

Health Consultation

Evaluation of the Vapor Intrusion Pathway

GARVEY ELEVATOR GROUNDWATER CONTAMINATION SITE
HASTINGS, ADAMS COUNTY, NEBRASKA

EPA FACILITY ID: NEN000704351

JULY 7, 2017

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners 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.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared By:

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Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
cEMEG	chronic environmental media evaluation guide
COPC	chemical of potential concern
CREG	cancer risk evaluation guide
CV	comparison value
DL	detection limit
EPA	U.S. Environmental Protection Agency
GET	groundwater extraction and treatment
HVAC	heating, ventilation, and air conditioning
µg/L	micrograms per liter
µg/m ³	micrograms per cubic meter
NA	not analyzed
ND	non-detect
NE	not evaluated
NPL	National Priorities List
PCE	perchloroethylene or tetrachloroethylene
RBC	risk based concentration
RfC	reference concentration
SVE	soil vapor extraction
TCE	trichloroethylene
VI	vapor intrusion
VOC	volatile organic compound

Summary

Introduction	<p>The Agency for Toxic Substances and Disease Registry (ATSDR) understands that people who might have been exposed to harmful substances need information to help protect their health. These include people who work at, visit, or live near the Garvey Elevator site in Hastings, Nebraska. Those people could have been exposed to vapors that might have migrated from fumigants used at the Garvey Elevator site into buildings on and near the site. ATSDR performs public health assessments at all sites on the U.S. Environmental Protection Agency's (EPA) National Priorities List (NPL). ATSDR completed a public health assessment evaluating all exposure pathways for this site on January 12, 2016. This health consultation is a separate document focusing specifically on the vapor intrusion pathway. This health consultation was prepared separately from the public health assessment because the vapor intrusion pathway is complex. The analysis and technical discussions are written mainly for scientists and engineers to advise them on protective action. Including the vapor intrusion analysis would have delayed final release of the public health assessment.</p> <p>ATSDR published a draft of this health consultation for public comment on February 13, 2017. The comment period ended March 31, 2017. ATSDR received no comments during that period. Our objective in this health consultation is to give community members and EPA the information needed to protect public health.</p>
Background	<p>On September 14, 2005, the Garvey Elevator site was listed on the NPL. The grain elevator facility began operation in 1959 and continues to operate as a grain storage facility. Current site features include an office building, maintenance shop, grain elevator silos, head house, grain bin, flat storage, and chemical shed [HGL 2011]. A few homes are located within a quarter mile (1,320 feet) of the site.</p> <p>Carbon tetrachloride and carbon disulfide were stored on-site in a former above-ground storage tank. These chemicals were used as fumigants to kill insects and other grain pests on-site until the use stopped in 1985 [EPA 2012a]. One source of contamination identified was a leak in the underground pipe that delivered the liquid fumigant to the grain elevator. Other sources might be present. Chloroform, tetrachloroethylene (PCE), and trichloroethylene (TCE) were also found on-site.</p> <p>An estimated 55 million cubic feet of contaminated soil extended from the surface down to the groundwater table at around 100 feet deep. Garvey Elevators, Inc. installed soil vapor extraction (SVE) and groundwater extraction and treatment systems to remove contamination</p>

	<p>beneath the facility in 1998. The groundwater plume is estimated to be more than 3 miles long and 1 mile wide.</p> <p>One municipal well and more than 35 private wells had carbon tetrachloride over the EPA maximum contaminant level of 5 micrograms per liter (µg/L). In 2001, Garvey Elevators, Inc., began installing whole-house carbon filtration units for private wells. The municipal wells were shut down because of TCE/PCE contamination from another site. In 2008, EPA began connecting locations using private wells to municipal water from non-contaminated wells.</p> <p>EPA conducted a vapor intrusion investigation for the office/shop and maintenance buildings on-site. The investigation included only one subslab soil gas, indoor air, and outdoor air sampling in August 2009. ATSDR is publishing this focused health consultation as a follow-up report to the full January 12, 2016, public health assessment.</p> <p>This health consultation evaluates the possibility of health effects from vapor that might rise into buildings from volatile contaminants under the site. ATSDR reached four conclusions in this report. Recommendations and next steps are presented to help protect susceptible persons from health problems related to site contamination. Other pathways of potential concern are addressed in the public health assessment for the site [ATSDR 2016].</p>
Conclusion 1	Based on the data reviewed, ATSDR concludes that adult workers are not expected to be harmed by breathing the vapors that might have migrated into the commercial and industrial buildings currently on-site.
Conclusion 1 basis	<p>This conclusion is dependent on the current exposure scenarios with continued operation, maintenance, and performance of the SVE system at the efficiency reported to ATSDR.</p> <p>This conclusion was also made with the assumption that the preliminary data were representative of typical indoor air contaminant levels. However, because the effects of changing seasons and weather on the vapor intrusion pathway was not evaluated for on-site buildings, and levels might vary or increase over time, this conclusion could change.</p> <p>EPA has managed the currently operational SVE remediation system since 2008. Indoor air and subslab gas sampling was performed with the SVE remediation system operating. Testing of the samples did not find chemicals at levels expected to cause harm to workers or visitors to the site maintenance building or office/shop building, based on the current understanding of the site. This assumes that workers will spend limited time in the maintenance building to work on equipment.</p>

	<p>In August 2009, benzene, carbon disulfide, carbon tetrachloride, chloroform, naphthalene, PCE, and TCE were detected in subslab gas. Of these chemicals, only TCE was detected in indoor air. The levels of TCE in indoor air were low. Higher concentration chemicals co-mingled with the subslab TCE were not detected in the indoor air, indicating that the TCE was likely a result of indoor chemical use. Chronic exposure at these low levels could cause a slight increase in lifetime cancer risk. However, chronic exposures are not expected, given current building use. Additionally, ATSDR computer modeling did not predict vapor intrusion at levels of concern. However, multiple samplings during different seasons are needed to evaluate variations in vapor migration potential. Cold weather could cause greater pressure differentials between the subsurface and indoor air, resulting in greater vapor intrusion.</p>
Next steps for conclusion 1	<p>ATSDR recommends the following for EPA:</p> <ul style="list-style-type: none"> • Examine sampling data over the seasons (including subslab gas, indoor air, and outdoor air samples). Use methods sensitive enough to compare with the one-in-a-million cancer risk level and other ATSDR comparison values when possible. • Educate facility occupants on interpreting and responding to performance indicators for the SVE system, such as pressure gauges or alarms. • Continue proper operation and maintenance of the SVE system for the duration of its use. If the SVE system is altered or no longer used in the future, follow-up sampling could show whether or not the changes cause vapor intrusion above acceptable levels. • Periodically inspect site characteristics. Changes to site characteristics, such as heating, ventilation, and air condition (HVAC) systems; utility conduits; exhaust fans; slab integrity; and landscaping might affect vapor migration and warrant follow-up sampling. • Periodically monitor for the formation of biodegradation products in soil gas and air samples on-site until the hazardous parent contaminants are below levels of health concern.
Conclusion 2	<p>The indoor air of on-site buildings appears to be contaminated by the commercial and industrial chemicals currently used or stored within the buildings, and not from vapor intrusion. People in these buildings could have a slight increase in lifetime cancer risk if they are often exposed to indoor air contamination within buildings on-site over many years.</p>
Conclusion 2 basis	<p>Indoor air testing in August 2009 found that benzene concentrations in on-site buildings were more than three times higher in indoor air than</p>

	<p>in the subslab, indicating an indoor source. The benzene subslab gas concentrations were less than the screening levels. Additionally, except for TCE, the most prevalent subsurface contaminants, chlorinated volatile organic compounds (VOCs), were not detected at levels of concern in indoor air. These chemicals were present at concentrations less than levels where EPA requires action. The added cancer risk is less than one extra cancer case in ten thousand people. This is much lower than people's normal cancer risk from other factors in the U.S.</p>
Next steps for conclusion 2	<p>ATSDR recommends reducing VOC exposures in the following ways:</p> <ul style="list-style-type: none"> • Use as much ventilation as possible when using VOC-containing products indoors • Promptly return VOC-containing products into a designated chemical safety cabinet • Appropriately discard VOCs that are no longer needed. <p>Workers may also follow appropriate occupational exposure guidelines, such as those from the National Institute for Occupational Safety and Health and American Conference of Governmental Industrial Hygienists, to protect their health.</p>
Conclusion 3	<p>Conversion of on-site buildings or property to residences or use by more chemical-sensitive persons or more frequent exposures could harm people's health and might warrant additional investigations of contamination on-site in the underground area above the water table.</p>
Conclusion 3 basis	<p>Site-related VOCs are in the soil on-site. People could breathe greater amounts of VOCs over longer durations in buildings on-site in the future if the buildings or types of occupants change.</p>
Next steps for conclusion 3	<p>ATSDR recommends additional vapor intrusion investigation and possibly the use of mitigation systems and monitoring if residences or chemical-sensitive persons occupy the site in the future.</p>
Conclusion 4	<p>Vapor intrusion from off-site groundwater contamination is not expected to occur.</p>
Conclusion 4 basis	<p>VOCs have migrated off-site in groundwater at depths of more than 100 feet. The groundwater contamination is unlikely to be a source of off-site indoor air contamination. Soil gas off-site is not expected to travel long distances because no preferential pathways are present.</p>
For more information	<p>If you have questions or comments, you can call ATSDR toll-free at 1-800-CDC-INFO and ask for information on the Garvey Elevator site.</p>

Introduction

The Garvey Elevator site is located in a mainly rural area southwest of Hastings, Nebraska. The grain storage facility encompasses 22 acres of the 106-acre site. The site is bordered mainly by farmland, with an asphalt paving contractor to the north, a railroad track to the east, and several residences to the northwest and east [HGL 2011]. According to the 2000 U.S. Census, 19 people live within a quarter mile of the site (Appendix A).

Garvey Elevator began operation as a grain storage facility. It used fumigant containing carbon tetrachloride, carbon disulfide, and possibly minor amounts of 1,2-dibromoethane from 1959 to 1985 [HGL 2011]. Small-scale parts cleaning activities might have released tetrachloroethylene (PCE) and trichloroethylene (TCE) at the site [HGL 2011]. A solvent bath was seen in the shop area next to the office building during a 1994 inspection [HGL 2011]. Biodegradation products of some of these chemicals also might have formed on-site. **Figure 1** shows potential source areas from past uses at the site in red. **Figure 2** shows an abbreviated timeline of site activities and evaluations.

During 1986–2006, one municipal well and more than 35 private wells had carbon tetrachloride over the EPA maximum contaminant level of 5 micrograms per liter ($\mu\text{g/L}$) [ATSDR 2016]. In 2001, Garvey Elevators, Inc., began installing whole-house carbon filtration units for private wells. The municipal wells were shut down because of TCE/PCE contamination from another site. In 2008, EPA began connecting locations using private wells to municipal water supplied from non-contaminated wells.

Figure 1. Site use and past locations of buildings at the Garvey Elevator site, Hastings, Nebraska [HGL 2011] -

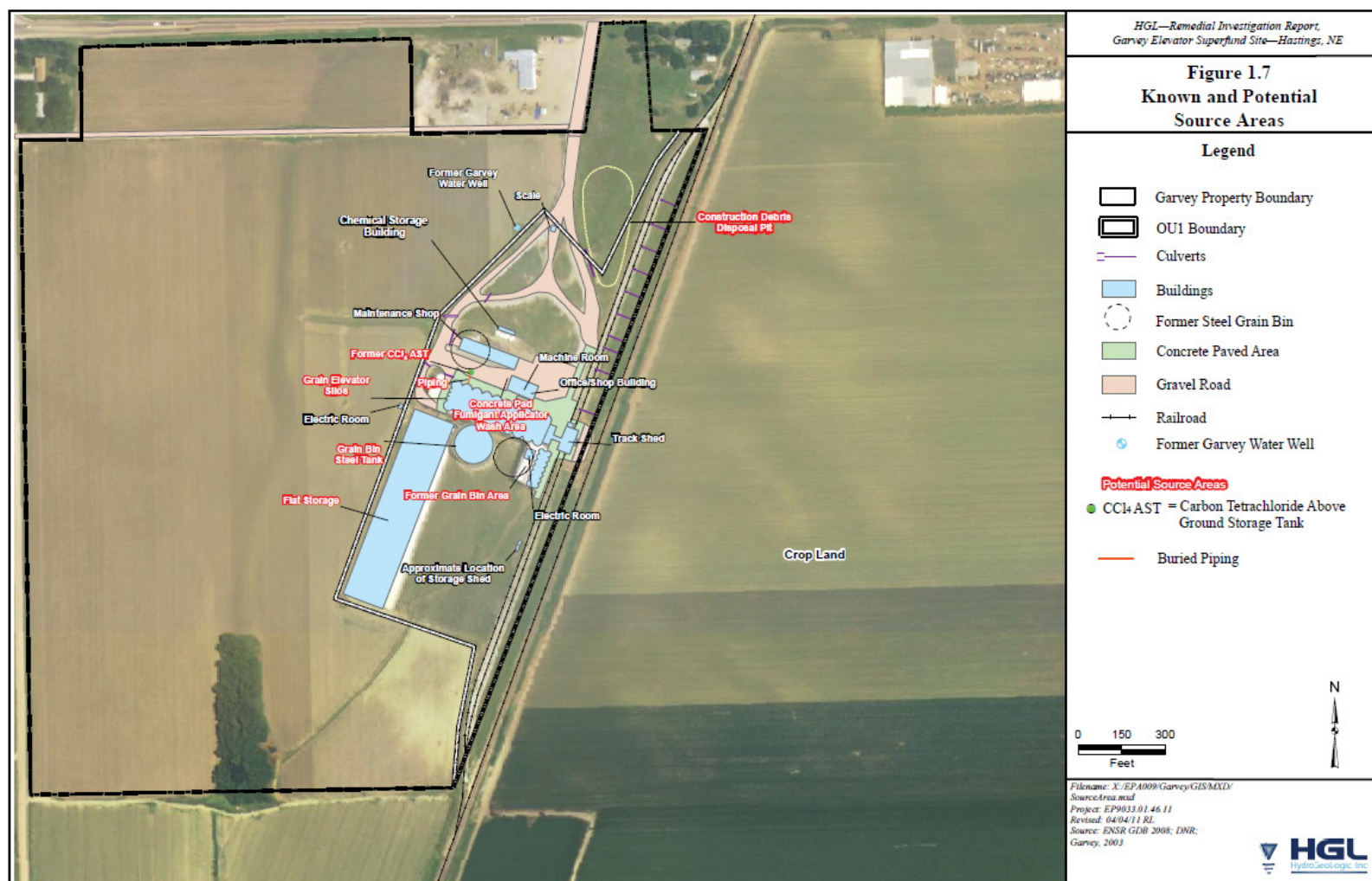


Figure 2. ATSDR's summary of Garvey Elevator site activities and evaluations [HGL 2011]

