ashley Street on June 10, 2003. Minor differences were observed when compared with the first sampling day on

June 6 (Table 8). Basement concentrations declined from 25 to 12 ppbv, whereas the first-floor (kitchen) and front porch samples increased from non-detect to 0.68 and 1.5 ppbv. Ann Arbor meteorological data (http://www.epa.gov/castnet/metdata.html) indicated that southerly winds predominated to a greater extent on June 10 than on June 6, potentially causing greater relative ambient air transport from the site due north to 628 South Ashley Street.

Table 8 also presents the TAGA outdoor and indoor air monitoring points for the residence. Nine locations were sampled in the basement, including three collected near the Summa canister samples (TAGA locations "Basement Room Three," "Hole One," and "Hole Two"). The TAGA results were lower than the Summa canister results for the basement sampling, ranging from 1.3 to 3.7 ppbv. In assessing first-floor conditions, the TAGA data agreed with the Summa canister data, reporting only two low concentration detections of PCE (less than 1 ppbv) out of 10 locations sampled. The first-floor TAGA locations included outdoor air sampling points at the entries to the building, which were among the non-detections. These findings implied that the vapor intrusion pathway to basement residential receptors, if present, is of greatest concern for the property. However, Figure 22 indicates that the wind was from the northwest at 12 mph on the TAGA sampling date, which would have carried vapors from the site away from the property during sampling. Differences between the TAGA data and the Summa indoor air samples could also result because the Summa canisters were 24-hour integrated samples, while the TAGA sampling occurred over an averaging time of a few minutes. Thus, the longer averaging time associated with the Summa canister sampling may have included more emissions maxima from the facility (associated with discrete cleaning batches or cycles of the building ventilation system) when compared with the TAGA sampling.

635 South First Street

The highest vapor probe concentrations measured on the property at 635 South First Street were at ACVP-001 (550 ppbv) and ACVP-011 (690 ppbv), both located between the residence and the site. The soil vapor, Summa canister, and TAGA data for the residence at 635 South First Street are combined in Table 9. Sample locations within the residence are illustrated on Figure 23. Soil vapor concentrations decline to the west across the property to less than 10 ppbv, as reported in probes ACVP-007, ACVP-009, and ACVP-010 at the property boundaries. The MIP survey indicated that vapor transport in this area may be inhibited by clays (Figure 13). However, unlike 628 South Ashley Street, the sub-slab (37 ppbv) and basement Summa canister samples (15 ppbv) exhibited similar concentrations, and a higher concentration of 70 ppbv was measured in a

Summa canister sample collected on the back porch. These concentrations were again above the MDEQ indoor air criterion of 6.20 ppbv.

Like the other property immediately adjacent to the site (628 South Ashley Street), a second Summa sampling event was performed at 635 South First Street on June 6, 2003. (The initial Summa sampling event occurred immediately after the vapor probe sampling on June 4.) Lower concentrations were observed at all three Summa locations during the second sampling event (Table 9), although the result for the sample location on the back porch remained above the MDEQ indoor air criterion at 48 ppbv. The reduction in concentration may have occurred because northeasterly winds predominated for much of the sampling day on June 4 (potentially carrying contaminants downwind from the site), while southwesterly winds predominated on June 6. This observation confirmed the significance of the ambient air pathway for 635 South First Street and indicated that concentrations of concern can still be present in outdoor air on the property despite opposing winds.

Table 9 shows that TAGA monitoring results collected on June 3, 2003, at 635 South First Street were also similar to the indoor air results obtained with the Summa canister. Four monitoring points in the basement showed concentrations ranging from 23 to 26 ppbv. PCE was also detected at all seven first-floor monitoring points at concentrations ranging from 9.6 to 29 ppbv. Two outdoor monitoring points at the building entrances showed lower concentrations of 0.87 ppbv (east side) to 0.32 ppbv (west side). The predominant wind direction on the TAGA sampling day was from the general direction of the site (from the northeast at 13 mph; see Figure 23). Therefore, the ambient air pathway may have contributed more significantly to the indoor air contamination observed at 635 South First Street when compared with 628 South Ashley Street at the time of sampling. The June 3 TAGA data for the 635 South First Street property are also shown on Figure 19 compared with the upwind samples from the cleaners property collected on the same date.

A second TAGA monitoring event occurred on June 5, 2003. Ambient concentrations declined when compared with the first TAGA sampling 2 days earlier because the wind was from the north rather than from the northeast. Maximum concentrations on the first floor of the residence dropped from near 30 ppbv to 5 ppbv. PCE was not detected in samples from many of the first-floor monitoring locations.

Downgradient Properties

Compared with the adjacent properties discussed above, other properties surrounding the site that were included in EPA's data collection displayed isolated, low-level detections of PCE. The detections observed for these properties were for soil vapor and Summa canister samples only; no detections were reported from TAGA monitoring. The data are summarized in Table 10. No vapor probe samplers were installed at the property immediately northwest of the site, 631 South First Street. However, the sub-slab sample from this property contained only 6 ppbv of PCE. No PCE was detected in the corresponding basement Summa canister sample from the property, but concentrations up to 1.4 ppbv were reported in two first-floor canister samples that were collected. Similarly, a sub-slab sample (ACSS-003) collected at the second property north of the site, 622 South Ashley Street, contained 36 ppbv of PCE, but no detections were reported in the Summa canister samples from this property. However, blank results indicated that this concentration may have been biased high from carryover in the "old" sampling train (see Section 3.2.1). Along with the data described earlier for 628 South Ashley Street and 631 South First Street, these data indicate that threats from soil vapor intrusion and airborne transport from the site decline quickly to the north and west.

As noted previously, a secondary PCE plume is apparent well north of the site near the intersection of West Madison Street and South Ashley Street. This second plume may or may not be site-related. The maximum soil vapor concentration measured in this area was 82 ppbv at vapor point ACVP-036, near the intersection of the two streets (Table 10). Other detections in this area include a vapor point (11 ppbv) and a basement Summa canister sample (3.3 ppbv) at 610 South Ashley Street. In addition, a sub-slab concentration of 40 ppbv was reported at 213 West Madison Street, which correlated to low-level TAGA detections (about 0.1 ppbv) measured in the basement of this residence. However, blank results indicated that the sub-slab concentration may have been biased high from carryover in the "old" sampling train (see Section 3.2.1). The complete data set for 213 West Madison is presented in Table 11. Further investigation may be necessary to assess whether the PCE detections in this area reflect a preferred pathway away from the site, or whether there is another source of PCE.

Finally, Table 10 also lists additional detections of PCE in vapor probe samples east and south of the site, across South Ashley Street and along West Mosley Street. As discussed in Section 3.2.1, concentrations range from 6.1 to 61 ppbv in these borings and indicate that the extent of PCE is not fully delineated in this area.

Mobile and Stationary Monitoring Results

Additional survey data were collected during EPA ERT's investigation with the TAGA in mobile monitoring mode, so that instantaneous samples were collected at multiple points as the TAGA proceeded along a defined route on the streets surrounding the site. Two mobile monitoring sequences were conducted on consecutive days, along routes presented in Figures 24 and 25. The mobile monitoring data are presented in Table 12. Concentrations of PCE slowly rose from non-detect to 6.4 ppbv during the first mobile monitoring day as the TAGA circled the blocks surrounding the site. The highest concentrations were measured at the end of the monitoring route, well northeast of the site near the intersection of West Madison Street and South Main Street. The wind speed at the airport around the time of the first mobile monitoring event was 8 mph from 230 degrees (that is, from the southwest), placing the highest PCE readings downwind of the site. Other relatively high concentrations were measured immediately across South Ashley Street east of the site, and at the corner of South First Street and West Mosley (the 635 South First Street property).

The second monitoring event on the next day followed a similar route. This time, however, the highest concentrations were measured west of the site, at the intersection of South First Street and West Mosley Street, ranging as high as 26 ppbv. The wind speed at the airport around the time of the mobile monitoring was 10 mph from 50 degrees (that is, from the northeast), again placing the highest PCE readings generally downwind of the site. Compared with the highest PCE readings from the first mobile monitoring event, the measurements from the second event were taken much nearer to the site in the downwind direction. This closer downwind location may explain why the maximum readings measured on the second day were higher than on the first day. Overall, the qualitative correlation of PCE detections with site proximity and wind direction in the mobile monitoring data imply possible transport of PCE well away from the site, at concentrations comparable to the indoor air data collected during the other sampling activities. These data support the conclusion that the ambient air pathway may contribute significantly to total risk associated with the site, depending on meteorological conditions.

Additional stationary monitoring was performed along the monitoring routes by parking the TAGA at three locations:

(1) North of the cleaners site, at 614 South Ashley Street on June 2, 2003 (location A on Figure 24)

(2) At the intersection of South First and West Mosley Streets on June 3, 2003 (location A-B on Figure 25)

(3) One-half block east of the cleaners building along West Mosley Street on June 4, 2003.

The first two stationary sampling events lasted 15 minutes, and the last event lasted 45 minutes. The first two sampling locations were downwind of the cleaners on the sampling dates (with wind speeds between 8 and 12 mph) and provided additional evidence of vapor transport away from the site. Specifically, a maximum PCE concentration of 14 ppbv and an average of 2.3 ppbv were measured at location A, whereas a maximum PCE concentration of 60 ppbv with an average of 4.5 ppbv was measured at location A-B. The proximity of location A-B to 635 South First Street further confirms the significance of the ambient air pathway for this residence. The third stationary sample location was located crosswind of the cleaners on the sampling day, and recorded no VOCs at concentrations above the quantitation limits.

3.3 REFINED CONCEPTUAL SITE MODEL

The preceding discussions of investigation results are summarized in a refined CSM on Figure 26. The figure shows a PCE source area of high concentration that includes DNAPL in soil and groundwater beneath the site that may spread to adjacent properties at 628 South Ashley Street and 635 South First Street (see Figure 12). PCE migrates in the vapor phase in the vadose zone, as well as in the dissolved phase below the water table. Although the geology within 20 feet bgs beneath the site consists primarily of fairly permeable sands and silts, migration of PCE may be inhibited in some directions (west, south, and northeast) by less permeable clay zones within this 20-foot interval, as delineated by the MIP survey. Furthermore, the predominant geology below 20 feet is silt (Figure 26), though this silt is not lithified. This silt is believed to act as a relatively non-porous and impermeable barrier to contamination from the Armen Cleaner site. Groundwater migration is most likely to the northwest and southeast, based on the groundwater divide MDEQ (DLZ) observed beneath the site in 2002 (Enclosure A). Overall, however, the soil vapor data EPA collected, in combination with the earlier soil and groundwater data MDEQ

collected, indicate that migration of PCE away from the site is fairly limited, affecting only a few adjacent properties.

The TAGA monitoring program verified that vents and windows on the cleaners building were significant sources of PCE. Figure 26 also shows a vapor plume emanating from the site in the prevailing wind direction. Furthermore, PCE detections in ambient air correlated with the wind direction from the site during both the mobile monitoring events and the residential TAGA sampling (at 635 South First Street, for example). Therefore, although the vapor plume attenuated quickly, ambient air transport could be significant from the site, depending on conditions. In general, persistent impacts from ambient air transport appeared probable for properties immediately adjacent to the site. Although seemingly low, ambient vapor impacts at greater distances from the site are uncertain and might be further resolved by additional data analysis (such as identification of atmospheric stability classifications during the TAGA sampling) and longer-term ambient monitoring.

Other observations on the CSM are noted below, along with aspects of the CSM that require further refinement (data gaps):

- Horizontal delineation is fairly complete in terms of delineating the crude lateral extent of the source area based on the MIP pushes, except south and east of the site. Vapor probe, soil, and groundwater data confirm the general extent of the area, as well as the source vapor and groundwater plumes, again except south and east of the site (as noted above). Additional data collection will be needed to define the vertical extent of the free-phase and related groundwater plume. More extensive soil sampling and well installation in and around the source area may be needed to support design of a remedy if deemed necessary. The need for this additional work is indicated by saturated response the MIP ECD displayed to the greatest depths sampled (26 and 40 feet bgs) in two adjacent borings north of the cleaners building.

- The investigation uncovered no evidence of a preferred pathway from the site where significant migration had occurred. However, as shown in Figure 26, a permeable and conductive zone of glacial sand and gravel is interpreted to a depth of approximately 20 feet bgs surrounding the site. This zone has not been fully characterized.

- Given the lack of PCE daughter products detected during the EPA investigation, the general rate of biodegradation at the site appears to be low. The investigation found no potential for exposure to vapors of PCE daughter products, although low levels of daughter products had previously been reported in other media (see Section 3.3.2 below). Further study is necessary at the site to assess biodegradation and the potential applicability of monitored natural attenuation (MNA) should enhanced MNA be considered as a potential remedy.

- Vapor intrusion to basements appears to be of greater concern to the north of the site than to the west, as indicated by comparisons between results obtained from residences located at 628 and 622 South Ashley Street to the north, and 635 and 631 South First Street to the west. Several factors that may contribute include the distribution of the principal source materials, the groundwater gradients, the existence of clay zones west of the site, and the historical excavation that focused on the western side of the site.

- A low-level plume was partially delineated in soil vapor well north of the site, along West Madison Street (Figure 18). Low-level PCE detections were also reported by the TAGA at a home in this area, at 213 West Madison Street. Given that this plume appears to be at least partially separated from the plume that emanates from the site, it may not be site-related. Alternatively, a man-made or natural conduit (such as a utility corridor or sand/gravel zone) could provide a preferred pathway from the site to this area. Thus, further study may be required in this area north of the site, including data for groundwater as well as soil vapor. Data gaps between this northern plume and the site should be addressed, particularly along the east side of South Ashley Street, where only limited sampling was performed. However, the presence of blank contaminants in some related QC samples suggests the potential that the plume observed could be an artifact of cross-contamination.

- In addition to the northern portion of the study area, the lateral extent of PCE contamination is not well delineated east and south of the site (Figures 12 and 18). Detections of PCE were still measured in perimeter vapor probes in this area, and no historical soil or groundwater data exist. Migration of PCE in groundwater and the vapor phase to potential commercial/industrial receptors in this area may need to be further assessed.

The CSM for the site is also presented on Figure 27 in the form of a pathway receptor diagram, or Berger Chart. This diagram indicates that both the vapor intrusion and ambient air pathways have been verified as complete to residential receptors immediately surrounding the site. The relative contributions of each pathway differ for the various properties and are not easily quantified. For example, vapor intrusion appears to be the primary pathway of concern at the residences located at 628 South Ashley Street given the strong correlations among the soil vapor, sub-slab, and basement Summa canister data and the weaker correlations between indoor and outdoor TAGA monitoring data. At 635 South First Street, however, the relative contributions of the two pathways are uncertain.

Figure 27 also documents that the exposure pathways for air and vapor have not been completely delineated for industrial receptors (located northeast and east of the site). In addition, although the groundwater pathways have not been fully studied, Figure 27 shows that these pathways are likely incomplete based on the distance of the site from downgradient wells and surface water bodies.

3.3.1 Correlation and Comparability of EPA Data Sets

In presenting the results of the EPA START and EPA ERT field activities, Sections 3.1 and 3.2 also alluded to the comparability between the different data sets. The comparability of these data sets is summarized below, along with the roles and relative utility of the different data collection tools in refining the CSM.

Source Evaluation Data

The Flexliner borings confirmed that MIP points with high ECD and PID response indicated potential source zones and probable DNAPLs. On this basis, possible DNAPLs were identified in two areas of the site (just north of the cleaners building and in the southwestern portion of the site) where ECD response was saturated and PID response was also high (exceeding 500,000 counts). Because the cleaners building lies over these two areas, it is not known whether they constitute a single source zone. This verification of MIP utility implies that further delineation of DNAPL and source zones for remedial design or action is feasible strictly using the MIP.

Before the MIP is further applied, however, it is necessary to evaluate why vertical delineation of the source zone was questionable at borings ACMB-045 and ACMB-045B. The sustained saturation observed in the ECD traces (Figure 15) indicated that the detector had been cross-contaminated or was otherwise not operating properly. PID traces during these two coincident borings were contradictory in delineating vertical extent. Differences in the performance of the PID and other sensors may be related to the much higher push speed used at ACMB-045B to minimize detector saturation.

Further refinement of source extent may have been possible through increased sample densities with the MIP, the Flexliners, or both. Step-out borings surrounding probable DNAPL "hits," for example, may have facilitated engineering evaluations for site cleanup. The ability of the field team to expand the sampling program in this manner may have been hampered by the initial size of the study area combined with time and budget constraints. Traditional soil sampling coupled with vapor probes and small gauge wells could also be used to further characterize the source area in support of remedy design.

Vapor Intrusion Pathway Data

Through sample collection in multiple media along the exposure pathway, EPA's vapor intrusion study provided a strong weight of evidence to document the limited extent of PCE in soil vapor and indoor air at concentrations of concern and to clearly tie these concentrations to the site. Generalized comparisons were difficult between the three media sampled (soil vapor, sub-slab vapor, and indoor air) because of the limited number of properties that exhibited detections in all three media. The observed detections at properties adjacent to the site indicated that the degree of correlation was highly variable even though indoor air detections correlated with detections in the surrounding soil vapor. For example, similar indoor air concentrations were found in basements at 631 South First Street and 628 South Ashley Street. Whereas the First Street concentration was only an order of magnitude lower than upgradient vapor points on the property, however, the Ashley Street concentrations were more than four orders of magnitude below the results for the immediately upgradient vapor points.

Similar variability was observed in the correlations between the sub-slab and indoor air data; attenuation factors between the sub-slab and basement Summa canister results at the two primary surrounding properties of interest ranged from 0.01 to 0.4. Likewise, no detections were observed in the corresponding basement Summa canisters at three other properties where sub-slab samples reported concentrations of PCE ranging from 6 to 40 ppbv. In summary, although the EPA data sets confirmed that the vapor intrusion pathway is complete, they also illustrated the difficulties inherent in estimating indoor air concentrations based on only soil vapor concentrations and attenuation factors. Although soil vapor data appear important in linking indoor air contaminants to a site, data for indoor air are necessary to accurately estimate risk. Additionally, however, the vapor probe data set correlated well with the MIP data in delineating plume and source zone extent to focus subsequent investigations.

Ambient Air

Although the ambient air pathway is assumed to be complete based on the TAGA monitoring program, the contributions of this pathway to overall exposure are difficult to estimate. Correlations between TAGA outdoor air, TAGA indoor air, and Summa canister results were highly variable and were again hampered by limited data (that is, few properties with significant or multiple detections). In the end, the TAGA investigation generally agreed with the Summa data in indicating that ambient air impacts of concern from the site are localized. Relative

contributions to residential risk at nearby properties appear to be of lower overall concern than the vapor intrusion contributions, but may vary based on meteorological conditions and other factors (such as building construction and ventilation, work cycles and activities at the cleaners facility, seasonal factors, or hydrogeologic conditions that inhibit transport of soil vapor).

The TAGA mobile monitoring program showed that downwind outdoor concentrations of PCE could occasionally exceed MDEQ residential criteria within a few blocks of the site. These data also revealed no significant or broadly distributed outdoor background levels for PCE that may affect the interpretation of results for residential outdoor or indoor air.

Compared with TAGA monitoring data, the Summa canister data from the vapor intrusion study appeared to provide a more conservative estimate of indoor air quality. Canister concentrations of PCE were generally equivalent to or higher than the TAGA concentrations, and canister detections were reported at multiple locations where the TAGA reported non-detect. As noted previously, a longer integrated sampling period (24 hours) was used for the Summa canisters than for the TAGA measurements (a few minutes).

3.3.2 Consistency with Historical MDEQ Data Sets

Summary statistics for the air, groundwater, and soil data sets collected by MDEQ during the RI data collection events are presented in Table 13 for comparison to Tables 2 and 5. As shown, MDEQ detected a range of compounds in air that were not confirmed by the EPA data collection programs. These compounds may not be site-related. MDEQ also reported biodegradation products of PCE in the soil and groundwater samples that were not detected in EPA's soil vapor investigation. In comparison to the MDEQ study, the EPA investigation attempted to work with residents to reduce or eliminate background or other non-site sources of VOCs before the sampling programs began. EPA's data also underwent QC review to meet EPA DC1 data quality requirements (EPA 1992). The level of QC review for the MDEQ data is unknown.

In assessing the extent of PCE contamination in the subsurface, the EPA data collection programs generally confirmed and refined the CSM outlined by the MDEQ data for soil and groundwater. For example, the MIP and Flexliner borings confirmed historical source zones in soil with some additional delineation in the southwestern portion of the site. However, MIP and vapor probe data contradicted MDEQ's conclusions from the RI that vertical delineation had been achieved at 18 feet bgs (Sect 1.5.2) and that the extent of contamination had been delineated east of the site.

MDEQ apparently assessed only a few potentially affected properties north and west of the site, interpreted to be downgradient from the principal source zone, for indoor air. MDEQ's data concurred with the EPA data that receptors at the 628 South Ashley Street property could be exposed to PCE vapors at concentrations similar to those found by the EPA investigation. MDEQ reported no indoor air data for the 635 South First Street property.

3.4 SAMPLE RESULT DATABASE AND VIEWING TOOL

The data collected at the site by the EPA START and the EPA ERT, as well as the earlier RI and site inspection data collected by MDEQ, have been combined in an Excel spreadsheet database on CD-ROM that is included as Enclosure D. In addition to the database, the CD-ROM includes a data posting and visualization tool built for use with ArcExplorer freeware that allows posting and comparison of the various data sets on a map of the site and of the surrounding area. Reviewers who own versions of ArcView (Version 3.2 or higher) can also load and view the data and map on the CD-ROM. Basic instructions for use of the database and viewer are included on the CD-ROM.

Enclosure D also includes an electronic copy of this report in Adobe Portable Document File format. In addition, the CD-ROM provided in Enclosure D includes the data reports prepared for the investigation by EPA ERT (EPA 2003a through d) in WordPerfect format.

4.0 CONCLUSIONS AND SUGGESTIONS

EPA's detailed study of the Armen Cleaners site was successful in building a collaborative data set to confirm whether the vapor intrusion and ambient air pathways are complete. The study also better defined the extent of indoor air contamination and potential residential receptors of concern north and west of the site. Overall, although EPA's investigation built on previous data to delineate significant sources of PCE at the site, it also found that concentrations in vapor and air were fairly localized, dropping quickly with distance from the site.

The project was unique in its application of a number of innovative, real-time analytical approaches. This project could have been improved through more aggressive integration of systematic planning and dynamic work strategies focused on a real-time, "learn as you go" adaptive sampling strategy. However, some systematic planning and adaptive strategies were used. For example, a task force was assembled to involve project stakeholders in developing the technical approach and principal project objectives. In addition, this communication strategy was expanded to the affected public through public meetings, resident interviews, and a project website. The overall goal driving the data collection was broad-based characterization of the site to assess risk, addressing the source term and the potential transport pathways for exposure to airborne VOCs. Based on this goal, a limited dynamic work strategy was applied to assess the nature and extent of contamination for these transport pathways. An initial grid-based sampling approach for the MIP and vapor probe surveys, designed using EPA Region 5's Field Environmental Decision Support (FIELDS) software, was refined and optimized in the field during the investigation based on the initial data collected. The extent of the study area for the later phases of investigation was also refined in this manner.

4.1 DATA GAPS AND SUGGESTIONS FOR FURTHER INVESTIGATION

EPA's study produced a thorough characterization of the vapor intrusion and ambient air pathways in the area immediately surrounding the site. Some additional data gaps were identified for other pathways and media of interest in the refined CSM in Section 3.3. These data gaps include:

- Further delineation of the source zone to assist in the selection and design of remedial or removal measures. Refinements to the lateral extent of this zone on the site may be needed immediately beneath and southwest of the cleaners building. More importantly, however, the vertical extent of contamination should be better defined using MIP or

direct-push soil sampling coupled with dye testing and headspace analysis followed by analysis by a fixed laboratory for the presence of VOCs.

- Groundwater sampling and further delineation of a suspected highly conductive zone of glacial sand and gravel, interpreted at approximately 40 feet bgs. This sampling is suggested to assess the potential for the conductive zone to act as a preferred pathway for contaminant migration away from the site.

- Assessment of biodegradation mechanisms at the site and the potential applicability of MNA and enhanced MNA remedies.

- Further study of a low-level plume that was partially delineated in soil vapor well to the north of the site along West Madison Street. Further vapor or groundwater sampling (or both) in this area and along the east site of South Ashley Street should verify whether this plume is related to the site and indicates a preferred pathway.

- Further characterization of soil vapor and groundwater east and south of the site, where PCE contamination has not been delineated. Migration of groundwater and vapor PCE concentrations to potential commercial/industrial receptors should be further assessed in this area.

4.2 RISK ASSESSMENT AND HEALTH CONSULTATION

EPA OSRTI's role is not to assess the risk associated with the site; comparisons to MDEQ screening concentrations in this report are for information only and do not amount to an evaluation of risk. These comparisons are instead provided to lend perspective on the concentrations measured. Risks to the health of surrounding residents have been assessed for the cleaners property in a health consultation prepared by MDCH (MDCH 2005). The health consultation was consistent with the findings of this report in focusing on the two adjacent properties of 628 South Ashley Street and 635 South First Street as the primary properties of concern for exposure to PCE vapors from Armen Cleaners. Although concentrations in outdoor (ambient) air at 635 South First Street exceeded the Agency for Toxic Substances and Disease Registry (ATSDR) minimal risk level (MRL) of 40 ppbv, the health consultation concluded that exposures to outdoor and indoor air based on ambient transport from the cleaners represented an "indeterminate health hazard as they are sporadic and seasonal in nature." Further rationale for assessing "indeterminate" risk stemmed from the parity of the measured PCE concentrations with the applicable risk-based exposure standards, when combined with uncertainties in the measurements and in the exposure standards themselves.

The health consultation also acknowledged the potential contributions of vapor intrusion to indoor air concentrations of PCE at both 635 South First Street and 628 South Ashley Street

based on the vapor probe and sub-slab data. Initial mitigation measures suggested by the consultation report included additional GAC air purifying units at adjacent properties (like those already installed at 628 South Ashley Street) and at the exhaust vents on the cleaners building. These initial measures should be followed by additional verification sampling to assess their effectiveness, as well as by a long-term remedial strategy (for example, addressing ongoing sources of PCE, such as DNAPL and impregnated building materials).

4.3 LESSONS LEARNED REGARDING FIELD-BASED METHODS AND THE TRIAD APPROACH

The EPA STSC has learned that when Triad concepts are applied for the first time, there is often a tendency to implement innovative technologies without aggressively designing and applying a dynamic work strategy. The application of a dynamic work strategy tied to decisions that may be needed to reach mitigation and cleanup goals can result in significant savings in cost and time on projects such as the Armen Cleaners site. The application of an efficient dynamic work strategy requires data to be compiled, reviewed, and assessed on a real-time basis and then input into the CSM for communication to technical team members and other stakeholders. As a consequence, a clear, detailed data management and data visualization strategy must be developed before entering the field.

Although many different technologies were brought to bear at the site, the nature and extent of contamination at levels of potential concern for the applicable exposure pathways and residential receptors are still not complete. Had a dynamic work strategy been used, it might have been possible to not only limit the extent of the MIP investigation, but also to expand the investigation to the south, east, and vertically to assure that plume was more completely delineated. More detailed sampling and analysis of the source term, including collection of data for engineering evaluations (such as MNA parameters), might also have been possible, providing detailed information for evaluating cleanup alternatives.

The use of this type of focused investigative strategy can require more upfront planning and some idea of the presumptive remedies that might be considered for the site. Obtaining provisional access agreements to neighboring properties “just in case” they are needed can also assure that work can proceed without unforeseen delays as the plumes are better defined. It is understandable that the EPA project team was focused on assuring that vapor issues were addressed, but a dynamic work strategy could have saved significant cost and resulted in the

collection of more data, helping to minimize the need for further investigation phases (for example, to obtain data to support any potential remedies under consideration). Clarifying the need to assess other groundwater-based exposure pathways (for example, downgradient drinking water or surface water receptors) may have also allowed better apportionment of resources between source delineation and extent delineation in soil and groundwater. Other specific types of activities that might have also benefited the project are listed below:

- Earlier correlation of the MIP data with information on soil vapor in the field might have eliminated the need to sample some far-downgradient properties north and northwest. However, it is understandable that the EPA ERB wanted to ensure that all of the residences in the "study area" were addressed to verify that they were not at risk.

- Analysis of an initial set of Summa canisters with rapid turnaround times may have allowed real-time comparisons of the vapor and ambient air pathways and refinement of the data collection approach for the field-based methods. For example, these comparisons might have eliminated some unnecessary TAGA sampling locations in clean areas and allowed additional sampling density where needed.

- A more detailed decision logic to guide and unify the various data collection activities may have provided more focus to the investigation, eliminated data gaps, and allowed the study to achieve a broader range of objectives, such as mitigation or remediation design/implementation.

- Some pilot work upfront may have improved the ability of the MIP to delineate DNAPL.

- Planning to develop a clear understanding of what data each analytical tool would provide, how the data would be used (what decisions it would support), and how the team would confirm that the data were of decision quality would have helped to optimize the data collection strategy and to minimize the data gaps that remained after the investigation.

Overall, the project was extremely successful in most ways. It provided the data needed to support risk assessment and mitigation efforts at the site, as well as begin to support decisions related to cleanup options. The project provided sufficient data for a site-specific evaluation of the vapor intrusion pathway in accordance with EPA guidance (EPA 2002). It further provided a "research" function by generating analytical data from multiple tools for comparison, such that some of these tools can be selected and optimized for more efficient use in future investigations of sites with vapor or ambient air issues. For example, the TAGA provided a largely confirmatory and complementary "picture" of the study area when compared with the MIP and vapor sampling programs. Correlations were apparent in the data sets despite the significant differences between the technologies (for example, 24-hour Summa canister sampling compared

with soil vapor and TAGA ambient air samples with much shorter sampling times). These comparisons between discrete vapor samples and real-time sensing devices, such as the TAGA or portable GC/MS units, could be built on for later vapor pathway programs. Moreover, the strengths of these real-time techniques for assessing the variability in ambient vapor impacts over time, and management of uncertainty associated with assessing vapor extent, could be further explored.

Other efficiencies can be realized through the more aggressive use of the CSM and real-time data management and assessment. Keeping any potential presumptive remedies in mind can also compress data collection, such that reaching project milestones is as efficient as possible.

Much of the above discussion and comment in Section 4.0 represent the opinion of the report authors and should not be construed as EPA's opinion. Although this discussion has been included for the consideration and benefit of the reader, it should not be construed as guidance authorized or approved by EPA.

