

Health Consultation

BELGRAVIA (FACTORY CONDOMINIUMS)

SOUTH HAVEN, VAN BUREN COUNTY, MICHIGAN

EPA FACILITY ID: MIR000100362

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

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An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

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HEALTH CONSULTATION

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SOUTH HAVEN, VAN BUREN COUNTY, MICHIGAN
EPA FACILITY ID: MIR000100362

Prepared By:

Michigan Department of Community Health
Under A Cooperative Agreement with the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Acronyms and Abbreviations

1,1-DCE	1,1-dichloroethylene (1,1-dichloroethene)
1,2-DCE	1,2-dichloroethylene (1,2-dichloroethylene, cis- and trans- isomers)
µg	microgram
AIAC	Acceptable Indoor Air Concentration
ASGSC	Acceptable Soil Gas Screening Concentration
Association	Factory Condominium Association
ATSDR	Agency for Toxic Substances and Disease Registry
bsg	below surface grade
DCC	Direct Contact Criteria
DNAPL	dense non-aqueous phase liquid
DWC	Drinking Water Criteria
DWPC	Drinking Water Protection Criteria
ERM	Environmental Resources Management
GCC	Groundwater Contact Criteria
GCPC	Groundwater Contact Protection Criteria
GRT	Global Remediation Technologies, Inc.
GSI	Groundwater Surface Water Interface Criteria
GSIPC	Groundwater Surface Water Interface Protection Criteria
GVIC	Groundwater Volatilization to Indoor Air Inhalation Criteria
IARC	International Agency for Research on Cancer
kg	kilogram
L	liter
m ³	cubic meter
mg	milligram
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
NAPL	non-aqueous phase liquid
PAH	polycyclic aromatic hydrocarbon
PCE	tetrachloroethylene (perchloroethylene)
PID	photoionization detector
PSIC	Particulate Soil Inhalation Criteria
PVC	polyvinyl chloride
RI	Remedial Investigation
SDBL	Statewide Default Soil Background Level
SVIC	Soil Volatilization to Indoor Air Inhalation Criteria
TCE	trichloroethylene (trichloroethene)
VSIC	Volatile Soil Inhalation Criteria

Summary

The Belgravia property is a former factory in South Haven, Van Buren County, Michigan, that has been developed into a fitness center and residential condominiums. Former businesses at the site disposed of their chemical waste to a septic tank, which discharged to a drain field and the sewer system. The primary chemicals of concern are trichloroethylene and its breakdown products. Other contaminants include petroleum hydrocarbons, polycyclic aromatic hydrocarbons, and metals. The soil and groundwater on site and at nearby off-site properties contain concentrations of chemicals above direct contact and inhalation screening levels. Some steps have been taken to prevent unacceptable indoor air exposures; however, there may still be a risk for vapor intrusion on-site. Additionally, workers conducting excavations may be exposed to unacceptable levels of chemicals in the soil and groundwater. “Free product” (visible liquid contamination) may be uncovered, causing an acute exposure hazard by direct contact or inhalation. The contamination in the soil may be impacting ambient air (which can affect indoor air concentrations), but there are insufficient air monitoring data to verify this. The site poses an indeterminate public health hazard: current conditions suggest excessive exposure is not occurring, but future conditions are not known and may be influenced by the proposed thermal remediation. Further investigation of soil gas and ambient air is necessary. Deed restrictions, worker education, or site remediation would prevent potentially harmful future exposures.

Purpose and Health Issues

The purpose of this document is to discuss the public health implications of the contamination and to provide recommendations protective of public health at the Belgravia site in South Haven, Van Buren County, Michigan. The Michigan Department of Environmental Quality (MDEQ) requested assistance from the Michigan Department of Community Health (MDCH) in assessing potential human health threats at the site.

The consultation considers both on-site contamination and off-site migration. The primary chemicals of concern are chlorinated solvents, specifically trichloroethylene (TCE) and its breakdown products. Discussion of metals and polycyclic aromatic hydrocarbons (PAHs) is also included.

MDCH conducted this health consultation for the federal Agency for Toxic Substances and Disease Registry (ATSDR) under a cooperative agreement. ATSDR conducts public health activities (assessments/consultations, advisories, education) at sites of environmental contamination and concern. ATSDR is primarily an advisory agency. Therefore, its reports usually identify what actions are appropriate to be undertaken by the regulatory agency overseeing the site, other responsible parties, or the research or education divisions of ATSDR. As such, ATSDR recommendations may not encompass all types of federal and state requirements from a regulatory perspective.

Background

The Belgravia site is a former factory built around 1916. The property consists of 2.14 acres of land with a brick building up to three stories high (Figure 1). The factory was used for various purposes, including pipe organ assembly, picture frame construction, wood working, and

**Figure 1. Belgravia (Factory Condominiums),
South Haven, Van Buren County, Michigan**



 Belgravia site



cyanide-based metal plating. The plating company filed for bankruptcy around 1979. A developer purchased the site in 1997 and converted the building into a fitness center and condominiums (Figure 2) (GRT 2006, Landmark 2006).

MDCH first became aware of the site in August 2005, when a local health department contacted the state agency with a citizen's health concerns. The citizen had read a newspaper article that discussed the contamination at the site, thought that she had been exposed to potentially hazardous substances, and wanted to know what medical testing she should undergo. (This question and MDCH's response are discussed further in the *Community Health Concerns* section of this document.) MDCH contacted MDEQ for more detailed information on the site and offered future public health assistance, if needed.

MDEQ subsequently requested that MDCH attend a community information meeting regarding the site and that the agency assess the public health implications associated with contaminants at the site. MDCH attended the community meeting on October 12, 2005, providing general information about chemical exposures and the health consultation process. Several attendees had specific questions, which are discussed in the *Community Health Concerns* section of this document.

On January 6, 2006, toxicologists from MDCH and MDEQ met with the MDEQ site manager, the developer, and the condominium association's consultant at the Belgravia site to gain a better understanding of site-related contamination issues.

Discussion

Environmental Contamination and Remedial Actions To-Date

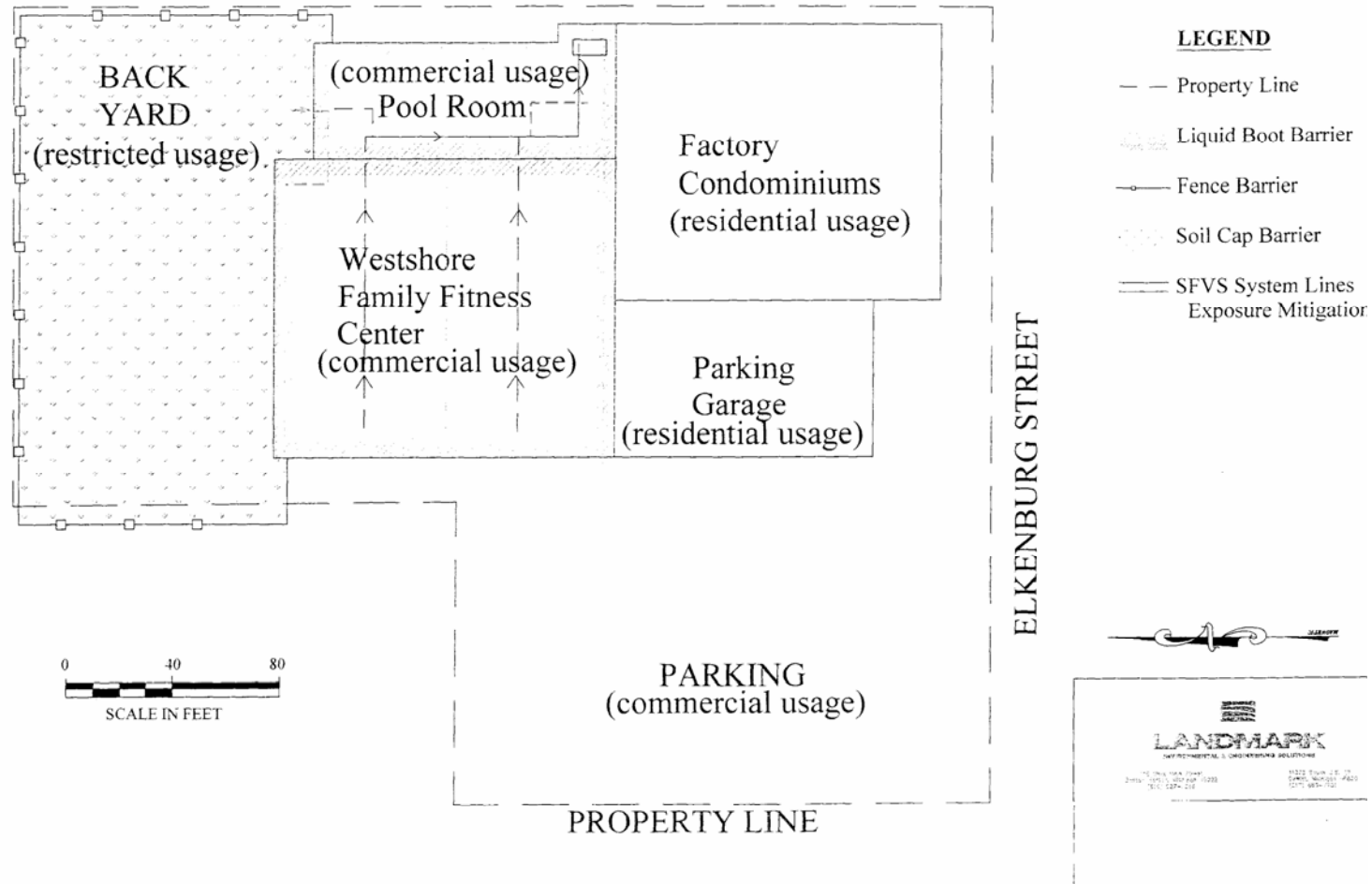
The following discussion focuses primarily on the data gathered in the 2005 Remedial Investigation (GRT 2006) and the 2002-2003 off-site investigation (Gannett Fleming 2003). These are the most up-to-date data for the site.

MDCH compared environmental data to the MDEQ Part 201 Cleanup Criteria, to screen for chemicals needing further evaluation. Those chemicals not exceeding their respective applicable criteria of interest were eliminated from further scrutiny. Note that this consultation, as stated under the *Purpose and Health Issues* section, is not to evaluate or confirm Part 201 compliance but to determine if any potentially harmful exposures are occurring or may occur in the future.

Screening Level Descriptions

The MDEQ **Statewide Default Soil Background Levels (SDBLs)** identify concentrations of inorganic chemicals (metals and cyanide) in soils that can be used to determine if on-site soils may have been impacted. Site-specific or regional background levels may be used instead of the SDBLs (MDEQ 2006c). Although the reports that MDCH used in its assessment of the Belgravia site compared detected chemicals to their respective SDBLs, these are not health-based numbers and were *not* used in this consultation.

**Figure 2. Belgrava site layout,
South Haven, Van Buren County,**



The **Drinking Water Criterion (DWC)** identifies a chemical's drinking water concentration that is safe for long-term (30 years), daily consumption (MDEQ 2004b). The **Drinking Water Protection Criterion (DWPC)** identifies a chemical's concentration in soil that will not leach to the groundwater and exceed the DWC (MDEQ 2005b). Although the Remedial Investigation (RI) at Belgravia compared soil data to the chemicals' DWCs and DWPCs, MDCH chose *not* to make this comparison because the residences and businesses are served by municipal water from Lake Michigan. Therefore, people would not be exposed to site-related contaminants via the drinking water.

The **Particulate Soil Inhalation Criterion (PSIC)** identifies a chemical's concentration in soil that, when airborne as particulate (dust) in ambient air, is not expected to cause adverse health effects via inhalation (MDEQ 2007a). Although the RI at Belgravia compared soil data to the chemicals' PSICs, MDCH chose *not* to make this comparison because particulate emissions from the soil are not expected at the site. The main chemicals of interest in this assessment are volatile, meaning they tend to vaporize into the air, and are less likely to enter air as particulates.