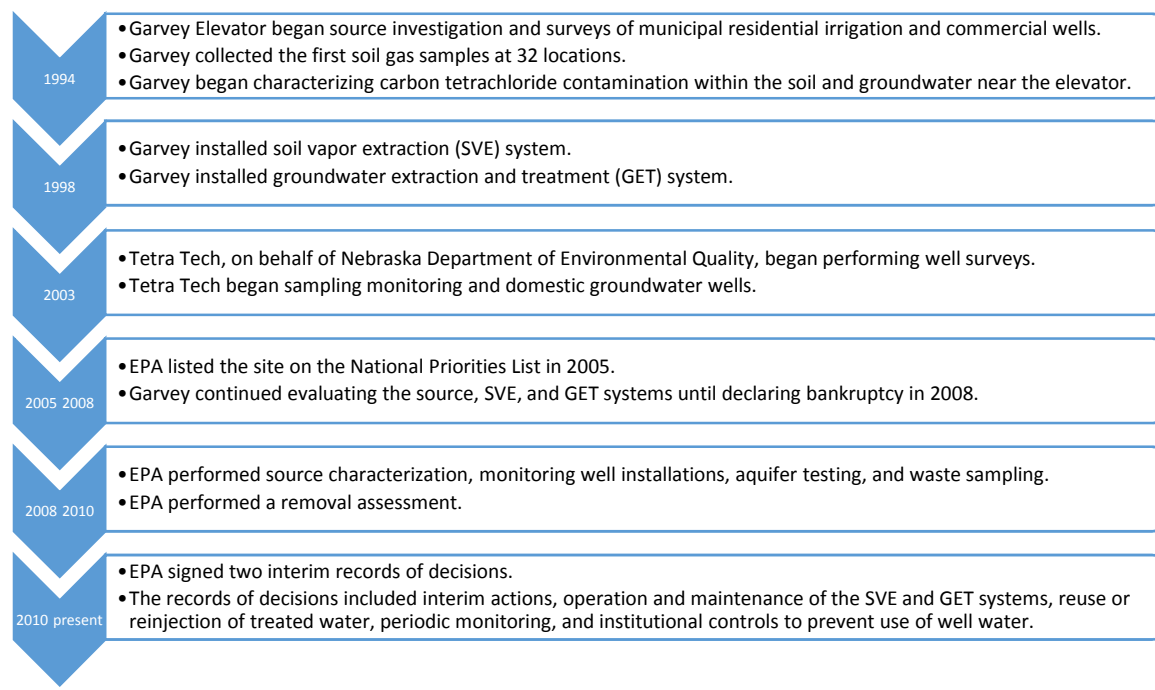
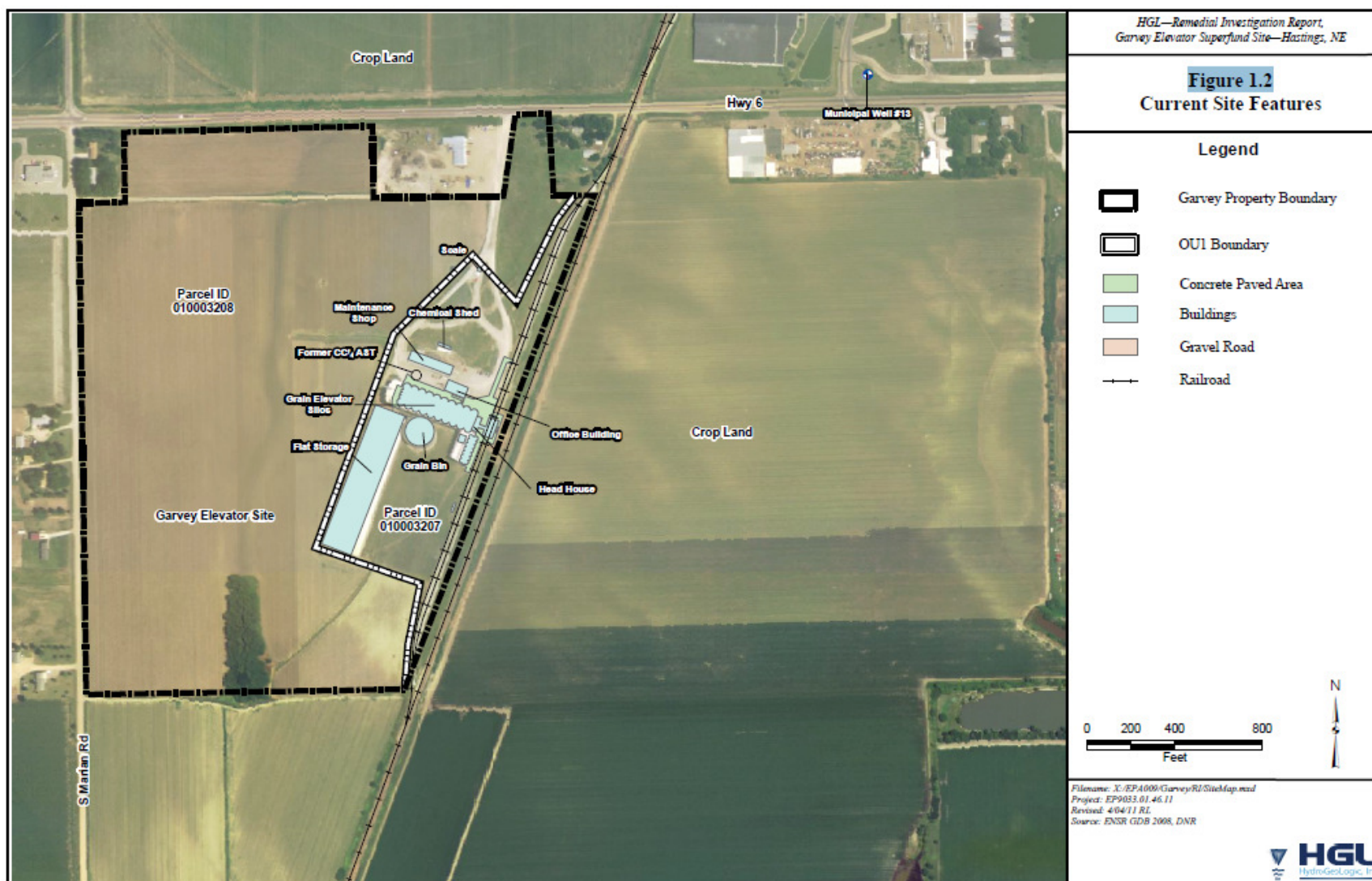


Figure 3 shows the current location and uses of buildings at the site. AGP Grain Marketing, LLC, currently owns and operates the site. Workers and visitors could potentially breathe contaminated indoor air in buildings on-site. People might live or work in new structures on-site in the future if the site use changes.

The Occupational Safety and Health Administration sets regulations to limit exposures directly related to worker activities. However, ATSDR is evaluating this site for potential future use exposures and for current exposures related to historical environmental contaminant releases being addressed by the cleanup [ATSDR 2005].

Vapor intrusion is the process in which volatile organic compounds (VOCs) or solvents from the subsurface, including soil gas or groundwater off-gas, rise into indoor air [ITRC 2007, EPA 2008a]. People can be harmed only when they breathe high enough concentrations of VOCs in indoor air for sufficient lengths of time. Many VOCs are off-gassed into indoor air from building materials and commercial products. It can be hard to tell if indoor air contamination is coming from vapor intrusion or from indoor or outside sources. Therefore, ATSDR looks at VOC levels in the subsurface soil and groundwater to help determine and verify the source of indoor air contaminants [ATSDR 2008]. ATSDR completed a vapor intrusion screening checklist (Appendix B) to help identify other evidence for human exposure.

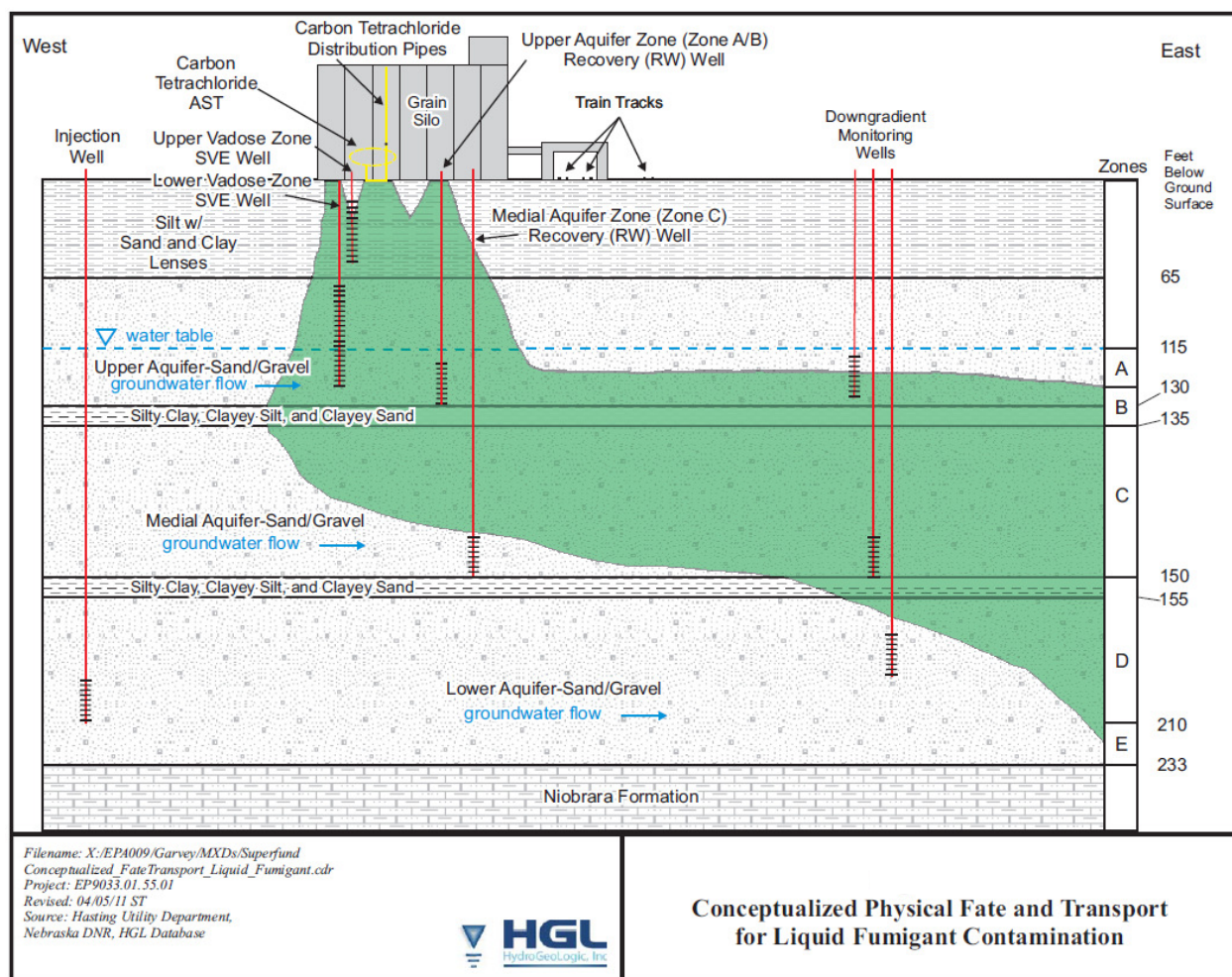
Figure 3. Current Garvey Elevator site features [HGL 2011]



Environmental Data Evaluation

The main contaminant area consists of an estimated 55,000,000 ft³ of fumigant-contaminated soil extended from the surface down to the groundwater table at around 100 feet deep on-site. On-site buildings are expected to be most susceptible to vapor intrusion due to releases from the above ground storage tanks and pipe source area (**Figure 4**).

Figure 4. Schematic of Garvey Elevator grain silo, wells, and subsurface source area [HGL 2011]



Subslab gas samples were collected from worker-occupied buildings on-site near the release area. Each subslab sample port was leak-tested before sample collection and duplicate samples were consistent [HGL 2011]. The subslab gas, indoor air, and outdoor air samples were collected into SUMMA canisters over an 8-hour workday. Appendix C includes an assessment of information concerning data quality.

Only one indoor air sampling from the two most occupied buildings was available for ATSDR to review for this site. That limited our evaluation of people's exposures from breathing indoor air at the site to a snapshot in time. Vapor intrusion rates can vary substantially over time because of changes in temperature, barometric pressure, heating and ventilation, and other factors [EPA 2012b]. ATSDR will discuss the results of the available data, the limitations of the data, and the

recommendations for filling data gaps to better evaluate whether or not exposures of concern might occur.

The data indicated that improper handling of liquid fumigant might have occurred in the construction debris disposal pit area [EPA 2010]. The large amount of contaminated soil on-site could be a source of soil gases that migrate into nearby buildings.

Soil borings and geology studies on-site found no bedrock or karst features above the contaminated groundwater that could serve as preferential pathways [HGL 2011]. Preferential pathways include cracks and other openings or conditions that gases and other contaminants can easily pass through.

Operations occurred on 22 acres of the 106-acre facility. The closest off-site buildings are to the northeast and are at least a quarter mile (1,320 feet) from the above ground storage tank and pipe source area and 450 feet from the construction debris and disposal pit area. The closest off-site buildings in the direction of groundwater flow (to the east-southeast) are 3,000 feet away. No unnatural preferential pathways, such as pipes, are suspected between the source areas and off-site buildings because agriculture fields are present between contaminant areas and residences. Agriculture fields are not generally expected to have underground utilities or sewage lines because those might be damaged by heavy farm equipment or digging.

Although no karst features or fractured bedrock were identified, site soils consist primarily of silt, clay, and loam at the site and some porous (sandy) geological layers extend across the site. Because source characterization and soil gas profiles in the construction debris and disposal pit area were not available for review, we do not know how far shallow soil gases might travel across the agricultural area (Appendix D). If releases generally traveled downward rather than sideways, as shown in **Figure 4**, vapor intrusion into nearby homes would not be expected. The nature and extent of TCE contamination is unknown because the soil gas delineation focused on fumigants.

Contaminated groundwater nearest homes ranges from 115 feet to 150 feet deep. The groundwater contamination is unlikely to be a source of indoor air contamination off-site. Soil gas does not tend to migrate much over long distances (100 feet is a rule of thumb) without preferential pathways. The plume of contaminated groundwater is greater than 100 feet deep and no preferential pathways were identified. However, because the groundwater contamination is so extensive, it likely resulted from a large volume of contamination in overlying soils on-site. In 1994, the U.S. Environmental Protection Agency (EPA) did soil gas testing of 32 locations at the Garvey Elevator site. It found high concentrations of carbon tetrachloride ranging from non-detect to >29,000,000 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) at 9–30 feet below ground surface (bgs). Concentrations were highest near the former above ground storage tank [HGL 2011]. However, the 1994 soil gas testing is not useful for evaluating recent exposures because the SVE system installed in 1998 removes soil gases and influences soil gas migration patterns.

Site Remediation Activities

EPA installed 11 soil vapor extraction wells (eight screened at 20–50 feet and three at 60–110 feet bgs); eight groundwater extraction and treatment (GET) wells (screened in the upper and middle aquifers between about 116 feet and 150 feet) were installed around the site buildings in

1999 [HGL 2011]. The systems removed about 10,000 pounds of carbon tetrachloride within the first 2 years of operation [EPA 2010].

The SVE and GET systems initially had high rates of VOC recovery. The SVE system required treatment by catalytic oxidation before discharging the effluent for the first 4 months of operation. The GET system required treatment before re-injecting the effluent into the ground on-site [HGL 2011]. After recovery dropped, the systems were operated intermittently until 2008, when EPA began performance monitoring, operation, and maintenance on the SVE systems [HGL 2011]. EPA has operated the systems continuously since 2008. SVE well concentrations of carbon tetrachloride ranged from 1,030 $\mu\text{g}/\text{m}^3$ to 356,000 $\mu\text{g}/\text{m}^3$ in individual wells, with a combined effluent of 20,100 $\mu\text{g}/\text{m}^3$. The GET well concentrations ranged from 9.4 $\mu\text{g}/\text{L}$ to 439 $\mu\text{g}/\text{L}$.

Vertical profiling of soil gas contamination was performed in 2007 and 2008 at 10 foot intervals down to groundwater. Shallow soil gas contamination contained relatively low levels of carbon tetrachloride compared with deeper samples, perhaps because of the SVE system.

On-site Building Evaluations

EPA collected an inventory of chemical products from the office/shop and maintenance buildings on-site to account for background sources during the vapor intrusion investigation (Appendix E) [HGL 2011]. Three chemicals detected in subslab gas on-site (naphthalene, PCE, and TCE) are found in the types of products identified from the inventory [NLM 2010]. Naphthalene was also detected during soil investigations, mainly at a former debris disposal area north of the main grain silos [HGL 2011]. The benzene concentration detected in the indoor air was greater than the subslab gas concentrations, and therefore most likely released from the products in the maintenance building (**Table 1**). Higher concentration chemicals intermixed with the subslab TCE were not detected in the indoor air, indicating that the TCE was likely a result of indoor chemical use in the maintenance building. In other words, a single chemical would not be expected to separate from a mixture of chemicals detected in the soil gas and migrate into indoor air.

Some chemical groups might change over time through biodegradation, such as vinyl chloride creation from chlorinated solvents. Chloroform is likely the biodegradation product of carbon tetrachloride. Potential biodegradation products of PCE and TCE, including dichloroethylene and vinyl chloride, were below reporting limits [HGL 2011]. Appendix C summarizes and discusses the reporting limits and screening levels.

Two buildings on-site in which workers spend a substantial amount of time indoors are susceptible to vapor intrusion: the maintenance (**Figure 5**) and office/shop (**Figure 6**) buildings. On August 24, 2009, EPA sampled indoor air, outdoor air, and subslab gas to directly measure VOC levels in and around these buildings [HGL 2011]. The office/shop building was characterized with six subslab gas and six indoor air samples. The maintenance building has a dirt floor in part of the building and a concrete slab in the enclosed shop area. The paved room in the maintenance building was characterized with four subslab gas and four indoor air samples. Subslab gas, indoor air, and outdoor air samples were collected over an 8-hour period to represent exposure during a typical full work day.