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TABLES

Table 1: Michigan Department of Environmental Quality
Risk-based Screening Concentrations for Tetrachloroethene
Armen Cleaners, Ann Arbor, Michigan

MDEQ Screening Value for PCE[1]	Concentration
Soil Screening Values (µg/kg)	
Industrial and Commercial Soil Volatilization to Indoor Air	60,000
Residential Soil Volatilization to Indoor Air	11,000
Infinite Source Volatile Soil Inhalation Criterion	180,000
Industrial and Commercial Direct Contact Criterion	88,000
Groundwater Contact Protection Criterion	88,000
Residential Drinking Water Protection Criterion	100
Industrial and Commercial Drinking Water Protection Criterion	100
Groundwater Screening Values (µg/L)	
Industrial and Commercial Drinking Water Criterion	5
Residential and Commercial Drinking Water Criterion	5
Industrial and Commercial Groundwater Volatilization to Indoor Air	170,000
Residential and Commercial Groundwater Volatilization to Indoor Air	25,000
Groundwater Contact Criterion	12,000
Air Screening Values (ppbv) [2]	
Acceptable Indoor Air Concentration [3]	6.20

Notes and abbreviations:

[1] Screening concentrations are summarized from MDEQ 2002.
[2] Air screening concentrations in ppbv at 25 degrees C are calculated from screening concentrations in µg/m^3 using the equation ppbv = (µg/m^3)(24.466/MW), where MW is the molecular weight of the chemical in grams per mole. Using this equation the MDEQ Residential Inhalation Criteria of 42 µg/m^3 for PCE (MW = 165.83 g/mole) converts to 6.20 ppbv.
[3] This concentration is also termed the "Residential Inhalation Criterion"

µg/kg micrograms/kilogram
µg/L micrograms/liter
µg/m^3 micrograms per cubic meter
MDEQ Michigan Department of Environmental Quality
PCE tetrachloroethene
ppbv parts per billion by volume

Table 2: Summary Statistics for EPA START Vapor Probe, Sub-Slab, and Summa Canister Data
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

Compound Results in ppbv	Detected Results	Total Number of Analyses	Detection Frequency	Mean	Confidence -95.000%	Confidence +95.000%	Geometric Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Standard Deviation	Skewness
Vapor Probe Data														
Tetrachloroethene	26	43	60%	20800	-8970	50600	28.9	8.40	2.00	550000	2.00	410	96700	4.90
Sub-slab Data														
Tetrachloroethene	5	18	28%	153	-151	456	5.16	2.00	2.00	2600	2.00	6.00	611	4.24
Summa Canister Data														
Acetone	35	54	65%	10.0	6.30	13.7	5.83	6.35	1.35	82.0	1.85	13.0	13.5	3.7
Benzene	11	54	20%	0.724	0.456	0.991	0.555	0.470	0.335	6.50	0.420	0.700	0.979	5.04
Chloromethane	12	54	22%	0.671	0.443	0.899	0.553	0.470	0.335	6.50	0.430	0.700	0.835	6.65
Ethanol	41	54	76%	91.1	14.2	168	19.4	25.0	1.35	1900	5.40	58.0	282	5.65
m,p Xylene	12	54	22%	0.739	0.495	0.983	0.578	0.470	0.335	6.50	0.430	0.690	0.894	5.38
Tetrachloroethene	14	54	26%	4.40	1.07	7.73	0.899	0.465	0.335	70.0	0.430	1.00	12.2	4.11
Toluene	36	54	67%	3.26	1.67	4.86	1.55	1.50	0.335	34.0	0.470	3.00	5.85	4.04

Notes:
Summary statistics were calculated using the Statistica software available from Stat Soft Inc. (www.stat-soft.com).
A value of one-half the reporting limit was used for nondetected results.
This table summaries only those compounds detected in more than 15% of samples collected.

EPA	U.S. Environmental Protection Agency
ppbv	parts per billion by volume
START	Superfund Technical Assistance and Response Team

Table 3: Summary of Soil Gas Results for Tetrachloroethene (PCE) from Vapor Points and Sub-Slab Samples
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

PT_ID	PT_TYPE	ADDRESS	SMP_DATE	PCE RESULT	QUALIFIER	UNITS	REP_LIMIT	METHOD
Vapor Points								
ACVP-001	vapor point	635 S. First	6/3/2003	550		ppbv	20.0	GCMS
ACVP-001 Rep	vapor point	635 S. First	6/3/2003	410		ppbv	20.0	GCMS
ACVP-001	vapor point	635 S. First	6/3/2003	1.10		ppmv	0.00	HAPSITE
ACVP-002	vapor point	634 S. Main	6/3/2003	6.10		ppbv	4.00	GCMS
ACVP-002	vapor point	634 S. Main	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-003	vapor point	704 S. Main	6/3/2003	21.0		ppbv	4.00	GCMS
ACVP-003	vapor point	704 S. Main	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-004	vapor point	119 W. Mosely	6/2/2003	4.00	U	ppbv	4.00	GCMS
ACVP-004	vapor point	119 W. Mosely	6/3/2003	7.40		ppbv	4.00	GCMS
ACVP-004	vapor point	119 W. Mosely	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-005	vapor point	207 W. Mosely	6/5/2003	4.00	U	ppbv	4.00	GCMS
ACVP-005	vapor point	207 W. Mosely	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-006	vapor point	Armen Cleaners	6/3/2003	330000		ppbv	10000	GCMS
ACVP-006	vapor point	Armen Cleaners	6/3/2003	290	J	ppmv	0.00	HAPSITE
ACVP-007	vapor point	635 S. First	6/3/2003	8.40		ppbv	4.00	GCMS
ACVP-007	vapor point	635 S. First	6/3/2003	0.090	U	ppmv	0.09	HAPSITE
ACVP-008	vapor point	223 W. Mosely	6/3/2003	4.00	U	ppbv	4.00	GCMS
ACVP-008	vapor point	223 W. Mosely	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-009	vapor point	635 S. First	6/3/2003	4.00	U	ppbv	4.00	GCMS
ACVP-009	vapor point	635 S. First	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-010	vapor point	635 S. First	6/3/2003	6.60		ppbv	4.00	GCMS
ACVP-010	vapor point	635 S. First	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-011	vapor point	635 S. First	6/3/2003	690		ppbv	25.0	GCMS
ACVP-011	vapor point	635 S. First	6/3/2003	1.50		ppmv	0.09	HAPSITE
ACVP-011 Rep	vapor point	635 S. First	6/3/2003	1.40	U	ppmv	0.09	HAPSITE
ACVP-012	vapor point	628 S. Ashley	6/2/2003	550000		ppbv	10000	GCMS
ACVP-012	vapor point	628 S. Ashley	6/2/2003	290	J	ppmv	0.09	HAPSITE
ACVP-012 Rep	vapor point	628 S. Ashley	6/2/2003	280	J	ppmv	0.09	HAPSITE
ACVP-013	vapor point	Armen Cleaners	6/2/2003	730		ppbv	20.0	GCMS
ACVP-013	vapor point	Armen Cleaners	6/2/2003	290		ppbv	20.0	GCMS
ACVP-013	vapor point	Armen Cleaners	6/2/2003	730		ppbv	20.0	GCMS
ACVP-013	vapor point	Armen Cleaners	6/2/2003	290		ppbv	20.0	GCMS
ACVP-013	vapor point	Armen Cleaners	6/2/2003	0.78	J	ppmv	0.09	HAPSITE
ACVP-014	vapor point	634 S. Main	6/2/2003	61.0		ppbv	4.00	GCMS
ACVP-014	vapor point	634 S. Main	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACVP-015	vapor point	628 S. Ashley	6/2/2003	460		ppbv	20.0	GCMS
ACVP-015	vapor point	628 S. Ashley	6/2/2003	0.48	J	ppmv	0.09	HAPSITE
ACVP-016	vapor point	628 S. Ashley	6/2/2003	8700		ppbv	250	GCMS
ACVP-016	vapor point	628 S. Ashley	6/2/2003	12.0	J	ppmv	0.09	HAPSITE
ACVP-017	vapor point	628 S. First	6/5/2003	4.00	U	ppbv	4.00	GCMS
ACVP-017	vapor point	628 S. First	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-019	vapor point	628 S. Ashley	6/5/2003	20.0		ppbv	4.00	GCMS
ACVP-019	vapor point	628 S. Ashley	6/5/2003	19.0		ppbv	4.00	GCMS
ACVP-019	vapor point	628 S. Ashley	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-020	vapor point	617-621 S. Ashley	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACVP-021	vapor point	618 S. Ashley	6/2/2003	4.00	U	ppbv	4.00	GCMS
ACVP-021	vapor point	618 S. Ashley	6/2/2003	0.09	UJ	ppmv	0.00	HAPSITE
ACVP-022	vapor point	622-618 S. Ashley	6/2/2003	4.00	U	ppbv	4.00	GCMS
ACVP-022	vapor point	622-618 S. Ashley	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACVP-023	vapor point	625 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACVP-023	vapor point	625 S. First	6/4/2003	0.09		ppmv	0.09	HAPSITE
ACVP-025	vapor point	617 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACVP-025	vapor point	617 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-026	vapor point	616 S. Ashley	6/3/2003	4.20		ppbv	4.00	GCMS
ACVP-026	vapor point	616 S. Ashley	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-027	vapor point	614 S. Ashley	6/2/2003	4.00	U	ppbv	4.00	GCMS
ACVP-027	vapor point	614 S. Ashley	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACVP-028	vapor point	610 S. Ashley	6/3/2003	11.0		ppbv	4.00	GCMS
ACVP-028	vapor point	610 S. Ashley	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-030	vapor point	609 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACVP-030	vapor point	609 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-031	vapor point	614 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACVP-031	vapor point	614 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-032	vapor point	609 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS

Table 3: Summary of Soil Gas Results for Tetrachloroethene (PCE) from Vapor Points and Sub-Slab Samples
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

PT_ID	PT_TYPE	ADDRESS	SMP_DATE	PCE RESULT	QUALIFIER	UNITS	REP_LIMIT	METHOD
ACVP-032	vapor point	609 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-036	vapor point	115 W. Madison	6/2/2003	82.0		ppbv	4.00	GCMS
ACVP-036	vapor point	115 W. Madison	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACVP-037	vapor point	602 S. Ashley	6/5/2003	10.0	U	ppbv	10.0	GCMS
ACVP-037	vapor point	602 S. Ashley	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-039	vapor point	217 W. Madison	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACVP-039	vapor point	217 W. Madison	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-040	vapor point	602 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACVP-040	vapor point	602 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACVP-041	vapor point	560 W. Madison	6/5/2003	4.00	U	ppbv	4.00	GCMS
ACVP-041	vapor point	560 W. Madison	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
Sub Slab								
ACSS-001	sub slab	610 S. Ashley	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACSS-001	Basement	610 S. Ashley	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-002	sub slab	628 S. Ashley	6/5/2003	2600		ppbv	100	GCMS
ACSS-002	Basement Room Three	628 S. Ashley	6/5/2003	2.70		ppmv	0.09	HAPSITE
ACSS-002 Rep	vapor point		6/5/2003	2.50		ppmv	0.09	HAPSITE
ACSS-003	sub slab	622 S. Ashley	6/3/2003	36.0		ppbv	4.00	GCMS
ACSS-003	Basement	622 S. Ashley	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-004	Basement	614 S. Ashley	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACSS-005	sub slab	635 S. First	6/3/2003	37.0		ppbv	4.00	GCMS
ACSS-005	sub slab	635 S. First	6/5/2003	37.0		ppbv	4.00	GCMS
ACSS-005	Store Room One	635 S. First	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-005	Store Room One	635 S. First	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-006	sub slab	606 S. Ashley	6/3/2003	4.00	U	ppbv	4.00	GCMS
ACSS-006	Basement	606 S. Ashley	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-007	sub slab	213 W. Madison	6/3/2003	40.0		ppbv	4.00	GCMS
ACSS-007	Basement	213 W. Madison	6/3/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-008	sub slab	616 S. Ashley	6/2/2003	4.00	U	ppbv	4.00	GCMS
ACSS-008	Basement	616 S. Ashley	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACSS-009	sub slab	115 Madison	6/2/2003	4.00	U	ppbv	4.00	GCMS
ACSS-009	Basement	115 Madison	6/2/2003	0.09	UJ	ppmv	0.09	HAPSITE
ACSS-010	sub slab	111 Madison	6/5/2003	4.00	U	ppbv	4.00	GCMS
ACSS-010	Basement	111 Madison	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-011	sub slab	631 S. First	6/5/2003	6.00		ppbv	4.00	GCMS
ACSS-011	Basement	631 S. First	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-012	sub slab	217 Madison	6/5/2003	4.00	U	ppbv	4.00	GCMS
ACSS-012	Basement	217 Madison	6/5/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-013	sub slab	606/608 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACSS-013	Laundry Room	606/608 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-014	sub slab	617 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACSS-014	sub slab	617 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACSS-014	sub slab	617 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACSS-014	sub slab	617 S. First	6/5/2003	4.00	U	ppbv	4.00	GCMS
ACSS-014	Basement	617 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-014 Rep	Basement	617 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE
ACSS-015	sub slab	625 S. First	6/4/2003	4.00	U	ppbv	4.00	GCMS
ACSS-015	Laundry Room	625 S. First	6/4/2003	0.09	U	ppmv	0.09	HAPSITE

Notes:
All soil gas samples were collected in Tedlar bags.

ADDRESS	Property on which sample was collected
GC/MS	Sample analyzed by Agilent bench-top gas chromatograph/mass spectrometer (GC/MS)
HAPSITE	Sample analyzed by Inficon HAPSITE portable GC/MS
J	Estimated concentration
PCE RESULT	Tetrachloroethene concentration
ppbv	parts per billion by volume
ppmv	parts per million by volume
PT_ID	Point identification number
PT_TYPE	Point type
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
U	Undetected; the associated value is the method reporting limit.
UJ	The analyte is considered not detected at the associated concentration, which is presented as the sample reporting limit. However, this sample reporting limit is considered to be an estimated value.

Table 4: Summary of Indoor and Outdoor Air Summa Canister Results for Tetrachloroethene
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

PT_ID	PT_TYPE	ADDRESS	SMP_DATE	PCE RESULT	QUALIFIER	REP_LIMIT
Indoor Air						
ACSC-015B	Den	625 S. First	6/5/2003	0.90	U	0.90
ACSC-015A	Basement	625 S. First	6/5/2003	0.67	U	0.67
ACSC-014B	Dining room	617 S. First	6/5/2003	0.98	U	0.98
ACSC-014A	Basement	617 S. First	6/5/2003	0.67	U	0.67
ACSC-013B	Kitchen	606/608 S. First	6/5/2003	2.00	U	2.00
ACSC-013A	Basement	606/608 S. First	6/5/2003	1.40	U	1.40
ACSC-012B	Dining room	217 Madison	6/6/2003	0.90	U	0.90
ACSC-012A	Basement	217 Madison	6/6/2003	0.84	U	0.84
ACSC-011C	Kitchen	631 S. First	6/6/2003	1.40		0.96
ACSC-011A	Basement	631 S. First	6/6/2003	1.30	U	1.30
ACSC-010B	Living Room	111 Madison	6/6/2003	1.00	U	1.00
ACSC-010A	Basement	111 Madison	6/6/2003	0.68	U	0.68
ACSC-009B	Living Room	115 Madison	6/3/2003	0.68	U	0.68
ACSC-009A	Basement	115 Madison	6/3/2003	13.0	U	13.0
ACSC-008D	Basement	616 S. Ashley	6/3/2003	0.92	U	0.92
ACSC-008B	Living Room	616 S. Ashley	6/3/2003	0.90	U	0.90
ACSC-008A	Basement	616 S. Ashley	6/3/2003	0.67	U	0.67
ACSC-007B	Living Room	213 W. Madison	6/3/2003	0.67	U	0.67
ACSC-007A	Basement	213 W. Madison	6/3/2003	0.70	U	0.70
ACSC-006B	Kitchen	606 S. Ashley	6/4/2003	0.92	U	0.92
ACSC-006A	Basement	606 S. Ashley	6/4/2003	0.88	U	0.88
ACSC-005B	Apartment Hallway	635 S. First	6/4/2003	5.90		0.84
ACSC-005B	Apartment Hallway	635 S. First	6/6/2003	0.95		0.70
ACSC-005A	Basement	635 S. First	6/4/2003	15.0		0.94
ACSC-005A	Basement	635 S. First	6/6/2003	3.60		0.67
ACSC-004B	Kitchen	614 S. Ashley	6/3/2003	0.68	U	0.68
ACSC-004A	Basement	614 S. Ashley	6/3/2003	0.92	U	0.92
ACSC-003B	Laundry Room	622 S.Ashley	6/4/2003	0.88	U	0.88
ACSC-003A	Basement	622 S.Ashley	6/4/2003	0.86	U	0.86
ACSC-002D	Basement	628 S. Ashley	6/6/2003	25.0		1.10
ACSC-002B	Kitchen	628 S. Ashley	6/6/2003	0.96	U	0.96
ACSC-002B	Kitchen	628 S. Ashley	6/10/2003	0.68		0.68
ACSC-002A	Basement	628 S. Ashley	6/6/2003	25.0		1.00
ACSC-002A	Basement	628 S. Ashley	6/10/2003	12.0		0.67
ACSC-001B	Stairwell	610 S. Ashley	6/5/2003	0.84	U	0.84
ACSC-001A	Basement	610 S. Ashley	6/5/2003	3.30		0.84
Outdoor Air						
ACSC-001C	Front Porch	610 S. Ashley	6/5/2003	0.90	U	0.90
ACSC-001D	Front Porch	610 S. Ashley	6/5/2003	7.70	U	1.00
ACSC-002C	Front Porch	628 S. Ashley	6/6/2003	1.10	U	1.10
ACSC-002C	Front Porch	628 S. Ashley	6/10/2003	1.50		0.84
ACSC-003C	Front Porch	622 S.Ashley	6/4/2003	0.67	U	0.67
ACSC-004C	Front Porch	614 S. Ashley	6/4/2003	0.86	U	0.86
ACSC-005C	Back Porch	635 S. First	6/4/2003	70.0		0.80
ACSC-005C	Back Porch	635 S. First	6/6/2003	48.0		1.00
ACSC-006C	Front Porch	606 S. Ashley	6/4/2003	0.67	U	0.67
ACSC-007C	Front Porch	213 W. Madison	6/3/2003	0.94	U	0.94
ACSC-008C	Front Porch	616 S. Ashley	6/3/2003	0.94	U	0.94
ACSC-009C	Front Porch	115 Madison	6/3/2003	0.88	U	0.88
ACSC-010C	Front Porch	111 Madison	6/6/2003	0.92	U	0.92
ACSC-011B	Front Porch	631 S. First	6/6/2003	1.10		0.80
ACSC-012C	Front Porch	217 Madison	6/6/2003	1.10	U	1.10
ACSC-013C	Back porch	606/608 S. First	6/5/2003	0.88	U	0.88
ACSC-014C	Front Porch	617 S. First	6/5/2003	0.94	U	0.94
ACSC-015C	Front Porch	625 S. First	6/5/2003	0.68	U	0.68

Notes:
All samples analyzed by Modified EPA Method TO-15.

ADDRESS	Property on which sample was collected
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)
PT_ID	Point identification number
PT_TYPE	Point type (location of sample on property)
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
U	Undetected; the associated value is the method reporting limit.

Table 5: Summary Statistics for EPA ERT TAGA Outdoor and Indoor Air Data
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

Compound Results in ppbv	Detected Results	Total Number of Analyses	Detection Frequency	Mean	Confidence -95.000%	Confidence +95.000%	Geometric Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Standard Deviation	Skewness
TAGA Outdoor (Ambient) Air Data														
Dichloroethene	17	67	25%	3.02	-0.352	6.40	0.650	0.445	0.400	88.0	0.445	0.750	13.8	5.71
Tetrachloroethene	34	67	51%	1,200	-296	2,690	7.73	1.60	0.195	50,000	0.550	750	6,120	7.93
Trichloroethene	31	67	46%	3.08	-0.508	6.67	0.370	0.200	0.090	120	0.120	0.400	14.7	7.83
Vinyl Chloride	33	67	49%	4.28	3.98	4.58	4.16	4.15	2.70	11.0	3.50	4.50	1.23	3.28
TAGA Indoor Air Data														
Tetrachloroethene	38	166	23%	2.27	1.45	3.08	0.765	0.430	0.093	29.0	0.350	1.90	5.31	3.99

Notes:
Summary statistics were calculated using the Statistica software available from Stat Soft Inc. (www.stat-soft.com).
A value of one-half the reporting limit was used for nondetected results.
This table summaries only those compounds detected in more than 15% of samples collected.

EPA	U.S. Environmental Protection Agency
ERT	Environmental Response Team
ppbv	parts per billion by volume
TAGA	Trace Atmospheric Gas Analyzer

Table 6: Summary of TAGA Indoor and Outdoor Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_DATE	RESULT	QUALIFIER	REP_LIMIT
TAGA Results							
ARMN003	Pre-entry ambient	213 W. Madison	outdoor air	6/2/2003	0.28	U	0.28
ARMN003	Foyer	213 W. Madison	indoor air	6/2/2003	0.28	U	0.28
ARMN003	Kitchen	213 W. Madison	indoor air	6/2/2003	0.28	U	0.28
ARMN003	Dining room	213 W. Madison	indoor air	6/2/2003	0.28	U	0.28
ARMN003	Living Room	213 W. Madison	indoor air	6/2/2003	0.28	U	0.28
ARMN003	Center of basement	213 W. Madison	indoor air	6/2/2003	0.12	J	0.28
ARMN003	Store room one	213 W. Madison	indoor air	6/2/2003	0.09	J	0.28
ARMN003	Store room two	213 W. Madison	indoor air	6/2/2003	0.10	J	0.28
ARMN003	Basement shower drain	213 W. Madison	indoor air	6/2/2003	0.11	J	0.28
ARMN003	Post-exit ambient	213 W. Madison	outdoor air	6/2/2003	0.28	U	0.28
ARMN005	Pre-entry ambient	616 S. Ashley	outdoor air	6/2/2003	0.32	U	0.32
ARMN005	Living room	616 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN005	Bathroom	616 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN005	Kitchen	616 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN005	Pantry	616 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN005	Basement	616 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN005	Post-exit ambient	616 S. Ashley	outdoor air	6/2/2003	0.32	U	0.32
ARMN007	Pre-entry ambient	614 S. Ashley	outdoor air	6/2/2003	0.32	U	0.32
ARMN007	Classroom	614 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN007	Bathroom/kitchenette	614 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN007	Floor drain in bathroom	614 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN007	Center of the basement	614 S. Ashley	indoor air	6/2/2003	0.32	U	0.32
ARMN007	Post-exit ambient	614 S. Ashley	outdoor air	6/2/2003	0.32	U	0.32
ARMN008	Stationary Monitoring	614 S. Ashley	outdoor air	6/2/2003	2.30		0.39
ARMN009	Mobile Monitoring Route	Starting north on South Ashley Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Madison Street	outdoor air	6/2/2003	0.20	J	0.39
ARMN009	Mobile Monitoring Route	Stopping at South Main Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South Main Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Mosley Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South Ashley Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Madison Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South Main Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Mosley Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South First Street	outdoor air	6/2/2003	1.00		0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Madison Street	outdoor air	6/2/2003	1.60		0.39
ARMN009	Mobile Monitoring Route	Passing South Ashley Street	outdoor air	6/2/2003	0.90		0.39
ARMN009	Mobile Monitoring Route	Stopping at South Main Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South Main Street	outdoor air	6/2/2003	1.10		0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Mosley Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South Ashley Street	outdoor air	6/2/2003	3.60		0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Madison Street	outdoor air	6/2/2003	0.80		0.39
ARMN009	Mobile Monitoring Route	Stopping at South Main Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South Main Street	outdoor air	6/2/2003	1.40		0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Mosley Street	outdoor air	6/2/2003	2.40		0.39
ARMN009	Mobile Monitoring Route	Passing South Ashley Street	outdoor air	6/2/2003	0.80		0.39
ARMN009	Mobile Monitoring Route	Turning right onto South First Street	outdoor air	6/2/2003	5.00		0.39
ARMN009	Mobile Monitoring Route	Turning right onto West Madison Street	outdoor air	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	Turning right onto South Ashley Street	outdoor air	6/2/2003	1.40		0.39
ARMN009	Mobile Monitoring Route	Turning left onto West Mosley Street	outdoor air	6/2/2003	2.40		0.39
ARMN009	Mobile Monitoring Route	Turning left onto South Main Street	outdoor air	6/2/2003	3.40		0.39
ARMN009	Mobile Monitoring Route	Stopping at West Madison Street	outdoor air	6/2/2003	4.40		0.39
ARMN009	Mobile Monitoring Route	Turning left onto West Madison Street	outdoor air	6/2/2003	5.40		0.39
ARMN009	Mobile Monitoring Route	Stopping at South Ashley Street	outdoor air	6/2/2003	6.40		0.39
ARMN011	Pre-entry ambient	115 Madison	outdoor air	6/2/2003	1.60	U	1.60
ARMN011	Living room	115 Madison	indoor air	6/2/2003	1.60	U	1.60
ARMN011	Dining room	115 Madison	indoor air	6/2/2003	1.60	U	1.60
ARMN011	Kitchen	115 Madison	indoor air	6/2/2003	1.60	U	1.60
ARMN011	Center of the basement	115 Madison	indoor air	6/2/2003	1.60	U	1.60
ARMN011	Post-exit ambient	115 Madison	outdoor air	6/2/2003	1.60	U	1.60
ARMN015	Pre-entry ambient	606 S. Ashley	outdoor air	6/3/2003	0.70	U	0.70
ARMN015	Living room	606 S. Ashley	indoor air	6/3/2003	0.70	U	0.70
ARMN015	Dining room	606 S. Ashley	indoor air	6/3/2003	0.70	U	0.70
ARMN015	Kitchen	606 S. Ashley	indoor air	6/3/2003	0.70	U	0.70
ARMN015	Center of the basement	606 S. Ashley	indoor air	6/3/2003	0.70	U	0.70
ARMN015	Basement floor drain	606 S. Ashley	indoor air	6/3/2003	0.70	U	0.70
ARMN015	Basement sump	606 S. Ashley	indoor air	6/3/2003	0.70	U	0.70
ARMN015	Store room	606 S. Ashley	indoor air	6/3/2003	0.70	U	0.70
ARMN015	Post-exit ambient	606 S. Ashley	outdoor air	6/3/2003	0.70	U	0.70
ARMN018	Pre-entry ambient	622 S. Ashley	outdoor air	6/3/2003	0.83	U	0.83
ARMN018	Living room	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83
ARMN018	Dining room	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83
ARMN018	Laundry room/bathroom	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83

Table 6: Summary of TAGA Indoor and Outdoor Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_DATE	RESULT	QUALIFIER	REP_LIMIT
ARMN018	Kitchen	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83
ARMN018	Center of the basement	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83
ARMN018	Basement floor drain	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83
ARMN018	Basement sump	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83
ARMN018	Crawl space	622 S. Ashley	indoor air	6/3/2003	0.83	U	0.83
ARMN018	Post-exit ambient	622 S. Ashley	outdoor air	6/3/2003	0.83	U	0.83
ARMN020	Pre-entry ambient	635 S. First	outdoor air	6/3/2003	0.32	J	0.63
ARMN020	Living room	635 S. First	indoor air	6/3/2003	10.0		0.63
ARMN020	Kitchen	635 S. First	indoor air	6/3/2003	9.60		0.63
ARMN020	Bathroom	635 S. First	indoor air	6/3/2003	9.80		0.63
ARMN020	Bedroom	635 S. First	indoor air	6/3/2003	11.0		0.63
ARMN020	Laundry room/basement	635 S. First	indoor air	6/3/2003	23.0		0.63
ARMN020	Store room one	635 S. First	indoor air	6/3/2003	26.0		0.63
ARMN020	Store room two	635 S. First	indoor air	6/3/2003	26.0		0.63
ARMN020	Basement floor drain	635 S. First	indoor air	6/3/2003	23.0		0.63
ARMN020	Living room two	635 S. First	indoor air	6/3/2003	29.0		0.63
ARMN020	Kitchen two	635 S. First	indoor air	6/3/2003	28.0		0.63
ARMN020	Bathroom two	635 S. First	indoor air	6/3/2003	27.0		0.63
ARMN020	Post-exit ambient	635 S. First	outdoor air	6/3/2003	0.87		0.63
ARMN021	Stationary Monitoring	635 S. First	outdoor air	6/3/2003	4.50		0.63
ARMN022	Mobile Monitoring Route	Starting south on South First Street from Unit AC-005	outdoor air	6/3/2003	2.00		1.10
ARMN022	Mobile Monitoring Route	Turning left onto West Mosley Street	outdoor air	6/3/2003	26.0		1.10
ARMN022	Mobile Monitoring Route	Turning left onto Ashley Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto West Madison Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto First Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto West Mosley Street	outdoor air	6/3/2003	8.00		1.10
ARMN022	Mobile Monitoring Route	Turning left onto Main Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto Madison Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto South Ashley Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto West Mosley Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Stopping at West Madison Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto Main Street	outdoor air	6/3/2003	0.50	J	1.10
ARMN022	Mobile Monitoring Route	Stopping at West Madison Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Turning left onto West Madison Street	outdoor air	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	Stopping at Unit AC-012	outdoor air	6/3/2003	1.10	U	1.10
ARMN026	Window one	Armen Cleaners	on-site air	6/3/2003	1000	J	1500
ARMN026	Vent two	Armen Cleaners	on-site air	6/3/2003	2000		1500
ARMN026	Window two	Armen Cleaners	on-site air	6/3/2003	2000		1500
ARMN026	Vent three	Armen Cleaners	on-site air	6/3/2003	1000		1500
ARMN026	Window three	Armen Cleaners	on-site air	6/3/2003	3000		1500
ARMN026	Vent four	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Window four	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Vent five	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Vent six	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Vent one on roof	Armen Cleaners	on-site air	6/3/2003	3000		1500
ARMN026	Vent two on roof	Armen Cleaners	on-site air	6/3/2003	2000		1500
ARMN026	Vent three on roof	Armen Cleaners	on-site air	6/3/2003	1000	J	1500
ARMN026	Vent four on roof	Armen Cleaners	on-site air	6/3/2003	3000		1500
ARMN026	Vent five on roof	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Vent six on roof	Armen Cleaners	on-site air	6/3/2003	3000		1500
ARMN026	Vent seven on roof	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Vent eight on roof	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Vent nine on roof	Armen Cleaners	on-site air	6/3/2003	1500	U	1500
ARMN026	Vent ten on roof	Armen Cleaners	on-site air	6/3/2003	3000		1500
ARMN026	Vent eleven on roof	Armen Cleaners	on-site air	6/3/2003	50000		1500
ARMN029	Pre-entry ambient	610 S. Ashley	outdoor air	6/4/2003	3.80	U	3.80
ARMN029	Living room	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Office	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Kitchen	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Bathroom	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Bedroom	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Center of the basement	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Center of rear basement	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Floor drain in basement	610 S. Ashley	indoor air	6/4/2003	3.80	U	3.80
ARMN029	Post-exit ambient	610 S. Ashley	outdoor air	6/4/2003	3.80	U	3.80
ARMN030	West Mosley Street	Stationary Monitoring	outdoor air	6/4/2003	4.00	U	4.00
ARMN032	Pre-entry ambient	606/608 S. First	outdoor air	6/4/2003	4.40	U	4.40
ARMN032	Living room/dining room	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Bedroom one	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Bedroom two	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Bedroom three	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Bathroom one	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Laundry room	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40

