Health Consultation

Fort Gillem

Forest Park, Clayton County, Georgia

EPA Facility ID: GA0210020046

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Health Consultation: A Note of Explanation

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. To prevent or mitigate exposures, a consultation may suggest specific actions, such as restricting the use of water, replacing water supplies, intensifying environmental sampling, restricting site access, or removing 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 report concludes the health consultation process for this site, unless additional information is obtained by ATSDR. If the new information, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued, the consultation may resume.

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LIST OF ACRONYMS

ATSDR: Agency for Toxic Substances and Disease Registry
BPC: Building Pressure Cycle
BRAC: Base Realignment and Closure
CTET: Carbon Tetrachloride
CV: Comparison Value
DDT: Dichlorodiphenyltrichloroethane
DPH: Department of Public Health
FTG: Fort Gillem
HVAC: Heating, Ventilation, and Air Conditioning
IARC: International Agency for Research on Cancer
kg: kilogram
MRL: Minimal Risk Level
ND: Not Detected above laboratory reporting limit
NLA: North Landfill Area
OSWER: Office of Solid Waste and Emergency Response
PCE: Perchloroethylene
ppb: Parts Per Billion
RSL: Regional Screening Level
SEBS: South East Burial Site
TCE: Trichloroethylene
TeCA: 1,1,2,2-Tetrachloroethane
µg/L: Micrograms per Liter
$\mu g/m^3$: Micrograms per Cubic Meter
USEPA: United States Environmental Protection Agency
VI: Vapor Intrusion
VOC: Volatile Organic Compound

1.0 Summary

Introduction

In August 2016, the Georgia Environmental Protection Division (EPD) asked the Georgia Department of Health (DPH) for assistance with evaluating the public health implications of exposure to chemicals from the Fort Gillem site. DPH conducted this health consultation under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR performs health consultations at sites where environmental contamination may impact human health. The purpose of this health consultation is to determine if any potentially harmful exposures to site-related contaminants are occurring or may occur in the future. The contaminants of concern are in groundwater plumes associated with historical activities at Fort Gillem.

The United States Army conducted a vapor intrusion investigation of the residential and commercial properties adjacent to the former Fort Gillem Army Installation. The Army chose this area because shallow groundwater contaminated with volatile organic compounds (VOCs) migrated offsite. The Army's investigation was conducted in multiple phases. The investigation included conducting seasonal vapor intrusion data collection; using data from prior soil and groundwater investigations; identifying and filling data gaps; and making recommendations for what additional steps were necessary.

DPH analyzed the available groundwater, soil gas, and indoor air data from the Army's vapor intrusion investigation. Groundwater data were obtained between 2012 and 2014, and indoor air samples were collected in 2014 and 2015. DPH evaluated whether volatile organic compounds (VOCs) could cause vapor intrusion near the Fort Gillem site in the North Landfill Area (NLA) and the Southeast Burial Site (SEBS) locations (See Figure A.1). The VOCs detected in groundwater are also common indoor air contaminants.

DPH reached the following conclusions about the Fort Gillem site.

Conclusion 1

For residences and several commercial buildings (parcels with a minimum of two seasonal sample sets for indoor air) that border the Fort Gillem site, DPH concludes that breathing in volatile organic compounds in indoor air is not expected to harm people's health.

Basis for Conclusion	In properties where benzene, chloroform, or TCE exceeded health-based comparison values in air, soil gas, and groundwater, DPH examined available groundwater, soil gas, and indoor air data from the Fort Gillem site. Then, DPH selected certain locations (map IDs) for further evaluation. DPH chose 26 locations from the NLA and 16 from the SEBS for further evaluation. Within those selected properties, there were 16 properties in the NLA and 9 properties in the SEBS that had at least two seasonal rounds of indoor air samples (Figures A-18 and A-19). VOCs were present. However, based on the available data, vapor migration of these chemicals into homes and commercial buildings from vapor intrusion does not appear to be occurring *(with the possible exception of one commercial building, Map ID 144; see Conclusion 2 for more details).* Although some contaminant levels exceeded health screening levels, the contaminant concentrations were within expected outdoor background levels and well below levels that might result in noncancer health effects. Background air samples were collected to represent outdoor air conditions near the buildings being sampled. In addition, cancer risk estimates for properties with at least two seasonal rounds of indoor air sampling were not a health concern and indicated either a no increased concern or a low concern risk for cancer from exposure to benzene, chloroform, or TCE. Low levels of these chemicals are often found in indoor and outdoor air.
Conclusion 2	Vapor intrusion may be occurring at Map ID 144; a commercial property located along the northern boundary of the site. However, there is no increased concern for noncancer and cancer health risks for full-time employees, even if they work in the building for decades. Although it is likely that the majority contribution to indoor air contaminants detected at this property is from indoor sources, vapor intrusion cannot be ruled out.
Basis for Conclusion	The Army conducted secondary forensic testing at Map ID 144. The tests included subslab soil gas, as well as indoor and outdoor air sampling on a long-term basis to improve the representativeness of data. In addition, cross-slab differential pressure data were collected during the 28-day sampling period. The cross-slab data indicated that indoor conditions at Map ID 144 were favorable to vapor intrusion. This was especially evident during the night when the commercial building was not occupied.

	DPH further evaluated this property based on the data maps. In the winter of 2014, the data maps indicated the presence of chloroform at 14,000 µg/L in groundwater, 1,700 µg/m^3 in deep soil gas, and 110 µg/m^3 in shallow soil gas within 100 feet of the parcel. A spatial pattern consistent with a subsurface source of chloroform shows evidence that a concentration gradient from a subsurface source to indoor air does exist at Map ID 144. For example, if the concentration of chloroform found in groundwater is higher than the concentration found in deep soil gas, and the deep soil gas concentration is higher than the concentration found in shallow or subslab soil gas and is also detected in indoor air at a lower concentration than subslab soil gas, this would show a concentration pattern consistent with vapor intrusion. Based on DPH's evaluation, vapor intrusion cannot be ruled out because of the very high soil gas concentrations and the cross-slab differential pressure. Chloroform was detected at Map ID 144 in indoor air at 1.2 µg/m^3 (summer 2014) and at 1.0 µg/m^3 (winter 2015.) During more intensive testing at Map ID 144 in 2015, the mean chloroform concentration in indoor air was calculated to be 1.2 µg/m^3. The cancer risk for full-time workers employed for 20 years was estimated at less than 1 cancer in a million workers exposed. This indicates no concern for risk of cancer for exposed full-time employees.
Conclusion 3	For residences or businesses where indoor air was only sampled once or not sampled at all, DPH cannot determine whether a health hazard exists.
Basis for Conclusion	DPH evaluated multiple media, including indoor air data obtained during the Fort Gillem investigation. In order to fully evaluate the vapor intrusion pathway, multiple indoor air samples must be obtained during different seasons. Multiple samples help to determine whether vapor intrusion may be occurring because of seasonal differences. Some seasonal differences include the effect of heating and air conditioning systems on increasing or decreasing air flow from the subsurface into buildings. Some homeowners declined participation in the study before sampling started or after one round of sampling. Of the homes that only had one round of indoor air sampling, three homes showed concentrations of TCE in indoor air above ATSDR's cancer screening level also known as a cancer risk evaluation guide (CREG). One home sampled only one time showed a chloroform concentration in indoor air above ATSDR's CREG.

Next Steps

DPH recommends the following to the Army:

1. Conduct intermittent indoor air sampling of Map ID 144 until the subsurface chloroform concentrations are below ATSDR subsurface vapor intrusion comparison values (CVs).
2. Continue to monitor the groundwater plumes in both the NLA and SEBS areas to determine the overall effectiveness of attenuation. Implement source removal action in the NLA and SEBS areas to include Fort Gillem (FTG) locations FTG-01, FTG-07, FTG-09, and FTG-10.
3. Resume soil gas sampling every 5 years if contaminated groundwater sources continue to exist at levels exceeding ATSDR vapor intrusion CVs (CREGs of 0.52 µg/L for TCE, 0.57 µg/L for benzene, and 0.29 µg/L for chloroform) in residential areas.
4. If soil gas sampling resumes and concentrations exceed vapor intrusion comparison values, offer to repeat indoor air sampling for residents/business owners at Map IDs impacted by groundwater plumes. Offer subslab/crawlspace and outdoor air sampling to show stronger lines of evidence that there is a vapor intrusion exposure pathway.
5. Seasonally, offer follow-up indoor air sampling to residents near contamination who are making modifications to their homes. Modification examples include replacing heating, ventilation, and air conditioning (HVAC) systems; upgrading windows or insulation; modifying slabs or ground cover; or installing drains or sump pumps.

DPH will:

1. Focus on educating residents in the Fort Gillem area about the potential health effects of exposure to indoor air contaminants identified in this health consultation.
2. Address potential health risks associated with harmful exposures to VOCs in consumer products and create a fact sheet for distribution to Fort Gillem residents. The fact sheet will describe how to reduce or eliminate exposures in the home or work environment.
3. Distribute a fact sheet to educate homeowners whose homes were sampled. The fact sheet will describe how home alteration can affect air quality in their homes.

	4. Distribute a copy of this health consultation or a fact sheet summarizing our findings to EPD and to any Fort Gillem resident who requests copies. 5. Work with the Army to re-evaluate the need for additional soil gas and indoor air sampling if requested and if groundwater remediation efforts do not achieve targeted reduction.
For More Information	If you have questions or comments, call ATSDR toll-free at 1-800-CDC-INFO. Ask for information on the Fort Gillem Vapor Intrusion Health Consultation in Forest Park, Clayton County, Georgia.

2.0 Background and Statement of Issues

In August 2014, the Georgia Environmental Protection Division (EPD) requested the Georgia Department of Health's (DPH) assistance. EPD asked DPH to help evaluate the public health implications of exposure to chemicals from the Fort Gillem site. DPH conducted this health consultation under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR performs health consultations at sites where environmental contamination may impact human health. The purpose of this health consultation is to determine if any potentially harmful exposures to site-related contaminants are occurring or may occur in the future because of groundwater plumes associated with activities at Fort Gillem.

2.1 Site History and Description

Fort Gillem is a former United States Army Installation located in Forest Park, Clayton County, Georgia. It was closed in 2011 under the Army's Base Realignment and Closure Division (BRAC). The base was active from 1941 to 2011, serving the Army from World War II through Operation Desert Shield/Storm. The site (Figure A.1) spans approximately 1,400 acres and is located between Georgia Highway 54 (Jonesboro Road) and U.S. Highway 23 (Moreland Avenue).

Some volatile organic compounds (VOCs) associated with past Fort Gillem operations were detected in off-site groundwater monitoring wells during environmental investigations. The investigations have been performed since the 1970s. For the purposes of this health consultation, the Army designated five areas for evaluation: the FTG 01 western, central, and eastern North Landfill Area; and the FTG09 and FTG 07/10, in the Southeast Burial Site (SEBS). Figure A.1 and maps in the Appendices illustrate these areas. In 2002, remedial actions began in the Southeast Burial Site area (SEBS) with soil excavation. In 2009, remedial actions expanded to soil and groundwater treatment. The actions included a groundwater extraction treatment system to capture dissolved volatile organic compounds (VOCs) prior to leaving the site [Geosyntec 2016a]. Remedial activities in the Northeast Landfill Area (NLA) included the construction of another groundwater extraction treatment system, soil and waste excavation, and flood control structures [Geosyntec 2016b]. In June 2015, the Army began remediation efforts to mitigate VOC contamination of the subsurface at the designated NLA and SEBS locations. The 2015 efforts were on an accelerated schedule [Geosyntec 2016a and b].

Army Selected Map IDs

The Army's vapor intrusion investigation was conducted in multiple phases and began in summer 2014 [Geosyntec 2016a, b and c]. The investigation included three sampling events that took place in summer 2014, winter 2015, and summer 2015. Vapor intrusion (VI) sampling events were conducted in the summer and winter to account for seasonal variability. Map IDs selected for the vapor intrusion study areas were primarily residential but included several commercial buildings as well. The Army collected and analyzed data from groundwater, soil gas, crawl space, subslab soil gas, indoor, and outdoor air. Site areas were assigned abbreviated descriptions to designate the region under investigation. "FTG" indicates Fort Gillem. Each

description also had a numeric identifier (01, 07/10, and 09). The North Landfill Area (NLA) has been designated FTG-01 (Figure A.1).

During the VI investigation, the U.S. Army evaluated 204 buildings in the NLA. All 204 were deemed to have a potential vapor intrusion exposure pathway [Geosyntec 2016b]. The U.S. Army evaluated 104 buildings in the SEBS [Geosyntec 2016a]. Of those,

- 100 buildings have a potential VI pathway.
- Pride and Joy Daycare was included in the Army's investigation. This building has undergone mitigation because children are present. The Army has allowed the mitigation system to remain on the premises but is no longer financing its operation. DPH addressed Pride and Joy Daycare in a separate health consultation [DPH 2015].
- Three buildings are indeterminate for a VI exposure pathway due to access denial. Their building owners declined participation in the investigation.

2.2 Area Demographics

Using 2010 U.S. Census data, ATSDR calculated civilian population information within a 1-mile radius of the Fort Gillem site boundary. The civilian population in this area is 13,528 and there are 5,583 housing units. The area includes 1,679 children ages 6 and under. There are 3,104 women of childbearing age and 1,146 adults aged 65 and over. Figure A.2 in the Figures and Appendices section shows detailed demographic information.

2.3 Geology and Hydrogeology

The Fort Gillem site, including adjacent properties, is located in the Piedmont region of the southeastern U.S. This geographic region is comprised of pre-Cambrian to Paleozoic igneous rock. Rock types include Stonewall and Crider Gneiss. Stonewall is characterized as deformed, schistose, pegmatitic, and biotite rich. Crider rock is characterized as slabby, muscovite rich, and biotite-muscovite-quartz gneiss [WENCK 2015a and b; Crawford et al. 1999].

Groundwater beneath the site flows in different directions depending on the location within the site. In the NLA, groundwater flows to the west/northwest (see Figure B.16 in Appendix B) in the western region. Groundwater flow is to the northwest in the central and eastern regions [Geosyntec 2016b; WENCK 2015a]. In the northwest corner of the site, groundwater flows within the overburden soil toward Conley Creek where it discharges.

In the SEBS area, groundwater flows south and southeast (Figure B.17 in Appendix B) [Geosyntec 2016a] and flows toward Upton Creek [WENCK 2015b]. Groundwater flow in the SEBS also occurs within overburden soil. There is limited groundwater data south of Upton Creek [WENCK 2015b].

The Army conducted a well water survey to evaluate the potential for people to encounter VOCs in groundwater using private off-site wells as a drinking water source. North of the NLA, 10 private wells were identified, and south of the SEBS area, 14 private wells were identified. All 24 off-site private wells were abandoned, capped, or inoperable [Geosyntec 2016a and b].

2.4 Known Sources of Contamination

Five groundwater plumes exist at the Fort Gillem installation, all of which originate inside of the base and extend outward to surrounding residential and commercial properties. Three plumes, all designated FTG-01, originated in the NLA. All three plumes are in the northwestern portion of the Fort Gillem base and groundwater depth is approximately 15 feet below ground surface. The plumes are further subdivided as western, central, and eastern. The SEBS area contains the other two groundwater plumes located in the southeastern portion of the Fort Gillem base with a groundwater depth approximately 10 feet below ground surface. These plumes are designated FTG 07/10 and FTG 09. FTG-07 and FTG-10 are associated with two separate disposal areas but are combined because they are part of the same watershed. Figure A.1 is the Fort Gillem site map that illustrates all groundwater plumes. The Army's past disposal activities in the NLA and SEBS locations have contributed to contamination of the groundwater plumes in these areas.

2.4.1 NLA (FTG-01)

The NLA was the disposal area between 1941-1980. Surplus army equipment, industrial wastes such as food products and sludge, rubber products, sludge from sewage treatment plants, dichlorodiphenyltrichloroethane (DDT), pharmaceutical/surgical supplies and materials, petroleum oil and lubricants, and gas mask parts were disposed of in the NLA. Disposal practices included landfilling, trenching, burning, burial, and surface deposition.

2.4.2 SEBS (FTG-07, FTG-10 and FTG-09)

The Southeast Burial Site is divided into three areas. The areas were combined in the vapor intrusion investigation. Past activities in the FTG-07 area included sub-surface disposal of pharmaceutical wastes, intravenous tubes, needles, wire fragments, wood, metal pipe, and tetrachloroethane (1,1,2,2-TeCA). In the FTG-10 area adjacent to FTG-07, sub-surface disposal included rubber products, battery acid, office equipment and supplies, as well as an array of unspecified chemicals such as stripping compound. In FTG-09, waste disposal included petroleum, oil, lubricants, pharmaceutical wastes, food products, and a 500-kilogram mustard bomb that was deactivated at Fort Gillem before it was buried.

The FTG-07 and FTG-10 areas of the SEBS were combined into one study area because of their location within the same watershed. They also had similar contaminants without an identifiable common source [Geosyntec 2016a]. In 2000, dissolved trichloroethene (TCE) and tetrachloroethane (1,1,2,2-TeCA) in groundwater were identified off-site, originating from FTG-07 and migrating southeast of the installation boundary.

2.5 Potential Sources of Contamination

The Army performed environmental site assessments near the NLA and SEBS regions to identify other potential sources of contamination located at properties adjacent to the Fort Gillem site. These properties were classified according to risk (no, high, or low). The risk was based on their history of handling, generating, and/or disposing of hazardous waste. 'No risk' was assigned to

sites with no history associated with hazardous waste. 'Low risk' was assigned to sites with a history of hazardous waste handling, generation, and/or disposal but no reported history of regulatory violations. 'High risk' was assigned to sites with the same history with hazardous waste but with a reported history of regulatory violations. In the NLA region, one property was identified as low risk. In the SEBS region, six commercial properties were identified as low risk and one commercial property identified as high risk. Operations at these seven sites included a municipal landfill, biomedical waste collection, automobile repair services, and/or the use of underground storage tanks. None of the locations were residential properties.

3.0 Discussion

Vapor intrusion is defined as the migration of hazardous gases from any subsurface contaminant source into an overlying building or occupied structure through any opening or conduit [USEPA 2015]. The hazardous gases released into residential or commercial buildings, if inhaled, could potentially harm the health of the occupants of those buildings. Vapor intrusion can occur when certain chemicals, such as VOCs, are released below the ground surface and form hazardous vapors that migrate or are transported through the vadose zone to ambient air and into buildings. The vadose zone is the soil between the groundwater table and land surface [USEPA 2015]. Vapors formed in the vadose zone can migrate into buildings through seams, interstices, basement floors, walls, building foundations, utility conduits, drains, and sewer lines.

3.1 Identifying Contaminants of Concern from Available Sampling Data

DPH uses a screening process to identify contaminants of concern (COCs) for further evaluation. As a preliminary step, DPH examines the types and concentrations of chemicals and then compares them with comparison values generally established by ATSDR and USEPA. Comparison values (CVs) are concentrations of a contaminant that are not expected to be harmful to human health, assuming health-protective conditions of exposure. Concentrations greater than screening levels do not necessarily mean that people will become ill from exposures, but that further evaluation is necessary to evaluate the potential for harmful health effects [ATSDR 2005].

CVs include uncertainty factors to ensure sensitive populations are protected. Because CVs do not represent thresholds of toxicity, exposure to contaminant concentrations above CVs will not necessarily lead to adverse health effects [ATSDR 2005].

Screening values are media-specific contaminant concentrations unlikely to cause noncancer health effects. In soil, water, or air, the values are associated with a low risk of cancer (i.e., 1 additional cancer in a million people exposed). For this health consultation, DPH used the following CVs and health guidelines:

- **ATSDR soil gas intrusion CVs, or SVI CVs**. These subsurface screening levels for vapor intrusion provide screening level concentrations for groundwater and soil gas.
- **ATSDR Cancer Risk Evaluation Guides, or CREGs**. CREGs are media-specific concentrations in water, soil, or air that are unlikely to result in an increase in cancer in a population exposed over an entire lifetime. CREGs are derived from USEPA's cancer slope factors, which indicate the relative potency of cancer-causing chemicals. Not all

carcinogenic compounds have a USEPA or state-based cancer slope factor, so not all carcinogens have a CREG [ATSDR 2005].

For this health consultation, DPH created maps using available environmental data for groundwater, soil gas, and parcel identification information that linked indoor air sampling results from the Army's investigation.

3.2 Environmental Sampling Data

Tables 1 and 2 below summarize the contaminant concentrations in all environmental media samples for the Map IDs chosen for evaluation. All reported concentration values, if detected, are above health-based CVs. Tables 3 and 4 summarize the indoor air concentration ranges in indoor air for each contaminant obtained during the three sampling events that occurred in summer 2014, winter 2015, and summer 2015, within their respective region of the vapor intrusion study. All groundwater data were obtained between 2012 and 2014. All soil gas data were acquired in August 2014 and February 2015 [Geosyntec 2016a and b].

Table 1. Groundwater and soil gas sampling results both on- and off-site in the North Landfill Area (NLA)

Contaminant of Concern	Groundwater Concentration Range (µg/L)	SVI – Groundwater CV (µg/L)	NE/NP GW	Deep Soil Gas Concentration Range (10 ft below ground) (µg/m³)	NE/NP DSG	Shallow Soil Gas Concentration Range (2-3 ft below ground) (µg/m³)	NE/NP SSG	SVI – Soil Gas CV (µg/m³)
Benzene	68 – 100*	0.57	2/2	18 – 25*	2/2	3.8 – 18*	2/2	4.3
Chloroform	0.48 – 14,000*	0.29	13/13	ND – 1,700*	5/13	ND – 63,000*	5/13	1.4
Trichloroethene	ND – 130*	0.52	13/18	8.1 – 10,000*	18/18	ND – 1,200*	12/18	7.3

Data Source: Geosyntec, Vapor Intrusion Investigation. Volume III
µg/L: micrograms per liter
µg/m^3: micrograms per cubic meter
CV: Comparison Value
NE/NP: Number of properties exceeding CV/Number of properties represented in the data
SVI: ATSDR Soil gas Intrusion CVs (September 2016)
GW: groundwater; DSG: deep soil gas (approximately five (5) feet above the water table or around 10 feet below grade); SSG: shallow soil gas (approximately two to three (2-3) feet below grade)
*Text indicates comparison value was exceeded.

Table 2. Groundwater and soil gas sampling results both on- and off-site in the Southeast Burial Site (SEBS)

Contaminant of Concern	Groundwater Concentration Range (µg/L)	SVI – Groundwater CV (µg/L)	NE/NP GW	Deep Soil Gas Concentration Range (10 ft below ground) (µg/m³)	NE/NP DSG	Shallow Soil Gas Concentration Range (2-3 ft below ground) (µg/m³)	NE/NP SSG	SVI - Soil Gas CV (µg/m³)
Chloroform	0.31 – 2.74*	0.29	8/8	ND – 140*	8/6	5.8 – 39*	8/8	1.4
Trichloroethene	ND – *	0.52	11/16	ND – 17,000*	11/16	ND – 100*	5/16	7.3

Data Source: Geosyntec, Vapor Intrusion Investigation. Volume III
µg/L: micrograms per liter
µg/m³: micrograms per cubic meter
CV: Comparison Value
NE/NP: Number of properties exceeding CV/Number of properties represented in the data
SVI: ATSDR Soil gas Intrusion CVs (September 2016)
GW: groundwater; DSG: deep soil gas (approximately five (5) feet above the water table or around 10 feet below grade); SSG: shallow soil gas (approximately two to three (2-3) feet below grade)
*Text indicates comparison value was exceeded.

Table 3. Indoor Air Sampling Results from Select Map IDs in the North Landfill Area (NLA)

Contaminant of Concern	Number of Properties exceeding CVs/ Number represented	Indoor Air Concentration Range (µg/m³)	CV (µg/m³)	CV Type
Benzene	2/2	0.64 – 0.82*	0.13	CREG
Chloroform	11/13	ND – 8.6*	0.043	CREG
Trichloroethene	2/18	ND – 6.3*	0.22	CREG

Data Source: Geosyntec, Vapor Intrusion Investigation. Volume III
CV: comparison value
CREG: Cancer Risk Evaluation Guide (February 2017)
µg/m³: micrograms per cubic meter
*Text indicates comparison value was exceeded.

Table 4. Indoor Air Sampling Results from Select Map IDs in the Southeast Burial Site (SEBS)

Contaminant of Concern	Number of Properties exceeding CVs/ Number represented	Indoor Air Concentration Range (µg/m³)	CV (µg/m³)	CV Type
Chloroform	7/8	ND – 3.2*	0.043	CREG
Trichloroethene	5/16	ND – 1.1*	0.22	CREG

Data Source: Geosyntec, Vapor Intrusion Investigation. Volume III
CV: comparison value
CREG: Cancer Risk Evaluation Guide (February 2017)
µg/m³: micrograms per cubic meter
*Text indicates comparison value was exceeded.

DPH Selected Map IDs

From the visual representation of all available data, DPH selected certain Map IDs in the NLA (FTG-01) and SEBS (FTG-07/09/10) areas for further evaluation. Specifically, we selected locations where benzene, chloroform, and TCE were identified in groundwater, soil gas, and indoor air that exceeded health-based comparison values (CVs).

