Risk Assessment/ Alternatives Analysis Report Downtown Environmental Assessment Project, Montgomery, Alabama

Prepared for

Alabama Department of Environmental Management by the Downtown Environmental Alliance

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ch2m

PG and PE Certification

This Risk Assessment/Alternatives Analysis Report was prepared under the supervision of a Professional Geologist licensed by the Alabama Board of Licensure for Professional Geologists. It has also been prepared under the supervision of a Professional Engineer licensed by the Alabama Board of Licensure for Professional Engineers and Land Surveyors.

Stephanie Park
Alabama PG No. 1225

7-16-18
Date

Glen S. Davis
Alabama PE No. 26705

7/16/18
Date

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Acronyms and Abbreviations

µg/L	micrograms per liter
$\mu g/m^3$	micrograms per cubic meter
AA	alternatives analysis
ADEM	Alabama Department of Environmental Management
AG	Attorney General
AMS	AMS retract-a-tip
Annex	County Annex III
ARAR	applicable, relevant, and appropriate requirement
AS-SVE	air sparging and soil vapor extraction
$atm\text{-}m^3/mole$	atmospheric cubic meter per mole
ATSDR	Agency for Toxic Substances and Disease Registry
BCF	bioconcentration factor
bgs	below ground surface
CEM	conceptual exposure model
CH2M	CH2M HILL Engineers, Inc.
City	City of Montgomery
cm/s	centimeters per second
COC	chemical of concern
COG	Community Outreach Group
COPC	chemical of potential concern
CSM	conceptual site model
DAF	dilution attenuation factor
DCE	dichloroethene
DEA	Downtown Environmental Alliance
DEAP	Downtown Environmental Assessment Project
DO	dissolved oxygen
EI	Environmental Investigation
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
FYR	Five-year Review
GIS	geographic information system
GSI	groundwater-surface water interface
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IC	institutional control
IELCR	individual excess lifetime cancer risk
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
LTM	long-term monitoring
MCL	maximum contaminant level
MDL	method detection limit
MNA	monitored natural attenuation
MWWSSB	Montgomery Water Workers and Sanitary Sewer Board
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
PCE	tetrachloroethene

PRG	preliminary remediation goal
RA	remedial action
RA/AA	Risk Assessment/Alternatives Analysis
RAO	remedial action objective
RM	risk management
RSA	Retirement Systems of Alabama
RSL	Regional Screening Level
site	Montgomery DEAP site
SLERA	screening-level ecological risk assessment
SVE	soil vapor extraction
TCE	trichloroethene
USGS	U.S. Geological Society
VC	vinyl chloride
VF	volatilization factor
VI	vapor intrusion
VIMS	vapor intrusion monitoring system
VISL	vapor intrusion screening level
VOC	volatile organic compound
WQS	water quality standard

Introduction

This Risk Assessment/Alternatives Analysis (RA/AA) Report is being submitted to the Alabama Department of Environmental Management (ADEM) by the Downtown Environmental Alliance (DEA) to document the results of the human health risk assessment (HHRA), screening-level ecological risk assessment (SLERA), and remedial alternatives analysis (AA) for the Downtown Environmental Alliance Project (DEAP) site. The DEAP site includes the extent of tetrachloroethene (PCE) in groundwater that originally was discovered in former public water supply well PW-9W in 1991 and during the construction of the Retirement Systems of Alabama (RSA) Tower Energy Plant (hereinafter referred to as the RSA Energy Plant) in 1993. Since the discovery of PCE impacted groundwater, the site has been the subject of numerous investigations (see Section 1.1.1).

The HHRA, SLERA, and AA documented in this report were performed to assess potential risks to human health and the environment, and evaluate alternatives to mitigate those potential risks. The assessments were performed using the results of the supplemental environmental investigation (EI) conducted by the DEA in 2016 and 2017 (CH2M, 2018).

Figure 1-1 presents the DEAP site boundary, major site features, and the EI investigation locations. The DEAP site covers approximately 30 city blocks in downtown Montgomery. Although not within the site boundary, the HHRA and remedial AA also considered the results of the Supplemental EI sampling conducted near the County Annex III (Annex) Building and the Alabama Attorney General (AG) Building, which was performed to evaluate the potential for vapor intrusion (VI) impacts based on previous odor/indoor air quality complaints received during site work conducted by the U.S. Environmental Protection Agency (EPA).

1.1 Background

After the discovery of PCE in groundwater in downtown Montgomery, remedial actions (RAs) and investigations were conducted by various parties to address and/or evaluate potential contamination in downtown Montgomery.

1.1.1 Site History

In response to the 1991 discovery of PCE in well PW-9W, the Water Works and Sanitary Sewer Board of the City of Montgomery, Alabama, discontinued use of the North Well Field. All water supply wells within the DEAP site boundary were abandoned in 2011, except PW-9W, which was retained for environmental monitoring. However, the pump was removed from the well in 2017 based on 3 years of analytical results that indicate PCE is no longer present in the well at concentrations above the EPA Maximum Contaminant Level (MCL). The potential abandonment of PW-9W was discussed with ADEM in August 2017 and the well is planned to be abandoned in 2018.

In response to the discovery of PCE during construction of the RSA Energy Plant in 1993, an emergency removal was conducted by the RSA under ADEM oversight. Since then, multiple investigations have been conducted in the area to assess the nature and extent of remaining contamination across the DEAP site, and other investigations have been conducted as environmental site assessments for commercial and industrial properties within downtown Montgomery. These investigations evaluated soil, groundwater, sewer water, soil vapor, and tree core samples through 2017 (including the Supplemental EI summarized in Section 1.1.2).

Over the course of these investigations, a PCE plume in groundwater emanating from the former RSA Energy Plant location was identified and subsequently monitored (however, no residual PCE contamination was identified in vadose zone soil). Additionally, potential indoor air quality concerns were identified at two buildings (the Annex Building and the AG Building, see Figure 1-1). During investigations in 2011, EPA installed a vapor intrusion monitoring system (VIMS), consisting of five soil vapor sampling points installed at 10-foot intervals from 10 to 50 feet below ground surface (bgs), across the street from the Annex Building to evaluate soil vapor concentrations.

Investigation results concluded that multiple sources of contamination likely exist within the downtown Montgomery area. Data from investigative work conducted between 1993 and 2012 were compiled and evaluated to develop the scope of the Supplemental EI work as documented in the ADEM-approved work plan (CH2M, 2016).

1.1.2 Supplemental EI Summary

The Supplemental EI was implemented at the DEAP site between July 2016 and February 2017 to refine the conceptual site model (CSM). Although other chemicals that are commonly found in industrial or commercial areas were observed during the historical investigations, chemicals of potential concern (COPCs) assessed as part of this investigation are PCE, identified at the RSA Energy Plant and former public water supply well PW-9W, and associated degradation products, namely trichloroethene (TCE), cis-1,2-dichloroethene (DCE), trans-1,2-DCE, and vinyl chloride (VC). The term COPC is used according to Section 5.1 of the Risk-Based Corrective Action Guidance (ARBCA) guidance manual (ADEM, 2017a) throughout this report to refer to the site-specific chemical list. Investigation locations, shown on Figure 1-1, include:

- One temporary piezometer (TMPZ-1), installed near the downgradient edge of the PCE plume (Although TMPZ-1 initially was intended for use as a temporary piezometer, it was completed following the *Alabama Environmental Investigation and Remediation Guidance* (ADEM, 2017b) as a Type II permanent monitoring well. Because it may be used to collect groundwater samples in the future and was installed as a permanent well, TMPZ-1 will be considered a monitoring well and referred to as TMPZ-1/MW-13S through the remainder of this document.)
- Groundwater samples from 14 monitoring wells (including TMPZ-1/MW-13S) analyzed for COPCs, PCE and degradation products, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC
- Sixteen soil vapor samples from eight locations analyzed for the COPCs
- Bus wash water from Capital Trailways Bus Station, analyzed for the COPCs (At the time, the business was using an industrial groundwater supply well to supply bus wash water; the business switched to using publicly supplied water in 2017 and discontinued use of the industrial water supply.)
- Six geotechnical samples collected at four locations using Shelby tubes
- Two hydraulic studies (both wet- and dry-weather seasons) at the downgradient edge of the PCE plume, located adjacent to Cypress Creek (and near the confluence of Cypress Creek and the Alabama River)

The data were collected to meet the following objectives:

- Assess the nature and extent of PCE in groundwater.
- Identify concentrations of COPCs in soil vapor within the site boundary where groundwater exceeds EPA residential vapor intrusion screening levels (VISLs; EPA, 2018).
- Evaluate the potential for VI at the AG and Annex Buildings.
- Evaluate the potential for groundwater to impact surface water in Cypress Creek.
- Provide sufficient data to evaluate potential exposure risk.

1.1.3 Supplemental EI Results

Results from the Supplemental EI are summarized below. The Supplemental EI report (CH2M, 2017) is publicly available on the DEAP website at:
http://www.montgomeryal.gov/home/showdocument?id=8961

1.1.3.1 Groundwater

Analytical results from the Supplemental EI groundwater sampling identified only PCE and TCE above respective screening levels (Table 1-1). Because PCE is the parent compound, is historically identified as the source of the plume, and is present over the largest extent, groundwater impacts were delineated to the MCL for PCE. Figure 1-2 presents the horizontal extent of the PCE plume. Based on the investigation results, the following were concluded:

- PCE has been laterally and vertically delineated.
- PCE in groundwater is composed of two commingling plumes from different sources:
  - From the historical RSA Energy Plant, a plume extends to the downstream end of Cypress Creek, adjacent to the Alabama River.
  - From the industrialized area around MW-12S, a second plume extends toward the downstream end of Cypress Creek, which discharges to the Alabama River, where the two plumes comingle.
- PCE concentrations generally increase in the downgradient areas of the plumes, with the highest concentration reported at the farthest downgradient well, TMPZ-1/MW-13S.

1.1.3.2 Soil Vapor

PCE and TCE results from the EI soil vapor sampling effort are shown in Table 1-2 and on Figure 1-3; both PCE and TCE exceeded their respective VISLs. Based on the investigation results, the following was concluded:

- The highest PCE concentrations in soil vapor (above VISLs) were reported at MW-02S, downgradient of the RSA Energy Plant where PCE also is present in groundwater.
- Soil vapor TCE concentrations above VISLs were reported at MW-08S and from the 10- and 50-foot VIMS points (VIMS-10 and VIMS-50, respectively), installed north across Washington Avenue from the Annex Building (Figure 1-3).
  - TCE in soil vapor at these locations is not considered related to groundwater based on the low concentrations of dissolved TCE (maximum concentration 1.01 micrograms per liter [µg/L]) in groundwater, and is attributed to historical vadose zone releases.
  - The lateral extent of TCE at the VIMS, where soil vapor TCE concentrations are the highest, is also limited as it was not detected in the Annex Building samples collected less than 100 feet away.

1.1.3.3 Hydraulic Study

Results of the wet and dry period hydraulic studies are presented on Figure 1-4. Study results indicate the surface water and porewater of the Alabama River communicates directly with, and is the primary influence of, the movement of surface water in the downstream portion of Cypress Creek (connected via an open culvert) and groundwater at TMPZ-1/MW-13S, respectively. Influence on groundwater from the Alabama River occurs as porewater exchange, the cycling of water between the river's surface and sediments below the river. Due to the large volume of flow in the Alabama River near Montgomery (over 37 billion liters per day[1]), porewater from the Alabama River acts as a hydraulic barrier that limits the migration of the PCE plume into the creek and dilutes concentrations of PCE at the downgradient edge.

1.2 Conceptual Site Model

The CSM (Figure 1-5) identifies the sources, and fate and transport pathways of the COPCs based on the physical characteristics of the Montgomery DEAP site. The CSM is used to support the risk assessment (Section 2), risk management decisions, and remedial alternatives analysis (Section 3), as applicable. The physical characteristics, primary release sources, transport pathways, receiving media, and potential receptors are described in the following subsections.

1.2.1 Geology/Hydrogeology

The geology beneath the DEAP consists of a thin soil layer on top of quaternary terrace deposits comprised of medium to coarse-grained sand, with interbedded clay and gravel lenses. Underlying these recent terrace deposits are Cretaceous sediments of the Eutaw, Gordo, and Coker formations. The Eutaw formation is an aquifer unit characterized by two thick layers of marine sands separated by a thin layer of marine clay (Scott et al., 1987). The terrace deposits and Eutaw formation are combined to comprise the shallow aquifer. The Gordo and Coker aquifers consist of an estimated 500 feet of interbedded clay, sand, and gravel above crystalline bedrock.

The shallow aquifer is unconfined and 120 to 150 feet thick underneath the DEAP, but a localized low permeability zone may exist from approximately 35 to 50 feet bgs (ADEM, 1995). Beneath the shallow aquifer, a low-permeability sandy clay unit effectively separates it from the underlying Gordo and Coker formations.

Water levels measured at the site in July 2016 range from approximately 25 to 57 feet bgs and groundwater generally flows west-northwest (toward Cypress Creek and the Alabama River) (Figure 1-6). Based on slug tests, hydraulic conductivity in the shallow aquifer has been estimated between 8.14×10^{-4} centimeters per second (cm/s) and 4.38×10^{-3} cm/s, with a geometric mean of 3.60×10^{-3} cm/s (Black & Veatch, 2002). The groundwater pore velocity in the shallow aquifer was calculated at 8.63×10^{-5} cm/s, based on the following equation:

$$v = Ki/n$$

Where:

K = geometric mean of the hydraulic conductivity slug test results (0.0036 cm/s)

n = geometric mean of the porosity values obtained from the Shelby tube samples in September 2016 (0.42)

i = hydraulic gradient between MW-10S and TMPZ-1/MW-13S (calculated as 0.008 based on July 2016 groundwater elevation data

1.2.2 Surface Water Features

The northwestern portion of the site is located within the 100-year flood plain of the Alabama River (Office of Water Resources, 2017). Surface water features near the site include the Alabama River and Cypress Creek; the creek comprises approximately a one-third mile portion of the northwestern DEAP site boundary and drains directly into the Alabama River (Figure 1-1). Surface water contributions to Cypress Creek include overland flow during rainfall events as well as contributions from multiple

[1] Mean discharge obtained from U.S. Geological Survey station 02420000 based on 79 years of record.

industries located along upstream portions of the creek. In addition, treated groundwater discharges into Cypress Creek upstream of the site from the Coliseum Boulevard TCE plume treatment system operated by the Alabama Department of Transportation under National Pollutant Discharge Elimination System (NPDES) permit AL0081167.