The C_{sat} criterion represents a theoretical threshold above which a contaminant may exist in free-phase or as "free product." It is a concentration in soil at which the solubility limits of the soil pore water, the vapor phase limits of the soil pore air, and the absorptive limits of the soil particles have been reached. At concentrations above C_{sat} , a liquid contaminant changes from an aqueous phase, where it is dissolved in water, to a non-aqueous phase liquid (NAPL), also called free-phase. As the free-phase contaminant displaces the air and water in the pore space (the spaces between the soil particles), "free product" forms. "Free product" is visible to the naked eye and is at least 1/8-inch of measurable thickness (MDEQ 2006c, 2007b; NREPA 1994). The generic C_{sat} concentrations derived by MDEQ do not account for the effects of multiple contaminants. Additionally, MDEQ does not allow the derivation of facility-specific C_{sat} values at sites where free-phase or "free product" is observed (MDEQ 2007b).

Some of the criteria discussed below are not applicable as generic criteria when chemical concentrations are at or above C_{sat} or when "free product" is present, which is the case at this site. MDCH chose to include these criteria for comparison so that the consultation can provide a general concept of the degree of contamination. The reader should understand that a "non-exceedance" in the tables does not necessarily indicate an absence of risk. Further discussion occurs in this and subsequent sections.

The **Direct Contact Criterion (DCC)** is a concentration of a chemical in soil that is protective against adverse health effects that could arise from long-term (30 years) incidental (unintentional) ingestion of (eating) and dermal (skin) exposure to contaminated soil. The Residential/Commercial I DCC is more restrictive than the values for other commercial or industrial uses (MDEQ 2005a). (For chemicals whose health-based DCC is greater than the C_{sat} value, the criterion reverts to the C_{sat} value [MDEQ 2007b].) There is limited open space at Belgravia, and the "back yard" is currently off-limits to residents and health-club users. However, access restriction may not be reliably enforced. Future use at the property may include a picnic area for residents in the "back yard" and landscaping and gardening by the residents or professional companies. These activities would increase the likelihood of exposure to the contaminants in the soil. Exposure to "free product" in soil may result in different or additional

health concerns than exposure to contamination that is bound to soil particles. The bioavailability of NAPL in soil may significantly exceed that assumed in the derivation of the DCC. MDCH used the generic DCC as a comparison value, with the understanding that sampling locations with “free product” present likely have additional risks associated with them.

The **Groundwater Contact Criterion (GCC)** identifies the groundwater concentration of a chemical that is protective against adverse health effects resulting from dermal exposures typically experienced by workers in subsurface excavations (e.g., trenches, utility openings; MDEQ 2006b). The **Groundwater Contact Protection Criterion (GCPC)** identifies a chemical’s concentration in soil that will not leach to the groundwater and exceed the GCC. The generic values for these criteria were derived to protect a worker against less-than-daily (20 days per year for 21 years) exposure (MDEQ 2005b, 2006b). (For chemicals whose health-based GCPC is greater than the C_{sat} value, the criterion reverts to the C_{sat} value [MDEQ 2007b].) In situations where residents at or near a contaminated site are expected to come into dermal contact with water affected by the site, inputs to the GCC may be adjusted, based on exposure-specific information or assumptions, to derive an informal screening value. Exposure to groundwater may occur at the Belgravia site. As soil concentrations approach C_{sat} , there is less soil-water partitioning as more of the contaminant is in NAPL rather than dissolved form (fewer pore spaces). Once “free product” is formed, soil-water partitioning does not occur. Soil-water partitioning is necessary to derive the GCPC (MDEQ 2005b, 2007b). MDCH compared groundwater concentrations to the GCC and soil concentrations to the GCPC with the understanding that sampling locations with “free product” present likely have additional risks associated with them.

The **Groundwater Surface Water Interface Criterion (GSI)** identifies the groundwater concentration of a chemical that is protective of a surface water body to which the groundwater vents, such as a stream, pond, or lake (MDEQ 2004c). Lake Michigan is less than one-quarter mile west of the Belgravia site. People swimming at the lake near this area potentially could be exposed to contaminants from the site. The **Groundwater Surface Water Interface Protection Criterion (GSIPC)** identifies a chemical’s concentration in soil that will not leach to the groundwater and exceed the GSI (MDEQ 2005b). MDEQ uses the most restrictive GSI value based on the protection of humans, wildlife (including fish), or aquatic life (smaller organisms.) For some chemicals, the GSI value is dependent on the pH and water hardness of the receiving surface water body. If the surface water body is one of the Great Lakes or their connecting waters, or the point of groundwater discharge is near a water supply intake on an inland surface water, then the GSI value must reflect the protection of drinking water (MDEQ 2004c). (For chemicals whose GSIPC is greater than the C_{sat} value, the criterion reverts to the C_{sat} value [MDEQ 2007b].) As soil concentrations approach C_{sat} , there is less soil-water partitioning as more of the contaminant is in NAPL form. Once “free product” is formed, soil-water partitioning does not occur. Soil-water partitioning is necessary to derive the GSIPC (MDEQ 2005b, 2007b). MDCH compared groundwater concentrations to the GSI and soil concentrations to the GSIPC with the understanding that sampling locations with “free product” present likely have additional risks associated with them.

The **Groundwater Volatilization to Indoor Air Inhalation Criterion (GVIIC)** addresses the migration of vapors from chemicals in groundwater, through soil into buildings. This is called

“vapor intrusion.” The GVIIC identifies the groundwater concentration of a chemical that is protective against resulting indoor air concentrations that may be harmful to occupants. The **Soil Volatilization to Indoor Air Inhalation Criterion (SVIIC)** identifies a chemical’s concentration in soil that is not expected to migrate into buildings at concentrations that may cause adverse health effects. The generic GVIIC and SVIIC assume that groundwater is at least 3 meters below surface grade (bsg), that the structure’s basement (if it has one) is made of poured or concrete block walls (versus a dirt, or “Michigan,” basement), and that any sump present is isolated from the surrounding soil (MDEQ 1998). (For chemicals whose SVIIC is greater than the C_{sat} value, the criterion reverts to the C_{sat} value [MDEQ 2007b].) Conditions at this site do not meet the requirements for generic vapor intrusion criteria: the depth to groundwater is occasionally shallower than 3 meters bsg, depending on season, and geologic studies of the subsurface indicate a fractured lithology (GRT 2006). Soil-water partitioning is necessary to derive the GVIIC and SVIIC. The presence of “free product” does not allow the partitioning to occur (MDEQ 2007b). Therefore, the generic criteria cannot be used to determine regulatory compliance. However, the criteria can be used to view the contamination situation in a general, non-regulatory light. MDCH compared groundwater concentrations to the GVIIC and soil concentrations to the SVIIC with the understanding that sampling locations with “free product present likely have additional risks associated with them.

When assessing vapor intrusion risks, soil gas sampling, especially when done directly below a building, is usually more informative than sampling the soil or groundwater. Indoor air testing, in conjunction with soil gas sampling, also can aid in assessing the risk, especially in cases where the GVIIC or SVIIC may not be applicable. Soil gas and indoor air samples can be used to determine if there are immediate concerns that need addressing before a complete remediation action plan is developed, but the sampling may *not* be used to determine that remedial action is *not* necessary. MDEQ has established **Acceptable Soil Gas Screening Concentrations (ASGSCs)** and **Acceptable Indoor Air Concentrations (AIACs)** for chemicals capable of vapor intrusion (MDEQ 2006a). These values are not affected by C_{sat} conditions. Limited soil gas sampling has been conducted at the Belgravia site, most of it occurring off-site in neighboring residential yards. Indoor air sampling has been and continues to be conducted on-site in the health club and condominiums, as discussed in the *On-Site* section below. Indoor air sampling occurred off-site as well, as discussed in the *Off-Site* section.

In some cases, VOC contamination in soil may be high enough that the chemical off-gases to ambient (outdoor) air. The **Volatile Soil Inhalation Criterion (VSIC)** identifies a chemical’s soil concentration that is not expected to result in an ambient air concentration that would cause adverse human health effects through long-term inhalation. In cases where the thickness of the source is known, a VSIC value for a 2-meter or 5-meter thickness may be used, if appropriate. If the thickness is greater than 5 meters or is unknown, the “infinite” VSIC value should be used. The generic criteria are based on a ½-acre source area, with a modifier being applied to the generic value when the source area is a different size (MDEQ 2007a). If the VSIC appropriate for the source area and thickness is greater than C_{sat} , then C_{sat} should be used as the screening level. This is because the derivation of the VSIC considers partitioning of a chemical between soil pore water and pore air, and “free product” causes this partitioning not to occur (MDEQ 2007b). MDCH compared soil concentrations to the VSIC with the understanding that sampling locations with “free product present likely have additional risks associated with them.

On-Site

The “Back Yard”

During the 1970s, plating and solvent wastes at the Belgravia site were discharged to a septic tank and drain field on the north side of the building (labeled as the “back yard” in Figure 2) via floor drains in the former plating room (now the “pool room”). In 2000 and 2001, the city of South Haven cleared the site, installed fencing, conducted a geophysical survey, and began environmental sampling. As a result of this assessment, the city relocated part of the storm sewer, to which the drainage system had discharged. Additionally, the septic tank was excavated, along with about 200 yards of contaminated soil (GRT 2006).

The investigation carried out by the city revealed volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and metals in soils and groundwater exceeding Part 201 criteria on the Belgravia property (data not shown; ERM 2000, 2001a). MDEQ contracted with Global Remediation Technologies, Inc. (GRT) to conduct a Remedial Investigation (RI) of the site. GRT conducted the RI, which focused only on areas outside the building’s footprint, in 2005. (The RI did not include the building footprint because a vapor barrier had been installed under the fitness club and pool room and sampling inside the residential side had already occurred. See further discussion in the following sections.)

GRT sampled “shallow” (0.5 to 4 feet bsg) and “deep” (4.2 to 106.5 feet bsg) soils and analyzed them for VOCs, separating the compounds into classes associated with petroleum compounds and classes associated with chlorinated hydrocarbons; PAHs (in “shallow” soils only); and metals. There were 39 “shallow” samples taken at 39 locations, and 348 “deep” samples taken at 53 locations. Tables 1 and 2 show the chemicals that exceeded the criteria of interest.

The RI identified three groundwater zones under the Belgravia property. An unconfined, or shallow, groundwater zone occurs at about 0 to 5 feet bsg. Groundwater flow in the unconfined zone is northwesterly on the north side of the Belgravia site, and westerly on the west side of the site. The intermediate zone begins at about 10 feet bsg, and does not have a defined groundwater flow direction. The deep zone begins at about 64 feet bsg, with direction of groundwater flow being south to southeasterly (GRT 2006). There were 119 groundwater samples taken at 61 locations at various depths. (These samples did not include the wells in which “free product” was found, discussed below, or the water in the sumps at several residences, discussed in the *Off-Site* section.) Table 3 shows the chemicals in groundwater that exceeded the criteria of interest.