The Map IDs were selected using these criteria:

- The availability of indoor air data
- The presence of chemicals of concern detected in groundwater within 100 feet of a building whose concentrations exceeded groundwater CVs for vapor intrusion
- The presence of chemicals of concern detected within 100 feet in deep and/or shallow soil gas whose concentrations exceeded the soil-gas CVs for vapor intrusion

Maps showing Map IDs are available in Appendix B, Figures B.1 – B.15. All available data were compiled for each selected Map ID and evaluated according to USEPA's Office of Solid Waste and Emergency Response (OSWER) and ATSDR vapor intrusion guidelines [USEPA 2016, ATSDR 2016].

DPH chose 26 Map IDs from the NLA/FTG-01 for further evaluation: lots 107, 109, 112, 113, 114, 115, 116, 117, 118, 121, 123, 124, 129, 136, 144, 145, 149, 150, 153,169, 174, 188, 189, 190, 198, and 202. See Figures B.1 through B.6 and B.13 through B.15 in Appendix B for Map ID locations and environmental data.

Additionally, DPH chose the following 16 Map IDs from the SEBS/FTG-07/09/10 for further evaluation: lots 701, 704, 705, 707, 712, 713, 714, 909, 910, 914, 917, 925, 930, 931, 937 and 942. See Figures B.7 through B.9 and B.13 through B.15 in Appendix B for Map ID locations and environmental data.

3.3 Indoor Air Data Evaluation

Data ranges illustrated in Tables 3 and 4, represent the lowest and highest indoor air concentrations reported in their respective region. The following chemicals were detected indoors in the NLA (Figure B.18):

- Benzene concentrations ranged from 0.2 $\mu g/m^3$ to 0.82 $\mu g/m^3$, with Map ID 129 having the highest concentration of benzene in indoor air at 0.82 $\mu g/m^3$. Map ID 129 was the only one of eight homes in the highest benzene area that was sampled.
- Chloroform concentrations ranged from 0.73 $\mu g/m^3$ to 8.6 $\mu g/m^3$ with Map ID 136 having the highest concentration of chloroform detected in indoor air.
- TCE concentrations ranged from below the detection limit of 0.13 $\mu g/m^3$ to 6.3 $\mu g/m^3$. The highest concentration was at Map ID 124. Health-based comparison values (CVs) established for cancer health effects were exceeded for all contaminants.

The following chemicals were detected indoors in the SEBS (Figure B.19):

- Chloroform concentrations ranged from below the detection limit of 0.12 $\mu g/m^3$ to 3.2 $\mu g/m^3$. Map ID 704 had the highest concentration.

- TCE concentrations ranged from below detection limits of 0.13 µg/m^3 to 1.1 µg/m^3 at Map ID 930.
- Cancer CVs (CREGs) at these Map IDs were exceeded for chloroform and TCE.

Individual indoor air results for each Map ID may or may not include more than one round of sampling. The intent of the vapor intrusion investigation was to include two rounds of seasonal indoor air sampling data (one in summer and one in winter) per Map ID. However, some homeowners or building owners denied access for the first or second round of sampling. This represents a gap in the indoor air data, as the entire investigation at each parcel could not be completed. Other data gaps include the lack of indoor air and soil gas data from the years 2012 and 2013, when groundwater data were available.

4.0 Exposure Pathways Analysis

Exposure pathways are the means by which people in areas near the Fort Gillem site could have been or could currently be exposed to site-related contaminants. An exposure pathway consists of five elements:

1. Source of contamination
2. Contaminated environmental medium (air, soil, water)
3. Location where someone contacts the contaminated medium (exposure point)
4. Exposure route, such as inhalation (breathing), dermal absorption (skin contact), or ingestion (swallowing or eating)
5. The population that might be exposed

An exposure pathway is complete when all five elements are present. Potential exposure pathways exist when one of the elements is missing. For example, if soil samples are not available for a yard, the people who live at that property are part of a potential soil ingestion pathway until their soil is sampled. Health assessors eliminate pathways from further assessment if one or more elements are missing and are never likely to be present [ATSDR 2005].

4.1 Exposure Assumptions

DPH assumed residents living or working at selected Map IDs near the Fort Gillem site may have been exposed to benzene, chloroform, and TCE vapors from contaminated groundwater plumes. Assumptions also include exposure to these VOCs from unidentified sources located somewhere internally or externally of the building structures. This is due to these contaminants frequently having background concentrations in indoor air originating from a variety of sources other than vapor intrusion [USEPA 2011a]. Exposure assumes the inhalation pathway route only. In the case of vapor intrusion, data has been evaluated to determine whether VOC vapors entered into indoor air of commercial and residential buildings surrounding Fort Gillem at concentrations that could cause harm to the occupants breathing the contaminated air.

DPH independently evaluated environmental data and indoor air data acquired in the vapor intrusion investigation according to the OSWER Technical Guide for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air and ATSDR's vapor intrusion guidelines [ATSDR 2016; USEPA 2015]. The technical manuals describe conditions

that must be met in order for the vapor intrusion pathway to be considered complete, as well as other phenomenon that may potentially contribute to the presence of contaminants of concern in indoor air. The OSWER manual stipulates the following [ATSDR 2016; USEPA 2015].

- **Results indicating vapor intrusion as solely responsible for vapor concentrations in indoor air:** The predominant vapor-forming chemicals in sub-slab soil gas and their relative proportions in indoor air and sub-slab vapor samples would be expected to be similar, whereas their concentrations in sub-slab soil gas would be expected to be substantially higher than in indoor air, if vapor intrusion is solely responsible for indoor air concentrations. If not subject to biodegradation in the vadose zone, the predominant vapor-forming chemicals and their relative proportions in the subsurface vapor source would likewise tend to be similar to those in indoor air if vapor intrusion is solely responsible for indoor air concentrations.
- **Results indicating indoor vapor sources as primarily responsible for indoor air concentrations:** If a vapor-forming chemical is present with an elevated concentration in indoor air but is not present or is negligibly present in subslab soil gas samples, then the presence of this contaminant in indoor air may not arise from the vapor intrusion pathway, but rather from indoor sources or other background sources (e.g., ambient air).
- **Results indicating outdoor vapor sources as primarily responsible for indoor air concentrations:** If a vapor-forming chemical is detected in outdoor air and indoor air at similar concentrations, but is not present in subslab soil gas samples or is present in the subsurface samples at concentrations similar to indoor air, then the presence of this contaminant in indoor air may not arise from the vapor intrusion pathway but rather from outdoor sources (ambient air).

In general, gas concentrations from the subsurface, regardless of source (such as groundwater), will decrease as the chemicals move from the source, through the soil and into indoor air [ATSDR 2016; USEPA 2015]. This decrease in concentration as gases move through soil is expected to result in detections in indoor air at lower concentrations than what is measured in subslab soil gas or crawlspace air. Attenuation factors are used to estimate the expected change in concentration observed between subslab or crawlspace air and indoor air. DPH evaluated Map IDs from the SEBS and NLA regions for the corresponding contaminants identified in groundwater and other environmental media and where indoor air sampling occurred during the vapor intrusion investigation. This approach by DPH does not reflect the comprehensive forensic approach taken by the Army. Rather it is an evaluation of the environmental and air sampling data acquired compared to the anticipated patterns outlined in the OSWER manual that describe the vapor intrusion pathway. It is also a review of the steps taken by the Army to address potential vapor intrusion issues that were discovered during the investigation.

4.2 Exposure Pathway

In Table 5, DPH summarizes the exposure pathways for selected chemicals of concern in the Fort Gillem investigation. The results of the DPH evaluation for each contaminant and associated Map IDs are described below.

Table 5. Inhalation Exposure Pathway for Select Map IDs at Fort Gillem

Source	Environmental Medium	Exposure Point	Exposure Route	Exposed Population	Timeframe	Type of Exposure Pathway
NLA and SEBS at Fort Gillem Army Base	Groundwater	Indoor Air	Inhalation	Residential or commercial occupants in off-site buildings located over groundwater plume	Past, Present, and Future	Potential
Unidentified Source	Indoor Air	Indoor Air	Inhalation	Residential or commercial occupants in off-site buildings located over groundwater plume	Past, Present, and Future	Potential for past; Completed for present and future

NLA: North Landfill Area
SEBS: Southeast Burial Site

4.2.1 Benzene

NLA Map IDs 129 and 136

The Army conducted a review of petroleum hydrocarbons in off-site buildings near the installation perimeter (fence line). This was performed in response to regulatory interest in the possibility that the source of petroleum hydrocarbons was released to the surface in small, recurring events along the fence line. The Army believes the releases were part of herbicide/pesticide blends and were responsible for lateral vapor migration from Fort Gillem through the soil to nearby offsite buildings. As a result, it was theorized that petroleum hydrocarbons, like benzene, in shallow soil could have also contributed to vapor intrusion at Map IDs located off-site on the perimeter of the Fort Gillem property boundary. Only Map IDs located along the Fort Gillem boundary were included in this supplemental evaluation [Geosyntec 2016b]. This additional step was included in the vapor intrusion investigation and

represents the Army's conservative approach to include more Map IDs that were potentially impacted by Army contaminants that were independent of, yet still identified in, the groundwater plume. For the purposes of this health consultation, DPH identified 2 Map IDs that met the criteria for evaluation. Specifically, where benzene was detected within 100 feet of all sampled environmental media, including groundwater as well as in deep and shallow soil gas. Map IDs where benzene was identified in soil gas and not within 100 feet of groundwater were not selected for evaluation by DPH.

Background outdoor air samples were collected to capture ambient conditions near buildings where indoor air samples were collected [WENCK 2015a]. During the summer 2014 sampling event, outdoor background samples were obtained at a rate of 1 per 2 buildings evaluated. During the winter 2015 and summer 2015 sampling events, the rate of sampling was 1 per 3 buildings evaluated. Outdoor background samples were obtained prior to indoor or crawl space sampling, with wind direction documented at the beginning of sampling day and samples acquired on the upwind side of the respective building [WENCK 2015a]. Summa canisters were placed away from home structures and the nearest street and affixed to a fence, tree, telephone pole, or other stable structure [WENCK 2015a].

Benzene concentrations in groundwater ranged from 68 µg/L to 100 µg/L near Map IDs 129 and 136, with deep soil gas concentrations between 18 $\mu g/m^3$ to 28 $\mu g/m^3$ and shallow soil gas concentrations between 6 to 18 $\mu g/m^3$. This is illustrated in Figures B.1, B.2, and B.3 in Appendix B. Benzene was identified in the crawlspace and indoor air at Map ID 129 both in the summer of 2014 and the winter of 2015. Benzene was also detected in crawlspace air at Map ID 136 but not detected in indoor air during summer 2014. However, it was detected in crawlspace air and indoor air during winter 2015. Table 6 summarizes background, crawlspace, and indoor air sampling results.

Table 6: Summary of Background, Crawlspace, and Indoor Air Sampling Results for Benzene During the Summer of 2014 and Winter of 2015 in the NLA (concentrations are in $\mu g/m^3$ of air)

Map ID Sampled	Summer 2014 Outdoor Background $\mu g/m^3$	Summer 2014 Crawlspace $\mu g/m^3$	Summer 2014 Indoor Air $\mu g/m^3$	Winter 2015 Outdoor Background $\mu g/m^3$	Winter 2015 Crawlspace $\mu g/m^3$	Winter 2015 Indoor Air $\mu g/m^3$
129	ND @ 0.061	2.4	0.82*	0.72	0.64	0.64*
136	0.7	2	ND @ 1.5	0.85	1.6	0.74*

$\mu g/m^3$: micrograms per cubic meter
*Text indicates comparison value was exceeded.

Both Map IDs were included in the Army's evaluation of volatile petroleum hydrocarbon sources in soil [Geosyntec 2016b]. The Army's comparative analysis of benzene in crawlspace air samples and shallow soil gas samples at Map ID 129 were determined to be characteristic of vapor extrusion. Vapor extrusion is a phenomenon where gases are migrating to soil gas from a benzene source in the home, the opposite of vapor intrusion. In addition, crawlspace air and indoor air concentrations are similar to what was detected in outdoor, background air. For Map ID 136, as an additional line of evidence, a chemical known as perchloroethylene (PCE) was

used as a tracer to compare its levels to those of benzene. This chemical is useful as a tracer for interpreting these results because it is less prone to degradation in the vadose zone than benzene. PCE was detected in the same shallow soil gas sample at 190 µg/m^3 and in the crawlspace air at 0.43 µg/m3 and 0.22 µg/m^3. At least a 400-fold dilution between soil gas and crawlspace air was identified to exist for PCE, and thus, a similar result was to be expected for benzene in transit from soil gas to crawlspace air. This means that for benzene, no more than 0.01 µg/m^3 could have come from Army-related VOC contaminants because a shallow soil gas concentration for benzene was detected at 3.8 µg/m^3. The origin of benzene appears to be located within the home or outdoors since indoor air concentrations are similar to what was detected in outdoor air. The DPH agrees with the Army's forensic analysis of both Map IDs, which indicates indoor or outdoor sources for benzene, such as consumer products or internal combustion engines [Geosyntec 2016b].

Benzene was not detected in groundwater or deep or shallow soil gas in the SEBS region.

4.2.2 Chloroform

NLA Map IDs 114, 115, 116, 117, 118, 129, 136, 144, 145, 149, 150, 153, and 174

DPH identified 13 Map IDs in the NLA for evaluation and 8 in the SEBS region. Chloroform concentrations in groundwater near selected Map IDs in the NLA ranged from 0.44 µg/L to 14,000 µg/L. Deep soil gas concentrations ranged from non-detect up to 1,700 µg/m^3 and shallow soil gas concentrations were between non-detect and 63,000 µg/m^3. Figures B.4, B.5 and B.6 in Appendix B illustrate the groundwater and soil gas concentrations where chloroform was detected.

In the NLA, based on the sampling results for summer 2014, chloroform was detected in indoor air at Map ID 114 at 7.4 µg/m^3 and at Map ID 139 at 8.6 µg/m^3, though concentrations in crawlspace air were significantly lower. Prior to the second round of sampling, residents were instructed to remove consumer products such as cleaners, glue, spray paint, pine sol, and other products such as solvents, lubricants, and WD-40. Table 7 summarizes background, sub slab/crawlspace, and indoor air sampling results.

Table 7: Summary of Background, Sub slab/Crawlspace and Indoor Air Sampling Results for Chloroform During the Summer of 2014 and Winter of 2015 in the NLA (concentrations are in µg/m³ of air)

Map ID Sampled	Summer 2014 Outdoor Background µg/m³	Summer 2014 Subslab/ Crawlspace µg/m³	Summer 2014 Indoor Air µg/m³	Winter 2015 Outdoor Background µg/m³	Winter 2015 Sub slab/ Crawlspace µg/m³	Winter 2015 Indoor Air µg/m³
114	ND @ 0.12	0.81JD	7.4D*	ND @ 0.19	ND @ 0.19	1.4*
115	0.22J	0.89J	0.36J*	ND @ 0.19	ND @ 0.19	ND @ 0.19
116	ND @ 0.98	ND @ 0.98	ND @ 0.98	ND @ 0.19	ND @ 0.19	ND @ 1.9
117	ND @ 0.12	ND @ 0.12	1.3*	ND @ 0.19	ND @ 0.19	1.7*
118	0.19	2.3JD*	2.9*	ND @ 0.19	ND @ 0.19	0.65J*
129	ND @ 0.12	.32J	1.3*	ND @ 0.19	ND @ 0.19	0.76J*
136	ND @ 0.12	0.82J	8.6J D*	ND @ 0.19	ND @ 0.19	0.97*
145	ND @ 0.98	ND @9.8	Sample	ND @ 1.9	ND @ 1.9	1.9*
149	0.17J	0.72J	0.63J*	ND @ 0.19	ND @ 0.19	0.73J*
150	0.19J	0.68J	2.9*	ND @ 0.19	ND @ 0.19	1.1M*
153	ND @ 0.12	1.1	1.8J D M*	ND @ 0.19	1.4	1.5*
174	not sampled	not sampled	not sampled	ND @ 0.19 0.12*	0.25 0.5*	4.2* 1.2#**

#Sampled in Summer 2015
µg/m³: micrograms per cubic meter
J: analyte detected; estimated value
JD: analyte detected; estimated value is from dilution
M: manual integrated compound
D: value from dilution
*Text indicates comparison value was exceeded.

Winter 2015 sampling results were significantly impacted by the product removal for chloroform and other VOCs in the home. Chloroform was detected at 1.4 µg/m³ indoors at Map ID 114 and 0.97 µg/m³ at Map ID 136(as opposed to 7.4 µg/m³ and 8.6 µg/m³ in the summer of 2014; respectively), though it was not detected in crawlspace or background air. Thus, indoor sources such as municipal water are believed to be responsible for chloroform concentrations detected in indoor air [WENCK 2015c]. Chloroform is known to be a common indoor air contaminant. Municipal water is usually treated with chlorine, which can lead to the formation of chloroform. Chloroform has been found in the air from all areas of the United States and in nearly all of the public drinking water supplies [ATSDR 2024].

For Map IDs 117, 118, 129, 145, 149, 150, 153, and 174, chloroform was detected at low levels indoors. It was either detected at lower levels in crawlspace air or not detected at all in crawl space air during summer 2014 and winter 2015. Chloroform was not detected at Map ID 116 during summer 2014 or winter 2015 sampling. Because chloroform is a common indoor air contaminant that results from the off-gassing of chlorine-treated municipal water, it is likely that the treated water serves as an indoor source of the low levels of chloroform at these locations [Geosyntec 2016b].

Chloroform was detected at Map ID 144 in indoor air at 1.2 µg/m^3 during summer 2014 and at 1.0 µg/m^3 during winter 2015. DPH evaluated this Map ID further based on the data maps, which indicated the presence of chloroform at 14,000 µg/L in groundwater (Figure B.6, MW-06), 1,700 µg/m^3 in deep soil gas, and 110 µg/m^3 in shallow soil gas (Figure B.6, VISG-141) within 250 feet of the parcel. Map ID 144 is a commercial building and is only occupied during business hours of operation. The Army conducted secondary forensic testing, to include subslab soil gas, indoor, and outdoor air sampling on a continuous, long-term basis to improve the representativeness of data [Geosyntec 2016b]. Beginning on September 28, 2015, time-integrated samples of indoor and outdoor air were collected at Map ID 144 over a period of 28 days to estimate the long-term average concentrations versus a snapshot of concentrations obtained in a normal 24-hour duration sampling event for indoor air. In addition, cross-slab differential pressure data collected during the 28-day sampling period indicated that indoor conditions at Map ID 144 were favorable to vapor intrusion. This was especially evident during the night when the building was not occupied. Whereas during business hours, the frequent opening and closing of doors, operation of bathroom fans, HVAC mode, and generally higher wind speeds during the day would hamper conditions favorable to vapor intrusion. Chloroform was detected in one subslab soil gas sample (Location J) at a concentration of 300 µg/m^3 and in 4 indoor air sample locations (Locations B, F, G and J) at concentrations ranging from 0.54 to 2.1 µg/m^3. Table 8 below summarizes subslab soil gas, indoor air, and outdoor air sampling results found during the secondary forensics investigation in September 2015. During forensic testing at Map ID 144, the mean chloroform concentration in indoor air, sampled seasonally in 2015, was 1.2 µg/m^3. Figure A.3 shows the locations from which subslab soil gas and indoor air samples were obtained and their concentrations.

Table 8. Summary of Map ID 144 (in the NLA) Secondary Forensics Subslab Soil Gas and Indoor Air Sampling Results During September 2015

Subslab Soil Gas# Location	Chloroform Concentration µg/m^3	Indoor Air Location	Chloroform Concentration µg/m^3	Outdoor Air Chloroform Concentration µg/m^3	CV µg/m^3	Type of CV
SBSL-B	ND	IA-B	0.58*	0.096	0.043	CREG
SBSL-F	ND	IA-F	2.1*	0.096	0.043	CREG
SBSL-G	ND	IA-G	1.8*	0.096	0.043	CREG
SBSL-J	300	IA-J	0.54*	0.096	0.043	CREG

Data Source: Geosyntec, Vapor Intrusion Investigation. Volume III
#24-hour sampling event that occurred on September 27, 2015
µg/m^3: micrograms per cubic meter
CV: Comparison Value
CREG: ATSDR Cancer Risk Evaluation Guide
SBSL: Subslab
IA: Indoor Air
Locations B, F, G, and J are the sampling locations in Map ID 144 depicted in Figure A.3 in the appendix.
*Text indicates comparison value was exceeded.

Subslab samples taken from Location J varied from 470 µg/m^3 in (February 2015) to 130 µg/m^3 (June 2015) to 300 µg/m^3 (September 2015). Over the same three sampling events, chloroform

was detected in indoor air samples ranging from 0.45 to 2.1 µg/m^3 [Geosyntec 2016b]. However, the reported range in indoor air is similar to the median background concentration range described by USEPA in 2011 [USEPA 2011a].

Throughout the period of indoor air sampling, the cross-slab differential pressure was close to neutral, varying from -1.25 to +0.7 Pascals (Pa), but was slightly negative more than 90 percent of the time (Figure A.4). This means the building was under-pressurized with respect to the subslab. Differential pressure data indicate that conditions favorable to vapor intrusion from the subslab could have occurred throughout the indoor air sampling period [Geosyntec 2016b].

Based on the results of the 28-day sampling interval, the Army concluded that chloroform in the subsurface is not contributing significantly to the concentrations in indoor air. The Army made this conclusion noting that indoor air concentrations of chloroform are not distinguishable from the influence of background contributions [Geosyntec 2016b].

Our analysis, however, shows that a spatial pattern consistent with a subsurface source of chloroform shows evidence that a concentration gradient from a subsurface source to indoor air could exist. Although it is possible that most of the contribution to indoor air levels of chloroform is from indoor sources, vapor intrusion cannot be ruled out. Therefore, future, intermittent indoor air sampling of Map ID 144 would be prudent until the subsurface chloroform concentrations are below ATSDR subsurface vapor intrusion CVs.

SEBS Map IDs 704, 705, 714, 909, 914, 921, 930, and 931

In the SEBS area, groundwater concentrations of chloroform near selected Map IDs ranged from 0.31 µg/L to 2.74 µg/L, with deep soil gas concentrations ranging from non-detect up to 140 µg/m^3 and shallow soil gas ranging from 5.8 µg/m^3 to 39 µg/m^3. Figures B.7, B.8 and B.9 in Appendix B illustrate groundwater and soil gas concentrations, and corresponding Map IDs where chloroform was detected in the SEBS. Table 9 below summarizes background, sub slab/crawlspace, and indoor air sampling results in the SEBS.

Table 9: Summary of Background, Sub slab/Crawlspace, and Indoor Air Sampling Results for Chloroform During the Summer of 2014 and Winter of 2015 in the SEBS (concentrations are in µg/m³ of air)

Map ID Sampled	Summer 2014 Outdoor Background µg/m³	Summer 2014 Subslab/ Crawlspace µg/m³	Summer 2014 Indoor Air µg/m³	Winter 2015 Outdoor Background µg/m³	Winter 2015 Sub slab/ Crawlspace µg/m³	Winter 2015 Indoor Air µg/m³
704	ND @ 0.98	2.1	3.2*	ND @ 0.19	ND @ 0.19	1.1*
705	ND @ 0.12	ND @ 0.12	0.56*	ND @ 0.19	0.45	1.8*
714	ND @ 0.98	1.3	ND @ 2.7	declined	declined	declined
909	ND @ 0.12	0.14	0.38*	ND @ 0.19	ND @ 0.19	ND @ 0.24
914	0.26 JD	ND @ 0.12	8.1 D*	declined	declined	declined
921	ND @ 0.12	ND @ 0.98	0.64 J*	ND @ 0.19	ND @ 1.9	ND @ 0.19
930	ND @ 0.12	0.17 JM	0.26 J*	ND @ 0.19	ND @ 1.9	ND @ 0.19
931	ND @ 0.19	ND @ 1.9	0.84 JD*	ND @ 0.19	ND @ 1.9	ND @ 0.19

Data Qualifiers

J: analyte detected; estimated value
JD: analyte detected; estimated value is from dilution
JM: analyte detected; manually integrated compound
D: estimated value from dilution

µg/m³: micrograms per cubic meter
*Text indicates comparison value was exceeded.

We made the following observations based on the available data reported in Table 9:

- Chloroform was not detected at Map ID 714 during summer 2014 and homeowners declined participation in the winter 2015 sampling event. Low levels of chloroform were detected in the sub slab/crawlspace in summer 2014.
- During summer 2014, chloroform was detected at Map ID 914 in indoor air at 8.1 µg/m³ but was not detected in crawlspace air. Homeowners declined participation in the winter 2015 sampling event.
- Chloroform was detected in indoor air above cancer CVs at Map IDs 704, 705, 921, 930, and 931 during summer 2014. During winter 2015, chloroform was not detected in Map IDs 921, 930, and 931. In addition, chloroform was detected either below indoor air levels in crawlspace air or not at all in the crawlspace.
- Chloroform was detected in indoor air at Map ID 909 at 0.38 µg/m³ and at 0.14 µg/m³ in crawlspace air. However, chloroform was not detected during the winter 2015 sampling event.