Table 6: Summary of TAGA Indoor and Outdoor Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_DATE	RESULT	QUALIFIER	REP_LIMIT
ARMN032	Laundry room floor drain	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Basement living room	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Basement kitchen	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Basement dining room	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Basement bathroom two	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Bedroom four	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Bedroom five	606/608 S. First	indoor air	6/4/2003	4.40	U	4.40
ARMN032	Post-exit ambient	606/608 S. First	outdoor air	6/4/2003	4.40	U	4.40
ARMN034	Pre-entry ambient	617 S. First	outdoor air	6/4/2003	1.36	U	1.36
ARMN034	Living room	617 S. First	indoor air	6/4/2003	1.36	U	1.36
ARMN034	Dining room	617 S. First	indoor air	6/4/2003	1.36	U	1.36
ARMN034	Kitchen	617 S. First	indoor air	6/4/2003	1.36	U	1.36
ARMN034	Basement store room	617 S. First	indoor air	6/4/2003	1.36	U	1.36
ARMN034	Center of the basement	617 S. First	indoor air	6/4/2003	1.36	U	1.36
ARMN034	Post-exit ambient	617 S. First	outdoor air	6/4/2003	1.36	U	1.36
ARMN036	Pre-entry ambient	625 S. First	outdoor air	6/4/2003	2.10	U	2.10
ARMN036	Office	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Living room	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Dining room	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Kitchen	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Bathroom	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Bedroom one	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Bedroom two	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Laundry room	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Sump	625 S. First	indoor air	6/4/2003	2.10	U	2.10
ARMN036	Post-exit ambient	625 S. First	outdoor air	6/4/2003	2.10	U	2.10
ARMN040	Pre-entry ambient	217 Madison	outdoor air	6/5/2003	0.86	U	0.86
ARMN040	Living room	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Dining room	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Bedroom	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Kitchen	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Basement storage area	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Basement storage area	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Center of the basement	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Radon removal system	217 Madison	indoor air	6/5/2003	0.86	U	0.86
ARMN040	Post-exit ambient	217 Madison	outdoor air	6/5/2003	0.86	U	0.86
ARMN042	Pre-entry ambient	628 S. Ashley	outdoor air	6/5/2003	0.63	U	0.63
ARMN042	Bedroom one	628 S. Ashley	indoor air	6/5/2003	0.90		0.63
ARMN042	Kitchen one	628 S. Ashley	indoor air	6/5/2003	1.00		0.63
ARMN042	Living room	628 S. Ashley	indoor air	6/5/2003	0.63	U	0.63
ARMN042	Bedroom two	628 S. Ashley	indoor air	6/5/2003	0.63	U	0.63
ARMN042	Office	628 S. Ashley	indoor air	6/5/2003	0.63	U	0.63
ARMN042	Bathroom	628 S. Ashley	indoor air	6/5/2003	0.63	U	0.63
ARMN042	Kitchen two	628 S. Ashley	indoor air	6/5/2003	0.63	U	0.63
ARMN042	Bedroom three	628 S. Ashley	indoor air	6/5/2003	0.63	U	0.63
ARMN042	Basement	628 S. Ashley	indoor air	6/5/2003	1.30		0.63
ARMN042	Basement room one	628 S. Ashley	indoor air	6/5/2003	3.70		0.63
ARMN042	Basement room two	628 S. Ashley	indoor air	6/5/2003	3.00		0.63
ARMN042	Furnace room	628 S. Ashley	indoor air	6/5/2003	1.80		0.63
ARMN042	Basement room three	628 S. Ashley	indoor air	6/5/2003	3.70		0.63
ARMN042	Hole one through con	628 S. Ashley	indoor air	6/5/2003	3.70		0.63
ARMN042	Hole two through con	628 S. Ashley	indoor air	6/5/2003	3.30		0.63
ARMN042	Drain one	628 S. Ashley	indoor air	6/5/2003	2.80		0.63
ARMN042	Drain two	628 S. Ashley	indoor air	6/5/2003	1.30		0.63
ARMN042	Post-exit ambient	628 S. Ashley	outdoor air	6/5/2003	0.63	U	0.63
ARMN044	Pre-entry ambient	631 S. First	outdoor air	6/5/2003	0.73	U	0.73
ARMN044	Living room	631 S. First	indoor air	6/5/2003	0.73	U	0.73
ARMN044	Dining room	631 S. First	indoor air	6/5/2003	0.73	U	0.73
ARMN044	Library	631 S. First	indoor air	6/5/2003	0.73	U	0.73
ARMN044	Kitchen	631 S. First	indoor air	6/5/2003	0.73	U	0.73
ARMN044	Basement	631 S. First	indoor air	6/5/2003	0.73	U	0.73
ARMN044	Furnace room	631 S. First	indoor air	6/5/2003	0.73	U	0.73
ARMN044	Post-exit ambient	631 S. First	outdoor air	6/5/2003	0.73	U	0.73
ARMN046	Pre-entry ambient	111 Madison	outdoor air	6/5/2003	0.58	U	0.58
ARMN046	Living room	111 Madison	indoor air	6/5/2003	0.58	U	0.58
ARMN046	Dining room	111 Madison	indoor air	6/5/2003	0.58	U	0.58
ARMN046	Kitchen	111 Madison	indoor air	6/5/2003	0.58	U	0.58
ARMN046	Basement	111 Madison	indoor air	6/5/2003	0.58	U	0.58
ARMN046	Workshop	111 Madison	indoor air	6/5/2003	0.58	U	0.58
ARMN046	Workshop floor drain	111 Madison	indoor air	6/5/2003	0.58	U	0.58
ARMN046	Post-exit ambient	111 Madison	outdoor air	6/5/2003	0.58	U	0.58
ARMN048	Pre-entry ambient	635 S. First	outdoor air	6/5/2003	0.70	U	0.70
ARMN048	Living room	635 S. First	indoor air	6/5/2003	0.70	U	0.70
ARMN048	Kitchen	635 S. First	indoor air	6/5/2003	0.70	U	0.70

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EPA June 2003 Sampling Events
Armen Cleaners, Ann Arbor, Michigan

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_DATE	RESULT	QUALIFIER	REP_LIMIT
ARMN048	Bathroom	635 S. First	indoor air	6/5/2003	0.70	U	0.70
ARMN048	Bedroom	635 S. First	indoor air	6/5/2003	0.70	U	0.70
ARMN048	Laundry room	635 S. First	indoor air	6/5/2003	0.60	J	0.70
ARMN048	Store room one	635 S. First	indoor air	6/5/2003	0.98		0.70
ARMN048	Store room one	635 S. First	indoor air	6/5/2003	0.98		0.70
ARMN048	Store room two	635 S. First	indoor air	6/5/2003	2.30		0.70
ARMN048	Laundry room floor drain	635 S. First	indoor air	6/5/2003	0.70	U	0.70
ARMN048	Store room two window	635 S. First	indoor air	6/5/2003	2.90		0.70
ARMN048	Living room two	635 S. First	indoor air	6/5/2003	5.40		0.70
ARMN048	Bathroom two	635 S. First	indoor air	6/5/2003	5.40		0.70
ARMN048	Kitchen two	635 S. First	indoor air	6/5/2003	5.40		0.70
ARMN048	South basement 4-inch	635 S. First	indoor air	6/5/2003	1.80		0.70
ARMN048	4-inch pipe (unplugged)	635 S. First	indoor air	6/5/2003	1.90		0.70
ARMN048	Post-exit ambient	635 S. First	outdoor air	6/5/2003	0.70	U	0.70

Notes:

ADDRESS	Property on which sample was collected
J	Estimated concentration
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)
PT_ID	Point identification number
PT_TYPE	Point type (location of sample on property)
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
SMP_MATRIX	Sample matrix
SMP_TYPE	Sample type (collection medium or container)
TAGA	Trace Atmospheric Gas Analyzer
U	Undetected; the associated value is the method reporting limit.

Table 7: Soil Gas and On-site Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
Armen Cleaners Property

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_TYPE	SMP_DATE	PCE RESULT	QUALIFIER	REP_LIMIT	METHOD
Discrete Vapor Samples									
ACVP-013	vapor point	Armen Cleaners	soil gas	Tedlar Bag	6/2/2003	730		20.0	GCMS
ACVP-006	vapor point	Armen Cleaners	soil gas	Tedlar Bag	6/3/2003	330000		10000	GCMS
ACVP-013	vapor point	Armen Cleaners	soil gas	Tedlar Bag	6/2/2003	730		20.0	GCMS
Stack 11	Vent eleven on roof	Armen Cleaners	soil gas	Tedlar Bag	6/3/2003	18000		1000	GCMS
TAGA Monitoring Points									
ARMN026	Window one	Armen Cleaners	on-site air	TAGA	6/3/2003	1000	J	1500	TAGA
ARMN026	Window two	Armen Cleaners	on-site air	TAGA	6/3/2003	2000		1500	TAGA
ARMN026	Window three	Armen Cleaners	on-site air	TAGA	6/3/2003	3000		1500	TAGA
ARMN026	Window four	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent two	Armen Cleaners	on-site air	TAGA	6/3/2003	2000		1500	TAGA
ARMN026	Vent three	Armen Cleaners	on-site air	TAGA	6/3/2003	1000		1500	TAGA
ARMN026	Vent four	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent five	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent six	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent one on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	3000		1500	TAGA
ARMN026	Vent two on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	2000		1500	TAGA
ARMN026	Vent three on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	1000	J	1500	TAGA
ARMN026	Vent four on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	3000		1500	TAGA
ARMN026	Vent five on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent six on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	3000		1500	TAGA
ARMN026	Vent seven on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent eight on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent nine on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	1500	U	1500	TAGA
ARMN026	Vent ten on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	3000		1500	TAGA
ARMN026	Vent eleven on roof	Armen Cleaners	on-site air	TAGA	6/3/2003	50000		1500	TAGA

Notes:

ADDRESS	Property on which sample was collected
GC/MS	Sample analyzed by Agilent bench-top gas chromatograph/mass spectrometer (GC/MS)
J	Estimated concentration
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)
PT_ID	Point identification number
PT_TYPE	Point type (sample location)
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
SMP_MATRIX	Sample matrix
SMP_TYPE	Sample type (collection medium or container)
TAGA	Trace Atmospheric Gas Analyzer
U	Undetected

Table 8: Soil Gas and Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
628 South Ashley Street

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_TYPE	SMP_DATE	PCE RESULT	QUALIFIER	REP_LIMIT	METHOD
Surrounding Soil Vapor									
ACVP-015	vapor point	628 S. Ashley	soil gas	Tedlar Bag	6/2/2003	460		20.0	GCMS
ACVP-012	vapor point	628 S. Ashley	soil gas	Tedlar Bag	6/2/2003	550000		10000	GCMS
ACVP-016	vapor point	628 S. Ashley	soil gas	Tedlar Bag	6/2/2003	8700		250	GCMS
ACVP-019	vapor point	628 S. Ashley	soil gas	Tedlar Bag	6/5/2003	20.0		4.00	GCMS
ACSS-002	sub slab	628 S. Ashley	soil gas	Tedlar Bag	6/5/2003	2600		100	GCMS
Discrete Air Samples									
ACSC-002A	Basement	628 S. Ashley	indoor air	Summa	6/6/2003	25.0		1.00	Modified TO-15
ACSC-002D	Basement	628 S. Ashley	indoor air	Summa	6/6/2003	25.0		1.10	Modified TO-15
ACSC-002B	Kitchen two	628 S. Ashley	indoor air	Summa	6/6/2003	0.96	U	0.96	Modified TO-15
ACSC-002C	Front Porch	628 S. Ashley	outdoor air	Summa	6/6/2003	1.10	U	1.10	Modified TO-15
ACSC-002A	Basement	628 S. Ashley	indoor air	Summa	6/10/2003	12.0		0.67	Modified TO-15
ACSC-002B	Kitchen	628 S. Ashley	indoor air	Summa	6/10/2003	0.68		0.68	Modified TO-15
ACSC-002C	Front Porch	628 S. Ashley	outdoor air	Summa	6/10/2003	1.50		0.84	Modified TO-15
TAGA Monitoring Points									
ARMN042	Basement	628 S. Ashley	indoor air	TAGA	6/5/2003	1.30		0.63	TAGA
ARMN042	Basement Drain one	628 S. Ashley	indoor air	TAGA	6/5/2003	2.80		0.63	TAGA
ARMN042	Basement Drain two	628 S. Ashley	indoor air	TAGA	6/5/2003	1.30		0.63	TAGA
ARMN042	Basement Furnace Room	628 S. Ashley	indoor air	TAGA	6/5/2003	1.80		0.63	TAGA
ARMN042	Basement Room one	628 S. Ashley	indoor air	TAGA	6/5/2003	3.70		0.63	TAGA
ARMN042	Basement Room two	628 S. Ashley	indoor air	TAGA	6/5/2003	3.00		0.63	TAGA
ARMN042	Basement Hole one	628 S. Ashley	indoor air	TAGA	6/5/2003	3.70		0.63	TAGA
ARMN042	Basement Hole two	628 S. Ashley	indoor air	TAGA	6/5/2003	3.30		0.63	TAGA
ARMN042	Basement Room three	628 S. Ashley	indoor air	TAGA	6/5/2003	3.70		0.63	TAGA
ARMN042	Bathroom	628 S. Ashley	indoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA
ARMN042	Bedroom one	628 S. Ashley	indoor air	TAGA	6/5/2003	0.90		0.63	TAGA
ARMN042	Bedroom three	628 S. Ashley	indoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA
ARMN042	Bedroom two	628 S. Ashley	indoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA
ARMN042	Kitchen one	628 S. Ashley	indoor air	TAGA	6/5/2003	1.00		0.63	TAGA
ARMN042	Kitchen two	628 S. Ashley	indoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA
ARMN042	Living Room	628 S. Ashley	indoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA
ARMN042	Office	628 S. Ashley	indoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA
ARMN042	Post-exit ambient	628 S. Ashley	outdoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA
ARMN042	Pre-entry ambient	628 S. Ashley	outdoor air	TAGA	6/5/2003	0.63	U	0.63	TAGA

Notes:

ADDRESS	Property on which sample was collected
GC/MS	Sample analyzed by Agilent bench-top gas chromatograph/mass spectrometer (GC/MS)
J	Estimated concentration
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)
PT_ID	Point identification number
PT_TYPE	Point type (sample location)
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
SMP_MATRIX	Sample matrix
SMP_TYPE	Sample type (collection medium or container)
TAGA	Trace Atmospheric Gas Analyzer
U	Undetected

Table 9: Soil Gas and Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
635 South First Street

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_TYPE	SMP_DATE	PCE RESULT	QUALIFIER	REP_LIMIT	METHOD
Surrounding Soil Vapor									
ACVP-011	vapor point	635 S. First	soil gas	Tedlar Bag	6/3/2003	690		25.0	GCMS
ACVP-010	vapor point	635 S. First	soil gas	Tedlar Bag	6/3/2003	6.60		4.00	GCMS
ACVP-009	vapor point	635 S. First	soil gas	Tedlar Bag	6/3/2003	4.00	U	4.00	GCMS
ACVP-007	vapor point	635 S. First	soil gas	Tedlar Bag	6/3/2003	8.40		4.00	GCMS
ACVP-001	vapor point	635 S. First	soil gas	Tedlar Bag	6/3/2003	550		20.0	GCMS
ACSS-005	sub slab	635 S. First	soil gas	Tedlar Bag	6/3/2003	37.0		4.00	GCMS
Discrete Air Samples									
ACSC-005C	Back Porch	635 S. First	outdoor air	Summa	6/4/2003	70.0		0.80	Modified TO-15
ACSC-005B	Apartment Hallway	635 S. First	indoor air	Summa	6/4/2003	5.90		0.84	Modified TO-15
ACSC-005A	Basement Store Room one	635 S. First	indoor air	Summa	6/4/2003	15.0		0.94	Modified TO-15
TAGA Monitoring Points									
ARMN020	Basement floor drain	635 S. First	indoor air	TAGA	6/3/2003	23.0		0.63	TAGA
ARMN020	Basement Laundry room	635 S. First	indoor air	TAGA	6/3/2003	23.0		0.63	TAGA
ARMN020	Basement Store room one	635 S. First	indoor air	TAGA	6/3/2003	26.0		0.63	TAGA
ARMN020	Basement Store room two	635 S. First	indoor air	TAGA	6/3/2003	26.0		0.63	TAGA
ARMN020	Bathroom	635 S. First	indoor air	TAGA	6/3/2003	9.80		0.63	TAGA
ARMN020	Bathroom two	635 S. First	indoor air	TAGA	6/3/2003	27.0		0.63	TAGA
ARMN020	Bedroom	635 S. First	indoor air	TAGA	6/3/2003	11.0		0.63	TAGA
ARMN020	Kitchen	635 S. First	indoor air	TAGA	6/3/2003	9.60		0.63	TAGA
ARMN020	Kitchen two	635 S. First	indoor air	TAGA	6/3/2003	28.0		0.63	TAGA
ARMN020	Living room	635 S. First	indoor air	TAGA	6/3/2003	10.0		0.63	TAGA
ARMN020	Living room two	635 S. First	indoor air	TAGA	6/3/2003	29.0		0.63	TAGA
ARMN020	Post-exit ambient (east)	635 S. First	outdoor air	TAGA	6/3/2003	0.87		0.63	TAGA
ARMN020	Pre-entry ambient (west)	635 S. First	outdoor air	TAGA	6/3/2003	0.32	J	0.63	TAGA
ARMN021	Stationary Monitoring	635 S. First	outdoor air	TAGA	6/2/2003	4.50		0.63	TAGA
ARMN048	4-inch pipe (unplugged)	635 S. First	indoor air	TAGA	6/5/2003	1.90		0.70	TAGA
ARMN048	Baement Laundry room floor drain	635 S. First	indoor air	TAGA	6/5/2003	0.70	U	0.70	TAGA
ARMN048	Basement Laundry room	635 S. First	indoor air	TAGA	6/5/2003	0.60	J	0.70	TAGA
ARMN048	Basement Store room one	635 S. First	indoor air	TAGA	6/5/2003	0.98		0.70	TAGA
ARMN048	Baement Store room two	635 S. First	indoor air	TAGA	6/5/2003	2.30		0.70	TAGA
ARMN048	Basement Store room two window	635 S. First	indoor air	TAGA	6/5/2003	2.90		0.70	TAGA
ARMN048	Bathroom	635 S. First	indoor air	TAGA	6/5/2003	0.70	U	0.70	TAGA
ARMN048	Bathroom two	635 S. First	indoor air	TAGA	6/5/2003	5.40		0.70	TAGA
ARMN048	Bedroom	635 S. First	indoor air	TAGA	6/5/2003	0.70	U	0.70	TAGA
ARMN048	Kitchen	635 S. First	indoor air	TAGA	6/5/2003	0.70	U	0.70	TAGA
ARMN048	Kitchen two	635 S. First	indoor air	TAGA	6/5/2003	5.40		0.70	TAGA
ARMN048	Living room	635 S. First	indoor air	TAGA	6/5/2003	0.70	U	0.70	TAGA
ARMN048	Living room two	635 S. First	indoor air	TAGA	6/5/2003	5.40		0.70	TAGA
ARMN048	Post-exit ambient (east)	635 S. First	outdoor air	TAGA	6/5/2003	0.70	U	0.70	TAGA
ARMN048	Pre-entry ambient (west)	635 S. First	outdoor air	TAGA	6/5/2003	0.70	U	0.70	TAGA

Notes:

ADDRESS	Property on which sample was collected	REP_LIMIT	Reporting limit
GC/MS	Sample analyzed by Agilent bench-top gas chromatograph/mass spectrometer (GC/MS)	SMP_DATE	Sample date
J	Estimated concentration	SMP_MATRIX	Sample matrix
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)	SMP_TYPE	Sample type (collection medium or container)
PT_ID	Point identification number	TAGA	Trace Atmospheric Gas Analyzer
PT_TYPE	Point type (sample location)	U	Undetected

Table 10: Soil Gas and Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
Detections at Other Downgradient Properties

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_TYPE	SMP_DATE	PCE RESULT	QUALIFIER	REP_LIMIT	METHOD
631 South First									
ACVP-010	vapor point	635 S. First	soil gas	Tedlar Bag	6/3/2003	6.60		4.00	GCMS
ACSS-011	sub slab	631 S. First	soil gas	Tedlar Bag	6/5/2003	6.00		4.00	GCMS
ACSC-011A	Basement	631 S. First	indoor air	Summa	6/6/2003	1.30	U	1.30	Modified TO-15
ACSC-011B	Living Room	631 S. First	indoor air	Summa	6/6/2003	1.10		0.80	Modified TO-15
ACSC-011C	Outside	631 S. First	outdoor air	Summa	6/6/2003	1.40		0.96	Modified TO-15
622 South Ashley									
ACVP-022	vapor point	622-618 S. Ashle	soil gas	Tedlar Bag	6/2/2003	4.00	U	4.00	GCMS
ACSS-003	sub slab	622 S. Ashley	soil gas	Tedlar Bag	6/3/2003	36.0	B	4.00	GCMS
ACSC-003A	Basement	622 S.Ashley	indoor air	Summa	6/4/2003	0.86	U	0.86	Modified TO-15
ACSC-003B	Laundry Room	622 S.Ashley	indoor air	Summa	6/4/2003	0.88	U	0.88	Modified TO-15
ACSC-003C	Front Porch	622 S.Ashley	outdoor air	Summa	6/4/2003	0.67	U	0.67	Modified TO-15
616 South Ashley									
ACSS-008	sub slab	616 S. Ashley	soil gas	Tedlar Bag	6/2/2003	4.00	U	4.00	GCMS
ACVP-026	vapor point	616 S. Ashley	soil gas	Tedlar Bag	6/3/2003	4.20		4.00	GCMS
ACSC-008A	Basement	616 S. Ashley	indoor air	Summa	6/3/2003	0.67	U	0.67	Modified TO-15
ACSC-008B	Living Room	616 S. Ashley	indoor air	Summa	6/3/2003	0.90	U	0.90	Modified TO-15
ACSC-008C	Front Porch	616 S. Ashley	outdoor air	Summa	6/3/2003	0.94	U	0.94	Modified TO-15
ACSC-008D	Basement	616 S. Ashley	indoor air	Summa	6/3/2003	0.92	U	0.92	Modified TO-15
610 South Ashley									
ACVP-028	vapor point	610 S. Ashley	soil gas	Tedlar Bag	6/3/2003	11.0		4.00	GCMS
ACSS-001	sub slab	610 S. Ashley	soil gas	Tedlar Bag	6/4/2003	4.00	U	4.00	GCMS
ACSC-001A	Basement	610 S. Ashley	indoor air	Summa	6/5/2003	3.30		0.84	Modified TO-15
ACSC-001B	Living Room	610 S. Ashley	indoor air	Summa	6/5/2003	0.84	U	0.84	Modified TO-15
ACSC-001C	Front Porch	610 S. Ashley	outdoor air	Summa	6/5/2003	0.90	U	0.90	Modified TO-15
ACSC-001D	Front Porch	610 S. Ashley	outdoor air	Summa	6/5/2003	7.70	U	1.00	Modified TO-15
West Mosley Street									
ACVP-003	vapor point	704 S. Main	soil gas	Tedlar Bag	6/3/2003	21.0		4.00	GCMS
ACVP-004	vapor point	119 W. Mosely	soil gas	Tedlar Bag	6/3/2003	7.40		4.00	GCMS
ACVP-008	vapor point	223 W. Mosely	soil gas	Tedlar Bag	6/3/2003	4.00	U	4.00	GCMS
ACVP-005	vapor point	207 W. Mosely	soil gas	Tedlar Bag	6/5/2003	4.00	U	4.00	GCMS
East Side of South Ashley Street									
ACVP-002	vapor point	634 S. Main	soil gas	Tedlar Bag	6/3/2003	6.10		4.00	GCMS
ACVP-014	vapor point	634 S. Main	soil gas	Tedlar Bag	6/2/2003	61.0		4.00	GCMS
ACVP-036	vapor point	115 W. Madison	soil gas	Tedlar Bag	6/2/2003	82.0		4.00	GCMS

Notes:
This table presents other downgradient properties with one or more detections of PCE.

ADDRESS	Property on which sample was collected
B	Results my be biased high due to carryover in sampling equipment (as indicated by field blank results).
GC/MS	Sample analyzed by Agilent bench-top gas chromatograph/mass spectrometer (GC/MS)
J	Estimated concentration
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)
PT_ID	Point identification number
PT_TYPE	Point type (sample location)
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
SMP_MATRIX	Sample matrix
SMP_TYPE	Sample type (collection medium or container)
TAGA	Trace Atmospheric Gas Analyzer
U	Undetected

Table 11: Soil Gas and Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
213 West Madison Street

PT_ID	PT_TYPE	ADDRESS	SMP_MATRIX	SMP_TYPE	SMP_DATE	PCE RESULT	QUALIFIER	REP_LIMIT	METHOD
Surrounding Soil Vapor									
ACVP-037	vapor point	602 S. Ashley	soil gas	Tedlar Bag	6/5/2003	10.0	U	10.0	GCMS
ACVP-032	vapor point	609 S. First	soil gas	Tedlar Bag	6/4/2003	4.00	U	4.00	GCMS
ACSS-007	sub slab	213 W. Madison	soil gas	Tedlar Bag	6/3/2003	40.0	B	4.00	GCMS
Indoor Air									
ACSC-007A	Basement	213 W. Madison	indoor air	Summa	6/3/2003	0.70	U	0.70	Modified TO-15
ACSC-007B	Living Room	213 W. Madison	indoor air	Summa	6/3/2003	0.67	U	0.67	Modified TO-15
ACSC-007C	Front Porch	213 W. Madison	outdoor air	Summa	6/3/2003	0.94	U	0.94	Modified TO-15
Ambient Air									
ARMN003	Basement	213 W. Madison	indoor air	TAGA	6/2/2003	0.12	J	0.28	TAGA
ARMN003	Basement store room one	213 W. Madison	indoor air	TAGA	6/2/2003	0.09	J	0.28	TAGA
ARMN003	Basement store room two	213 W. Madison	indoor air	TAGA	6/2/2003	0.10	J	0.28	TAGA
ARMN003	Basement Shower Drain	213 W. Madison	indoor air	TAGA	6/2/2003	0.11	J	0.28	TAGA
ARMN003	Pre-entry Ambient	213 W. Madison	outdoor air	TAGA	6/2/2003	0.28	U	0.28	TAGA
ARMN003	Foyer	213 W. Madison	indoor air	TAGA	6/2/2003	0.28	U	0.28	TAGA
ARMN003	Kitchen	213 W. Madison	indoor air	TAGA	6/2/2003	0.28	U	0.28	TAGA
ARMN003	Dining Room	213 W. Madison	indoor air	TAGA	6/2/2003	0.28	U	0.28	TAGA
ARMN003	Living Room	213 W. Madison	indoor air	TAGA	6/2/2003	0.28	U	0.28	TAGA

Notes:

ADDRESS	Property on which sample was collected
B	Results my be biased high due to carryover in sampling equipment (as indicated by field blank results).
GC/MS	Sample analyzed by Agilent bench-top gas chromatograph/mass spectrometer (GC/MS)
J	Estimated concentration
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)
PT_ID	Point identification number
PT_TYPE	Point type (sample location)
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
SMP_MATRIX	Sample matrix
SMP_TYPE	Sample type (collection medium or container)
TAGA	Trace Atmospheric Gas Analyzer
U	Undetected

Table 12: Outdoor Air Results for Tetrachloroethene
EPA June 2003 Sampling Events
TAGA Mobile Ambient Air Monitoring

PT_ID	PT_TYPE	ADDRESS	SMP_DATE	PCE RESULT	QUALIFIER	REP_LIMIT
Mobile Monitoring Path #1						
ARMN009	Mobile Monitoring Route	A - Starting north on South Ashley Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	B - Turning right onto West Madison Street	6/2/2003	0.20	J	0.39
ARMN009	Mobile Monitoring Route	C - Stopping at South Main Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	D - Turning right onto South Main Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	E - Turning right onto West Mosley Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	F - Turning right onto South Ashley Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	G - Turning right onto West Madison Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	H - Turning right onto South Main Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	I - Turning right onto West Mosley Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	J - Turning right onto South First Street	6/2/2003	1.00		0.39
ARMN009	Mobile Monitoring Route	K - Turning right onto West Madison Street	6/2/2003	1.60		0.39
ARMN009	Mobile Monitoring Route	L - Passing South Ashley Street	6/2/2003	0.90		0.39
ARMN009	Mobile Monitoring Route	M - Stopping at South Main Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	N - Turning right onto South Main Street	6/2/2003	1.10		0.39
ARMN009	Mobile Monitoring Route	O - Turning right onto West Mosley Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	P - Turning right onto South Ashley Street	6/2/2003	3.60		0.39
ARMN009	Mobile Monitoring Route	Q - Turning right onto West Madison Street	6/2/2003	0.80		0.39
ARMN009	Mobile Monitoring Route	R - Stopping at South Main Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	S - Turning right onto South Main Street	6/2/2003	1.40		0.39
ARMN009	Mobile Monitoring Route	T - Turning right onto West Mosley Street	6/2/2003	2.40		0.39
ARMN009	Mobile Monitoring Route	U - Passing South Ashley Street	6/2/2003	0.80		0.39
ARMN009	Mobile Monitoring Route	V - Turning right onto South First Street	6/2/2003	5.00		0.39
ARMN009	Mobile Monitoring Route	W - Turning right onto West Madison Street	6/2/2003	0.39	U	0.39
ARMN009	Mobile Monitoring Route	X - Turning right onto South Ashley Street	6/2/2003	1.40		0.39
ARMN009	Mobile Monitoring Route	Y - Turning left onto West Mosley Street	6/2/2003	2.40		0.39
ARMN009	Mobile Monitoring Route	Z - Turning left onto South Main Street	6/2/2003	3.40		0.39
ARMN009	Mobile Monitoring Route	AA - Stopping at West Madison Street	6/2/2003	4.40		0.39
ARMN009	Mobile Monitoring Route	BB - Turning left onto West Madison Street	6/2/2003	5.40		0.39
ARMN009	Mobile Monitoring Route	CC - Stopping at South Ashley Street	6/2/2003	6.40		0.39
Mobile Monitoring Path #2						
ARMN021	Stationary Monitoring Point AC-005	635 South First Street	6/3/2003	4.50		1.10
ARMN022	Mobile Monitoring Route	A - Starting south on South First Street from Unit AC-005	6/3/2003	2.00		1.10
ARMN022	Mobile Monitoring Route	B - Turning left onto West Mosley Street	6/3/2003	26.0		1.10
ARMN022	Mobile Monitoring Route	C - Turning left onto Ashley Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	D - Turning left onto West Madison Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	E - Turning left onto First Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	F - Turning left onto West Mosley Street	6/3/2003	8.00		1.10
ARMN022	Mobile Monitoring Route	G - Turning left onto Main Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	H - Turning left onto Madison Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	I - Turning left onto South Ashley Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	J - Turning left onto West Mosley Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	K - Stopping at West Madison Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	L - Turning left onto Main Street	6/3/2003	0.50	J	1.10
ARMN022	Mobile Monitoring Route	M - Stopping at West Madison Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	N - Turning left onto West Madison Street	6/3/2003	1.10	U	1.10
ARMN022	Mobile Monitoring Route	O - Stopping at Unit AC-012	6/3/2003	1.10	U	1.10

Notes:

ADDRESS	Property on which sample was collected
J	Estimated concentration
PCE RESULT	Tetrachloroethene concentration in parts per billion by volume (ppbv)
PT_ID	Point identification number
PT_TYPE	Point type (sample location)
REP_LIMIT	Reporting limit
SMP_DATE	Sample date
SMP_MATRIX	Sample matrix
SMP_TYPE	Sample type (collection medium or container)
TAGA	Trace Atmospheric Gas Analyzer
U	Undetected