The RI revealed that there were significant amounts (percentage levels) of TCE and xylene present in several of the monitoring wells in Belgravia’s “back yard.” Analysis of the “free product” indicated that it was approximately 65% (650,000,000 micrograms per liter [$\mu\text{g/L}$]) TCE and 4% (40,000,000 $\mu\text{g/L}$) xylene (GRT 2006). TCE, being heavier than water, is a dense non-aqueous-phase liquid, or DNAPL. In the case of the Belgravia site, one of the four affected monitoring wells contained nearly 10 feet of “free product,” or DNAPL. The DNAPL occurred within the clayey till separating the unconfined and intermediate groundwater zones, at a depth of 17 to 27 feet bsg. The estimated source zone was located near the northeast corner of the

Table 1. Chemicals in "shallow"^A soils that exceeded criteria of interest at the Belgravia site, South Haven (Van Buren County), Michigan. (Samples taken in 2005. Concentrations in mg/kg.)^B

Chemical	No. detections / No. samples	Concentration Range	Criteria of Interest (No. exceedances)		
			DCC	GSIPC	SVIIC ^C
<i>VOCs - Petroleum Compounds</i>					
Total xylenes	7 / 39	0.15 - 1.64	150 (0) ^D	0.7 (2)	150 (0) ^D
<i>VOCs - Chlorinated Hydrocarbons</i>					
Trichloroethylene	11 / 39	0.09 - 3.5	500 (0) ^D	0.58 (6)	7.1 (0)
Vinyl chloride	2 / 39	1.2 - 3.1	3.8 (0)	0.3 (2)	0.27 (2)
<i>PAHs</i>					
Benzo(a)pyrene	4 / 18	0.28 - 8.5	2 (2)	NLL	NLV
Fluoranthene	10 / 18	0.23 - 26	46,000 (0)	5.5 (2)	1,000,000 (0)
Fluorene	3 / 18	0.13 - 6.5	27,000 (0)	5.3 (1)	580,000 (0)
Naphthalene	3 / 18	0.13 - 8.0	16,000 (0)	0.87 (1)	250 (0)
Phenanthrene	10 / 18	0.15 - 24	1,600 (0)	5.3 (1)	2,800 (0)
<i>Metals</i>					
Arsenic	24 / 25	0.6 - 21	7.6 (2)	23 (0)	NA

Reference: GRT 2006

DCC Direct Contact Criterion
 GSIPC Groundwater Surface Water Interface Protection Criterion
 mg/kg milligrams per kilogram
 NA not applicable (chemical does not volatilize)
 NLL not likely to leach
 NLV not likely to volatilize
 PAH polycyclic aromatic hydrocarbon
 SVIIC Soil Volatilization to Indoor Air Inhalation Criterion
 VOC volatile organic compound

Notes:

- A. Sample depth ranged from 0.5 to 4 feet.
- B. Due to the presence of free product in some areas, "non-exceedances" do not necessarily imply an absence of risk. See text for discussion.
- C. The generic SVIIC is not applicable for regulatory purposes, due to several parameters not meeting the model used for the criterion. The comparison is shown here to provide a general concept of the degree of contamination.
- D. Criterion reverts to Csat (soil saturation concentration) when the health-based value exceeds Csat. However, the generic Csat criteria are not applicable at sites where there are multiple contaminants. The comparison is shown here to provide a general concept of the degree of contamination.

Table 2. Chemicals in "deep"^A soils that exceeded criteria of interest at the Belgravia site, South Haven (Van Buren County), Michigan. (Samples taken in 2005. Concentrations in mg/kg.)^B

Chemical	No. detections / No. samples	Concentration Range	Criteria of Interest (No. exceedances)				
			DCC	GCPC	GSIPC	SVIIC ^C	VSIC ^D
<i>VOCs - Petroleum compounds</i>							
1,2,4-Trimethylbenzene	4 / 348	0.1 - 7.6	110 (0) ^E	110 (0) ^E	0.57 (2)	110 (0) ^E	110 (0) ^E
1,3,5-Trimethylbenzene	3 / 348	0.071 - 2.1	94 (0) ^E	94 (0) ^E	1.1 (2)	94 (0) ^E	94 (0) ^E
Ethylbenzene	7 / 348	0.14 - 19	140 (0) ^E	140 (0) ^E	0.36 (6)	87 (0)	140 (0) ^E
Toluene	26 / 348	0.073 - 130	250 (0) ^E	250 (0) ^E	2.8 (9)	250 (0) ^E	250 (0) ^E
	9 / 348	0.16 - 93	150 (0) ^E	150 (0) ^E	0.7 (8)	150 (0) ^E	150 (0) ^E
<i>VOCs - Chlorinated hydrocarbons</i>							
1,1-Dichloroethene	3 / 348	0.07 - 0.1	200 (0)	220 (0)	0.48 (0)	0.062 (3)	0.8 (0)
	34 / 348	0.12 - 140	640 (0) ^E	640 (0) ^E	12 (9)	22 (4)	140 (0)
cis-1,2-Dichloroethene	20 / 348	0.087 - 34	88 (0) ^E	88 (0) ^E	0.22 (13)	11 (1)	88 (0) ^E
tetrachloroethylene	76 / 348	0.063 - 17,000	500 (22) ^E	440 (26)	0.58 (59)	7.1 (51)	60 (45)
Trichloroethylene	18 / 348	0.053 - 44	3.8 (7)	20 (1)	0.3 (13)	0.27 (13)	3.2 (8)
Vinyl chloride							
<i>Metals</i>							
	144 / 146	0.9 - 13.5	7.6 (2)	2,000 (0)	23 (0)	NA	NA

Reference: GRT 2006

- DCC Direct Contact Criterion
- GCPC Groundwater Contact Protection Criterion
- GSIPC Groundwater Surface Water Interface Protection Criterion
- NA not applicable (chemical does not volatilize)
- SVIIC Soil Volatilization to Indoor Air Inhalation Criterion
- VOC volatile organic compound
- VSIC Volatile Soil Inhalation Criterion

Notes:

- A. Sample depth ranged from 4.2 to 106.5 feet.
- B. Due to the presence of free product in some areas, "non-exceedances" do not necessarily imply an absence of risk. See text for discussion.
- C. The generic SVIIC is not applicable for regulatory purposes, due to several parameters not meeting the model used for the criterion. The comparison is shown here to provide a general concept of the degree of contamination.
- D. VSIC value reflects size of site (2 acres).
- E. Criterion reverts to Csat (soil saturation concentration) when the health-based value exceeds Csat. However, the generic Csat criteria are not applicable at sites where there are multiple contaminants. The comparison is shown here to provide a general concept of the degree of contamination.

Table 3. Chemicals that exceeded at least one groundwater criterion of interest at the Belgravia site, South Haven (Van Buren County), Michigan. (Samples taken in 2005. Concentrations in ug/L.)^A

Chemical	No. detections / No. samples	Concentration Range	Criteria of Interest (No. exceedances)		
			GCC	GSI ^B	GVIIC ^C
<i>VOCs - Petroleum Compounds</i>					
Toluene	8 / 119	3 - 240	530,000 (0)	140 (1)	530,000 (0)
Total xylenes	6 / 119	4.9 - 109	190,000 (0)	35 (1)	190,000 (0)
<i>VOCs - Chlorinated Hydrocarbons</i>					
cis-1,2-Dichloroethene	52 / 119	1.2 - 77,000	200,000 (0)	620 (19)	93,000 (0)
Methylene chloride	NR / 119 ^D	NR ^D	220,000 (0)	940 (4)	220,000 (0)
Tetrachloroethylene	4 / 119	4.7 - 73	12,000 (0)	11 (3)	25,000 (0)
Trichloroethylene	60 / 119	1.1 - 550,000	22,000 (7)	29 (33)	15,000 (32)
Vinyl chloride	36 / 119	1.3 - 24,000	1,000 (11)	15 (27)	1,100 (11)
<i>Metals</i>					
Antimony	1 / 18	2.6	68,000 (0)	2 (1)	NLV
Arsenic	28 / 37	1.3 - 65	4,300 (0)	50 (1)	NLV
Chromium	12 / 29	1.2 - 81	460,000 (0)	11 (5)	NLV
Lead	20 / 42	1.2 - 150	ID	--	NLV
Mercury	1 / 37	0.3	74,000,000 (0)	0.0013 (1)	NLV
Nickel	65 / 65	2.3 - 960	7,400,000 (0)	--	NLV
Silver	4 / 37	0.4 - 4.6	1,500,000 (0)	0.2 (4)	NLV
Vanadium	21 / 59	2.1 - 91	970,000 (0)	12 (7)	NLV

Reference: GRT 2006

ug/L micrograms per liter
GSI Groundwater Surface Water Interface
Criterion
GCC Groundwater Contact Criterion
GVIIC Groundwater Volatilization to Indoor Air Inhalation Criterion
ID insufficient data to determine criterion
NLV not likely to volatilize
NR not reported
VOC volatile organic compound

Notes:

- A. Due to the presence of free product in some areas, "non-exceedances" do not necessarily imply an absence of risk. See text for discussion.
- B. Not enough information to calculate GSI for lead or nickel.
- C. The generic GVIIC is not applicable for regulatory purposes, due to several parameters not meeting the model used for the criterion. The comparison is shown here to provide a general concept of the degree of contamination.
- D. No data presented for methylene chloride. Text of Remedial Investigation indicated exceedances of GSI.

building, moving northward into the “back yard” and neighboring property. As an interim response, MDEQ installed a free-product pumping system in the “back yard” to collect recoverable product (GRT 2006). The agency is considering the selection of in situ (“in place,” rather than removing soil) thermal remediation to address the full remediation of the DNAPL (C. Hefferan, MDEQ Remediation and Redevelopment Division, personal communication, 2007).

The Fitness Club

The soil sampling conducted in 2000 by the city of South Haven’s consultant, Environmental Resources Management (ERM), indicated that TCE and some of its breakdown products were present at Belgravia under the northern portion of the building (Figure 2). Further soil sampling in 2002 indicated that an area encompassing about two-thirds of the future pool room and fitness center contained soils with VOC concentrations exceeding the individual generic SVIICs for the chemicals. The northeastern portion of the building, near where the septic tank had been located in the “back yard,” had the most impacted soil, with concentrations of TCE greater than 100 milligrams per kilogram (mg/kg) at depths of 10 feet to 35 feet bsg. Concentrations declined significantly to the south and west of this area. Based on the depth and extent of contamination beneath the building, the consultant felt that excavation of the soil to prevent a vapor intrusion hazard was not feasible (data not shown; ERM 2000, 2002a).

As a result of the findings of the investigation of soils beneath the future pool room and fitness center, the city of South Haven installed a sub-slab depressurization system under the future fitness center. Additionally, a spray-on membrane called Liquid Boot®, which acts as a barrier against vapor intrusion, was applied to the existing floor before topping with two inches of new cement. The old cement floor in the future pool area, which formerly was the plating room, was removed and four feet of soil excavated. Then, after the pool shape was dug, workers laid a geotextile layer over the area and applied Liquid Boot® before finishing the pool. This work was completed in 2004. In 2005, the developer cut through the cement and the Liquid Boot® barrier in the fitness center, to repair a water discharge line. The manufacturer of the barrier resealed the area that had been breached. Results from indoor air testing in the fitness center after the repair work was finished suggested that the Liquid Boot® barrier and overlaying cement were adequately protective.

The Condominiums

Very little soil has been sampled from under the southern portion of the building at the Belgravia site. Three samples were taken in 2000 and analyzed for PAHs and metals. There were no exceedances of the criteria of interest. The samples were field-screened for total VOCs to direct future investigative efforts (data not shown; ERM 2000).

Soil gas sampling for the entire site, including under the building, occurred in 2001. Of the 12 samples taken, five were from the “back yard,” four were taken from under the northern (future health club) portion of the building, and three were taken from under the southern (future residential) portion of the building. Sample results indicated that the highest soil gas concentrations were found in the “back yard” whereas the samples from the southern portion of the building (through the cement slab) had the lowest, and sometimes undetectable, concentrations. The concentrations of VOCs detected in the samples taken through the slab from inside the building did not exceed the screening concentrations calculated, with MDEQ

guidance, for the chemicals detected (data not shown; ERM 2001b), suggesting no health risk from vapor intrusion was occurring at that time.

Following the soil gas investigation, ERM conducted indoor air sampling in 2002 in the only (at that time) finished and occupied residential unit. The consultants collected one sample, in an evacuated Summa canister, and analyzed the contents for VOCs. Several VOCs were detected but only TCE exceeded its Acceptable Indoor Air Concentration (AIAC; 14.7 micrograms per cubic meter [$\mu\text{g}/\text{m}^3$] reported versus the $14 \mu\text{g}/\text{m}^3$ criterion). It was not known whether the source of the TCE was from vapor intrusion, from contaminated outdoor air drawn in through doors or windows, due to the residence having been cleaned recently, or due to construction materials (paints, glues) in use at the property (ERM 2002b).