Surface water flow in Cypress Creek along the site boundary is partially restricted between two culverts (shown on Figure 1-1) that are at a higher elevation than the creek bed. The downstream culvert between the creek and the Alabama River restricts outflow, creating a ponded area immediately upstream. Alabama River water also flows into the ponded area when elevations are higher than the culvert.

1.2.3 Identification of Groundwater Plumes

The DEAP site boundary includes the area where PCE was discovered during the construction of the RSA Energy Plant in 1993, as well as groundwater surrounding and downgradient from that area toward former public water supply well PW-9W, where PCE was detected at concentrations above the MCL in 1991 (Figure 1-1).

Multiple potential sources of PCE contamination exist within the DEAP site boundary due to historical use of PCE across multiple industries such as dry cleaning. However, the DEAP investigation is related only to the PCE identified in soil during construction of the RSA Energy Plant in 1993. During a 1993 emergency removal action, impacted soil was excavated prior to construction of the RSA Energy Plant. Following the removal action, concentrations of PCE were not identified above the EPA Regional Screening Level (RSL) in soil, indicating that the source was removed. In addition, a historical data review indicated there are no ongoing sources of PCE (i.e., no residual mass in the vadose zone) within the site boundary. Therefore, there are no ongoing sources of PCE to groundwater.

Although the PCE identified during construction of the RSA Energy Plant contributed to PCE in groundwater, other historical releases within the site boundary are indicated by the portion of the plume that originates near MW-12S (Figure 1-2). The plume in this area is not directly downgradient of the RSA Energy Plant and is located in an industrialized area. Based on a historical review of records, several former dry cleaners and other industrial facilities were identified in downtown Montgomery that are potential PCE sources to this area.

1.2.4 Chemical Transport

Chemical transport mechanisms that may be acting on the site groundwater plumes and influencing groundwater migration are summarized in this section. Once dissolved in groundwater, three processes govern the transport of contaminants: advection, dispersion, and retardation. Advection is the most important transport process driving groundwater contaminant migration in the subsurface. Because the primary lithology in the aquifer (sand) does not appreciably retard the rate of contaminant migration relative to advective groundwater velocity, retardation is not discussed further in this section.

1.2.4.1 Advection

Advection refers to the lateral movement of dissolved-phase contaminants caused by the flow of groundwater. Lateral migration at the site has resulted largely from natural hydraulic gradients to the northwest (Figure 1-6), and groundwater pore velocity within the upper portion of the aquifer was calculated at 8.63×10^{-5} cm/s or 0.245 feet per day (CH2M, 2017). The general pattern of increasing contaminant concentrations in the downgradient flow direction is consistent with plume migration via advection and a decrease in advective flow as the plume approaches and encounters porewater from the Alabama River hydraulic barrier. The decrease in groundwater pore velocity reduces the migration of dissolved phase contaminants to Cypress Creek via advection likely contributing to the higher PCE concentrations observed at downgradient well TMPZ-1/MW-13S relative to other wells.

1.2.4.2 Dispersion

Hydrodynamic dispersion is the process that spreads out contaminants in groundwater in three dimensions: parallel to the direction of migration (longitudinal), laterally (transverse), and vertically. The underlying processes are mechanical dispersion and molecular diffusion. The magnitude of mechanical dispersion is proportional to groundwater velocity, and the result is typically spreading and mixing (and therefore reduced concentrations) at the plume edges. The lack of PCE exceedances/detections in the intermediate wells indicates vertical dispersion is limited to the upper portion of the aquifer (approximately 40 to 60 feet bgs), as noted by the lack of PCE in MW-07S (screened from 85 to 94.7 feet bgs).

At the downgradient edge of the plume, dispersion near Cypress Creek occurs as commingling with porewater from the Alabama River. As noted in the hydraulic study (CH2M, 2017), the influence of the porewater exchange from the Alabama River acts as a hydraulic barrier between the leading edge of the plume and Cypress Creek; this impacts the lateral dispersion of chemicals into the creek by diluting concentrations as the plume commingles with the Alabama River pore water (hydraulic barrier).

1.2.5 Fate of Chemicals

1.2.5.1 Volatility and Vapor Migration

The partitioning of a molecule from aqueous phase to the vapor phase is termed volatilization. Depending on the Henry’s Law constant (a partitioning coefficient between adjacent liquid and air phases) (Table 1-3), COPCs in groundwater can volatilize at the water table into the overlying soil. The Henry’s Law constants for PCE (0.0177 atmospheric cubic meter per mole [atm-m^3/mole]) and TCE (0.00985 atm-m^3/mole) are indicative of compounds that easily partition into the vapor phase, where they can migrate through air-filled soil pores via primarily diffusion along a concentration gradient. The tendency for COPCs to diffuse through soil depends on the chemical and physical properties (diffusion coefficients in air and water), soil porosity (higher porosity encourages diffusion), and soil moisture content (high moisture content may provide a barrier to vapor diffusion). Results of the geotechnical analysis conducted for the EI (Table 1-4) indicate little variability in soil properties across the site, with total soil porosity ranging from 0.36 to 0.48, which is typical for sandy lithology (Das, 2008).

1.2.5.2 Attenuation

Attenuation processes that act to reduce contaminant concentrations in groundwater include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater (EPA, 1999). These in situ processes include degradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants. Degradation of PCE typically is driven by reductive dechlorination, a process where the contaminant’s chlorine atoms are replaced by electrons coupled to hydrogen atoms. This results in sequential dechlorination of PCE as follows:

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{cis-1,2-DCE} \rightarrow \text{VC} \rightarrow \text{ethene}$$

Degradation of PCE via reductive dechlorination at the DEAP site appears limited based on very few daughter products detected in groundwater (CH2M, 2017). Therefore, dispersion and dilution are the primary mechanisms acting to attenuate the plume, although the presence of elevated PCE concentrations at co-located groundwater and soil vapor sampling locations indicates that volatilization also is occurring.

1.2.6 Land Use and Potential Exposure Scenarios

The DEAP site is located in a downtown commercial, municipal, and industrial area. The area is covered primarily with private and public buildings, paved streets, and parking areas, with few areas of open space. The buildings within the DEAP site boundary were reviewed to determine building use type, as provided on Figure 1-7. Most of the buildings were identified as government buildings (i.e., municipal, state, or RSA) or industrial/commercial buildings. Four first-floor residential properties[2], one school, and a child care facility were identified within the DEAP site boundary; however, these properties (Figure 1-7) are outside the groundwater plume areas. The current land use (i.e., primarily industrial/commercial) at the DEAP site is expected to stay the same.

Potable water at the DEAP site is currently served by the Montgomery Water Works and Sanitary Sewer Board (MWWSSB). The primary public water source is surface water from the Tallapoosa River, a tributary to the Alabama River, located several miles upstream of the DEAP site. Water is also obtained from public water supply wells located at MWWSSB's West and Southwest well fields, located generally 4 to 5 miles from the DEAP site. All public water supply wells from the former North Well Field (which extended within the DEAP site) were abandoned in 2011 except PW-9W, which was retained for environmental sampling and is planned for abandonment in 2018. MWWSSB is not aware of any domestic wells in use at the DEAP site (ATSDR, 2004). Additionally, the City enacted an ordinance in 2003 to prohibit future well drilling in the downtown area. Therefore, groundwater exposures for a potable use scenario will not occur while the ordinance remains in place.

One industrial well is known to exist within the site boundary at the Capital Trailways bus station on North Court Street (Figure 1-1). The industrial well is not currently being used and there are no plans to use it in the future. The power lines and plumbing connected to the well and the water storage tank that the water was pumped into were removed in February of 2017, rendering the well unusable in its current state (see Appendix B). Capital Trailways has since connected to the City water supply and has no foreseeable future use for this well. However, because the well was not abandoned per ADEM guidance (the well is located within a building, making abandonment per the guidance cost prohibitive), ADEM directed that this HHRA conservatively assume that bus maintenance workers could potentially use this well for washing vehicles in the future. Therefore, under this unlikely scenario, exposures to wash water from the industrial well at the Capital Trailways bus station are considered potentially complete under a future scenario in the HHRA (Section 2).

Groundwater is present at approximately 25 to 40 feet bgs in the vicinity of the groundwater plumes. The COPCs detected in groundwater and soil vapor at the DEAP site could potentially migrate to the indoor air of overlying buildings, where commercial/industrial and government workers are present.[3] Therefore, the VI pathway is considered potentially complete for commercial/industrial and government workers in the HHRA.

The potentially complete exposure pathways identified for the DEAP site are described further in the HHRA (Section 2).

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[2] Loft apartments and other residential properties that are not on the first floor are not considered due to the improbability of potential impacts from vapor intrusion.

[3] As previously mentioned, the first-floor residential properties and schools identified within the DEAP site boundary are outside the groundwater plume areas (Figure 1-7) and therefore, the vapor intrusion pathway for the site COPCs is likely insignificant at these areas.

Risk Assessment

Data collected during the Supplemental EI were used to evaluate risk to human health and the environment following the ARBCA (ADEM, 2017a).

2.1 Human Health Risk Assessment

The HHRA was prepared for the Montgomery DEAP site to evaluate potential risks to human health associated with current and potential future exposures to soil vapor and groundwater within and at two buildings adjacent to the DEAP boundary.[4] Additionally, the HHRA evaluated potential exposures to surface water (including fish consumption) at Cypress Creek, assuming groundwater from the site is discharging to Cypress Creek. The HHRA incorporates the site information and analytical data collected during the Supplemental EI conducted in accordance with the work plan (CH2M, 2016).

The ARBCA guidance (ADEM, 2017a) recommends using a tiered risk-based approach for the assessment of cumulative risk at a site. The three tiers of evaluation are: 1) RSL Evaluation, 2) Risk Management-1 (RM-1) Level Evaluation, and 3) Risk Management-2 (RM-2) Level Evaluation.[5] If a chemical was detected at a concentration greater than its respective screening level in the RSL Evaluation, then the HHRA proceeded to an RM-1 Evaluation. In the RM-1 Evaluation, site-specific cumulative risks were calculated for the exposure scenarios using the chemical(s) exceeding their respective screening levels in the RSL Evaluation.

In accordance with the ARBCA process, the HHRA consists of the following:

- **Conceptual Exposure Model (CEM)** – Summarizes potential sources, current and reasonable-future receptors, and potentially complete exposure pathways.
- **RSL Evaluation** – Provides a comparison of the maximum detected site concentrations to the EPA RSLs, MCLs, or VISLs for each exposure medium.
- **RM-1 Evaluation** – Includes the estimation of site-specific, cumulative risks for the exposure scenarios using the chemicals exceeding the RSLs.

The CEM, RSL Evaluation, and RM-1 Evaluation are discussed in Sections 2.1.1 through 2.1.3, respectively. The supporting tables for the HHRA are provided in Appendix A-1, Tables A-1 through A-9.

2.1.1 Conceptual Exposure Model

The site characteristics, contaminant sources and migration pathways, and current/future land uses are described in Section 1.2. Based on the current and likely future land uses (i.e., primarily industrial/ commercial) and the potential sources and migration pathways associated with the groundwater plumes, the following exposure pathways are considered potentially complete for the DEAP site (Appendix A-1, Table A-1):

- **Groundwater (Discharge to Surface Water)** – Current/future recreational users potentially could be exposed to site groundwater that is mixing with the Alabama River porewater and then discharging to surface water in Cypress Creek. Potential human exposure routes to surface water include ingestion of fish caught from Cypress Creek (the primary pathway based on the surface water use

[4] Two properties were evaluated adjacent to the DEAP boundary and include the AG and Annex Buildings.

[5] An RM-2 Evaluation was not necessary because the conclusions of the HHRA were based on the results of the RM-1 Evaluation.

designation of Cypress Creek), incidental ingestion of water, and dermal contact during recreational activities.

- **Groundwater (Indoor Air)** – Current/future industrial/commercial and government workers are present in buildings near the groundwater PCE plume. Chemicals in underlying groundwater may migrate to indoor air through VI. The potential exposure route is inhalation.[6]
- **Soil Vapor (Indoor Air)** – Current/future industrial/commercial and government workers are present in buildings near the soil vapor sampling locations. Chemicals in soil vapor may migrate to indoor air through VI. The potential exposure route is inhalation.
- **Wash water (Capital Trailways Bus Station)** – Although unlikely, if the decommissioned bus station well is reconstructed/reconnected for future use, future bus maintenance workers could potentially contact wash water from the Capital Trailways bus station while washing vehicles. Potential exposure routes in that case would be dermal contact and inhalation.[7]

Figure 2-1 provides a graphical presentation of the CEM. The potentially complete exposure pathways are evaluated further in the RSL evaluation and RM-1 evaluation.

2.1.2 RSL Evaluation

The RSL evaluation consists of comparing the maximum detected concentration of each COPC to the EPA's RSLs, MCLs, and/or VISLs and selecting the chemicals of concern (COCs) for each medium (ADEM, 2017a). Therefore, the RSL evaluation for the DEAP site was conducted based on the following three steps: 1) data evaluation, 2) selection of screening levels, and 3) identification of COCs.

2.1.2.1 Data Evaluation

The groundwater and soil vapor samples included in the HHRA were collected during the sampling events conducted in July and September 2016. Additionally, one wash water sample (from the bus wash sprayers) and a field duplicate sample that were collected in February 2017 from the Capital Trailways Bus Station prior to connecting to publicly supplied water were included in the RSL Evaluation. The groundwater and soil vapor samples were analyzed for the following COPCs: PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, and VC. The samples were collected in accordance with the work plan (CH2M, 2016). The sample locations are depicted on Figure 1-1. The list of samples included in the HHRA are provided in Appendix A-1, Table A-2, and the complete dataset used in the HHRA is provided in Appendix A-2.

The samples were partitioned into various data groupings based on the potential exposure scenarios identified for the DEAP site. The data groupings for each medium are described below:

- **Groundwater (Discharge to Surface Water)** –TMPZ-1/MW-13S, the farthest downgradient well located near the edge of the PCE plume adjacent to Cypress Creek, was sampled in July 2016. The analytical data collected from TMPZ-1/MW-13S were used to evaluate potential exposures to surface water, assuming groundwater at TMPZ-1/MW-13S is discharging to Cypress Creek. A hydraulic study was conducted as part of the Supplemental EI Report and evaluated the interaction between groundwater in TMPZ-1/MW-13S and surface water in Cypress Creek and the Alabama River (CH2M, 2017). Using the data collected from the hydraulic study and the Remedial Investigation Report (Black & Veatch, 2002), and a conservative assumption that no dilution is occurring from the Alabama River porewater, a site-specific attenuation factor of 103 was

[6] Potential exposures to indoor air associated with vapor intrusion from groundwater are evaluated based on soil vapor data rather than groundwater data. The soil vapor data, which were collected at locations with groundwater concentrations greater than the VISLs, were used in the HHRA because these values are a better indicator of indoor air conditions than groundwater data.