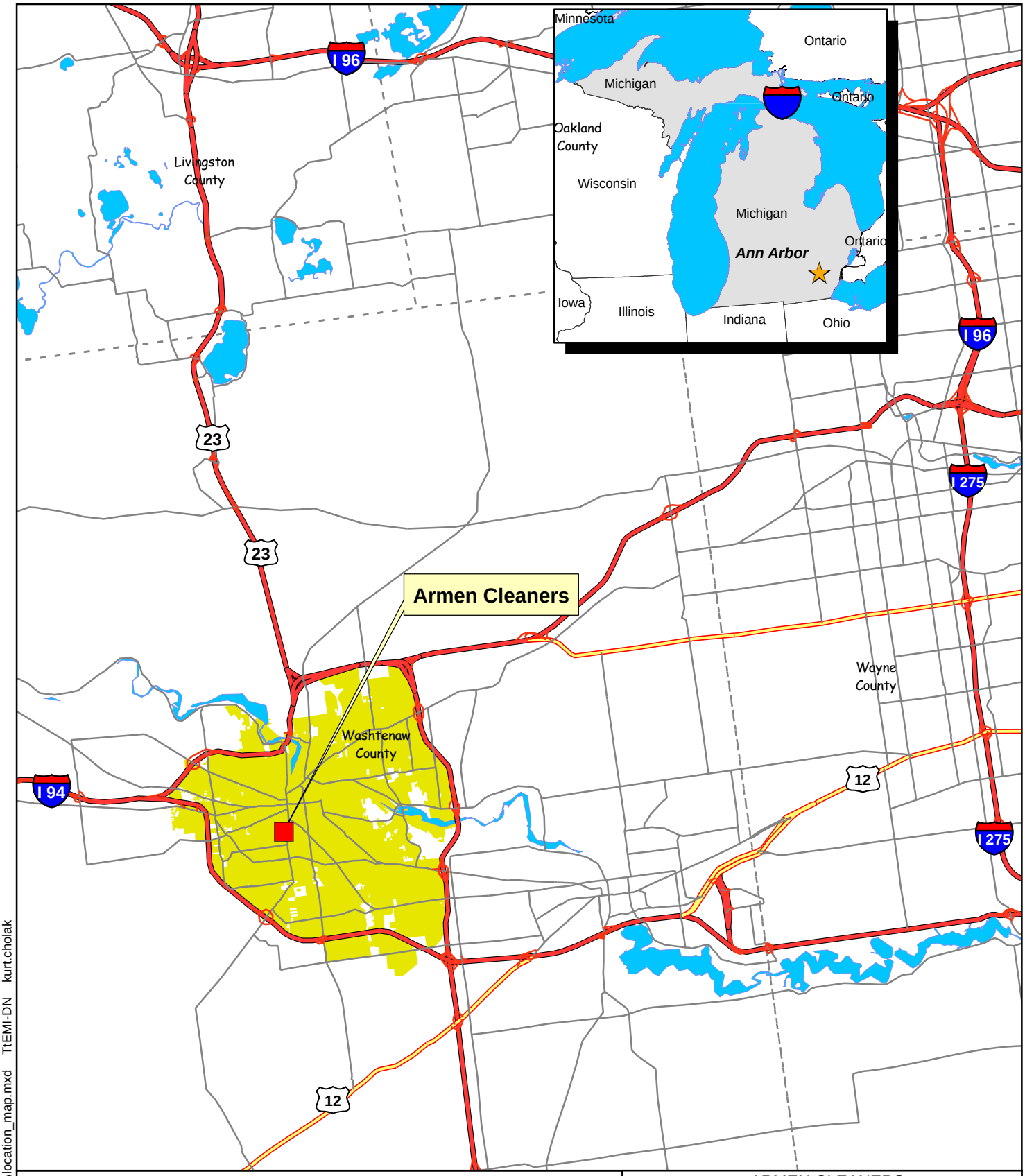
Table 13: Summary Statistics for MDEQ Data,
Remedial Investigation and Supplemental Investigation Sampling Events (2000-2002),
Armen Cleaners, Ann Arbor, Michigan

Compound Results in ppbv	Detected Results	Total Number of Analyses	Detection Frequency	Mean	Confidence -95.000%	Confidence +95.000%	Geometric Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Percentile 10.00000	Percentile 90.00000	Standard Deviation	Skewness
Summa Canister Indoor Air Data																
1,1,1-Trichloroethane	5	10	50%	4.9	-4.2	14.0	0.9	0.7	0.2	41.0	0.3	2.2	0.2	21.6	12.7	3.1
1,2,4-Trimethylbenzene	7	30	23%	2.0	-0.8	4.7	0.5	0.3	0.2	41.0	0.2	1.0	0.2	1.9	7.4	5.4
1,3,5-Trimethylbenzene	7	27	26%	2.0	-1.1	5.1	0.4	0.3	0.2	41.0	0.2	1.0	0.2	1.2	7.8	5.2
1,4-Dichlorobenzene	6	7	86%	6.8	-7.2	20.7	1.6	1.4	0.4	41.0	0.4	1.6	0.4	41.0	15.1	2.6
Acetone	5	6	83%	20.0	-1.4	41.4	14.6	13.5	5.0	61.0	11.0	16.0	5.0	61.0	20.4	2.3
Benzene	21	44	48%	1.5	-0.4	3.4	0.5	0.4	0.2	41.0	0.2	0.6	0.2	1.0	6.2	6.4
Chloroethane	4	19	21%	4.6	-2.3	11.5	0.4	0.2	0.2	60.0	0.2	0.3	0.2	22.0	14.3	3.7
Chloromethane	8	29	28%	0.9	0.6	1.2	0.7	0.6	0.2	4.0	0.5	1.0	0.4	2.0	0.8	2.5
Dichlorodifluoromethane/Freon-12	33	45	73%	1.6	-0.2	3.5	0.7	0.7	0.3	41.0	0.6	0.8	0.6	1.0	6.1	6.6
Ethylbenzene	4	19	21%	1.1	-0.1	2.4	0.4	0.2	0.2	11.4	0.2	1.0	0.2	2.4	2.6	3.9
Methylene Chloride	14	29	48%	5.3	-1.7	12.3	1.2	0.9	0.2	100	0.5	1.9	0.4	8.2	18.4	5.2
Tetrachloroethene (PCE)	36	45	80%	125	-108	359	5	5	0	5,100	1.6	19.4	1.0	26.0	767	6.6
Toluene	31	45	69%	3.5	1.0	6.1	1.2	1.2	0.2	41.0	0.6	1.7	0.2	6.0	8.5	4.1
Trichloroethene (TCE)	14	29	48%	9.9	-9.1	28.9	0.6	0.5	0.2	260	0.2	1.0	0.2	1.5	49.0	5.3
Trichlorofluoromethane/Freon-11	8	21	38%	2.4	-1.7	6.4	0.4	0.4	0.2	41.0	0.2	0.5	0.2	1.0	8.9	4.6
Xylenes	23	45	51%	2.7	0.0	5.4		0.4	0.0	45.1	0.2	1.0	0.2	2.1	0.0	4.4
Purge and Trap Soil Data																
cis-1,2-Dichloroethylene	5	10	50%	894	-366	2,150	19.6	55	0.5	5,400	0.5	650	0.5	3,950	1,760	2.3
Tetrachloroethene (PCE)	23	23	100%	37,700	-9,220	84,600	3,980	4,000	96	510,000	1,200	14,000	320	75,000	108,000	4.1
Trichloroethylene	5	10	50%	3,480	-1,660	8,620	39.1	210	0.5	23,000	0.5	4,100	0.5	14,600	7,180	2.7
Headspace Soil Data																
Tetrachloroethene (PCE)	61	90	68%	1,750	433	3,070	44	132	0.5	39,595	0.5	430	0.5	1,580.5	6,300	4.7
Purge and Trap Groundwater Data																
1,1,1-Trichloroethane	12	48	25%	1.6	0.7	2.4	0.8	0.5	0.5	13.0	0.5	0.5	0.5	4.6	2.7	3.0
1,1,2-Trichloroethane	1	5	20%	0.6	0.3	1.0	0.6	0.5	0.5	1.2	0.5	0.5	0.5	1.2	0.3	2.2
cis-1,2-Dichloroethene	13	57	23%	7.1	-1.5	15.6	0.9	0.5	0.5	110	0.5	0.5	0.5	6.6	25.4	4.0
Tetrachloroethene (PCE)	44	57	77%	6.8	0.9	12.7	0.9	0.5	0.5	110	0.5	0.5	0.5	7.0	22.2	4.0
Trichloroethylene	17	43	40%	3.4	0.6	6.1	1.1	0.5	0.5	55.0	0.5	1.8	0.5	7.8	8.8	5.1
Headspace Groundwater Data																
Tetrachloroethene (PCE)	38	40	95%	2,410	-152	4,970	135	127	0.5	50,000	13.0	1,266	3.0	5,703.5	8,010	5.7

Notes:
Summary statistics were calculated using the Statistica software available from Stat Soft Inc. (www.stat-soft.com).
A value of one-half the reporting limit was used for nondetected results.
This table summaries only those compounds detected in more than 15% of samples collected.

MDEQ Michigan Department of Environmental Quality
ppbv parts per billion by volume

FIGURES



Legend

- Limited Access Highway
- Other Highway
- Secondary Road
- Ann Arbor City Area
- Lake, River or Stream
- County Boundary

N

3 0 3

Miles

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 1
LOCATION MAP

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

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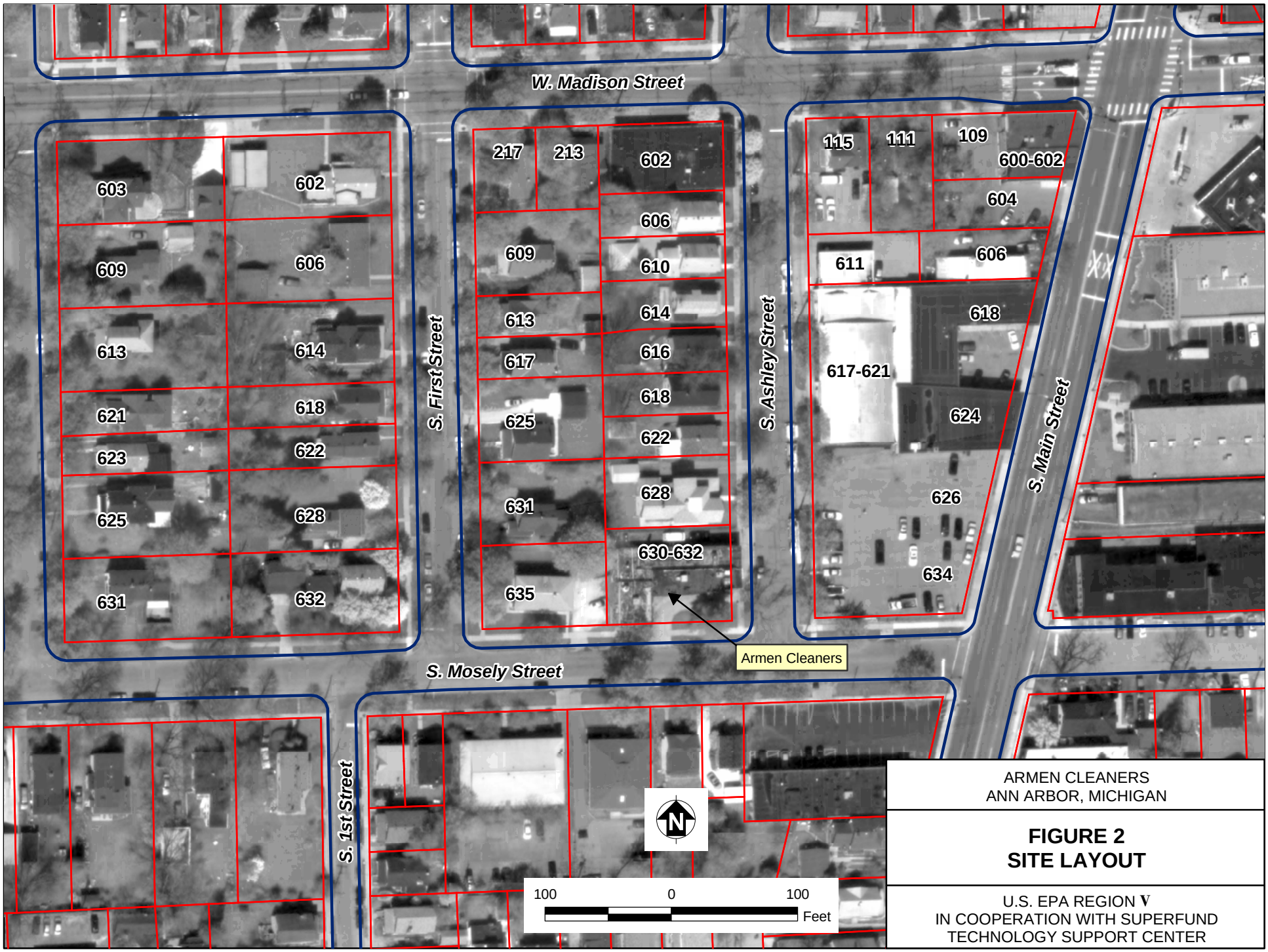

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 2
SITE LAYOUT

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

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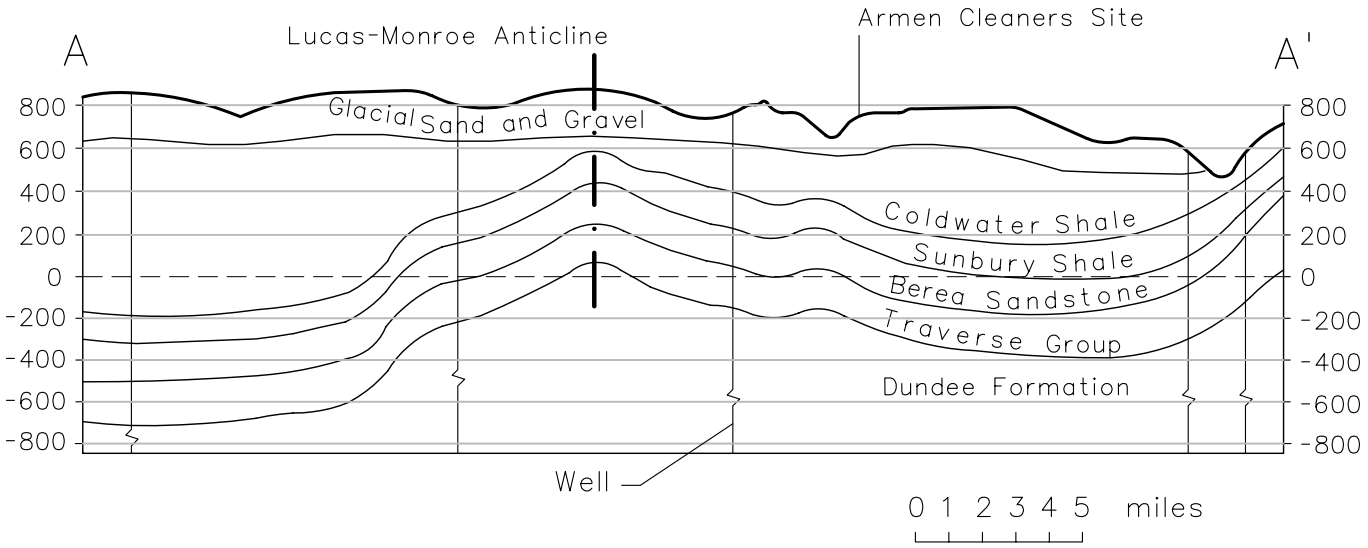

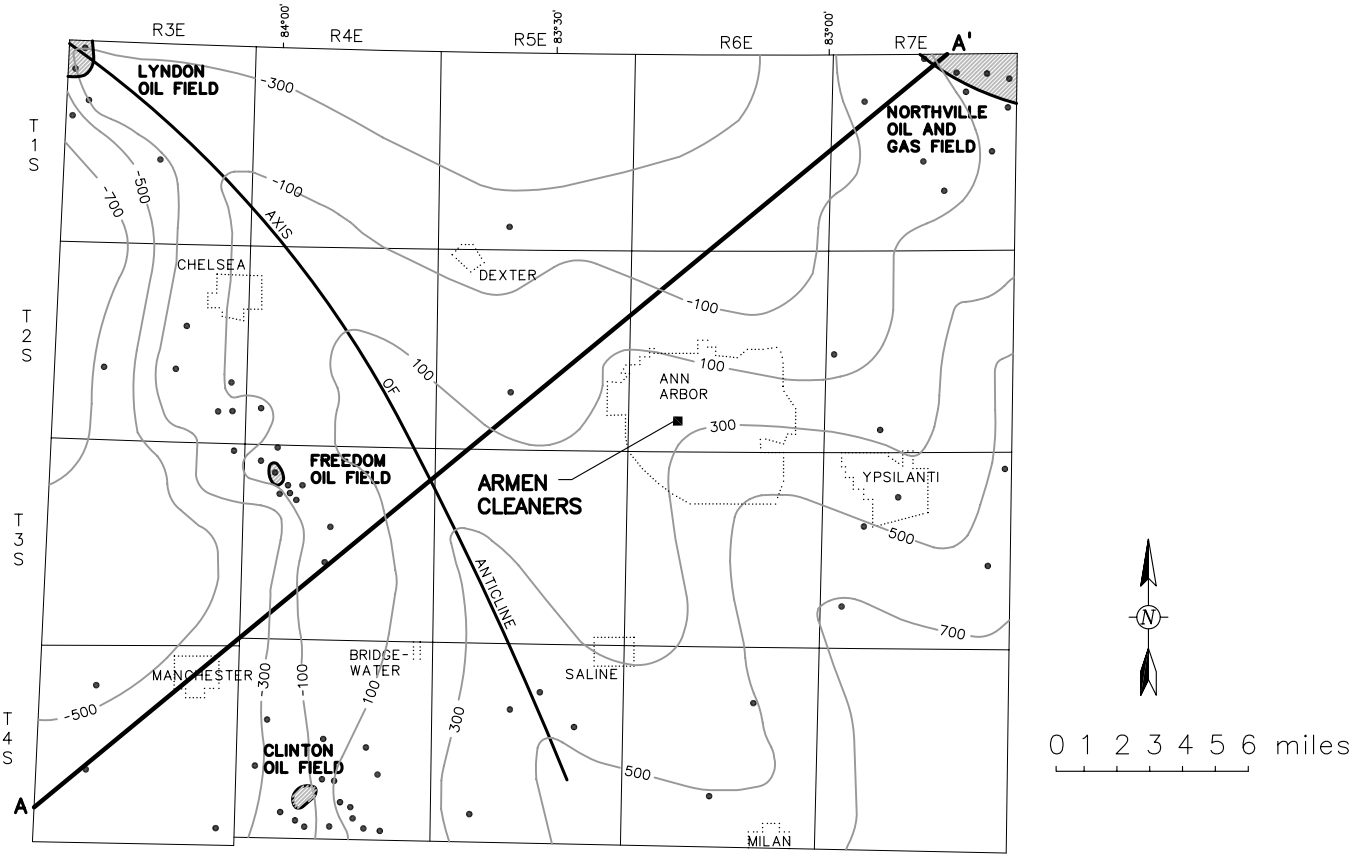

LEGEND

300 — CONTOUR OF TRAVERSE GROUP

• OIL, GAS OR TEST WELL

Figure based on Fleck, William, 1980, *Geology and Hydrology for Environmental Planning in Washtenaw County, Michigan,* USGS Open-File Report.

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 3
REGIONAL GEOLOGICAL MAP AND GEOLOGIC CROSS-SECTION

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TRIAD SUPPORT CENTER

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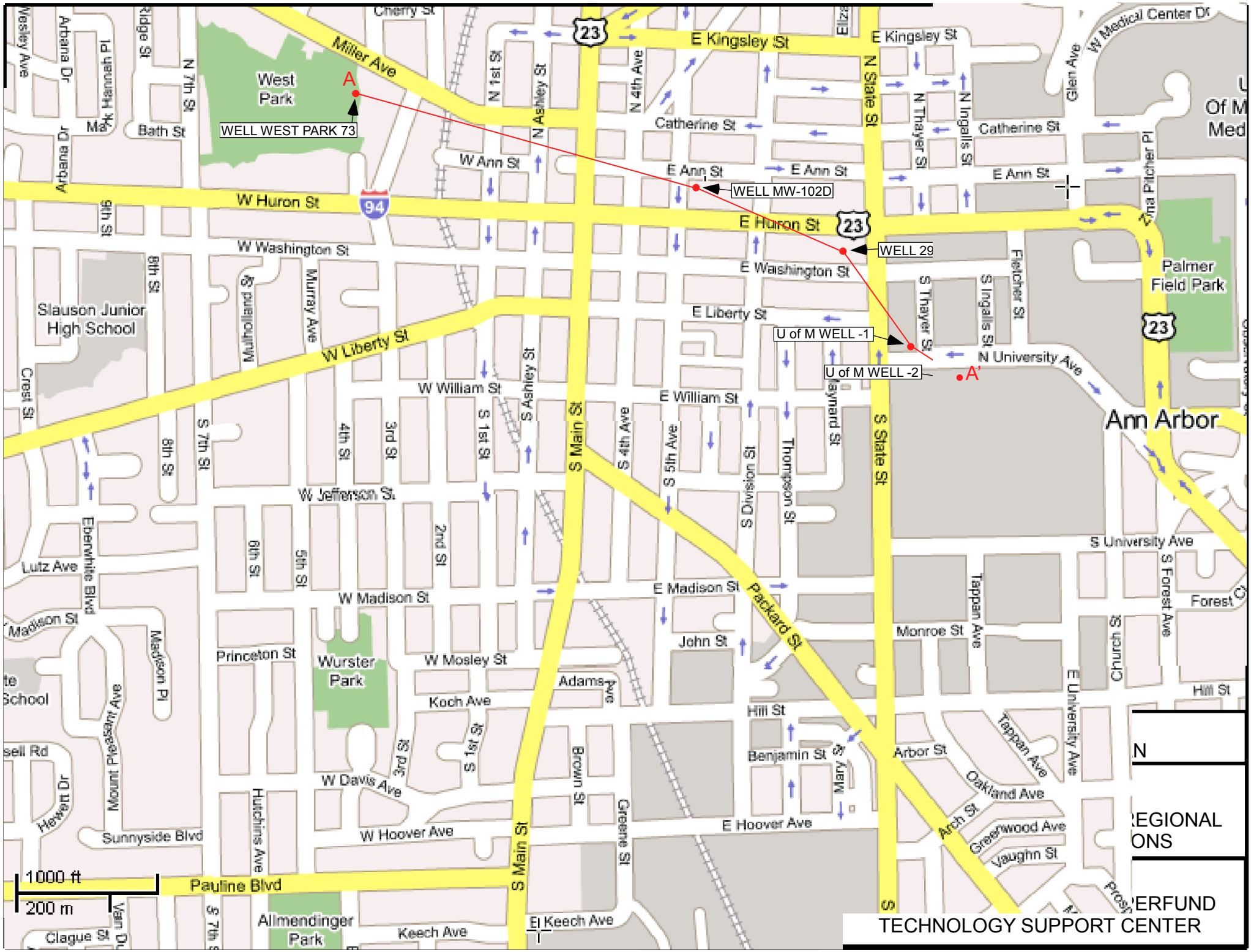

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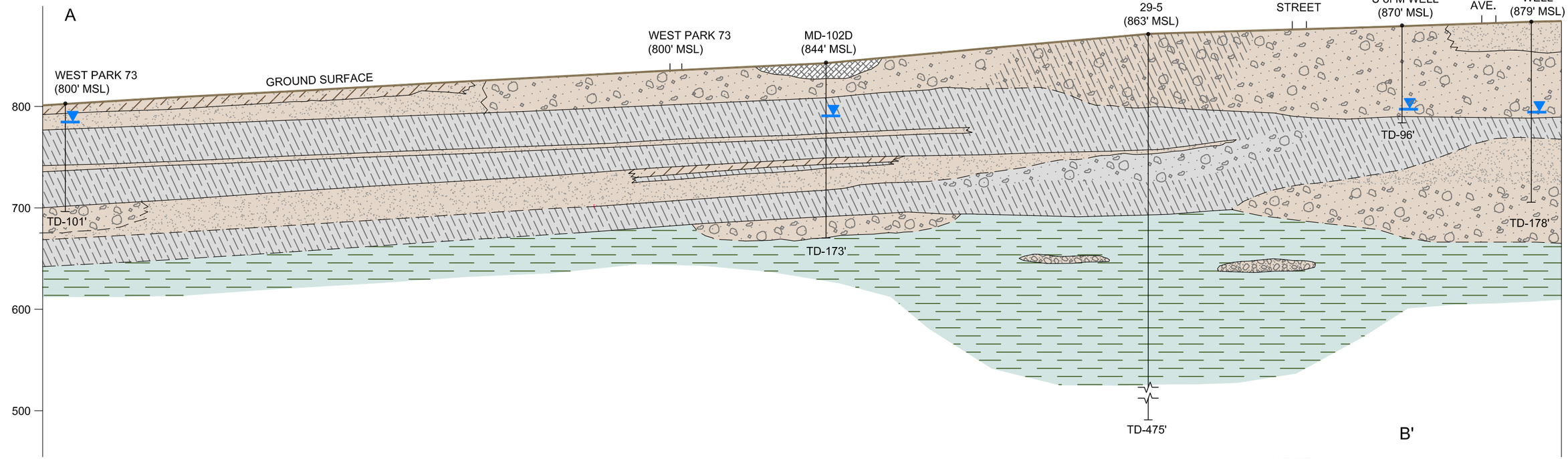
TECHNOLOGY SUPPORT CENTER



LEGEND

- AMBIENT AIR PLUME BOUNDARY
- SOIL GAS PLUME BOUNDARY
- APPROXIMATE POSITION OF GROUNDWATER DIVIDE
- WATER TABLE (WATER MEASUREMENT FROM DIFFERENT SAMPLING EVENTS)

- FILL
- SOIL ZONE
- SILTY SAND
- SANDS - MAY BE LATERALLY DISCONTINUOUS
- SANDS AND GRAVEL
- CLAY/SILT
- SHALE
- MIXED LITHOLOGY SAND/SILT DEPOSITS

150' 0 150' 300'
SCALE: 1" = 300'
HORIZONTAL SCALE

50' 0 50' 100'
SCALE: 1" = 100'
VERTICAL SCALE

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 5

GENERAL GEOLOGIC CROSS-SECTION OF ANN ARBOR, MICHIGAN

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TRIAD SUPPORT CENTER

R:\EPA\Armen Cleaners\G9015.3.046.02.01\ Fig. 5 _Armen CSM Regional Sections.dwg 08/07/2006 deborah.ford DN

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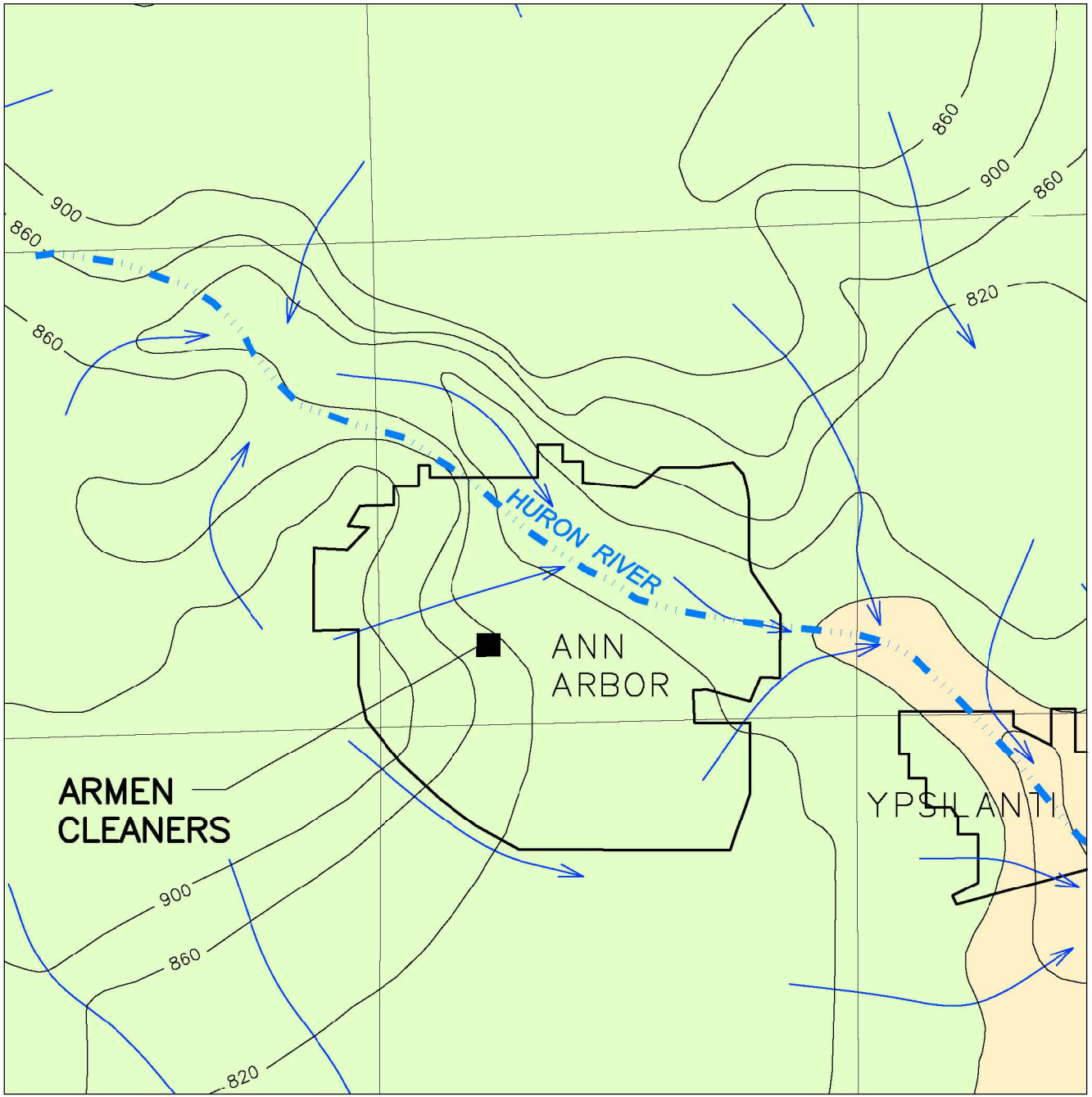


Water Table

The water table is the surface of the saturated zone. In Washtenaw County, the altitude of the water table is generally highest in the western and southern parts, and lowest in southeastern parts. Locally, water in the saturated zone moves toward minor streams; overall movement is south and southwest.