The Army concluded that chloroform levels indoors are not consistent with a sub-surface source because the concentrations in crawlspace air were lower than indoor air. DPH agrees with this conclusion.

Chloroform is also known to be a common indoor air contaminant. Municipal water is usually treated with chlorine, which can lead to the formation of chloroform. Chloroform has been found in the air from all areas of the United States and in nearly all of the public drinking water supplies [ATSDR 2024]. In the SEBS, the concentrations of chloroform in indoor air exceeded

the concentrations in crawl spaces most of the time, regardless of the Map IDs location or proximity to groundwater where chloroform was detected [Geosyntec 2016a]. The Army determined that these observations served as evidence to support an indoor source for chloroform and not a vapor intrusion pathway [Geosyntec 2016a]. DPH agrees with this analysis and conclusion.

4.2.3 TCE

NLA Map IDs 107, 109, 112, 113, 114, 115, 116, 117, 118, 121, 123, 124,169, 188, 189, 190, 198, and 202

DPH identified 18 Map IDs in the NLA and 16 Map IDs in the SEBS for evaluation. TCE groundwater concentrations near selected Map IDs in the NLA ranged from non-detect to 130.0 µg/L. Deep soil gas was detected at concentrations ranging from 8.1 µg/m^3 to 10,000 µg/m^3. Shallow soil gas concentrations ranged from non-detect to 1,200 µg/m^3. Figures B.10, B.11, and B.12 in Appendix B show sampling locations and results where TCE was detected in groundwater and soil gas. Table 10 below summarizes background, subslab/crawlspace, and indoor air sampling results for selected Map IDs in the NLA.

Table 10: Summary of Background, Sub slab/Crawlspace and Indoor Air Sampling Results for TCE During the Summer of 2014 and Winter of 2015 in the NLA (concentrations are in µg/m^3 of air)

Map ID Sampled	Summer 2014 Outdoor Background µg/m^3	Summer 2014 Crawlspace µg/m^3	Summer 2014 Indoor Air µg/m^3	Winter 2015 Outdoor Background µg/m^3	Winter 2015 Crawlspace µg/m^3	Winter 2015 Indoor Air µg/m^3
107	ND @ 1.1	ND @ 0.13	0.49*	declined	declined	declined
109	ND @ 1.1	ND @ 1.1	ND @ 1.1	ND @ 0.16	ND @ 0.16	ND @
112	ND @ 1.1	ND @ 2.1	ND @ 2.7	ND @ 0.16	ND @ 0.16	ND @
113	ND @ 1.1	ND @ 1.1	ND @ 2.7	ND @ 0.16	ND @ 0.16	ND @
114	ND @ 0.13	ND @ 0.39	ND @ 0.26	ND @ 0.16	ND @ 0.16	ND @
115	ND @ 0.13	ND @ 0.13	ND @ 0.13	ND @ 0.2	ND @ 0.2	0.63 J*
116	ND @ 1.1	ND @ 1.1	ND @ 1.1	ND @ 0.16	ND @ 0.16	ND @ 1.6
117	ND @ 0.13	ND @ 0.13	ND @ 0.13	ND @ 0.16	ND @ 0.16	ND @
118	ND @ 0.13	ND @ 0.32	ND @ 1.24	ND @ 0.16	ND @ 0.16	ND @
121	ND @ 0.13	ND @ 0.13	ND @ 0.13	declined	declined	declined
123	ND @ 0.13	0.14 J	0.34 JD*	declined	declined	declined
124	ND @ 0.16	ND @ 0.16	ND @ 0.16	ND @ 0.16	ND @ 0.16	6.3*
169	not sampled	not sampled	not sampled	0.19 J*	0.22 JM*	ND @
188	not sampled	not sampled	not sampled	0.18 JM*	ND @ 0.16	ND @
189	not sampled	not sampled	not sampled	ND @ 0.16	ND @ 0.16	ND @
190	not sampled	not sampled	not sampled	ND @ 0.16	ND @ 0.16	ND @
198	not sampled	not sampled	not sampled	ND @ 0.16	ND @ 0.16	ND @
202	not sampled	not sampled	not sampled	ND @ 0.16	ND @ 0.16	ND @

Data Qualifiers:
J: analyte detected; estimated value
JD: analyte detected; estimated value is from dilution
JM: analyte detected; manually integrated compound
µg/m^3: micrograms per cubic meter
*Text indicates comparison value was exceeded.

Results from the vapor intrusion investigation indicate Map ID 107 underwent one round of sampling in summer 2014 and homeowners declined participation for the remainder of the study. However, for Map IDs 109, 112, 113, 114, 115, 116, 117, and 118, TCE was not detected in indoor air during summer 2014 or winter 2015 sampling. TCE was not detected at Map IDs 169, 188, and 198 during winter 2015. Homeowners declined participation for additional sampling in summer 2015. TCE was not detected at Map ID 189 and 202 during sampling in winter 2015 or summer 2015. Summer 2014 results from Map ID 123 indicated that TCE was detected at 0.34 µg/m^3, though data qualifiers indicate that though the contaminant was detected, the concentration is an estimated value. Additionally, the indoor concentration was higher than the concentration of 0.14 µg/m^3 in crawlspace air. Further analysis could not be performed because homeowners declined participation for follow up sampling in winter 2015. TCE was not detected indoors at Map ID 190 during winter 2015, yet was detected at distinctly similar, low concentrations below cancer CVs, in both crawlspace 0.19 µg/m^3 and indoor air at 0.14 µg/m^3 summer 2015.

TCE was not detected at Map ID 124 during the first round of sampling in summer 2014. However, in winter 2015, TCE was detected at 6.3 µg/m^3. It was below the detection limit in crawl space and ambient air samples [Geosyntec 2016b]. Because the occupants of the home included a woman of child-bearing age, the Army's response included reviewing canister history to determine past use and verify the integrity of the instrument, offering to relocate residents, and installing an interim carbon-filter mitigation system [WENCK 2016]. Duplicate verification samples were conducted within 48 hours of reporting and just prior to mitigation system installation. TCE was not detected in any of the follow up samples for indoor air, crawl space, or ambient air. The Army was unable to reproduce the winter sampling event after multiple follow up sampling intervals and thus concluded that an unidentified indoor source may exist in the home [WENCK 2016].

SEBS Map IDs 701, 704, 705, 707, 712, 713, 714, 909, 910, 914, 917, 925, 930, 931, 937, and 942

In the SEBS area, TCE concentrations near selected Map IDs ranged from non-detect to 25.4 µg/L in groundwater. Deep soil gas concentrations ranged from non-detect to 17,000 µg/m^3 and shallow gas from non-detect to 100 µg/m^3. Figures B.13, B.14, and B.15 in Appendix B illustrate groundwater and soil gas concentrations, along with corresponding Map IDs, where TCE was detected in the SEBS. Table 11 below summarizes background, sub slab/crawlspace, and indoor air sampling results for selected Map IDs in the SEBS.

Table 11: Summary of Background, Sub slab/Crawlspace and Indoor Air Sampling Results for TCE During the Summer of 2014 and Winter of 2015 in the SEBS (concentrations are in µg/m³ of air)

Map ID Sampled	Summer 2014 Outdoor Background µg/m³	Summer 2014 Subslab/ Crawlspace µg/m³	Summer 2014 Indoor Air µg/m³	Winter 2015 Outdoor Background µg/m³	Winter 2015 Sub slab/ Crawlspace µg/m³	Winter 2015 Indoor Air µg/m³
701	not sampled	not sampled	not sampled	declined	declined	declined
704	ND @ 1.1	ND @ 1.1	ND @ 1.1	ND @ 0.16	ND @ 0.16	ND @ 0.16
705	ND @ 0.13	1.8	ND @ 0.13	ND @ 0.16	ND @ 0.16	ND @ 0.16
707	ND @ 1.1	ND @ 1.1	ND @ 2.1	ND @ 0.16	ND @ 0.16	ND @ 0.16
712	not sampled	not sampled	not sampled	0.4 JM	ND @ 0.16	ND @ 0.16
713	ND @ 1.1	ND @ 1.1	ND @ 1.1	declined	declined	declined
714	ND @ 1.1	ND @ 1.1	ND @ 2.7	declined	declined	declined
909	2	0.35 J	0.36 J*	ND @ 0.16	ND @ 0.16	ND @ 0.2
910	ND @ 0.13	1.2	ND @ 0.59	ND @ 0.16	0.17 J	ND @ 0.16
914	ND @ 0.18	ND @ 1.3/ 2.05 JDM*	0.84 J*	declined	declined	declined
917	2	ND @ 11	ND @ 0.13	ND @ 0.16	ND @ 0.16	ND @ 0.16
925	not sampled	not sampled	not sampled	ND @ 0.16	76 D/ 14 D*	ND @ 0.16
930	ND @ 0.13	0.29 J/ 1.3*	0.29 JM*	ND @ 0.16	230 D/170 D*	1.1*
931	ND @ 0.16	16 D	ND @ 0.32	ND @ 0.16	ND @ 0.16	ND @ 0.16
937	not sampled	not sampled	not sampled	ND @ 0.16	ND @ 0.16	ND @ 0.16
942	not sampled	not sampled	not sampled	ND @ 0.16	801 JD	ND @ 0.16

*Data Qualifiers
J: analyte detected; estimated value
JD: analyte detected; estimated value is from dilution
JM: analyte detected; manually integrated compound
D: duplicate sample
µg/m³: micrograms per cubic meter
*Text indicates comparison value was exceeded.

We made the following observations based on the available data reported in Table 11:

- Residents of Map ID 701 declined participation during the first round of sampling in winter 2015 and this residence was not sampled in summer 2014.
- TCE was not detected in indoor air at Map IDs 704, 705, 707, and 712 during summer 2014 and winter 2015 sampling events.
- TCE was not detected at Map IDs 713 and 714 during summer 2014. Both declined participation during winter 2015.
- TCE was not detected in indoor air at Map IDs 931, 937, and 942 during winter 2015 or summer 2014.
- TCE was not detected in indoor air at Map IDs 910, or 917 during sampling events in summer 2014 or winter 2015.
- In summer 2014, the TCE concentration at Map ID 914 was 0.84 µg/m³. The data qualifier indicates that the TCE detected in this sample is an estimated amount and the

actual concentration is uncertain. The homeowner declined participation for the follow up sampling event in winter 2015 [WENCK 2015e].

- Although outdoor background air was higher than indoor air results for Map ID 909, indoor air results were similar for summer 2014, where TCE was detected at an estimated concentration of 0.36 $\mu g/m^3$. However, TCE was not detected in both outdoor and indoor air during the winter 2015 sampling event at Map ID 909.
- Map ID 930, Grace Baptist Church, had elevated TCE concentrations in crawlspace air and in indoor air at 0.29 $\mu g/m^3$ during the summer 2014 sampling event. This increased to 230/170 $\mu g/m^3$ where duplicate samples were taken during the winter 2015 sampling event [WENCK 2016].

Consequently, Grace Baptist Church was selected for building pressure cycle (BPC) testing to create conditions that could induce vapor intrusion as well as conditions that could also inhibit vapor intrusion. The Army created a worst-case building specific vapor intrusion scenario using BPC testing where depressurization induced vapor intrusion into an occupied space and pressurization induced vapor extrusion from an occupied space. Analytical test results showed that TCE was detected at 0.2 $\mu g/m^3$ during depressurization. Detections of TCE in indoor air while the building was depressurized are consistent with the known groundwater source and concentrations measured in other media (soil gas, sub-slab soil gas, and crawlspace air). Additional VOCs detected in samples were deemed attributable to indoor sources because they were not present in groundwater. Though TCE was detected at a low concentration during an induced worst case depressurization scenario, concentrations remained below health-based cancer CVs. The Army concluded that vapor intrusion, if it occurs, is not expected to result in unacceptable exposure in indoor air under very conservative conditions at Map ID 930 [Geosyntec 2015]. DPH agrees with this analysis and conclusion.

5.0 Public Health Implications

VOCs such as benzene, chloroform, and TCE are common indoor air contaminants. These VOCs may originate from outdoor sources as well as indoor sources that combine and contribute to the overall concentration levels in indoor air [USEPA 2011a]. This is due to air exchanges between outdoor and indoor air inside of a building structure throughout the day, combined with the presence of consumer products in the home or business that emit VOCs. Common VOC emitting consumer products include air fresheners, adhesives, solvents, cleaners, paint strippers, aerosols, mothballs, insect repellents, and plastics. Other sources include combustion processes, such as smoking, cooking, and home heating; and building materials such as carpet, paint, insulation, and wood finishing products. And still other sources include fuel in garages, municipal tap water, dry cleaned clothing, and occupant activities such as craft hobbies [USEPA 2011a].

Table 12 summarizes Map IDs selected by DPH and compares sampling results with health-based comparison values and expected background concentrations. Cancer CVs were exceeded in the NLA and SEBS for all contaminants at the Map ID where the contaminant was detected.

Table 12. Summary of Indoor Air Concentrations of Map IDs Exceeding CVs in the NLA and the SEBS and Median Indoor Air Background Concentrations in North American Residences (all concentrations in µg/m^3)

Chemical of Concern	# Map IDs Selected	# Map IDs Where Contamin-ant Was Detected	Map IDs Exceeding Cancer CVs	Map IDs Exceeding Noncancer CVs	North American Residential Background Indoor Air Range of 50th %tile Concentrations	Map IDs Below Median Indoor Air Background Concentrations	Map IDs Exceeding Median Indoor Air Background Concentrations
Benzene	2	2	2*	0	<RL – 4.7**	2	0
Chloroform	21	19	19*	0	<RL – 2.4**	13	6
TCE	34	6	6*	1	<RL – 1.1**	33	1

*Indicates the number of Map IDs where a CV was exceeded during at least one sampling event. This number does not imply that concentrations exceeded CVs during both summer 2014 and winter 2015 sampling events.
Map IDs refers to Map Identification for each parcel designated by the Army for the vapor intrusion investigation.
CV: Comparison Value
Background concentrations for benzene, chloroform and TCE are the median value, or 50th percentile of concentrations reported.
Data sources: Vapor Intrusion Investigation for the Southeast Burial Site and North Landfill Area, Volume III, March 2016;
**USEPA Background Indoor Air Concentrations of Volatile Organic Compounds in North American Residences (1990-2005): A Compilation of Statistics for Assessing Vapor Intrusion
NLA: North Landfill Area
SEBS: Southeast Burial Site
RL: reporting limit

Table 12 shows the significance of median indoor air concentrations of contaminants commonly found in North American residences without the influence of vapor intrusion. However, even though cancer screening CVs were exceeded, contaminant concentrations for benzene, chloroform, and TCE were within the median background ranges in indoor air for most samples obtained during the Army's vapor intrusion investigation [USEPA 2011a]. The exceptions for chloroform are where 7 samples exceeded the upper median range value (2.4 µg/m^3) but remained within the upper 95th percentile range of background values (4.1 to 7.5 µg/m^3) [USEPA 2011a]. Of those 7 samples, 3 samples were above upper 95th percentile range background levels. For TCE, only 1 sample exceeded both the median and the upper 95th percentile range background level for indoor air at Map ID 124 in Winter 2015 [USEPA 2011b]. The TCE concentration of 6.3 µg/m^3 was not reproducible in follow-up sampling conducted within 48 hours. In the follow-up sampling, TCE was not detected and may have resulted from short-term use of a TCE-containing commercial product in the home.

5.1 Toxicological Evaluation for Noncancer Health Effects

Exposure pathways related to Army contaminants were determined to be "potential" at this time and vapor intrusion does not appear to have occurred. Nevertheless, contaminated groundwater as well as deep and shallow soil gas concentrations that exceed vapor intrusion CVs remain below some homes and business. The potential exists for the vapor intrusion pathway to be a concern in the future.

Indoor sample results where the analytes were detected were determined to be related to indoor or outdoor sources using multiples lines of evidence to rule out vapor intrusion. All but one indoor air sample were below the health-based CV for noncancer health effects. The one TCE sample result that exceeded a noncancer CV at a concentration of 6.3 µg/m^3 was not reproducible in follow-up sampling. In addition, TCE was not detected in indoor air in any follow-up duplicate samples, or in crawlspace or ambient air during any of the sampling intervals. Therefore, a toxicological evaluation for noncancer health effects was not performed. Below is a discussion of expected background levels of each contaminant and the health effects associated with each.

5.1.1 Benzene

Benzene is produced by industrial processes and is a common chemical in the environment. Motor vehicle exhaust, burning coal and oil, as well as benzene waste and storage operations contribute to benzene levels in outdoor air [ATSDR 2007a]. Tobacco smoke is a significant source of benzene in indoor air. Indoor air sources of benzene also include consumer products such as glues, paints, and detergents. According to the U.S. Environmental Protection Agency (USEPA) and the U.S. Department of Health and Human Services, benzene is classified as a human carcinogen [ATSDR 2007a]. The International Agency for Research on Cancer (IARC) has also classified benzene as a known human carcinogen [ATSDR 2007a].

Benzene levels in outdoor air range from 0.06 to 1.09 µg/m^3 in the U. S. Human exposure to higher levels occur in industrial areas and cities compared to rural settings [ATSDR 2007a]. Benzene concentration in residential indoor air is typically higher than in outdoor air. Studies report median background levels of benzene in indoor air ranging from 0.05 to 4.7 µg/m^3 and as high as 9.9 to 29 µg/m^3 in some homes, which lies in the 95th percentile of reported values in the U.S. [USEPA 2011a]. In the selected residences evaluated for benzene, outdoor air concentrations ranged from less than 0.06 to 0.72 µg/m^3, and indoor air concentrations ranged from 0.64 to 0.82 µg/m^3, falling within typical U.S. levels. Notably, benzene levels in the crawlspace and indoor air of Map IDs 129 and 139 were well below the benzene minimal risk level (MRL) for chronic inhalation (6.4 µg/m^3), indicating that residents in these homes are unlikely to experience noncancer health effects. See Section 5.2 for our evaluation of cancer risk from exposure to TCE.

5.1.2 Chloroform

Chloroform was once used as an anesthetic but now is primarily produced by industry for industrial applications. It is used in the manufacture of other chemicals, and its breakdown products include phosgene and hydrogen chloride. Chloroform is found in wastewater from sewage treatment plants and is a byproduct in chlorine treated municipal water. Common indoor sources of chloroform are chlorinated water from municipal water supplies (and activities associated with it such as drinking, bathing, and swimming), and certain pesticides [ATSDR 2024].

Human exposure occurs primarily by inhalation of air containing chloroform and ingestion of and dermal exposure to low levels of chloroform in treated municipal water. A review of ATSDR public health assessments completed between 1994 and 2009 identified 33 sites with chloroform detected in soil gas, crawl space, indoor air, or outdoor air [Burk and Zarus 2013]. Indoor air was sampled at 15 of the sites with chloroform detected from 0.03 to 23 $\mu g/m^3$ [ATSDR 2024].

In the selected residences evaluated for chloroform at Fort Gillem, outdoor air concentrations ranged from less than 0.1 to 0.2 $\mu g/m^3$, and indoor air concentrations ranged from less than 0.2 to 8.6 $\mu g/m^3$, aligning with indoor air concentrations found in other ATSDR health assessments. No data pertaining to potential nasal effects in humans following exposure to chloroform from toxicological literature were identified [ATSDR 2024]. In animal studies on inhalation toxicity, the most sensitive target of toxicity was nasal effects in mice at ≥5 ppm (24,412 $\mu g/m^3$), which is the lowest observed adverse health effects level (LOAEL) in the study. In animals, the nasal epithelium is a consistent target of toxicity in rodents following chronic-duration inhalation exposure. To determine the minimal risk level (MRL) for chronic inhalation of chloroform, ATSDR selected a 104-week study in mice by Yamamoto et al. [Yamamoto 2002] as the principal study because it provided the lowest candidate point of departure (POD) for the critical effect (nasal lesions). The POD used is 0.11 ppm (537 $\mu g/m^3$) and was derived when the observed LOAEL in mice was adjusted to the human equivalent concentration (HEC) [ATSDR 2024] after adjusting to continuous exposure and by accounting for the difference in breathing rates and surface area of the lungs in mice and humans.

The highest one-time concentration of 8.6 $\mu g/m^3$ of chloroform found in the NLA is far lower than the 537 $\mu g/m^3$ concentration where adverse health effects might be observed. Therefore, DPH does not expect residents in homes sampled to be harmed from chloroform exposure by breathing indoor air in their homes. Notably, chloroform levels in the crawl spaces at properties bordering Fort Gillem were either well below the chloroform MRL for chronic inhalation (2 $\mu g/m^3$), or not detected at all. Chloroform is a common indoor air contaminant that can result from the off-gassing of chlorine-treated municipal water and the use of chloroform-containing products in the home. It is possible that these indoor sources could result in low levels of chloroform at these locations [Geosyntec 2016b].

The US EPA and the U.S. Department of Health and Human Services classify chloroform as likely to be carcinogenic to humans by all routes of exposure when exposures are high enough to lead to cytotoxicity and regenerative hyperplasia in susceptible tissues. Chloroform is not likely to be carcinogenic by any route at dose levels that do not cause tissue damage that results in subsequent regeneration [USEPA 2001; NTP 2021]. Chloroform is considered a possible human carcinogen by IARC [ATSDR 2024]. Some human studies show a possible link between the consumption of chloroform from chlorinated drinking water and bladder, rectal, and colon cancer [USEPA 2001]; [ATSDR 2024]. Animal studies have shown kidney and liver cancer development in rodents exposed to drinking water with chloroform [ATSDR 2024]. See Section 5.2 for our evaluation of cancer risk from exposure to chloroform.

5.1.3 Trichlorethylene (TCE)

TCE is an industrial solvent that is used for degreasing metal parts and is also found in household products such as some adhesives, varnishes, paints, paint stripper, dishwashing detergent, pesticides, and lubricants. TCE is released into the environment during manufacture and use, with exposure in humans occurring by inhalation of outdoor air and ingestion of drinking water. USEPA and the U.S. DHHS have classified TCE as a human carcinogen [USEPA 2011b, NTP 2021]. IARC also has classified TCE as a human carcinogen [ATSDR 2014b].

Average TCE concentrations in ambient air across the United States range from 0.054 to 1.6 $\mu g/m^3$, [ATSDR 2019]. Studies have shown median background indoor air concentrations of TCE in the home between 0.02 to 1.1 $\mu g/m^3$ [USEPA 2011a]. Indoor air concentrations of TCE in the NLA and SEBS generally align with median indoor levels in the U.S., except for a single outlier at MapID 124, which recorded an indoor air concentration of 6.3 $\mu g/m^3$ in the winter of 2015. Notably, during the same sampling event, TCE concentrations in crawl space and ambient air samples at the same property were below detection (see Table 10) [Geosyntec 2016b]. The 6.3 $\mu g/m^3$ TCE concentration in indoor air appeared to be anomalous, as subsequent summer sampling and a duplicate verification sample 48 hours later indicated no TCE detection. Despite the inability to reproduce the winter sampling event in multiple follow-up intervals, an indoor air purification filter was installed in the home, given the presence of a child as a precautionary measure by the Army. See Section 5.2 for our evaluation of cancer risk from exposure to TCE.

5.2 Cancer Risk Estimates

Army-related groundwater contaminants were shown not to be responsible for vapor intrusion into residences in the investigation area. Nonetheless, the presence of indoor/outdoor sources of benzene, chloroform, and TCE above ATSDR cancer screening levels (CREGs) prompted DPH to estimate cancer risks for residents living in the households we selected for this health consultation. Cancer risk estimates were only provided for Map IDs that had at least two rounds of seasonal indoor air sampling (Appendix B: Figures B.18 and B.19).

Appendix D shows estimated excess lifetime cancer risk for residents living in the selected Map IDs for a maximum of 33 years and a minimum of 12 years. In addition, cancer risk estimates were provided for children from birth until age 21. The cancer risks reported below are from exposures to benzene, chloroform, and TCE.

DPH reached the following conclusions from our cancer risk estimates:

In the NLA:

- Estimated excess cancer risks for persons living at the same residence for 33 years ranges between approximately 8 in 100,000 people and 1 in 10,000,000 people.
- Estimated excess cancer risks for persons living at the same residence for 12 years ranges between approximately 3 in 100,000 people and 4 in 100,000,000 people.

- Estimated excess cancer risks for children from birth to 21 years ranges between 5 in 100,000 and 1 in 10,000,000 people.

In the SEBS:

- Estimated excess cancer risks for persons living at the same residence for 33 years ranges between approximately 3 in 100,000 people and 5 in 10,000,000 people.
- Estimated excess cancer risks for persons living at the same residence for 12 years ranges between approximately 1 in 100,000 people and 2 in 10,000,000 people.
- Estimated excess cancer risks for children from birth to 21 years ranges between 2 in a 100,000 and 5 in 10,000,000 people.