Figure 5. Garvey Elevator maintenance building sampling locations and results — August 24, 2009 [HGL 2011]

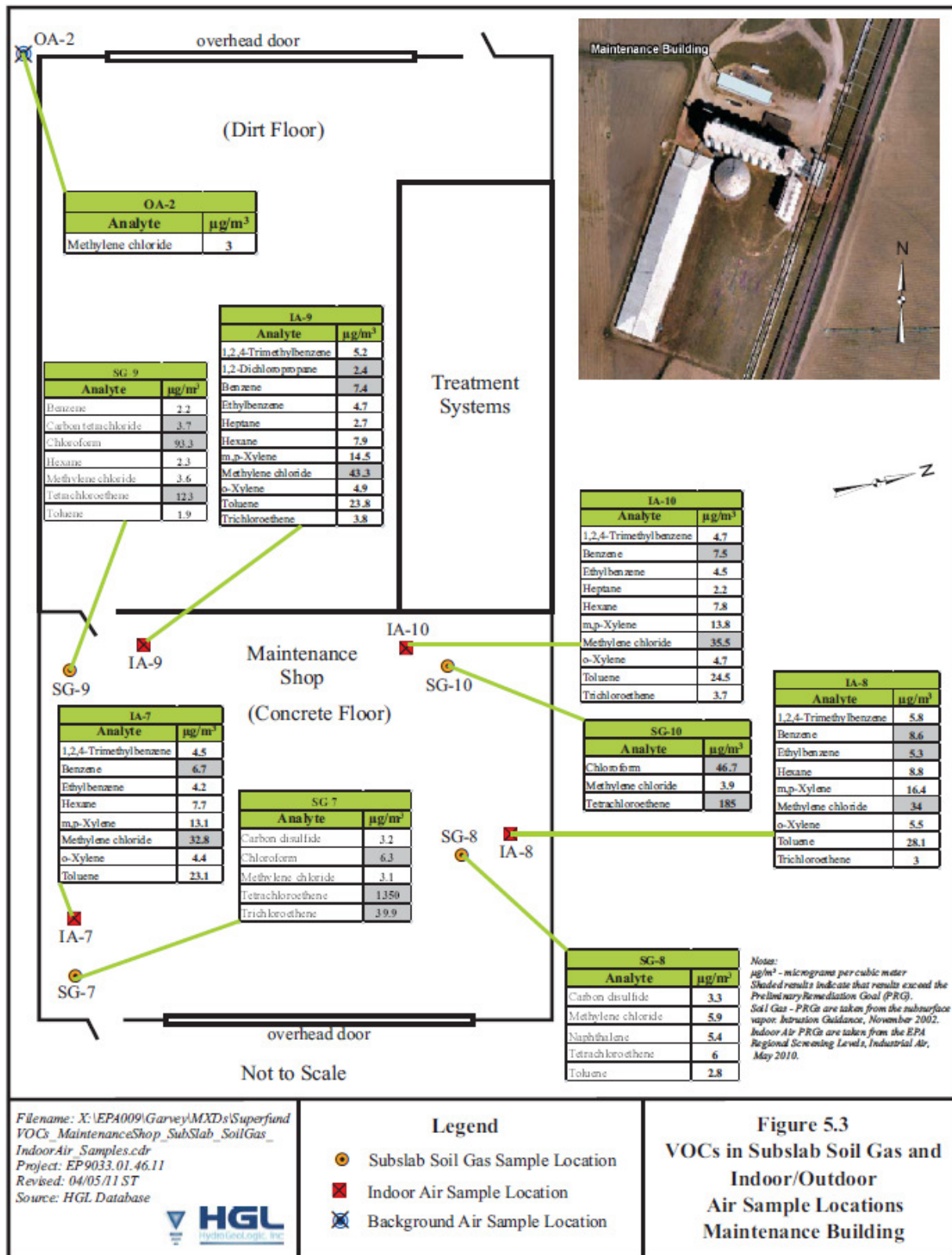
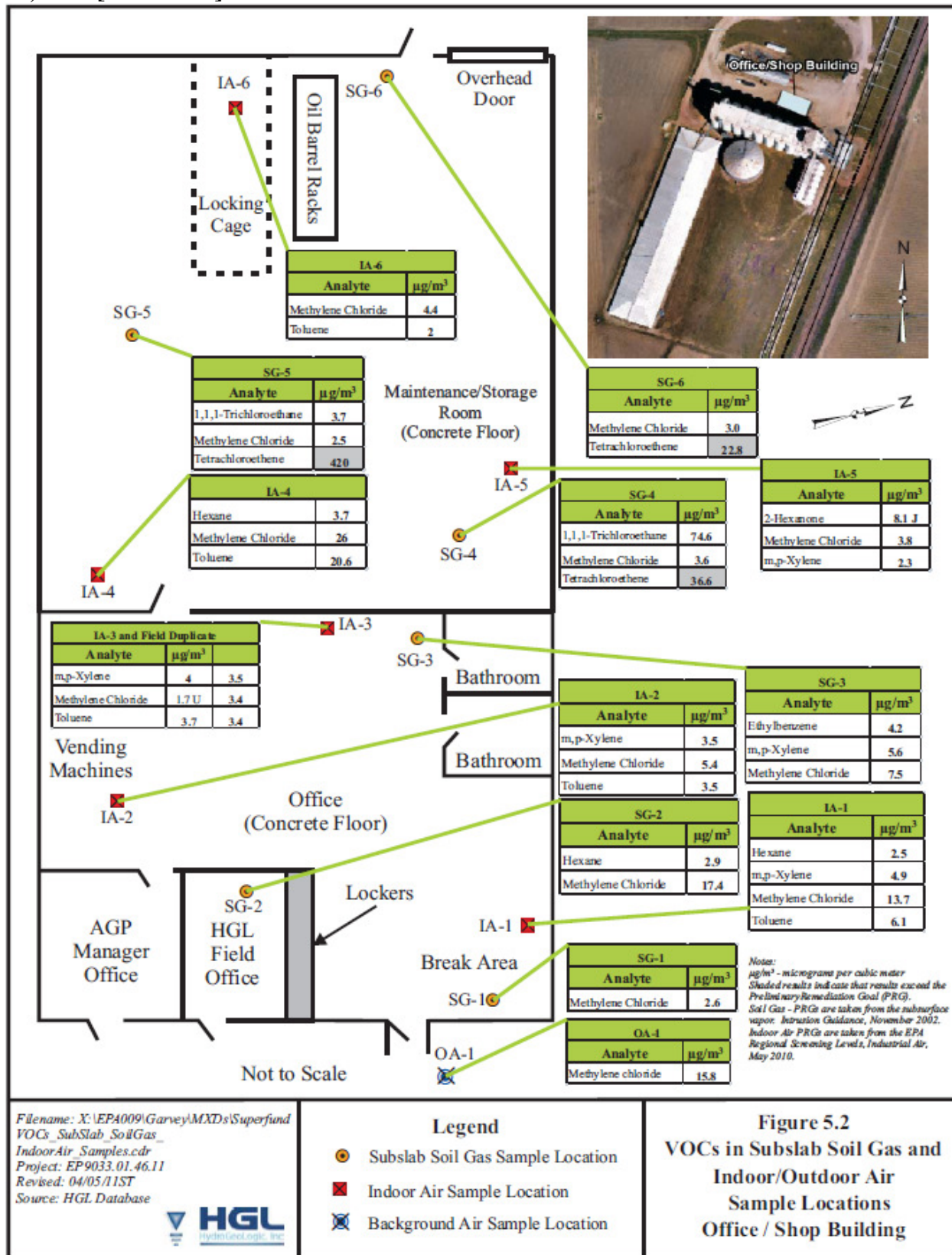


Figure 6. Garvey Elevator office/shop building sampling locations and results — August 24, 2009 [HGL 2011]



Maintenance Building

Table 1 shows the maximum detected concentrations in and beneath the maintenance building measured during the August 2009 sampling [HGL 2011]. Benzene and TCE were detected above ATSDR inhalation comparison values (CVs) and subslab gas screening levels. 1,2-Dibromoethane, carbon tetrachloride, chloroform, and naphthalene detection or reporting limits were greater than ATSDR inhalation CVs. CVs are concentrations set well below levels that are known or anticipated to result in adverse health effects (see **Box**). CVs are derived from scientific studies and modified by safety factors to be more protective of human health. Concentrations greater than CVs do not necessarily mean that people will get sick from exposures, but that further evaluation is needed to evaluate the potential for health effects. Subslab gas screening levels are derived from ATSDR inhalation CVs by dividing by EPA's attenuation factor (0.03) recommended for screening [EPA 2012b]. The attenuation factor is the ratio of the indoor air concentration arising from vapor intrusion to the subsurface vapor concentration.

Carbon tetrachloride, chloroform, naphthalene, and PCE were detected above subslab gas screening levels, but the detection limits were not sensitive enough to tell if they were below ATSDR inhalation CVs in indoor air. 1,2-Dibromoethane and naphthalene detection limits were not sensitive enough to determine whether or not inhalation CVs or subslab gas screening levels were exceeded.

Definitions of ATSDR-Derived Comparison Values

- **Environmental media evaluation guides (EMEGs)**
EMEGs are estimated contaminant concentrations that are not expected to result in adverse non-carcinogenic health effects based on ATSDR evaluation. EMEGs are based on ATSDR minimal risk levels and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight. A minimal risk level is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. Minimal risk levels are based on noncancer health effects only and are not based on a consideration of cancer effects.
- **Cancer risk guides (CREGs)** — CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (1E-06) persons exposed during their lifetime (78 years). ATSDR's CREGs are calculated from EPA's cancer slope factors for oral exposures or unit risk values for inhalation exposures. Cancer slope factors are used to estimate the risk of cancer associated with exposure to a carcinogenic or potentially carcinogenic substance. A slope factor is an upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent by ingestion or inhalation. CREGs are based on EPA evaluations and assumptions about hypothetical cancer risks at low levels of exposure.
- **Cancer regional screening levels (RSLs)** — EPA's cancer RSLs may be used in ATSDR's hierarchy of CVs in the absence of CREGs.

Table 1. Maximum detected concentrations ($\mu\text{g}/\text{m}^3$) in Garvey Elevator maintenance building indoor air and subslab gas, by August 24, 2009 sampling location (Figure 5) [HGL 2011]

Chemical	Indoor air*				Inhalation CV	Subslab gas*				Subslab gas screening level
	IA-7	IA-8	IA-9	IA-10		SG-7	SG-8	SG-9	SG-10	
1,2-Dibromoethane	<3.8	<3.8	<3.8	<3.8	0.0017 CREG, 9 RfC	<3.8	<3.8	<3.8	<3.8	0.057 CREG
Benzene	6.7	8.6	7.4	7.5	0.13 CREG, 9.6 cEMEG	<1.6	<1.6	2.2	<1.6	4.0 CREG
Carbon tetrachloride	<3.1	<3.1	<3.1	<3.1	0.17 CREG, 190 cEMEG	<3.1	<3.1	3.7	<3.1	6.0 CREG
Chloroform	<2.4	<2.4	<2.4	<2.4	0.043 CREG, 98 cEMEG	6.3	<2.4	93.3	46.7	1.43 CREG
Naphthalene	<5.2	<5.2	<5.2	<5.2	3.7 cEMEG, 0.083 cancer RSL [†]	<5.2	5.4	<5.2	<5.2	3.0 cancer RSL
PCE	<3.4	<3.4	<3.4	<3.4	3.8 CREG, 41 cEMEG	1350	6	123	185	127 CREG
TCE	<2.7	3	3.8	3.7	0.22 CREG, 2.1 cEMEG	39.9	<2.7	<2.7	<2.7	8.0 CREG

Abbreviations: CV = comparison value, CREG = cancer risk evaluation guide, RfC = U.S. Environmental Protection Agency (EPA) reference concentration, cEMEG = chronic environmental media evaluation guide, cancer RSL = EPA cancer regional screening level.

* All outdoor air samples for these chemicals were less than the detection or reporting limit. Bold values were greater than the inhalation CV or subslab gas screening level.

[†] The naphthalene cancer RSL is not listed in ATSDR's CV tables. It comes from an additional source commonly used when ATSDR values are not available [EPA 2016].

Office/Shop Building

No chemicals at levels of concern were detected in indoor air of the office/shop building (**Table 2**). No PCE was detected in the subslab gas beneath the office area. PCE subslab gas above the screening level (up to 420 $\mu\text{g}/\text{m}^3$) was detected beneath the shop room. The six other VOCs from **Figure 6** were not detected in indoor air or soil gas but had detection or reporting limits above the screening levels.

Table 2. Maximum detected concentrations ($\mu\text{g}/\text{m}^3$) in Garvey Elevator office/shop building indoor air and subslab gas, by August 24, 2009 sampling location (Figure 6) [HGL 2011]

Chemical	Indoor air [†]	Inhalation CV	Subslab gas [†]						Subslab gas screening level
	IA-1 – IA-6		SG-1	SG-2	SG-3	SG-4	SG-5	SG-6	
1,2-Dibromoethane	All <3.8	0.0017 CREG, 9 RfC	<3.8	<3.8	<3.8	<3.8	<3.8	<3.8	0.057 CREG
Benzene	All <1.6	0.13 CREG, 9.6 cEMEG	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	4.0 CREG
Carbon tetrachloride	All <3.1	0.17 CREG, 190 cEMEG	<3.1	<3.1	<3.1	<3.1	<3.1	<3.1	6.0 CREG
Chloroform	All <2.4	0.043 CREG, 98 cEMEG	<2.4	<2.4	<2.4	<2.4	<2.4	<2.4	1.43 CREG
Naphthalene	All <5.2	3.7 cEMEG, 0.083 cancer RSL [¶]	<5.2	<5.2	<5.2	<5.2	<5.2	<5.2	3.0 cancer RSL
PCE	All <3.4	3.8 CREG, 41 cEMEG	<3.4	<3.4	<3.4	36.6	420	22.8	127 CREG
TCE	All <2.7	0.22 CREG, 2.1 cEMEG	<2.7	<2.7	<2.7	<2.7	<2.7	<2.7	8.0 CREG
Abbreviations: CV = comparison value, CREG = cancer risk evaluation guide, RfC = U.S. Environmental Protection Agency (EPA) reference concentration, cEMEG = chronic environmental media evaluation guide, cancer RSL = EPA cancer regional screening level. [†] All outdoor air samples for these chemicals were less than the detection or reporting limit. Bold values were greater than the CV or subslab gas screening level. [¶] The naphthalene cancer RSL is not listed in ATSDR's CV tables but is from an additional source commonly used when ATSDR values are not available [EPA 2016].									

Detailed Environmental Data Review of 1,2-Dibromoethane

Some of the 80/20 (80% carbon tetrachloride and 20% carbon disulfide) fumigant mixture used on-site might have contained a small amount of 1,2-dibromoethane [HGL 2011]. EPA noted that none of the extensive database of soil, groundwater, and soil gas sampling results indicated that 1,2-dibromoethane was present beneath the site. The analytical techniques that EPA used in its analysis of the samples also have not changed since the samples were analyzed. The laboratory methods in use today do not have reporting limits sensitive enough to detect at ATSDR's screening levels (U.S. Environmental Protection Agency, personal communication, 2016).

Between February 2007 and June 2012, EPA collected and analyzed 1,045 groundwater samples for the presence of 1,2-dibromoethane. The samples were collected from monitoring wells, direct push technology probes, source area recovery wells, groundwater treatment system influent and effluent, and residential wells. Of the 1,045 samples, 78 were analyzed using the most sophisticated techniques available to EPA. Those techniques had a reporting limit of 0.02 $\mu\text{g}/\text{L}$. ATSDR's groundwater screening level for vapor intrusion is 0.064 $\mu\text{g}/\text{L}$; 116 samples had a

reporting limit of 0.025 µg/L, 365 samples had a reporting limit of 0.05 µg/L, and 371 samples had a reporting limit of 1.0 µg/L. Of all the groundwater samples tested, only two showed the presence of 1,2-dibromoethane. At a depth of 130 feet in two wells, 1,2-dibromoethane was reported at concentrations of 0.0261 µg/L and 0.0713 µg/L, respectively. However, both sample analyses were qualified as having high recovery, which means the results might have been biased towards greater values. Almost all of the other results were valid and did not have qualifiers (U.S. Environmental Protection Agency, personal communication, 2016).