[7] As discussed in Section 1.2.6, the well has been decommissioned by Capital Trailways and it is unlikely to be reconstructed for future use. However, per ADEM's direction, the sample collected from the wash water was evaluated in the HHRA.

estimated, as provided in Appendix A-1, Table A-3. Although the primary influence on subsurface dilution is the Alabama River porewater, to be conservative, the dilution attenuation factor (DAF) for Cypress Creek was used in the risk assessment. For comparison, the DAF calculated using the Alabama River discharge is 1,162,880.

The concentrations in Cypress Creek were estimated using the following equation, which is based on Equation C-11 in Appendix C of the ARBCA Guidance (ADEM, 2017a):

$$C_{SW} = \frac{C_{GW}}{AF}$$

Where:

C_{sw} = Concentration in surface water at Cypress Creek (µg/L)
C_{gw} = Concentration in groundwater at TMPZ-1/MW-13S (µg/L)
AF = Attenuation factor (unitless)

The estimated surface water concentrations in Cypress Creek were as follows: 1.69 µg/L for PCE, 0.0098 µg/L for TCE, and 0.00849 µg/L for cis-1,2-DCE. Supporting calculations are provided in Appendix A-1, Table A-4.

- **Soil Vapor (Indoor Air)** – Soil vapor samples were collected in September 2016 from locations where COPCs were present in shallow groundwater at concentrations exceeding the EPA residential VISLs during the supplemental EI sampling (CH2M, 2017). The soil vapor samples were partitioned into four data groupings, based on their proximity to buildings or association with groundwater sampling locations. The VIMS location was evaluated separately because it is not associated with a building or groundwater monitoring location. Only shallow soil vapor samples were included in this VI evaluation because the shallow samples are more likely to be representative of potential VI due to their proximity to a building's slab. The four soil vapor data groupings are as follows:

  - VIMS-10 (shallowest sample collected from the VIMS at 10 feet bgs)
  - AG Building – Includes locations AMS-03 and AMS-04
  - Annex Building – Includes locations AMS-01 and AMS-02
  - Monitoring wells – Includes locations TMPZ-1/MW-13S, MW-12S, MW-08S, and MW-02S

  The soil vapor samples within each data grouping were screened on a sample-by-sample basis.

- **Wash water (Capital Trailways Bus Station)** – One sample and a field duplicate sample were collected in February 2017 from the sprayers in the bus washing area (CT-01-S) at the Capital Trailways Bus Station before the business was connected to City water. The analytical data collected from the samples were used to evaluate potential direct contact exposures with wash water in the unlikely event that the well is reconstructed and used in the future by bus maintenance workers for washing vehicles.

- **Groundwater (Potable Use)** – Although potential exposures to groundwater are considered incomplete for a potable use scenario under current and foreseeable future site conditions, groundwater data from each monitoring well were evaluated for a potable use scenario in accordance with the work plan (CH2M, 2016). The groundwater analytical data were evaluated on a sample-by-sample basis for a future potable use scenario.

For samples with field duplicate analyses, the higher of the two detected concentrations was used in the HHRA.[8]

2.1.2.2 Identification of Screening Levels

The screening levels used for each medium in the RSL Evaluation are discussed below:

- **Groundwater (Discharge to Surface Water)** – The surface water screening levels were calculated using the equations, bioconcentration factors (BCFs), and exposure assumptions provided in ADEM Admin. Code r. 335-6-10 (February 2017). The toxicity values were updated and were obtained from the EPA's Integrated Risk Information System database (EPA, 2018a). The portion of the Alabama River that is located near Cypress Creek has a Fish and Wildlife Classification only and does not have a Public Water Supply Use or Swimming Classification. Therefore, the surface water screening levels for consumption of fish only are applicable for this portion of the Alabama River and Cypress Creek. However, as a conservative approach, two sets of surface water screening levels were calculated: one set of screening levels was calculated for ingestion of fish only and a second set of screening levels was calculated for consumption of fish and water. The surface water screening levels were calculated for carcinogenic and non-carcinogenic endpoints. The screening levels were calculated for carcinogens using Equations 16 and 17, and for non-carcinogens using Equations 18 and 19, of ADEM Admin. Code r. 335-6-10 (February 2017). The lower value of the carcinogenic and non-carcinogenic screening levels was selected as the final surface water screening level. Additionally, the BCF for trans-1,2-DCE was used as a surrogate for cis-1,2-DCE because this parameter value was not available for cis-1,2-DCE. The surface water screening level calculations are provided in Appendix A-1, Table A-4. The final surface water screening levels for each COPC detected in TMPZ-1/MW-13S are summarized below:
  - PCE – Screening levels of 36 µg/L and 11 µg/L were calculated for consumption of fish and consumption of water and fish, respectively.
  - TCE – Screening levels of 4.8 µg/L and 0.66 µg/L were calculated for consumption of fish and consumption of water and fish, respectively.
  - cis-1,2-DCE – Screening levels of 591 µg/L and 14 µg/L were calculated for consumption of fish and consumption of water and fish, respectively.
- **Soil Vapor (Vapor Intrusion)** – The screening levels used in the soil vapor screening comparison were the EPA VISLs for a commercial scenario (EPA, 2018b). The VISLs were based on a default attenuation factor of 0.03 for soil vapor-to-indoor air, a target individual excess lifetime cancer risk (IELCR) of 1×10^{-6} and a target noncancer hazard quotient (HQ) of 0.1. VISLs were not available for cis- and trans-1,2-DCE because EPA withdrew their inhalation toxicity values in 2014.
- **Wash Water (Capital Trailways Bus Station)** – The screening levels for wash water from the Capital Trailways bus station were calculated using the tap water RSLs (EPA, 2018c). The tap water RSLs were modified to only include the dermal and inhalation exposure routes because water that was formerly obtained from the now decommissioned industrial well at the bus station was used to wash vehicles and was not used as a potable water source. The modified tap water RSLs were based on a target IELCR of 1×10^{-6} and noncancer hazard index (HI) of 0.1. Although the exposure scenario at the bus station is commercial, the modified tap water RSLs are considered more protective of a bus maintenance worker because they are based mostly on conservative residential exposure assumptions; the reasonable maximum exposure duration and exposure frequency for a bus maintenance worker likely would be less than those for the EPA's 2014 default exposure frequency

[8] No COPCs were detected in the primary sample and associated field duplicate sample collected from location CT-01-S. The MDLs used for the RSL evaluation were the same for each constituent between the primary and field duplicate samples. Therefore, only the results from the primary sample (L891420-03) were used in the HHRA.

and duration for a resident, which are 350 days/year and 26 years, respectively (EPA, 2014). For the dermal exposure route, the default tap water RSLs assume the total body surface area of a receptor would be exposed to groundwater while showering, although the duration of bus washing may be longer than showering time incorporated in the development of tap water RSLs. For the bus maintenance worker scenario, the actual exposed skin surface area for dermal contact would be less than a showering scenario and likely would include only hands and arms. Additionally, for the inhalation exposure route, the default tap water RSLs assume an exposure time of 24 hours and a conservative volatilization factor (VF) of 0.5, whereas the exposure time for a bus maintenance worker likely would be considerably less and the concentrations in outdoor air would be less than those estimated using a VF of 0.5.

- **Groundwater (Potable Use)** – The detected concentrations at each groundwater sampling location were compared to the EPA's tap water RSLs and MCLs to evaluate a hypothetical future potable use scenario (EPA, 2018c). The tap water RSLs used in this evaluation were based on a target IELCR of 1×10^{-6} and noncancer HI of 0.1.

2.1.2.3 Identification of Chemicals of Concern

The COPCs were identified as COCs in the RSL Evaluation if they were detected at concentrations greater than their respective screening levels, except the sample collected at the Capital Trailways bus station. None of the analyzed chemicals were detected in the bus station sample; therefore, the method detection limits (MDLs) were used as a conservative, maximum estimate of concentrations and were compared to the screening levels in the RSL Evaluation. The results of the screening comparison for each exposure scenario are provided below:

- **Groundwater (Discharge to Surface Water)** – Three COPCs (cis-1,2-DCE, PCE, and TCE) were detected at TMPZ-1/MW-13S (Table 1-1); however, the estimated concentrations in surface water in Cypress Creek were less than their respective surface water screening levels for the protection of human health (Appendix A-1, Table A-4). Therefore, no COCs were identified in groundwater based on surface water screening levels protective of human health.
- **Soil Vapor (Vapor Intrusion)** – None of the detected COPCs exceeded the commercial VISLs at the AG Building or Annex Building. Two COPCs (PCE and TCE) were detected at concentrations greater than their respective commercial VISLs and were identified as COCs (Appendix A-1, Table A-5), as shown on Figure 2-2:
  - VIMS-10
    - TCE exceeded the commercial VISL in the sample collected from the VIMS (VIMS-10-0916).
  - Monitoring Wells
    - PCE exceeded the commercial VISL in the sample collected from monitoring well MW-02S (AMS-MW02-08). Additionally, TCE exceeded the commercial VISL in the sample collected from MW-08S (SV-MW08-08).
    - In soil vapor, cis- and trans-1,2-DCE were detected in one sample (VIMS-10-0916) at concentrations of 88.6 micrograms per cubic meter ($\mu g/m^3$) and 2.55 $\mu g/m^3$, respectively. However, there are no VISLs for these chemicals.
- **Wash Water (Capital Trailways Bus Station)** – No COPCs were detected in the wash water sample collected from the bus station. However, two COPCs (TCE and VC) had MDLs greater than the modified tap water RSLs (Appendix A-1, Table A-6).

- **Groundwater (Potable Use)**[9] – Two COPCs (PCE and TCE) were detected at concentrations greater than the tap water RSLs and/or MCLs and were identified as COCs (Appendix A-1, Table A-7):
  - PCE exceeded the tap water RSL and MCL at MW-02S, MW-03S, MW-08S, MW-12S, and TMPZ-1/MW-13S.
  - TCE exceeded the tap water RSL at MW-03S, MW-08S, MW-09S, MW-12S, and TMPZ-1/MW-13S. None of the detected TCE concentrations exceeded the MCL.

2.1.2.4 Summary of the RSL Evaluation

2.1.2.4.1 Scenarios Carried Forward to the RM-1 Evaluation

Based on the RSL evaluation, COPC concentrations in soil vapor exceeded the VISLs and COCs were identified for the soil vapor (VI) exposure scenario. Additionally, although the COPCs were not detected in the samples, the MDLs of the two COPCs in the sample collected at the Capital Trailways Bus Station were greater than the modified tap water RSLs. Therefore, as directed by ADEM, a further evaluation of a potential potable use exposure scenario was performed in the RM-1 Level Evaluation.

2.1.2.4.2 Scenarios Not Carried Forward to the RM-1 Evaluation

No COCs were identified for the groundwater discharge to surface water exposure scenario in the RSL evaluation. Therefore, additional evaluation at the RM-1 Level for this exposure scenario was not required in the HHRA. Furthermore, additional evaluation of the COCs identified for the groundwater potable use exposure scenario was not conducted in the RM-1 Level Evaluation because potable use of groundwater is an incomplete pathway under current and expected future site conditions (see footnote 9).

2.1.3 RM-1 Evaluation

The RM-1 Evaluation includes the calculation of risk for each COC, each complete exposure pathway, and the cumulative risks for each receptor (ADEM, 2017a). The estimated cumulative risks for each receptor scenario are then compared to the allowable risk standards. The allowable risk standards under the ARBCA process include an IELCR of 1×10^{-5} and a non-carcinogenic HQ or HI of 1. Generally, RAs are not warranted if the cumulative IELCR is equal to or less than 1×10^{-5} and the estimated HQ or HI is equal or less than 1, although actions may be warranted if a promulgated standard (such as an MCL) is exceeded.

2.1.3.1 Approach for Calculating Carcinogenic Risks and Non-carcinogenic Hazards

The IELCR is the increase in the probability of an individual developing cancer due to exposure to a COC through a complete exposure pathway. The probability of developing cancer as a result of exposure to two or more COCs and by two or more exposure pathways is calculated by summing the risk estimates for each COC in the appropriate scenarios. For non-carcinogenic effects, HQs and HIs are estimated to determine the potential for adverse health effects. The HQ represents the ratio of the estimated dose or exposure concentration of a COC to the reference dose or reference concentration, respectively. An HQ that exceeds 1 (i.e., estimated dose exceeds the reference dose or exposure concentration exceeds the reference concentration) indicates that there is a potential for adverse health effects associated with exposure to that COC. To assess the potential for non-carcinogenic health effects posed by exposure to multiple COCs and exposure routes, an HI approach is used (ADEM, 2017a). The HI approach assumes that non-carcinogenic hazards associated with exposure to more than one COC and exposure route are additive. The HI is calculated by summing the HQs for each COC in the appropriate scenarios.

[9] Potable use of groundwater is an incomplete pathway under current and anticipated future site conditions. The DEAP site is currently served by the MWWSSB. All public water supply wells from the former North Well Field were abandoned and there are no known domestic wells in use at the DEAP site. Additionally, the City enacted an ordinance in 2003 to prohibit future well drilling in the downtown area.

Potential IELCRs and non-carcinogenic HQs or HIs were estimated for the COCs identified in soil vapor samples and in wash water at the Capital Trailways bus station. The IELCR and HQs were estimated for the soil vapor COCs using the EPA's VISL Calculator (EPA, 2018b) and the default soil vapor-to-indoor air attenuation factor of 0.03. The estimated IELCRs and HQs for each soil vapor sampling location are provided in Appendix A-1, Table A-8. The VISL calculator worksheets are provided in Appendix A-3.

The potential IELCRs and non-carcinogenic HIs for the COCs identified in the wash water at the Capital Trailways bus station were estimated using a ratio approach based on the MDLs and modified tap water RSL, as provided in the following equations:

$$IELCR = TR \times \frac{C_{GW}}{SL_c} \qquad HI = THI \times \frac{C_{GW}}{SL_{nc}}$$

Where:

IELCR = Individual Excess Lifetime Cancer Risk
HI = Hazard Index
C_{GW} = Concentration (MDL) in groundwater at CT-01-S (µg/L)
SL_c = Modified carcinogenic tap water RSL, based on cancer risk of 1×10^{-6} (µg/L)
SL_n = Modified non-carcinogenic tap water RSL, based on hazard index of 1 (µg/L)
TR = Target Risk of 1×10^{-6}
THI = Target Hazard Index of 1

The estimated IELCRs and HQs for wash water from the bus station based on the MDLs are provided in Appendix A-1, Table A-9 of and are discussed in Section 2.1.3.2.