The Factory Condominium Association (Association), the current owners of the Belgravia property, must demonstrate and document that they are in compliance with Part 201 Due Care obligations. “Due care” means that an owner/operator of a facility, as defined by MDEQ, must prevent exacerbation of the contamination and unacceptable exposures to people using the facility (MDEQ 2004a). The Association conducts quarterly indoor air assessments in the residential portion of Belgravia’s building as part of its due-care obligations. The residential assessments began in March 2006 and involved taking 24-hour indoor air samples from several locations within each of three condominiums and analyzing for VOCs. (The Association had conducted indoor air sampling in 2005 but the samples had been taken from common areas in the building and not from residential units.) So far, no on-site indoor residential air sampling event, since the initial event in 2002, has resulted in an exceedance of the AIACs for TCE or its breakdown products (Landmark, unpublished data, 2006).

The Association’s consultant sought guidance from MDEQ and MDCH for appropriate placement of the Summa canisters during the indoor air sampling. While MDEQ provides written guidelines for residential testing, multi-unit structures require special considerations (MDEQ 2006a). MDCH suggested a sampling strategy that would help the agency’s public health assessment of the site (Appendix A).

Off-Site

Based on the 2002 findings that indicated that contamination may have spread off-site, MDEQ directed its consultant, Gannett Fleming, to determine whether any off-site migration of contamination had occurred and if indoor air of neighboring homes had been impacted. The consultant sampled subsurface soil, soil gas, groundwater, sump water, and indoor air at the residential properties (total of three) nearest the “back yard” of Belgravia.

Subsurface Soils

Gannett Fleming collected one to four subsurface soil samples from each of 11 soil borings at depths of 12 to 32 feet. Sample-depth selection from each boring was determined by photoionization detector (PID) readings and visual and olfactory (smelling) observations (Gannett Fleming 2003). (A PID is a field instrument that detects high concentrations of VOCs, such as those found at sites with short-term but large-scale hazards. More sensitive analytical methods are required for lower concentrations.)

Only one residential property (“Residence 3”) had detections of VOCs in the soil samples. TCE was detected at several soil depths (19 to 32 feet) in one of the three borings on this property, at concentrations ranging from 67 to 560 mg/kg. These concentrations exceeded the groundwater surface water interface protection criterion (GSIPC) of 0.58 mg/kg, the soil volatilization to indoor air criterion (SVIIC) of 7.1 mg/kg, and the generic (one-half acre) infinite-source volatile source inhalation criterion (VSIC) of 78 mg/kg for TCE. No other VOCs were detected in the soil samples (Gannett Fleming 2003).

Soil Gas

The consultant conducted two rounds of soil gas sampling, once when the ground was frozen and once when the ground was thawed. There were three probes placed on each property, two in the area of the yard closest to Belgravia and one on the other side of the property, farther from the site. (The probes were co-located with the soil borings. The consultant also conducted soil gas sampling at one of the probes placed on the Belgravia property during earlier investigations by ERM.) Samples were collected into evacuated Summa canisters over a 20-minute collection time. One of the properties could not be sampled for soil gas at either round, due to the presence of water in the soil probes. All VOCs detected in the samples collected from the other two residential properties, and from the Belgravia site, were below the respective MDEQ soil gas criteria for those chemicals (data not shown; Gannett Fleming 2003).

Groundwater

The consultant collected only one groundwater sample because only one of the 11 borings from the subsurface soil sampling had sufficient groundwater recharge. This sample contained 730 ppb TCE, which exceeded the GSI criterion of 29 µg/L. Other VOCs tested for were either not detected or below their respective screening levels (data not shown; Gannett Fleming 2003).

Sump Water

The consultant sampled water in the home’s sumps during each of the indoor air sampling events (Gannett Fleming 2003). Note that there are no MDEQ screening levels for chemicals in sump water. This testing was used to identify VOCs that could enter indoor air by volatilizing directly from groundwater to indoor air (versus volatilizing from groundwater to soil and then the vapors entering the structure).

Two of the three homes under investigation had sumps. (The third home did not have a basement but a crawlspace instead.) Field staff first purged the water in the sump by manually tripping the pump three times. The sump water in one home contained cis-1,2-dichloroethene, trans-1,2-dichloroethene, and vinyl chloride in at least one sample out of the three sampling events. The sump water in the other home contained TCE and cis-1,2-dichloroethene in at least one sample out of the three events (data not shown; Gannett Fleming 2003).

Indoor Air

Gannett Fleming conducted three rounds of indoor air sampling: one during the cooling season, and two during the heating season. Sampling during different seasons allowed comparison of the effects of different rates of ventilation (increased during warmer months, decreased during colder months), which can affect indoor air concentrations of vapors. The consultant administered a pre-sampling questionnaire to the homeowners, to identify pre-existing sources of VOCs in the

home (such as new construction, cleaning products, or hobbies using products containing VOCs), and instructed the homeowners which activities to avoid within two days of the sampling event (to prevent confounding results). Twenty-four-hour air samples were collected into evacuated Summa canisters from each floor (including basement or crawl space) of each home. Several ambient air samples were taken as well, to determine background concentrations (Gannett Fleming 2003).

The consultant compared indoor air sampling results to the MDEQ Acceptable Indoor Air Concentration (AIAC) for each chemical detected. For this site, the laboratory's reporting limit (the minimum analytical result that the laboratory has confidence reporting) for some chemicals exceeded the respective AIAC. Those chemicals included 1,1,2,2-tetrachloroethane; 1,1,2-trichloroethane; 1,1-dichloroethene; 1,2-dibromoethane; 1,2-dichloroethane; 1,4-dichlorobenzene; benzene; bromodichloromethane; carbon tetrachloride; dibromochloromethane; hexachloro-1,3-butadiene; and vinyl chloride (Gannett Fleming 2003). Chemicals detected at concentrations below their reporting limit may or may not exceed their respective AIAC. Table 4 shows the indoor air concentrations of chemicals that exceeded both their respective AIACs and their reporting limits during at least one sampling event at the three residences investigated near the Belgravia site.

Benzene was detected frequently and in several locations in Residences 1 and 3. These two homes have attached garages. Benzene commonly is found in gasoline and engine exhaust. It is possible benzene originated from the garages of these homes (Gannett Fleming 2003).

1,4-Dichlorobenzene is a common air deodorant and insecticide (mothballs). Based on a recommendation by MDEQ, the homeowner of Residence 2 removed several suspect items from the house before the final sampling event. That action may have removed the source of 1,4-dichlorobenzene, as there were no detections for the chemical for that sampling event (Gannett Fleming 2003).

Chloroform was detected intermittently in two of the homes. This chemical can emanate from chlorinated water or the use of household bleach. Bleach commonly is used in the laundry or in cleaning products. It is possible the chloroform originated from household cleaning products in the homes where it was detected (Gannett Fleming 2003).

The remaining chemicals listed in Table 4 are TCE and some of its breakdown products and were found only in indoor air samples from Residence 3. While the chemicals may have originated from the Belgravia site and were detected in the sump water, it is also possible that recent activities by the homeowner (specifically, carpet cleaning and wood staining) generated the chemicals detected (Gannett Fleming 2003).

Off-Site Remedial Actions

Due to the presence of site-related contaminants in the sump water of two of the investigated residences, MDEQ installed vapor remediation systems in these homes. Each system consists of a cap on the sump and a PVC pipe venting the air under the cap to the outside of the home. This is an interim remedial action, to remain in place until a full clean-up of the Belgravia site, addressing off-site migration of contaminants, occurs. Follow-up sampling of soil gas at these

Table 4. Indoor air concentrations of chemicals that exceeded their respective Acceptable Indoor Air Concentrations (AIACs) and reporting limits during at least one sampling event at the three residences located closest to the Belgravia site, South Haven (Van Buren County), Michigan. (Concentrations in $\mu\text{g}/\text{m}^3$. Sampling events occurred September and November 2002 and March 2003.)

<u>Location</u> Month	<i>1,1-Dichloroethene</i>		<i>1,4-Dichlorobenzene</i>		<i>Benzene</i>		<i>Chloroform</i>	
	Concentration Range	AIAC (No. exceedances)	Concentration Range	AIAC (No. exceedances)	Concentration Range	AIAC (No. exceedances)	Concentration Range	AIAC (No. exceedances)
<u>Residence 1^{A,C}</u>								
	ND ^D	0.49 (0)	ND	3.5 (0)	3.9 - 6.5	2.9 (3)	ND - 3.8	10 (0)
September	ND	0.49 (0)	ND	3.5 (0)	6.49 - 12.3	2.9 (3)	ND	10 (0)
November	ND	0.49 (0)	ND	3.5 (0)	5.2 - 7.47	2.9 (3)	ND	10 (0)
<u>Residence 2^{B,C}</u>								
	ND	0.49 (0)	ND - 1,000	3.5 (1)	ND	2.9 (0)	ND	10 (0)
September	ND	0.49 (0)	45.2 - 165	3.5 (2)	ND	2.9 (0)	7.94 - 10.4	10 (1)
November	ND	0.49 (0)	ND	3.5 (0)	ND - 4.55	2.9 (1)	ND	10 (0)
<u>Residence 3^{A,C}</u>								
	ND	0.49 (0)	ND - 15	3.5 (1)	6.2 - 12	2.9 (3)	ND - 11	10 (1)
September	ND	0.49 (0)	ND	3.5 (0)	ND - 6.82	2.9 (2)	ND - 99.3	10 (1)
November	ND - 4.03	0.49 (2)	ND	3.5 (0)	ND	2.9 (0)	ND	10 (0)

	<i>cis</i> -1,2-Dichloroethene		Trichloroethylene		Vinyl chloride	
	Concentration Range	AIAC (No. exceedances)	Concentration Range	AIAC (No. exceedances)	Concentration Range	AIAC (No. exceedances)
Residence 1^{A,C}						
	ND - 11	35 (0)	ND	14 (0)	ND	2.8 (0)
September	4.43 - 9.27	35 (0)	ND - 8.19	14 (0)	ND	2.8 (0)
November	ND - 3.67	35 (0)	ND	14 (0)	ND	2.8 (0)
Residence 2^{B,C}						
	ND	35 (0)	ND	14 (0)	ND	2.8 (0)
September	ND	35 (0)	ND	14 (0)	ND	2.8 (0)
November	ND	35 (0)	ND	14 (0)	ND	2.8 (0)
Residence 3^{A,C}						
	ND	35 (0)	ND	14 (0)	ND	2.8 (0)
September	ND - 7.66	35 (0)	ND - 25.7	14 (1)	ND	2.8 (0)
November	ND - 169	35 (2)	ND - 819	14 (2)	ND - 23.1	2.8 (2)

References: Gannett Fleming 2003, MDEQ 2006

- A. Residences 1 and 3 had 4 samples (including a duplicate) taken per sampling event, except in March when only 3 were taken, due to a canister malfunction.
- B. Residence 2 had 3 samples (including a duplicate) taken per sampling event.
- C. If duplicate and co-located sample both exceeded the AIAC, only 1 exceedance was counted.
- D. ND = not detected at or above reporting limit

properties, and sump water at these and other nearby properties, has shown no further impact (GRT 2006).

Exposure Pathways Analysis

To determine whether persons are, have been, or are likely to be exposed to contaminants, MDCH evaluates the environmental and human components that could lead to human exposure. An exposure pathway contains five elements:

- a source of contamination
- contaminant transport through an environmental medium
- a point of exposure
- a route of human exposure
- a receptor population

An exposure pathway is considered complete if there is evidence, or a high probability, that all five of these elements are, have been, or will be present at a site. It is considered either a potential or an incomplete pathway if there is no evidence that at least one of the elements above are, have been, or will be present, or that there is a lower probability of exposure. Table 5 shows the exposure pathways of potential concern at the Belgravia site.

The chemical waste generated by past operations at Belgravia was discharged to a septic tank and drain field, contaminating the soil of the “back yard” at the site. From there, some of the contamination leached to the groundwater. It is possible that contaminated groundwater could vent to Lake Michigan, which is less than one-quarter mile to the west of the site (Figure 1). The VOCs in the groundwater potentially could volatilize, travel through the soil, and enter a building’s indoor air. The VOCs remaining in the soil could also volatilize and enter indoor air, or volatilize to ambient (outdoor) air. Each of these potential exposure pathways is discussed below.