EPA collected and analyzed 121 soil samples in August 2009, of which 120 had a reporting limit of <10 µg/kg. 1,2-Dibromoethane was not detected in any of the samples. The 10 µg/kg reporting limit is below ATSDR's soil CV for direct exposure of 190 µg/kg, though soil concentrations are not a reliable indicator of vapor intrusion exposure (U.S. Environmental Protection Agency, personal communication, 2016).

EPA collected and analyzed 245 soil gas samples between October 2006 and September 2009. Of those samples, 10 had a reporting limit of 3.8 µg/m³ and 233 samples had a reporting limit of 250 µg/m³. These reporting limits are greater than ATSDR's screening level of 0.057 µg/m³ for vapor intrusion, but they were the lowest available to EPA at the time (U.S. Environmental Protection Agency, personal communication, 2016).

Exposure Evaluation (Dose Estimation)

An important part of determining if people will become sick from chemicals is finding out how much of the chemicals they come into contact with. For places like Garvey Elevator, where people do not stay all the time, the average amount people are exposed to (the dose) is estimated by making adjustments to the measured concentrations. ATSDR estimated adjusted indoor air exposures by using the following equation. We assumed that workers breathe the maximum indoor air concentrations detected (or the detection limit, when not detected) on the site 8 hours a day (8/24 hours) during 5 days of each week (5/7 days) over a 50-year career in a 78-year lifespan (**Table 3**).

$$\text{Adjusted indoor air concentration} = \text{Detected indoor air concentration} \times 8/24 \times 5/7 \times 50/78$$

Adjusted indoor air levels for six of the seven contaminants were detected or had detection limits above their cancer CVs, called cancer risk evaluation guides (CREGs)* (**Table 3**). None of the adjusted indoor air levels exceed non-cancer CVs for any contaminant tested.

Benzene and TCE were the only VOCs of concern that were detected. Both require further evaluation because they were greater than the comparison values. 1,2-Dibromoethane, carbon tetrachloride, chloroform, and naphthalene were not detected in indoor air, but require further evaluation because their detection limits were greater than the CVs.

* CREGs are estimated contaminant concentrations that would be expected to cause no more than one excess cancer in a million (1E-06) persons exposed during their lifetime. Concentrations greater than CREGs do not necessarily mean that people will develop cancer from exposures, but that further evaluation is needed to assess the cancer risk.

TCE was the only chemical of concern detected above levels typically found in homes in the United States (**Table 3**). The level detected was only slightly higher ($3.8 \mu\text{g}/\text{m}^3$) than the upper 95th percentile typical in homes ($3.3 \mu\text{g}/\text{m}^3$).

The chemicals found in greatest concentration in subslab gas, PCE ($1,350 \mu\text{g}/\text{m}^3$) and chloroform ($93.3 \mu\text{g}/\text{m}^3$), were not detected in indoor air, indicating that vapor intrusion was not occurring during this sampling. Benzene had the highest concentration in indoor air ($8.6 \mu\text{g}/\text{m}^3$) and the lowest in subslab gas ($2.2 \mu\text{g}/\text{m}^3$), indicating that the source may be inside the building.

However, the accuracy and precision of indoor air measurements (Appendix C) and small sample size limit our certainty in determining the benzene source. The lack of a vapor intrusion pathway could be due to multiple factors. Contamination greater than 100 feet deep is not likely a vapor intrusion source. The soil vapor extraction system could be actively removing soil vapors or decreasing subslab pressures enough to prevent vapor intrusion from occurring at levels of concern. Some ventilation systems create positive pressure within buildings to prevent vapors from entering. Opening windows and doors equalizes indoor air pressure with that of the subsurface preventing vapor intrusion from occurring. Many of these factors can be affected by weather conditions, so this single sampling might not be reflective of exposures during other weather conditions.

To complement the sampling at the Garvey Elevator site, ATSDR performed vapor intrusion modeling using the site subslab gas measurements and site-specific assumptions, where available (Appendix F). The indoor air concentrations modeled from measured subslab gas levels are substantially lower than the measured indoor air concentrations, with the exception of PCE (**Table 3**). This supports the hypothesis that indoor sources are likely contributing to indoor air contamination. However, vapor intrusion is highly unpredictable and requires robust sampling and analysis to characterize with a reasonable level of certainty.

Table 3. Comparison of adjusted maximum indoor air, modeled indoor air,* comparison values, and generic indoor air concentrations[†] (in µg/m³),[‡] Garvey Elevator site, Hastings, Nebraska

Chemical	Maximum detected indoor air	Adjusted [§] indoor air	Modeled indoor air [¶]	Inhalation comparison values	Generic indoor air ^{**}
1,2-Dibromoethane	< 3.8	0.28	0.00119	0.0017 (CREG) 9 RfC	No value
Benzene	8.6	1.26	0.00647	0.13 (CREG) 9.6 (cEMEG)	9.9–29
Carbon tetrachloride	< 3.1	0.23	0.0103	0.17 (CREG) 190 (cEMEG)	< Reporting limit - 1.1
Chloroform	< 2.4	0.18	0.292	0.043 (CREG) 98 (cEMEG)	4.1–7.5
Naphthalene	< 5.2	0.38	0.00305	0.083 (cancer RSL) ^{††} 3.7 (cEMEG)	No value
Tetrachloroethylene	<3.4	0.25	3.64	3.8(CREG) 41 (cEMEG)	4.1–9.5
Trichloroethylene	3.8	0.56	0.112	0.22 (CREG) 2.1 (cEMEG) ^{‡‡}	0.56–3.3

Abbreviations: CREG = cancer risk evaluation guide, RfC = U.S. Environmental Protection Agency (EPA) reference concentration, cEMEG = chronic environmental media evaluation guide, cancer RSL = EPA cancer regional screening level.

* Indoor air contaminant levels were modeled from subslab gas data.

[†] Samples collected August 24, 2009 [HGL 2011].

[‡] Values in bold exceed the inhalation comparison values.

[§] Environmental concentrations adjusted for worker exposures of 8 hours per day, 5 days per week, 50 weeks per year, and 50 years per 78-year lifespan. One-half the detection limit was used when chemicals were not detected.

[¶] See Appendix F.

^{**} *Background indoor air concentrations of volatile organic compounds in North American residences (1990–2005)*^{††} The naphthalene cancer RSL is not listed in ATSDR's comparison value tables. It comes from an additional source commonly used when ATSDR values are not available [EPA 2016].

^{‡‡} The cEMEG for trichloroethylene also applies to intermediate exposures from 2 weeks to one year duration for fetal heart defects and thymus effects.

Public Health Implications

ATSDR estimated increased lifetime cancer risks (Appendix G) based on the maximum indoor air measurements or one half of the detection or reporting limits, when results were less than detection or reporting limits (**Table 4**). Estimates of the first six of the VOCs in **Table 4** had a combined cancer risk of 31 extra cancer cases in a million people exposed, which is within the range where EPA weighs the advantages and disadvantages of the cleanup options in deciding on action.² The other VOC, 1,2-dibromoethane, was not detected above the detection or reporting limit. Based on half the limit, the cancer risk for 1,2-dibromoethane was estimated to be 1.7 extra cancer cases in ten thousand people exposed, which is just greater than EPA's acceptable cancer risk decision-making range. Because one in two men and one in three women will get cancer in their lifetime, an added lifetime risk of two in ten thousand people was considered a slight increase of cancer risk.

Table 4. Estimated cancer risks based on indoor air measurements at the Garvey Elevator site, Hastings, Nebraska

	Adjusted indoor air ($\mu\text{g}/\text{m}^3$)	Excess lifetime cancer risk*
Benzene	1.26	9.8E-06
Carbon tetrachloride	0.23	1.4E-06
Chloroform	0.18	4.1E-06
Naphthalene	0.38	1.3E-05
Tetrachloroethylene	0.25	6.5E-08
Trichloroethylene	0.56	2.3E-06
1,2-Dibromoethane	0.28	1.7E-04
Total		2.0E-04 [†]

* Excess lifetime cancer risk is the number of extra cancer cases estimated to occur in persons exposed compared to cancers in the same number of people in the general population without this exposure.

[†] The excess lifetime cancer risk without including 1,2-dibromoethane is 3.1E-05.

The U.S. Department of Health and Human Services has determined that 1,2-dibromoethane can reasonably be anticipated to be a human carcinogen [ATSDR 1995]. The scientific studies did not report increased cancer in people exposed for several years to 1,2-dibromoethane. However, rats and mice that breathed, swallowed, or touched it for long periods had cancer in many organs.

Chronic non-cancer effects usually depend on long-term average exposures. Some chemicals, such as TCE, can cause health effects within shorter periods of exposure at relatively low concentrations. The adjusted levels detected in indoor air at the Garvey Elevator site are below the ATSDR non-cancer CV for TCE health effects. The cMEG is based on the most sensitive health effects of an increase in fetal cardiac malformations in rats and impaired thymus glands in mice exposed to TCE [ATSDR 2014]. The effect level for fetal heart malformations, based on a human equivalent concentration derived from rat studies, is 21 $\mu\text{g}/\text{m}^3$ for 3 weeks exposure

² EPA's cancer risk management range is one in a million (1E-06) to one in ten thousand (1E-04).

during pregnancy. The risk for harmful health effects might increase if the indoor levels increased from background source emission, vapor intrusion, or installation of new buildings, unless preemptive systems are put in place to reduce exposure levels.

Uncertainties and Data Limitations

Indoor air variability — Indoor air TCE levels can vary greatly. Indoor air samples represent exposure levels at a single point in time. Actual average and peak levels could be considerably higher or lower than those found in the single sampling collected in August 2009 at the site. Fluctuations that result in higher short-term average exposures could result in exposures of concern to sensitive persons, especially fetuses in the first trimester of development. Results from subslab gas samples varied by location by more than two orders of magnitude (100×).

Detection limits — Carcinogenic VOCs have very low toxicity endpoints. The sampling and analysis methods used were not sufficiently sensitive to determine whether or not those endpoints were exceeded for five of the seven chemicals requiring further evaluation. ATSDR's analysis assumed the presence of VOCs at half the detection limit. At half the detection limit, no health hazard would be present for all but 1,2-dibromoethane, which is carcinogenic at extremely low levels. Site information indicates that 1,2-dibromoethane is not likely to be present in soil gas and air, but we cannot be certain without resampling using more sensitive methods.

Meteorological effects — Vapor intrusion rates tend to vary by area and on an hourly, daily, and monthly basis [Hers 2001]. Variability over time could be caused by changes in temperature, barometric pressure, precipitation, ground cover by snow and ice, and groundwater levels [EPA 2012b]. When vapor intrusion sampling took place on August 24, 2009, temperatures reached the mid-90s Fahrenheit (F) and no rain had fallen for several days. Average daily maximum temperatures range from 87.8°F in July to 36.0°F in January. Daily minimum temperatures range from 66.4°F in July to 16.0°F in January [NOAA 2014]. May tends to be the rainiest month, with an average of 4.57 inches of rain. Snowfall tends to average from 0.2 inches in September to 6.5 inches in February, with snowfall typically occurring from September through April. Vapor intrusion rates may be substantially different during winter conditions.

Other indoor air contributions — Indoor air exposures can result from a combination of breathing VOCs from vapor intrusion and indoor background sources. At the Garvey Elevator site, workers might be exposed to chemicals stored in the buildings on-site, actively in use, or from vapor intrusion from subsurface VOCs that resulted from past releases. EPA has summarized typical background levels of VOCs in homes from building materials, carpets, adhesives, concrete sealers, cabinet finishes, maintenance supplies, chemicals, commercial products, or cigarette smoke [EPA 2011a]. However, occupational buildings, such as those at the Garvey Elevator site, might have work-related solvents, fumigants, agro-products, fuels, lubricants, creosote-treated wood, or other chemicals stored on-site. Appendix E gives an inventory of potential indoor sources at the site [HGL 2011]. A list of chemicals present in many commercially available products can be obtained from the National Library of Medicine [NLM 2010].

In the maintenance building, EPA identified six contaminants in the indoor air: 1,2,4-trimethylbenzene, ethylbenzene, m,p-xylenes, methylene chloride, n-heptane, and o-xylene. None of those were detected in the soil gas. Three other contaminants (benzene, n-hexane, and toluene) were present in the indoor air at higher concentrations than in the soil gas. In the

office/shop building, EPA identified two contaminants (methyl isobutyl ketone and toluene) present in the indoor air, but absent in the soil gas. Three other contaminants (acetone, methyl ethyl ketone, and methylene chloride) were present in the indoor air at higher concentrations than in the soil gas.

Outdoor air samples were collected to establish background VOC levels, if present. Analysis of the outdoor air samples found no link between outdoor air and indoor VOC detections.

Improving indoor air quality — Actions that can reduce indoor source VOC exposure include the following:

- Provide for maximum ventilation while using VOC-containing products indoors
- Store VOC-containing products properly in a well-ventilated area
- Appropriately discard VOC-containing products that are no longer needed
- Keep doors between maintenance/shop areas and more frequently occupied offices closed [EPA 2011b]

If new buildings are built on the site, any located near areas with soil gas contamination should include vapor mitigation systems [EPA 2008b, 2008c].

Conclusions

1. Based on the data reviewed, ATSDR concludes that adult workers are not expected to be harmed by breathing the vapors that might have migrated into the commercial and industrial buildings currently on-site.
2. The indoor air of on-site buildings appears to be contaminated by the commercial and industrial chemicals currently used or stored within the buildings, and not from vapor intrusion. People in these buildings could have a slight increase in lifetime cancer risk if they are often exposed to indoor air contamination within buildings on-site over many years.
3. Conversion of on-site buildings or property to residences or use by more chemical-sensitive persons or more frequent exposures could harm people's health and might warrant additional investigations of contamination on-site in the underground area above the water table.
4. Vapor intrusion from off-site groundwater contamination is not expected to occur.

Recommendations

ATSDR recommends the following to EPA:

- Examine sampling data over the seasons (including subslab gas, indoor air, and outdoor air samples). Use methods sensitive enough to compare with the one-in-a-million cancer risk level and other ATSDR comparison values when possible.
- Educate facility occupants on interpreting and responding to performance indicators for the SVE system, such as pressure gauges or alarms.
- Continue proper operation and maintenance of the SVE system for the duration of its use. If the SVE system is altered or no longer used in the future, follow-up sampling could show whether or not the changes cause vapor intrusion above acceptable levels.

- Periodically inspect site characteristics. Changes to site characteristics, such as heating, ventilation, and air condition (HVAC) systems; utility conduits; exhaust fans; slab integrity; and landscaping might affect vapor migration and warrant follow-up sampling.
- Periodically monitor for the formation of biodegradation products in soil gas and air samples on-site until the hazardous parent contaminants are below levels of health concern.
- Additional vapor intrusion investigation and possibly the use of mitigation systems and monitoring are recommended if residents or chemical-sensitive persons occupy the site in the future.

ATSDR recommendations for employees at the Garvey Elevator site include the following:

- Use as much ventilation as possible when using VOC-containing products indoors
- Promptly return VOC-containing products into a designated chemical safety cabinet
- Appropriately discard VOCs that are no longer needed.
- Follow appropriate occupational exposure guidelines, such as those from the National Institute for Occupational Safety and Health and from the American Conference of Governmental Industrial Hygienists.

Public Health Action Plan

The public health action plan for the site contains a description of actions ATSDR has taken and will take. This plan has action items designed to limit and prevent harmful human health effects resulting from contact with hazardous substances in the environment.

Completed public health actions

ATSDR reviewed available historical information on site activities and information from environmental investigations including

- groundwater, soil gas, and indoor and outdoor air sampling, and
- remediation activities.

ATSDR invited members of the public to comment on this health consultation. ATSDR received no comments during the public comment period.

EPA completed

- site listing on the National Priorities List
- source characterization, monitoring well installations, aquifer testing, and waste sampling and disposal
- a removal assessment
- a record of decision
- installation of SVE and GET systems
- institutional controls to prevent use of well water

Planned public health actions

ATSDR is available to help address health concerns, on request, by

- making this health consultation and other information about exposures to toxic substances in the environment available at <https://www.atsdr.cdc.gov/>
- continuing to communicate with the community to address health and exposure concerns

- reviewing additional sampling data upon request and making recommendations to protect public health

EPA plans to continue operation and maintenance of the SVE and GET systems at the site. It will also continue reuse or reinjection of treated water and will conduct periodic monitoring.