2.1.3.2 Summary of Risk Results

The estimated IELCRs and HIs for each exposure scenario are summarized below:

- **Soil Vapor (Vapor Intrusion)** – Potential IELCRs and HQs were estimated for three soil vapor sampling locations (VIMS-10, MW-08S, and MW-02S), as provided in Appendix A-1, Table A-8:
  - VIMS-10
    - The estimated IELCR was 1×10^{-4} and the estimated non-carcinogenic HQ was 45 due to TCE.
  - Monitoring Wells
    - MW-08S – The estimated IELCR was 3×10^{-6} and the estimated non-carcinogenic HQ was 1 due to TCE.
    - MW-02S – The estimated IELCR was 3×10^{-6} and the estimated non-carcinogenic HQ was 0.8 due to PCE.
- **Wash Water (Capital Trailways Bus Station)** – The estimated IELCR was 2×10^{-6} and the estimated non-carcinogenic HI was 0.1 due to TCE and VC (Appendix A-1, Table A-9); however, the estimated risks are based on the MDLs because these chemicals were not detected.

The estimated cumulative IELCRs were compared to ADEM's target risk of 1×10^{-5} and the estimated non-carcinogenic hazards were compared to the target HQ and HI of 1. The estimated IELCRs for soil vapor were less than ADEM's target risk of 1×10^{-5}, except for the IELCRs estimated for VIMS-10. Additionally, the estimated HQs for soil vapor were less than ADEM's target HQ of 1, except for the HQs estimated for VIMS-10. The estimated IELCR and HI for wash water from the bus station were less than ADEM's target risk of 1×10^{-5} and target HI of 1, respectively.

TCE is identified as a risk driver in soil vapor at VIMS-10 sampling location; however, TCE concentrations in soil vapor at VIMS-10 are not considered to be related to the PCE plumes based on the following lines of evidence:

- TCE is present at low concentrations (less than 1 µg/L) in groundwater at MW-09S, which is adjacent to the VIMS.
- TCE soil vapor concentrations at the VIMS are upgradient of the PCE groundwater plume.
- The higher proportion of TCE to PCE concentrations in soil vapor at the VIMS (i.e., PCE and TCE were detected in shallow soil vapor at the VIMS-10 at concentrations of 99.6 µg/m^3 and 13,100 µg/m^3, respectively) indicate that TCE is from a source other than groundwater, in which PCE concentrations exceed TCE concentrations.

These data suggest that the vapors detected at VIMS-10 are not likely from groundwater but instead are related to historical releases of TCE from a separate source that likely was limited to the vadose zone. Based on the lack of TCE detections or concentrations below the VISL in the soil vapor samples collected at the Annex Building (less than 100 feet from the VIMS), the TCE exceedances at the VIMS appear to be localized to the vicinity of the VIMS. In addition, no buildings are currently located near VIMS-10; therefore, current site conditions do not present a VI concern.

2.1.4 HHRA Summary and Recommendations

A HHRA was conducted to evaluate potential risks to human health associated with current and future exposures to soil vapor and groundwater within and adjacent to the DEAP site boundary. The groundwater and soil vapor samples included in the HHRA were collected during the sampling events conducted in July and September 2016. Additionally, one wash water sample and a field duplicate were collected in February 2017 from the Capital Trailways bus station and were included in the HHRA per ADEM's direction.

The HHRA was conducted in accordance with the ARBCA guidance (ADEM, 2017) and was based on a tiered approach, which included an RSL Evaluation and RM-1 Level Evaluation. The HHRA did not proceed to an RM-2 Level Evaluation; an AA was performed to address potential risk identified in the RM-1 Evaluation. Therefore, additional evaluation at the RM-2 Level was not required in the HHRA.

The RSL Evaluation consists of comparing the maximum detected concentration of each COPC to the EPA's RSLs, MCLs, and/or VISLs, and selecting the COCs for each medium. The results of the RSL Evaluation are summarized below for each exposure scenario:

- **Groundwater (Discharge to Surface Water)** – No COCs were identified.
- **Soil Vapor (Vapor Intrusion)** – Two COPCs (PCE and TCE) were identified as COCs. PCE was identified as a COC at monitoring well MW-02S and TCE was identified as a COC at the VIMS-10 and monitoring well MW-08S. None of the detected COPCs exceeded the commercial VISLs at the AG Building or Annex Building.
- **Wash water (Capital Trailways Bus Station)** – No COPCs were detected in the sample collected from the sprayers at the bus station; however, the MDLs (used as maximum estimate of concentrations) of two COPCs (TCE and VC) were greater than the modified tap water RSLs.
- **Groundwater (Potable Use)** – Two COPCs (PCE and TCE) were identified as COCs. PCE exceeded the tap water RSL and MCL at MW-02S, MW-03S, MW-08S, MW-12S and TMPZ-1/MW-13S. TCE exceeded the tap water RSL at MW-03S, MW-08S, MW-09S, MW-12S and TMPZ-1/MW-13S. None of the detected TCE concentrations exceeded the MCL. Because potable use of groundwater is an incomplete exposure pathway for the DEAP site and well drilling is prohibited by City ordinance (see

footnote 9), the groundwater COCs for a potable use scenario were not evaluated further in the HHRA, rather were evaluated to support the remedial AA (Section 3).

The COCs identified in soil vapor and TCE and VC in wash water from the bus station (based on MDLs) were carried forward to an RM-1 Evaluation. Potential IELCRs and non-carcinogenic HQs or HIs were estimated for each COC, and the results are summarized below:

- **Soil Vapor (Vapor Intrusion) –** Potential IELCRs and HQs were estimated for three soil vapor sampling locations (VIMS, MW-08S, and MW-02S):
  - VIMS-10 – IELCR was 1×10^{-4} and non-carcinogenic HQ was 45 due to TCE.
  - MW-08S – IELCR was 3×10^{-6} and non-carcinogenic HQ was 1 due to TCE.
  - MW-02S – IELCR was 3×10^{-6} and non-carcinogenic HQ was 0.8 due to PCE.
- **Wash water (Capital Trailways Bus Station)** – The estimated IELCR was 2×10^{-6} and the estimated non-carcinogenic HI was 0.1 due to TCE and VC; however, these chemicals were not detected in the sample, rather the estimated risks are based on the MDLs.

The estimated IELCRs and HIs for soil vapor at MW-08S and MW-02S and for wash water at the Capital Trailways Bus Station were within acceptable levels; however, the estimated IELCR for soil vapor at VIMS-10 exceeded ADEM's target risk level of 1×10^{-5} based on concentrations of TCE. Therefore, it is recommended that the potential for VI be included in the alternatives analysis to mitigate the potential for future exposure. However, the TCE concentrations in soil vapor at the VIMS are not considered to be related to the PCE plumes in groundwater. The TCE in soil vapor at the VIMS likely is attributable to historical releases of TCE from separate sources that were limited to the vadose zone within the vicinity of the VIMS. Based on the lack of TCE detections and concentrations below the VISL in the soil vapor samples collected at the Annex Building (less than 100 feet from the VIMS), the TCE exceedances at the VIMS appear to be localized to the VIMS. No buildings are currently located near VIMS-10; therefore, this location does not present a VI concern under current site conditions.

2.2 Screening-Level Ecological Risk Assessment

This section presents a SLERA for the DEAP site, specifically for the discharge of groundwater containing COPCs into Cypress Creek. According to ARBCA guidance (ADEM, 2017a), any site where ecological receptors may be affected will undergo an RM-2 Evaluation.

The assessment follows the EPA Ecological Risk Assessment Guidance (EPA, 1997) and uses screening values from EPA Region 4 (EPA, 2018d). The SLERA includes Steps 1 and 2 of the EPA 8-step process:

- Step 1 Screening-Level Problem Formulation and Ecological Effects Evaluation
- Step 2 Screening-Level Preliminary Exposure Estimate and Risk Calculation

The objective of a SLERA is to determine whether there are complete exposure pathways to contamination at levels that warrant further risk evaluation or consideration of remedy.

2.2.1 Screening Level Problem Formulation

The screening-level problem formulation addresses the ecological setting and the ecological CSM. The ecological CSM is consistent with the overall CSM (Section 1.2), but focuses on the ecological exposure pathways and exposure routes.

2.2.1.1 Ecological Setting

Based on investigations to date (CH2M, 2017), groundwater associated with the plume may discharge into the partially restricted, “ponded” area of Cypress Creek, after mixing with porewater from the Alabama River. In a biological assessment of Cypress Creek conducted by the U.S. Army Corps of

Engineers (CH2M, 2012), the potential discharge zone is referred to as Reach 4. As noted in that study, the majority of the reach was a lentic (still water) environment with slow glides and deep pools with soft silts due to the impoundment at the bottom of the reach. The riparian corridor (floodplain closest to the stream channel) was constricted along the right bank with a nearby commercial property; however, the riparian buffer (i.e., vegetated area near the stream channel that helps shade and protect the stream from adjacent land uses) on the left bank provided a fairly dense canopy cover with several dominant overstory species such as box elder (*Acer negundo*), American elm (*Ulmus americana*), paper mulberry (*Broussonetia papyrifera*), and cottonwood (*Populus deltoides*). It also was observed that the stream had an excessive amount of green and brown filamentous algae and debris associated with runoff.

The results of the biological assessment indicated that the watershed has been 75 percent developed by multiple facilities upstream of the DEAP site and the available aquatic habitat and water quality have been negatively impacted by changes in hydrologic conditions, erosion, sedimentation, and multiple point and nonpoint sources of pollutants (CH2M, 2012). The fish community qualitative rating for sampling stations in Cypress Creek was very poor, the habitat condition ratings were poor or very poor, and the temperature and dissolved oxygen (DO) in the stretch subject to potential contaminant discharge did not meet ADEM temperature or DO standards.

2.2.2 Ecological Conceptual Site Model

The main objective of the ecological CSM is to identify any complete and critical exposure pathways that could be present for ecological receptors. Key components of the model are discussed in the following subsections.

2.2.2.1 Potential Source Areas

The source is COPCs in groundwater, as demonstrated by detections in well TMPZ-1/MW-13S (Figure 1-2). This well is closest to the potential Cypress Creek discharge point and is where the maximum COPC detections were reported at the site.

2.2.2.2 Release Mechanisms and Transport Pathways

The primary mechanism for chemical release and transport is migration of groundwater to the groundwater-surface water interface (GSI) at Cypress Creek. However, at this reach of Cypress Creek, ground water inflow towards the creek first encounters and mixes with Alabama River porewater. At the GSI, sediment (including sediment porewater) and surface water may be impacted. Once in the waterway, diffusion, river flow, and bioturbation can facilitate the movement of contaminants.

2.2.2.3 Exposure Pathways and Routes

Groundwater is not considered an exposure medium since ecological receptors, beyond microbes, are not directly exposed to it. Although there are no direct exposure pathways between ecological receptors and groundwater contaminants, there is the potential for exposure to ecological receptors due to groundwater inflow mixing with porewater and potentially migrating to the GSI.

Potentially complete exposure pathways exist for lower trophic level receptors that live in Cypress Creek (e.g., plants, invertebrates, fish, amphibians, and reptiles), primarily via direct contact. Ecological receptors that live in or on the surface of the sediment (e.g., benthic invertebrates) in the hypothetical discharge zone could be exposed to plume-related contaminants in sediment pore water or surface water. Receptors inhabiting the water column (e.g., fish) also could be exposed to contaminants in the discharge.

Upper-trophic-level receptors (e.g., fish-eating birds) are not expected to be significantly exposed because of the limited quality of the habitat and because the COPCs are not considered important bioaccumulative compounds (EPA, 2000).

2.2.2.4 Assessment and Measurement Endpoints

Problem formulation includes the selection of ecological endpoints based on the CSM. Two types of endpoints, assessment endpoints and measurement endpoints, are defined as part of the SLERA process (EPA, 1997). An assessment endpoint is an explicit expression of the environmental component or value that is to be protected. A measurement endpoint is a measurable ecological characteristic related to the component or value chosen as the assessment endpoint.

The endpoints and risk questions for this SLERA, which focused on lower trophic level receptors, were as follows:

- Assessment Endpoint – Survival, growth, and reproduction of the aquatic community.
- Risk Question – Are site-related constituent concentrations in groundwater sufficient to adversely affect the aquatic community?
- Measurement Endpoint – Comparison of estimated concentrations in surface water with screening values intended to be protective.

2.2.3 Ecological Effects Evaluation

The purpose of the ecological effects evaluation is to establish constituent exposure levels (screening values) that represent conservative thresholds for adverse ecological effects. One set of screening values typically is developed for each selected assessment endpoint.

TCE, PCE, and cis-1,2-DCE were detected in TMPZ-1/MW-13S (Table 1-1). There are no aquatic life criteria for these compounds in ADEM Admin. Code Ch. 335-6-10. Chronic freshwater screening values in EPA Region 4 (2018d) are as follows:

- PCE – 53 μg/L
- TCE – 220 μg/L
- cis-1,2-DCE – 620 μg/L

2.2.4 Screening-Level Preliminary Exposure Estimation

Two types of exposure values were considered: 1) the concentrations in groundwater, and 2) the concentrations estimated in Cypress Creek surface water considering attenuation and dilution. Concentrations in TMPZ-1/MW-13S were as follows:

- PCE – 174 μg/L
- TCE – 1.01 μg/L
- cis-1,2-DCE – 0.874 μg/L

The DAF estimated for Cypress Creek was 103 (Table 3 of Appendix A-1). Dividing the TMPZ-1/MW-13S groundwater concentrations by 103 yields the following estimated surface water concentrations[10]:

- PCE – 1.69 μg/L
- TCE – 0.009 μg/L
- cis-1,2-DCE – 0.008 μg/L

10 The COPC concentrations in Cypress Creek surface water samples, collected in 2006 and 2008 at stations 0241998809 and 024198808, were lower than the estimated values generated from this report using a DAF of 103. In the 2006 and 2008 surface water sampling events, only PCE was detected, at a maximum concentration of 0.52 μg/L. (USGS, 2008).

2.2.5 Screening-Level Risk Calculation

The HQs were calculated by dividing the exposure concentrations by the screening values. Two sets of HQs were calculated, with the first set conservatively using the measured groundwater concentrations at TMPZ-1/MW-13S as the exposure concentrations (assumes no dilution between TMPZ-1 and the creek). For example, the TMPZ-1/MW-13S concentration of 174 µg/L for PCE was divided by the PCE screening value of 53 µg/L, with a resulting HQ of 3.3. The second set of HQs used the COPC concentrations in Cypress Creek that were estimated based on the DAF presented in Appendix A, Table A-3 of Appendix A-1. The HQs calculated for the three COPCs were as follows:

- HQs Using Measured TMPZ-1/MW-13S Groundwater Concentrations
  - TCE – 0.005
  - PCE – 3.3
  - cis-1,2-DCE – 0.001
- HQs Using Estimated Surface Water Concentrations
  - TCE – <0.001
  - PCE – 0.03
  - cis-1,2-DCE – <0.001

A potential for risk is identified when the maximum concentration of a contaminant exceeds the chronic freshwater screening value (i.e., when the HQ exceeds 1). For TCE and cis-1,2-DCE, both the groundwater and estimated surface water concentrations were lower than their respective screening values (HQ < 1). For PCE, the groundwater concentration was higher than the screening value (HQ >1), but the estimated surface water concentration was two orders of magnitude lower than the screening value (HQ <1) and does not account for dilution from the Alabama River.