Soil Exposure

Benzo(a)pyrene and arsenic exceeded their respective DCCs in “shallow” soils at Belgravia (Table 1). The two benzo(a)pyrene DCC exceedances occurred outside of the east boundary of the property, on an abandoned railroad right-of-way, adjacent to an industrial property. Exposure to this area would be infrequent and would not likely result in adverse health effects. Similarly, one of the arsenic exceedances occurred in this area and should not cause harm. The other arsenic DCC exceedance occurred in the “back yard.” It is more likely that exposure to “shallow” soils would occur over several areas on a property, to an average concentration rather than to the highest concentration found. People are more likely to be exposed to Belgravia’s soil in the “back yard.” The average concentration of arsenic in “shallow” soils in the “back yard” was 5.4 ppm, which is below the DCC. Therefore, benzo(a)pyrene and arsenic in the “shallow” (no deeper than 4 feet) soils at Belgravia do not pose a public health concern via direct soil exposure.

TCE, vinyl chloride, and arsenic exceeded their respective DCCs in “deep” soils at Belgravia (Table 2). The minimum depth of samples from “deep” soils in the RI was 4.2 feet. Condominium residents and fitness center visitors are not likely to excavate “deep” soils on the Belgravia property. However, workers involved in any future underground utility, remediation, or construction work at the site, or at the affected neighboring properties, may excavate soils to

Table 5. Analysis of exposure pathways for chemicals of interest at the Belgravia site, South Haven (Van Buren County), Michigan.

Source	Environmental Transport and Media	Chemicals of Interest	Exposure Point	Exposure Route	Exposed Population	Time Frame	Status
Past operations at the Belgravia site	Soils	Petroleum compounds, chlorinated hydrocarbons, PAHs, metals (see Tables 1 and 2)	Soil	Dermal, oral	Residents, visitors, and workers at the Belgravia site and neighboring properties	Past	Potential
						Present	Potential
						Future	Potential
		TCE, total xylenes	"Free product"	Dermal, oral, inhalation	Workers at the Belgravia site	Past	Potential
						Present	Potential
						Future	Potential
		Petroleum compounds, chlorinated hydrocarbons, metals (see Table 3)	Groundwater	Dermal, oral, inhalation	Workers at the Belgravia site and neighboring properties	Past	Potential
						Present	Potential
						Future	Potential
		Petroleum compounds, chlorinated hydrocarbons, PAHs, metals (see Tables 1-3)	Surface water (Lake Michigan)	Dermal, oral, inhalation	People swimming in Lake Michigan near the groundwater discharge point	Past	Potential
						Present	Incomplete
						Future	Incomplete
		Chlorinated hydrocarbons (see Table 2)	Ambient air	Inhalation	Residents, visitors, and workers at the Belgravia site and neighboring properties	Past	Potential
						Present	Potential
						Future	Potential
Chlorinated hydrocarbons (see Tables 1-3)	Indoor air	Inhalation	Residents, visitors, and workers at the Belgravia site	Past	Complete		
				Present	Incomplete		
				Future	Potential		
PAH polycyclic aromatic hydrocarbons		TCE trichloroethylene					
NOTE: THE PRESENCE OF A COMPLETE EXPOSURE PATHWAY IN THIS TABLE DOES NOT IMPLY THAT AN EXPOSURE WOULD BE SUBSTANTIVE OR THAT AN ADVERSE HEALTH EFFECT WOULD OCCUR.							

or below this depth and may come into contact with contaminated soil. Utility workers and remediation crews would likely wear personal protective equipment as part of their jobs and therefore would be protected from excessive exposure. Construction workers at Belgravia or the neighboring properties could have a high degree of contact with the soil, similar to a groundskeeper, which is the receptor of interest for the Commercial IV DCC scenario. (The frequency and duration of exposure for workers [245 days per year for 21 years] would be less than that assumed for residents [350 days per year for 30 years; MDEQ 2005a].) The Commercial IV DCCs for TCE, vinyl chloride, and arsenic are 500, 40, and 41 mg/kg, respectively. Twenty-two TCE and 1 vinyl chloride “deep” soil concentrations exceeded their respective Commercial IV DCCs. These chemicals are retained for further evaluation in this assessment.

The concentrations of vinyl chloride and arsenic in “deep” soils on the neighboring properties did not exceed their respective DCCs. There were three exceedances of the TCE criterion, however these were from the same sampling location at a minimum depth of 15.5 feet. It is not likely that a property owner would excavate to this depth on his or her own. Therefore, the contaminants in “deep” soils at off-site properties next to the Belgravia site do not pose a public health concern via direct soil contact to those property owners.

“Free Product” Exposure

Some of the “deep” soil sampling locations in Belgravia’s “back yard” included the locations where “free product” was found (17 to 27 feet bsg). If the soil in these locations is excavated to that depth, the exposure scenarios expected with “free product” would be the same as those expected with “deep” soils, with the inclusion of inhalation of chemical vapors. Direct dermal contact with, or inhalation of vapors released from, the very high concentrations of TCE and xylene found in the “free product,” even if brief, could cause adverse health effects. Therefore, total xylenes, along with TCE as discussed earlier, are retained for further evaluation in this assessment.

Groundwater Exposure

The GCC exceedances for TCE and vinyl chloride occurred both on- and off-site. It is not likely that on-site residents and visitors would conduct excavations or enter subsurface utility structures. As discussed earlier, utility crews and remediation professionals likely would be equipped with personal protective equipment when performing their jobs, but construction crews and off-site property owners probably would not and could be exposed to contaminated groundwater in excavations or utility corridors. Therefore, TCE and vinyl chloride are retained for further evaluation in this assessment.

Surface Water Exposure

The groundwater GSI exceedances raised the concern that local surface waters may become contaminated by groundwater discharge. Lake Michigan, a popular recreation spot with many beaches along its shore, is less than one-quarter mile west of the Belgravia site (Figure 1). Additionally, earlier investigations had indicated that the drain field at Belgravia had discharged to the nearby storm drain, which may have carried contaminants from the site to the lake. Pore water (the water that fills the spaces between grains of sediment) sampling conducted by MDEQ in 2005 near the discharge point to the lake did not detect any VOCs. Some metals were

detected, however their concentrations were below their respective GSIs (GRT 2006). Exposure to Lake Michigan water near the Belgravia site is not expected to result in adverse health effects.

If a small pond is dug in the “back yard” of Belgravia or on the neighboring properties, it is possible that contaminated groundwater would vent to the pond. Due to the relatively small size of the yards of these properties, however, the pond would likely not be very large and could easily be lined with an impermeable material, such as plastic or polyethylene sheeting.

Ambient Air Exposure

The VSIC exceedances for TCE and vinyl chloride were located throughout the “back yard” at Belgravia and on one of the neighboring properties. The exceedances primarily occurred at depths of 15 to 30 feet, although some occurred closer to the ground surface (no shallower than 5 feet). Some of the locations with exceedances also contained “free product.” Although overlying soil might impede the volatilization of the chemicals, drier conditions (allowing more air space in the soil) and warmer temperatures could accelerate volatilization. These conditions would be more likely to occur during the summer months, when people spend more time outdoors and ventilate their work or living spaces more frequently. During cold weather, people likely would spend more of their time indoors with doors and windows closed, decreasing the possibility of exposure to contaminants in ambient air. People at or near the Belgravia site could be exposed to elevated concentrations of VOCs in the air during warm weather. Therefore, TCE and vinyl chloride are retained for further evaluation in this assessment.

Indoor Air Exposure

Limited indoor air testing has indicated that potentially harmful concentrations of VOCs have *not* entered the air within the building at Belgravia. However, there is not enough evidence to determine the likelihood of vapor intrusion in the future. Previous on-site soil gas sampling occurred before the installation of the Liquid Boot® spray-on barrier. The barrier protects the pool room and, along with the sub-slab depressurization system, the fitness center from vapor intrusion. It may be possible that VOCs in the soil in the “back yard” could circumvent the sub-slab depressurization system and migrate through the soil as vapors and enter indoor air in the residential areas. Therefore, 1,1-dichloroethene, cis-1,2-dichloroethene, tetrachloroethylene, TCE, and vinyl chloride are retained for further evaluation in this assessment.

Off-site indoor air testing in neighboring homes in 2002/2003 indicated a potential connection between VOCs in sump water and indoor air concentrations. Although residents of these homes may have been exposed to elevated indoor-air levels of VOCs in the past, any exposure from vapor intrusion likely has stopped as a result of the mitigation systems MDEQ installed.

Toxicological Evaluation

1,1-Dichloroethene

1,1-Dichloroethene (1,1-DCE) is a man-made chemical and also can be generated by the breakdown of TCE. In manufacturing, 1,1-DCE is used to make certain plastics, such as packaging materials and food-wrapping film. When exposed to air, the chemical evaporates quickly (ATSDR 1994). 1,1-DCE is not a common indoor air contaminant, in that it is not normally found in household products (cleaners, glues) that contain VOCs. Therefore, when it is detected in indoor air sampling, its presence is likely due to an atypical source or vapor intrusion.

In occupational studies, people who breathed 1,1-DCE at work for several years experienced abnormal liver function, however whether this effect was due to exposure to 1,1-DCE or other chemicals in the workplace is unclear. Longer exposure appears to cause neurological (nervous system) effects, as well as liver and kidney damage. Animal research showed effects on the liver, kidneys, and lungs. Young born to pregnant rats exposed to 1,1-DCE in the air show signs of birth defects (ATSDR 1994).

The U.S. Environmental Protection Agency (EPA) has determined that 1,1-DCE is a possible human carcinogen. Human evidence was inconclusive, but animal evidence revealed the development of kidney cancer in mice exposed to the chemical in air. It should be noted that only one animal study showed this effect, suggesting that the particular strain of mouse used might be more sensitive to 1,1-DCE (ATSDR 1994).

1,1-DCE has not been detected in indoor air sampling in the condominiums at Belgravia. Although detected during one sampling event at one of the neighboring properties (Table 4), the interim remedial measures taken at those properties are preventing current and future exposures. If conditions remain the same, it is not likely that people at the site would be exposed to 1,1-DCE in indoor air. However, as discussed in the *Exposure Pathways Analysis* section, it is not clear what the future vapor intrusion risk is for the condominiums at Belgravia.

cis-1,2-Dichloroethene

cis-1,2-Dichloroethene and its sister chemical, *trans*-1,2-dichloroethene, (1,2-DCE) are also man-made chemicals and can be generated by the breakdown of TCE. 1,2-DCE is used to produce solvents and in chemical mixtures. Similar to 1,1-DCE, 1,2-DCE evaporates quickly when exposed to air. People who live in cities or suburbs are more likely to be exposed than people living in rural areas (ATSDR 1996).

More research has been conducted on the *trans*- form of 1,2-DCE than on the *cis*- form. Long-term human health effects after exposure to low concentrations are not known. No cancer studies have been performed (ATSDR 1996).

Similar to 1,1-DCE, 1,2-DCE has not been detected in indoor air sampling on-site at Belgravia. The chemical was detected during one sampling event at one of the off-site properties (Table 4), but the interim remedial measures that are in place are preventing further exposure. It is not clear what the future vapor intrusion risk is for the condominiums at Belgravia.

Tetrachloroethylene

Tetrachloroethylene, also known as perchloroethylene (PCE), is a common solvent, often used in drycleaners. People living near drycleaning facilities, or bringing home drycleaned clothing, may be exposed to this chemical. It is also present in a variety of consumer products, such as water repellents, spot removers, and wood cleaners. It is not a breakdown product of TCE but has similar industrial uses. It evaporates easily when exposed to air. Concentrations of PCE in the air are higher in cities or industrial areas where it is used more than in rural or remote areas. PCE can degrade (break down) to TCE and lower chlorinated chemicals, such as 1,1-DCE, 1,2-DCE, and vinyl chloride (ATSDR 1997a).