LEGEND

900

Line of equal altitude of water table above mean sea level: interval 40 feet

Altitude of groundwater table more than 940 feet above mean sea level

Altitude of groundwater table 780 to 940 feet above mean sea level

Altitude of groundwater table less than 780 feet above mean sea level

Direction of groundwater movement

1 0 1 2

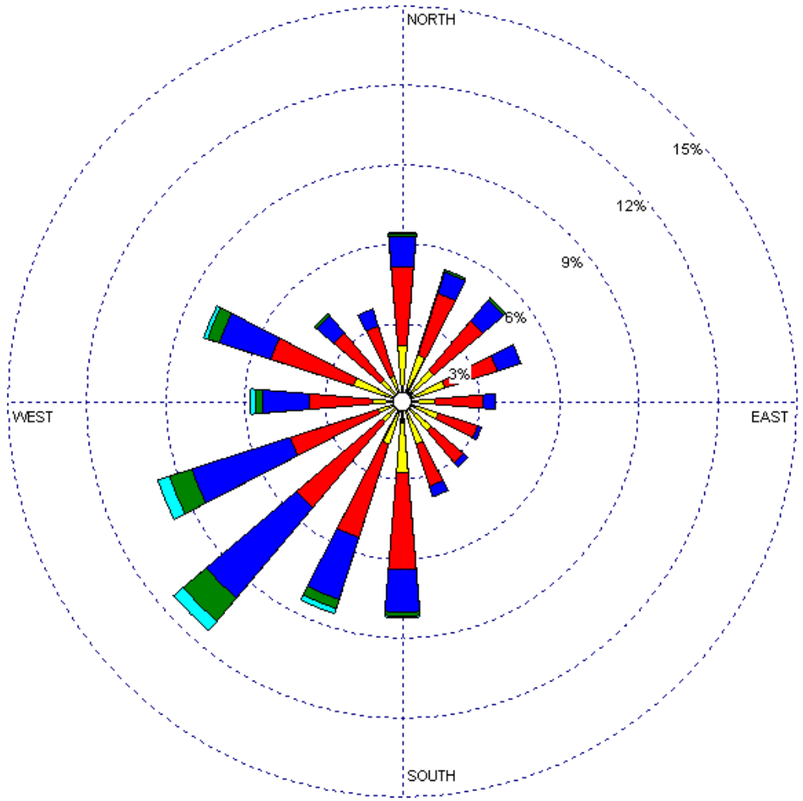
SCALE IN MILES

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

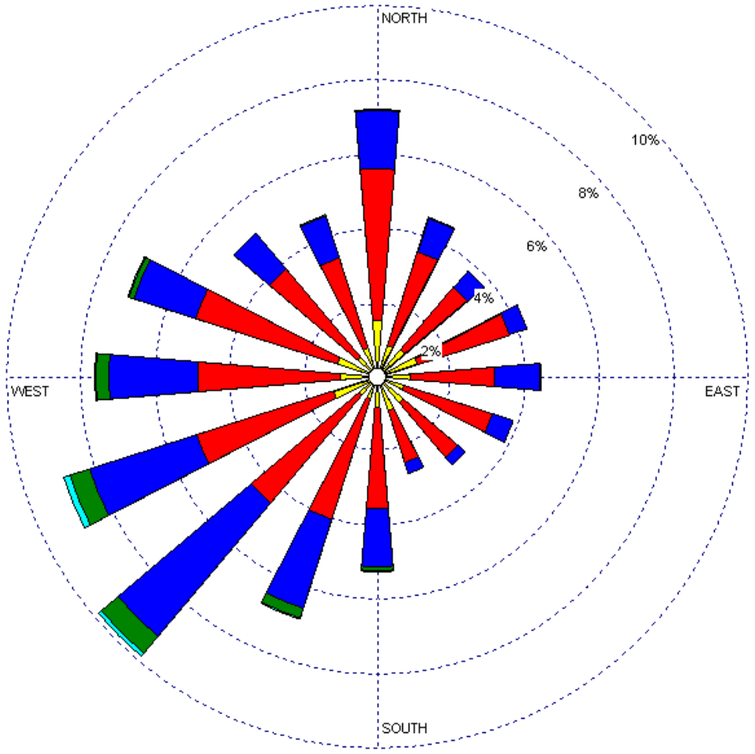
FIGURE 6

REGIONAL WATER TABLE MAP

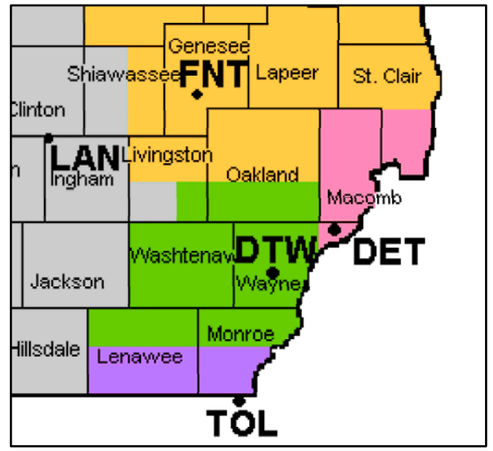
U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TRIAD SUPPORT CENTER



DTW-91



DET-91

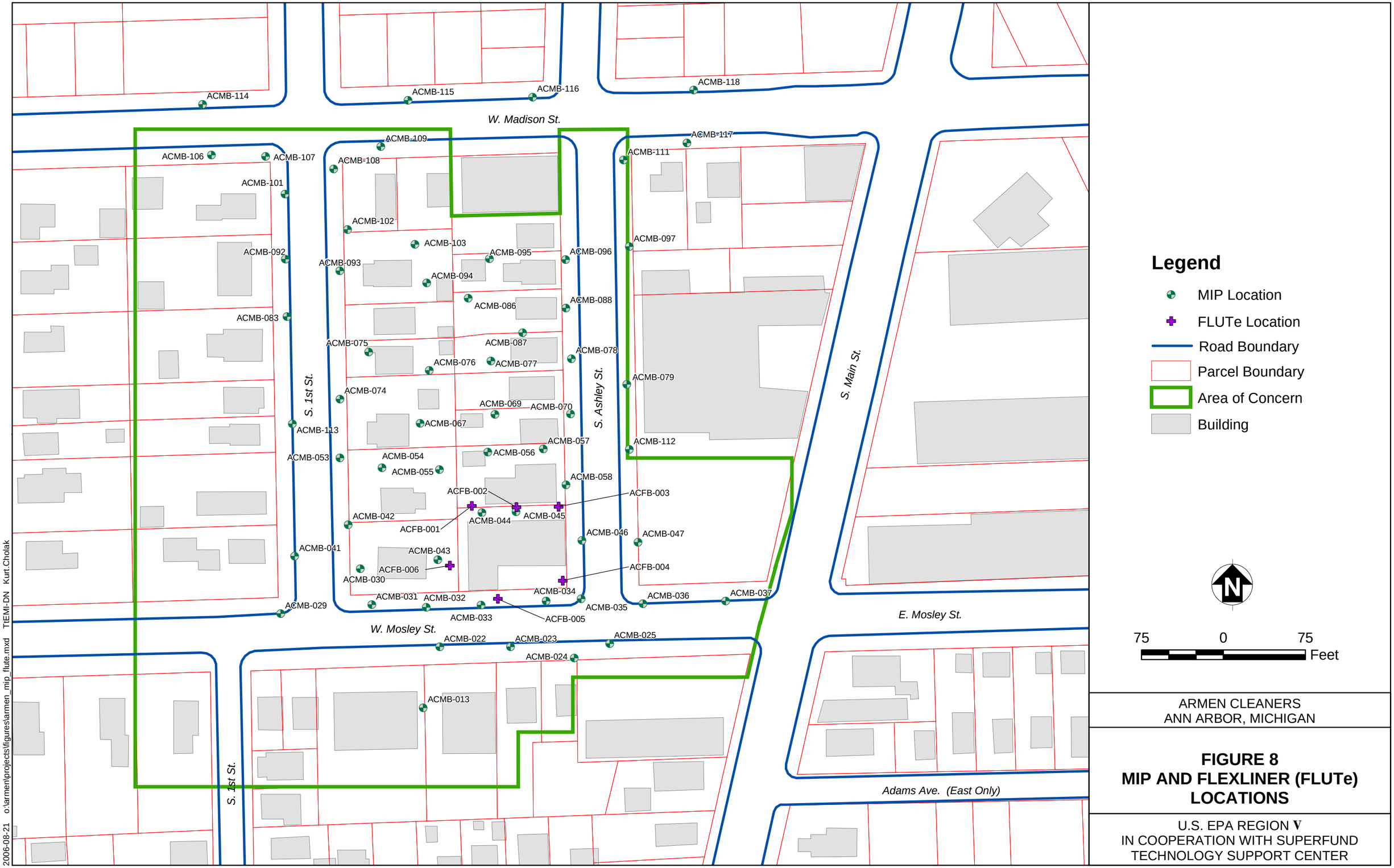


ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 7
HISTORICAL WIND ROSE DIAGRAMS FOR SOUTHEASTERN MICHIGAN (1987-1991)

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\armen_wind_roses.mxd TtEMI-DN kurt.cholak



ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 8
MIP AND FLEXLINER (FLUTe) LOCATIONS

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\armen_mip_flute.mxd TtEMI-DN Kurt.Cholak

213 West Madison	
Point ID	Point Location
ACSC-007A	Basement
ACSC-007B	Living Room
ACSC-007C	Front Porch

217 West Madison	
Point ID	Point Location
ACSC-012A	Basement
ACSC-012B	Dining Room
ACSC-012C	Front Porch

115 West Madison St.	
Point ID	Point Location
ACSC-009A	Basement
ACSC-009B	Living Room
ACSC-009C	Front Porch

111 West Madison St.	
Point ID	Point Location
ACSC-010A	Basement
ACSC-010B	Living Room
ACSC-010C	Front Porch

606 South Ashley St.	
Point ID	Point Location
ACSC-006A	Basement
ACSC-006B	Kitchen
ACSC-006C	Front Porch

610 South Ashley St.	
Point ID	Point Location
ACSC-001A	Basement
ACSC-001B	Stairwell
ACSC-001C	Front Porch
ACSC-001D	Front Porch

606/608 South First St.	
Point ID	Point Location
ACSC-013A	Basement
ACSC-013B	Kitchen
ACSC-013C	Back porch

614 South Ashley St.	
Point ID	Point Location
ACSC-004A	Basement
ACSC-004B	Kitchen
ACSC-004C	Front Porch

617 South First St.	
Point ID	Point Location
ACSC-014A	Basement
ACSC-014B	Dining Room
ACSC-014C	Front Porch

616 South Ashley St.	
Point ID	Point Location
ACSC-008A	Basement
ACSC-008B	Living Room
ACSC-008C	Front Porch
ACSC-008D	Basement

625 South First St.	
Point ID	Point Location
ACSC-015A	Basement
ACSC-015B	Den
ACSC-015C	Front Porch

622 South Ashley St.	
Point ID	Point Location
ACSC-003A	Basement
ACSC-003B	Laundry Room
ACSC-003C	Front Porch

631 South First St.	
Point ID	Point Location
ACSC-011A	Basement
ACSC-011B	Front Porch
ACSC-011C	Kitchen

628 South Ashley St.	
Point ID	Point Location
ACSC-002A	Basement
ACSC-002B	Kitchen
ACSC-002C	Front Porch
ACSC-002D	Basement

635 South First St.	
Point ID	Point Location
ACSC-005A	Basement
ACSC-005B	Apartment Hallway
ACSC-005C	Back Porch

ACVP-041
ACVP-039
ACVP-037
ACVP-036
ACSS-012
ACSS-007
ACSS-010
ACSS-009
ACVP-040
ACVP-032
ACSS-006
ACSS-013
ACSS-001
ACVP-030
ACVP-028
ACVP-027
ACVP-031
ACSS-008
ACSS-014
ACVP-026
ACVP-025
ACVP-021
ACVP-020
ACSS-015
ACVP-022
ACSS-003
ACVP-023
ACVP-019
ACVP-017
ACSS-002
ACVP-012
ACVP-012 Rep
ACSS-011
ACVP-015
ACVP-016
ACVP-010
ACVP-011
ACVP-011 Rep
ACVP-013
ACVP-014
ACVP-009
ACVP-001
ACSS-005
Stack 11
ACVP-002
ACVP-006
ACVP-007
ACVP-008
ACVP-004
ACVP-003
ACVP-005
ACVP-005

W. Madison St.
S. Ashley St.
S. 1st St.
S. Main St.
W. Mosley St.
E. Mosley St.
Adams Ave. (East Only)

Legend

- Summa Location (ACSC-XXX)
- Sub Slab Location (ACSS-XXX)
- Vapor Point Location (ACVP-XXX)
- Road Boundary
- Parcel Boundary
- Area of Concern
- Building

N

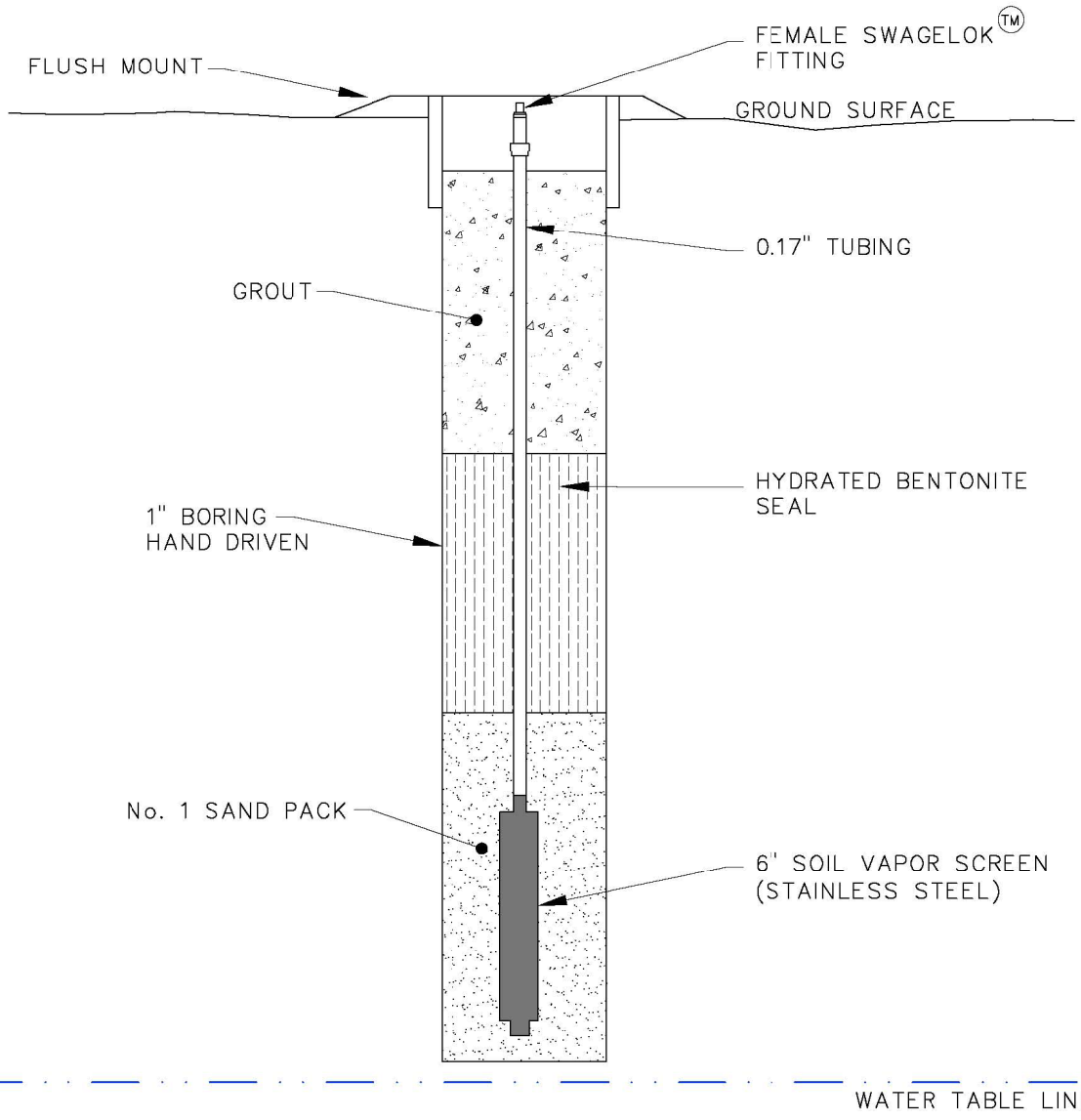
75 0 75 Feet

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 9
VAPOR POINT, SUB-SLAB, AND SUMMA LOCATIONS

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\vp_ss_suma.mxd THE_MI-DN.kdc



NOT TO SCALE

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 10

TYPICAL SCHEMATIC SOIL VAPOR MONITORING PROBE

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TRIAD SUPPORT CENTER

R:\EPA\Armen Cleaners\ VaporProbe.dwg 03/21/2005 deborah.ford DN

217 West Madison	
Point ID	Point Location
ARMN040	Basement Storage Area
ARMN040	Bedroom
ARMN040	Center of the Basement
ARMN040	Dining Room
ARMN040	Kitchen
ARMN040	Living Room
ARMN040	Post-exit Ambient
ARMN040	Pre-entry Ambient
ARMN040	Radon Removal System

213 West Madison	
Point ID	Point Location
ARMN003	Basement Shower Drain
ARMN003	Center of Basement
ARMN003	Dining Room
ARMN003	Foyer
ARMN003	Kitchen
ARMN003	Living Room
ARMN003	Post Exit Ambient
ARMN003	Pre-entry Ambient
ARMN003	Store Room One
ARMN003	Store Room Two

116 West Madison St.	
Point ID	Point Location
ARMN011	Center of the Basement
ARMN011	Dining Room
ARMN011	Kitchen
ARMN011	Living Room
ARMN011	Post-exit Ambient
ARMN011	Pre-entry Ambient

111 West Madison St.	
Point ID	Point Location
ARMN046	Basement
ARMN046	Dining Room
ARMN046	Kitchen
ARMN046	Living Room
ARMN046	Post-exit Ambient
ARMN046	Pre-entry Ambient
ARMN046	Workshop
ARMN046	Workshop Floor Drain

606/608 South First St.	
Point ID	Point Location
ARMN032	Basement Bathroom Two
ARMN032	Basement Dining Room
ARMN032	Basement Kitchen
ARMN032	Basement Living Room
ARMN032	Bathroom One
ARMN032	Bedroom five
ARMN032	Bedroom Four
ARMN032	Bedroom One
ARMN032	Bedroom Three
ARMN032	Bedroom Two
ARMN032	Laundry Room
ARMN032	Laundry Room Floor Drain
ARMN032	Living Room/Dining Room
ARMN032	Post-exit Ambient
ARMN032	Pre-entry Ambient

606 South Ashley St.	
Point ID	Point Location
ARMN015	Basement Floor Drain
ARMN015	Basement Sump
ARMN015	Center of the Basement
ARMN015	Dining Room
ARMN015	Kitchen
ARMN015	Living Room
ARMN015	Post-exit Ambient
ARMN015	Pre-entry Ambient
ARMN015	Store Room

614 South Ashley St.	
Point ID	Point Location
ARMN007	Bathroom/Kitchenette
ARMN007	Center of the Basement
ARMN007	Classroom
ARMN007	Floor Drain in Bathroom
ARMN007	Post-exit Ambient
ARMN007	Pre-entry Ambient

610 South Ashley St.	
Point ID	Point Location
ARMN029	Bathroom
ARMN029	Bedroom
ARMN029	Center of Rear Basement
ARMN029	Center of the Basement
ARMN029	Floor Drain in Basement
ARMN029	Kitchen
ARMN029	Living Room
ARMN029	Office
ARMN029	Post-exit Ambient
ARMN029	Pre-entry Ambient

616 South Ashley St.	
Point ID	Point Location
ARMN005	Basement
ARMN005	Bathroom
ARMN005	Kitchen
ARMN005	Living Room
ARMN005	Pantry
ARMN005	Post-exit Ambient
ARMN005	Pre-entry Ambient

622 South Ashley St.	
Point ID	Point Location
ARMN018	Basement Floor Drain
ARMN018	Basement Sump
ARMN018	Center of the Basement
ARMN018	Crawl Space
ARMN018	Dining Room
ARMN018	Kitchen
ARMN018	Laundry Room/Bathroom
ARMN018	Living Room
ARMN018	Post-exit Ambient
ARMN018	Pre-entry Ambient

ARMN036	Pre-entry Ambient

625 South First St.	

631 South First St.	
Point ID	Point Location
ARMN044	Basement
ARMN044	Dining Room
ARMN044	Furnace Room
ARMN044	Kitchen
ARMN044	Library
ARMN044	Living Room
ARMN044	Post-exit Ambient
ARMN044	Pre-entry Ambient

635 South First St.	
Point ID	Point Location
ARMN048	4-inch pipe (unplugged)
ARMN048	Bathroom
ARMN048	Bathroom Two
ARMN048	Bedroom
ARMN048	Kitchen
ARMN048	Kitchen Two
ARMN048	Laundry Room
ARMN048	Laundry Room Floor Drain
ARMN048	Living Room
ARMN048	Living Room Two
ARMN048	Post-exit Ambient
ARMN048	Pre-entry Ambient
ARMN048	South Basement 4-inch Pipe
ARMN048	Store Room One
ARMN048	Store Room Two
ARMN048	Store Room Two Window

632/630 South Ashley St.	
Point ID	Point Location
ARMN026	Vent Eight on Roof
ARMN026	Vent Eleven on Roof
ARMN026	Vent Five
ARMN026	Vent Five on Roof
ARMN026	Vent Four
ARMN026	Vent Four on Roof
ARMN026	Vent Nine on Roof
ARMN026	Vent One on Roof
ARMN026	Vent Seven on Roof
ARMN026	Vent Six
ARMN026	Vent Six on Roof
ARMN026	Vent Ten on Roof
ARMN026	Vent Three
ARMN026	Vent Three on Roof
ARMN026	Vent Two
ARMN026	Vent Two on Roof
ARMN026	Window Four
ARMN026	Window One
ARMN026	Window Three
ARMN026	Window Two

628 South Ashley St.	
Point ID	Point Location
ARMN042	Basement
ARMN042	Basement Room One
ARMN042	Basement Room Three
ARMN042	Basement Room Two
ARMN042	Bathroom
ARMN042	Bedroom One
ARMN042	Bedroom Three
ARMN042	Bedroom Two
ARMN042	Drain One
ARMN042	Drain Two
ARMN042	Furnace Room
ARMN042	Hole One Through Concrete
ARMN042	Hole Two Through Concrete
ARMN042	Kitchen One
ARMN042	Kitchen Two
ARMN042	Living room
ARMN042	Office
ARMN042	Post-exit Ambient
ARMN042	Pre-entry Ambient

W. Madison St.
S. 1st St.
S. Ashley St.
S. Main St.
W. Mosley St.
E. Mosley St.
Adams Ave. (East Only)

Legend

- Mobile Monitoring Point Locations
- TAGA Location
- Road Boundary
- Parcel Boundary
- Area of Concern
- Building

N

75 0 75 Feet

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 11
TAGA LOCATIONS

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\armen_taga.mxdT tEMI-DN Kurt.Cholak

W MADISON ST

E MOSLEY ST

S FIRST ST

ADAMS ST

Legend

- MIP Location
- Soil Vapor Probe Locations

ECD RESPONSE

- Less than 500,000
- 500,000 - 1,000,000
- 1,000,000 - 2,500,000
- 2,500,000 - 5,000,000
- 5,000,000 - 10,000,000
- 10,000,000 - 15,000,000
- 15,000,000 - 20,000,000
- 20,000,000 - 25,000,000
- 25,000,000 - 30,000,000
- 30,000,000 - 35,000,000
- 35,000,000 - 40,000,000
- 40,000,000 - 45,000,000
- 45,000,000 - 50,000,000

N

75 37.5 0 75

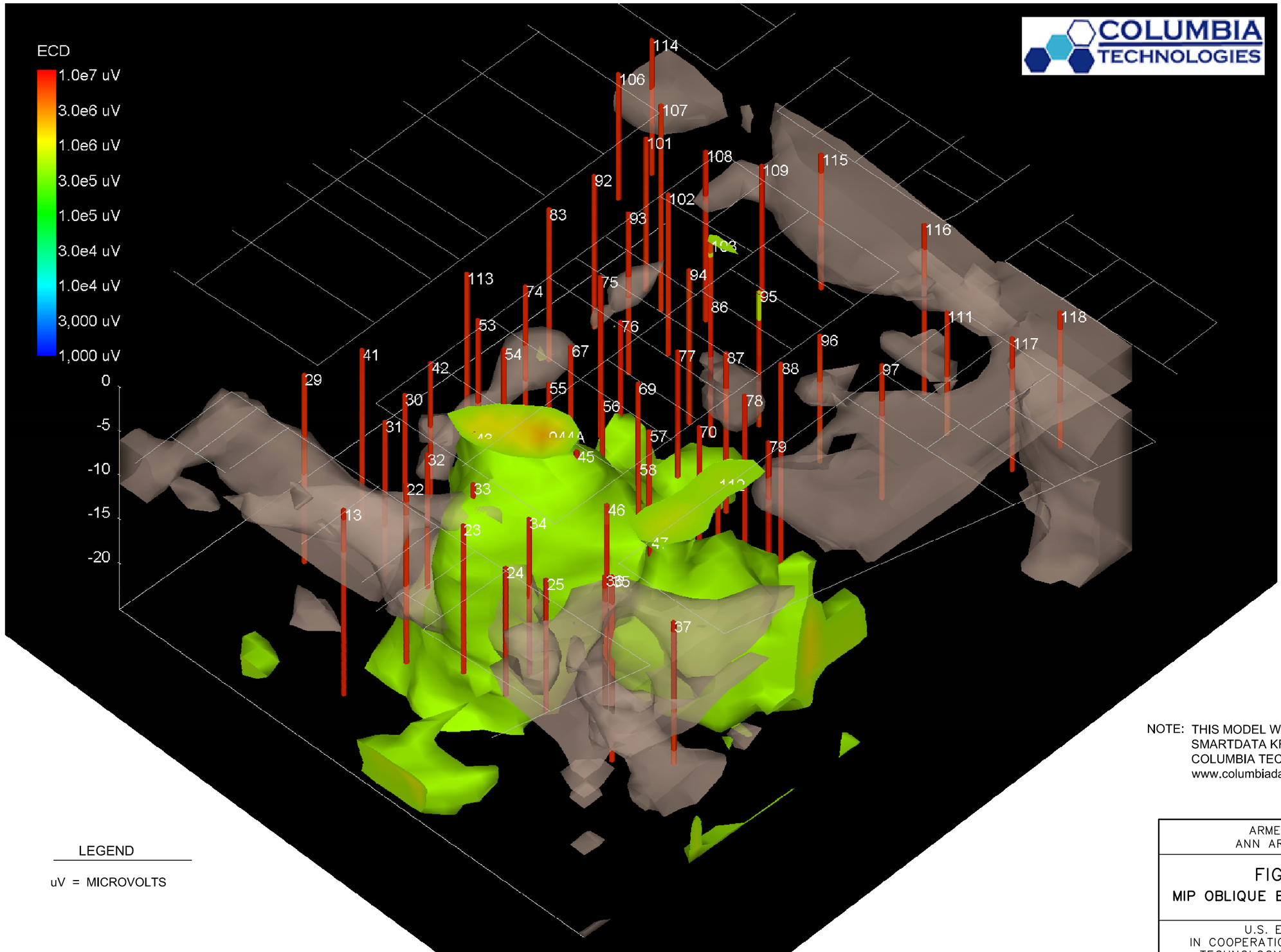
Feet

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 12
MIP ECD RESPONSE MAP

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

C:\Armen GIS\Maps\MIP_ECD Response.mxd hp8kc



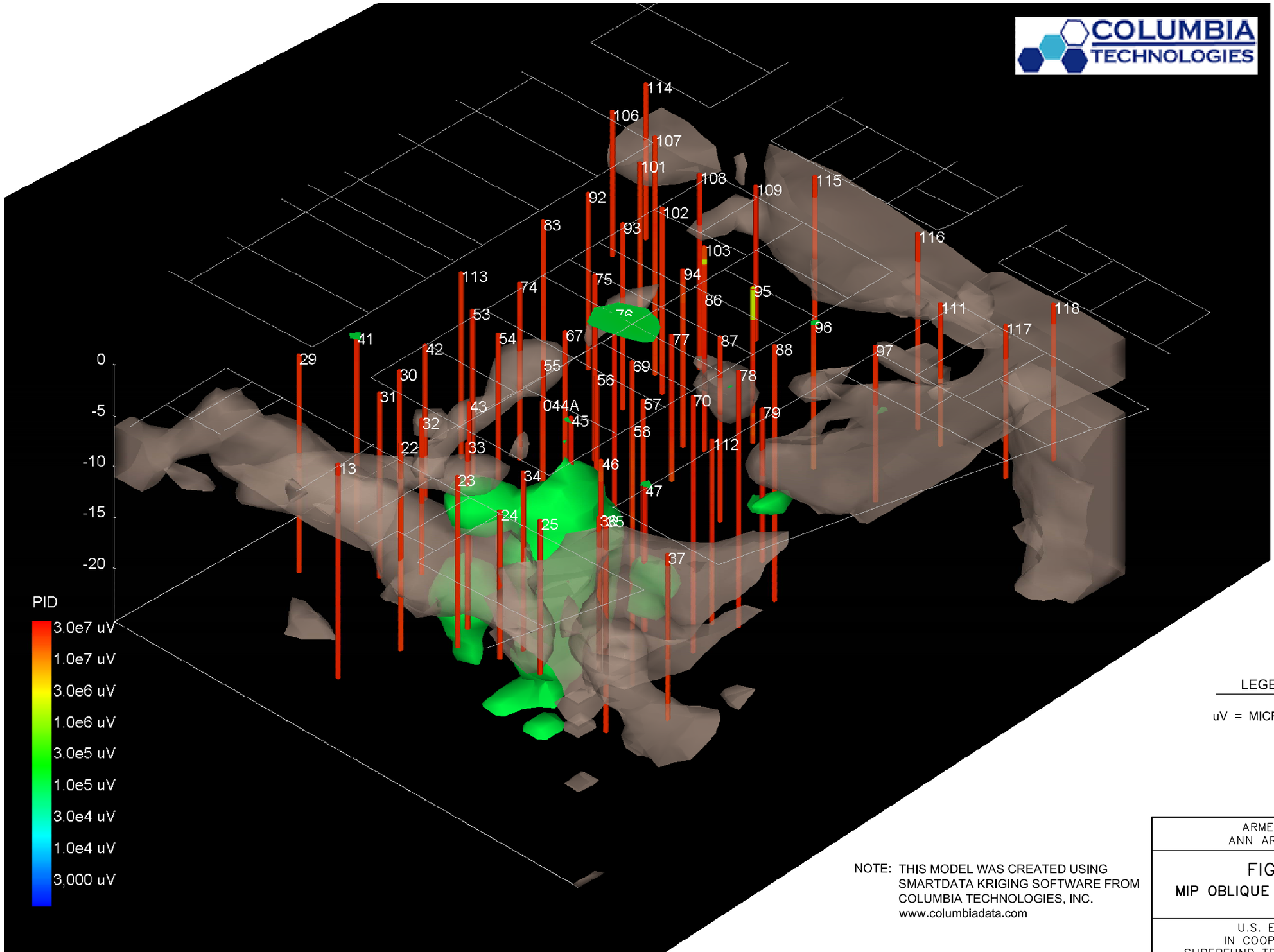
NOTE: THIS MODEL WAS CREATED USING SMARTDATA KRIGING SOFTWARE FROM COLUMBIA TECHNOLOGIES, INC. www.columbiadata.com

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 13
MIP OBLIQUE ECD MODEL DIAGRAM

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\ Armen-cleaners-ecd-soil.dwg 08/22/2006 deborah.ford DN



NOTE: THIS MODEL WAS CREATED USING SMARTDATA KRIGING SOFTWARE FROM COLUMBIA TECHNOLOGIES, INC. www.columbiadata.com

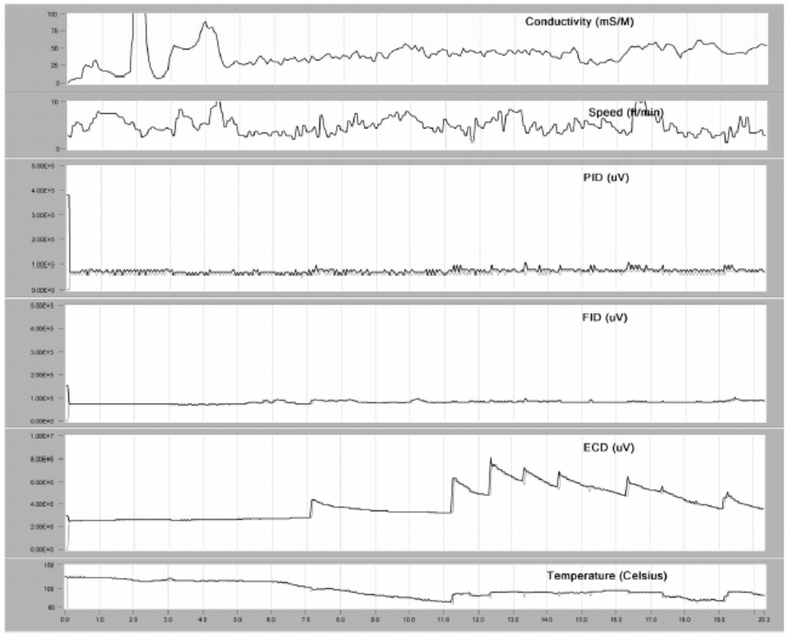
ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 14
MIP OBLIQUE PID MODEL DIAGRAM