Some uncertainty exists in these cancer risk estimates because we used the maximum detected concentration at a property and assumed residents were exposed to that level for many years. Given the health-protective nature of the cancer risk evaluations for benzene, chloroform, and trichloroethene, the estimated cancer risks are not a concern for increased cancer risks in the Fort Gillem vapor intrusion investigation area. Note that these are theoretical estimates of cancer risk and not an actual estimate of cancer cases in a community. ATSDR uses the estimates as a tool for deciding whether public health actions are needed to protect health. In addition, because DPH conservatively used the highest concentration of indoor contaminants found in air, the theoretical cancer risks presented are likely to overestimate the true cancer risks. In many cases, once indoor sources of these contaminants were removed before another round of indoor air sampling, sample results showed much lower levels of these contaminants; and sometimes, contaminants were not detected at all upon resampling.

At Map ID 144, a commercial location in the NLA:

During forensic testing at Map ID 144, the mean chloroform concentration in indoor air, calculated from seasonal sampling in 2015, was 1.2 $\mu g/m^3$. The cancer risk for full-time workers employed for 20 years was estimated at 8 excess cancers in 10 million workers exposed (or 2E-7 calculated from the exposure calculator for air using the default occupational scenario run in ATSDR's Public Health Assessment Site Tool [PHAST]). This cancer risk estimate is not a concern for increased cancer risk for employees in this commercial building.

Similarly, the carbon tetrachloride indoor air concentration was estimated at a mean of 0.5 $\mu g/m^3$. For the full-time worker, the chronic adjusted exposure point concentration (EPC) was 0.12 $\mu g/m^3$ based on an 8-hour work day, 5 days per week. The estimated cancer risk was calculated at 2 excess cancer cases in a population of 10,000,000 workers or 2E-7. Carbon tetrachloride did not significantly contribute to the cancer risk estimate for this property. There is no concern for increased cancer rates in workers based on the small amounts of chloroform or carbon tetrachloride detected in indoor air.

6.0 Child Health Considerations

In communities faced with contamination of the water, soil, air, or food, DPH recognizes that the unique vulnerabilities of infants and children demand special emphasis. Due to their immature and developing organs, infants and children are usually more susceptible to toxic substances than adults. Children are more likely to be exposed to contamination because they play outdoors, and they often bring food into contaminated areas. They are also more likely to encounter dust, soil, and contaminated vapors close to the ground. Children are generally smaller in size than adults, which results in higher doses of chemical exposure because of lower body weights relative to adults and higher intake of water, soil, and air. In addition, the developing body systems of children can sustain damage if toxic exposures occur during critical growth stages.

Health guidelines, such as ATSDR's minimal risk levels, are designed to protect adults and children of all ages. None of the indoor air levels of contaminants exceeded ATSDR's MRLs, except for TCE in one home. We determined that the TCE level in this home was not a health concern because the detected concentration was well below noncancer effect levels and because repeat air samples from this home were all non-detect. We also included children in estimates of cancer risk and determined that cancer is not a concern in children.

7.0 Conclusions

Based on evaluation of all environmental data for selected Map IDs, DPH concludes the following.

Conclusion 1

For residences and several commercial buildings (parcels with a minimum of two seasonal sample sets for indoor air) that border the Fort Gillem site, DPH concludes that breathing in volatile organic compounds in indoor air is not expected to harm people's health.

Basis for Conclusion

In properties where benzene, chloroform, or TCE exceeded health-based comparison values in air, soil gas, and groundwater, DPH examined available groundwater, soil gas, and indoor air data from the Fort Gillem site. Then, DPH selected certain locations (map IDs) for further evaluation. DPH chose 26 locations from the NLA and 16 from the SEBS for further evaluation. Within those selected properties, there were 16 properties in the NLA and 9 properties in the SEBS that had at least two seasonal rounds of indoor air samples (Figures A-18 and A-19). VOCs were present. However, based on the available data, vapor migration of these chemicals into homes and commercial buildings from vapor intrusion does not appear to be occurring *(with the possible exception of one commercial building, Map ID 144; see Conclusion 2 for more details).*

Although some contaminant levels exceeded health screening levels, the contaminant concentrations were within expected outdoor background levels and well below levels that might

result in noncancer health effects. Background air samples were collected to represent outdoor air conditions near the buildings being sampled.

In addition, cancer risk estimates for properties with at least two seasonal rounds of indoor air sampling were not at levels of health concern and indicated either a no increased concern or a low concern risk for cancer from exposure to measured levels of benzene, chloroform, or TCE. Low levels of these chemicals are often found in indoor and outdoor air.

Conclusion 2

Vapor intrusion may be occurring at Map ID 144, a commercial property located along the northern boundary of the site. However, there is no increased concern for noncancer and cancer health risks for full-time employees, even if they work in the building for decades. Although it is likely that the major contribution to indoor air contamination detected at this property is from indoor sources, vapor intrusion cannot be ruled out.

Basis of Conclusion

The Army conducted secondary forensic testing at Map ID 144. The tests included subslab soil gas, as well as indoor and outdoor air sampling on a long-term basis to improve the representativeness of data. In addition, cross-slab differential pressure data were collected during the 28-day sampling period. The cross-slab data indicated that indoor conditions at Map ID 144 were favorable to vapor intrusion. This was especially evident during the night when the commercial building was not occupied.

DPH further evaluated this property based on the data maps. In the winter of 2014 the data maps indicated the presence of chloroform at 14,000 µg/L in groundwater, 1,700 $\mu g/m^3$ in deep soil gas, and 110 $\mu g/m^3$ in shallow soil gas within 100 feet of the parcel. A spatial pattern consistent with a subsurface source of chloroform shows evidence that a concentration gradient from a subsurface source to indoor air does exist at Map ID 144. For example, if the concentration of chloroform found in groundwater is higher than the concentration found in deep soil gas, and the deep soil gas concentration is higher than the concentration found in shallow or subslab soil gas and is also detected in indoor air at a lower concentration than subslab soil gas, this would show a concentration pattern consistent with vapor intrusion. Based on DPH's evaluation, vapor intrusion cannot be ruled out because of the very high soil gas concentrations and the cross-slab differential pressure.

Chloroform was detected at Map ID 144 in indoor air at 1.2 $\mu g/m^3$ (summer 2014) and at 1.0 $\mu g/m^3$ (winter 2015.) During more intensive testing at Map ID 144 in 2015, the mean chloroform concentration in indoor air was calculated to be 1.2 $\mu g/m^3$. The cancer risk for full-time workers employed for 20 years was estimated to be less than 1 cancer in a million workers exposed. This indicates no concern for risk of cancer for exposed full-time employees.

Conclusion 3

For residences or businesses where indoor air was only sampled once or not sampled at all, DPH cannot determine whether a health hazard exists.

Basis for Conclusion

DPH evaluated multiple media, including indoor air data obtained during the Fort Gillem investigation. In order to fully evaluate the vapor intrusion pathway, multiple indoor air samples must be obtained during different seasons. Multiple samples help to determine whether vapor intrusion may be occurring because of seasonal differences. Some seasonal differences include the effect of heating and air conditioning systems on increasing or decreasing air flow from the subsurface into buildings. Some homeowners declined participation in the study before sampling started or after one round of sampling. Of the homes that only had one round of indoor air sampling, three homes showed concentrations of TCE in indoor air above ATSDR's cancer screening level also known as a cancer risk evaluation guide (CREG). One home sampled only one time showed a chloroform concentration in indoor air above ATSDR's CREG.

8.0 Next Steps

Next Steps

DPH recommends the following to the Army:

1. Conduct intermittent indoor air sampling of Map ID 144 until the subsurface chloroform concentrations are below ATSDR's subsurface vapor intrusion comparison values (CVs).
2. Continue to monitor the groundwater plumes in both the NLA and SEBS areas to determine the overall effectiveness of attenuation. Implement source removal action in the NLA and SEBS areas to include Fort Gillem (FTG) locations FTG-01, FTG-07, FTG-09, and FTG-10.
3. Resume soil gas sampling every 5 years if contaminated groundwater sources continue to exist at levels exceeding ATSDR vapor intrusion CVs (CREGs of 0.52 µg/L for TCE, 0.57 µg/L for benzene, and 0.29 µg/L for chloroform) in residential areas.
4. If soil gas sampling resumes and concentrations exceed vapor intrusion comparison values, offer to repeat indoor air sampling for residents/business owners at Map IDs impacted by groundwater plumes. Offer subslab/crawlspace and outdoor air sampling to support stronger lines of evidence for vapor intrusion exposure pathways.
5. Seasonally, offer follow-up indoor air sampling to residents near contamination who are making modifications to their homes. Modification examples include: replacing heating, ventilation, and air conditioning (HVAC) systems; upgrading windows or insulation; modifying slabs or ground cover; or installing drains or sump pumps.

DPH will:

1. Focus on educating residents in the Fort Gillem area about the potential health effects of exposure to indoor air contaminants identified in this health consultation.

2. Address potential health risks associated with harmful exposures to VOCs in consumer products and create a fact sheet for distribution to Fort Gillem residents. The fact sheet will describe how to reduce or eliminate exposures in the home or work environment from household consumable products.
3. Distribute a fact sheet to educate homeowners whose homes were sampled. The fact sheet will describe how home alteration can affect indoor air quality.
4. Distribute a copy of this health consultation or a fact sheet summarizing our findings to EPD and to any Fort Gillem resident who requests copies.
5. Work with the Army to re-evaluate the need for additional soil gas and indoor air sampling if requested and if groundwater remediation efforts do not achieve targeted reduction.

For More Information

If you have questions or comments, call ATSDR toll-free at 1-800-CDC-INFO. Ask for information on the Fort Gillem Vapor Intrusion Health Consultation in Forest Park, Clayton County, Georgia.

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Report Preparation

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Appendix A: Figures

Figure A.1: Fort Gillem Site Map

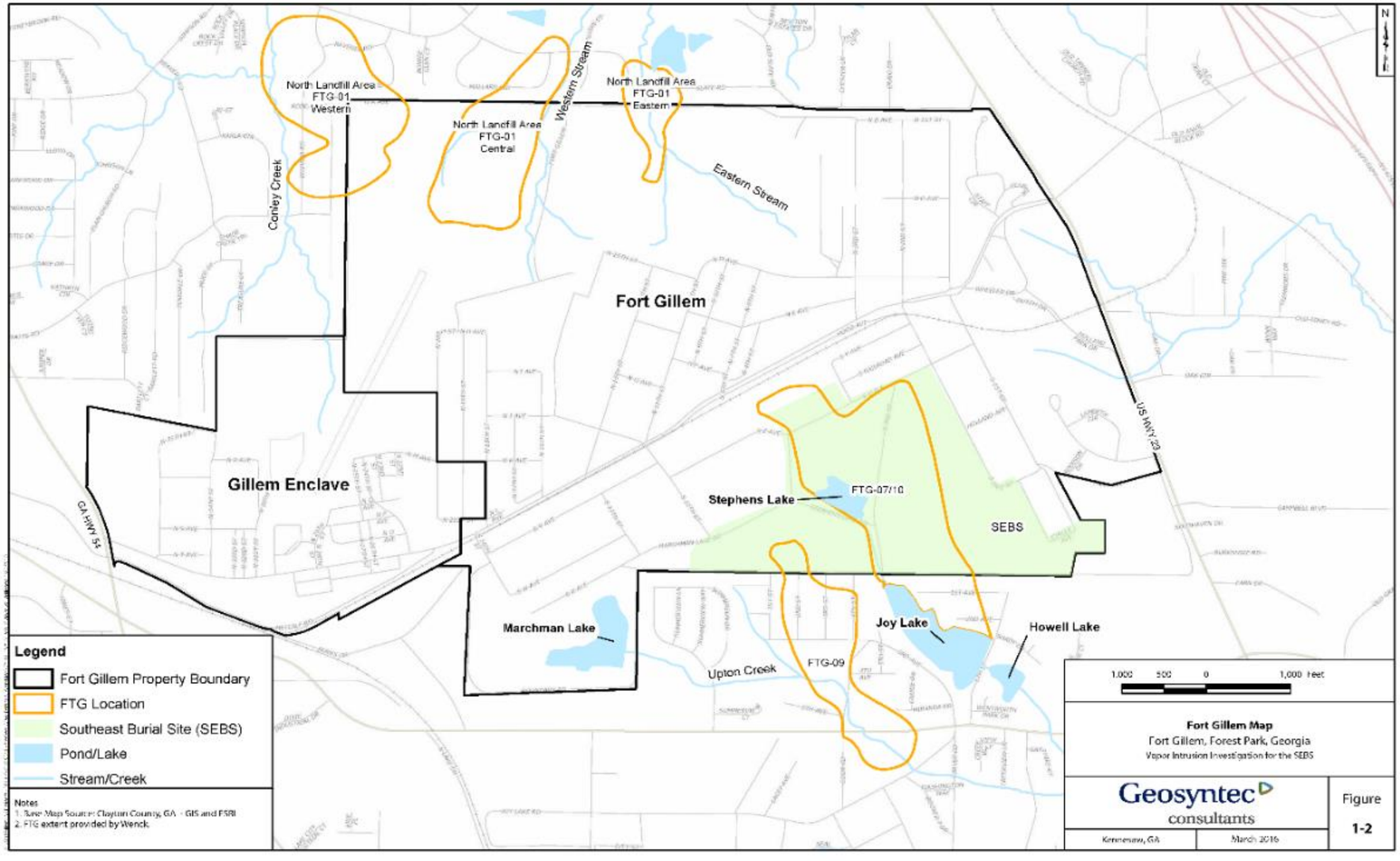


Figure A.2: Fort Gillem Vapor Intrusion Study Area Demographic Map

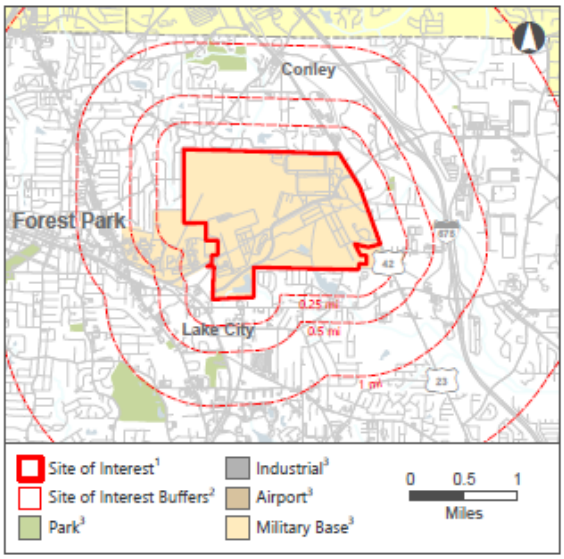
Fort Gillem

Forest Park, Clayton County, GA

INTRODUCTORY MAP SERIES

GENERAL SITE PROFILE

Site Vicinity Map

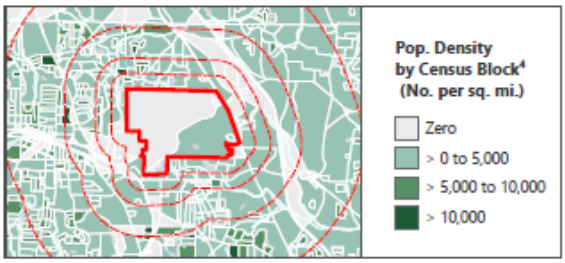


The **General Site Profile Map** depicts the hazardous waste site of interest, along with any airport, industrial, military, or park land uses. It also provides community demographic and housing statistics.

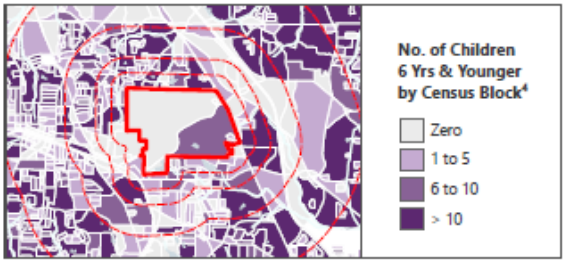
Demographic Statistics[4,5]
Within 1 Miles buffer of site boundary

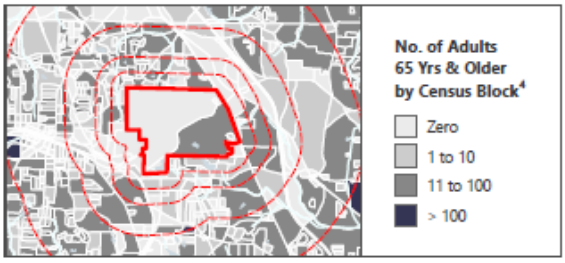
Measure	2010	2020	Change
Total Population	13,528	15,297	+13%
White Alone	3,301	1,903	-42%
Black Alone	7,013	8,933	+27%
Am. Indian/Alaska Native Alone	53	227	+328%
Asian Alone	696	824	+18%
Native Hawaiian & Other Pacific Islander Alone	1	8	+700%
Some Other Race Alone	2,123	2,321	+9%
Two or More Races	332	1,084	+226%
Hispanic or Latino[6]	3,325	3,627	+9%
Children Aged 6 and Younger	1,679	1,403	-16%
Adults Aged 65 and Older	1,146	1,599	+39%
Females Aged 15 to 44	3,104	3,432	+10%
Housing Units	5,583	5,725	+2%
Housing Units Pre 1950	227	199	-12%

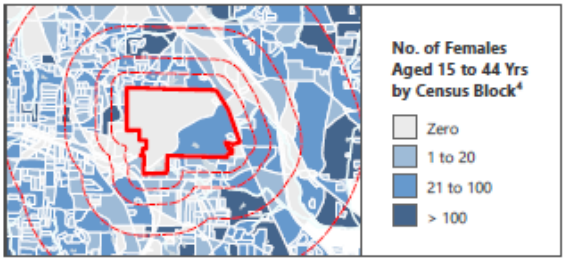
General Population Density



Sensitive Populations







Data Sources: [1]ATSDR GRASP, [2]ATSDR GRASP, [3]TomTom 2021Q3, [4]US Census 2020 Demographic and Housing Characteristics, **Notes:** [5]Calculated using area-proportion spatial analysis method, [6]Individuals identifying origin as Hispanic or Latino may be of any race. **Coordinate System:** Coordinate System used for all map panels is NAD 1983 StatePlane Georgia West FIPS 1002 Feet

ATSDR Agency for Toxic Substances and Disease Registry

GRASP Geospatial Research, Analysis, and Services Program

PRJ ID 13718 | **AUTHOR** Bethany Foust

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12/16/2024

Figure A.3: Sampling Locations for Subslab and Indoor Air in Map ID 144

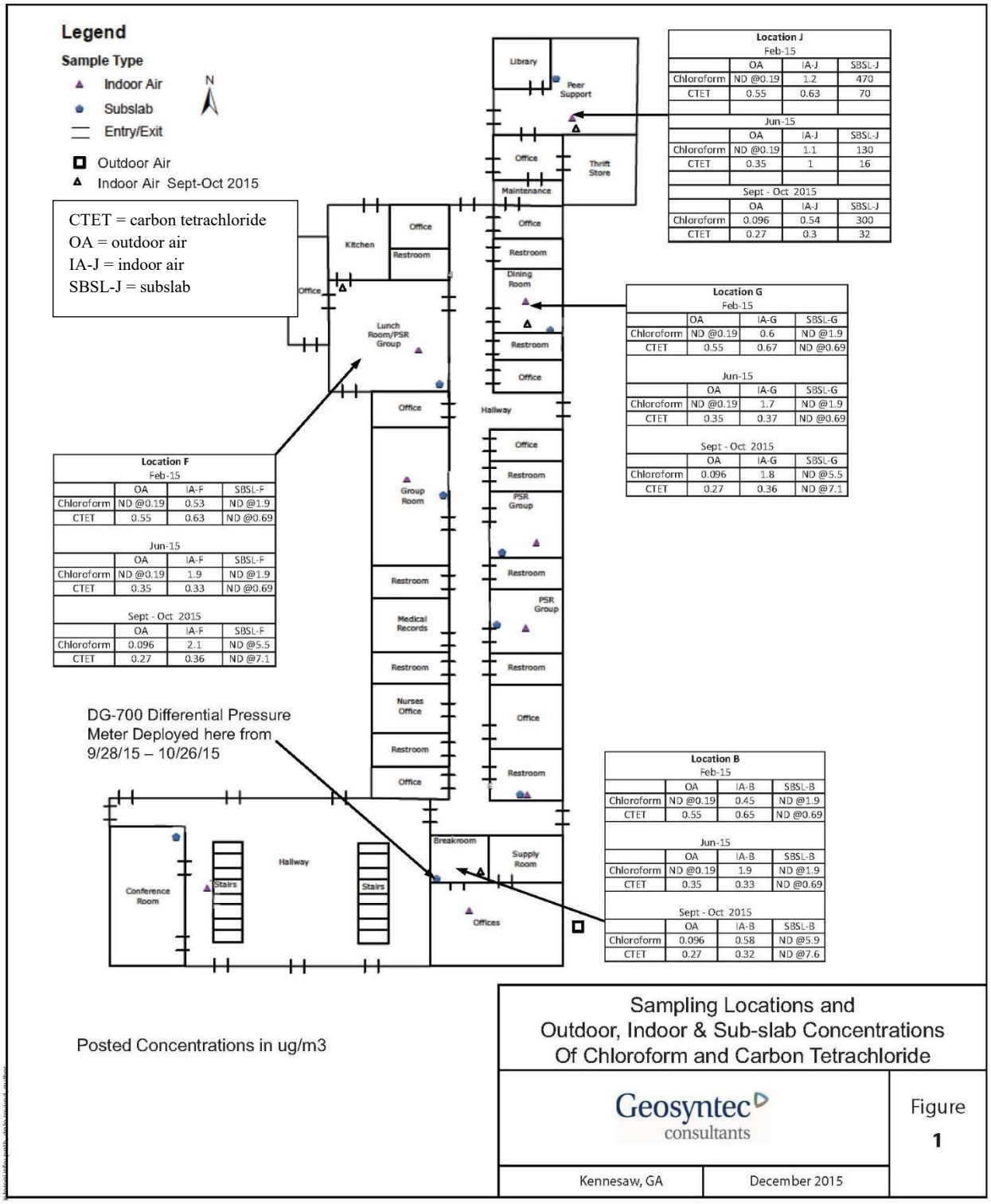
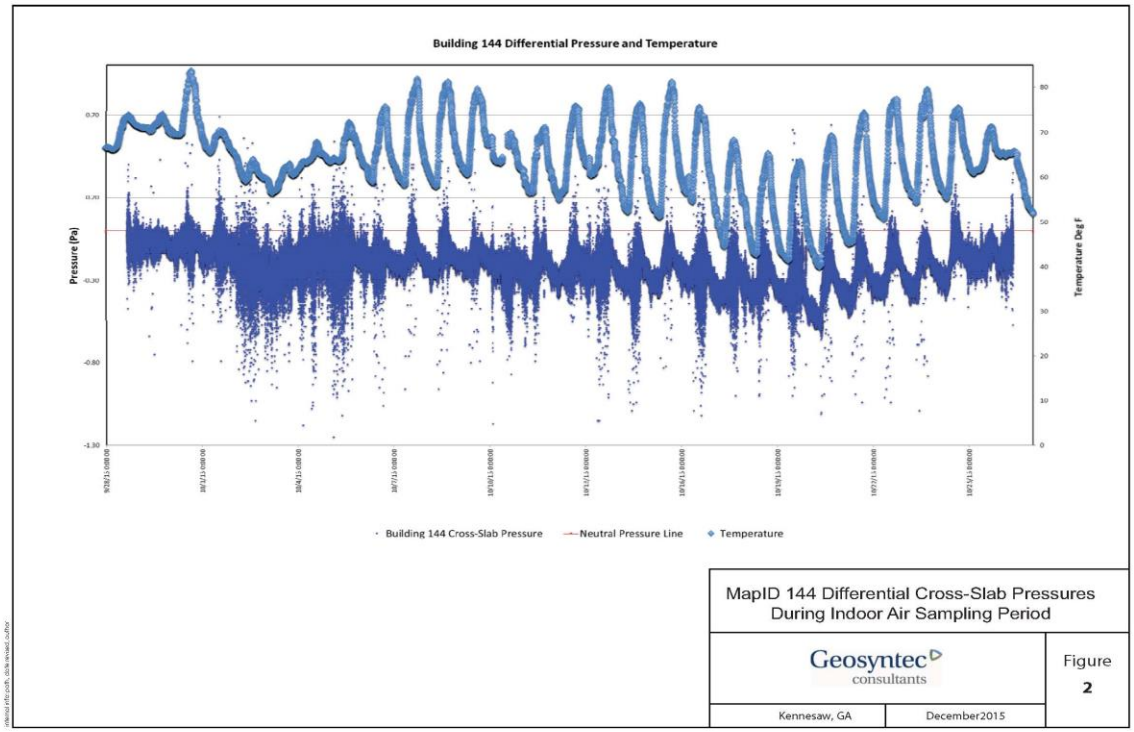


Figure A.4: Differential Pressure and Temperature Differences During Forensic Analysis of Map ID 144. Throughout the period of indoor air sampling, the cross-slab differential pressure was close to neutral, varying from -1.25 to +0.7 Pascals (Pa), but was slightly negative more than 90 percent of the time (Figure A.4). This means the building was under-pressurized with respect to the subslab. Differential pressure data indicate that conditions favorable to vapor intrusion from the subslab could have occurred throughout the indoor air sampling period [Geosyntec 2016b].