PCE has been used as a general anesthetic, so exposure to high concentrations of it in the air can cause loss of consciousness. Other effects observed at high airborne concentrations include dizziness, headache, confusion, nausea, and difficulty in speaking and walking. Some studies have suggested that women who work in drycleaning industries, where exposure to PCE can be quite high, may have more menstrual problems and miscarriages than those women who are not exposed. PCE can enter the breast milk, but it is not known if or how a nursing child may be affected (ATSDR 1997a).

Although the EPA has not determined whether PCE is carcinogenic, the U.S. Department of Health and Human Services and the International Agency for Research on Cancer (IARC) have determined that the chemical probably causes cancer in humans. Animal studies showed that the chemical caused liver and kidney damage, as well as cancer in those organs (ATSDR 1997a).

PCE was not detected in indoor air samples taken on-site or off-site. As discussed in the *Exposure Pathway Analysis* section, it is not clear what the future vapor intrusion risk may be for the Belgravia site.

TCE

TCE is a common solvent, frequently used to degrease metal parts. It is also found in many household products, such as typewriter correction fluid, paint and spot removers, and adhesives. It degrades into lower chlorinated chemicals, such as 1,1-DCE, 1,2-DCE, and vinyl chloride (ATSDR 1997b).

TCE is similar to PCE in its effects. It was once used as an anesthetic for surgery. High concentrations in the air cause dizziness or sleepiness. Lower levels may cause these effects, but to a lesser extent, and also cause headaches. Dermal contact with the chemical can result in drying of the skin, due to the defatting nature of the chemical, or rashes. Population studies of communities exposed to TCE in drinking water indicate that there may be an association between oral exposure and increased birth defects, leukemia, and hearing and speech impairment in children. It is not known if inhalation exposure to TCE might have similar associations to these disorders (ATSDR 1997b).

The EPA is updating its human health risk assessment of TCE. Evidence for liver and kidney cancer has strengthened, even since the agency's draft report (NRC 2006).

Persons at the Belgravia site and the neighboring properties may be exposed to elevated concentrations of TCE in the ambient (outdoor) air. If the concentrations are high enough and/or long enough, those exposed could experience transient effects, such as headaches or dizziness. Long-term exposure, such as what might be expected for someone residing on- or off-site, could result in increased cancer risk. Ambient air sampling has not occurred, however, so it is not known if TCE is vaporizing from the soil or "free product" at concentrations of concern.

On-site residents may be exposed in the future to elevated indoor air levels of TCE. While testing begun in 2006 has not detected TCE and its breakdown products in the condominiums, the future risk of vapor intrusion is not clear.

Those persons performing deep (17- to 27-foot) excavations in the area of Belgravia's "back yard" where "free product" was detected may come into direct contact with the chemical. If these persons are not wearing protective gear, they may experience dermal effects. Also, they could inhale high concentrations of TCE evaporating from exposed "free product" and experience acute effects, such as dizziness or nausea.

Vinyl chloride

Vinyl chloride is a man-made chemical and also one of the final degradation products of PCE, TCE, 1,1-DCE, and 1,2-DCE. In manufacturing, it is used to make the polymer polyvinyl chloride (PVC), which is used to make a number of products, including pipes, upholstery, housewares, and automotive parts. Low levels of vinyl chloride are found in tobacco smoke. At room temperature, the chemical is a gas, requiring high pressure or low temperature to form a liquid (ATSDR 2006).

Similar to PCE and TCE, high levels of vinyl chloride in the air can cause sleepiness or dizziness. Some people who have breathed vinyl chloride for several years have experienced changes in liver structure. Others who have worked with the chemical have experienced nerve damage, whereas still others developed an immune reaction. Some men who have worked with vinyl chloride experienced sexual dysfunction, while women workers reported irregular menstrual cycles or high blood pressure during pregnancy. Dermal contact with the chemical in its liquid form can result in numbing, redness, and blistering of the skin (ATSDR 2006).

Vinyl chloride is a known human carcinogen. Studies of people working with vinyl chloride indicate an association between exposure and several cancers (liver, lung, brain, blood). Animal studies, using very low levels of the chemical in air, suggested an increased rate in liver and mammary cancers (ATSDR 2006).

Vinyl chloride has not been detected in on-site indoor air sampling, however the risk of future vapor intrusion at Belgravia is not clear. Although detected during one sampling event at one of the neighboring properties (Table 4), the interim remedial measures taken at those properties are preventing current and future exposures.

Total xylenes

There are three forms, or isomers, of xylenes, but they are usually discussed as a group, rather than separately, in risk assessments, due to their having similar effects on health. Xylenes occur naturally in petroleum and coal tar, and can be formed during forest fires, but can also be manufactured. They are used as solvents in the printing, rubber, and leather industries; as cleaning agents; and as paint and varnish thinners. Xylenes occur in small amounts in airplane fuel and gasoline and can be detected in the exhaust from combustion engines. They also occur in cigarette smoke (ATSDR 2005).

Short-term exposure to high levels of xylenes can cause irritation of the skin and mucous membranes (eyes, nose, throat). A person may have difficulty breathing and other lung impairments following acute exposure. Other symptoms include central nervous system effects (delayed response to a stimulus, impaired memory, headache, dizziness, confusion), stomach

discomfort, and possible effects on the liver and kidneys. Animal studies have indicated that large amounts of xylenes can cause changes in the liver and harmful effects on the kidneys, lungs, heart, and nervous system. Long-term exposure of animals to low concentrations in the air suggests that harm may occur to the nervous system (ATSDR 2005).

EPA found insufficient information to determine whether xylenes are carcinogenic to humans (ATSDR 2005).

On-site indoor air sampling has indicated that xylenes were present but at levels well below the MDEQ Acceptable Indoor Air Concentration (Landmark, unpublished data, 2006). Concentrations of xylenes in the soil and groundwater did not suggest that vapor intrusion would be likely. There were no xylenes detected in off-site indoor air sampling. People likely are not being exposed to harmful levels of xylenes in the indoor air.

Those persons performing deep (17- to 27-foot) excavations in the area of Belgravia's "back yard" where "free product" was detected may come into direct contact with xylenes. If these persons are not wearing protective gear, they may experience dermal effects (drying, irritation). Also, they could inhale high concentrations of xylenes evaporating from exposed "free product" and experience acute effects, such as dizziness or nausea.

Children's Health Considerations

Children may be at greater risk than adults from exposure to hazardous substances at sites of environmental contamination. Children engage in activities such as playing outdoors and hand-to-mouth behaviors that could increase their intake of hazardous substances. They are shorter than most adults, and therefore breathe dust, soil, and vapors found closer to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures are high enough during critical growth stages. Fetal development involves the formation of the body's organs. Injury during key periods of prenatal growth and development could lead to malformation of organs (teratogenesis), disruption of function, and premature death. Exposure of the mother could lead to exposure of the fetus, via the placenta, or affect the fetus because of injury or illness sustained by the mother (ATSDR 1998). The obvious implication for environmental health is that children can experience substantially greater exposures to toxicants in soil, water, or air than adults can.

Although the "back yard" at Belgravia currently is off-limits, children can access the area, which is fenced in, from the fitness center and pool room. The neighboring properties likely have children residing or visiting there and playing in the yards. Children are not likely to be exposed to the contaminated "deep" soils, groundwater, or the "free product" on these properties. However, they may be exposed to elevated levels of VOCs in ambient and indoor air.

Children at the Belgravia site or the neighboring properties may be more at risk of negative health effects resulting from chemical exposures than adults. A partial-lifetime animal study showed that early exposure to vinyl chloride resulted in greater risk of cancer development (EPA 2005). For TCE exposures, children tend to have lower clearance activity of the TCE metabolites of concern, potentially increasing the likelihood of harm (EPA 2001). The

neurotoxic potential of the VOCs discussed in the *Toxicological Evaluation* section is of concern since childhood is a period of rapid brain development, and exposure could lead to developmental, learning, or behavioral deficits.

Community Health Concerns

The local health department contacted MDCH regarding a citizen's request for information on biomarker testing. According to the ATSDR Toxicological Profile for TCE, trichloroacetic acid, a metabolite of TCE and PCE, is slower to appear in the urine than trichloroethanol but is longer lived, which makes it a better biomarker for long-term exposure (ATSDR 1997a, b). MDCH provided this information to the local health department, but emphasized that air monitoring would be the best predictor of external exposure.

One citizen, who uses the health club but does not reside on-site, asked if her lungs might be more vulnerable (due to recent lung surgery) to potentially toxic exposures at the health club. Because the citizen visits in the site only intermittently, she would be experiencing minimal or even no exposure. Therefore, her risk would be much less than that of the residents.

A person considering purchasing one of the condominiums was concerned about short-term and long-term risks. Also, she wondered if the balcony of the unit in which she was interested might be close enough to the sub-slab depressurization output pipe to affect outdoor or indoor air quality. MDCH determined during its site visit that the output pipe was at least 19 feet from the air intake and that emissions would likely dissipate and be very diluted by ambient air by the time any were taken in by the intake pipe. MDCH felt that direct contact with "free product" represented the most important short-term risk and that inhalation of VOCs in ambient or indoor air represented the most important long-term risk.

Another person asked about concentrations of VOCs in the "back yard" of the property and whether they might affect air quality in or near the condominiums. There are only limited ambient air data for the site so it is unclear what impact VOCs generated in the "back yard" would have on indoor air quality.

A family that had rented one of the condominiums during their summer vacation had not been informed of the contamination issue. They contacted MDEQ, who forwarded their question to MDCH, asking if any exposure they may have experienced could have been harmful. It is not likely that the brief time the family spent at the site was sufficient to cause harm.

Conclusions

The "shallow" soils at the Belgravia site and neighboring properties, and nearby surface waters of Lake Michigan, pose no apparent public health hazard. Due to data gaps and uncertainty of future activity at Belgravia, the remaining public health implications are indeterminate. (See Appendix B for descriptions of hazard categories.)

The contamination at the Belgravia site and neighboring properties poses a potential public health hazard. (Note that "potential" hazard is not one of the official public health hazard categories ATSDR uses for sites of contamination.) The "deep" soils on- and off-site contain levels of TCE and vinyl chloride that could cause adverse health effects from long-term

exposure. Construction workers engaged in excavations may not wear appropriate protective gear. Deed restrictions prohibiting future digging at Belgravia and neighboring properties, education of workers, or remediation of the site would protect against potentially harmful future exposure.

The “free product” in the “back yard” of Belgravia could cause acute adverse health effects from direct contact with or inhaling vapors of exposed product. Currently, the “free product” recovery system is preventing further spread of the chemicals. However, excavations may uncover “free product” and increase the risk of exposure to construction workers. Deed restrictions prohibiting future digging at Belgravia, education of workers, or remediation of the site would protect against potentially harmful future exposure.

Groundwater that seeps into on- or off-site excavations may contain site-related contaminants at levels above screening levels. Deed restrictions, worker education, or site remediation would protect against potentially harmful future exposure.

There are no ambient air data, making it difficult to determine to what degree the soil contamination might be affecting outdoor air. If the site is not remediated, or if excavation occurs at Belgravia or affected neighboring properties, it may be necessary to monitor ambient air to determine if measures should be taken to prevent excessive exposure to airborne VOCs.

The limited indoor air data indicate that there are no current unacceptable exposures inside the building. However, VOCs, especially chlorinated hydrocarbons, can move through soil fairly easily. It is possible that the VOCs in the soils in the “back yard” could circumvent the sub-slab depressurization system under the fitness center and enter the residential portion of the building. Although indoor air testing can define the level of exposure for a specific time, soil gas sampling, beneath the building, would indicate the degree of risk for vapor intrusion.

Recommendations

1. Continue to restrict access to the “back yard” until the “free product” is addressed.
2. Inform construction companies intending to work on or near the Belgravia site, and neighboring property owners, about the contamination and how to take protective measures when excavating deep soils.
3. Conduct sub-slab soil gas testing under the condominium side of the building to determine vapor intrusion risk.
4. Conduct ambient air testing.
5. Notify MDEQ of future breaches, accidental or intentional, to the Liquid Boot® barrier, or other changes that may increase the risk of vapor intrusion.