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TRIAD SUPPORT CENTER

R:\EPA\Armen Cleaners\ Armen-cleaners-pid-soil.dwg 08/22/2006 deborah.ford DN

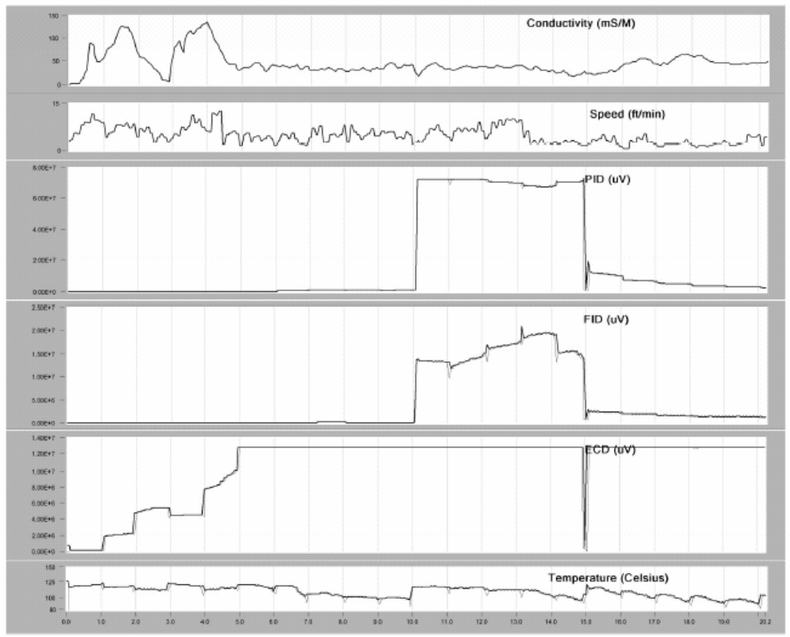
ACMB-044



Tetra Tech EMI
Arman Cleaners
05/19/03

COLUMBIA TECHNOLOGIES

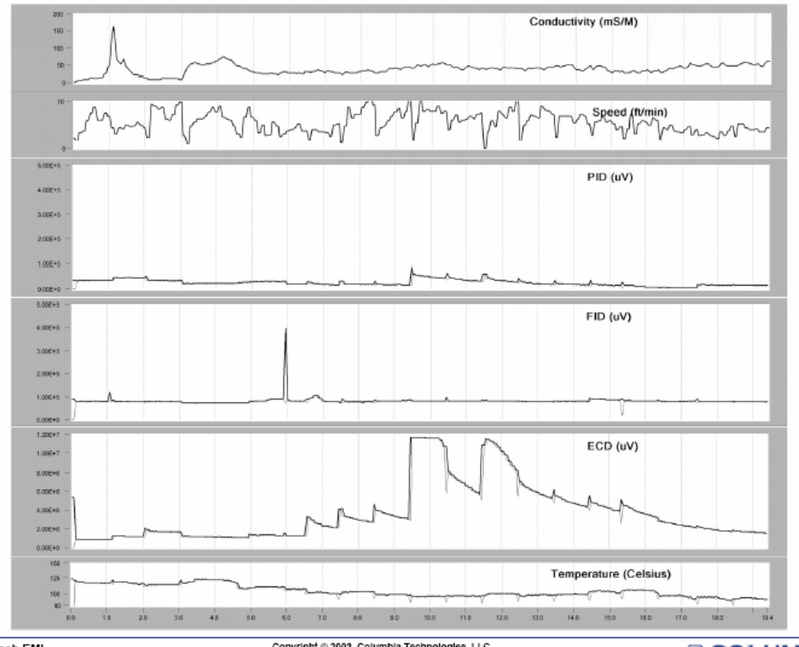
ACMB-045



Tetra Tech EMI
Arman Cleaners
05/15/03

COLUMBIA TECHNOLOGIES

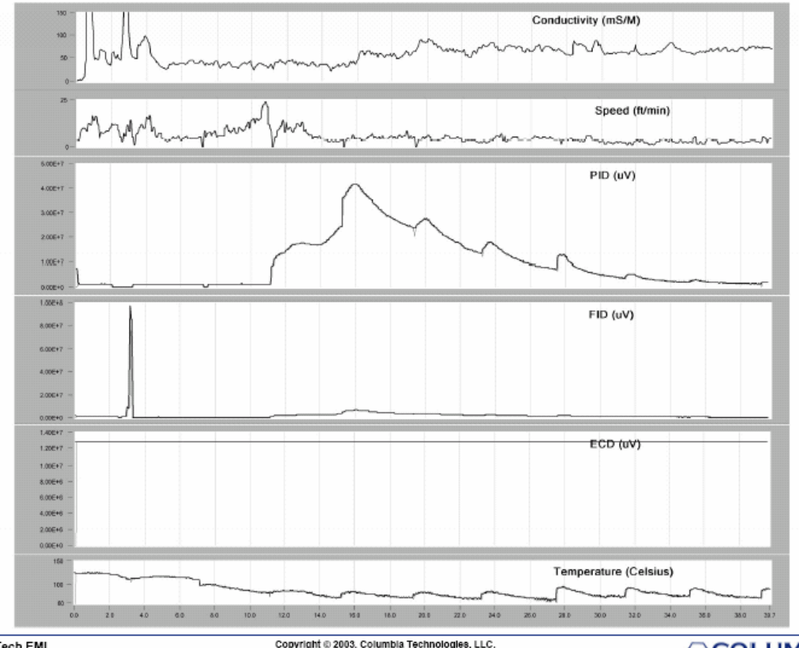
ACMB-044A



Tetra Tech EMI
Arman Cleaners
05/19/03

COLUMBIA TECHNOLOGIES

ACMB-45B



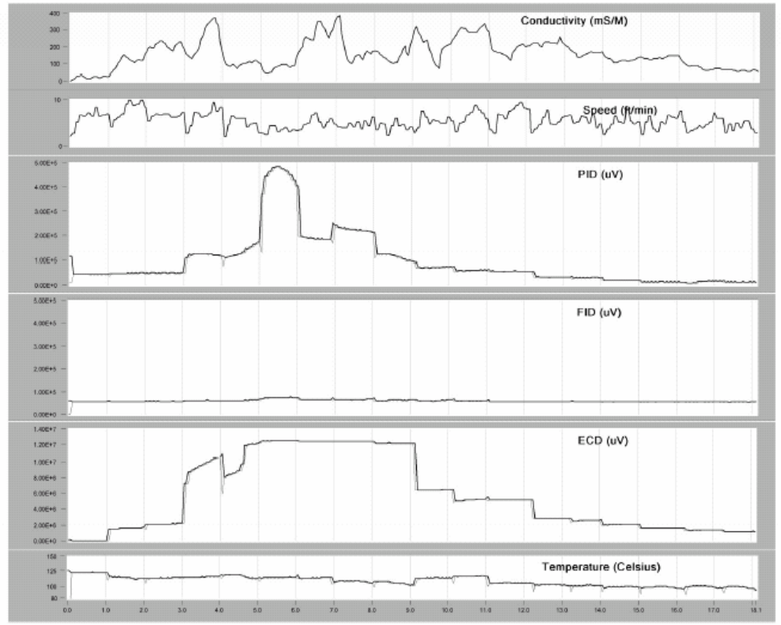
Tetra Tech EMI
Arman Cleaners
05/15/03

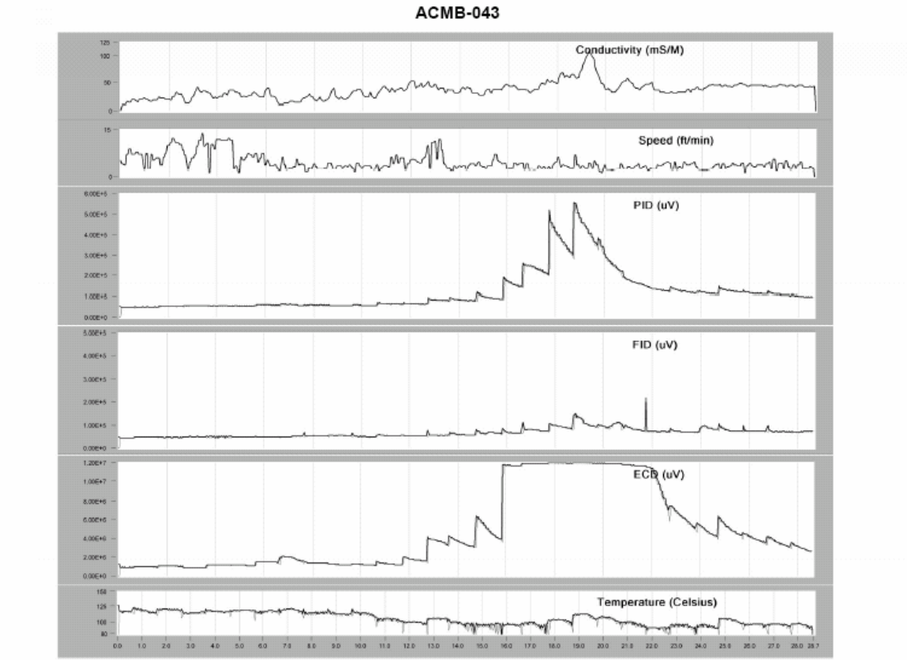
COLUMBIA TECHNOLOGIES

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 15
MIP BORING LOGS
NORTHERN BOUNDARY OF
ARMEN CLEANERS PROPERTY

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER





ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 16
MIP BORING LOGS FOR OTHER HIGH CONCENTRATION ZONES NEAR THE ARMEN CLEANERS PROPERTY

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\Armen_Columbia_Other.mxd TtEMI-DN Kurt.Cholak

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 17
COMPARATIVE OBSERVATIONS
FROM FLEXLINER BORINGS LOGS

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\Comparative_Ob.mxd TtEMI-DN Kurt.Cholak

Legend

Vapor Point and Sub Slab PCE Results

- (Non-Detect 4.0 ppbv Report Limit)
- 4.0-550,000 ppbv

PCE Contours

- PCE Contour (Dashed where inferred)
- 10-100 ppbv
- 100-1,000 ppbv
- 1,000-10,000 ppbv
- 10,000-100,000 ppbv
- Above 100,000 ppbv
- Area of Concern
- Parcel Boundary
- Building
- Road Boundary

Note: ppbv = parts per billion by volume

N

70 0 70

Feet

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 18
SOIL VAPOR PCE PLUME BASED ON VAPOR POINT AND SUB-SLAB RESULTS

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND TECHNOLOGY SUPPORT CENTER

2007-08-21 o:\armen\projects\figures\armen_vp_pcenew.mxd T tEMI-DN kurt.cholak

Armen Cleaners - West Wall	
Onsite Air - PCE Results (ppbv)	
Vent five	
	1500.00 U
	1500.00 U
	3000.00
	1000.00
	2000.00
	2000.00
	1000.00 J

SAMPLING DAY
Mean Wind Direction ~ 60°
Mean Wind Speed ~ 10 mph

635 S 1st St - First Floor	
Indoor Air - PCE Results	(ppbv)
Kitchen two	28.00
Bathroom two	27.00
Bathroom	9.80
Kitchen	9.60
Living room two	29.00
Bedroom	11.00
Living room	10.00

Armen Cleaners -Roof	
Onsite Air - PCE Results (ppbv)	
Vent eight on roof	1500.00 U
Vent seven on roof	1500.00 U
Vent six on roof	3000.00
Vent three on roof	1000.00 J
Vent five on roof	1500.00 U
Vent eleven on roof	50000.00
Vent two on roof	2000.00
Vent ten on roof	3000.00
Vent one on roof	3000.00
Vent four on roof	3000.00
Vent nine on roof	1500.00 U

635 S 1st St - Pre-entry and Post-exit	
Outdoor Air - PCE Results	(ppbv)

635 First Street

Armen Cleaners

V5 W4 V4 W3 V3 W2 V2 W1
6 7 3 5 8 2 11 10 1 4 9

S. 1st St.

S. Ashley St.

W. Mosley St.

Armen Cleaners - Mobile Monitoring	
Outdoor Air - PCE Results	(ppbv)
Turning left onto Ashley St	1.10 U

635 S 1st St - Stationary Monitoring	
Outdoor Air - PCE Results	(ppbv)
Stationary Monitoring	4.50

635 S 1st St - Basement	
Indoor Air - PCE Results	(ppbv)
Basement floor drain	23.00
Basement Store room two	26.00
Basement Store room one	26.00
Basement Laundry room	23.00

635 S 1st St - Mobile Monitoring	
Outdoor Air - PCE Results	(ppbv)
Turning left onto West Mosley S	26
Turning left onto West Mosley S	8.00

Legend

- Mobile Monitoring Point Locations
- TAGA Location
- Road Boundary
- Parcel Boundary
- Area of Concern
- Building

ppbv Parts per billion by volume
U Not detected at indicated reporting limit
J Estimated concentration below reporting limit

Note: All TAGA measurements were taken between 1:00 P.M. and 4:30 P.M.

N

15 0 15 30 Feet

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 19
INDOOR AND OUTDOOR AIR CONCENTRATIONS OF PCE, AS MEASURED BY TAGA ON JUNE 3, 2003

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND TECHNOLOGY SUPPORT CENTER

2006-08-24 o:\armen\projects\figures\armen_PCE_withText.mxd TtEMI-DN kurt.cholak

W. Madison St.

S. 1st St.

S. Ashley St.

S. Main St.

628 South Ashley St.

635 South First St.

Armen Cleaners

W. Mosley St.

E. Mosley St.

Adams Ave. (East O

S. 1st St.

Legend

- Parcel with Vapor Point or Sub-slab Concentration 100 times greater than Inhalation Criteria.
- Building with TAGA Exceedance of Inhalation Criteria
- Building with Summa and Sub-slab Exceedance of Inhalation Criteria
- Building
- Parcel Boundary
- Area of Concern
- Road Boundary

Note: The MDEQ Acceptable Indoor Air Concentration for Tetrachloroethene (PCE) is 6.19 parts per billion by volume (pbbv).

N

70 0 70

Feet

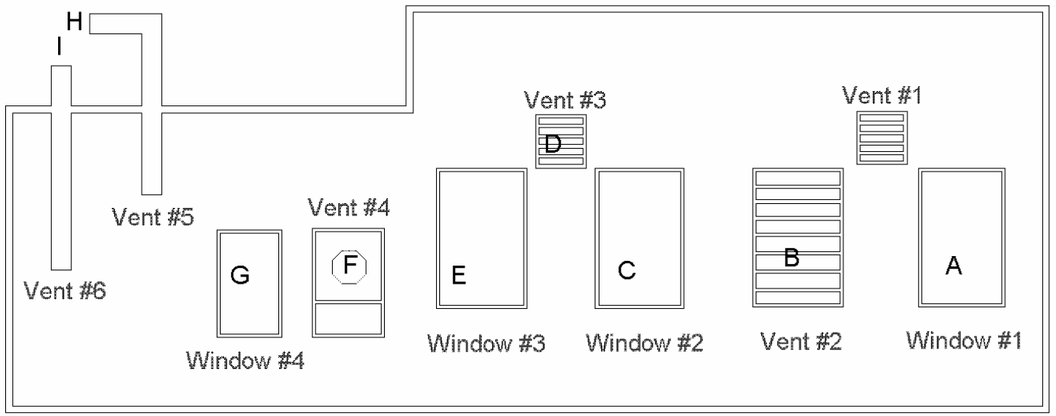
ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 20
PROPERTIES EXCEEDING THE MDEQ ACCEPTABLE INDOOR AIR CONCENTRATION FOR PCE

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND TECHNOLOGY SUPPORT CENTER

2006-08-24 o:\armen\projects\figures\armen_vp_ss_suma_pce_notext.mxd TtEMI-DN kurt.cholak

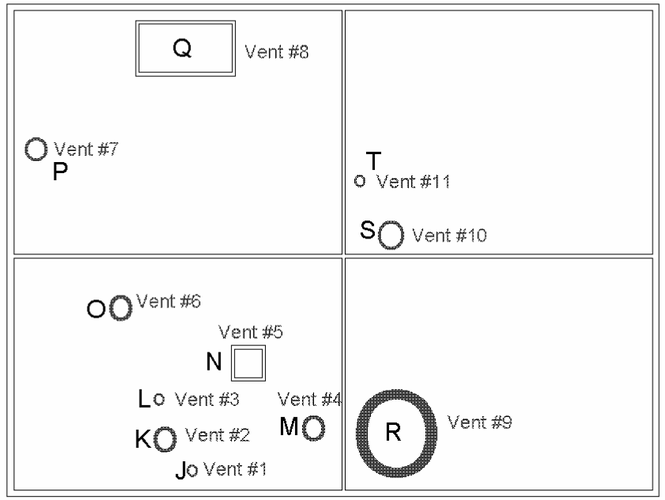
WEST SIDE OF ARMEN CLEANERS



North

HOUSE SURVEY
Armen Cleaners - Figure #1
ARMN026
Armen Cleaners Site
Ann Arbor, MI
Wind Northeast @ 10 mph

ROOF OF ARMEN CLEANERS



North

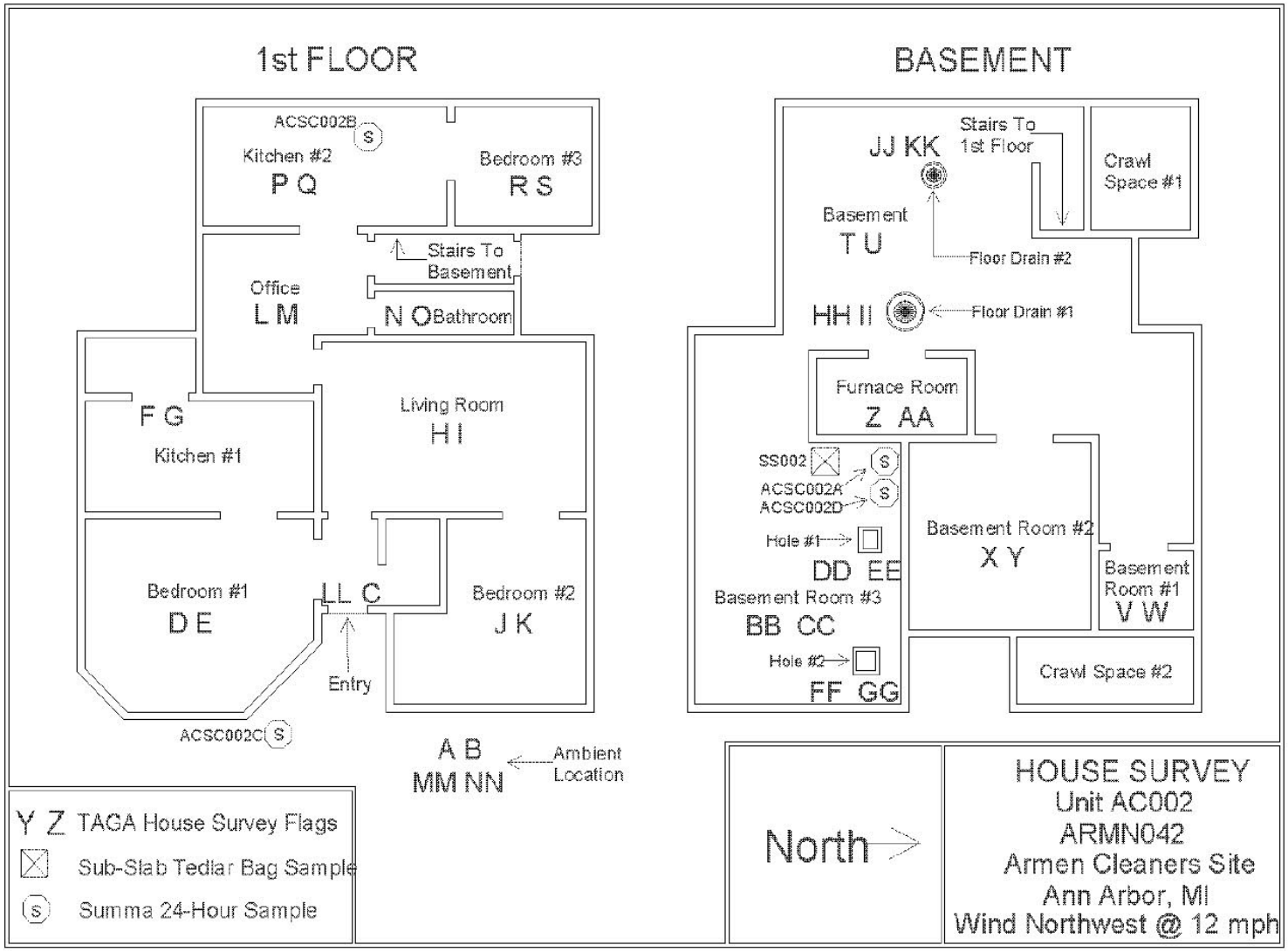
HOUSE SURVEY
Armen Cleaners - Figure #2
ARMN026
Armen Cleaners Site
Ann Arbor, MI
Wind Northeast @ 10 mph

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 21
TAGA SAMPLE LOCATIONS
ARMEN CLEANERS BUILDING

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\Armen_TAGA_Sample_Diagram.mxd TtEMI-DN Kurt.Cholak

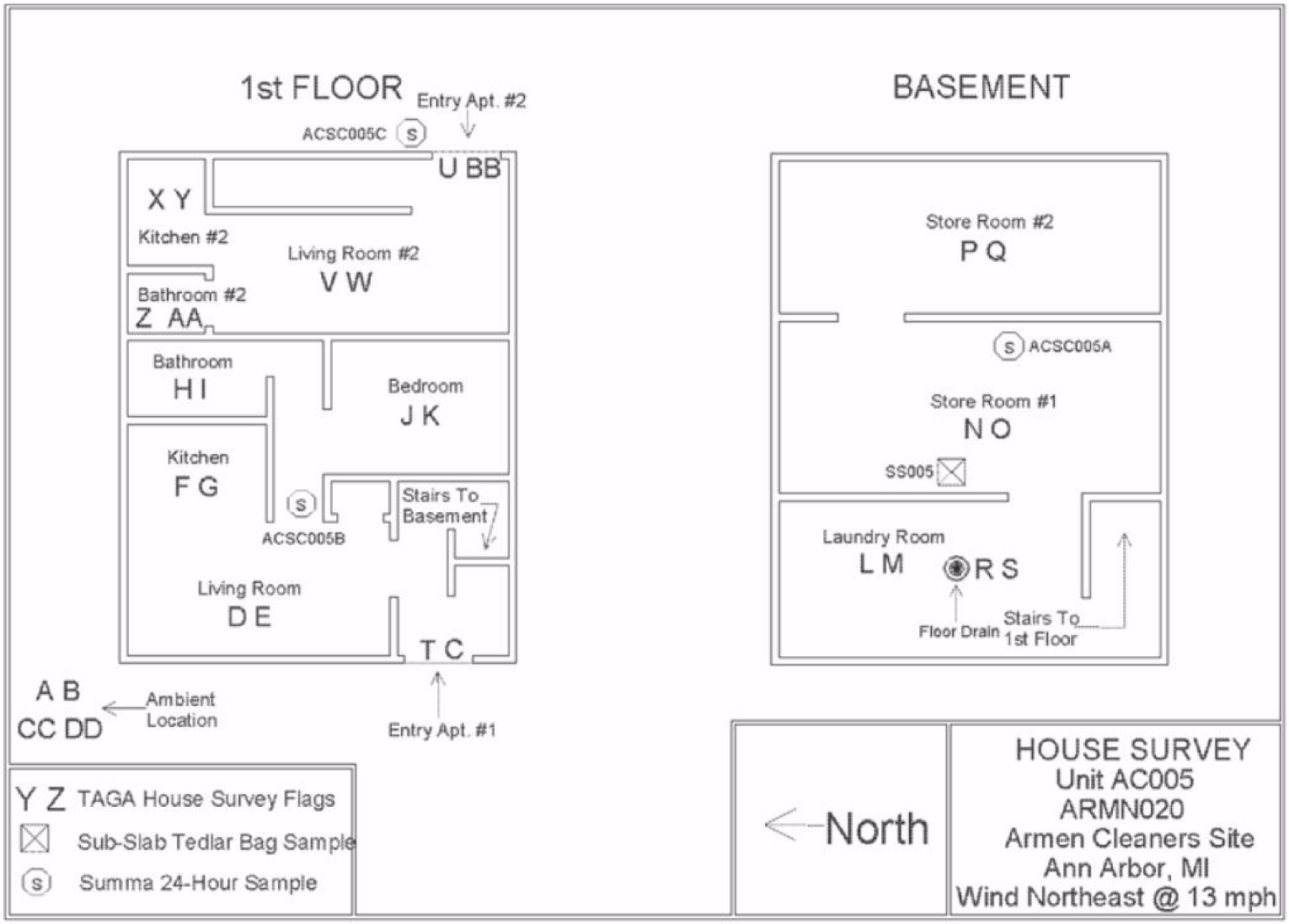


ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 22
AIR AND VAPOR SAMPLING LOCATIONS
628 SOUTH ASHLEY STREET

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-21 o:\armen\projects\figures\Armen_AV_Ashley_Diagram.mxd TtEMI-DN Kurt.Cholak

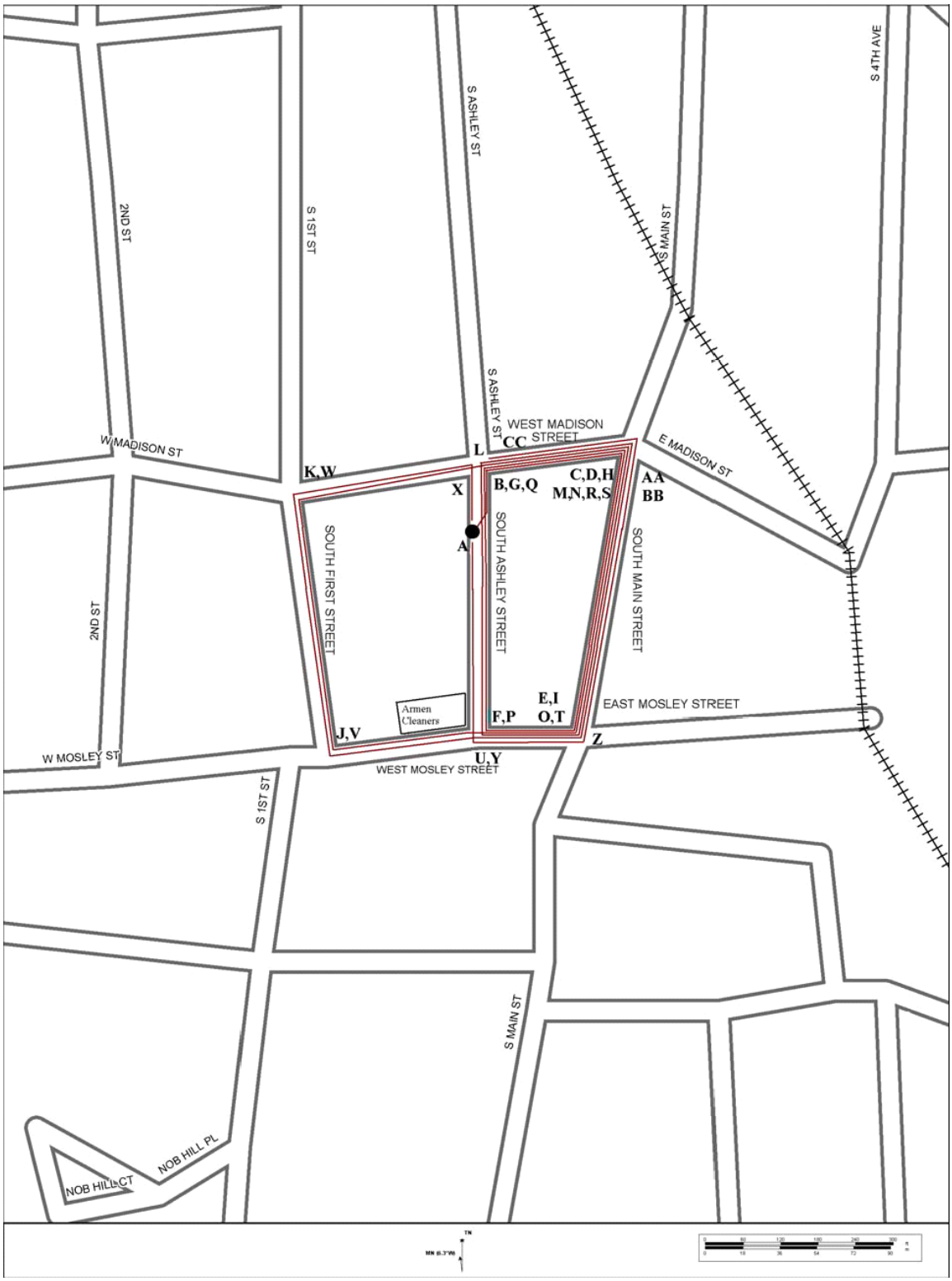


ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 23
AIR AND VAPOR SAMPLING LOCATIONS
635 SOUTH FIRST STREET

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-21 c:\armen\projects\figures\Armen_AV_635FirstSt_Diagram.mxd TtEMI-DN Kurt.Cholak

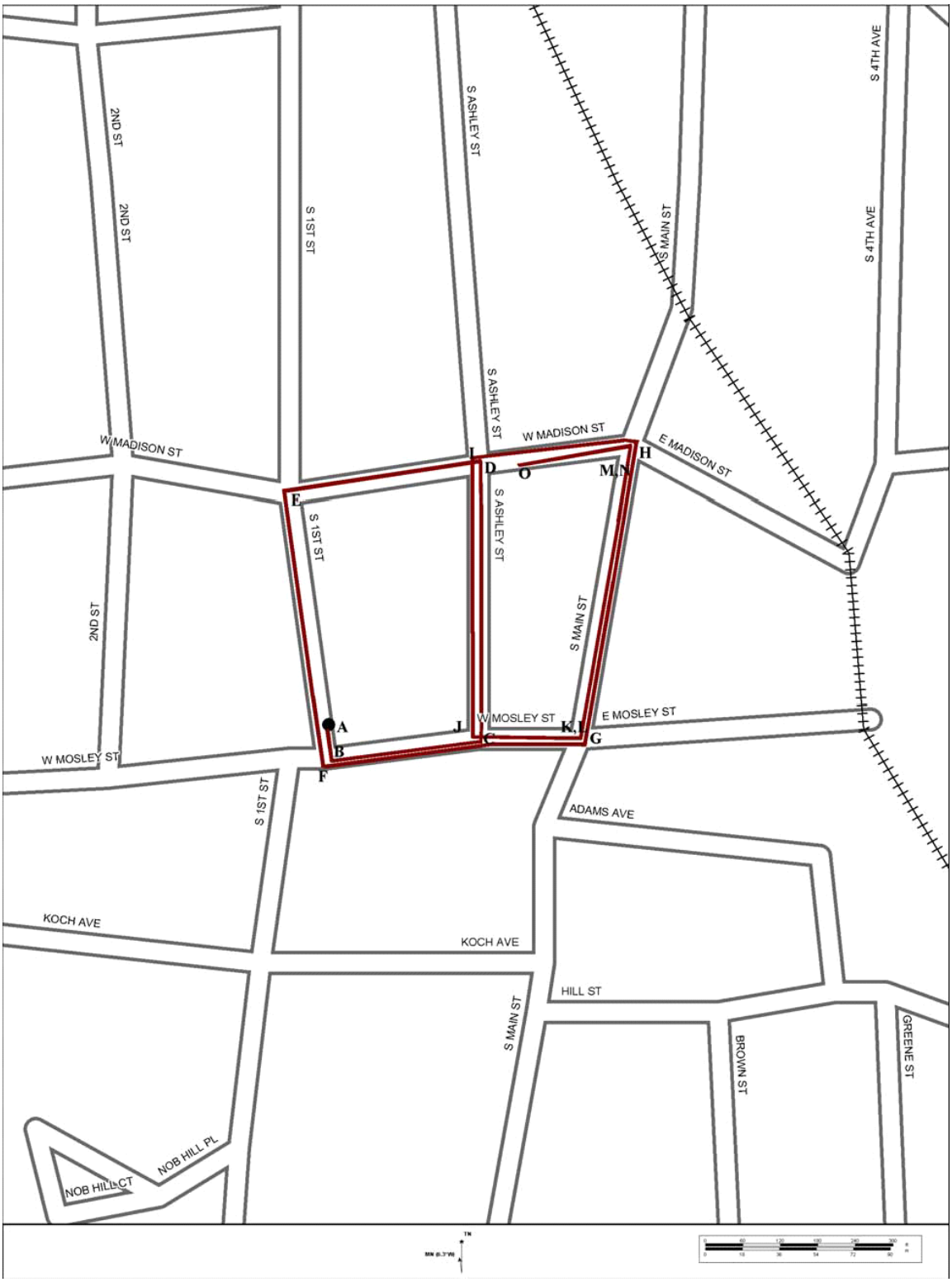


ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 24
TAGA MOBILE MONITORING PATH #1
ARM009
JUNE 2, 2003