2.2.6 Uncertainties

Uncertainties are present in all ecological risk assessments (ERAs) because of the limitations of available data and the need to make certain assumptions and extrapolations based on incomplete information. The main uncertainties in this ERA are the groundwater and dilution modeling and the available data for TMPZ-1/MW-13S. However, given the extremely low HQs for the estimated surface water concentrations, it is unlikely that inaccuracies in estimated surface water concentrations would cause an incorrect conclusion about risks. In addition, given that dilution with Alabama River porewater is not considered, dilution and retardation of plume movement within the porewater exchange increase the likelihood by over four orders of magnitude that the plume will not negatively impact the creek.

2.2.7 Risk Characterization

The HQs indicate little potential for significant risk to receptor populations associated with the potential discharge of COPCs in groundwater into Cypress Creek. In addition, because of development within the majority of the Cypress Creek watershed upstream of the DEAP site, the habitat in the reach of Cypress Creek at the downgradient boundary of the DEAP site is considered to be poor to very poor (CH2M, 2012).

EPA (1997) defines a scientific/management decision point at the end of Step 2. The decision to be made is whether a full ecological risk assessment is necessary (or remediation should be considered). Based on the results of the SLERA, the assessment endpoint was met and no further risk assessment or consideration of remedy is recommended for ecological receptors at this time.

Alternatives Analysis

This section describes the steps to evaluate alternatives for addressing potential identified risks to human health, including presentation of remedial action objectives (RAOs) and applicable, relevant, and appropriate requirements (ARARs), definition of preliminary remediation goals (PRGs), and the evaluation of potential alternatives.

3.1 Remedial Action Objectives

RAOs establish the goals of the proposed RA and provide the basis for the RA alternatives. As detailed in the HHRA in Section 2.1.4, PCE concentrations in groundwater were identified at concentrations exceeding the MCL, which may pose potential risks to human health if groundwater were used for potable purposes. Although groundwater is not currently used for potable purposes at the site, RAOs for groundwater were conservatively established to address the potential for future potable use. Therefore, the MCLs are selected as the PRGs for this pathway.

Based on the results of the 2017 hydraulic study (CH2M, 2017), PCE concentrations in groundwater are mixing with porewater from the Alabama River and potentially discharging to surface water in Cypress Creek. However, estimated PCE concentrations in Cypress Creek were less than the human and ecological surface water quality criteria. The estimated PCE concentrations in the creek are considered biased high because the calculated DAF of 103 did not consider dilution from the Alabama River porewater, which mixes with groundwater in the subsurface as far as TMPZ-1/MW-13S based on the hydraulic studies (Appendix A, Table A-3 of Appendix A-1). The DAF would increase by orders of magnitude if the Alabama River discharge were included in the calculations. Given the discharge of the Alabama River (over 37 billion L/day) and poor habitat of the creek, risk-based target levels are not needed for surface water.

In soil vapor, TCE concentrations were identified that contribute to potential future human health risks through the VI exposure pathway.

The RAOs for the DEAP site are:

- Protect human health and the environment from exposure to COPCs in groundwater at concentrations above their respective MCLs.
- Protect human health from potential future exposure to COPCs in soil vapor.
- Minimize disruptions to property owners and business from activities related to the implementation of the RA.

These RAOs will serve as the foundation for the development and evaluation of RA alternatives at the site.

3.2 Development and Screening of Alternatives

This section presents the development and preliminary screening of alternatives. Alternatives identified as potentially applicable to the DEAP site are based on the identified potential future risks and compliance with the two threshold criteria established by EPA:

1. **Overall protection of human health and the environment**– The selected alternative must provide adequate protection to human health and the environment. The selected alternative should focus on providing adequate protection and describe how potential future site risks posed through each pathway are addressed, eliminated, reduced, or controlled.

2. **Compliance with ARARs** – Each alternative is evaluated to assess compliance with chemical-specific, action-specific, and location-specific ARARs, as summarized in Table 3-1.

Site characteristics such as location and aquifer chemistry are included in the screening step to identify potentially significant problems with the implementability, safety, and effectiveness of possible remedial technologies. The technologies that remained following screening were assembled into RAs for each medium that meet the RAOs, satisfy ARARs, and address chemicals that pose potential future risks. In addition, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires that No Action be included as an alternative to provide a baseline for comparison of the other alternatives and is carried forward throughout the alternatives evaluation.

3.2.1 Potential Alternatives

Remedial alternatives considered to be potentially applicable at the DEAP site to address PCE in groundwater include:

- Pump and treat
- In situ chemical reduction (ISCR)
- In situ chemical oxidation (ISCO)
- Air sparging and soil vapor extraction (AS-SVE)
- Enhanced bioremediation
- Institutional controls (ICs) with Five-year Reviews (FYRs)
- ICs with FYRs and long-term monitoring (LTM)
- ICs with FYRs and monitored natural attenuation (MNA)

Site-specific conditions such as the location of the DEAP site in a densely populated downtown area and the aerobic nature of the aquifer (DO greater than 3.46 mg/L in the shallow portion of the aquifer [Table 4-3 of the Supplemental EI Report]) would negatively affect the implementability, safety, and/or effectiveness of several of the potential technologies, including the pump and treat, ISCR, ISCO, AS-SVE, and/or enhanced bioremediation options, as follows:

- Implementability – Significant aboveground and subsurface urban infrastructure would make identifying suitable locations with sufficient open area to implement the aboveground and subsurface components of the pump and treat, ISCR, ISCO, AS-SVE, and enhanced bioremediation options difficult, and could result in damage to infrastructure and physical hazards to pedestrians.
- Technical Effectiveness – The technical effectiveness of the enhanced bioremediation and ISCR treatment options, both of which require reducing conditions to be effective (generally DO less than 0.5 mg/L), would be limited in an aerobic aquifer such as that present at the DEAP site.
- Safety and Security – High levels of traffic in the downtown area increase the risks of personal injury and would require pedestrian and traffic control around remediation equipment for the pump and treat, ISCR, ISCO, AS-SVE, and enhanced bioremediation options. In addition, storage and handling of treatment chemicals that can be hazardous to human health in a public area would be required for ISCO and ISCR, and therefore, are not recommended.

Based on the above implementability, technical effectiveness, and safety considerations, the pump and treat, ISCR, ISCO, AS-SVE, and enhanced bioremediation treatment options are not considered further.

The remaining remedial alternatives carried forward in the evaluation include:

- No Action
- ICs with FYRs
- ICs with FYRs and LTM
- ICs with FYRs and MNA

These alternatives are described briefly in the following sections.

3.2.1.1 Alternative 1 – No Action

The No Action alternative assumes that the DEA will not implement any treatment as part of an RA. The site will remain in its current state, and no actions will be conducted to remove, isolate, monitor, or remediate the contamination. Because concentrations of PCE contributing to potential future human health risks exceeding ADEM's target IELCR of 1×10^{-5} were detected in groundwater and there is potential for future risks based on exposure to TCE concentrations in soil vapor, the No Action alternative would not be protective of human health and the environment and therefore, is not in accordance with ARARs. However, the No Action alternative will be used for comparison purposes in the alternatives analysis.

3.2.1.2 Alternative 2 – Institutional Controls with Five-year Reviews

ICs are non-engineering measures, usually legal or administrative means, of limiting potential exposures to a site or medium of concern by limiting or preventing access. ICs would comply with ARARs and protect human health from contaminants in groundwater at the DEAP site by restricting use of groundwater at the site, and would protect human health from contaminants identified in soil vapor by providing notification of the potential for VI to applicants for new construction and current property owners within the site boundary. The FYRs are conducted to periodically confirm that ICs remain in place and are being implemented. Overall, implementation of ICs with FYRs would include the following:

- Working with the local jurisdiction to maintain and develop ordinances to restrict well drilling and prohibit groundwater access, respectively
- Developing a permitting and notice procedure for the City to implement when building permit applications for new development or renovation are submitted
- Providing information about the potential to encounter COPCs and a link to the most up-to-date information for the DEAP site as part of the City's permitting process for contractors requesting permits to excavate within the DEAP site boundary
- Notifying applicants for new construction and current property owners within the site boundary of the potential for VI
- Notifying applicants for new construction or renovation of the potential for VI
- Conducting FYRs to ensure that the City geographic information systems (GIS) and County GIS show the boundaries of the DEAP site and areas where COPCs are potentially present in groundwater or soil vapor and that applicants for new construction are notified
- Completing FYR reports

These ICs would remain in place indefinitely under Alternative 2.

3.2.1.3 Alternative 3 –Institutional Controls with Five-Year Reviews and Long-term Monitoring

Alternative 3, ICs with FYRs and LTM, addresses potential risks to current and potential future receptors by using ICs to prevent immediate groundwater COPC and potential future VI COPC exposure, and performing groundwater monitoring as part of the FYRs at site wells where groundwater COPCs have been detected at levels above protective criteria. These data may be used to evaluate whether groundwater ICs are still needed in the future. RA activities would be conducted in compliance with ARARs. The following are the main components of ICs with FYRs and LTM:

- Implementing ICs (according to Alternative 2) to prevent use of groundwater and notifying applicants for new construction and current property owners within the DEAP site boundary of the potential for VI

- Conducting FYRs to ensure that the City GIS and County GIS show the boundaries of the DEAP site and areas where COPCs are potentially present in groundwater or soil vapor and that applicants for new construction are notified
- Monitoring groundwater during the FYRs with analysis for COPCs at the five site monitoring wells where concentrations above criteria were detected (MW-02S, MW-03S, MW-08S, MW-12S, and TMPZ-1/ MW-13S) (Figure 1-2)
- Completing FYR reports with updated plume and potentiometric surface maps

ICs for groundwater would remain in place for as long as concentrations of COPCs exceeding MCLs are detected in groundwater. ICs for soil vapor impacts would remain in place indefinitely under Alternative 3.

3.2.1.4 Alternative 4 – Institutional Controls with Five-year Reviews and Monitored Natural Attenuation

Alternative 4, ICs with FYRs and MNA, addresses potential risks to current and potential future receptors by using ICs to prevent immediate groundwater COPC and potential future VI COPC exposure. MNA, conducted as part of the FYRs, addresses potential risks to current and potential future receptors by relying on natural attenuation to decrease COPC concentrations in groundwater. RA activities would be conducted in compliance with ARARs. The following are the main components of ICs with FYRs and MNA:

- Implementing ICs (according to Alternative 2) to prevent use of groundwater and notifying applicants for new construction and current property owners within the DEAP site boundary of the potential for VI
- Conducting FYRs to ensure that the City GIS and County GIS show the boundaries of the DEAP site and areas where COPCs are potentially present in groundwater or soil vapor and that applicants for new construction are notified
- Monitoring groundwater during the FYRs at five monitoring wells where concentrations above protective criteria were detected (MW-02S, MW-03S, MW-08S, MW-12S, and TMPZ-1/MW-13S) and one site monitoring well located upgradient of the current groundwater plumes (MW-01S) for the following analyses:
  - COPCs to assess concentration trends in the parent chemical (PCE) and daughter products over time
  - MNA parameters including nitrate, nitrite, total organic carbon, sulfate, sulfide, manganese, and ferric and ferrous iron to assess whether geochemical conditions in the aquifer are conducive to natural degradation of the contaminants
  - Field parameters including DO and oxidation-reduction potential.
- Completing FYR reports with updated plume maps, potentiometric surface maps, time-series evaluation of concentration trends, and evaluation of natural attenuation processes across the longitudinal transect of the plume

3.3 Detailed Evaluation of Alternatives

This section evaluates the RA alternatives:

- No action
- ICs with FYRs
- ICs with FYRs and LTM

- ICs with FYRs and MNA

These alternatives were carried forward from the alternatives screening described in in Section 3.2 and are considered to satisfy EPA's threshold criteria of protection of human health and the environment, except for the "No Action" alternatives. The other RAs that were carried forward would trigger and meet the various components of the threshold criterion for ARARs (Table 3-1) compliance. To ensure compliance, the RA activities will be performed in accordance with the alternative-specific ARARs listed in Table 3-1. The MCLs for drinking water were identified as the single chemical-specific ARAR for groundwater.

The RA alternatives are evaluated further using the five "balancing criteria" established by the EPA. The "balancing" criteria evaluate the balance between the relative effectiveness and reduction of toxicity, mobility, or volume through treatment, implementability, and cost. Evaluations against effectiveness criteria are qualitative, based largely on available literature and project experiences regarding expected technology performance. Evaluations against the cost criterion are completed on an order-of-magnitude basis, considering recent project experience, technology vendor estimates, and/or other conventional sources of cost data used by construction cost engineers:

1. **Long-term effectiveness and permanence** – The long-term effectiveness criterion relates to the sustainability of the RA results with respect to the potential risk remaining after the response objectives have been met. An RA that removes the highest percentage or mass of contamination and does not require additional treatments or actions and minimizes the need for ICs is favored for selection.
2. **Reduction of contaminant toxicity, mobility, or volume** – This evaluation criterion relates to the RA alternative's ability to reduce significantly (through treatment or recycling) the toxicity, mobility, or volume of the hazardous substances. This criterion can be accomplished through the destruction of toxic contaminants, irreversible reduction of contaminant mobility, or reduction of the volume of contaminated media.
3. **Short-term effectiveness** – This evaluation criterion focuses on the effects of the RA alternative on human health and the environment during the implementation phase. The RA alternative best accomplishes the short-term effectiveness criterion if it protects the community and workers during RA activities, mitigates potential adverse effects on the environment during RA activities (including limiting energy consumption), and limits the time required to achieve protection for the site.
4. **Implementability** – This evaluation criterion focuses on the technical and administrative feasibility of implementing a specific RA alternative. The technical aspects of this criterion include the following:

    a. Technical difficulties and unknowns associated with the RA alternative
    b. Reliability of the RA alternative
    c. Ease of undertaking additional RA alternatives
    d. Monitoring considerations of the RA alternative

    The administrative aspects of this criterion include the coordination between offices and agencies (such as prerequisite approvals and rights-of-way acquisition). This criterion also addresses the availability of the necessary materials and services to implement the RA alternative.
5. **Cost** – This evaluation criterion is used to evaluate the relative costs associated with implementation of the RA alternatives. The financial aspects of this criterion include direct capital costs (construction costs, equipment costs, land and development costs, building and services costs, and relocation costs), indirect capital costs (engineering costs, permitting costs, startup costs, and contingency costs), and annual operation and maintenance costs.