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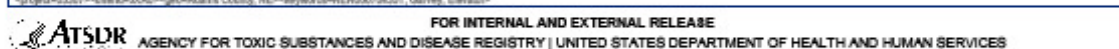
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Appendix A. Site Location Map and Demographic Data



Appendix B. Vapor Intrusion Site Evaluation Checklist*

ATSDR completed this checklist for Garvey Elevator Groundwater Site on 10/11/2016

This list serves as a tool to track the information available for weighing and assessing agreement among the lines of evidence for vapor intrusion health assessments. Check the box if the information is available. Underline specific factors that apply to the site and include any pertinent notes and references next to check list items or on attached pages. Health assessors will usually lack information, but please pay particular attention to items 2, 3, 8 and 9. Indoor air data along with evidence to support the presence or absence of a vapor intrusion migratory pathway must be collected to adequately characterize peoples' exposures. Sufficient information must also be included to assess variability over time and space.

1) Historical source type

- ☐ Dry cleaning / fabric laundering
- ☐ Wood processing / pulp and paper / creosote / resins
- ☐ Sanitary / industrial landfill
- X Metal working or degreasing / electronics / electroplating / engine maintenance-TCE, PCE, naphthalene
- X Agriculture / fumigation- carbon tetrachloride, chloroform
- ☐ Chemical manufacturing / transport / bulk storage (list main chemicals of concern)_____
- ☐ Refining / manufactured gas / oil production / pipelines / other petroleum (list petrochemicals)_____
- ☐ Other / unknown (list main chemicals of concern)_____

2) Contaminated media on the property or nearby

- ☐ Odors reported in indoor air (*expedite assessment*)
- X **FOR ALL SITES: Indoor air vapors:** concentrations, sample dates, HVAC settings, weather-benzene=8.6, TCE=3.8 ug/m³; Aug 2009
- X Soil / soil vapors: concentrations, sample dates, depths-benzene=2.2, CCl₄=3.7, chloroform=93.3, naphthalene=5.4,PCE=1350,TCE=39.9 ug/m³; Aug 2009
- ☐ Groundwater: concentrations, sample dates, depths, and flow direction >100 feet deep
- ☐ **FOR ALL SITES: Note whether groundwater use is potable or non-potable and radon zone-red zone >4piC**

3) Nature and extent of contamination

- ☐ Describe source distribution in vadose zone, capillary fringe, and phreatic zones (if possible)
- ☐ Describe aquifers affected, depths and lateral continuity (delineation wells below screening levels-Y/N)
- X Remediation complete or underway: soil excavated with clean sidewalls, SVE, air sparging, pump and treat, skimming, In Situ Chemical Oxidation, other method_____
- ☐ Temporal factors: contamination stable or trending, ongoing release, seasonal fluctuation
- ☐ LNAPL / DNAPL: estimated thickness or source volume_____
- X ASTs / USTs with or without product
- ☐ Surface water features (natural or manmade) present: rivers / ponds / drainage / dry wells

* This checklist is not an exhaustive list of all the factors that increase vapor intrusion, but includes the most common factors identified within ATSDR's work.

- X Note preferential pathways that may connect contamination to occupied buildings (provide maps with feature depths if possible): underground utilities/sewer/water/pipeline (removed)/lateral drains
 - X Contaminant distance (vertical and horizontal) to occupied buildings-vapor intrusion (VI confirmed)
 - ☐ Biodegradation evidence: vertical profiling O₂, CO₂, methane, or degradation products; other factors
- 4) - **Pervious / permeable foundation**
- X No foundation or vapor barrier (describe floor characteristics)-earthen floor in part of maintenance building
 - ☐ Crawl space (note number of open/closed vents, skirting, and condition of vapor barrier)_____
 - X Slab (note cracks or openings and thickness)_____
 - ☐ Basement
 - ☐ Floor drains / French drain / sump
 - ☐ Wet basement
- 5) - **Conveyance to and into building**
- X Public or private sewer; public or private water
 - ☐ Unsealed electrical conduits or plumbing
 - ☐ Lack or infrequent use of water trap (example: rarely used guest bathroom)
 - ☐ Pressure driven flow is enhanced (decomposing material, landfill, buried pressurized containers)
 - ☐ Fractured bedrock or karst
 - ☐ Heterogeneous fill (note kind if available)_____
 - ☐ Tree roots compromising foundation
 - ☐ Other preferential pathways observed_____
 - ☐ Nearby emissions (dry cleaners, commercial/industrial operations, heavy traffic, smoking areas)_____
 - X Evaluate other indoor air sources (see EPA and other guidance) background inventory provided
 - X Mitigation system (describe type and on/off status during visit/sampling) SVE on during sampling
- 6) - **Building and meteorological factors**
- X Number of floors and type of occupants on each-one floor, workers
 - ☐ Note locations of
 - HVAC units_____
 - ventilated / unventilated areas indoors_____
 - fresh air intake_____
 - ☐ Large ventilation features: bay doors / large open windows / large fans (such as in workshops)
 - ☐ Diagnostic results: air exchange rate / pressures (indoor vs subsurface and outdoor pressures)
 - ☐ Depressurizing features: elevator shaft / dryer in basement / exhaust fans to outside / other_____
 - X Climate: hottest month July, 84.8°F / coldest month Jan, 12.8°F / snowiest month Jan, 5.7 inch / ground ice

- X Precipitation: rainiest month [June 2014](#), [8.69 inch](#) / driest month [March 2014](#), [0.15 inch](#) / flooding potential
 - X Prevailing wind direction and speed (often seasonal) [Mar-Sep from SE](#), [Jul-Aug 3m/s](#); [winter NW 4.5-5 m/s](#); from S/SE on sample date ([Aug 4 2009](#); [HGL 2011 Vol 1 p107](#))
 - ☐ Building shape, orientation, dimensions, and surrounding surface terrain (provide map, photo, or sketch)
- 7) - **Sub-surface influence**
- X Describe soil type, stratification, staining, and odor from borings, excavations, and site documents [0-65 feet silt/clay/sand/loess](#); [65-85 feet silt/sand](#); [85-120 feet sand/gravel \(aquifer @ 115 feet\)](#)
 - ☐ Other measured parameters such as soil porosity, moisture, density, and organic content_____
 - ☐ Describe or map regional geology, lithology and topography_____
 - ☐ Hydraulic connectivity: groundwater influenced by contaminated surface water / tides / heavy run-off
 - ☐ Note changes in seasonal groundwater depth and flow direction_____
 - ☐ Impervious surface between building and source (seasonal ice or snow, concrete, paving, surface water)
 - ☐ Large building footprint
- 8) - **Data quality**
- X **Indoor air samples collected appropriately** - [benzene 8.6 µg/m³](#), [TCE 3.8 µg/m³](#)
 - X Used appropriate standard sampling and analytical methods [Summa, 8hr, EPA region 7 lab did analysis](#)
 - X Detection limits were at or less than comparison values and screening levels [some detection limits \(DLs\)>screening levels](#)
 - X Included hazardous degradation products (e.g. [No VC](#) for TCE, methane for gasoline with ethanol)
 - X Standard operating procedures were followed, for example
 - Summa canisters were not at zero pressure upon collection [unknown](#)
 - No water in soil gas borings / no heavy rainfall 2 to 3 days before sampling [no rain 4 days prior](#)
 - Leak testing [showed no leakage](#)
 - X Used appropriate sample durations (e.g. 8 hour worker, 24 hour resident, longer passive samples)
 - X Assessed contribution from indoor sources: indoor products [survey](#) / chemical ratios / handheld data
 - X **Samples placed appropriately / sufficient data to assess spatial variability**
 - X **Multiple samples taken in multiple seasons to assess temporal variability. Do the data reflect reasonable maximum exposures (No), i.e. collected in the more extreme seasons?**
 - ☐ Groundwater wells screened at groundwater surface for vapor intrusion or deep for DNAPL detection
- 9) - **Long-term stewardship considerations (until all media are below screening levels)**
- X Future periodic monitoring of indoor air to confirm long-term protection of health
 - ☐ Monitoring trends and migration of contaminants in groundwater and soil gas
 - X Continued operation and maintenance of mitigation systems and monitoring devices

- X Periodic inspections of structural, landscaping, and other factors affecting the conceptual site model
- X Follow-up sampling if structural, landscaping, or other changes occur affecting conceptual model
- ☐ Educating occupants on visible gauges, alarms, and equipment and who to notify in case of malfunction
- X Supporting institutional controls: future use restriction / access for future monitoring / zoning

Additional Information:

On-site:

- 2) Sources on the property or nearby
 - Primary contamination source (carbon tetrachloride and carbon disulfide): (1) former liquid fumigant above ground storage tank and (2) area in northeast corner of grain storage areas (possibly from treatment of rail cars or stockpiled grain)
 - Secondary source (TCE and PCE): possible use of solvents at the elevator facility for parts cleaning
 - Recent/current on-site contamination:
 - Subsurface soil (beneath or adjacent to former liquid fumigant above ground storage tank) – carbon tetrachloride, chloroform
 - Groundwater – carbon tetrachloride, TCE, and PCE
 - Soil gas (generally 50 ft. or more bgs in various areas of the site, such as the west end of the silos, the flat storage building, the area to the east toward the rail lines) – carbon tetrachloride and chloroform
 - Remedial Investigation vapor intrusion investigation (media sampled and contaminants detected)*:
 - Sub-slab soil gas (beneath the concrete floors of office/shop and maintenance buildings) –carbon disulfide, carbon tetrachloride, chloroform, PCE, and TCE
 - Indoor air (inside the office/shop and maintenance buildings) – low level COPCs (e.g., carbon disulfide, carbon tetrachloride, chloroform, PCE, and TCE) could present a slight increase in lifetime cancer risk; 1,2-dibromoethane could present a cancer risk greater than EPA’s acceptable range, but detection/reporting limits weren’t sensitive enough to know if levels were above or below the screening levels

- 5) Conditions during inspection or during sampling

The site’s vapor extraction (SVE) system was operating when Remedial Investigation sub-slab soil gas (beneath the office/shop and maintenance buildings) and air samples (inside the buildings) were collected. The sampling data showed that the primary site contaminants — carbon tetrachloride and chloroform — were detected in the soil gas samples but not in the indoor air samples. The absence of carbon tetrachloride and chloroform may be due to the influence of the SVE system. More specifically, the SVE draws air from the surrounding subsurface soils into extraction wells which may prevent or reduce the movement of carbon

tetrachloride and chloroform across the office/shop and maintenance building foundations into the air inside the buildings.

The potential for carbon tetrachloride and chloroform to infiltrate the buildings in the absence of the SVE system cannot be determined because no sub-slab soil gas or indoor air samples were collected when the SVE system was shut down.

Off-site:

- 3) A carbon tetrachloride groundwater plume extends approximately 4.5 miles east-southeast of the site in the direction of groundwater flow. However, because the depth to groundwater in this area is more than 100 feet, migration of carbon tetrachloride from the groundwater plume into nearby homes or other buildings is unlikely.

Appendix C. Vapor Intrusion Data Quality Evaluation Worksheet*

ATSDR completed this checklist for Garvey Elevator Groundwater Site on 10/11/2016.

This worksheet serves as a tool to track the elements of data quality important to vapor intrusion evaluations. Fill in any information relevant to each element & include any pertinent notes & references next to items or on attached pages.

1) Sample Collection Methods & Handling

- ☐ a. Methods used
 - i. Stainless canisters (active or passive collection) - *Ten subslab gas & indoor air samples were collected into 6-liter SUMMA canisters over 8 hours. Intake height of indoor air samples was 4.2 to 4.8 feet above the floor. Two outdoor air samples were collected at 4.8 feet above ground generally upwind (southeast & southwest of the buildings). Many exterior soil gas samples taken to delineate fumigant source area.*
- ☐ b. Ambient conditions
 - i. Precipitation over past 72 hours - *no*
 - ii. Temperature – *hot...high in the mid-90s (Fahrenheit)*
 - iii. Wind speed and direction – *Wind from the south/southeast*
 - iv. HVAC operation status - *unknown*
- ☐ c. Mitigation system operation status – *active during sampling*
- ☐ d. Review DLs, SOPs for field instruments & analytical methods, & quality assurance project plan (QAPP) – *DLs attached; SOPs & QAPP not available*
- ☐ e. Field records, shipping records, lab log books, raw data-field records not available for air data; data analyzed by EPA Region 7

2) Analytical Methods - unknown

3) Data Quality Indicators

- ☐ a. Precision:
 - i. Analyzed standards or split samples; repeat analytical analysis on the same sample - *Of 95 air lab control samples measured, 34% (32 results) were less than the lower limit (80% recovery) and 14% (13 results) were greater than the upper limit (120% recovery).*
- ☐ b. Bias:
 - i. Reviewed analytical reference material or spiked samples - *Of 188 matrix spiked air results, 10% (18 results) were less than the lower limit (80% recovery) and 23% (43 results) were greater than the upper limit (120% recovery).*
 - ii. Assessed indoor sources: indoor products survey / chemical ratios / handheld data – *survey in Appendix E*
- ☐ c. Accuracy:
 - i. Duplicate analysis – *The one pair of duplicate samples collected (from IA-3) ranged from -12.7 to 13.3 relative percent difference (limit 20%).*

* References on data quality:

<http://www.epa.gov/quality/qs-docs/g5-final.pdf>, <http://www2.epa.gov/sites/production/files/2015-06/documents/g8-final.pdf>
<http://www.itrcweb.org/documents/VI-1.pdf> (section D.1) <http://www.epa.gov/oswer/vaporintrusion/documents/OSWER-Vapor-Intrusion-Technical-Guide-Final.pdf> exh B-1

- ii. Final pressures of stainless canisters (ambient final pressure effectively decreases sample duration) - *Soil gas samples SG-2, 3, 4, 6, 7, 9, and 10 and indoor air samples IA-3 & 4 had zero final pressure*
- iii. No water in soil gas borings / no heavy rainfall 2 to 3 days before sampling – *no rain prior*
- iv. Leak testing showed tight seal – *leak testing was performed (results not available)*
- ☐ d. Representativeness:
 - i. Samples placed appropriately / sufficient data to assess spatial variability - *multiple subslab gas samples per building; soil gas/contamination not delineated in disposal pit area*
 - ii. Multiple samples taken in multiple seasons to assess temporal variability. Does the data reflect reasonable maximum exposures, i.e. collected in the more extreme seasons? *The single sampling in August 2009 is insufficient to assess temporal variability*
 - iii. Used appropriate sample durations – *8 hours, but final pressure was zero in 9 canisters effectively shortening those collection times to an unknown duration*
 - iv. Groundwater wells screened at groundwater surface (for VI) or deep (for DNAPL detection) – *vadose zone contamination is the vapor source of concern, so groundwater samples (~100 feet deep) not evaluated*
 - v. Statistical analysis (difficult for VI) – *insufficient data*
- ☐ e. Comparability:
 - i. Qualitative confidence that different data sets can be compared for decision making, i.e. soil gas, indoor air, outdoor air collected concurrently – *yes, concurrently collected & subslab gas locations close to indoor air locations*
 - ii. Measured concentrations reflect reasonable maximum exposure concentrations – *insufficient data*
- ☐ f. Completeness:
 - i. Degradation products considered – *Yes, but some reporting limits were above screening levels (see 1d)*
 - ii. Sufficient number of samples to meet all other data quality indicators – *no (see dii)*
 - iii. Usability of existing samples – *100% of the 470 soil gas and 611 air sample and duplicate data points were considered usable.*
- ☐ g. Sensitivity (method and instrument detection limits): *Some reporting limits were above screening levels.*

Additional information:

1d) Detection limits in air (all in $\mu\text{g}/\text{m}^3$) [HGL 2011]

Contaminant	Garvey Reporting Limit	Lowest Screening Level	Basis for Screening Level
1,1,2,2-Tetrachloroethane	3.4	0.048	EPA RBC (cancer)
1,1,2-Trichloroethane	2.7	0.063	CREG
1,2,3-Trichlorobenzene	NA	NE	NE
1,2-Dibromo-3-chloropropane	NA	0.2	RfC

1,2-Dibromoethane	3.8 (>100× CREG)	0.0017	CREG
1,2-Dichloroethane	2	0.038	CREG
1,3,5-Trimethylbenzene	2.5	NE (surrogate 1,2,4- trimethylbenzene RSL=7.3)	NE
1,3-Dichlorobenzene	3	NE	NE
1,4-Dichlorobenzene	NA	60	cEMEG
Acetone	NA	31,000	cEMEG
Benzene	1.6	0.13	CREG
Bromochloromethane	NA	NE	NE
Bromodichloromethane	3.4	0.076	EPA RBC (cancer)
Bromoform	5.2	0.91	CREG
Carbon tetrachloride	3.1	0.17	CREG
Chloroform	2.4	0.043	CREG
Cis-1,2-dichloroethene	2	NE	NE
Cis-1,3-dichloropropene	2.3	0.25	CREG
Cyclohexane	NA	6,000	RfC
Dibromochloromethane	4.3	0.1	EPA RBC (cancer)
Dichlorodifluoromethane	NA	100	EPA RBC (non-cancer)
Heptane	2.1	NE	NE
Hexachlorobutadiene	5.3 (>100× CREG)	0.045	CREG
Methyl acetate	NA	NE	NE
Methyl tert-butyl ether	NA	2500	cEMEG
Methylcyclohexane	NA	NE	NE
Naphthalene	5.2	0.083	Cancer RSL
Trans-1,3-dichloropropene	2.3	0.25	CREG
Tetrachloroethylene	3.4	3.8	CREG
Trichloroethylene	2.7	0.22	CREG
Trichlorofluoromethane	NA	730	EPA RBC (non-cancer)
Vinyl chloride	1.3	0.07	CREG

Abbreviations: EPA = U.S. Environmental Protection Agency; RBC = risk-based concentration (June 2015, residential); CREG = cancer risk evaluation guide; NA = not analyzed; NE = not evaluated; RfC = reference concentration; RSL = EPA regional screening value.