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-11 o:\armen\projects\figures\Armen_TagaPath1.mxd TtEMI-DN kurt.cholak

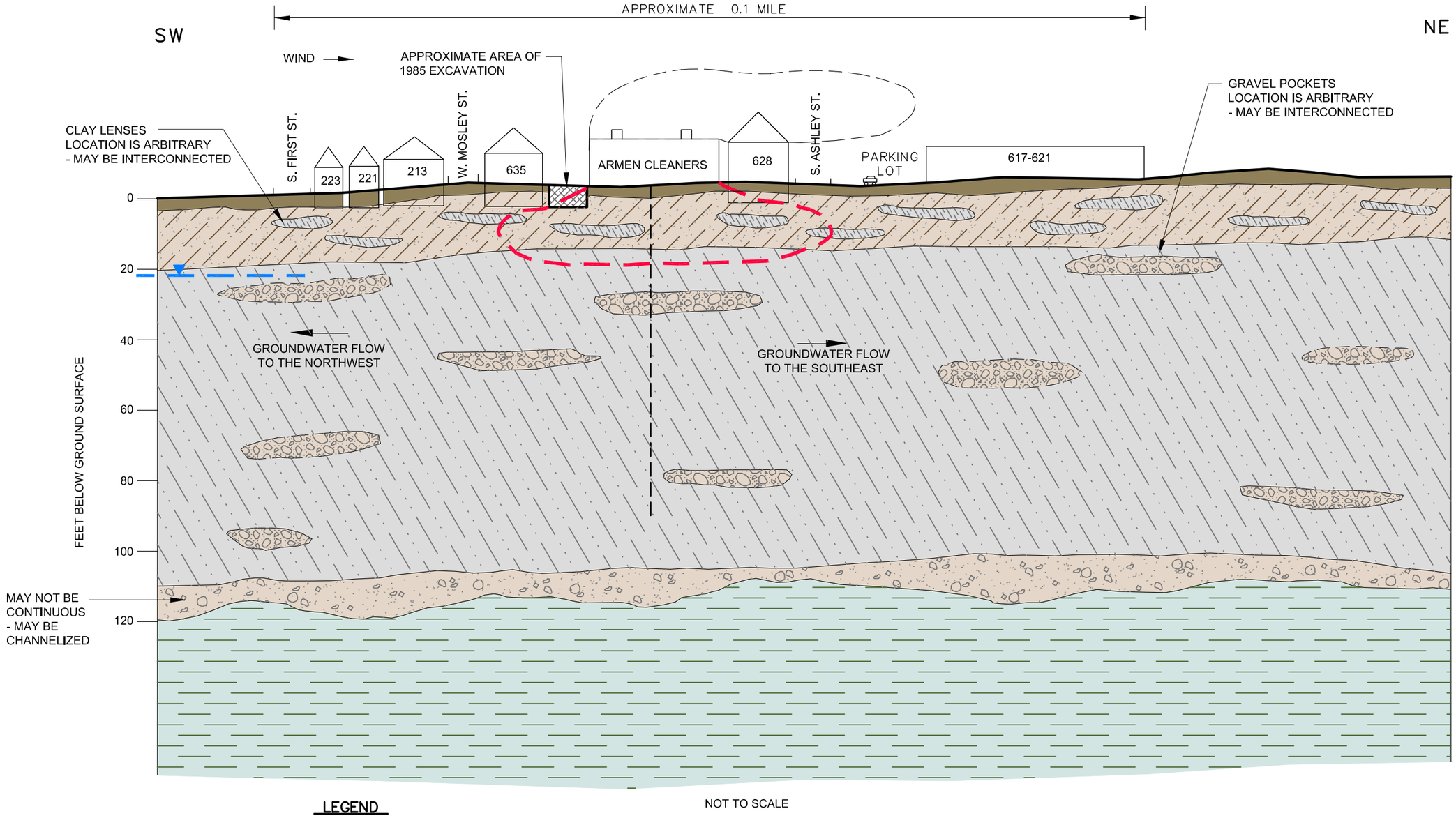


ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 25
TAGA MOBILE MONITORING PATH #2
ARMN022
JUNE 3, 2003

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TECHNOLOGY SUPPORT CENTER

2006-08-11 o:\armen\projects\figures\Armen_TagaPath2.mxd TtEMI-DN kurt.cholak



LEGEND

- AMBIENT AIR PLUME BOUNDARY
- SOIL GAS PLUME BOUNDARY
- APPROXIMATE POSITION OF GROUNDWATER DIVIDE
- WATER TABLE
- FILL
- SOIL ZONE
- SILTY SAND
- CLAY/SILT
- SANDS AND GRAVEL
- COLDWATER SHALE

NOTE: GROUNDWATER TABLE, FLOW, AND DIVIDE LOCATION BASED ON DLZ DRAFT SUPPLEMENTAL INVESTIGATION REPORT, JULY 2002

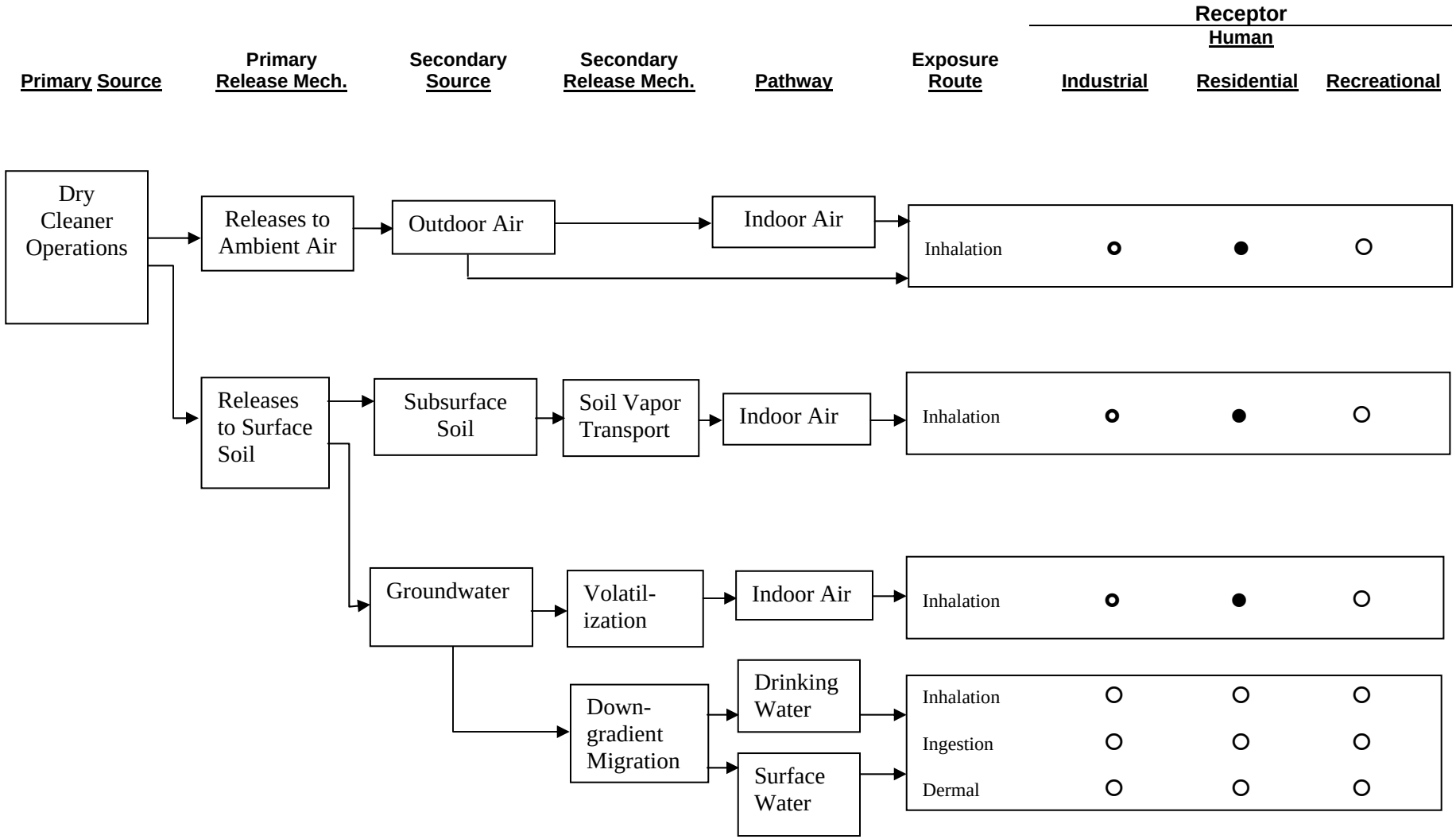
ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 26

INTERPRETIVE CONCEPTUAL SITE MODEL AND GEOLOGIC CROSS-SECTION FOR THE ARMEN CLEANERS SITE

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TRIAD SUPPORT CENTER

R:\EPA\Armen Cleaners\G9015.3.046.02.01\ Fig 26 _Armen CSM Cross Section.dwg 08/07/2006 deborah.ford DN



ARMEN CLEANERS
ANN ARBOR, MICHIGAN

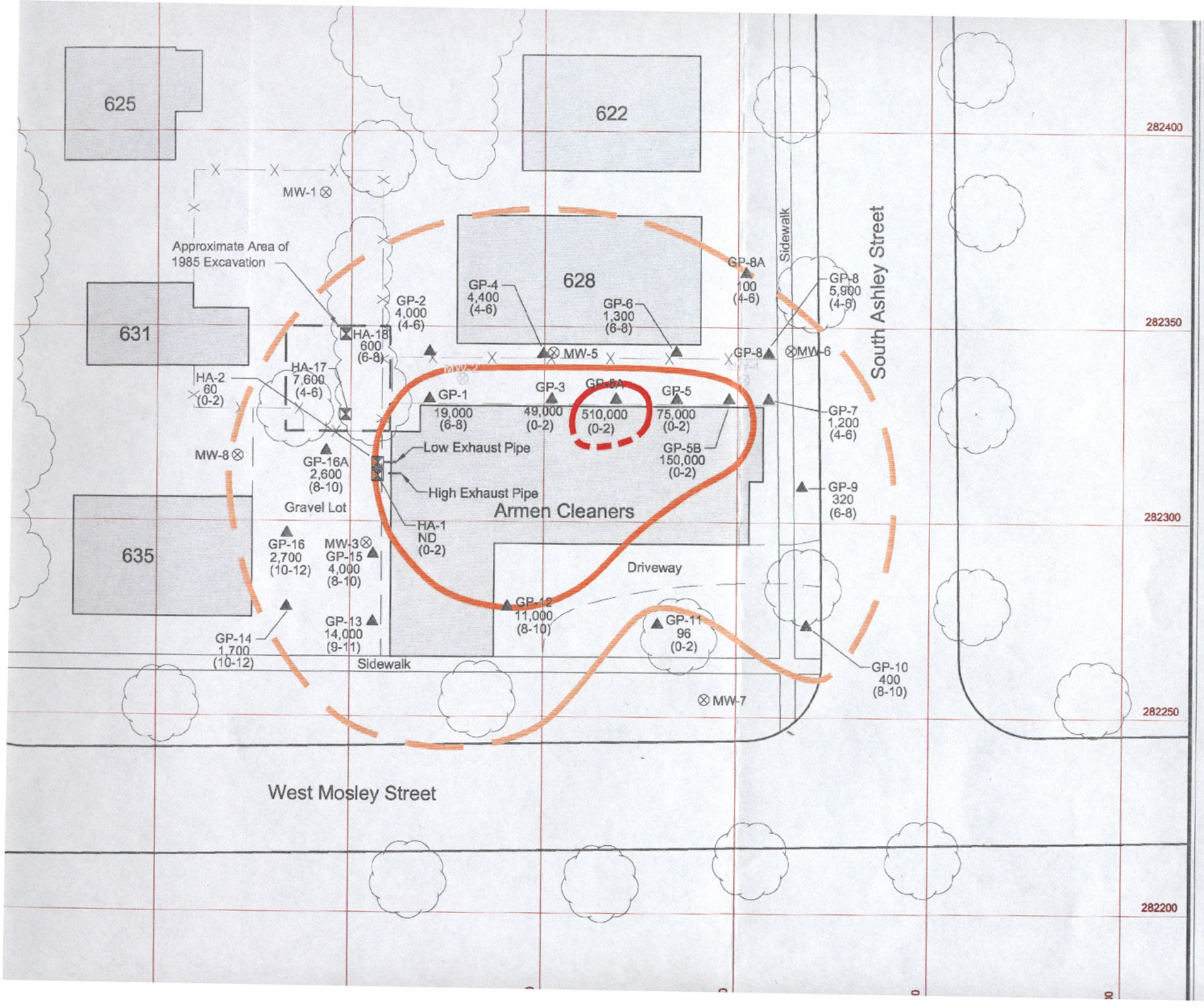
FIGURE 27

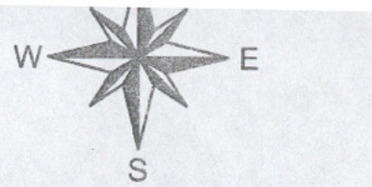
PATHWAY RECEPTOR DIAGRAM
CONCEPTUAL MODEL

U.S. EPA REGION V
IN COOPERATION WITH SUPERFUND
TRIAD SUPPORT CENTER

ENCLOSURE A

SELECTED DATA SUMMARY MAPS
FROM THE REMEDIAL AND SUPPLEMENTAL INVESTIGATIONS





LEGEND

- Tree Line
- Fence
- Monitoring Well
- Railroad Ties
- Abandoned Monitoring Well
- Driveway
- Geoprobe Boring
- Hand Auger Location
- Existing Structure
- 510,000 Highest PCE Concentrations From Location (ug/Kg)
- (0-2) Depth Interval of Highest PCE Concentration
- Exceeds Drinking Water Protection (DWP) Criterion (100 ug/Kg)
- Exceeds Soil Volatilization (SVII) Criterion (11,000 ug/Kg)
- Exceeds Direct Protection (DC) Criterion (88,000 ug/Kg)
  Groundwater Contact Protection (GCP) Criterion (88,000 ug/Kg)
  Soil Satuation Concentration (Csat) Screening Level (88,000 ug/Kg)
  Infinite Source Volatile Soil Inhalation (VSIC) Criterion (1.8 E5 ug/Kg)
  Finite source Volatile Soil Inhalation (VSIC) Criterion (4.8 E5 ug/Kg)

NOTE: PCE Concentrations based on laboratory analysis only.
Lines Dashed Where Inferred

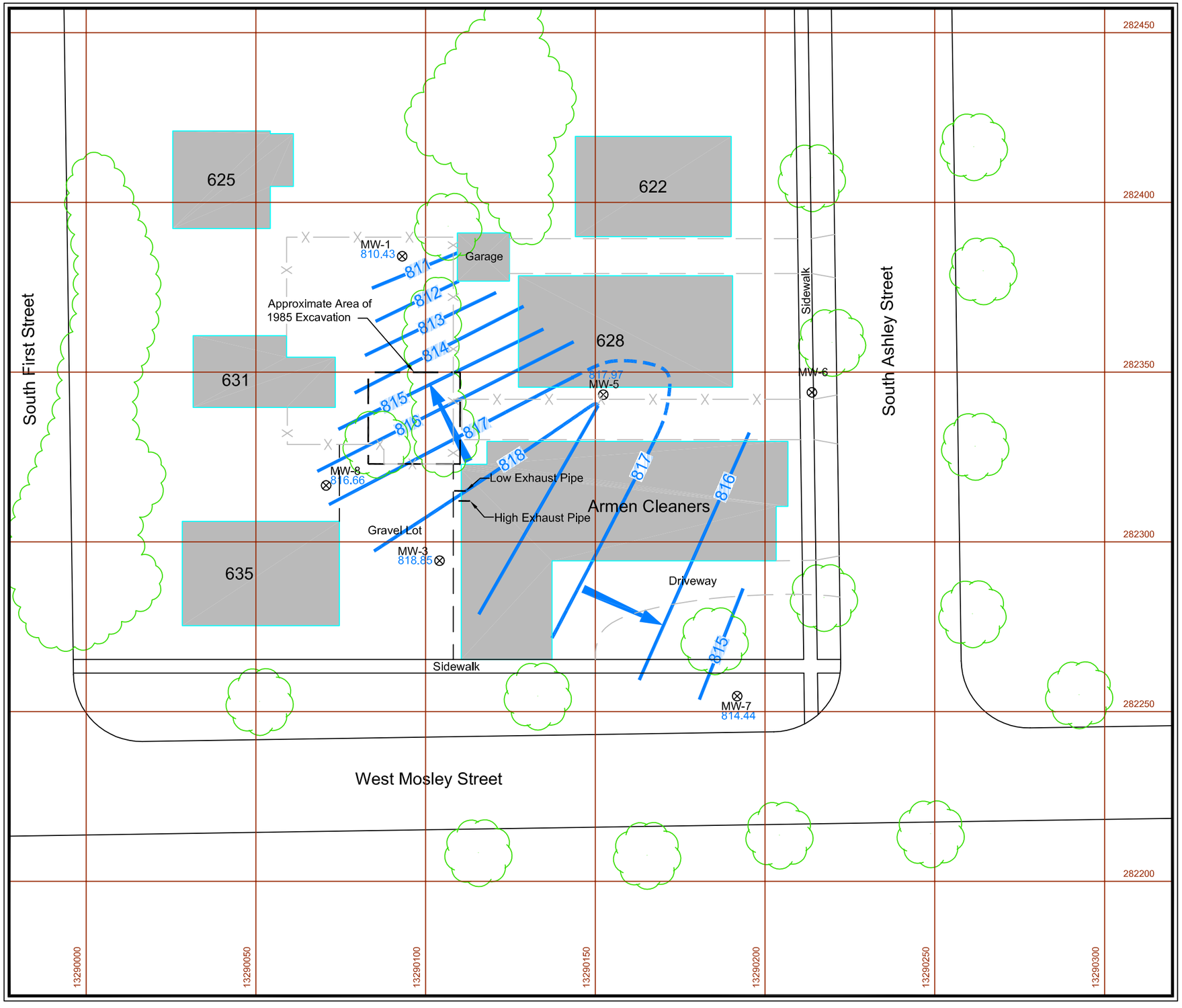
Sources:

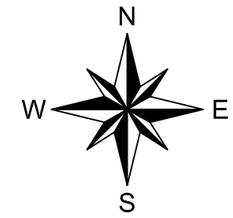
USGS 7.5 Minute Topographic Map
Aerial Photography (1999)
MIRIS Base Map
Grid Based on NAD83 Michigan State Plane,
South Zone

Extent of PCE in Soils
Residential Criteria

Armen Cleaners
Ann Arbor, Michigan

DLZ





GRAPHIC SCALE

15 0 7.5 15 30 60

(IN FEET)

LEGEND

- Monitoring Well
- Tree Line
- Existing Structure
- Fence
- Railroad Ties
- Driveway
- Groundwater Contours
- Groundwater Flow Direction
- 814.44 Groundwater Elevation Above Mean Sea Level

Sources:

USGS 7.5 Minute Topographic Map

Aerial Photography (1999)

MIRIS Base Map

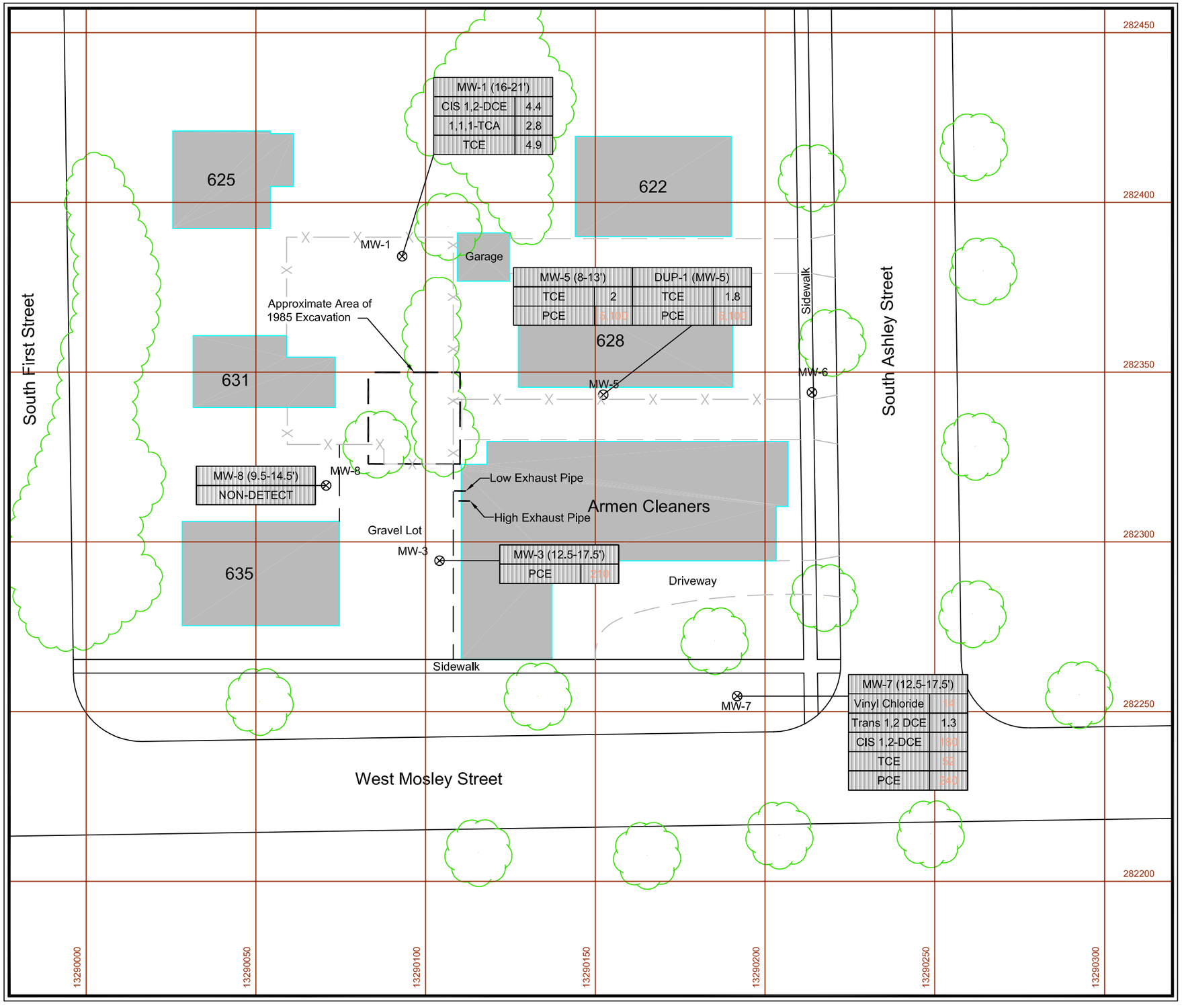
Grid Based on NAD83 Michigan State Plane, South Zone

Groundwater Flow Map
July 1, 2002 Data

Armen Cleaners
Ann Arbor, Michigan

DLZ
ENGINEERS - ARCHITECTS - SCIENTISTS
PLANNERS - SURVEYORS

Figure 2



N

W E

S

GRAPHIC SCALE

15 0 7.5 15 30 60

(IN FEET)

LEGEND

- Monitoring Well
- Tree Line
- Existing Structure
- Fence
- Railroad Ties
- Driveway
- 5,100 Indicates Exceedence of Residential Drinking Water Criteria (5 ug/L)

Sources:

USGS 7.5 Minute Topographic Map

Aerial Photography (1999)

MIRIS Base Map

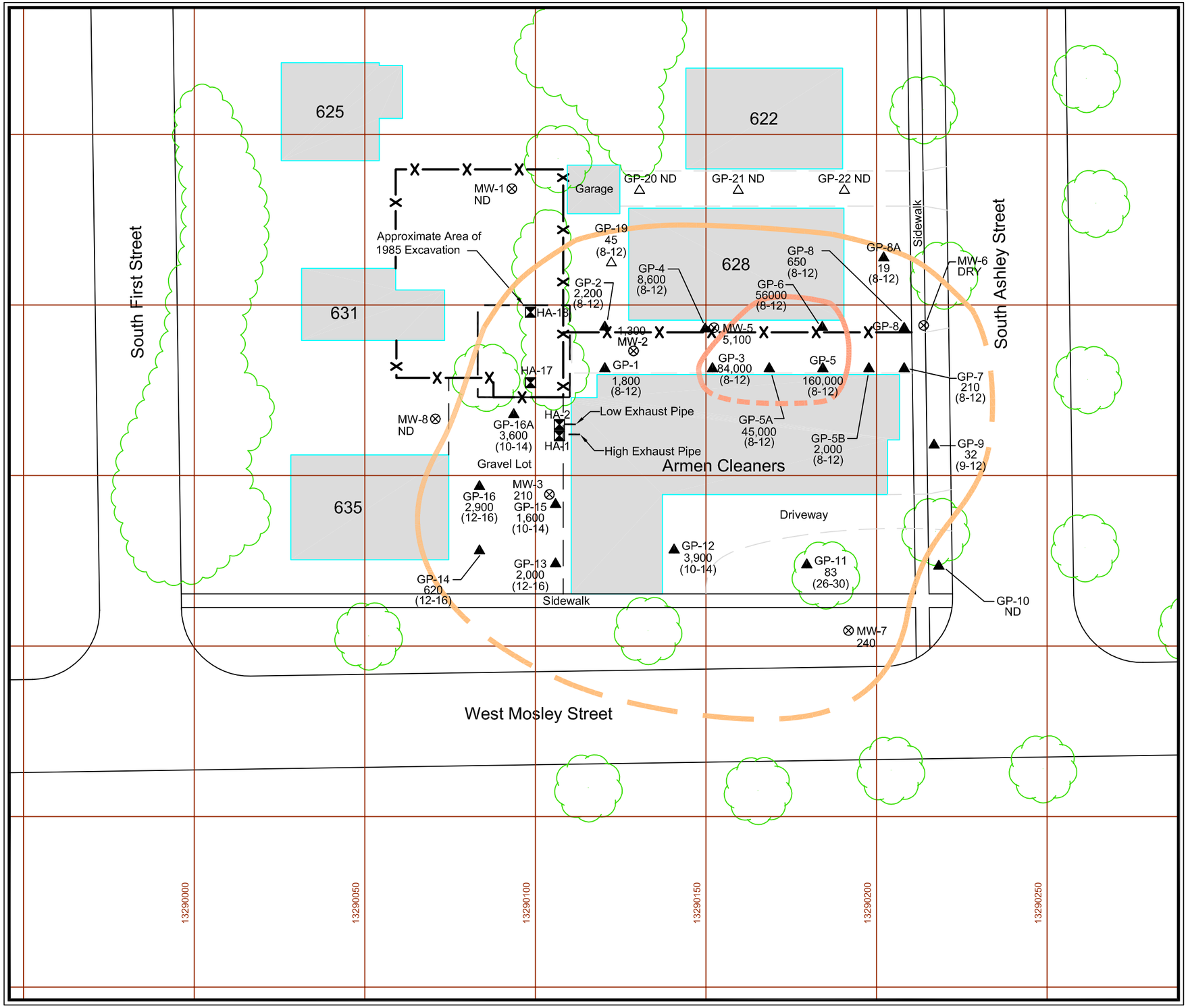
Grid Based on NAD83 Michigan State Plane, South Zone

VOCs in Groundwater Concentration Map (ug/L) July 1, 2002 Data

Armen Cleaners
Ann Arbor, Michigan

DLZ
ENGINEERS - ARCHITECTS - SCIENTISTS
PLANNERS - SURVEYORS

Figure 3



N

W E

S

GRAPHIC SCALE

15 0 7.5 15 30 60

(IN FEET)

LEGEND

- Tree Line
- Fence
- Monitoring Well
- Railroad Ties
- Geoprobe Boring (2000)
- Driveway
- Geoprobe Boring (2001)
- Hand Auger Location (2000)
- Existing Structure
- 56,000 Highest PCE Concentration From Boring Location (ug/L)
- (0-2) Depth Interval of Highest PCE Concentration
- Exceeds Drinking Water (DW) Criterion (5 ug/L)
- Exceeds Groundwater Volatilization to Indoor Air Inhalation (GVII) criterion (25,000 ug/L)
  Groundwater Contact (GC) Criterion (12,000 ug/L)

NOTE: PCE Concentrations based on laboratory analysis only.
Lines Dashed Where Inferred

Current and Historical Analytical Results Were Used to Estimate The Extent of Vocs Impacting The Groundwater.

July 1, 2002 Monitoring Well Data Depicted.