Modifying criteria are used to address state and community acceptance of the IRA, as follows:

1. **State Acceptance** – This evaluation criterion focuses on the technical and administrative issues and concerns of the state agency (ADEM).
2. **Community Acceptance** – The RA/AA Report findings and recommendations were reviewed with the Community Outreach Group (COG) on July 10, 2018. COG members attending were satisfied with the assessment and analysis results. COG members were encouraged to review the final report in detail and submit any additional feedback concurrently with ADEM Review. The public will have access to this document via the project website at: http://montgomeryal.gov/live/about-montgomery/capital-city-plume-information, where project contact information is available for questions or comments. Any comments received through the website will be considered in the final selection of alternatives. After a remedy is selected, the final remedial action plan will be subject to public notice and a formal comment period.

Table 3-2 summarizes the comparison of the potential alternatives against the five balancing criteria. The modifying criteria of state and community acceptance will be considered after the public information session.

3.3.1 Alternatives Evaluation Summary

As noted in Table 3-2, Alternative 2 (ICs with FYRs) best satisfies the “balancing” evaluation criteria for addressing potential future risks associated with direct exposure (potential future potable use) to groundwater and potential future exposure to soil vapor, and therefore is recommended. The ICs are effective in the short-term by immediately preventing direct exposure of human health to groundwater contaminants at the site and FYRs confirm that those protections remain in place. ICs with FYRs are readily implemented, as there are well established processes for implementing ICs and conducting FYRs. No additional protectiveness is gained from conducting LTM or MNA, rather costs are increased causing alternatives to score less favorably; therefore, LTM and MNA are not recommended or needed.

Summary and Conclusions

The results of the Supplemental EI conducted at the DEAP site indicate PCE is present in groundwater above its MCL in two commingled plumes in the shallow portion of the aquifer; these plumes extend from the RSA Energy Plant and MW-12S along the groundwater flow direction toward Cypress Creek (Figure 1-2). In addition, PCE in soil vapor was detected at concentrations exceeding the residential VISL at MW-02S, and TCE in soil vapor was detected at concentrations exceeding the residential VISL at MW-08S and exceeding the industrial VISL at the VIMS. Because PCE and TCE in groundwater and soil vapor were identified at concentrations exceeding their appropriate screening levels, an HHRA and ERA were conducted to assess whether COPCs at the DEAP site may pose risks to human health and the environment.

PCE concentrations above the MCL were identified in groundwater; however, there is no potable use of groundwater in the DEAP site boundary. In addition, the elevated concentrations of TCE in soil vapor at the VIMS were identified as posing potential future risks to human health through the VI exposure pathway, although no VI exposure concerns were identified under the current site conditions. The SLERA concluded that the assessment endpoint was met and no further risk assessment or consideration of remedy is recommended for ecological receptors.

Because of the potential future risks to human health identified because PCE exceeds its MCL in groundwater and because of the potential risk for future exposure to TCE concentrations detected in soil vapor at the VIMS, RAs for the site were assessed using EPA's threshold and balancing evaluation criteria. In addition to Alternative 1 – No Action (used to provide a baseline comparison for the other alternatives), three alternatives were established that satisfy the threshold criteria of protection of human health and the environment and compliance with ARARs, as follows:

- Alternative 2 – ICs with FYRs
- Alternative 3 – ICs with FYRs and LTM
- Alternative 4 – ICs with FYRs and MNA

The comparative analysis of these alternatives included evaluating each alternative against the balancing criteria of long-term and short-term effectiveness; reduction of toxicity, mobility, or volume; implementability; and cost. The results of these assessments indicate that Alternative 2 – ICs with FYRs would provide the best overall balance between effectiveness, implementability, and cost to address potential future risks due to COPCs identified at the DEAP site.

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Tables

TABLE 1-1

Groundwater Sampling Results from the Supplemental EI

Downtown Environmental Assessment Project, Montgomery, Alabama

Station ID	Date Sampled	PCE VISL: 15 MCL: 5 RSL: 11	TCE VISL: 1.2 MCL: 5 RSL: 0.49	cis-1,2-DCE VISL: NA MCL: 70 RSL: 36	trans-1,2-DCE VISL: NA MCL: 100 RSL: 360	VC VISL: 0.15 MCL: 2 RSL: 0.019
Shallow Interval Wells						
MW-01S	7/12/2016	1.56	0.398 U	0.260 U	0.396 U	0.259 U
MW-02S	7/13/2016	**34.1**	0.398 U	0.260 U	0.396 U	0.259 U
MW-03S	7/13/2016	**6.27**	**0.566 J**	0.260 U	0.396 U	0.259 U
MW-03S FDUP	7/13/2016	**6.02**	0.442 J	0.260 U	0.396 U	0.259 U
MW-08S	7/13/2016	**78.4**	**0.599 J**	0.260 U	0.396 U	0.259 U
MW-09S	7/11/2016	0.372 U	**0.567 J**	0.260 U	0.396 U	0.259 U
MW-10S	7/12/2016	0.372 U	0.398 U	0.260 U	0.396 U	0.259 U
MW-12S	7/13/2016	**58.9**	0.414 J	0.268 J	0.396 U	0.259 U
TMPZ-1/MW-13S	7/22/2016	**174**	**1.01**	0.874 J	0.396 U	0.259 U
Intermediate Interval Wells						
MW-01I	7/12/2016	0.372 U	0.398 U	0.260 U	0.396 U	0.259 U
MW-05I	7/14/2016	0.595 J	0.398 U	0.260 U	0.396 U	0.259 U
MW-05I FDUP	7/14/2016	0.573 J	0.398 U	0.260 U	0.396 U	0.259 U
MW-07I	7/12/2016	0.372 U	0.398 U	0.260 U	0.396 U	0.259 U
MW-07S	7/12/2016	0.372 U	0.398 U	0.260 U	0.396 U	0.259 U
MW-08I	7/13/2016	0.372 U	0.398 U	0.260 U	0.396 U	0.259 U
MW-12I	7/13/2016	0.372 U	0.398 U	0.260 U	0.396 U	0.259 U
Commercial Bus Washing Station						
BSW-0217	2/20/2017	0.372 U	0.398 U	0.260 U	0.396 U	0.259 U

Notes:

Concentrations presented in micrograms per liter (µg/L).

Bold text indicates concentration exceeds the lower of the MCL/RSL.

Shaded cell indicate shallow interval well concentration exceeds the EPA VISL.

PCE = tetrachloroethene

TCE = trichloroethene

DCE = dichloroethene

VC = vinyl chloride

FDUP = field duplicate

MCL = U.S. Environmental Protection Agency (EPA) Maximum Contaminant Level

RSL = EPA Regional Screening Level (tap water; based on a target risk = 1×10^{-6} and target hazard quotient = 1), May 2016

VISL = vapor intrusion screening level (based on a residential scenario, target risk = 1×10^{-6} , target hazard quotient = 1, default groundwater temperature), May 2016

NA = no VISL available

DEAP = Downtown Environmental Assessment Project

J = concentration is estimated

U = analyte was not detected

TABLE 1-2

Soil Vapor Sampling Results from the Supplemental EI

Downtown Environmental Assessment Project, Montgomery, Alabama

Station ID	Sample Depth (ft bgs)	Date Sampled	PCE Residential VISL: 1,400	TCE Residential VISL: 70	cis-1,2-DCE Residential VISL: NA	trans-1,2-DCE Residential VISL: NA	VC Residential VISL: 56
Plume Area							
MW-02S	7.8 - 8	09/23/2016	**4,940**	3.21	1.59 U	1.59 U	1.02 U
	34 - 35	09/22/2016	**5,280**	34.5	1.59 U	1.59 U	1.02 U
MW-08S	7 - 8	09/22/2016	493	**336**	1.59 U	1.59 U	1.02 U
	29 - 30	09/22/2016	361	27.8	1.59 U	1.59 U	1.02 U
MW-12S	7 - 8	09/21/2016	23.3	3.56	1.59 U	1.59 U	1.02 U
	21 - 22	09/21/2016	4.36 J	42.3 J	1.59 U	1.59 U	1.02 U
	21 - 22 (FD)	09/21/2016	6.41 J	64.6 J	5.67 J	1.59 U	1.02 U
TMPZ-1/MW-13S	7 - 8	09/21/2016	3.49	2.14 U	1.59 U	1.59 U	1.02 U
	26 - 27	09/21/2016	1,240	10	1.59 U	1.59 U	1.02 U
Vapor Intrusion Monitoring System							
VIMS-10	10	09/21/2016	99.6	**13,100**	88.6	2.55	1.02 U
VIMS-50	50	09/22/2016	286	**98,800**	873	19.1	4.09 U

Station ID	Sample Depth (ft bgs)	Date Sampled	PCE Commercial VISL: 5,800	TCE Commercial VISL: 290	cis-1,2-DCE Commercial VISL: NA	trans-1,2-DCE Commercial VISL: NA	VC Commercial VISL: 930
County Annex III Building							
AMS-01	11.8 - 12	09/19/2016	14.2	2.14 U	1.59 U	1.59 U	1.02 U
AMS-02	11.8 - 12	09/19/2016	6.28	6.67	1.59 U	1.59 U	1.02 U
Alabama Attorney General's Building							
AMS-03	14.8 - 15	09/20/2016	9.68	2.14 U	1.59 U	1.59 U	1.02 U
AMS-04	11.8 - 12	09/20/2016	9.37	2.14 U	1.59 U	1.59 U	1.02 U
	11.8 - 12 (FD)	09/20/2016	9.18	2.14 U	1.59 U	1.59 U	1.02 U

Notes:

Concentrations presented in micrograms per meter cubed ($\mu g/m^3$).

Bold text indicates concentration exceeds EPA residential VISL.

ft bgs = feet below ground surface

PCE = tetrachloroethene

TCE = trichloroethene

DCE = dichloroethene

VC = vinyl chloride

FD = field duplicate

VISL = EPA Vapor Intrusion Screening Level (based on target risk of 1×10^{-5} and target hazard quotient of 1), May 2016.

NA = no VISL available

DEAP = Downtown Environmental Assessment Project

J = concentration is estimated

U = analyte was not detected

TABLE 1-3

Physical Properties of the Chemicals of Potential Concern

Downtown Environmental Assessment Project, Montgomery, Alabama

Chemical	Vapor Pressure (mm Hg @ 25°C)	Henry's Law[a] (atm-m^3/mole)	Density[b] (g/cm^3)	log K_{ow}[a] (L/kg)	Solubility[a] (mg/L)
Tetrachloroethene	18.5[c]	1.77E-02	1.623	3.4	206
Trichloroethene	69[d]	9.85E-03	1.4642	2.42	1,280
cis-1,2-Dichloroethene	200[c]	4.08E-03	1.2837	1.86	6,410
trans-1,2-Dichloroethene	331[a]	9.40E-03	1.2565	2.09	4,520
Vinyl chloride	2980[e]	2.78E-02	0.9106	1.62[f]	8,800

Notes:

mm Hg @ 25°C = millimeters of mercury at 25 degrees Celsius

atm-m^3/mole = atmospheres in cubic meters per mole

g/cm^3 = grams per cubic centimeter

L/kg = liters per kilogram

mg/L = milligrams per liter

[a] The Estimation Programs Interface (EPI) Suite™ was developed by the U.S. Environmental Protection Agency's Office of Pollution Prevention and Toxics and Syracuse Research Corporation (SRC). These programs estimate various chemical-specific properties.

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TABLE 1-4

Geotechnical Sampling Results from the Supplemental EI

Downtown Environmental Assessment Project, Montgomery, Alabama

	Station ID	TMPZ-1/MW-13S		MW-12S		MW-08S	MW-02S
	Sample Depth (ft bgs)	9-11	18-20	4-6	22-24	28-30	5-7
Analyte	**Unit**	**Result**	**Result**	**Result**	**Result**	**Result**	**Result**
Saturated Porosity*	%	34	45	44	41	29	33
Total Soil Porosity	cm^3/cm^3-soil	0.37	0.48	0.47	0.44	0.36	0.4
Soil Dry Bulk Density	g/cm^3	1.73	1.46	1.46	1.53	1.71	1.6
Fraction Organic Carbon	%	0.51	0.11	0.15	0.08	0.11	0.16

Notes:

* Saturated porosity was calculated from total porosity.