ATSDR cannot assess the potential for health effects from the chemicals that were not included in the analysis. ATSDR also cannot determine if undetected chemicals exceeded screening levels when reporting limits were greater than screening levels.

The reporting levels that exceeded cancer-based screening levels did so by less than 100-fold, except for 1,2-dibromoethane and hexachlorobutadiene. Thus, cancer risks for undetected chemicals other than 1,2-dibromoethane and hexachlorobutadiene are likely below EPA's upper bound for cancer risk (1 in 10,000 excess lifetime cancer risk). According to ATSDR's ToxFAQs, 1,2-dibromoethane has been used as a pesticide on grain crops and as a fuel additive for leaded gasoline [ATSDR 1995]. Hexachlorobutadiene has been commercially used as a

solvent, lubricant, heat transfer liquid, and hydraulic fluid. Each of these uses is plausible for the Garvey Elevator site, based on historical operations.

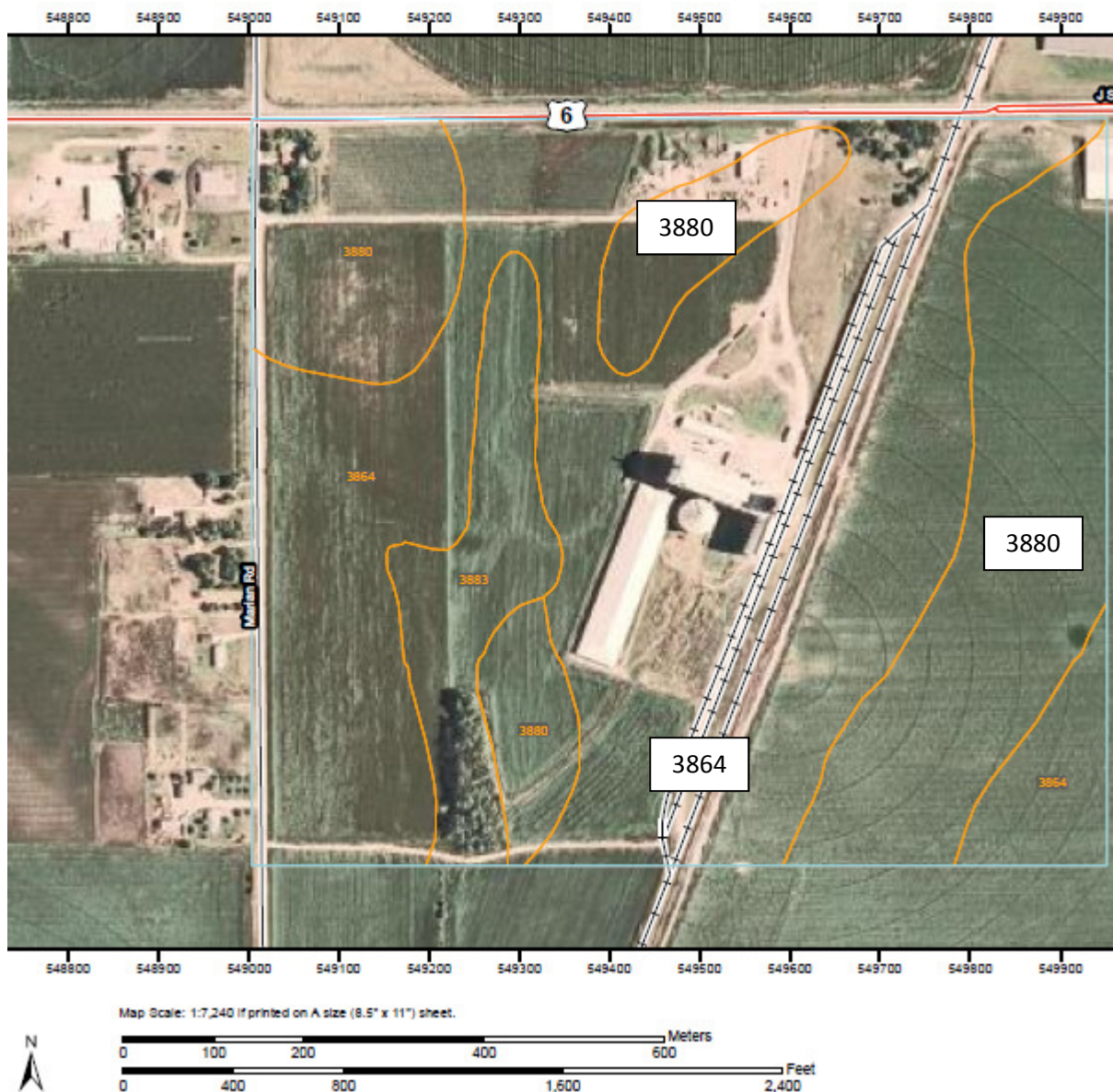
The cEMEG for naphthalene is based on a 300 uncertainty factor (10 for the use of lowest observed adverse effect level, 3 for extrapolating from a rodent study to humans, and 10 for human variability). This means that the cEMEG is 300 times less than the concentration found to cause health effects in studies. Therefore, the reporting limit is well below the levels found to be hazardous.

Appendix D. Supplemental Fate and Transport Information

Site Geology

A U.S. Department of Agriculture custom soil resource report found generally homogeneous soil conditions across the site zone 3864 generally consisting of flat (0% to 1% slopes) well-drained soil of silt loam 0–11 inches, silty clay loam 11–41 inches, and silt loam 41–80 inches deep (**Figure D.1.**). Zones 3880 just north and east of the site are also generally flat (1% to 3% slopes) well-drained soil of silt loam 0–7 inches, silty clay loam 7–30 inches, and silt loam 30–80 inches deep.

Figure D.1. U.S. Department of Agriculture soils map for the Garvey Elevator site [HGL 2011]



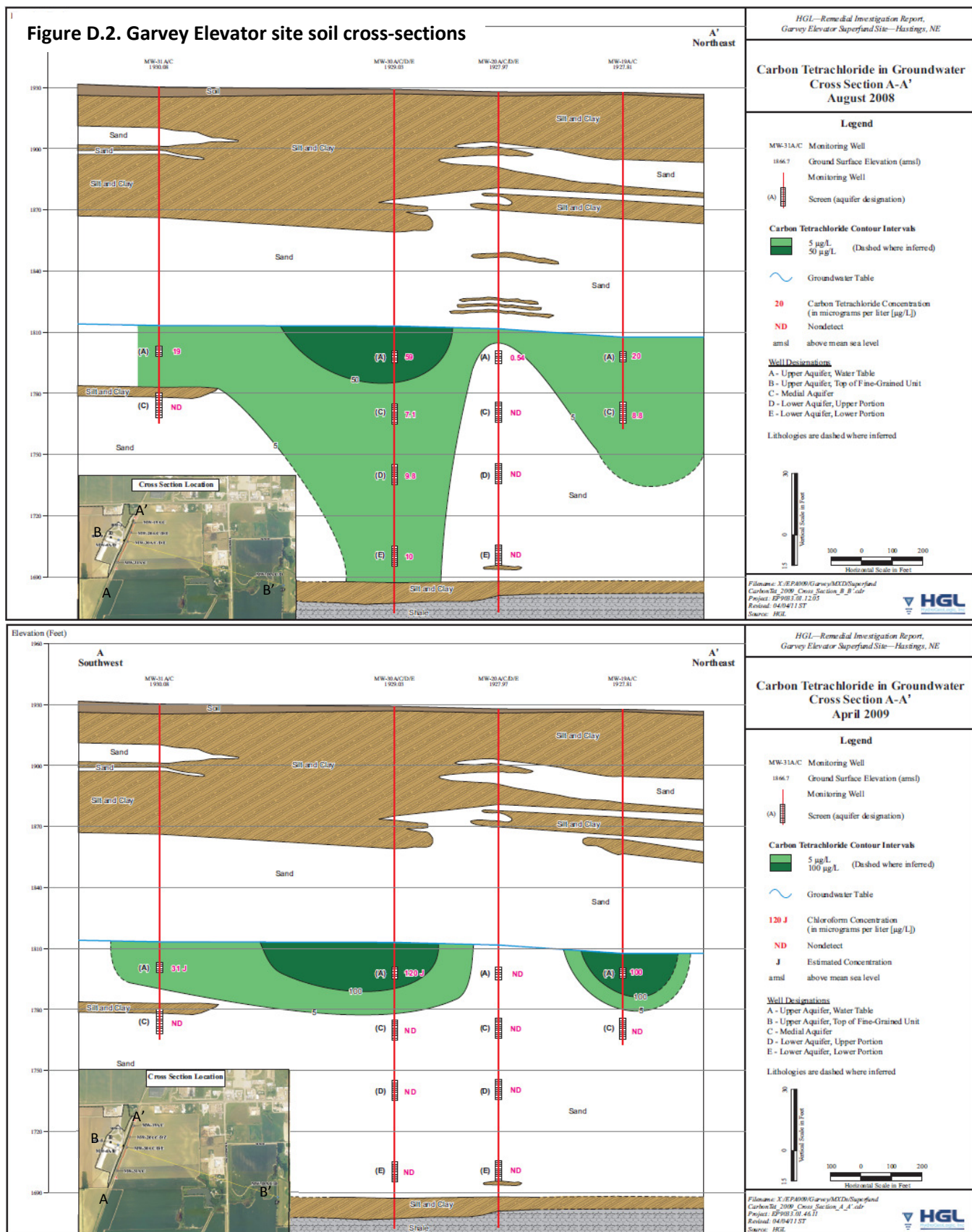
Cross-sections of the soil on-site show the upper silty clay loam zones contain some horizontal pockets of sand that could increase lateral migration of soil gases, though not as much as would

be expected of fractured bedrock, karst features, or sewer lines (**Figure D.2.**). Cross-section A–A' appears to show a sand feature about 30 feet deep near the construction debris and disposal pit that extends to the northeast toward the residence (**Figure D.2.**). ATSDR has difficulty estimating how far the soil gas has migrated without soil gas measurements.

Soil Gas Delineation

Carbon tetrachloride soil gas measurements in the vicinity of the grain elevator show the contamination migrating in a general downward direction without a strong tendency to spread laterally in the shallowest 50 feet (**Figure D.3.**). The carbon tetrachloride soil gas from the grain elevator area appears to spread to the south at and below 50 feet at 5,000 $\mu\text{g}/\text{m}^3$ to 10,000 $\mu\text{g}/\text{m}^3$. Very high concentrations (79,900 $\mu\text{g}/\text{m}^3$) were detected north of the buildings, beginning at 80 feet deep, that were not clearly connected to the shallower soil gas contaminants. This deeper soil gas contamination north of the buildings could be from the construction debris disposal pit area. The nature and extent of subsurface contamination from the construction debris disposal pit area is not well understood, but does not appear to remain in the shallower regions (within the top 70 feet). Additionally, solvent contaminant levels and distribution in soil gas across the site are not well understood, as the environmental assessment focused primarily on describing the nature and extent of fumigant contamination. Recent toxicity studies of the solvent trichloroethylene indicate increased concern for short-term, low-level exposures, as described in the Public Health Implications sections of this health consultation.