Public Health Action Plan

1. The Factory Condominium Association (Association) and the Westshore Fitness Club will maintain the fence encircling the “back yard” and the signs restricting access. MDEQ is considering in situ thermal remediation (heating the soils on-site) as a strategy to eliminate the “free product” and other contamination in the soil.
2. The Association will inform construction firms with whom they contract about the contamination. MDCH can provide information regarding prevention of exposure.

3. MDEQ will request soil gas data, for beneath the condominiums, from either their contractor or the Association.
4. The Association will conduct ambient air monitoring if construction companies perform excavations in the “back yard” or affected neighboring properties. Any companies performing remedial work will conduct air monitoring to assure no unacceptable levels of site-related contaminants enter the air.
5. The Association will notify MDEQ of any changes to the condition of the building, the Liquid Boot® barrier, the sub-slab depressurization system, the “back yard,” or other areas of the Belgravia site that may impact their Due Care responsibilities.

MDCH will remain available as needed for future consultation at this site.

If any citizen has additional information or health concerns regarding this health consultation, please contact MDCH’s Division of Environmental Health at 1-800-648-6942.

Preparers of Report

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Toxicology and Response Section

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References

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. ATSDR, Division of Health Assessment and Consultation. Guidance on Including Child Health Issues in Division of Health Assessment and Consultation Documents. July 2, 1998.

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for 1,1-dichloroethene. Atlanta: US Department of Health and Human Services; 1994 May. <http://www.atsdr.cdc.gov/toxprofiles/tp39.html>

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for 1,2-dichloroethene. Atlanta: US Department of Health and Human Services; 1996 Aug. <http://www.atsdr.cdc.gov/toxprofiles/tp87.html>

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for tetrachloroethylene. Atlanta: US Department of Health and Human Services; 1997 Sept. <http://www.atsdr.cdc.gov/toxprofiles/tp18.html> (1997a)

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for trichloroethylene. Atlanta: US Department of Health and Human Services; 1997 Sept. <http://www.atsdr.cdc.gov/toxprofiles/tp19.html> (1997b)

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for vinyl chloride. Atlanta: US Department of Health and Human Services; 2006 July. <http://www.atsdr.cdc.gov/toxprofiles/tp20.html>

Agency for Toxic Substances and Disease Registry (ATSDR). Toxicological profile for xylenes (draft for public comment). Atlanta: US Department of Health and Human Services; 2005 Sept. <http://www.atsdr.cdc.gov/toxprofiles/tp71.html>

Environmental Resources Management (ERM). Belgravia/Hamlin, South Haven: Site Investigation Results. Holland (MI): ERM; 2000 June 1.

Environmental Resources Management (ERM). Belgravia/Hamlin Overton Site: Additional Site Investigation Results by ERM. Holland (MI): ERM; 2001 March 16. (2001a)

Environmental Resources Management (ERM). Former Belgravia Site: Soil Gas Monitoring Results, prepared by ERM. Holland (MI): ERM; 2001 Nov 9. (2001b)

Environmental Resources Management (ERM). Belgravia/Hamlin Overton, South Haven (Van Buren County): Soil Sampling Results. Holland (MI): ERM; 2002 May 22. (2002a)

Environmental Resources Management (ERM). Former Belgravia Site, South Haven: Air Sampling Results and Work Plan for Additional Investigation. Holland (MI): ERM; 2002 May 9. (2002b)

Gannett Fleming of Michigan, Inc. (Gannett Fleming). Final technical memorandum, Former Belgravia Site, South Haven, Michigan. Wixom (MI): Gannett Fleming; 2003 Sept. Project No. 40325.001.

Global Remediation Technologies, Inc. (GRT). Belgravia site (80000010) Remedial Investigation report. Traverse City (MI): GRT; 2006 Mar.

Landmark Environmental and Engineering Solutions (Landmark). Second quarter Section 7a Compliance Analysis Document of Compliance for the Former Belgravia Facility, Site ID No. 80000010 (currently the Factory Condominiums and Westshore Family Fitness Center), 125 Elkenburg Street, South Haven, Michigan. Benton Harbor (MI): Landmark; 2006 Feb. Landmark Project No. 05-012.

Michigan Department of Environmental Quality (MDEQ). Due Care Requirements. January 2004. <http://www.deq.state.mi.us/documents/deq-rrd-duecare-citizenguide.pdf> (2004a)

Michigan Department of Environmental Quality (MDEQ). Environmental Response Division: Generic Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria – Technical Support Document. 1998 August. <http://www.deq.state.mi.us/documents/deq-erd-td5.pdf>

Michigan Department of Environmental Quality (MDEQ). Part 201 Generic Soil Inhalation Criteria for Ambient Air: Technical Support Document – Draft Document. Lansing (MI): MDEQ Remediation and Redevelopment Division; 2007 February. (2007a)

Michigan Department of Environmental Quality (MDEQ). Part 201/213 Acceptable Indoor Air Concentrations (AIACs) and Acceptable Soil Gas Screening Concentrations (ASGSCs). From: MDEQ Remediation and Redevelopment Division Memorandum No. 4 – Part 201/213 Site Characterization and Remediation Verification: Attachment 4 – Soil Gas and Indoor Air (Appendix D). Peer Review Draft. 2006 Feb. (2006a)

Michigan Department of Environmental Quality (MDEQ). Remediation and Redevelopment Division Operational Memorandum No. 1 – Technical Support Document – Attachment 3: Part 201 Drinking Water Criteria/Part 213 Tier I Drinking Water Risk-based Screening Levels. 2004 December. http://www.deq.state.mi.us/documents/deq-rrd-OpMemo_1-Attachment3DrinkingWaterCriteriaTechnicalSupportDocument.pdf (2004b)

Michigan Department of Environmental Quality (MDEQ). Remediation and Redevelopment Division Operational Memorandum No. 1 – Technical Support Document – Attachment 4: Part 201 Groundwater Contact Criteria/Part 213 Tier I Groundwater Contact Risk-based Screening Levels. 2006 July. http://www.deq.state.mi.us/documents/deq-rrd-OpMemo_1-Attachment4.pdf (2006b)

Michigan Department of Environmental Quality (MDEQ). Remediation and Redevelopment Division Operational Memorandum No. 1 – Technical Support Document – Attachment 6: Part 201 Soil Direct Contact Criteria/Part 213 Soil Direct Contact Risk-based Screening Levels. 2005 April. http://www.deq.state.mi.us/documents/deq-rrd-OpMemo_1-Attachment6.pdf (2005a)

Michigan Department of Environmental Quality (MDEQ). Remediation and Redevelopment Division Operational Memorandum No. 1 – Technical Support Document – Attachment 8: Part 201 C_{sat} Concentrations/Part 213 Tier I C_{sat} Concentrations. 2007 May.

http://www.deq.state.mi.us/documents/deq-rrd-Op_MemoNo.1_Attachment8-CsatTechnicalSupportDocumentRevisedApril2006.pdf (2007b)

Michigan Department of Environmental Quality (MDEQ). Remediation and Redevelopment Division Operational Memorandum No. 1 – Technical Support Document – Attachment 9: Part 201 Groundwater Protection Criteria/Part 213 Tier I Risk-based Screening Levels. 2005 March.

http://www.deq.state.mi.us/documents/deq-rrdOpMemo_1-Attachment9GWPCTechnicalSupportDocument.pdf (2005b)

Michigan Department of Environmental Quality (MDEQ). Remediation and Redevelopment Division Operational Memorandum No. 5: Groundwater Surface Water Interface Criteria. 2004 September. http://www.deq.state.mi.us/documents/deq-rrd-OpMemo_5.pdf (2004c)

Michigan Department of Environmental Quality (MDEQ). Training Material: Part 201 Cleanup Criteria and Part 213 Risk-Based Screening Levels. 2006 June.

<http://www.deq.state.mi.us/documents/deq-rrd-TrainingMaterialPart201CleanupCriteriaPart213RiskBasedScreeningLevels-6-02-06.doc> (2006c)

National Research Council (NRC). 2006. Assessing the human health risks of trichloroethylene: key scientific issues. Washington, D.C.: Committee on Human Health Risks of Trichloroethylene, National Research Council, National Academy of Sciences; 2006.

Natural Resources and Environmental Protection Act (NREPA). State of Michigan Public Act 451 of 1994.

U.S. Environmental Protection Agency (EPA). 2001. Trichloroethylene health risk assessment: synthesis and characterization (external review draft). Washington, D.C.: EPA, Office of Research and Development; 2001 Aug. Report No. EPA/600/P-01/002A.

U.S. Environmental Protection Agency (EPA). 2005. Supplemental guidance for assessing susceptibility from early-life exposure to carcinogens. Washington, D.C.: EPA, Risk Assessment Forum; 2005 March. Report No. EPA/630/R-03/003F.

Appendix A. MDCH letter to Factory Condominium Association consultant providing guidance for indoor air sampling at the Belgravia site, South Haven (Van Buren County), Michigan.

May 12, 2006

Landmark Technologies
115 W. Main St.
Benton Harbor, MI 49022
Attn: (name deleted to protect privacy)

Dear (name deleted),

I am a toxicologist with the Michigan Department of Community Health (MDCH) and am assisting Carol Hefferan of the Michigan Department of Environmental Quality (MDEQ) with the Belgravia/Factory Condominiums site (Belgravia) in South Haven, Michigan. My role is to assess public health implications of exposure to contaminants found at the site, determine whether a public health hazard exists, and make recommendations to mitigate any hazard. I have been involved at the Belgravia site since August 2005 and have received much data through Ms. Hefferan, including data generated by the consultants for the site. It is prudent, since the site was not fully characterized before being redeveloped and will not be completely remediated for the foreseeable future, that testing for potential human exposures continues.

This letter specifically deals with testing indoor air for contaminants (trichloroethylene [TCE] and its breakdown products) that may be entering the structure from the underlying soils. Indoor air testing previous to 2006 was conducted in the hallway between the condominium units, in the hallway of the fitness center, and in the pool room. These locations, while convenient, were not ideal because people in these areas would not be spending as much time in the building as those residing in the condominiums. (My primary concern is for those persons being exposed for long durations on a regular basis – the residents.) Also, the sub-slab depressurization system, designed to prevent vapor intrusion, exists only under the fitness center and pool and not below the residential part of the building. We do not have sufficient data to determine whether vapors are entering the residential areas at harmful concentrations.

The testing conducted March 2006 was a start in obtaining the data needed to determine human health risks. This testing should continue. Specifically, **occupied** units, where **construction is complete**, should be tested. **Ground-floor** units are preferred, since those would be closer to vapor entry points. However, a previous sampling event in a second-floor unit indicated the presence of TCE. Therefore, upper-level units should not be ruled out.

Occupants willing to have their units tested should be informed that **common household chemicals and other items give off volatile compounds, which can confound the sampling results**. Therefore, occupants must be educated as to what to do and what not to do before and during the sampling. MDEQ has an instruction form and questionnaire (attached) that it uses to prepare a site's residents/tenants for indoor air sampling and to document potential confounders.

Not complying with the instructions listed will only waste effort and money and not give useful information.

I understand that preliminary MDEQ guidance requires 1 sample per 250 ft² in residential buildings, which would increase greatly the number of canisters presently used. However, the guidance also indicates that multiple-unit residential structures require special sampling considerations. As I recall, none of the units have below-grade rooms and most are single-floor dwellings. For purposes of MDCH assessing any human health risk, I recommend that 1 air sample continue to be taken from the lowest “liveable” area in the condominium. **In addition to that sample**, I recommend that a second sample be taken from a bedroom, on the second story if the unit has one. These would be areas where residents would be spending most of their time at home and therefore where the longest-duration exposures would occur. If MDEQ requires additional sampling canisters per unit, I can review that data as well.