Appendix B: Fort Gillem Study Area Environmental Data Maps

Figure B.1. Benzene in Groundwater in the NLA

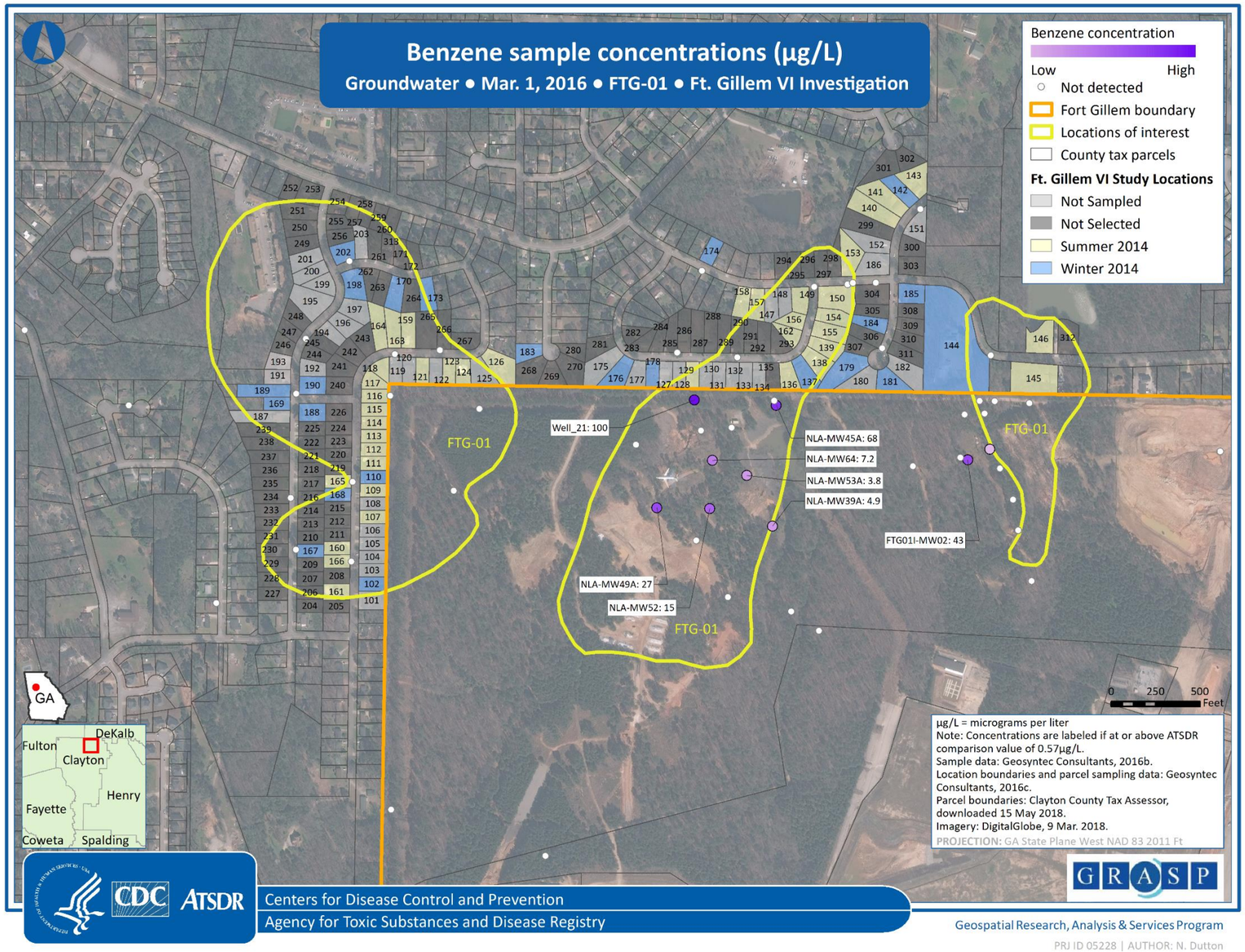


Figure B.2. Benzene in Deep Soil Gas in the NLA

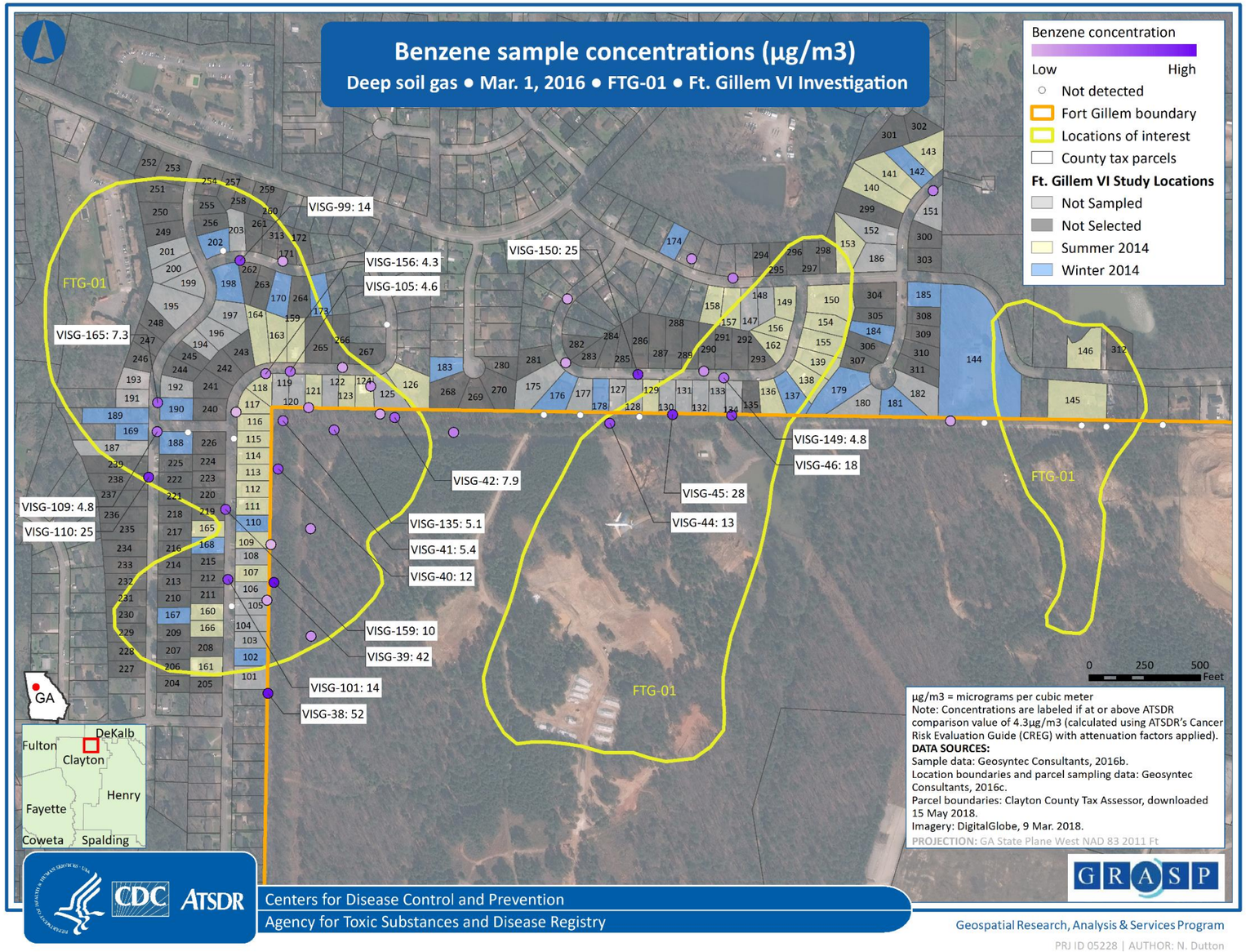


Figure B.3. Benzene in Shallow Soil Gas in the NLA

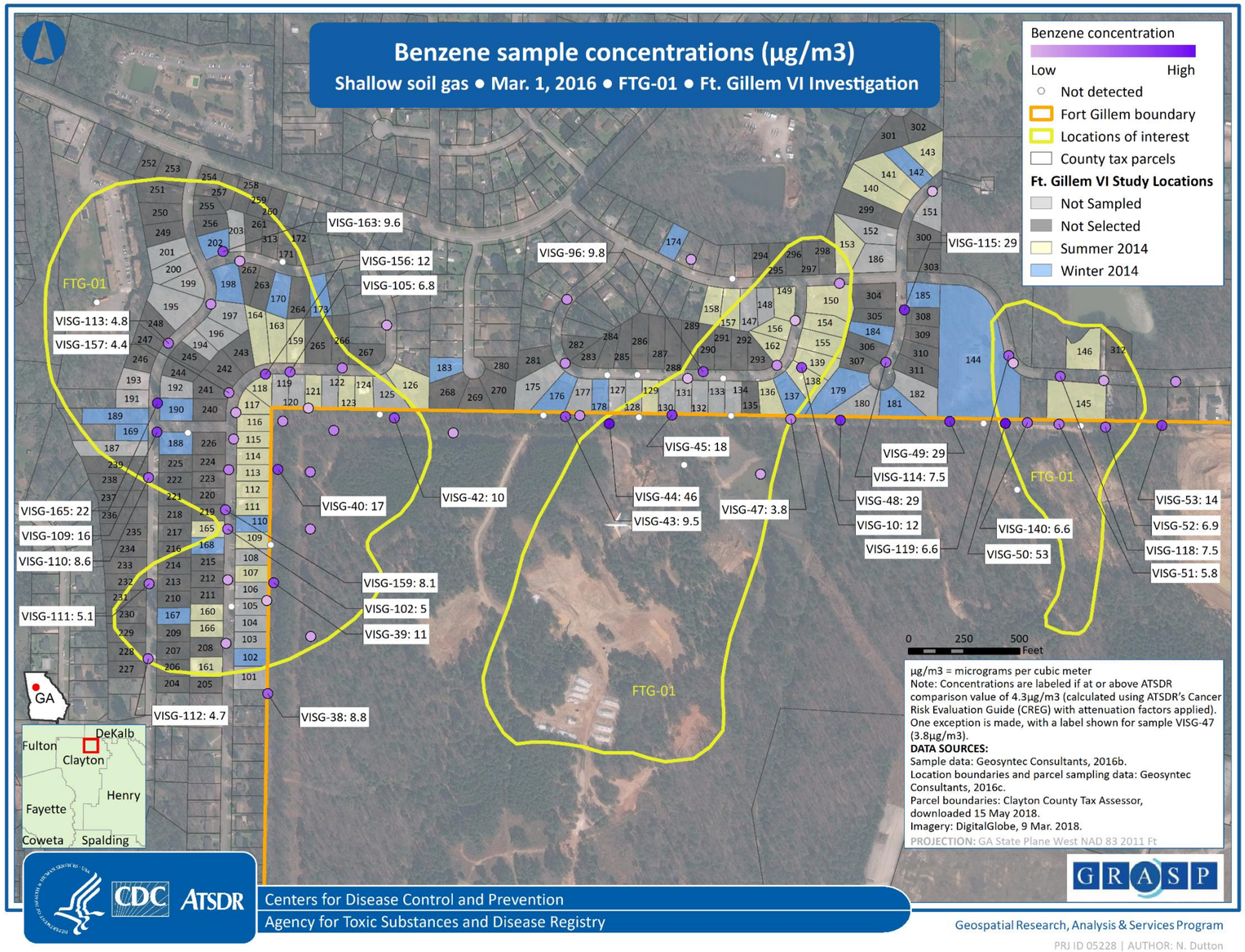


Figure B.4. Chloroform in Groundwater in the NLA

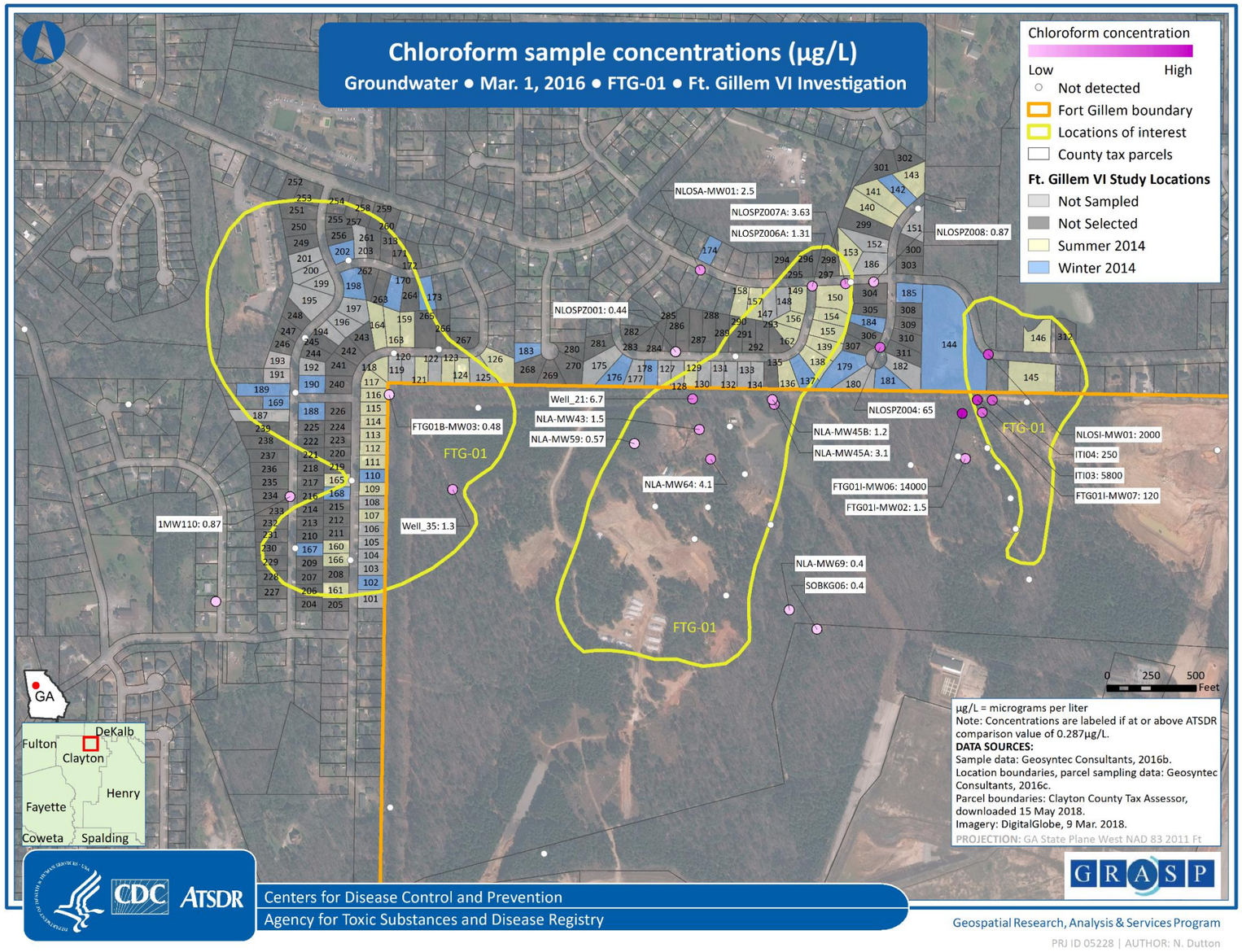


Figure B.5. Chloroform in Deep Soil Gas in the NLA

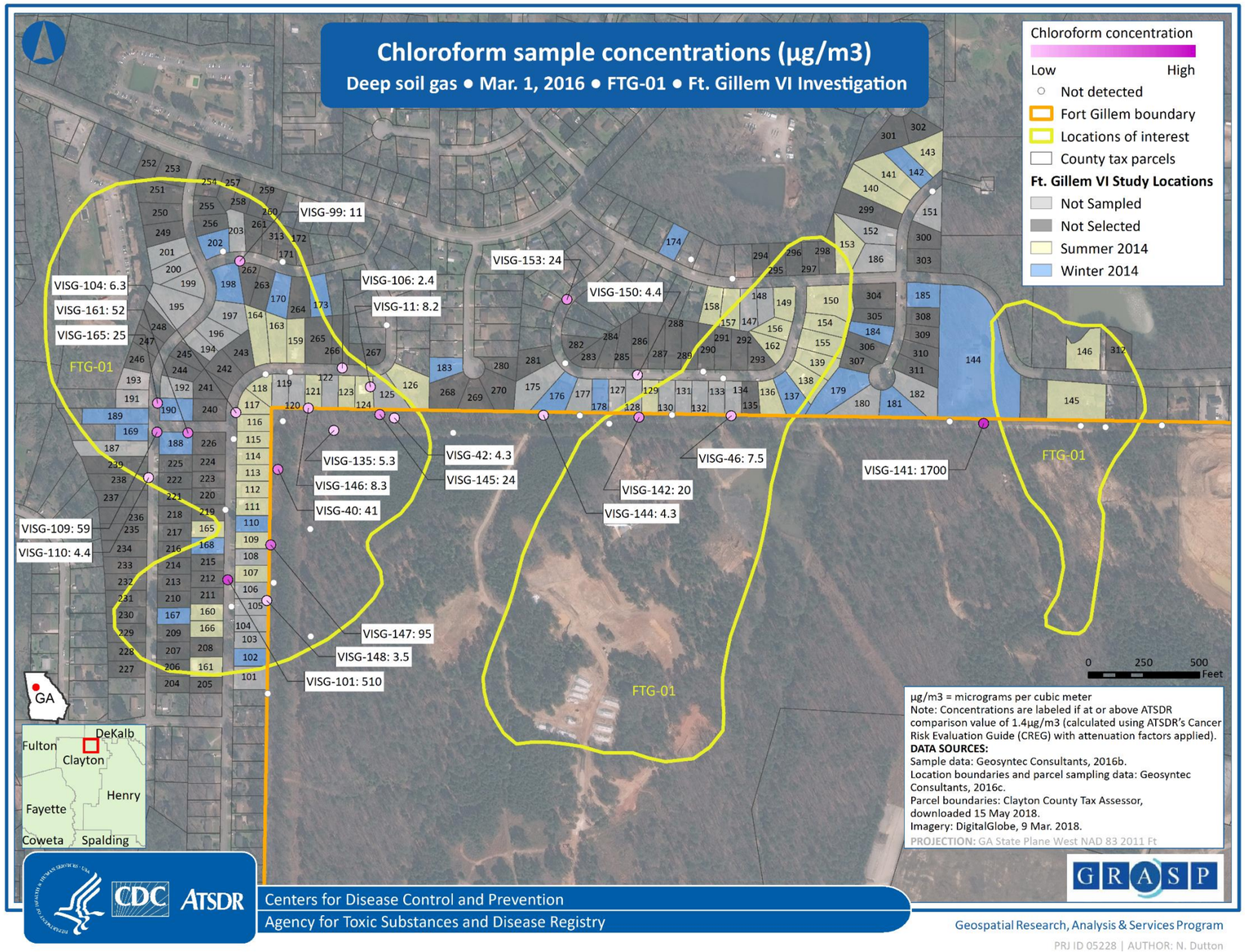


Figure B.6. Chloroform in Shallow Soil Gas in the NLA

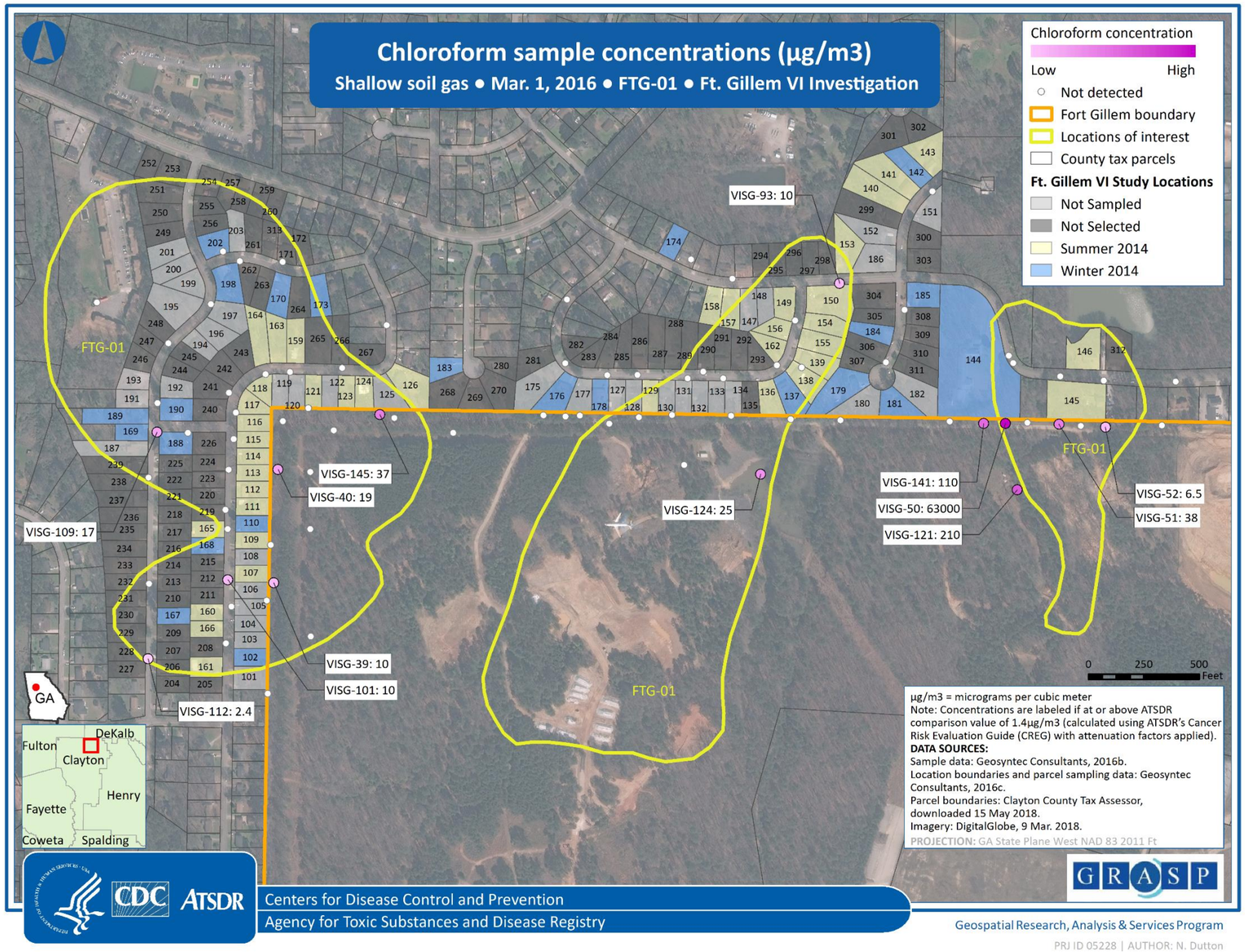


Figure B.7. Chloroform in Groundwater in the SEBS

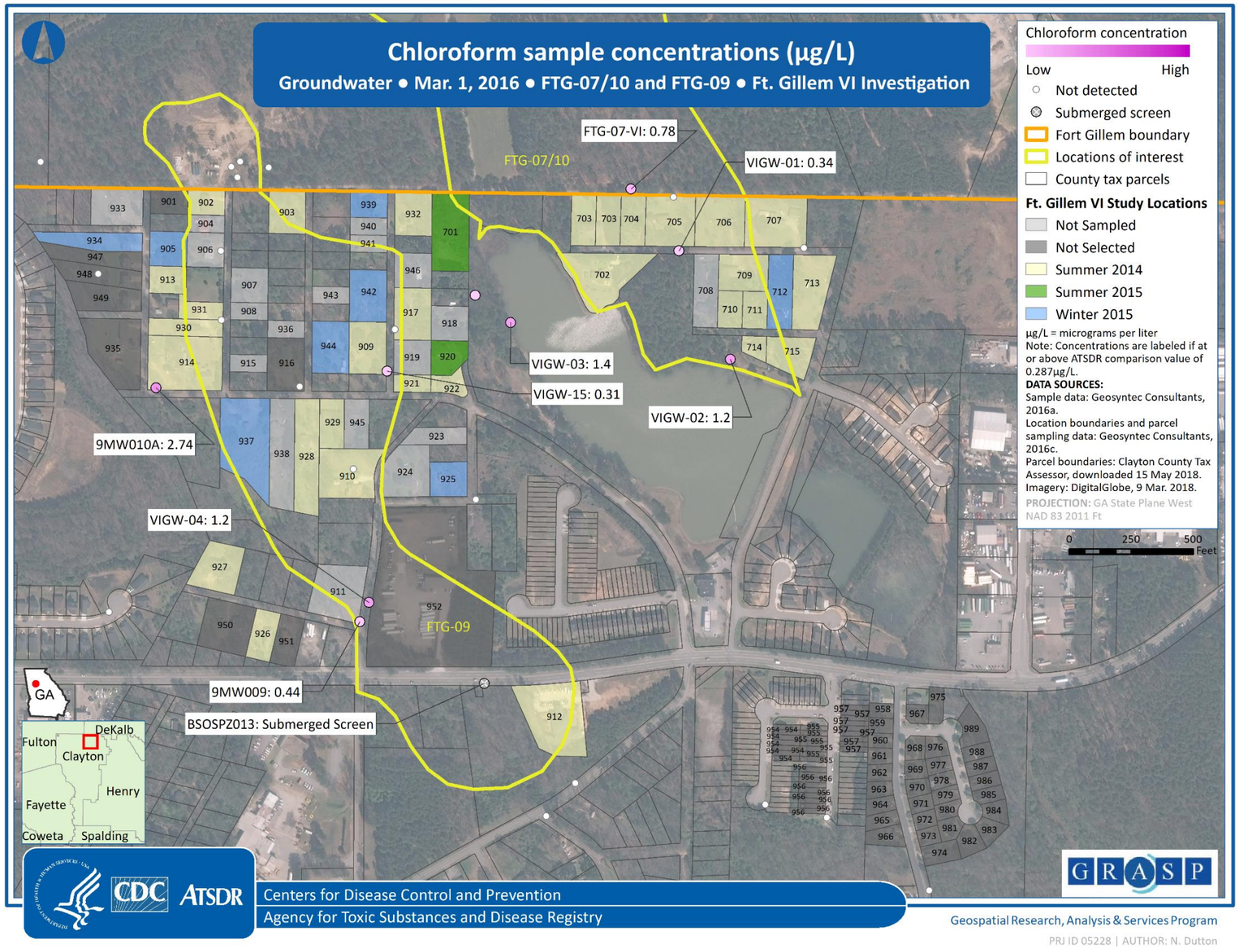


Figure B.8. Chloroform in Deep Soil Gas in the SEBS

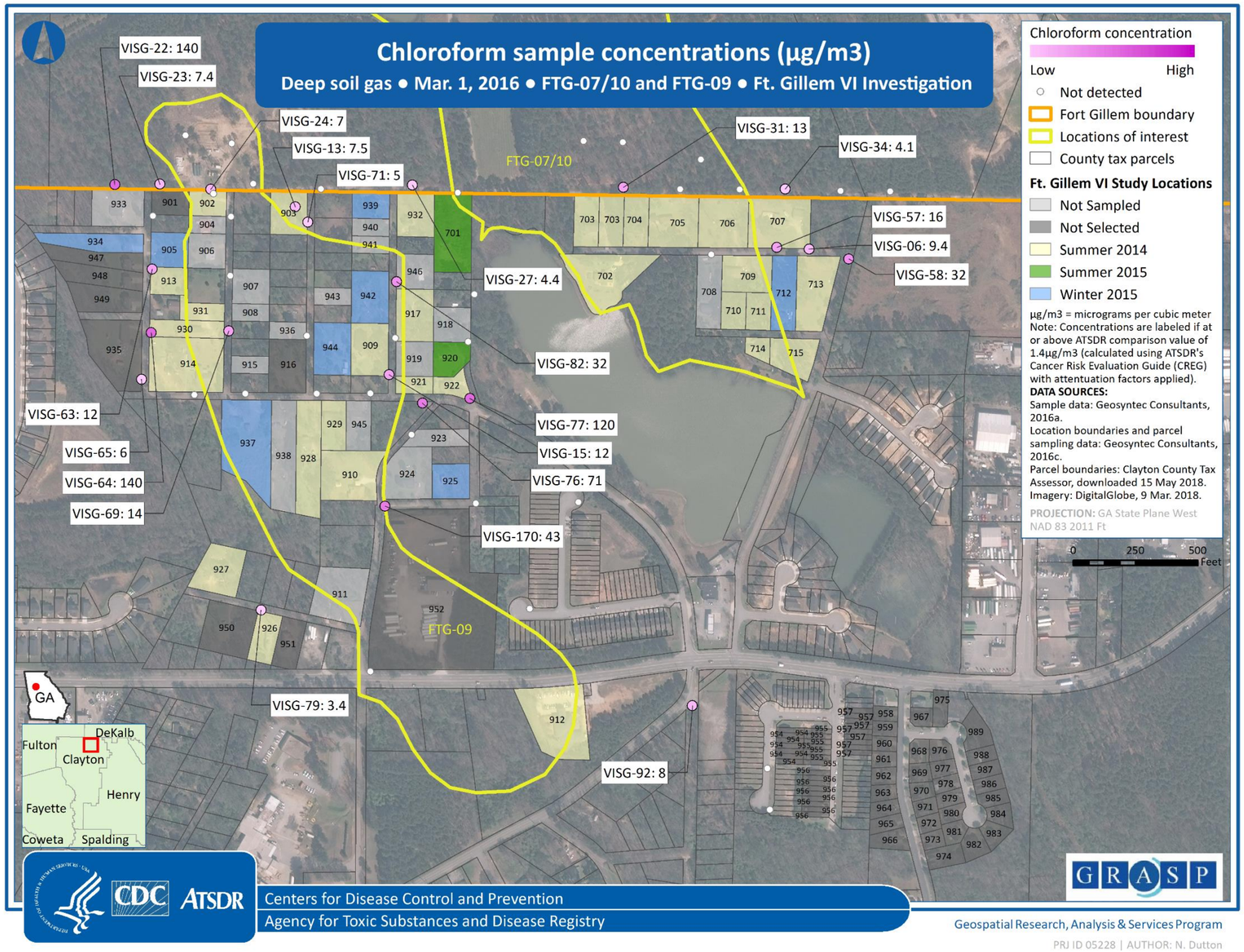


Figure B.9. Chloroform in Shallow Soil Gas in the SEBS

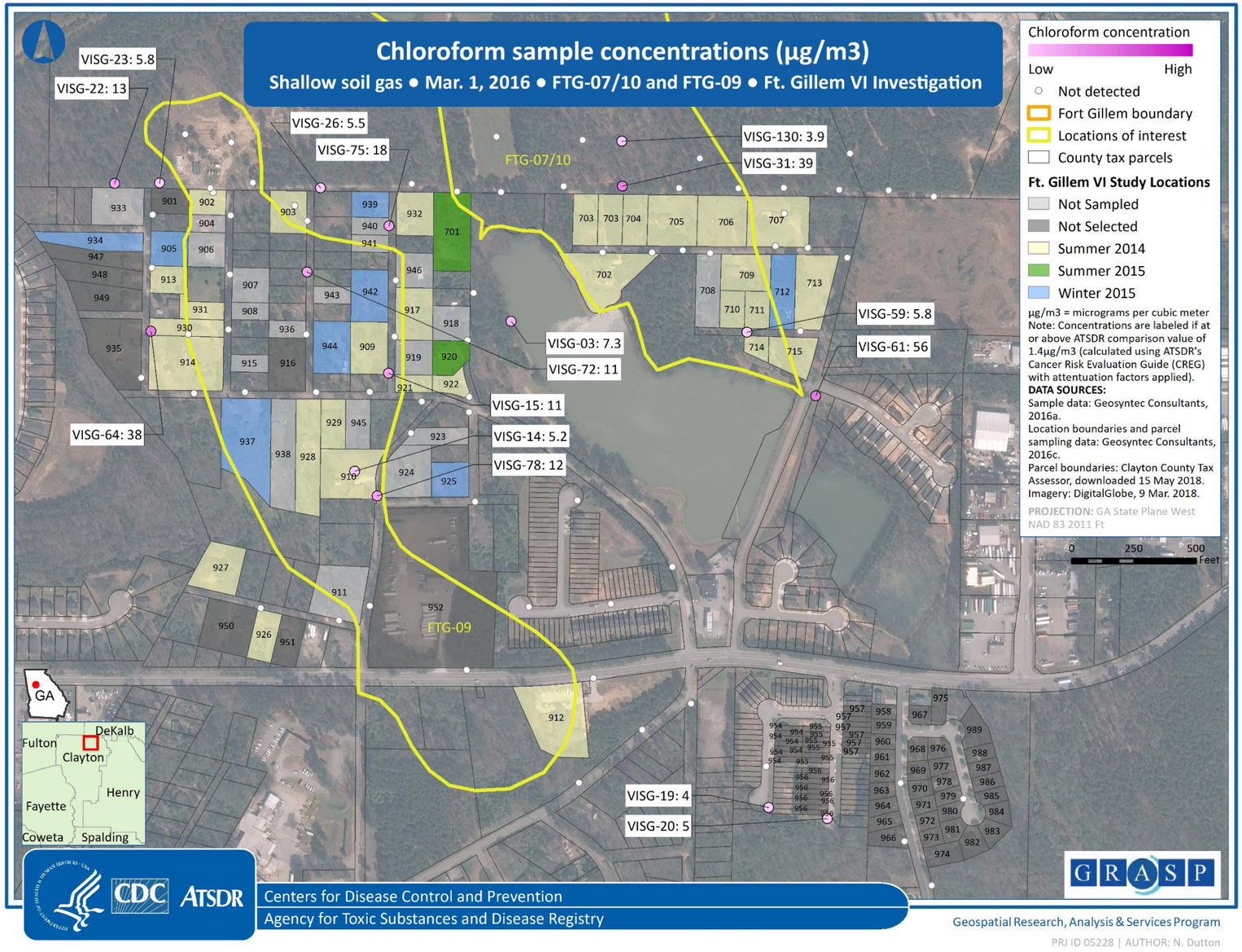