Figure D.2. Garvey Elevator site soil cross-sections



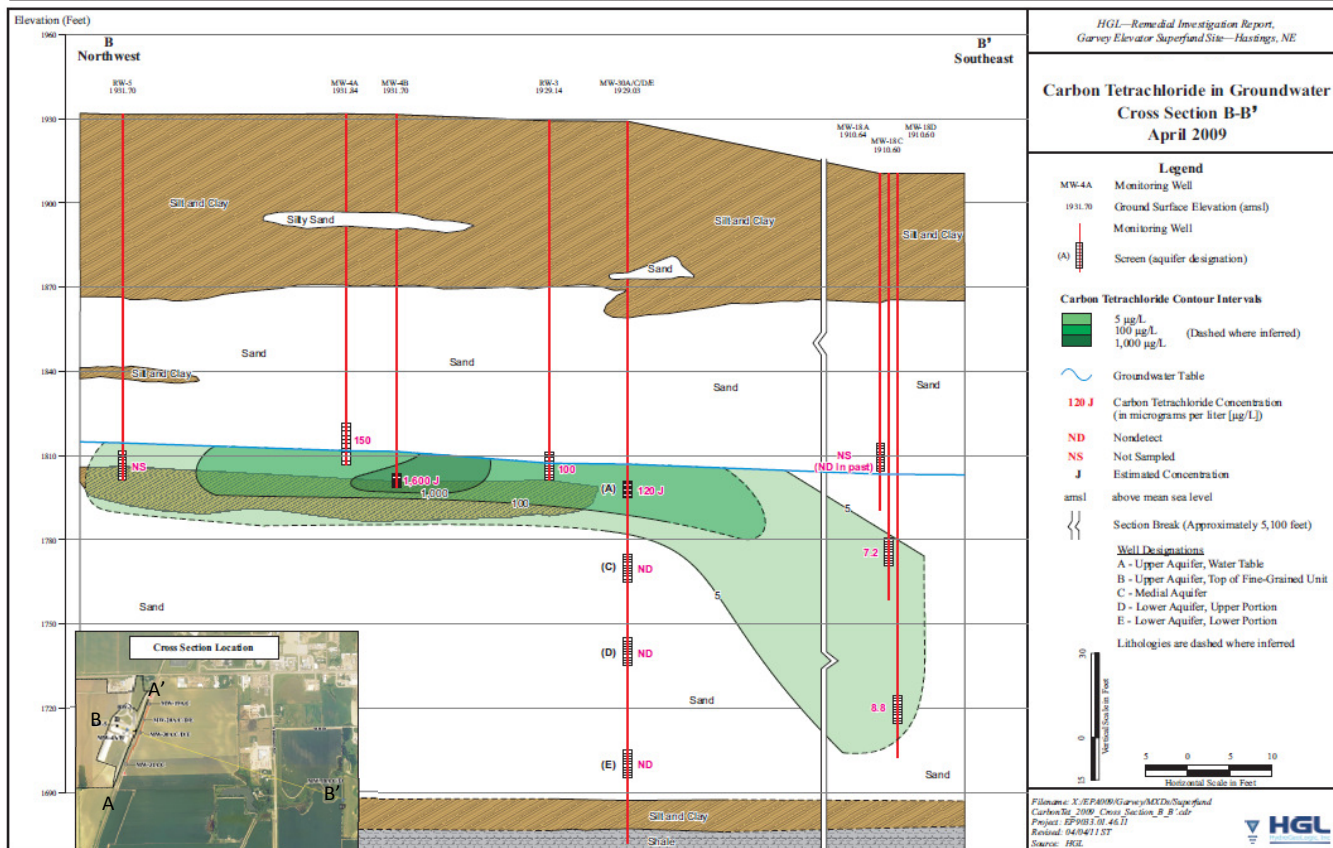
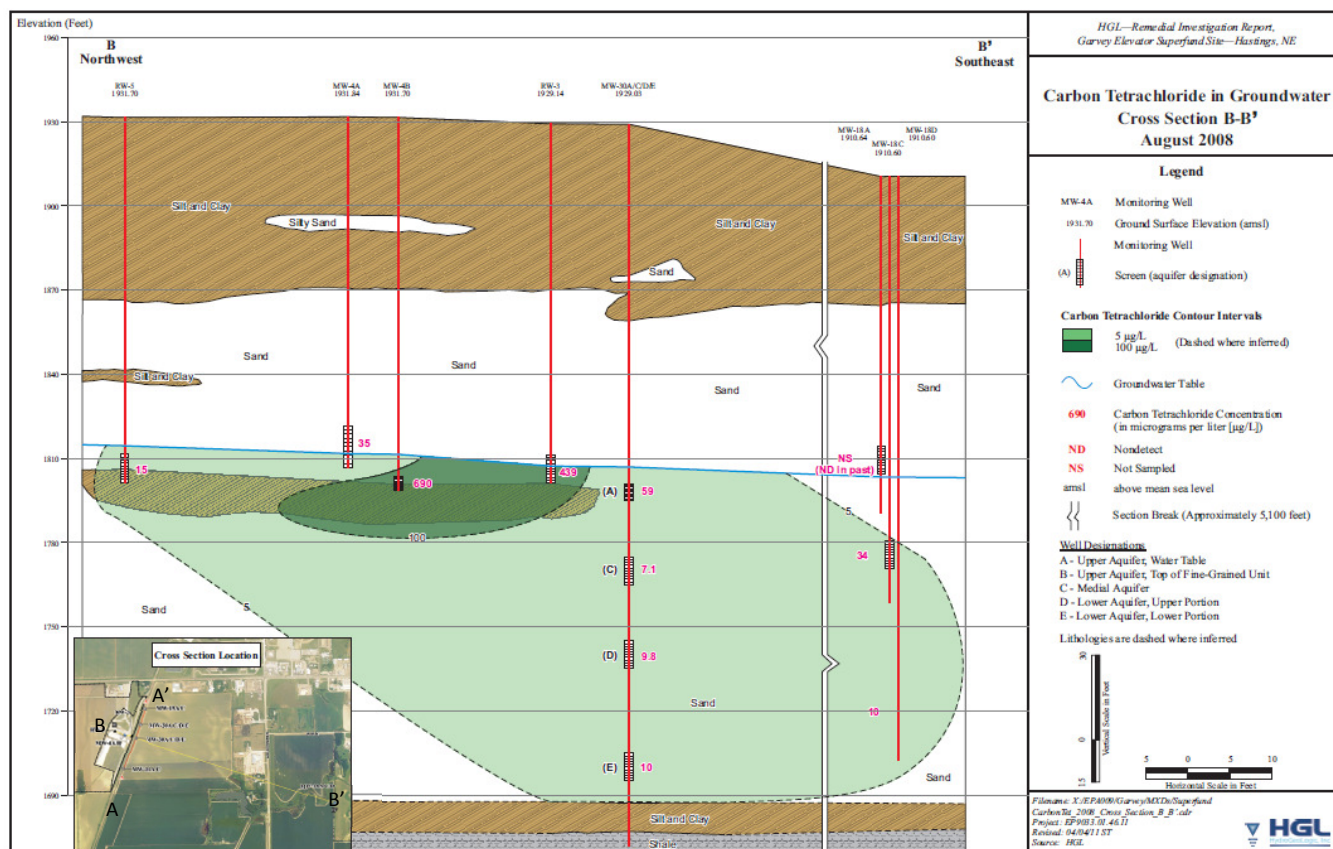
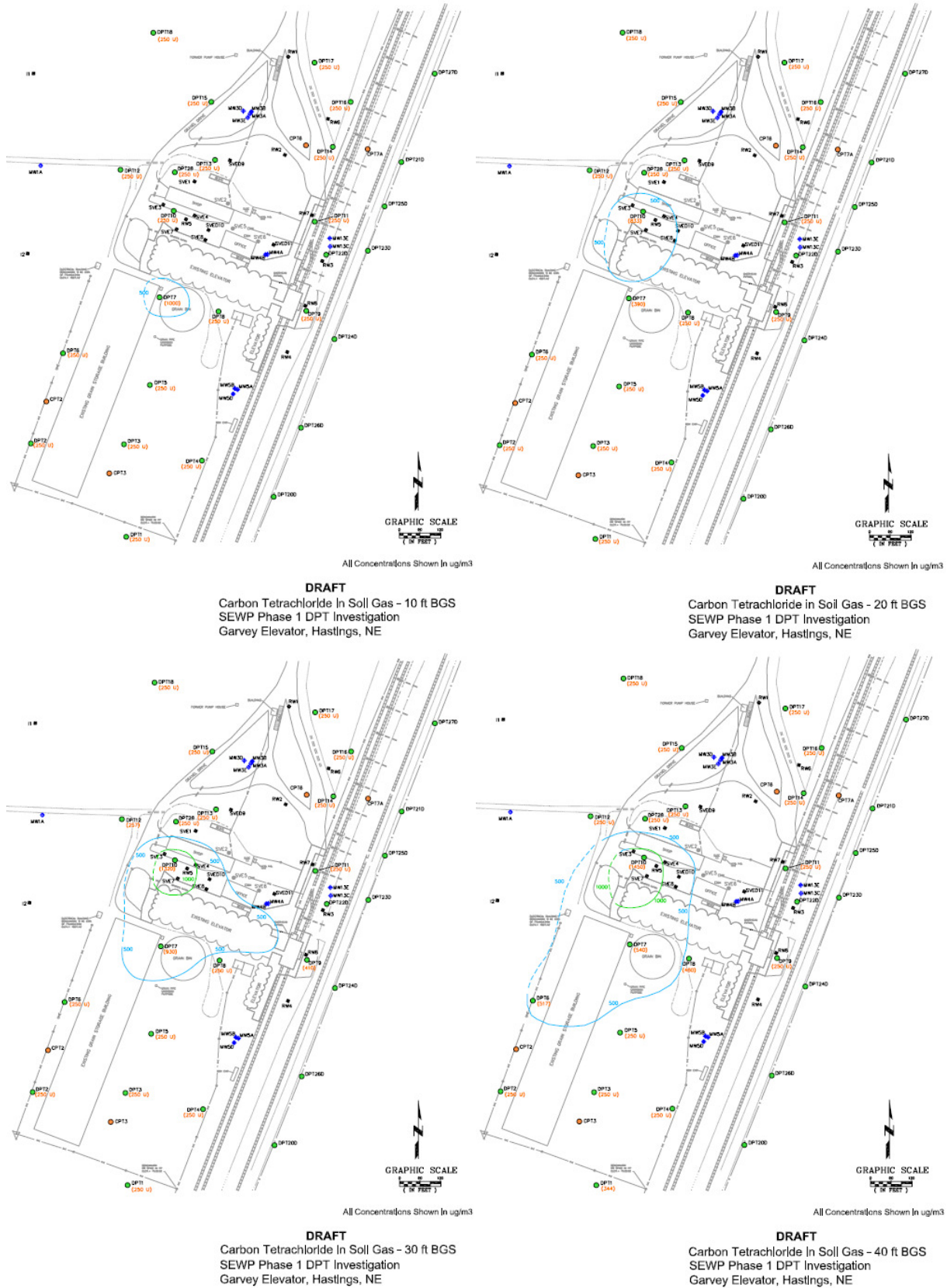
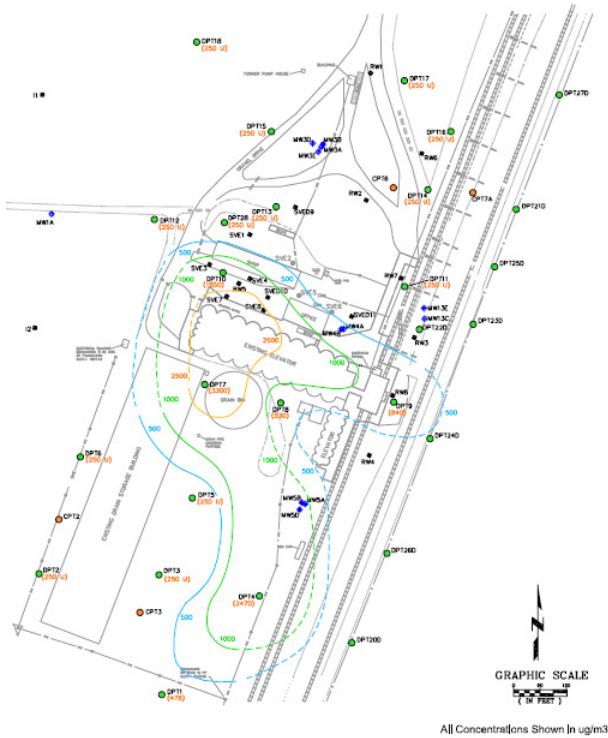
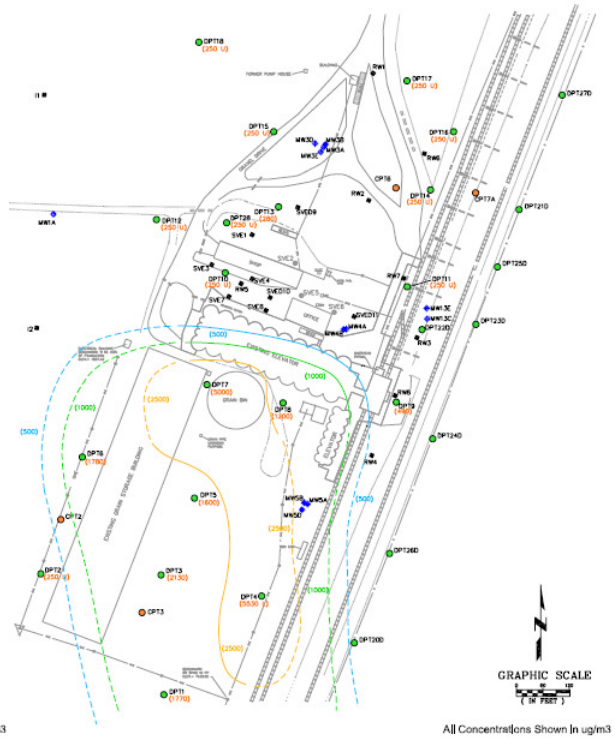


Figure D.3. Carbon tetrachloride in soil gas at Garvey Elevator site (2007) [HGL 2011]

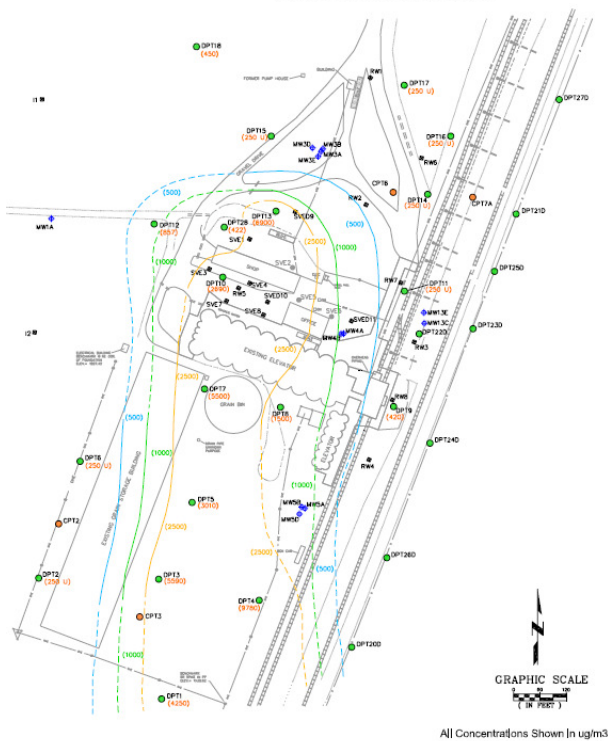




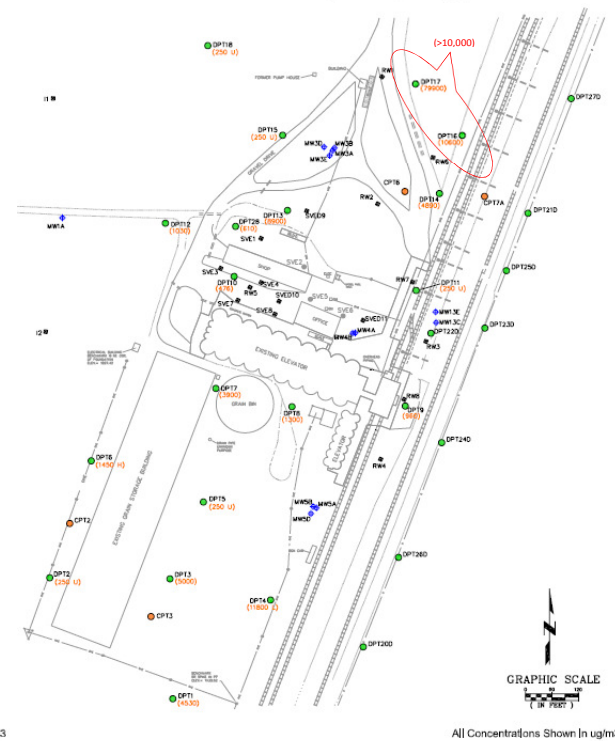
DRAFT
Carbon Tetrachloride In Soil Gas - 50 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



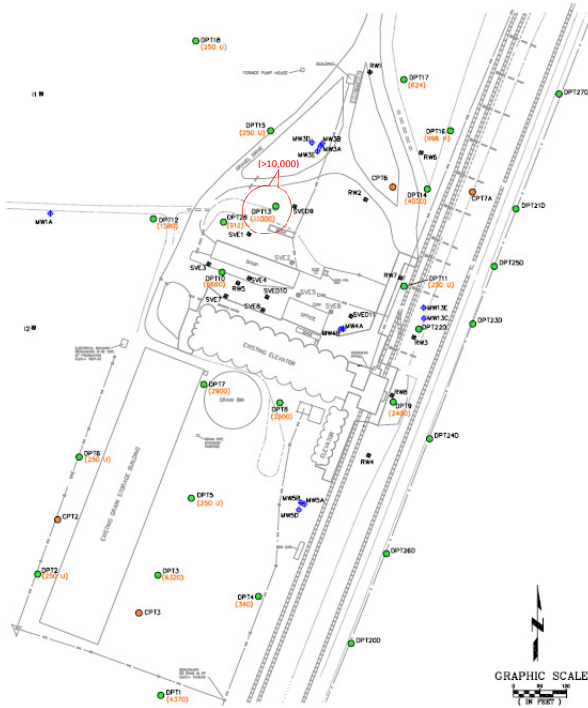
DRAFT
Carbon Tetrachloride In Soil Gas - 60 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



DRAFT
Carbon Tetrachloride In Soil Gas - 70 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE

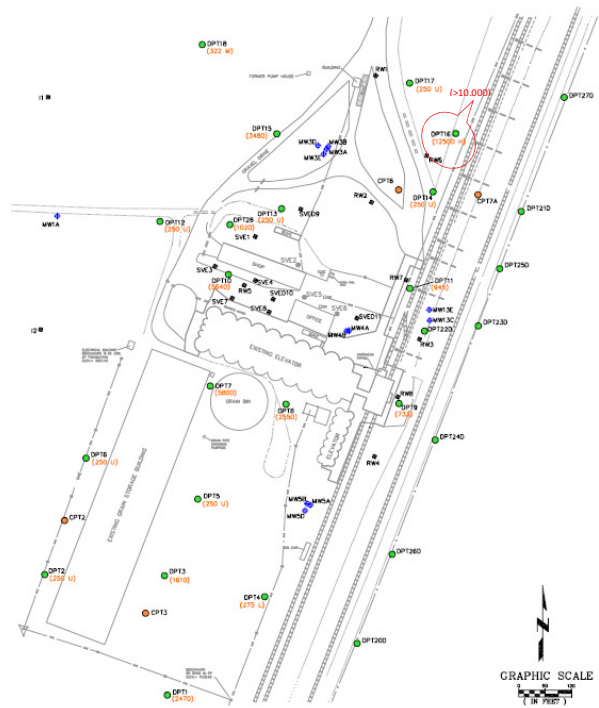


DRAFT
Carbon Tetrachloride In Soil Gas - 80 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