Sources:

USGS 7.5 Minute Topographic Map
Aerial Photography (1999)
MIRIS Base Map
Grid Based on NAD83 Michigan State Plane, South Zone

Extent of PCE in Groundwater Residential Criteria July 2002

Armen Cleaners
Ann Arbor, Michigan

DLZ
ENGINEERS - ARCHITECTS - SCIENTISTS
PLANNERS - SURVEYORS

Figure 4

ENCLOSURE B

WELL AND BORING LOG DATA FOR THE ANN ARBOR AREA

Well logs in Washtenaw County

WaAa, 27-3. Alt. 900.

	thickness ft.	depth ft.
Clay	21	21
Yellow sand	50	71
Sandy hardpan	21	92
Blue clay	54	146
Soft sand	21	167
WB sand	19	186

WaAa, 27-4a. Alt. 761.

	thickness ft.	depth ft.
Gray sand, gravel & boulders	1	1
Compact gray sand & gravel with clay	4	5
Hard gray clay, sandy	3	8
Compact fine sand, some clay & gravel	10	18
Compact gray sand & gravel, some clay	4	22
Hard gray clay, some sand & gravel lenses	1	23
Compact fine sand	4	27

WaAa, 28-1. Alt. 880.

	thickness ft.	depth ft.
Soil, fine sand	45	45
Gravel, 10' large boulders at 80'	45	90
Bluish clay, large boulders at 113'	145	235
Bluish shales	30	265
Red shale	15	280

WaAa, 28-2. Alt. 880.

	thickness ft.	depth ft.
Coarse gravel & boulders	100	100
Sandy clay	48	148
Sand & gravel	17	165

WaAa, 29-1. Alt. 822.

	thickness ft.	depth ft.
Soil	10	10
Sand	10	20
Clay	90	110
Water, sand & gravel	10	120
Shale	55	175

WaAa, 29-5. Alt. 863.

	thickness ft.	depth ft.
Gravelly clay	70	70
Clay	50	120
WB sand	2	122
Clay, gravelly at top	56	178
Coldwater shale	197	375
Berea sandstone	70	445
Antrim shale	30	475

WaAa, 29-6. Alt. 836.

	thickness ft.	depth ft.
Gravel	29	29
Blue clay	2	31
Gravel	3	34

WaAa, 30-1. Alt. 900.

	thickness ft.	depth ft.
Gravel & clay	20	20
Clay	62	82
Fine sand	8	90
Good coarse sand & gravel	7	97
Fine sand	18	115
WB gravel	5	120
Fine dark sand	3	123
Yellow sand	7	130
Coarse yellow sand & gravel	20	150
Clay	50	200

WaAa, 30-2. Alt. 893.

	thickness ft.	depth ft.
Red clay	20	20
Blue clay	18	38
Sandy hardpan	10	48
Dry coarse sand	10	58

fishbeck, thompson, carr & huber
engineers • scientists • architects

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Lansing (517) 627-1141
Kalamazoo (616) 349-3717
Farmington Hills (248) 324-2090

BOREHOLE LOG

BORING/WELL ID: West Park 73
TOTAL DEPTH (ft.): 101'

PROJECT: Pall Life Sciences
SITE LOCATION: Ann Arbor, Michigan
PROJECT NO.: F96502
PROJECT MANAGER: James W. Brode, Jr., C.P.G.
LOGGED BY: Todd Campbell

START DATE: 2-18-02
END DATE: 2-27-02
TOC ELEV.: NA
GROUND ELEV.: Approx. 800'amsl
STATIC WATER LVL.: Approx.15'

DRILLING CO.: Stearns Drilling
DRILLER: Dennis, Rich, Denny, John
RIG TYPE: CME 95/CME 1050
METHOD OF DRILLING: Hollow Stem Auger
SAMPLING METHODS: Split Spoon, Simulprobe

NOTES: Approximately 31' North, 8' West of Northwest corner of bld.
Field GPS Coordinates (Lat. N42.28347, Long. W083.75445)

▼ Static Water Level

DESCRIPTION	PID ppm	GRAPHIC LOG	DEPTH (ft. bgl)	Static Water Level	Sample/ Revovery	Sample ID	Blows Counts	WELL CONSTRUCTION DETAIL
TOPSOIL: Topsoil, Dark Brown			0					Boring Over drilled from 0-40' with 6 1/4" Augers then seated with Neat Cement (Portland Cement/Bentonite)
SILTY SAND: Silty Sand, Brown, moist			2					
			4					
			6					
			8					
SAND: Sand, fine to medium grained (100%). Brown, well sorted, medium dense, moist to wet			10		1.5'		2,4,7,8	
			12					
			14	▼				
			16					
			18					Neat Cement (Portland Cement/Bentonite)
Sand, medium to fine grained (100%). Brown, well sorted, very loose, wet			20		2'		2,2,2,2	
			22					Simulprobe Water sample from 23-23.5' (<1ug/L)
DIAMICTON: Clay matrix with Silt and trace fine grained Sand. Grayish brown, soft, moist			24					
			26					
			28					
			30		1'		1,2,2,2	
			32					
			34					
			36					
			38					
Silt (80-90%); Clay (10-20%); trace fine grained Sand. Gray, very dense, moist to dry			40		0.8'		25,31,50	
			42					
			44					
			46					
			48					
Silty Clay with trace fine Gravel and fine Sand. Gray, medium dense, dry to slightly moist			50		1.5'		9,11,17,23	Portland Cement
			52					
			54					
			56					

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BOREHOLE LOG

BORING/WELL ID: West Park 73

TOTAL DEPTH (ft.): 101'

PROJECT: Pall Life Sciences
SITE LOCATION: Ann Arbor, Michigan
PROJECT NO.: F96502
PROJECT MANAGER: James W. Brode, Jr., C.P.G.
LOGGED BY: Todd Campbell

START DATE: 2-18-02
END DATE: 2-27-02
TOC ELEV.: NA
GROUND ELEV.: Approx. 800'amsl
STATIC WATER LVL.: Approx. 15'

DRILLING CO.: Stearns Drilling
DRILLER: Dennis, Rich, Denny, John
RIG TYPE: CME 95/CME 1050
METHOD OF DRILLING: Hollow Stem Auger
SAMPLING METHODS: Split Spoon, Simulprobe

NOTES: Approximately 31' North, 8' West of Northwest corner of bld.
Field GPS Coordinates (Lat. N42.28347, Long. W083.75445)

▼ Static Water Level

DESCRIPTION	PID ppm	GRAPHIC LOG	DEPTH (ft. bgl)	Static Water Level	Sample/ Revovery	Sample ID	Blows Counts	WELL CONSTRUCTION DETAIL
SAND: Sand, coarse to fine grained (100%). Brown, well sorted, medium dense, wet. Silty at 60.8'			60		2'		6,16,12,15	
DIAMICTON: Silt (60-70%); Sand, fine grained (20-30%); fine Gravel (10%); trace Clay. Grayish brown, very dense, dry			70		1.2'		9,14,25,34	
As above with approximately 15% fine Gravel. Grayish brown, very dense, dry			80		1.1'		23,26,30, 32	
Silt (80%); Clay (15%); Gravel, fine (15%); Sand, fine grained (10%). Grayish brown, very dense, dry			90		2'		11,34,43, 35	
SAND AND GRAVEL: Sand, coarse to fine grained (40%); Gravel, fine grained (40%); Silt (20%). Grayish brown, wet (Boring terminated and plugged due to flowing artesian conditions).			100		1'		NA	Water flowing out top of augers sampled (<1 ug/L)

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Grand Rapids (616) 575-3824
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Kalamazoo (269) 375-3824
Farmington Hills (248) 324-2090

BOREHOLE LOG

BORING/WELL ID: MW-102d

TOTAL DEPTH (ft.): ~~173'~~

PROJECT: Pall Life Sciences Inc.	**START DATE:** 2-16-06	**DRILLING CO.:** Stearns Drilling
SITE LOCATION: Ann Arbor, Michigan	**END DATE:** 2-23-06	**DRILLER:** Dennis/John, Jerry
PROJECT NO.: P96502	**TOC ELEV.:** 843.62'	**RIG TYPE:** CME 95
PROJECT MANAGER: James W. Brode, Jr., C.P.G.	**GROUND ELEV.:** App. 844' AMSL	**METHOD OF DRILLING:** Hollow Stem Auger
LOGGED BY: Todd Campbell, C.P.G.	**STATIC WATER LVL.:** 46.60'	**SAMPLING METHODS:** Split Spoon, Simulprobe

NOTES: City Hall, Northwest Portion of Property in Grass Area
Field GPS Coordinates (N42.28211, W083.74586), Acc. 20'. PLS-06-06 boring.

▼ Static Water Level

DESCRIPTION	PID ppm	GRAPHIC LOG	DEPTH (ft. bgl)	Static Water Level	Sample/ Recovery	Sample ID	Blow Counts	WELL CONSTRUCTION DETAIL
TOPSOIL FILL: Sand, medium to fine grained; Gravel, fine; Silt; Clay. Brown, dry			0					#6 Sand Pack
SAND AND GRAVEL Cobble or possible Concrete slab (Rock in Shoe)			10		0.1'		8,13,13,14	2" Galvanized Steel Well Casing Bentonite Grout
Sand, medium to fine grained (60%); Gravel, fine (40%). Brown, moderately sorted, dense, dry			20		1.2'		11,28,20, 12	
Sand, coarse to fine grained (80%); Gravel, fine (20%). Brown, moderately sorted, medium dense, dry			30		1.5'		7,10,12,13	
DIAMICTON Silt; Clay; Gravel, fine (10%). Grayish brown, dry, hard			40		1.5'		14,19,30, 37	
As above with trace Clay			50		1.5'		15,43,75	
As above			60		1.6'		10,17,23, 26	
SAND: Driller notes Sand			70		0.8'		17,53,80	2" Galvanized Steel Well Casing
DIAMICTON: Silt; Clay; Gravel, fine (20%); trace Sand, fine grained. Grayish brown, dry, hard			72					Bentonite Grout
As above with trace Clay			80		1.7'		15,52,65	

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Farmington Hills (248) 324-2090

BOREHOLE LOG

BORING/WELL ID: MW-102d

TOTAL DEPTH (ft.): 173'

PROJECT: Pall Life Sciences Inc.
SITE LOCATION: Ann Arbor, Michigan
PROJECT NO.: P96502
PROJECT MANAGER: James W. Brode, Jr., C.P.G.
LOGGED BY: Todd Campbell, C.P.G.

START DATE: 2-16-06
END DATE: 2-23-06
TOC ELEV.: 843.62'
GROUND ELEV.: App. 844' AMSL
STATIC WATER LVL.: 46.60'

DRILLING CO.: Stearns Drilling
DRILLER: Dennis/John, Jerry
RIG TYPE: CME 95
METHOD OF DRILLING: Hollow Stem Auger
SAMPLING METHODS: Split Spoon, Simulprobe

NOTES: City Hall, Northwest Portion of Property in Grass Area
Field GPS Coordinates (N42.28211, W083.74586), Acc. 20'. PLS-06-06 boring.

▼ Static Water Level

DESCRIPTION	PID ppm	GRAPHIC LOG	DEPTH (ft. bgl)	Static Water Level	Sample/ Recovery	Sample ID	Blow Counts	WELL CONSTRUCTION DETAIL
As above			88					
			90		1.5'		33,40,35	
			92					
SILTY SAND			94					
Sand, fine to medium grained; Silt (30-40%); Gravel, fine. Grayish brown, very dense, moist			96					
			98					
			100		1.5'		23,53,62	
DIAMICTON: Driller notes Clay and Gravel			102					
			104					
SAND: Sand, medium to fine grained; trace Gravel, fine. Grayish brown, moderately sorted, very dense, wet			106					
			108					
			110		1.8'	PLS-06-06 (110'-111.5')	3,6,9,20	Simulprobe sample 110-111.5' (<1 ug/L)
Cobbles throughout			112					
			114					2" Galvanized Steel Well Casing
			116					Bentonite Grout
			118					
			120		1.5'	PLS-06-06 (120'-121.5')	15,19,40	Simulprobe sample 120-121.5' (<1 ug/L)
			122					
			124					
			126					
DIAMICTON			128					
			130		0.5'		45,100 (3")	
Silt; Sand, fine to medium grained (20-30%); Gravel, fine (10%). Grayish brown, hard, dry			132					
			134					
			136					
			138					
			140		0.5'		120	
Silt; Clay; Sand, fine grained (20%); trace Gravel, fine. Grayish brown, hard, dry			142					
			144					
			146					
			148					
6 inch Sand and Gravel seam			150		0'		55,100 (4")	#6 Sand Pack
			152					
SAND AND GRAVEL: Cobbles throughout			154					2" Stainless Steel Screen (10 Slot). Screened from 158 to 163 feet below ground surface
			156					
			158					
			160		0.5'	PLS-06-06 (160'-161.5')	18,140	Simulprobe sample 160-161.5' (<1 ug/L)
Sand, fine to coarse grained; Gravel, fine; Silt (20-30%); Cobbles. Grayish brown, very dense, wet			162					
			164					
			166					
Cobbles throughout			168					
			170		0.5'		34,150	
SHALE: Shale, weathered, platy. Gray to bluish gray, hard, dry			172					

2 GEOLOGICAL SURVEY SAMPLE No.

JUL 09 1980

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

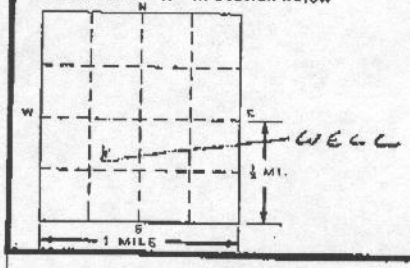
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
WASHTENAW	ANN ARBOR	¼ ¼ SW ¼	28	2S	6E W.

Distance And Direction from Road Intersections: 809 N. UNIVERSITY

Street address & City of Well Location: ANN ARBOR

Locate with "X" in section below — Sketch Map:



3 OWNER OF WELL: U of M

Address: ANN ARBOR MICH

4 WELL DEPTH: (completed) Date of Completion: 96 ft. 6-2-80

5 ☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ ____

6 USE: ☐ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☒ RESEARCH

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 89 ft. Depth; ____ in. to ____ ft. Depth

Height: Above/~~Below~~ Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☒ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
GRAVEL	93	93
CLAY	3	96

8 SCREEN: Type WW STAINLESS Dia. 3¾ Slot/Gauge 25 Length 4 Set between 89 ft. and 93 ft.

Fittings: PACKER, 3' BLANK

9 STATIC WATER LEVEL 80 ft. below land surface

10 PUMPING LEVEL below land surface 80 ft. after 2 hrs. pumping 12 g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts per Million: Iron (Fe) ____ Chlorides (Cl) ____ Hardness ____ Other ____

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☒ Pitless Adapter ☐ 12" Above Grade

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☒ Bentonite ☐ ____ Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination ____ feet ____ Direction ____ Type ____ Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not Installed Manufacturer's Name RED JACKET Model Number 20RW1-CL9BC HP ½ Volts 230 Length of Drop Pipe 84 ft. capacity 12 G.P.M. Type: ☒ Submersible ☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
*CORRECTED BY CB.
**ADDITION BY
ELEVATION
DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION: This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

CRISLEY DRILLING CO — REGISTERED BUSINESS NAME — 81-1586 REGISTRATION NO.

Address DEXTER MICH.

Signed Charles Crisley — AUTHORIZED REPRESENTATIVE — Date 6-6-80

D67d 100M (Rev. 12-88)

GEOLOGICAL SURVEY COPY

2 GEOLOGICAL SURVEY SAMPLE No.

JUL 09 1980

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

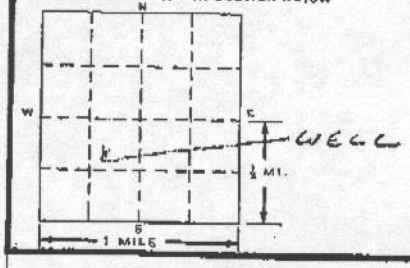
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
WASHTENAW	ANN ARBOR	¼ ¼ SW ¼	28	2 S.	6 W.

Distance And Direction from Road Intersections: 809 N. UNIVERSITY

Street address & City of Well Location: ANN ARBOR

Locate with "X" in section below — Sketch Map:



3 OWNER OF WELL: U of M

U of M WELL -1

Address: ANN ARBOR MICH

4 WELL DEPTH: (completed) **Date of Completion:** 96 ft. 6-9-80

5 ☐ Cable tool ☒ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ ____

6 USE: ☐ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☒ RESEARCH

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 89 ft. Depth; ____ in. to ____ ft. Depth

Height: Above/~~Below~~ Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes ☒ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
GRAVEL	93	93
CLAY	3	96

8 SCREEN: Type WW STAINLESS Dia.: 3¾ Slot/Gauge 25 Length 4 Set between 89 ft. and 93 ft.

Fittings: PACKER, 3' BLANK

9 STATIC WATER LEVEL 80 ft. below land surface

10 PUMPING LEVEL below land surface 80 ft. after 2 hrs. pumping 12 g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts per Million: Iron (Fe) ____ Chlorides (Cl) ____ Hardness ____ Other ____

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☒ Pitless Adapter ☐ 12" Above Grade

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☒ Bentonite ☐ ____ Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination ____ feet ____ Direction ____ Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not Installed

Manufacturer's Name RED JACKET

Model Number 20RW1-CLPBE HP ½ Volts 230

Length of Drop Pipe 84 ft. capacity 12 G.P.M.

Type: ☒ Submersible ☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

ADDED INFO BY DRILLER, ITEM NO.
CORRECTED BY CB.
**ADDITION BY
ELEVATION
DEPTH TO ROCK

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

CRISLEY DRILLING CO — REGISTERED BUSINESS NAME — 81-1586 REGISTRATION NO.

Address DEXTER MICH.

Signed Charles Crisley — AUTHORIZED REPRESENTATIVE — Date 6-6-80

D67d 100M (Rev. 12-88)

GEOLOGICAL SURVEY COPY

NORTH UNIVERSITY

GEOLOGICAL SURVEY NO.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH
WATER WELL AND PUMP RECORD

PERMIT NUMBER

1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
WASHTENAW	ANN ARBOR	SE ¼ SW ¼ NW ¼	28	2 S	6 E

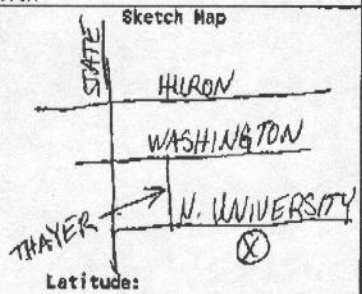
Distance And Direction From Road Intersection
CHEMISTRY BUILDING

NORTH UNIVERSITY
ANN ARBOR, MI 48104
Street Address & City of Well Location

Locate with "X" in Section Below

N / W / E / S
¼ MI.
1 MILE

Sketch Map



Latitude:
Longitude:

3 OWNER OF WELL
UNIVERSITY OF MICHIGAN
Address
U of M WELL -2
Address Same As Well Location?

4 WELL DEPTH: 178 FT. **Date Completed** 05/04/93 NEW WELL

5 DRILLING METHOD: ROTARY

6 USE: OTHER

7 CASING: PLASTIC
Diameter 5 " to 170 ft. depth
Diameter " to ft. depth
Height: ABOVE
Surface 1'
Weight SDR 21
Drive Shoe: NO

Grouted Drill Hole Diameter
8 " to 120 ft. depth
" to ft. depth

8 SCREEN:
Type STAINLESS Diameter 4 " Nominal
SLOT 20Y 25B Length 8 ft.
Set Between 170 ft. and 178 ft.
FITTINGS: K-PACKER Blank above screen 1 ft.

9 STATIC WATER LEVEL
80 ft. below land surface Flow: NO

10 PUMPING LEVEL: below land surface
80 ft. after 1 hrs. pumping at 20 G.P.M.
80 ft. after 2 hrs. pumping at 20 G.P.M.

11 WELL HEAD COMPLETION: PITLESS ADAPTOR

12 WELL GROUTED? YES
NEAT CEMENT From 0 to 120 ft.
27 bags of cement. Additives

13 Nearest source of contamination
Type SEWER Distance 50 ft Direction N
Well disinfected upon completion? YES
Was old well plugged? N/A

14 PUMP:
Manufacturers name RED JACKET
Model number 15DCN4-CN11CC HP 1 1/2 VOLTS 230V
Length of Drop Pipe 125 ft. capacity 18 G.P.M.
Type SUBMERSIBLE
PRESSURE TANK:
Manufacturers Name AMTROL
Model Number WX251 Capacity 19.2 Gallons

2 FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SANDY BROWN CLAY	30	30
GRAVEL	60	90
GRAY CLAY	27	117
FINE SAND	37	154
MEDIUM SAND	10	164
MEDIUM GRAVEL	14	178

RECEIVED
JUN -5 '95
LOCAL DEPT. OF PUBLIC HEALTH
BUREAU OF ENVIRONMENTAL AND OCCUPATIONAL HEALTH

RECEIVED
MAY 12 1995
ENV. HEALTH

MS31292
PS31292
WELLS AWC 5-2 1 1/2" PVC

15. Remarks, elevation, source of data, etc.
FOR LAB USE ONLY

17. Rig Operator's Name:
LARRY CLARK

16. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Cribley Drilling Co., Inc. 81-0524
REGISTERED BUSINESS NAME REGISTRATION NO.

Address 8300 Dexter Chelsea Rd, Dexter, MI 48130

Signed AUTHORIZED REPRESENTATIVE Date 6-24-93

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a misdemeanor.

D67d 2/89 CDCW10699P13333 05/04/93

IMPORTANT: File with deed.

4 HAN 05-15-95

Elevation = 880

ENCLOSURE C

CROSS SECTIONS DERIVED FROM MIP LOGS


ACMB-114
ACMB-115
ACMB-116
ACMB-118
ACMB-106
CMB-107
CMB-109
CMB-117
CMB-108
CMB-111
CMB-101
CMB-102
CMB-097
CMB-103
CMB-092
CMB-095
CMB-096
CMB-093
CMB-094
CMB-086
CMB-088
CMB-083
CMB-087
CMB-075
CMB-078
CMB-077
CMB-076
CMB-079
CMB-074
CMB-069
CMB-070
CMB-113
CMB-067
CMB-053
CMB-056
CMB-057
CMB-112
CMB-054
CMB-055
CMB-058
CMB-044
CMB-045
CMB-042
CMB-046
CMB-047
CMB-041
CMB-043
CMB-030
CMB-031
CMB-032
CMB-033
CMB-034
CMB-036
CMB-035
CMB-029
CMB-037
CMB-022
CMB-023
CMB-025
CMB-024
CMB-013
A
A'
B
B'
C
C'
D
D'
E
E'
F
F'
G
G'
H
H'
I
I'
J
J'
K
K'
L
L'

A

A'

ACMB-22

ACMB-23

ACMB-24

ACMB-25

Clay

Silty Sand

Clay

Clay

Clay

Silty Sand

5 ft. bgs

10 ft. bgs

15 ft. bgs

20 ft. bgs

Silty Sand

Clay

Silty Sand

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 3'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 1-2
CROSS-SECTION A-A'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\G9015.3.046.02.01\Cross Sections\ A-A'_CS.dwg 08/11/2006 deborah.ford DN

B

B'

ACMB-29

ACMB-31

ACMB-32

ACMB-33

ACMB-34

ACMB-35

ACMB-36

5 ft. bgs

10 ft. bgs

15 ft. bgs

20 ft. bgs

Clay

Silty Sand

Clay

Clay

Silty Sand

Clay

Clay

Silty Sand

Clay

Silty Sand

Clay

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 5'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 2-3
CROSS-SECTION B-B'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\09015.3.046.02.01\Cross Sections\ B-B'_CS.dwg 08/14/2006 deborah.ford DN

C

C'

ACMB-41

ACMB-30

ACMB-43

ACMB-46A

ACMB-47

Clay

5 ft. bgs

10 ft. bgs

15 ft. bgs

Silty Sand

Silty Sand

Plume

Clay

Silty Sand

Clay

20 ft. bgs

25 ft. bgs

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 4'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 3-2
CROSS-SECTION C-C'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\G9015.3.046.02.01\Cross Sections\ C-C'_CS.dwg 08/11/2006 deborah.ford DN

D

D'

ACMB-53

ACMB-54

ACMB-55

ACMB-56

ACMB-57

ACMB-112

Clay

5 ft. bgs

10 ft. bgs

Silty Sand

15 ft. bgs

20 ft. bgs

Clay

Clay

Silty Sand

Silty Sand

Clay

Silty Sand

25 ft. bgs

30 ft. bgs

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 5'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 4-3
CROSS-SECTION D-D'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\09015.3.046.02.01\Cross Sections\ D-D'_CS.dwg 08/11/2006 deborah.ford DN

E

E'

ACMB-75

ACMB-76

ACMB-77

ACMB-78

ACMB-79

Clay

5 ft. bgs

10 ft. bgs

Clay

15 ft. bgs

Silty Sand

Clay

20 ft. bgs

Clay

Clay

25 ft. bgs

30 ft. bgs

35 ft. bgs

40 ft. bgs

Clay

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 5'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 5-1
CROSS-SECTION E-E'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\09015.3.046.02.01\Cross Sections\ E-E'_CS.dwg 08/14/2006 deborah.ford DN

F

F'

ACMB-92

ACMB-93

ACMB-103

ACMB-95

ACMB-96

ACMB-97

Clay

Clay

Clay

Clay

Clay

5 ft. bgs

10 ft. bgs

15 ft. bgs

Sitly Sand

Silty Sand

Sitly Sand

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 5'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 6-1

CROSS-SECTION F-F'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\G9015.3.046.02.01\Cross Sections\ F-F'_CS.dwg 08/11/2006 deborah.ford DN

G

G'

ACMB-111

ACMB-97

ACMB-79

ACMB-112

ACMB-47

ACMB-36

ACMB-25

5 ft. bgs

10 ft. bgs

15 ft. bgs

Clay

Clay

Clay

Clay

Clay

Silty Sand

Silty Sand

VERTICAL SCALE: 1" = 5'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 7-3
CROSS-SECTION G-G'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\09015.3.046.02.01\Cross Sections\ G-G'_CS.dwg 08/14/2006 deborah.ford DN

H

H'

ACMB-96

ACMB-88

ACMB-78

ACMB-70

ACMB-58

ACMB-46A

ACMB-35

ACMB-24

5 ft. bgs

10 ft. bgs

15 ft. bgs

20 ft. bgs

25 ft. bgs

30 ft. bgs

35 ft. bgs

40 ft. bgs

45 ft. bgs

50 ft. bgs

Clay

Clay

Clay

Silty Sand

Clay

Silty Sand

Clay

Silty Sand

Clay

Silty Sand

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 10'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 8-3
CROSS-SECTION H-H'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\G9015.3.046.02.01\Cross Sections\ H-H'_CS.dwg 08/11/2006 deborah.ford DN

I

I'

ACMB-95

ACMB-87

ACMB-77

ACMB-69

ACMB-56

ACMB-45

ACMB-23

5 ft. bgs

10 ft. bgs

15 ft. bgs

20 ft. bgs

25 ft. bgs

30 ft. bgs

Silty Sand

Clay

Silty Sand

Clay

Clay

Silty Sand

Clay

Silty Sand

Clay

Silty Sand

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 5'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 9-3
CROSS-SECTION I-I'

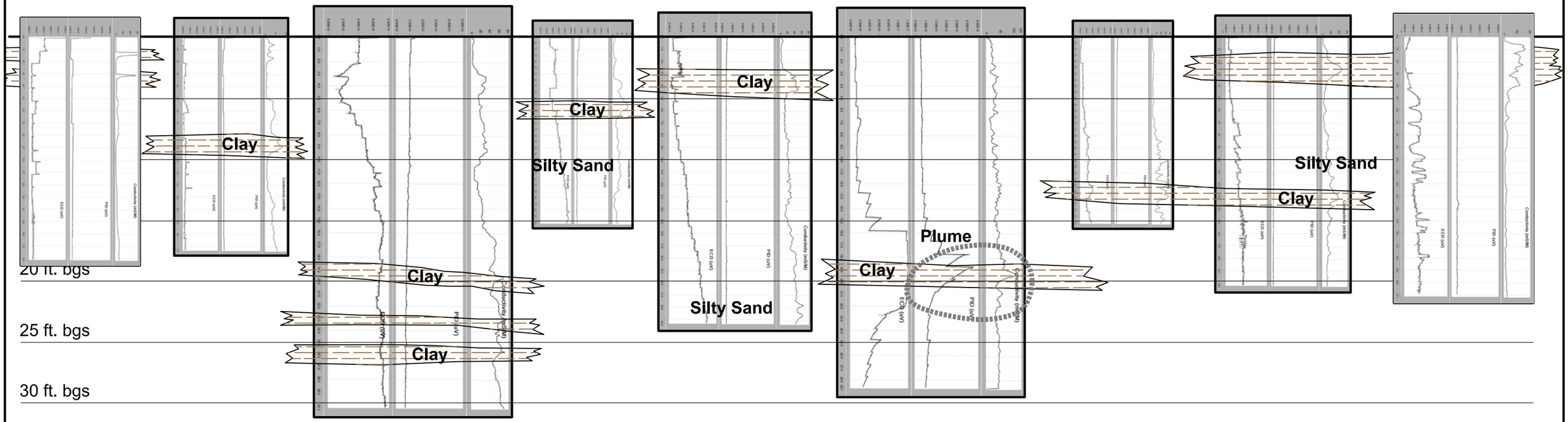
U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\G9015.3.046.02.01\Cross Sections\ I-I'_CS.dwg 08/11/2006 deborah.ford DN

J

J'

ACMB-103 | ACMB-94 | ACMB-76 | ACMB-67 | ACMB-55 | ACMB-43 | ACMB-32 | ACMB-22 | ACMB-13



VERTICAL SCALE: 1" = 8'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 10-3
CROSS-SECTION J-J'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\09015.3.046.02.01\Cross Sections\ J-J'_CS.dwg 08/14/2006 deborah.ford DN

K

K'

ACMB-108

ACMB-102

ACMB-93

ACMB-75

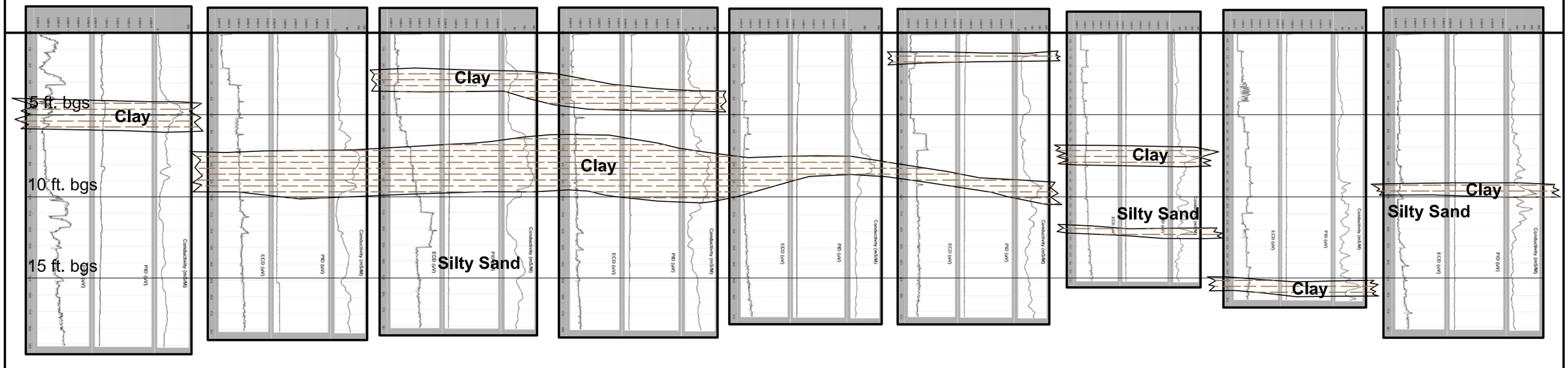
ACMB-74

ACMB-53

ACMB-42

ACMB-30

ACMB-31



VERTICAL SCALE: 1" = 6'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 11-3
CROSS-SECTION K-K'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\09015.3.046.02.01\Cross Sections\ K-K'_CS.dwg 08/14/2006 deborah.ford DN

L

L'

ACMB-29 | ACMB-42 | ACMB-54 | ACMB-67 | ACMB-77 | ACMB-87 | ACMB-88 | ACMB-96 | ACMB-97 | ACMB-117

5 ft. bgs

10 ft. bgs

15 ft. bgs

20 ft. bgs

25 ft. bgs

30 ft. bgs

35 ft. bgs

40 ft. bgs

Silty Sand

Silty Sand

Clay

Silty Sand

Clay

Silty Sand

Clay

Clay

Clay

Silty Sand

ECD (uV)

PID (uV)

Conductivity (mS/M)

VERTICAL SCALE: 1" = 8'

ARMEN CLEANERS
ANN ARBOR, MICHIGAN

FIGURE 12-3
CROSS-SECTION L-L'

U.S. EPA REGION V
IN COOPERATION WITH
SUPERFUND TECHNOLOGY SUPPORT CENTER

R:\EPA\Armen Cleaners\09015.3.046.02.01\Cross Sections\ L-L'_CS.dwg 08/11/2006 deborah.ford DN

ENCLOSURE D

DATA CD-ROM FOR
MDEQ AND EPA DATA COLLECTION ACTIVITIES
ARMEN CLEANERS SITE

6/22/2005

1. Copy the directory ArmenCleaners to your C drive
2. Install ArcExplorer according the pdf file called ArcExplorer\using_arcexplorer_java.pdf
3. Open the GIS project file called GIS_projects\Armen_cleaners_arcexplorer.axl