Figure B.10. TCE in Groundwater in the NLA

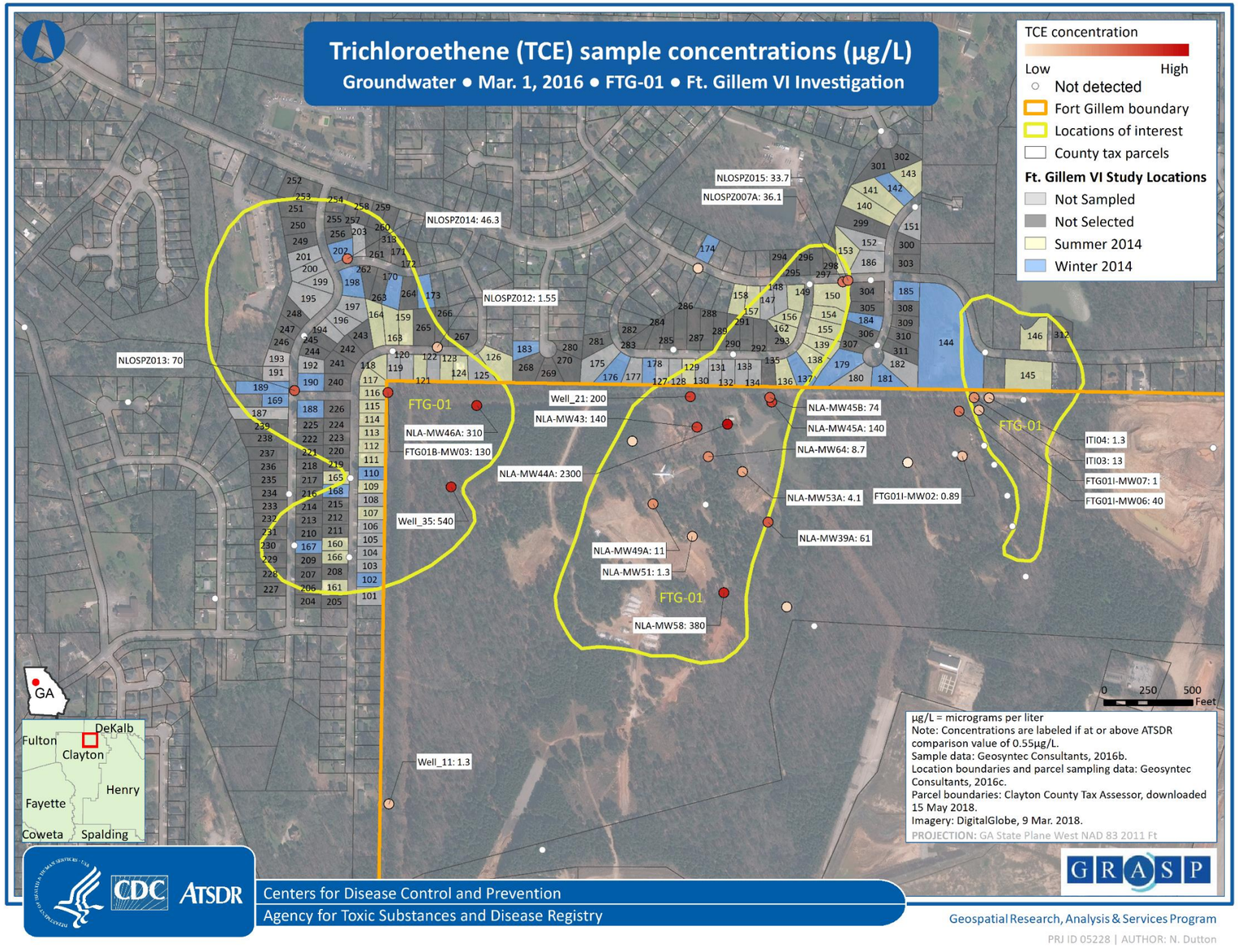


Figure B.11. TCE in Deep Soil Gas in the NLA

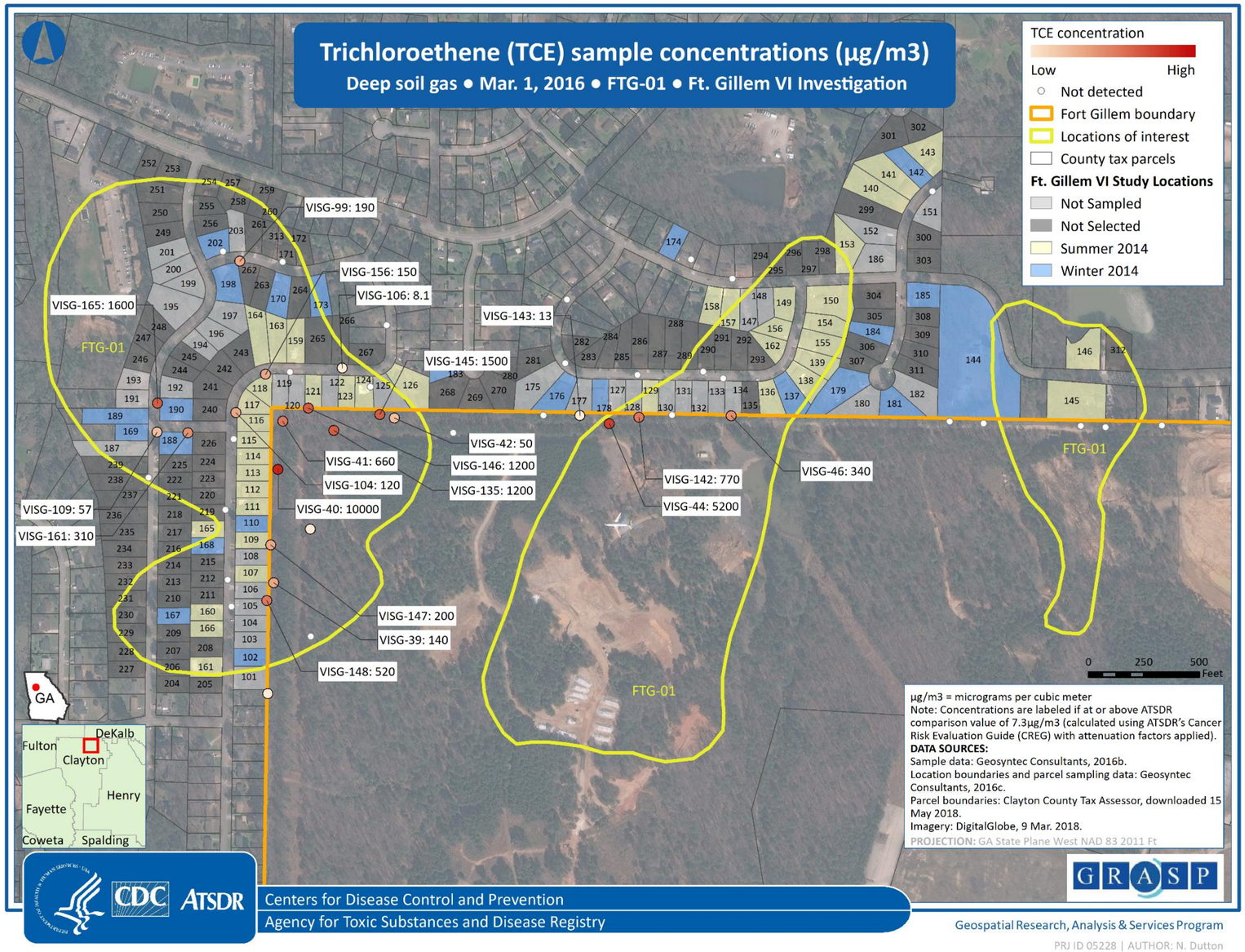


Figure B.12. TCE in Shallow Soil Gas in the NLA

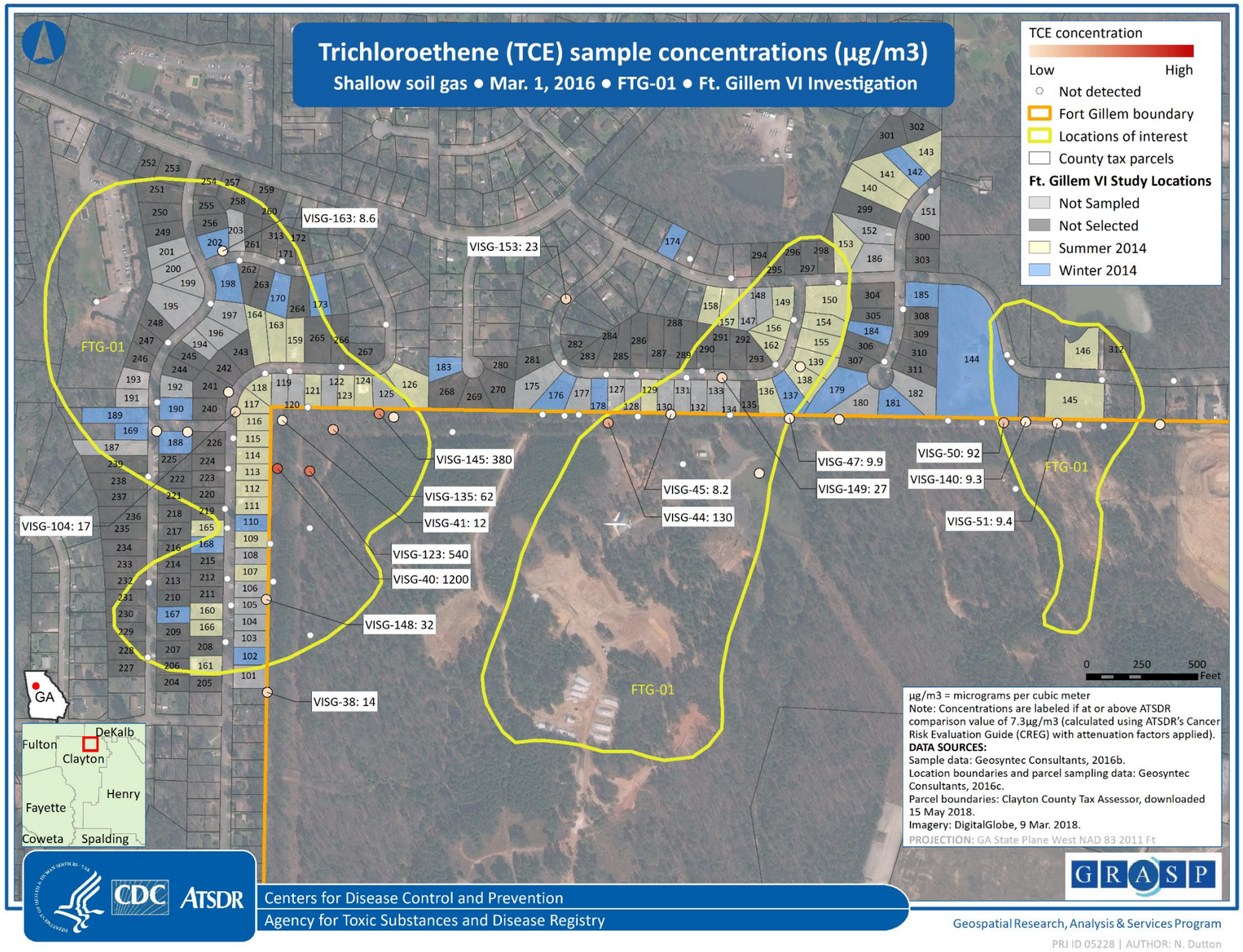


Figure B.13. TCE in Groundwater in the SEBS

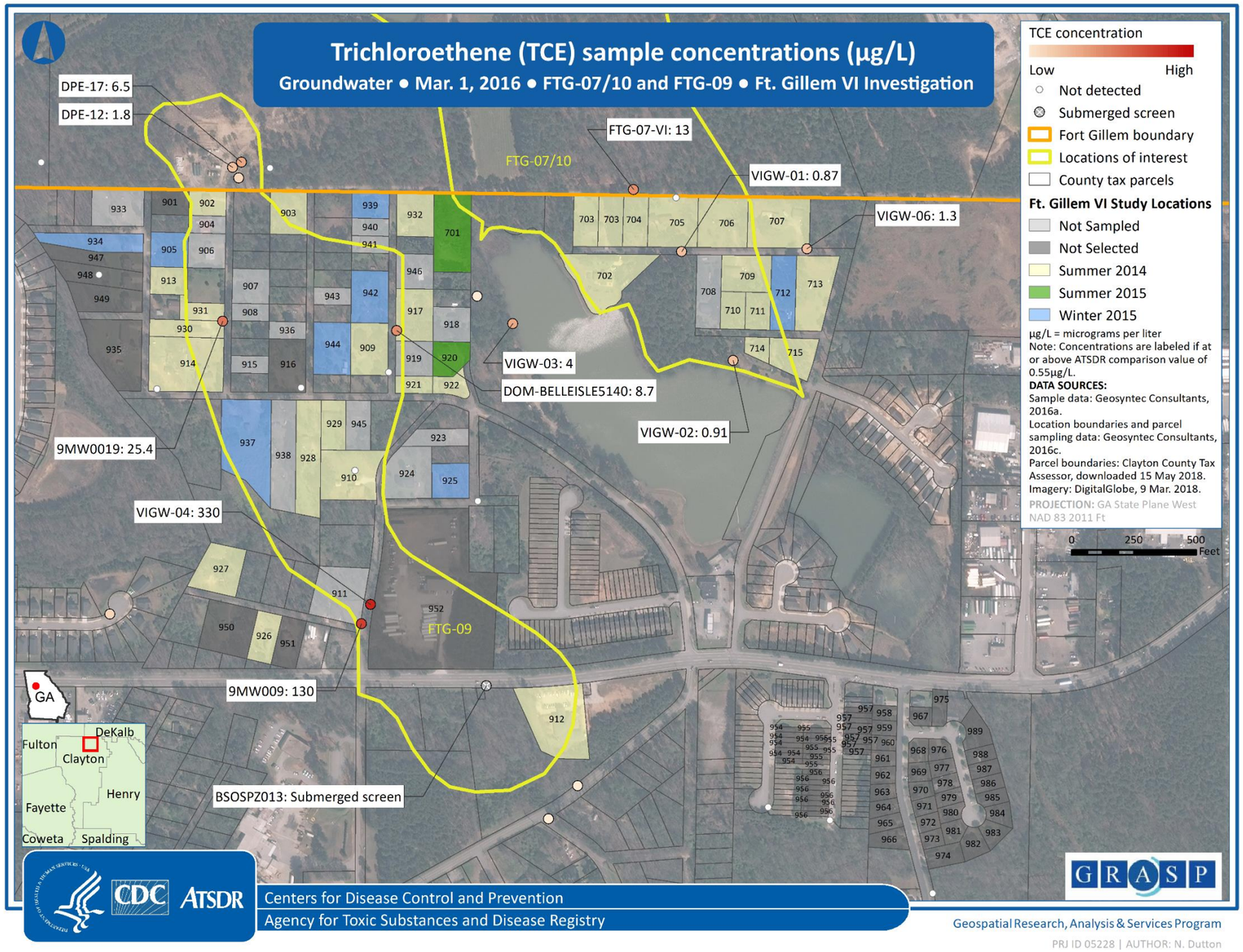


Figure B.14. TCE in Deep Soil Gas in the SEBS

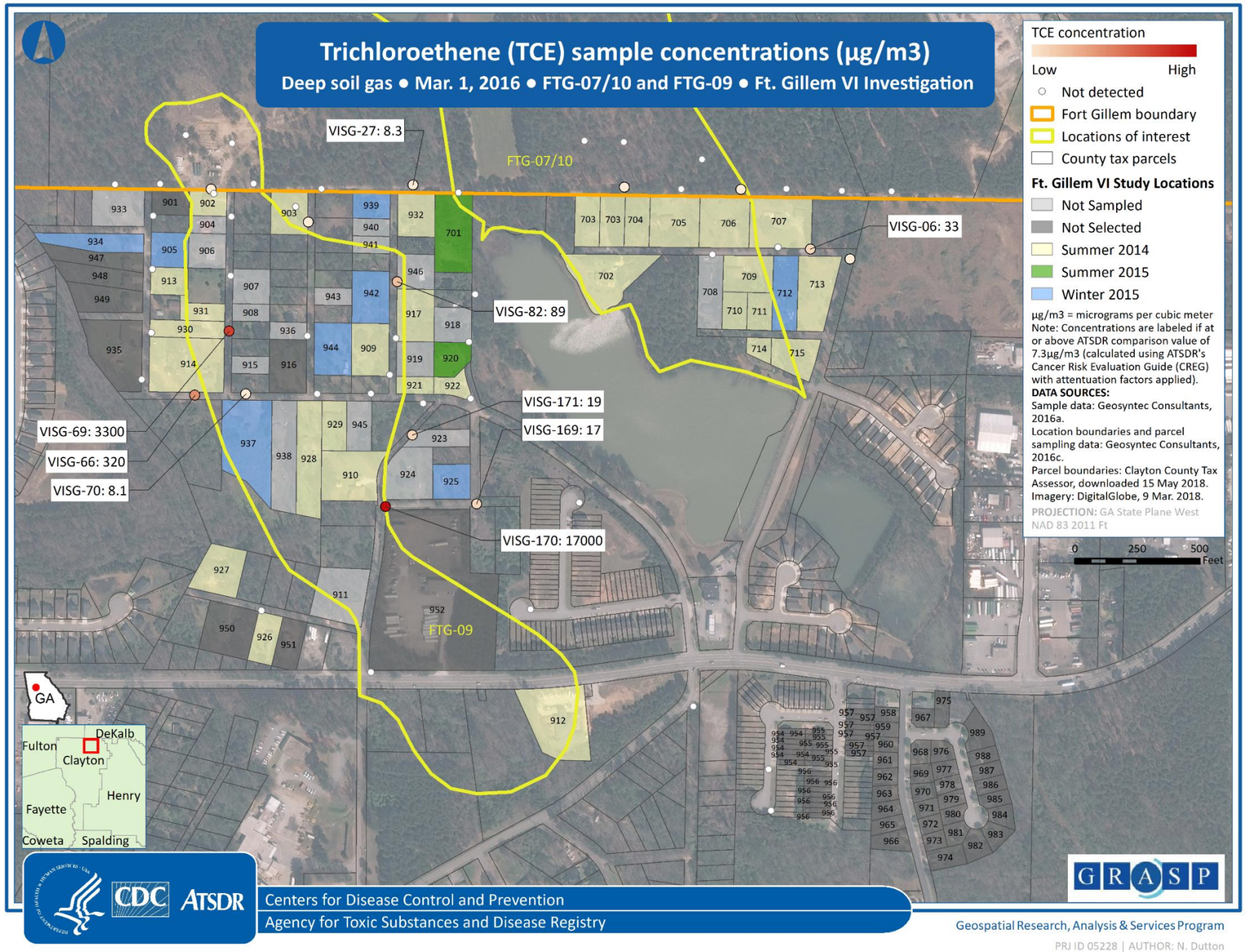


Figure B.15. TCE in Shallow Soil Gas in the SEBS

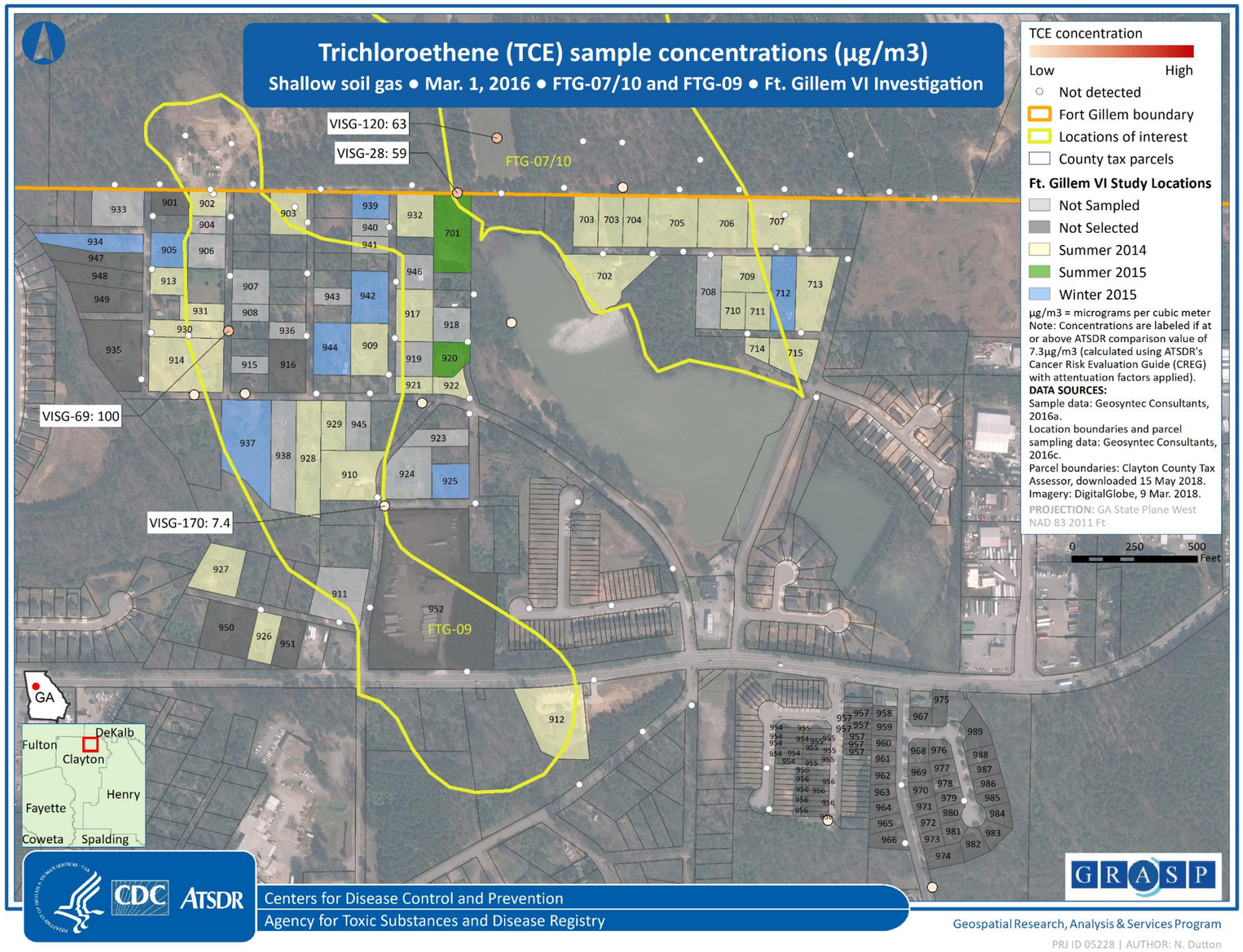


Figure B.16. Groundwater Flow Direction in the NLA

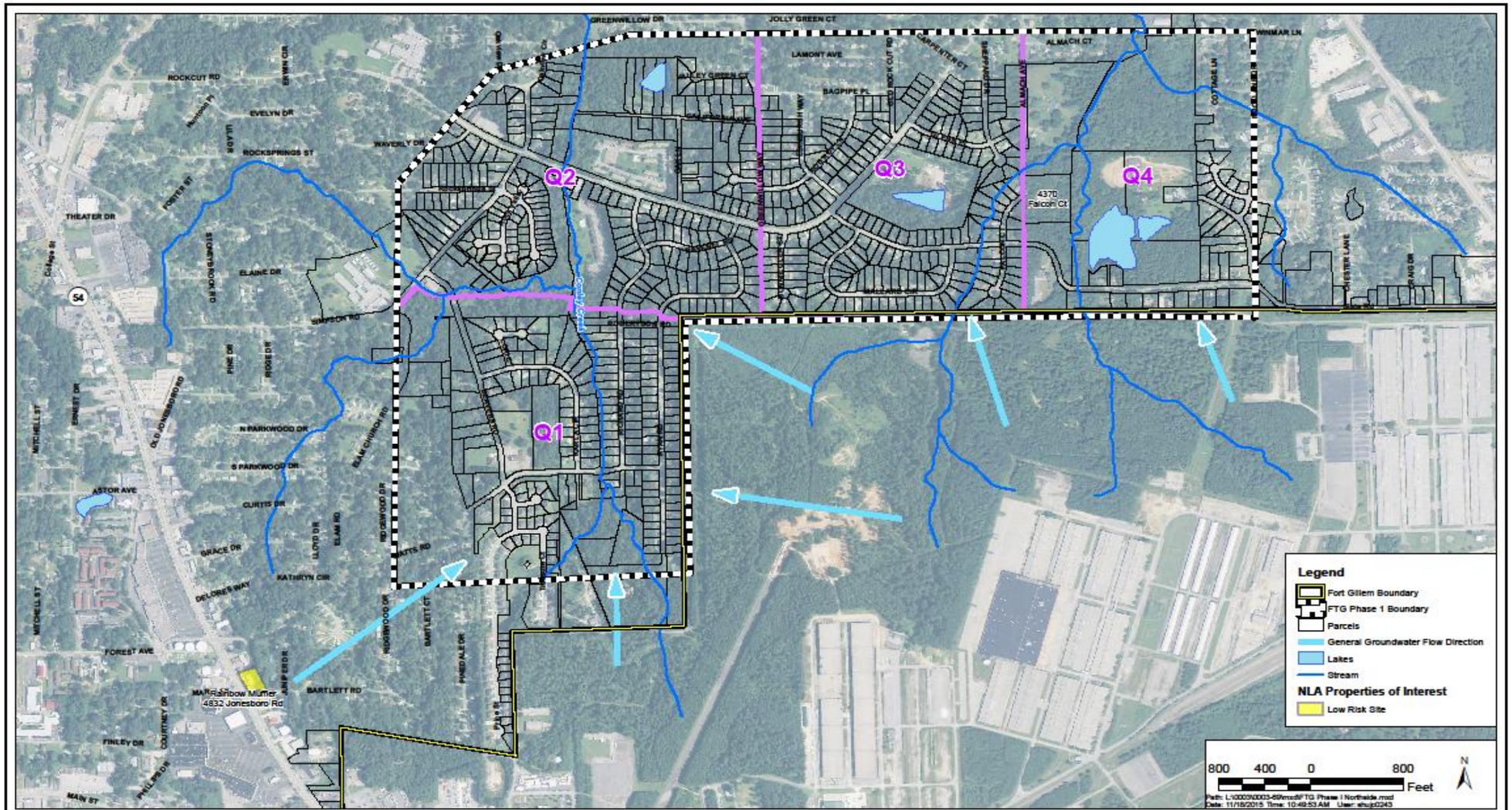
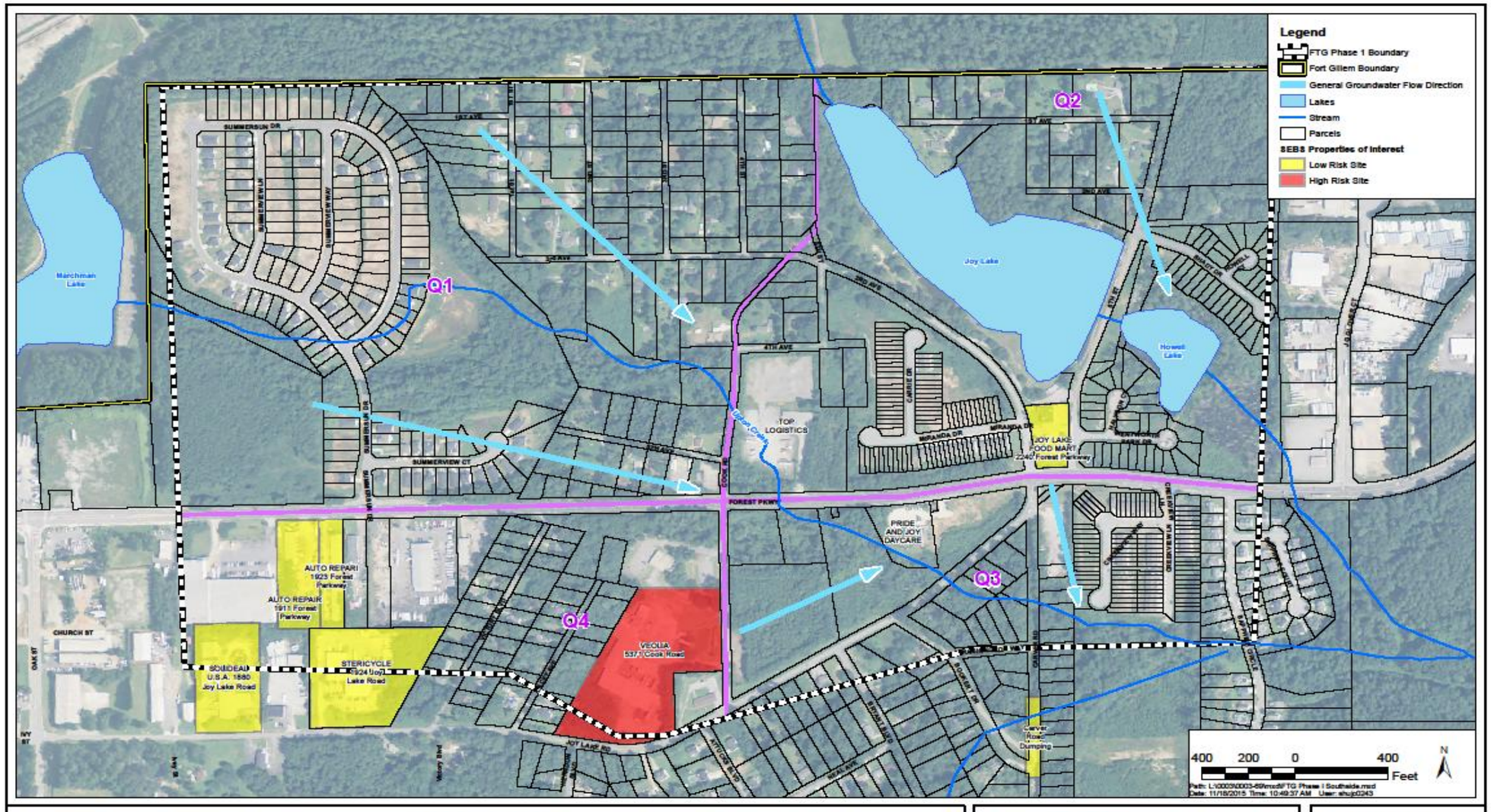


Figure B.17. Groundwater Flow Direction in the SEBS



FORT GILLEM	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	NOV 2015
FTG SEBS Properties of Interest		Figure 2

Figure B.18. Map IDs with Two Rounds of Seasonal Indoor Air Sampling in the NLA