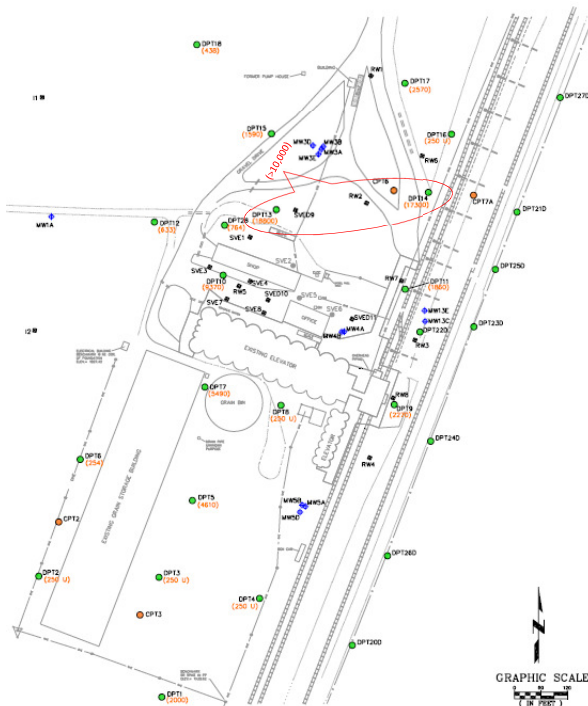
All Concentrations Shown In ug/m3

DRAFT
Carbon Tetrachloride In Soil Gas - 90 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



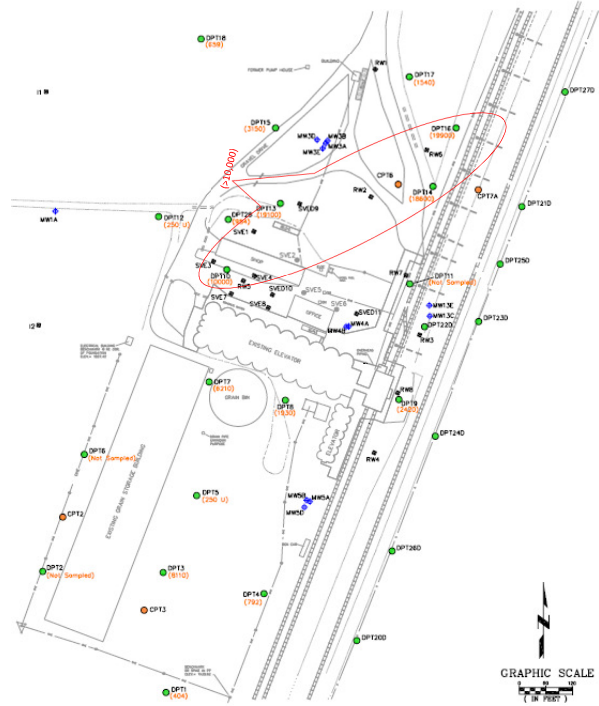
All Concentrations Shown In ug/m3

DRAFT
Carbon Tetrachloride In Soil Gas - 100 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown In ug/m3

DRAFT
Carbon Tetrachloride In Soil Gas - 110 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE



All Concentrations Shown In ug/m3

DRAFT
Carbon Tetrachloride In Soil Gas - 115 ft BGS
SEWP Phase 1 DPT Investigation
Garvey Elevator, Hastings, NE

Appendix E. List of Commercial/Industrial Products Used/Stored in the Office/Shop and Maintenance Buildings [HGL 2011]

Office/Shop Building		Maintenance Building
Closet Adjacent to Office	Men's Restroom	Maintenance Shop
(2) cans air duster	(2) cans bathroom cleaner	(1) aerosol battery cleaner
(1) lime-away	(1) can clog remover crystals	(1) 5 gal. oil eater
(1) bottle insecticide	(1) can AJAX	(2) cans tire cleaner
(1) 1.5 qt. Pine sol	Breakroom	(1) 1 gal. lubricant- tire mounting
(1) bottle all-purpose cleaner	(1) aerosol lubricant	(1) can rust inhibitor
(1) aerosol insecticide	(1) bottle bug repellent	(1) 1 gal. engine oil
(2) bottles cleaner-disinfectant	Office Building Shop Shelves	(1) 5 gal. carburetor cleaner
(1) aerosol glass cleaner	(2) cans adhesive	(1) 8 oz. can tire cement
(1) box RID-X	(1) can elastomeric roof coating	(1) 32 oz. bottle air tool oil
(1) calibration gas (hydrogen sulfide, pentane, CO, N)	(1) can aerosol bi lubricant	(1) bottle tire sealant
(1) calibration gas (methane, N)	(3) boxes of 400g grease	(2) 8 oz. starting fluid
(1) calibration gas (sulfur dioxide)	(2) cans wire pulling lubricant	(1) 4 L hydraulic oil
(2) 1 gal. antifreeze	(1) bag snow and ice melter (magnesium chloride)	(1) 5 qt. motor oil
(1) can oil-based paint	(1) can sealing cement	(1) can acrylic enamel
(1) can latex paint	(2) bottles motor oil	(1) 18 oz. aerosol tire cleaner
Office Building Shop	(1) 16 oz. hydraulic oil	(1) 1 qt. motor oil
(1) aerosol Dry film lubricant	(1) 5 gal. power tran fluid	(1) tube weather-strip adhesive
(2) 12 oz. aerosol fire extinguishers	(1) 1 gal. motor oil	(2) 1 qt. brake fluid
(1) 8 oz. bonding agent (low heat)	(1) 1 gal. antifreeze/coolant	(1) bottle lacquer thinner
(2) tubes barrier cream	(4) cans solvent based enamel	(1) .5 gal. acetone
(1) 1 qt. aluminum cleaner	(2) cans semi-gloss latex	(1) 2 oz. caliper lube
(1) can gearing flux	(1) 55 gal. drum multi-purpose transmission fluid	(1) can VM & P Naphtha
(1) fast flash fuel	(1) 55 gal. drum motor oil	(1) can Xylol
(5) cans asphalt preservative and primer	(1) 55 gal. drum petroleum oil	(1) can Acetone
Office Building Shop Cabinet	(1) 55 gal. drum switch oil/composition unknown	(2) 4 lb. multipurpose grease
(1) 1 qt. gear lubricant	(1) 2 qt. vinyl adhesive	(1) 5 gal. 80/90 grease
(1) pipe thread compound	(1) tube silicone	(2) 5 gal. transmission fluid
(2) cans adhesive	(1) large can brushable ceramic	(16) 5 gal. acrylic latex room coating
(1) can super enamel finish	(2) small cans brushable ceramic	(2) 2.5 gal. herbicides (Glyphosate pro & Diuron 4L)
(1) can hardener	(1) 5 gal. industrial gear oil	(1) 12 oz. lube and cleaner
(1) bottle neutralizer	(1) aerosol gear lube	(4) bottles motor oil
(1) can engine enamel	(4) emulsion coating	(1) can bug repellent
(2) can nut and bolt buster	(4) emulsion floor coating	(1) 1 gal. WD-40
(3) cans rust prevention	(2) 2 gal. sealant for roofs	(8) cans rust stop
(2) cans acrylic enamel	(4) 1 gal. roof coating	(18) bottles motor oil
(1) can carb and choke cleaner	(2) 5 oz. glazing compound	(12) cans enamel coating
(1) can brake cleaner	(6) 1 gal. bonding primer	(1) can water proof sealer
(1) 16 oz. can anti-freeze	(1) can spackling compound	(8) cans acrylic enamel
(1) can multi-use lube	(1) 1 qt. multipurpose resurfacer	(2) cans gasket sealant
(1) aerosol insecticide	(1) 1 gal. contact cement	(1) 5 gal. grease gun grease
(1) bottle motor oil	(1) 1 gal. enamel	(1) 5 gal. lubricating grease
(1) can resin	(1) can pipe joint compound	(1) 55 gal. antifreeze
(1) can moisture displacer	(1) can aluminum paint	
(1) 32 oz. can antifreeze	(1) gal. gloss enamel	
(1) can gear lube		
(1) can foam sealant		
(1) can lube and cleaner		
(3) bottles de-icer		

Notes:
qt. - quart

gal. - gallon
oz. - ounce

L - liter
lb. - pound

Appendix F. Johnson and Ettinger Modeling

The Johnson and Ettinger model for subsurface vapor intrusion into buildings [EPA 1991] was used with a combination of default and site-specific information to model vapor intrusion into buildings on the Garvey Elevator site (**Table F.1.**)

Table F.1. Johnson and Ettinger Modeling (SG-ADV-Feb04.xls, Version 3.1; 02/04)

Chemical	Soil gas ($\mu\text{g}/\text{m}^3$)	Modeled indoor air estimate ($\mu\text{g}/\text{m}^3$)*
Benzene	2.2	0.00647
Carbon tetrachloride	3.7	0.0103
Chloroform	93.3	0.292
Naphthalene	5.4	0.00305
Tetrachloroethylene	1350	3.64
Trichloroethylene	39.9	0.112

* Site-specific assumptions

1. Soil gas sampling depth below grade (depth below the slab): 91 cm
2. Average soil temperature: 53°F (12°C)
3. Soil type: sandy loam (SL)

Basis for assumptions:

1. The subslab gas sampling depth was unknown. EPA recommends a sampling depth of 3–5 feet). Therefore, the most conservative value within this range was assumed: 3 feet (91 cm).
2. A soil temperature of 53°F (12°C) was estimated from Figure 8 of the EPA *User's Guide for Evaluating Subsurface Vapor Intrusion Into Buildings* [EPA 2004].
3. Soil type: The upper 65 feet were classified as silt, clayey silt, silty clay, clayey and/or silty fine sand/Peoria and Loveland loess (**Figure F.1**) [HGL 2011]. Of these classifications, ATSDR assumed the soil type with the highest permeability (Peoria loess upper zone 22%–34% fines; [Muhs and Bettis 2000], **Tables F.2 and F.3**)

Figure F.1. Generalized soil boring characterization [HGL 2011]

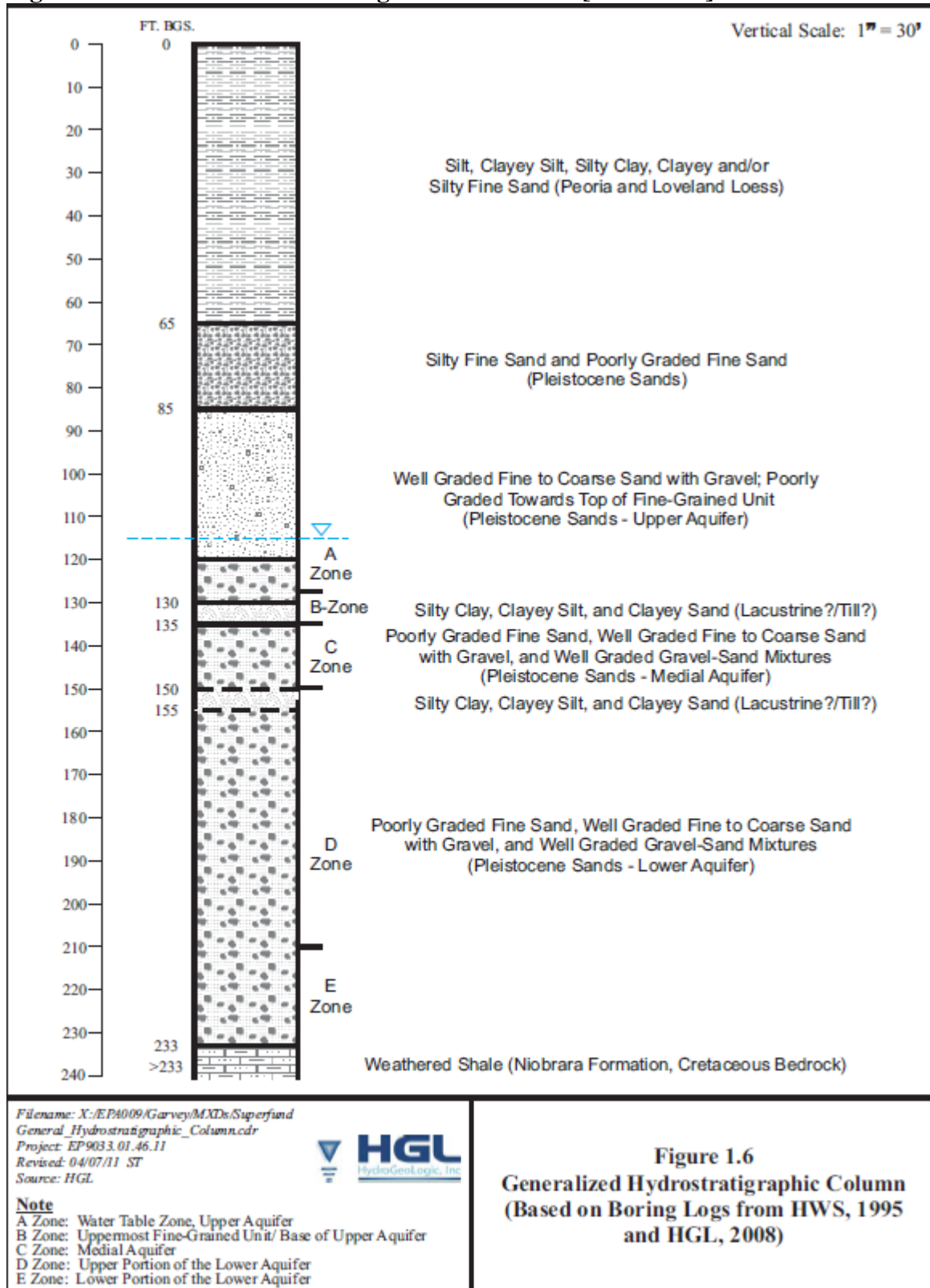


Table F.2. Soil type and hydraulic conductivity [EPA 2004]

Soil texture , USDA	Class average saturated hydraulic conductivity, cm/h
Sand	26.78
Loamy sand	4.38
Sandy loam	1.60
Sandy clay loam	0.55
Sandy clay	0.47
Loam	0.50
Clay loam	0.34
Silt loam	0.76
Clay	0.61
Silty clay loam	0.46
Silt	1.82
Silty clay	0.40

Table F.3. Soil type selection [EPA 2004]

If your boring log indicates that the following materials are the predominant soil types ...	Then you should use the following texture classification when obtaining the attenuation factor
Sand or Gravel or Sand and Gravel , with less than about 12 % fines, where “fines” are smaller than 0.075 mm in size.	Sand
Sand or Silty Sand , with about 12 % to 25 % fines	Loamy Sand
Silty Sand, with about 20 % to 50 % fines	Sandy Loam
Silt and Sand or Silty Sand or Clayey, Silty Sand or Sandy Silt or Clayey, Sandy Silt, with about 45 to 75 % fines	Loam
Sandy Silt or Silt, with about 50 to 85 % fines	Silt Loam

Appendix G. Cancer Calculations

ATSDR calculated a conservative excess lifetime cancer risk (ELCR) for continuous adult exposure over a lifespan (**Table G.1**). Workers would typically be exposed for only 5 days per week, 8 hours per day, and 50 weeks per year for 50 of their 78 years, at most. The ELCR was calculated using the following equation:

$$\text{IUR} * C_{\text{air}} = \text{ELCR}$$

where IUR = Inhalation unit risk with units $(\mu\text{g}/\text{m}^3)^{-1}$

C_{air} = Contaminant concentration in air. The maximum detected concentration or detection limit for non-detects in air with units $\mu\text{g}/\text{m}^3$

Table G.1. Excess lifetime cancer risk (ELCR) calculation for continuous adult exposure to selected chemical contaminants

Contaminant	IUR / $(\mu\text{g}/\text{m}^3)$	Adjusted C_{air}^* $(\mu\text{g}/\text{m}^3)$	ELCR
1,2-Dibromoethane	6.0E-04	0.28	1.7E-04
Benzene	7.8E-06	1.26	9.8E-06
Carbon tetrachloride	6.0E-06	0.23	1.4E-06
Chloroform	2.3E-05	0.18	4.1E-06
Naphthalene	3.4E-05	0.38	1.3E-05
Tetrachloroethylene	2.6E-07	0.25	6.5E-08
Trichloroethylene	4.1E-06	0.56	2.3E-06
Total			2.0E-04 [†]

Abbreviations: IUR = inhalation unit risk; C_{air} = contaminant concentration in air; $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter.

* Environmental concentrations adjusted for worker exposures of 8 hours per day, 5 days per week, 50 weeks per year, and 50 years per 78 years lifespan. One-half the detection limit was used when chemicals were not detected.

[†] The excess lifetime cancer risk without including 1,2-dibromoethane is 3.1E-05.