% = percent

g/cm^3 = gram(s) per centimeter cubed

cm^3/cm^3 = centimeter(s) cubed per centimeter(s) cubed

ft bgs = feet below ground surface

DEAP = Downtown Environmental Assessment Project

TABLE 3-1

ARARs

Downtown Environmental Assessment Project, Montgomery, Alabama

Chemical-Specific ARARs			
Media	**Requirement**	**Prerequisite**	**Citation**
Groundwater	Shall not exceed the Safe Drinking Water Act National Revised Primary Drinking Water Regulations: maximum contaminant levels (MCLs) for organic contaminants specified in 40 CFR 141.61(a).	Groundwaters that are an existing or potential source of drinking water **- Relevant and Appropriate to all alternatives.**	40 CFR 141.61(a) ADEM 335-7-2-.05
Action-Specific ARARs			
Action	**Requirement**	**Prerequisite**	**Citation**
Waste Characterization and Storage — Primary Wastes (i.e., excavated contaminated soils)			
Storage of solid waste	All solid waste shall be disposed in manner consistent with the requirements of the Land Division.	Generation of solid waste that is determined *not* to be hazardous **- Applicable to Alternatives 3 and 4.**	ADEM 335-13-1-.11
Temporary accumulation of hazardous waste in containers	A generator may accumulate hazardous waste at the facility for up to 90 days provided that: · Waste is placed in containers that comply with 40 CFR 262.15(a); and · The date upon which accumulation begins is clearly marked and visible for inspection on each container; · Container is marked with the words "hazardous waste"; or · Container may be marked with other words that identify the contents.	Accumulation of RCRA hazardous waste onsite as defined in 40 CFR 260.10 **- Applicable to Alternatives 3 and 4.**	ADEM 335-14-3-7(a) only as it incorporates the following citations: 40 CFR 262.17(a)(1)(ii) 40 CFR 262.17(a)(5)
Location-Specific ARARs			
Location	**Requirement**	**Prerequisite**	**Citation**
Migratory Flyway	Almost all species of native birds in the United States are protected from unregulated taking.	Any activity taking place within a migratory flyway. **Applicable for Alternatives 3 and 4.**	Migratory Bird Treaty Act, 16 USC 703

Notes:

ADEM = Alabama Department of Environmental Management

ARAR = Applicable, relevant and appropriate requirement

CFR = Code of Federal Regulations

MCL = maximum contaminant level

RCRA = Resource Conservation and Recovery Act

USC = United States Code

TABLE 3-2

Balancing Criteria Evaluation Summary for Remedial Alternatives

Downtown Environmental Assessment Project, Montgomery, Alabama

Alternative	Balancing Criteria	Evaluation Summary	Criteria Ranking	Overall Ranking
No Action	Long-term Effectiveness	Does not satisfy - COC concentrations above risk criteria are left in place.	5	4
	Short-term Effectiveness	Does not satisfy - COC concentrations exceeding risk criteria are left in place.	5	
	RTMV	Does not satisfy - no active treatment.	5	
	Implementability	Readily Implemented - no action.	1	
	Cost	$0	1	
	Total		**17**	
Institutional Controls with Five-Year Reviews	Long-term Effectiveness	Satisfies - prevents exposure to elevated COC concentrations in groundwater[1] and provides notifications to prevent potential future VI risks. Also includes a process to evaluate continued protectiveness every 5 years.	1	1
	Short-term Effectiveness	Satisfies - immediately prevents exposure to elevated COC concentrations in groundwater[1] and provides notifications to prevent potential future VI risks; there are no short-term risks from implementation.	1	
	RTMV	Does not satisfy - no active treatment.	5	
	Implementability	Readily implemented - process exists for preparing ICs.	1	
	One-Time IC Cost	$20,000	---	
	FYR Report	$10,000	---	
	Total Cost (30 years)	$70,000	2	
	Total		**8**	
Institutional Controls with Five-Year Reviews and Long-term Monitoring	Long-term Effectiveness	Satisfies - prevents exposure to elevated COC concentrations in groundwater[1] by restricting potable use and provides notifications to prevent potential future VI risks, provides longer-term data.	1	2
	Short-term Effectiveness	Satisfies - immediately prevents exposure to elevated COC concentrations in groundwater[1] and provides notifications to prevent potential future VI risks; there are no short-term risks from implementation.	1	
	RTMV	Does not satisfy - no active treatment.	5	
	Implementability	Readily implemented - process exists for implementing ICs and wells exist for monitoring.	1	
	Monitoring Cost	$11,000	---	
	One-Time IC Cost	$20,000	---	
	FYR Report	$20,000	---	
	Total Cost (30 years)	$206,000	3	
	Total		**11**	
Institutional Controls with Five-Year Reviews and Monitored Natural Attenuation	Long-term Effectiveness	Satisfies - prevents exposure to elevated COC concentrations in groundwater1 by restricting potable use and provides notifications to prevent potential future VI risks; although attenuation processes permanently transform COCs to nontoxic compounds, the processes that break down COCs are expected to occur slowly at the site.	1	3
	Short-term Effectiveness	Satisfies - immediately prevents exposure to elevated COC concentrations in groundwater[1] and provides notifications to prevent potential future VI risks; there are no short-term risks from implementation.	1	
	RTMV	Does not satisfy - no active treatment.	5	
	Implementability	Readily implemented - wells exist for monitoring.	1	
	Monitoring Cost	$15,000	---	
	One-Time IC Cost	$20,000	---	
	FYR Report	$30,000	---	
	Total Cost (30 years)	$290,000	4	
	Total		**12**	

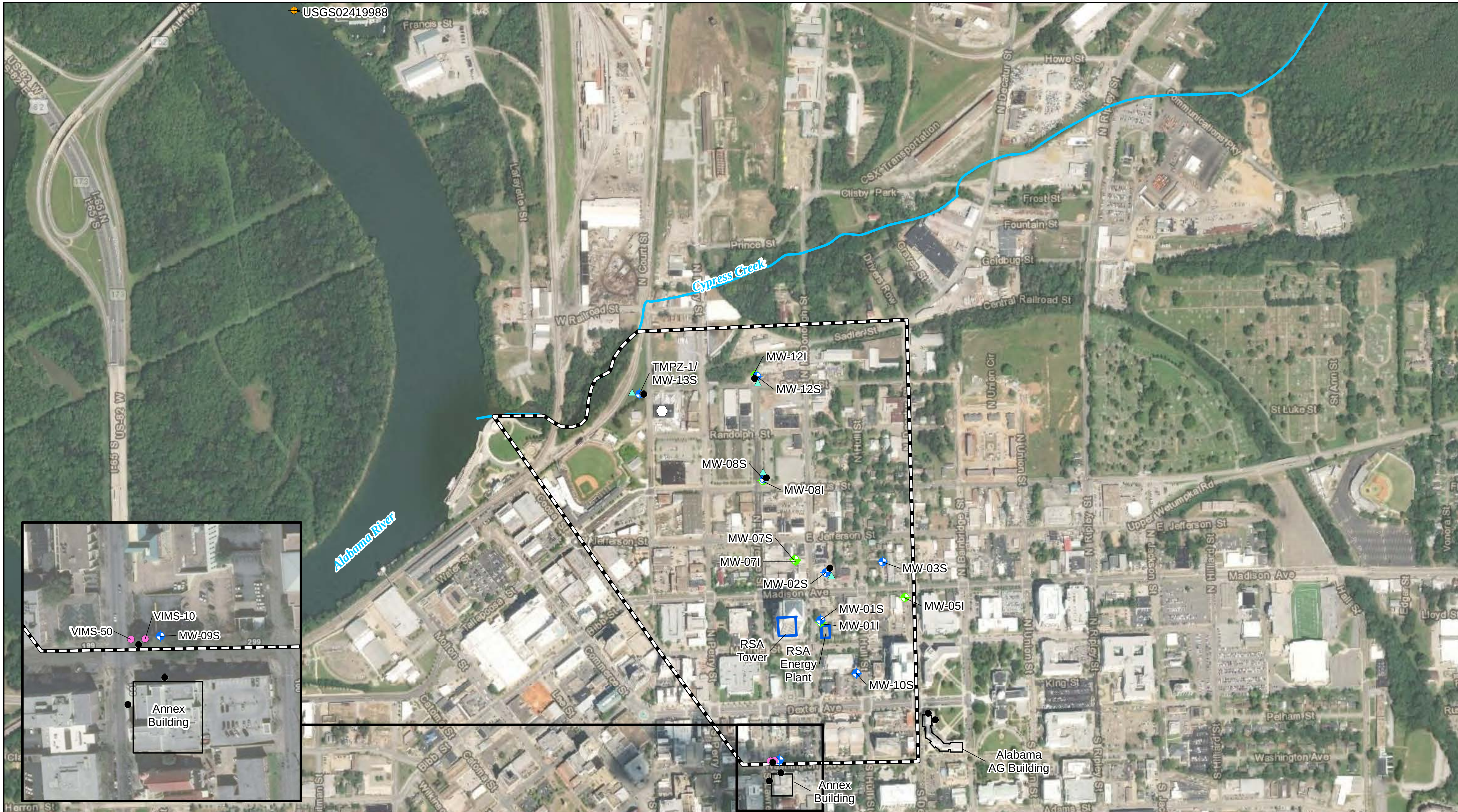
Notes:

[1] Potable use of groundwater is an incomplete pathway under current and future site conditions. The DEAP site is currently served by the Montgomery Water Works and Sanitary Sewer Board. All public water supply wells from the former North Well Field were abandoned and there are no known domestic wells in use at the DEAP site. Additionally, the City enacted an ordinance in 2003 to prohibit future well drilling in the downtown area.

RTMV = reduction of toxicity, mobility, or volume through treatment

Criteria ranking on a scale of 1 to 5, where 1 indicates criteria is fulfilled well and 5 indicates criteria is not fulfilled.
Overall criteria ranking is given relative to the other alternatives evaluated.
Monitoring costs are given based on a 30-year monitoring cycle.

Figures



LEGEND

- Shallow Monitoring Well
- Intermediate Monitoring Well
- VIMS
- Soil Vapor Sampling Location
- Geotechnical Sampling Location
- Alabama River Gauge Station
- Commercial Bus-Washing Station
- RSA Building
- Site Boundary

Notes:
1. AG = Attorney General
2. RSA = Retirement Systems of Alabama
3. VIMS = Vapor Intrusion Monitoring System
4. DigitalGlobe Aerial Imagery (September 26, 2017).
5. Figure extent increased to show location of the Alabama River Gauge.

N

0 350 700
Feet

FIGURE 1-1
Site Map with Investigation Locations
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project
Montgomery, AL

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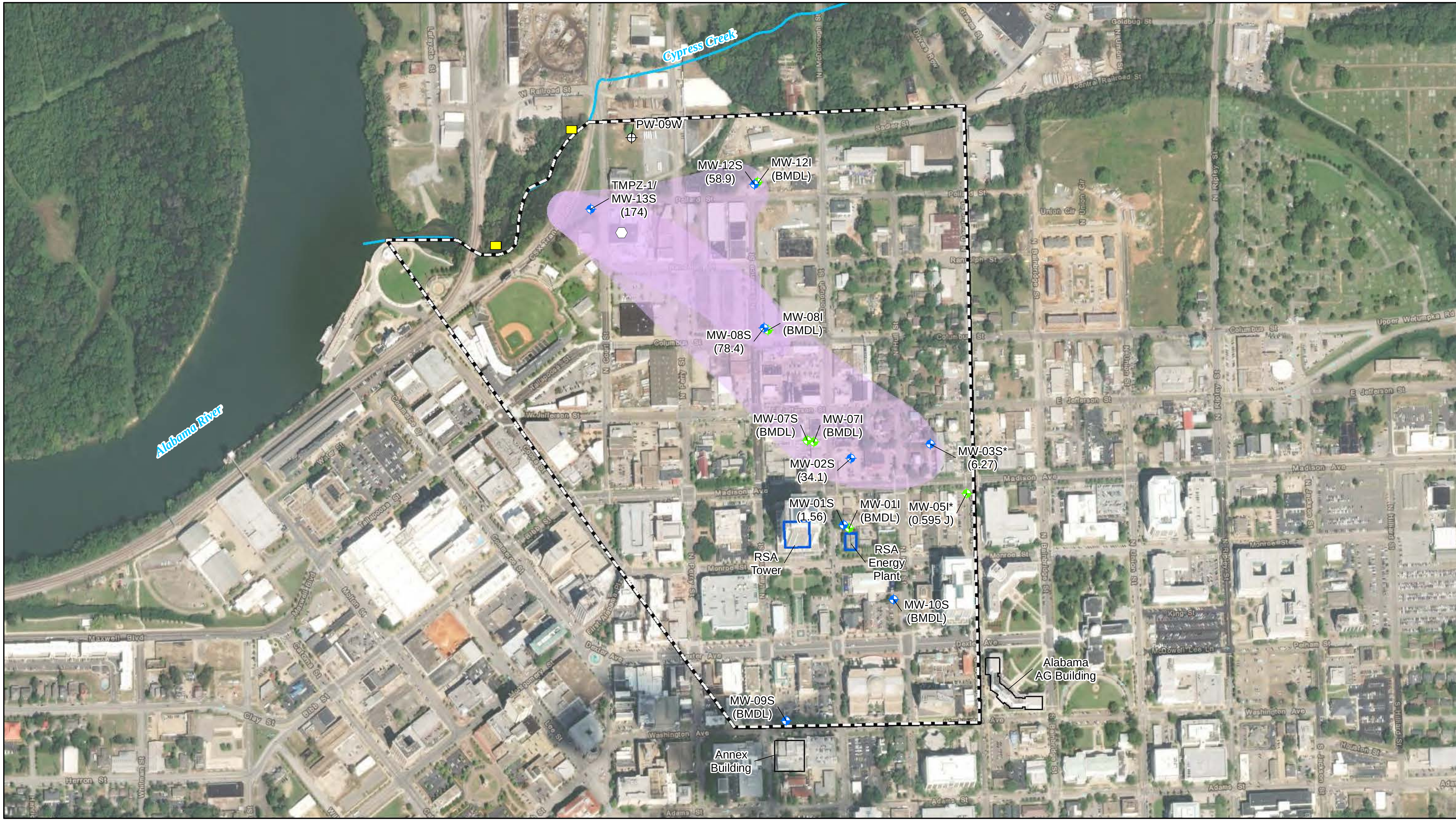

LEGEND

- Shallow Monitoring Well
- Intermediate Monitoring Well
- Former City Water Supply Well
- Approximate Culvert Location
- Commercial Bus-Washing Station
- Approximate Extent of PCE > 5 µg/L
- RSA Building
- Site Boundary

Notes:
1. AG = Attorney General
2. BMDL = below method detection limit
3. J = concentration is estimated
4. PCE = tetrachloroethene
5. RSA = Retirement Systems of Alabama
6. µg/L = micrograms per liter
7. * = field duplicate sample location, highest result presented
8. (34.1) = PCE concentration in groundwater in µg/L
9. Darker plume shading shows the approximate extent of the commingled portion of the PCE plumes.
10. DigitalGlobe Aerial Imagery (September 26, 2017).