In conclusion, I recommend the following:

1. Continue indoor air testing in **occupied** units in which **no construction activities** are taking place. (Air currents and construction solvents may confound the data.) You may continue testing in the same unit until one year of data is collected (through all seasons). Then, if testing is to continue, selecting another unit, for a whole year’s worth of testing, is acceptable. Three units per quarter of testing is sufficient, although if all residents are amenable, then all units should be tested each time.
2. **Inform all** building residents/tenants, including fitness center employees and maintenance/construction workers, of the testing and the need not to confound the data. **Activities to suspend** during the testing include: lawn mowing, barbequeing/grilling, smoking in the tested units, propping doors and windows open in the tested units, and other activities generating odors, exhaust, or excessive air movement or pressure differences. Normal use of the tested condominium unit, other than the confounding activities, can occur.
3. Conduct indoor air sampling in the lowest “liveable” area and in a bedroom. If the unit is multi-story, use a bedroom on the upper story.

I will be documenting MDCH’s activity at the Belgravia/Factory Condominiums site in a report called a public health consultation later this calendar year. The report will be publicly available and I will be happy to send you a copy of it when it is complete.

If I can be of further assistance, please do not hesitate to contact me. Thank you.

Christina Bush, Toxicologist
Toxicology and Response Section
Division of Environmental and Occupational Epidemiology

Instructions for Occupants for Indoor Air Sampling Events

Global Remediation Technologies, Inc. will be collecting one or more indoor air samples from your building in the near future. In order to collect an indoor air sample in your structure that is both representative of indoor conditions and avoids the common sources of background air contamination associated with household activities and consumer products, your assistance is requested.

Please follow the instructions below starting at least 48 hours prior to and continuing through the indoor air sampling event:

- Operate your furnace and whole house air conditioner as appropriate for the current weather conditions
- Do not use wood stoves, fireplaces or auxiliary heating equipment
- Do not open windows or keep doors open
- Avoid using window air conditioners, fans or vents
- Do not smoke in the building
- Do not use air fresheners or odor eliminators
- Do not use paints or varnishes (up to a week in advance, if possible)
- Do not use cleaning products (e.g., bathroom cleaners, furniture polish, appliance cleaners, all-purpose cleaners, floor cleaners)
- Do not use cosmetics, including hair spray, nail polish remover, perfume, etc.
- Avoid bringing freshly dry cleaned clothes into the building
- Do not partake in hobbies indoors that use solvents
- Do not apply pesticides
- Do not store containers of gasoline, oil or petroleum based or other solvents within the building or attached garages (except for fuel oil tanks)
- Do not operate or store automobiles in an attached garage
- Do not operate gasoline powered equipment within the building, attached garage or around the immediate perimeter of the building

You will be asked a series of questions about the structure, consumer products you store in your building, and household activities typically occurring in the building. These questions are designed to identify "background" sources of indoor air contamination. While this investigation is looking for a select number of chemicals related to the subsurface contamination, the laboratory will be analyzing indoor air samples for a wide variety of chemicals. Thus, various compounds found in common household products (such as paint, new carpeting, nail polish remover), might be found in your sample results.

Your cooperation is greatly appreciated.

If you have any questions about these instructions, please feel free to contact **Bill Prall** at GRT Inc. at **(231) 941-8622**.

INDOOR AIR BUILDING SURVEY & SAMPLING FORM

Date: _____ Survey Performed by: _____

1. OCCUPANT:

Rent _____ Own _____

Resident Name: _____

Address: _____

Telephone: Home _____ Work _____

How long have you lived at this location? _____

List of Current Occupants/Occupation (attach additional page if necessary):

Age (If under 18)	Sex (M/F)	Occupation

2. OWNER OR LANDLORD: (If same as occupant, check here ___ and go to Item # 3)

Last Name: _____ First Name: _____

Address: _____

City and State: _____

County: _____

Home Phone: _____ Office Phone: _____

INDOOR AIR BUILDING SURVEY & SAMPLING FORM

3. SENSITIVE POPULATION: (circle all that apply)

daycare / nursing home / hospital / school / other (specify):

4. BUILDING CHARACTERISTICS: (circle all that apply)

Residential / multi-family residential / office / strip mall / commercial / industrial / school

Describe building: _____

Year Constructed: _____

Number of floors at or above grade: _____

Number of floors below grade: _____

(full basement / crawl space / slab on grade)

Depth of structure below grade: _____ ft. Basement size: _____ ft²

If the property is residential, what type? (Circle all appropriate responses)

Ranch	2-Family	3-Family	Raised Ranch
Split Level	Colonial	Cape Cod	Contemporary
Mobile Home	Duplex	Apartment House	Townhouses/Condos
Modular	Log Home	Other: _____	

If multiple units, how many? _____

If the property is commercial:

Business type(s) _____

Does it include residences (i.e., multi-use)? Y / N If yes, how many? _____

INDOOR AIR BUILDING SURVEY & SAMPLING FORM

Identify all potential soil vapor entry points and estimated size (e.g., cracks, utility parts, drains)

Are the basement walls or floor sealed with waterproof paint or epoxy coatings? Y / N

Type of ground cover outside of building: grass / concrete / asphalt / other _____

Sub-slab vapor/moisture barrier in place? Y / N

Type of barrier: _____

7. HEATING, VENTING, and AIR CONDITIONING (Circle all that apply)

Type of heating system(s) used in this building: (circle all that apply - note the primary)

Hot air circulation	Heat pump	Hot water baseboard
Space Heaters	Steam radiation	Radiant floor
Electric baseboard	Wood stove	Outdoor wood boiler
Other _____		

The primary type of fuel used is:

Natural Gas	Fuel Oil	Kerosene
Electric	Propane	Solar
Wood	Coal	

Domestic hot water tank fueled by:

Boiler/furnace located in: Basement Outdoors Main Floor Other

Air conditioning: Central Air Window Units Open Windows None

Are there air distribution ducts present? Y / N

Is there a whole house fan? Y / N

INDOOR AIR BUILDING SURVEY & SAMPLING FORM

Describe the air intake system (outside air supply, cold air return, ductwork, etc.), and its condition where visible. Indicate the locations on the floor plan diagram.

8. FACTORS THAT MAY INFLUENCE INDOOR AIR QUALITY

- a. Is there an attached garage? Y / N
If yes, does it have a separate heating unit? Y / N
- b. Are any petroleum-powered machines or vehicles stored
In an attached garage (e.g., lawnmower, ATV, car) Y / N
- c. Has the building ever had a fire? Y / N
- d. Is there a fuel-burning or unvented gas space heater? Y / N
- e. Is there a workshop or hobby/craft area? Y / N
If yes; Where & what type: _____
- f. Is there smoking in the building? Y / N
If yes; How frequently? _____
- g. Have cleaning products been used recently? Y / N
If yes; When & what type? _____
- h. Have cosmetic products been used recently? Y / N
If yes; When & what type? _____
- i. Has there been painting/staining in the last 6 months? Y / N
If yes; When & where? _____
- j. Is there new carpet, drapes or other textiles? Y / N
If yes; When & where? _____
- k. Have air fresheners been used recently? Y / N
If yes; When & what type? _____

INDOOR AIR BUILDING SURVEY & SAMPLING FORM

- l. Is there a kitchen exhaust fan? Y / N
If yes, where vented? _____
- m. Is there a clothes dryer? Y / N
If yes, is it vented outside? Y / N
- n. Has there been a pesticide application? Y / N
If yes; When & what type? _____
- o. Are there odors in the building? Y / N
If yes, please describe: _____
- p. Do any of the building occupants use solvents at work? Y / N
(e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist)
If yes, what types of solvents are used? _____
If yes, are their clothes washed at work? Y / N
- q. Do any of the building occupants regularly use or work at a dry-cleaning service?
(circle appropriate response)
 No Unknown
 Yes, use dry-cleaning regularly (weekly)
 Yes, use dry-cleaning infrequently (monthly or less)
 Yes, work at a dry-cleaning service
- r. Is there a subsurface depressurization system (often used for radon mitigation) for the building/structure? Y / N
If yes; Date of Installation: _____ Active or passive? Active / Passive

INDOOR AIR BUILDING SURVEY & SAMPLING FORM

Sample Collection (to be completed by sample collection team)

On a separate sheet(s), provide a sketch of the building (including each floor as applicable), all (unremovable) potential indoor sources found in the building (including attached garages), the location of the source (floor & room), and each sample location (see item # 9 below). Any ventilation implemented after removal of potential sources shall be completed at least 24 hours prior to the commencement of the indoor air sampling event.

Photographs should be taken at each sample location, and of any unremovable source, to supplement the documentation recorded below. The photographs must be of good quality with legible labels .

Location	Sample ID	Sample Container Size	Sample Duration	Flow Rate Verification (Y / N)	Comments

Sampling Information:

Sample Technician: _____ Phone #: _____

Analytical Method: TO-15 / TO-17 / other: _____

Laboratory: _____

INDOOR AIR BUILDING SURVEY & SAMPLING FORM

Were "Instructions for Occupants" followed? Y / N

If not, describe modifications:

Was field screening performed? Y / N

If yes, describe Make & Model of field instrument used:

Meteorological Conditions

Was there significant precipitation within 12 hours prior to (or during) the sampling event? Y / N

Describe the general weather conditions:

General Observations

Provide any information that may be pertinent to the sampling event and may assist in the data interpretation process.

INDOOR AIR BUILDING SURVEY & SAMPLING FORM
Sketch of Building (include additional sheets as needed)

A large grid of graph paper, consisting of 20 columns and 25 rows of squares, intended for sketching a building. The grid is empty and occupies the majority of the page below the title.

Appendix B. ATSDR Public Health Hazard Categories

Depending on the specific properties of the contaminant(s), the exposure situations, and the health status of individuals, a public health hazard may occur. Sites are classified using one of the following public health hazard categories:

Urgent Public Health Hazard

This category applies to sites that have certain physical hazards or evidence of short-term (less than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. These sites require quick intervention to stop people from being exposed. ATSDR will expedite the release of a health advisory that includes strong recommendations to immediately stop or reduce exposure to correct or lessen the health risks posed by the site.

Public Health Hazard

This category applies to sites that have certain physical hazards or evidence of chronic (long-term, more than 1 year), site-related exposure to hazardous substances that could result in adverse health effects. ATSDR will make recommendations to stop or reduce exposure in a timely manner to correct or lessen the health risks posed by the site.

Indeterminate Public Health Hazard

This category applies to sites where critical information is lacking (missing or has not yet been gathered) to support a judgment regarding the level of public health hazard. ATSDR will make recommendations to identify the data or information needed to adequately assess the public health risks posed by this site.

No Apparent Public Health Hazard

This category applies to sites where exposure to site-related chemicals might have occurred in the past or is still occurring, but the exposures are not at levels likely to cause adverse health effects. ATSDR may recommend any of the following public health actions for sites in this category:

- cease or further reduce exposure (as a preventive measure)
- community health/stress education
- health professional education
- community health investigation.

No Public Health Hazard

This category applies to sites where no exposure to site-related hazardous substances exists. ATSDR may recommend community health education for sites in this category.

For more information, consult Chapter 9 and Appendix H in the 2005 ATSDR Public Health Assessment Guidance Manual (<http://www.atsdr.cdc.gov/HAC/PHAManual/index.html>).

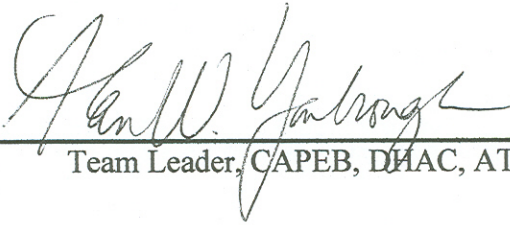
Certification

This **Belgravia (Factory Condominiums) Health Consultation** was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures. Editorial review was completed by the cooperative agreement partner.



Technical Project Officer, Cooperative Agreement Program Evaluation Branch (CAPEB),
Division of Health Assessment and Consultation (DHAC), ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health consultation and concurs with the findings.



Team Leader, CAPEB, DHAC, ATSDR