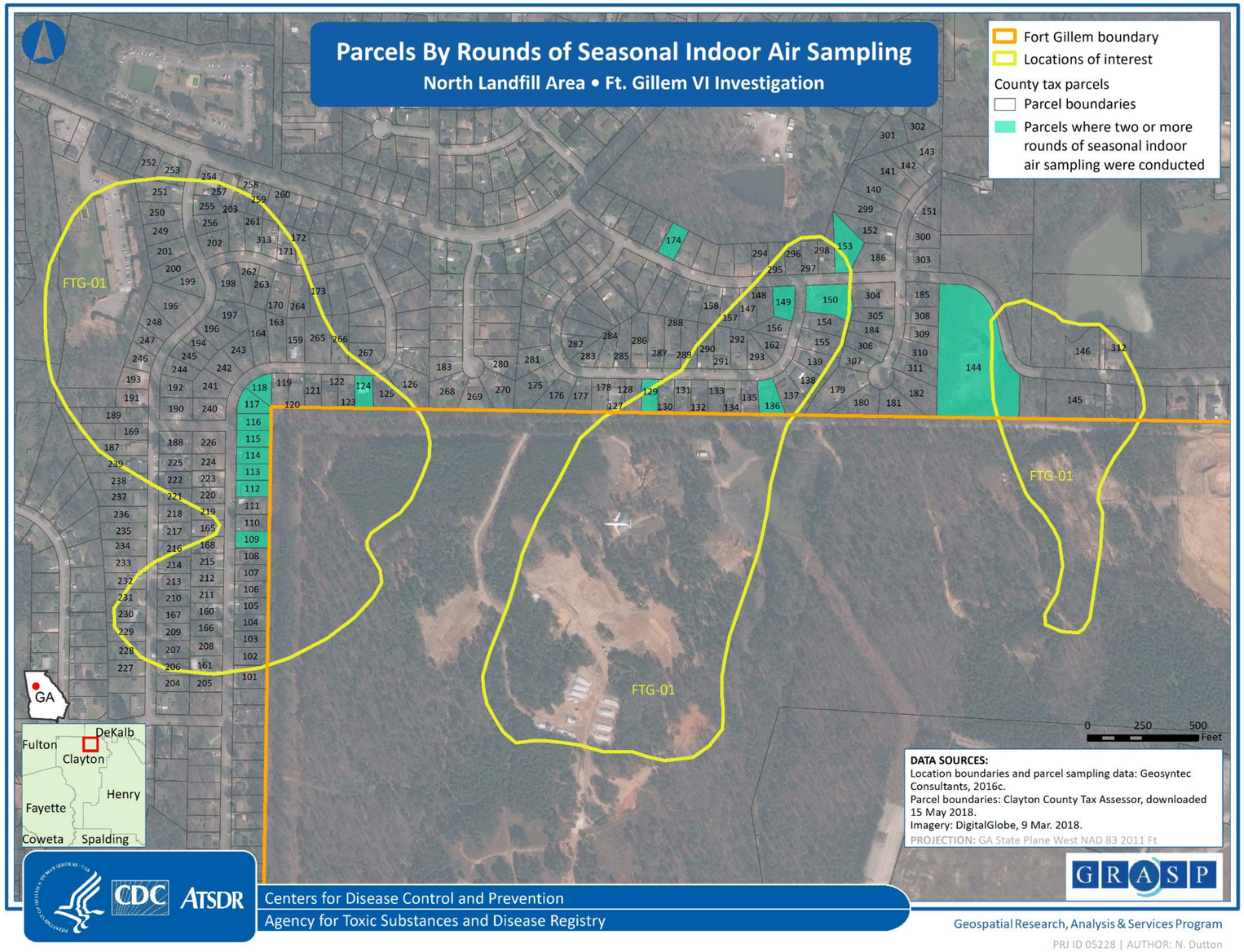
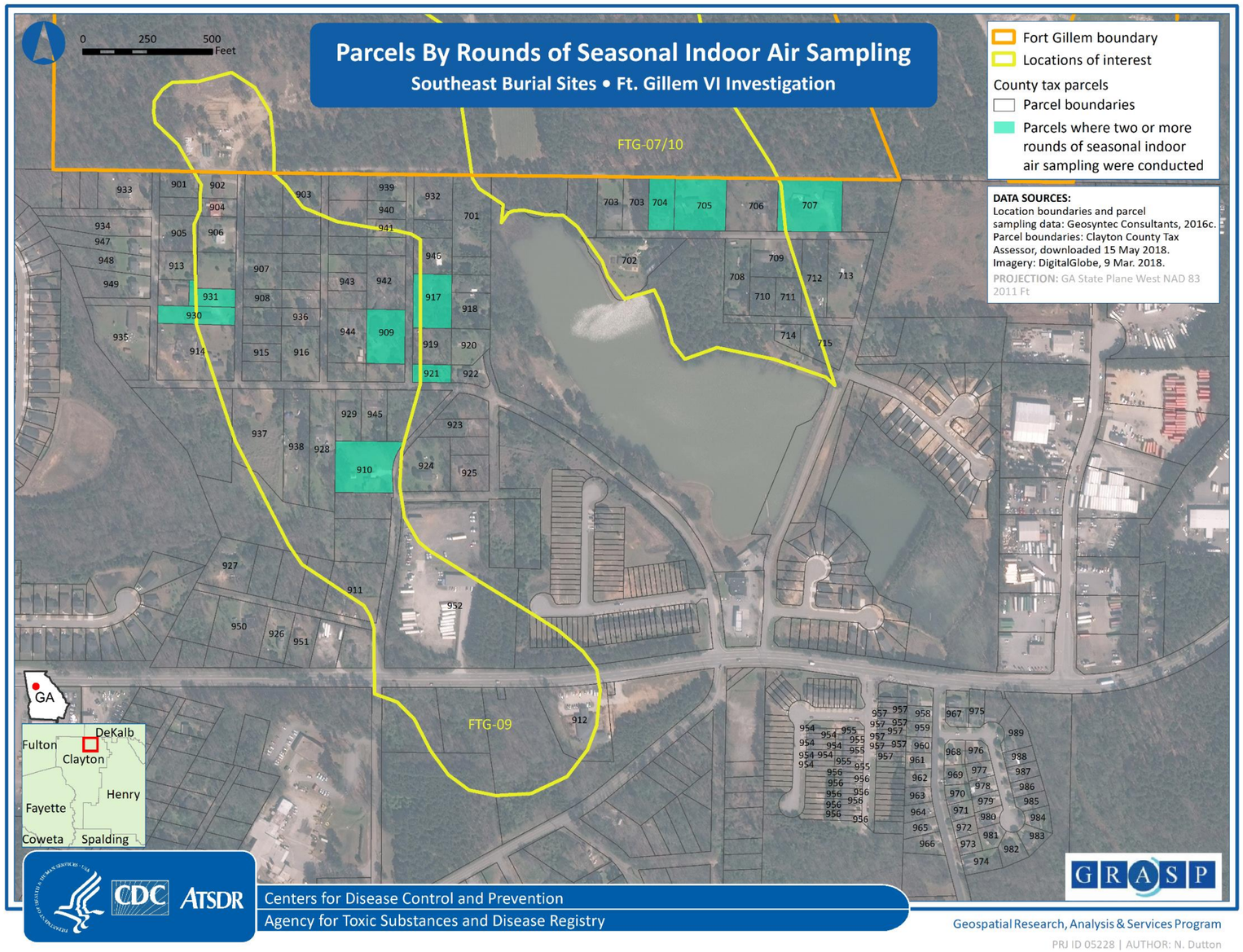
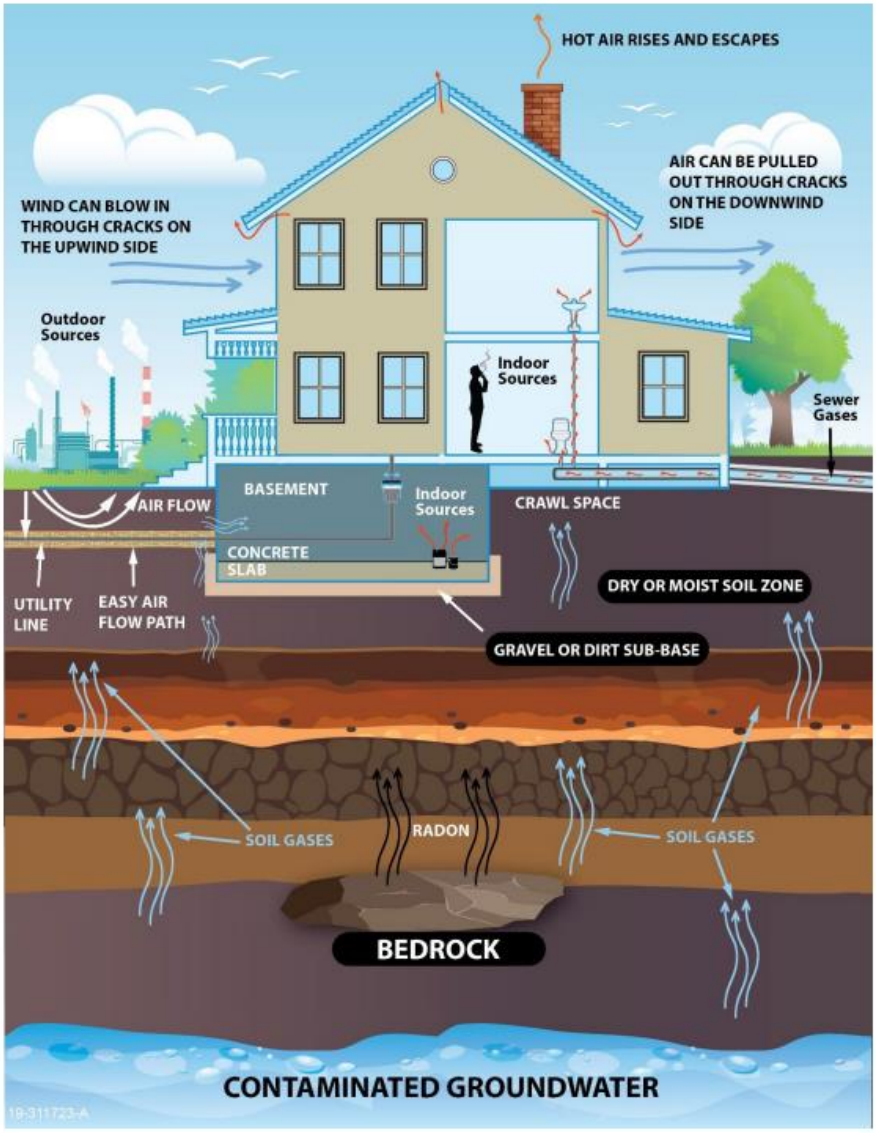


Figure B.19. Map IDs with Two Rounds of Seasonal Indoor Air Sampling in the SEBS



Appendix C: Fort Gillem Vapor Intrusion Study and Data Evaluation Steps

Figure C.1. Basic Diagram of Vapor Intrusion



Diagrammatic representation showing how soil gases can migrate from contaminated groundwater up through the soil and into crawl spaces and building structures through advection, diffusion, openings and preferential pathways.
Source: (ATSDR 2016)

Health assessors often need to distinguish between the contribution of vapor intrusion contaminants and those of indoor sources. Common indoor sources include household cleaning products, stored fuels, furniture, flooring, and dry-cleaned clothing. Outdoor air might also be a source from motor vehicles, chemical use (e.g. pesticides), and nearby industry.

Indoor air is a dynamic medium. Contaminant concentrations can change significantly over the course of a single day as a result of indoor air exchange rates or the introduction of a temporary source of contaminants, such as furniture polish or paints.

The Army developed a conceptual site model (CSM) to integrate all available site information. They used the CSM to perform the vapor intrusion investigation using data from groundwater, soil, and indoor air. The following details the steps followed by the Army to obtain environmental and building sampling data for the vapor intrusion investigation.

1. Environmental Investigation Data

Groundwater

The Army installed 21 monitoring wells in the SEBS area [Geosyntech 2016a] with submerged well screens during the vapor intrusion investigation, in addition to the off-site monitoring wells already in existence prior to the investigation. In the NLA, the Army installed 19 monitoring wells, of which only 15 were usable for sampling [Geosyntech 2016b]. The monitoring wells permit screening for contaminants just below the water table. Groundwater depth is approximately 15 feet beneath ground surface in the NLA and the SEBS [WENCK 2015a].

Soil Gas

The Army installed a total of 86 [Geosyntech 2016a] soil gas probes in the SEBS and 84 [Geosyntech 2016b] soil probes in the NLA areas to evaluate trends and the spatial distribution of VOC concentrations in soil gas [Geosyntec 2016a]. Soil gas probes were installed at two depths, shallow and deep at approximately 2-3 feet and 5 feet below ground, respectively [WENCK 2015a]. Probes were installed where there was sufficient distance between the surface and water table, so that soil-gas concentration gradients of VOCs in the vadose zone could be measured.

2. Building Sampling

Building-specific data were collected for indoor air, crawlspace, and/or subslab soil gas for assigned Map IDs in the SEBS and NLA [Geosyntec 2016a; Geosyntec 2016b]. Data were collected during heating season and non-heating season to address temporal variability. The Army collected data where and when access was granted. Thus, some Map IDs have two rounds of sampling data if access was permitted for the entire study, while other Map IDs may only have one round of sampling data if access was denied in advance of whatever round of sampling was to be conducted [Geosyntec 2016a; Geosyntec 2016b].

Building Survey and Product Removal

Once access was gained, the building occupant/owner was contacted to schedule the sampling event. Events required 3 separate appointments for each building. The first visit included a home survey, questionnaire, and briefing on potential VOC-emitting consumer products in the home. The Army attempted to identify potential background sources of contamination prior to sampling using [Geosyntec 2016a; Geosyntec 2016b]:

1. Occupant questionnaires
2. Building surveys
3. Forensic analysis identified in USEPAs VI Guide to evaluate background sources by
    a. comparing indoor air and subslab soil gas;
    b. comparing indoor and outdoor air concentrations;
    c. comparing background concentrations identified from the literature

Inficon Hazardous Air Pollutants on Site Emergency Response, a mobile gas chromatograph-mass spectrometer, was used to collect multiple samples of indoor and outdoor air for a four-hour period to evaluate the presence of background sources.

Surveys were conducted upon the first visit. USEPA's Occupied Dwelling Questionnaire was used to collect relevant information related to building construction, product usage, and activities performed that could impact sampling results. A sketch of the building was performed to identify sample locations [WENCK 2015a]. When sampling was scheduled, occupants were asked to remove potential sources 24 hours prior to the event. In instances where the occupant did not remove the items, all potential sources were documented and recorded [WENCK 2015a]. Potential background sources were not removed prior to the Sample Set 1, Round 1 sampling event in summer 2014, but were removed prior to the follow-up event if the Army was granted permission by the owner to remove them. Some of the products identified in buildings as possible contributors to the presence of VOCs being investigated were cleaners, air fresheners, insecticides, nail polish, cleaners, glue, adhesives, degreasers, paints, fire extinguishers, gasoline, and mothballs [Geosyntec 2016a, b; and c; WENCK 2015a].

Subslab Port Installation and Sampling

If a building was on a slab or had a basement with sub-floor, up to two sub slab implants were installed in the central location of the building and away from exterior walls [WENCK 2015a]. Subslab implants were installed according to the VI Study Work Plan by WENCK associates. Implants were sampled within 24 hours following installation in 1L Summa canisters at a rate between 100 to 200 mL/min. Subslab samples were analyzed using USEPA Method TO-15 [WENCK 2015a].

Crawl Space Sampling

For buildings with crawl spaces, samples were collected according to the VI Study Work Plan by WENCK associates [WENCK 2015a]. One-fourth inch Teflon tubing was attached to 10-foot PVC piping that was extended into the crawl space interior. The Teflon tubing was attached to a 6L Summa canister using 1–2-inch Tygon tubing to obtain a tight seal [WENCK 2015a]. Crawl space samples were collected concurrently with indoor and outdoor air samples and analyzed by USEPA Method TO-15 [WENCK 2015a].

Indoor and Ambient Air Sampling

Indoor and outdoor background air sampling was performed according to the VI Study Work Plan by WENCK Associates [WENCK 2015a]. Samples were collected over a 24-hour time period in 6L Summa canisters. Samples for indoor and ambient (outdoor) air were analyzed using USEPA Method TO-15 and by TO-15 Low level to obtain lower detection limits [WENCK 2015a].

Indoor samples were collected in the central portion of the building, with the Summa canister sample port placed in the breathing zone, approximately 3 to 5 feet from the floor. When necessary, samples were collected from the lowest level of the structure in either the first floor or basement [WENCK 2015a].

Outdoor background air samples were collected to capture ambient conditions [WENCK 2015a]. Despite USEPA recommendations for the VI investigation to obtain outdoor background samples at a minimum rate of 1 per 5 buildings evaluated, summer 2014 background samples were obtained at a rate 1 per 2 buildings evaluated. During the winter 2015 and summer 2015 sampling events, the rate of sampling was 1 per 3 buildings evaluated. Outdoor background samples were obtained prior to indoor or crawl space sampling, with wind direction documented at the beginning of the sampling day and samples acquired from the upwind side of the respective building [WENCK 2015a]. Summa canisters were placed away from home structures and the nearest street. The canisters were affixed to a fence, tree, telephone pole, or other stable structure [WENCK 2015a].

Vapor Intrusion Pathway Evaluation

1. Need for Immediate Action: Interim Mitigation

The Army assessed data obtained from indoor air, crawlspace, and/or subslab soil gas and compared the data to EPA vapor intrusion screening level (VISLs). During their evaluation, they used generic attenuation factors as suggested by the USEPA VI guide. Sub-surface data exceeded EPA's screening levels and triggered additional investigation. Building-specific data were evaluated to determine the need for immediate action, regardless of the origin of the contaminant. Buildings were classified into one of four risk classifications to determine whether an intervention (evacuation, mitigation) strategy was necessary. All analytes were tested for and identified during Round 1 sampling. Based on Round 1 sampling results and subsequent risk classification, carbon filtration mitigation units were installed at various locations to protect human health. The decision to install activated carbon mitigation units was based on proximity to Army-derived sub-surface contamination, risks associated with VOCs detected in the building, and the sensitivity of the receptor population [Geosyntec 2016a and b]. Buildings classified as Tier II received additional rounds of sampling and/or mitigation. All Map ID information was used during forensic analysis to determine whether vapor intrusion pathways were complete, regardless of tier classification. The need for immediate action/mitigation was assessed in two ways:

A. Tiered Risk Classification was employed to determine if an intervention strategy was necessary to protect human health from VOC exposure. Tier classifications met the following criteria:
   a. Tier I: at least one sensitive receptor and at least one analyte whose indoor air or crawlspace air concentration exceeded 10% of the lower explosive limit (LEL)
   b. Tier II: a target contaminant or cumulative cancer risk of all contaminants exceeded 10^{-4} or a hazard index of 2
   c. Tier III: any analyte exceeded USEPA RSL; cumulative cancer risk less than 10^{-4} but greater than 10^{-6} or a target organ with a HI less than 2 but greater than 1

d. Tier IV: no analyte exceeded the screening level; cumulative cancer risk was less than 10^{-6}; had an HI less than 1

Map IDs investigated were classified Tier II or Tier III. IDs close to or at Tier II levels received interim mitigation prior to forensic analysis. No Tier I or Tier IV Map IDs were identified during the investigation.

B. Analyte data from indoor air, crawlspace and subslab air, soil gas beyond the building foundation, and groundwater was used to identify contaminants that exhibited a spatial pattern consistent with vapor intrusion from an Army-derived sub-surface source. Tier II Map IDs, regardless of source, received interim mitigation systems (air filtration units with activated carbon).

2. Vapor Intrusion Pathway Evaluation: Forensic Analysis

Site-specific forensic systematic evaluation included a variety of spatial analysis techniques for each VOC contaminant. Techniques used helped identify the source in soil gas, subslab and crawlspace air, and indoor air as either vapor intrusion, outdoor sources, or indoor sources (such as consumer products). The Army developed a forensic analysis tool to facilitate a systematic evaluation of data collected from media sources (soil and groundwater), subslab, crawlspace, and indoor air, based on USEPA's VI approach. The tool used Excel and included site-specific data, screening levels, action levels, applicable attenuation factors, geographical information, and proximity to installation fence line. Combined with visualization tools, the tool simultaneously analyzed spatial comparisons of analytes.

Forensic evaluation approach was conservative because:

a. It included screening for target analytes.
b. It reported all analytes detected in air samples.
c. It included evaluating buildings that were greater than the 100-foot distance from the edge of Army derived subsurface impacts.

Forensic analysis was conducted in two stages:

A. **Preliminary**: If building-specific data were available, the Army compared analytical results from indoor air, crawlspace and subslab soil gas to conservative VI screening levels. The four steps of the preliminary process:

1. Evaluate the need for immediate action by comparing VOC concentrations to action levels defined by a 10^{-4} excess lifetime cancer risk and/or a hazard index (HI) of 2.
2. Assess the VI pathway completeness. The Army used the forensic evaluation tool to identify buildings that exhibited spatial concentration patterns consistent with a subsurface source and conservative medium-specific screening levels to identify the subset of buildings with the potential to pose a risk through the vapor intrusion pathway.

3. Perform detailed VI-pathway evaluation for selected buildings. The Army used the VI conceptual site model to evaluate buildings and VOCs (step 2) that exhibited spatial patterns consistent with VI and potentially posed a VI risk.
4. Evaluate petroleum hydrocarbons at the installation perimeter. In addition to evaluating buildings with building specific data and all reported analytes according to Steps 1-3, the Army conducted a review of petroleum hydrocarbons in buildings at the installation perimeter (fence line). This was performed in response to regulatory interest in the potential that the source of those petroleum hydrocarbons was lateral vapor migration from Fort Gillem through soil to the buildings.

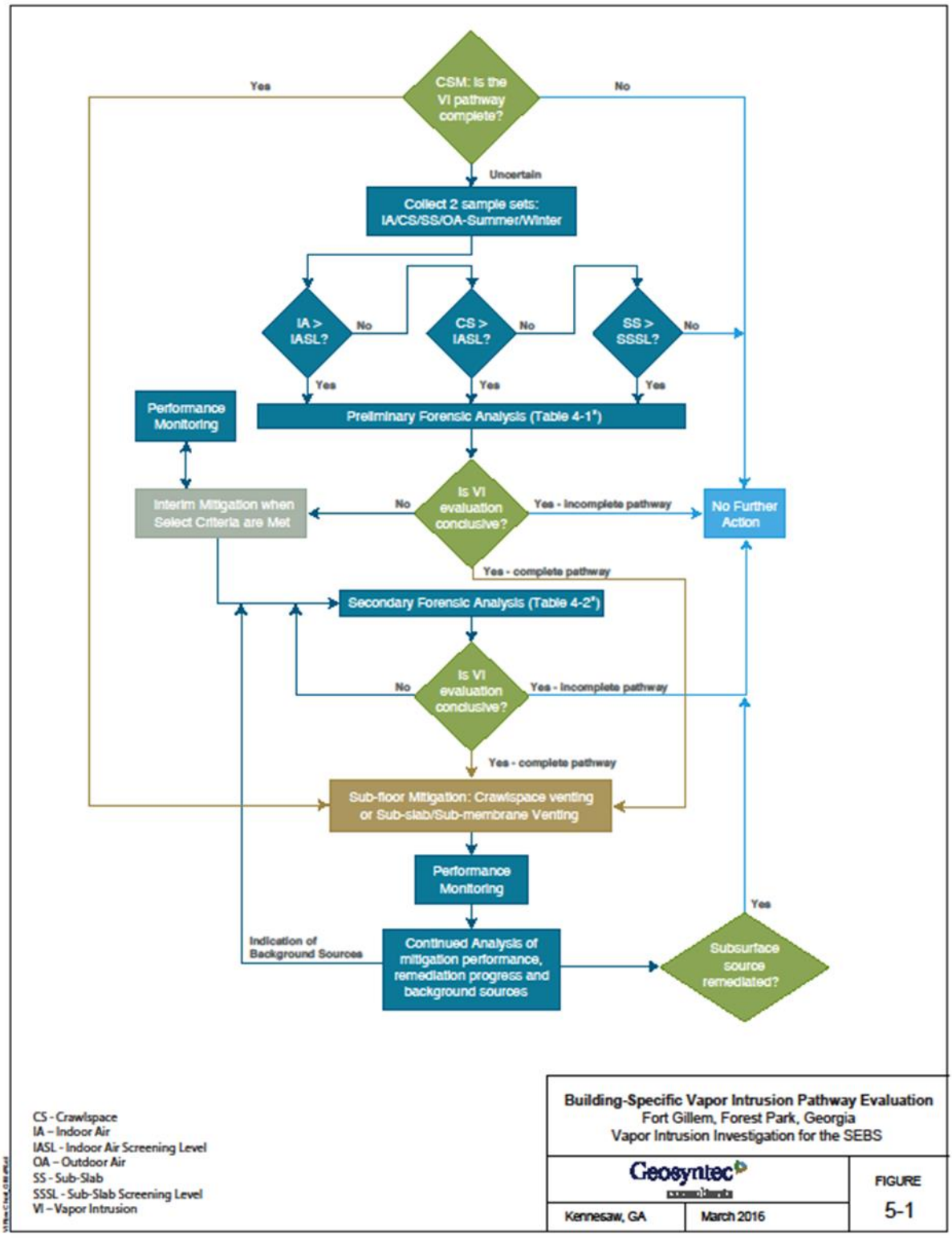
B. **Secondary**: If Preliminary analysis was inconclusive with respect to the VI pathway, the Army collected additional data. If no building-specific data were available, the Army used the vapor intrusion conceptual site model and evaluations from neighboring buildings to evaluate the pathway for that building.

Forensic evaluation included spatial analysis of VOCs detected in indoor air, crawlspace, or subslab gas samples to determine potential sources such as consumer products, vapor intrusion, or outdoor sources.

Evaluating Completeness of the Pathway:

- VOC concentration in indoor air was greater than the health-protective screening value
- VOC concentration in indoor air was greater than in outdoor air
- VOC concentration in crawlspace air was greater than the screening value
- VOC concentration in crawlspace air was equal to (attenuation factor of 1) or greater than in indoor air, allowing for 30% variability
- VOC concentration in subslab soil gas multiplied by 0.03 (screening level attenuation factor) was greater than in the VOC concentration of indoor air
- VOC concentration in groundwater and/or soil gas was greater than the reporting limit from at least one soil gas or groundwater sample location within the FTG drainage basin

Figure C.2. Flow Chart of the Army's Building Specific Vapor Intrusion Pathway Evaluation



Appendix D: Cancer Risk Evaluation Process

Cancer Risks

For evaluation purposes, exposure to a cancer-causing chemical, even at low concentrations, could be associated with some increased risk of cancer. The estimated increased risk is called an excess cancer risk. The excess cancer risk from exposure to contaminants associated with the site was calculated by multiplying the site-specific air concentrations by US EPA's chemical-specific cancer Inhalation Unit Risk, or IURs available at Integrated Risk Information System | US EPA. This calculation estimates an excess cancer risk expressed as a proportion of the population that might be affected by a carcinogen over their lifetime. For example, an estimated risk of 1×10^{-6} predicts the probability of one additional cancer over background in a population of 1 million similarly exposed individuals. An increased cancer risk is not a specified number of cancers in a community. Rather; it is an estimate of the increase in the probability that a person may develop cancer sometime in his or her lifetime following exposure to a contaminant under specific exposure scenarios. For children, the estimated excess cancer risk is not calculated for a lifetime of exposure, but from a fraction of lifetime; based on known or suspected length of exposure during childhood.

When there is sufficient weight of evidence to conclude that a carcinogen operates through a mutagenic mode of action, and in the absence of chemical-specific data on age-specific susceptibility, US EPA's Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens [USEPA 2005] advises that increased early-life susceptibility be assumed and recommends that default age-dependent adjustment factors or ADAFs be applied to adjust for this potential increased susceptibility from early-life exposure. The current ADAFs and their age groupings are 10 for <2 years, 3 for 2 <16 years, and 1 for ≥16 years [USEPA 2005]. For risk assessments based on specific exposure assessments, the 10- and 3-fold adjustments to the unit risk estimates are to be combined with age-specific exposure estimates when estimating cancer risks from early-life (<16-years-of-age) exposure. An ADAF of one is used for persons 16 years and older. ADAF adjustments for cancer risk are used only for those carcinogens that have a mutagenic mode of action.

Estimated cancer risks from exposure to indoor air are shown in Table D.1. Per ATSDR guidelines, when you have less than 8 samples in a sample set, the maximum concentration is used from a minimum of two seasonal sampling events, to derive cancer risk estimates.

Table C.1: Cancer Risk Estimates from Exposure to Indoor Air in the North Landfill Area and the Southeast Burial Site Where a Minimum of Two Seasonal Indoor Air Samples Were Obtained. Cancer Risk Estimates Are Based on Residents Living in Their Homes for a Maximum of 33 years (RME) for Adults and an Average of Twelve Years (CTE) for Childhood Exposure.

Analyte Detected	Map ID	Maximum Indoor Air Concentration µg/m³	Estimated Cancer Risk Using RME (33 years exposure)	Estimated Cancer Risk Using CTE (12 years exposure)	Estimated Cancer Risk from Birth to Age 21*
Benzene	129	0.82	3E-06	1E-06	2E-06
Benzene	136	0.75	3E-06	9E-07	2E-06
Chloroform	114	7.4	7E-05	3E-05	5E-05
Chloroform	115	0.36	4E-06	1E-06	2E-06
Chloroform	116	0.49	5E-06	2E-06	3E-06
Chloroform	117	1.7	2E-05	6E-06	1E-05
Chloroform	118	2.9	3E-05	1E-05	2E-05
Chloroform	129	1.3	1E-05	5E-06	8E-06
Chloroform	136	8.6	8E-05	3E-05	5E-05
Chloroform	144	1.2	1E-05	4E-06	N/A
Chloroform	149	2.1	2E-05	7E-06	1E-05
Chloroform	150	2.9	3E-05	1E-05	2E-05
Chloroform	153	1.8	2E-05	6E-06	1E-05
Chloroform	174	4.2	4E-05	2E-05	3E-05
Trichloroethene	109	0.55	1E-06	4E-07	9E-07
Trichloroethene	112	1.35	2E-06	9E-07	2E-06
Trichloroethene	113	1.35	2E-06	9E-07	2E-06
Trichloroethene	114	0.13	2E-07	8E-08	2E-07
Trichloroethene	115	0.065	1E-07	4E-08	1E-07
Trichloroethene	116	0.08	1E-07	5E-08	1E-07
Trichloroethene	117	0.08	1E-07	5E-08	1E-07
Trichloroethene	118	0.62	1E-06	4E-07	1E-06
Trichloroethene	124	6.3	1E-05	4E-06	1E-05
Chloroform	704	3.2	3E-05	1E-05	2E-05
Chloroform	705	1.8	2E-05	6E-06	1E-05
Chloroform	909	0.84	8E-06	3E-06	5E-06
Chloroform	921	0.64	6E-06	2E-06	4E-06
Chloroform	930	0.38	4E-06	1E-06	2E-06
Chloroform	931	0.26	4E-06	9E-07	2E-06
Trichloroethene	704	1.1	2E-06	7E-07	2E-06
Trichloroethene	705	1.1	2E-06	7E-07	2E-06
Trichloroethene	707	1.05	2E-06	7E-07	2E-06
Trichloroethene	909	0.55	1E-06	4E-07	9E-07
Trichloroethene	910	0.36	6E-07	2E-07	6E-07
Trichloroethene	917	0.295	5E-07	2E-07	5E-07
Trichloroethene	930	1.1	2E-06	7E-07	2E-06
Trichloroethene	931	1.1	2E-06	7E-07	2E-06

RME: Residential Maximum Exposure

CTE: Central Tendency Exposure

*Cancer risk estimates for children less than 21 years of age assumes an exposure of 21 years in a 78-year lifespan

Note: USEPA inhalation unit risks used in the cancer risk estimation were as follows: 7.8E-6 $(\mu g/m^3)^{-1}$ for benzene, 2.3E-5 $(\mu g/m^3)^{-1}$ for chloroform, and 4.1E-6 $(\mu g/m^3)^{-1}$ for trichloroethene

Appendix E: General Cancer Information

Cancer will affect 1 in 2 men and 1 in 3 women in the United States, according to statistics collected by the Surveillance Epidemiology and End Results program at the National Cancer Institute [Surveillance, Epidemiology, and End Results Program]. Cancer is a group of more than 100 diseases characterized by uncontrolled growth and spread of abnormal cells. Different types of cancers have differing rates of occurrence, different causes, and chances for survival. Therefore, we cannot assume that all the different types of cancers in a community or workplace share a common cause or can be prevented by a single intervention.

Cancers may be caused by a variety of factors acting alone or together, usually over a period of many years. Scientists estimate that most cancers are due to factors related to how we live, or lifestyle factors, which increase the risk for cancer. Examples include smoking cigarettes, drinking heavily, and diet (for example, excess calories, high fat, and low fiber). Other important cancer risk factors include reproductive patterns, sexual behavior, and sunlight exposure. A family history of cancer may also increase a person's chances of developing cancer.

Smoking is by far the leading risk factor for lung cancer. Smokers are about 20 times more likely to develop lung cancer than nonsmokers. People who don't smoke but who breathe the smoke of others also have a higher risk of lung cancer. A non-smoker who lives with a smoker has about a 20% to 30% greater risk of developing lung cancer than a non-smoker. Workers exposed to tobacco smoke in the workplace are also more likely to get lung cancer. Exposure to radon, asbestos, arsenic, chromium, nickel, soot, tar, and other substances can also increase the risk of lung cancer. An increased risk for lung cancer has also been associated with personal or family history of lung cancer. Most people are older than 65 years when diagnosed with lung cancer.

Smoking tobacco is also an important risk factor for kidney cancer. Obesity and high blood pressure have also been linked to kidney cancer. People with a family member who had kidney cancer have a slightly increased risk of kidney cancer. Also, certain hereditary conditions can increase the risk. Kidney cancer is about twice as common in men as in women and is slightly more common among blacks than other races. Workplace exposure to asbestos, cadmium, some herbicides, benzene, and organic solvents, particularly trichloroethylene, has also been associated with an increased risk for kidney cancer.

While cancer occurs in people of all ages, new cases of most types of cancer rise sharply among people over 45 years of age. When a community, neighborhood, or workplace consists primarily of people over the age of 45 (and even more so over the age of 60), we would expect more cancers than in a neighborhood or workplace with people of younger ages. However, cancer is also the second leading cause of death in children.

Many people believe that cancer is usually caused by toxic substances in the home, community, or workplace. Although we do not know the exact impact now of environmental pollutants on cancer development, less than 10% of cancers are estimated to be related to toxic exposures – only 2 percent are attributed to environmental causes.

Since the 1970s, when state cancer registries were first being organized, many public health scientists and residents hoped that anecdotal observations of clusters of cancer in the community might lead to prevention of new cases via discovery of specific causes of these cancers. Since then, thousands of investigations have taken place throughout the country, mainly conducted by state, local, or federal agencies. With one or two possible exceptions involving childhood cancers, none of these investigations have led to the identification of the causes of any of these possible clusters, even when a statistically elevated number of cancers in a geographic area could be documented. The Georgia Department of Public Health has developed strategies for active cancer surveillance. This systematic approach to monitoring cancer trends in Georgia will lead to more opportunities for prevention and control of cancer in Georgia.