N

0 250 500
Feet

FIGURE 1-2
PCE Groundwater Results - July
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project
Montgomery, AL

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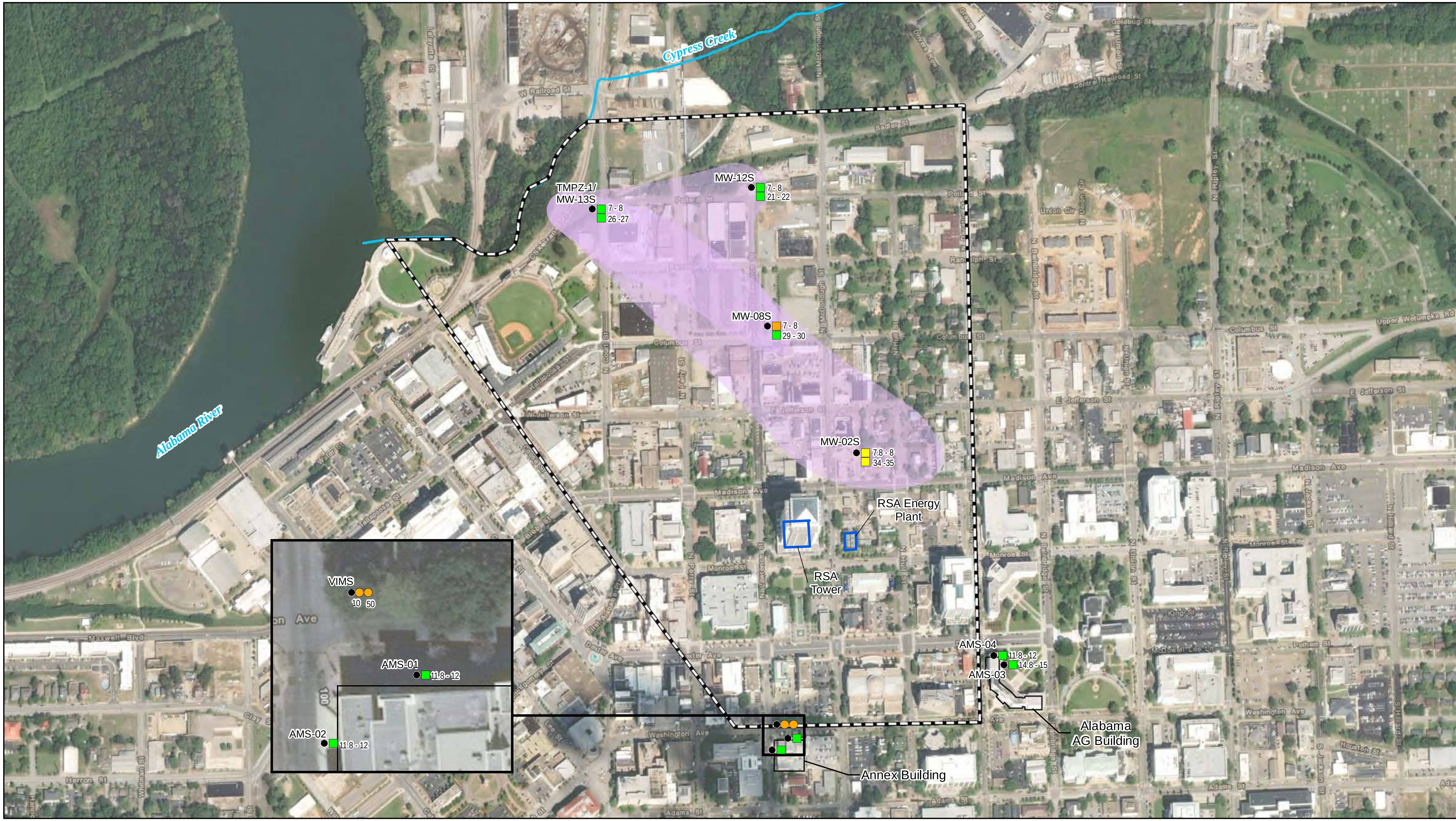

LEGEND

Soil Vapor VISL Screening Results

- Result Does Not Exceed VISL
- Result Exceeds Residential VISL for PCE
- Result Exceeds Residential VISL for TCE
- Result Exceeds Commercial VISL for TCE

- Soil Vapor Sample Location
- Approximate Extent of PCE > 5 µg/L
- Site Boundary
- Building
- RSA Building

Notes:

1. VISL = EPA vapor intrusion screening level (based on target risk of $1x10^{-5}$ and target hazard quotient of 1) (EPA, 2016)
2. µg/L = micrograms per liter
3. PCE = tetrachloroethene
4. TCE = trichloroethene
5. # - # = the depth interval in feet below ground surface.
6. Soil vapor results collected adjacent to the Annex and Attorney General (AG) Buildings were compared to commercial VISLs, results from all other locations were compared to residential VISLs.
7. Darker plume shading shows the approximate extent of the commingled portion of the PCE plumes.
8. DigitalGlobe Aerial Imagery (September 26, 2017).

N

0 250 500

Feet

FIGURE 1-3

Soil Vapor Results

Risk Assessment/Alternatives Analysis Report

Downtown Environmental Assessment Project

Montgomery, AL

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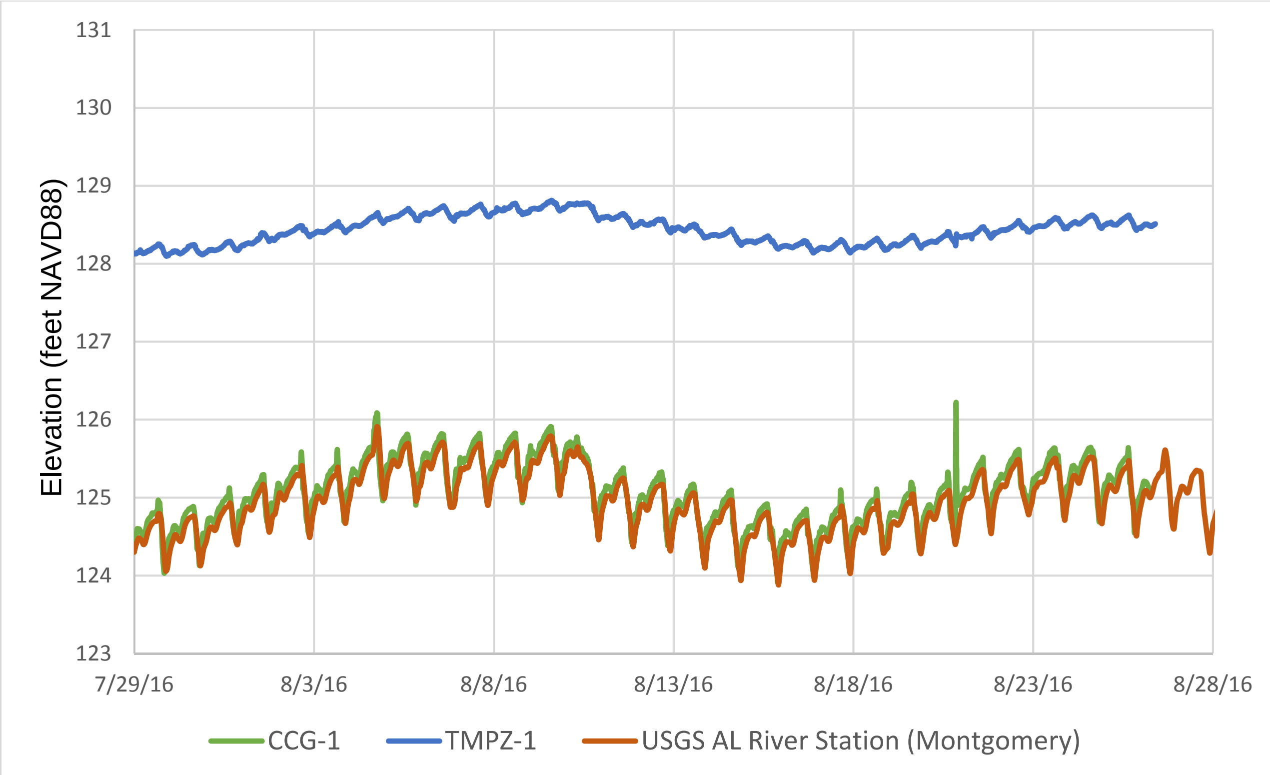
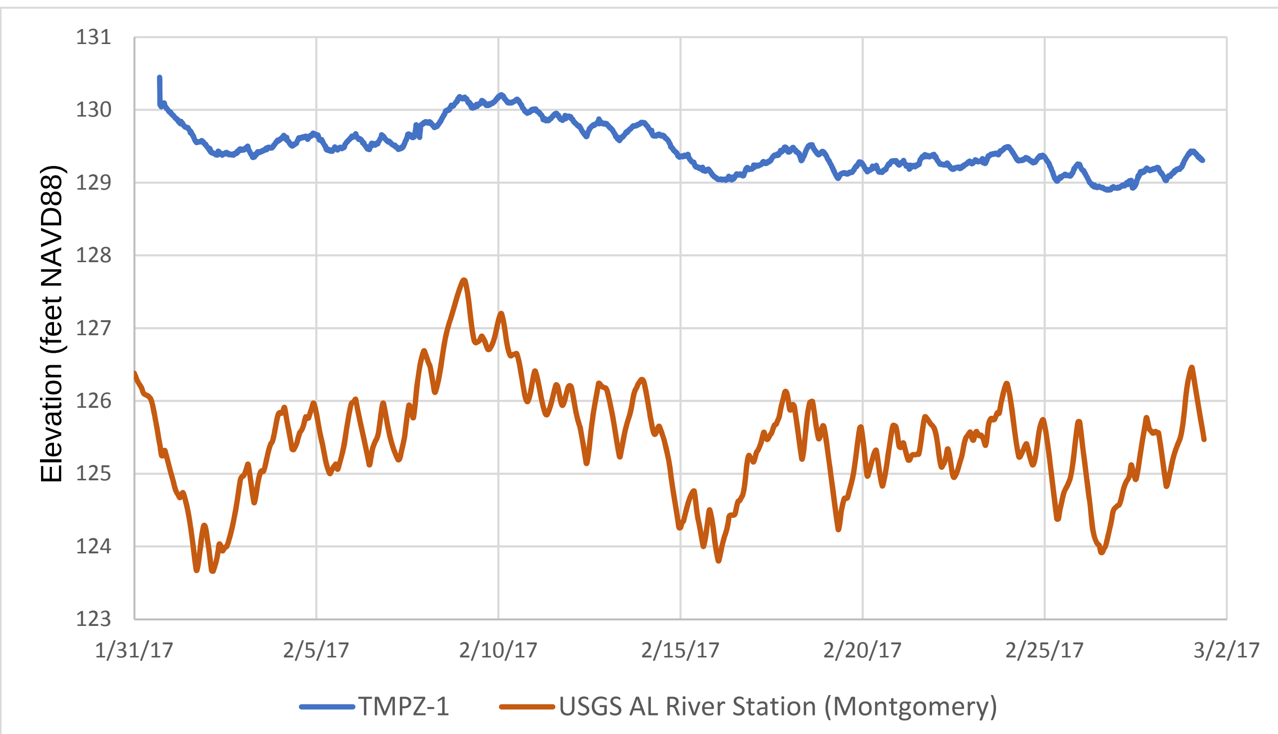
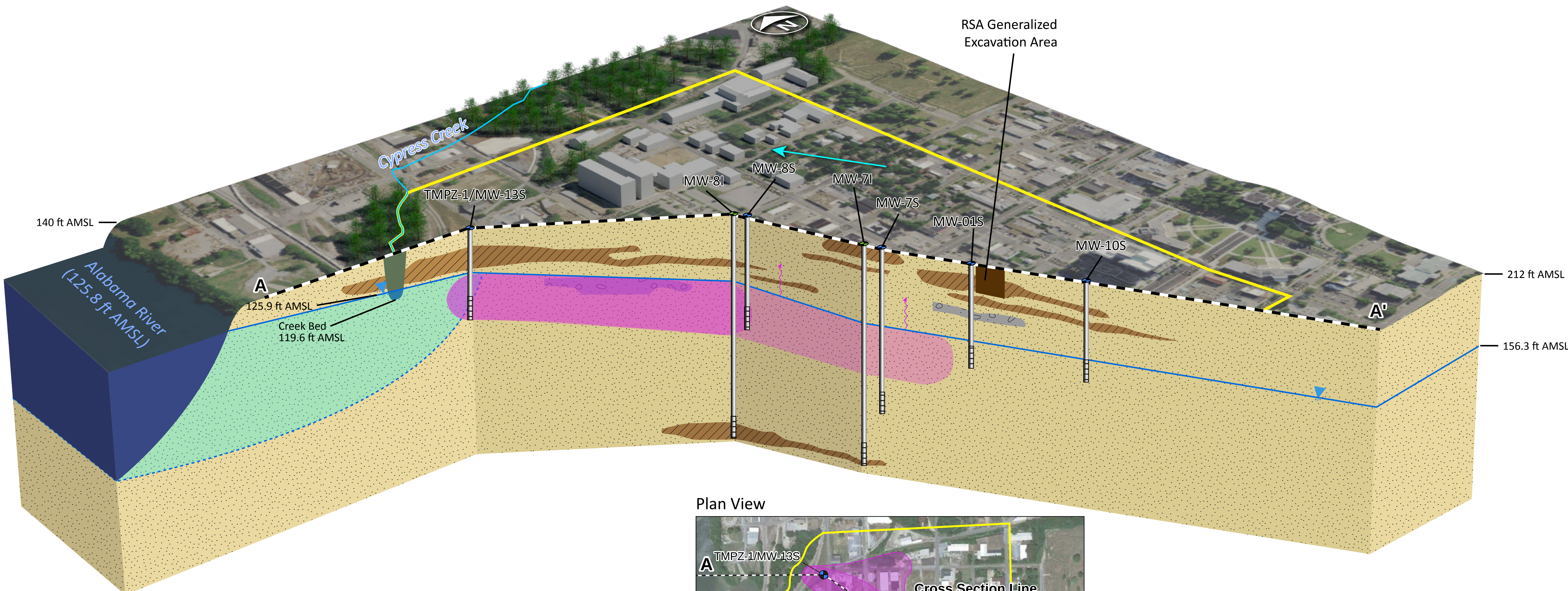


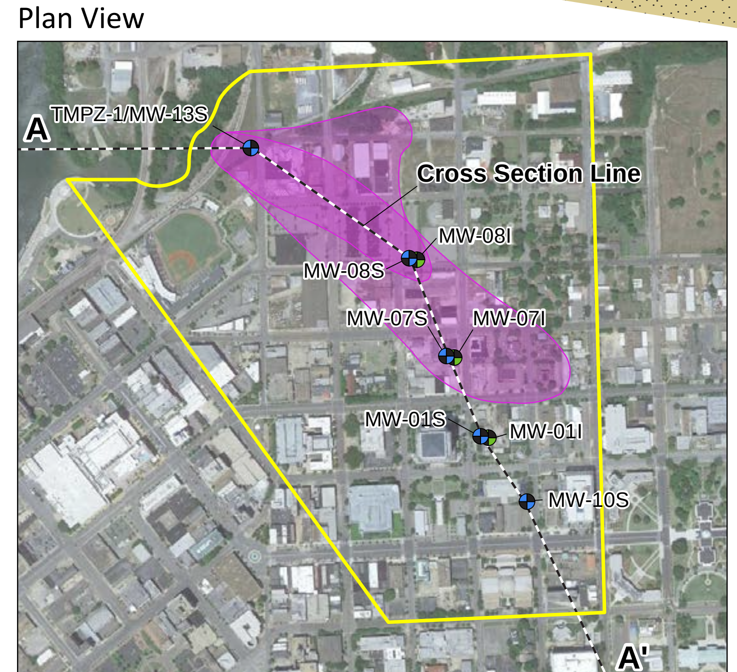


Notes:
CCG-1 = Cypress Creek Gauge
USGS AL River Station = United States Geological Society Alabama River Gauge 02419988
NAVD88 = North American Vertical Datum of 1988

Figure 1-4
Cypress Creek Hydraulic Study Results
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project
Montgomery, AL



Plan View

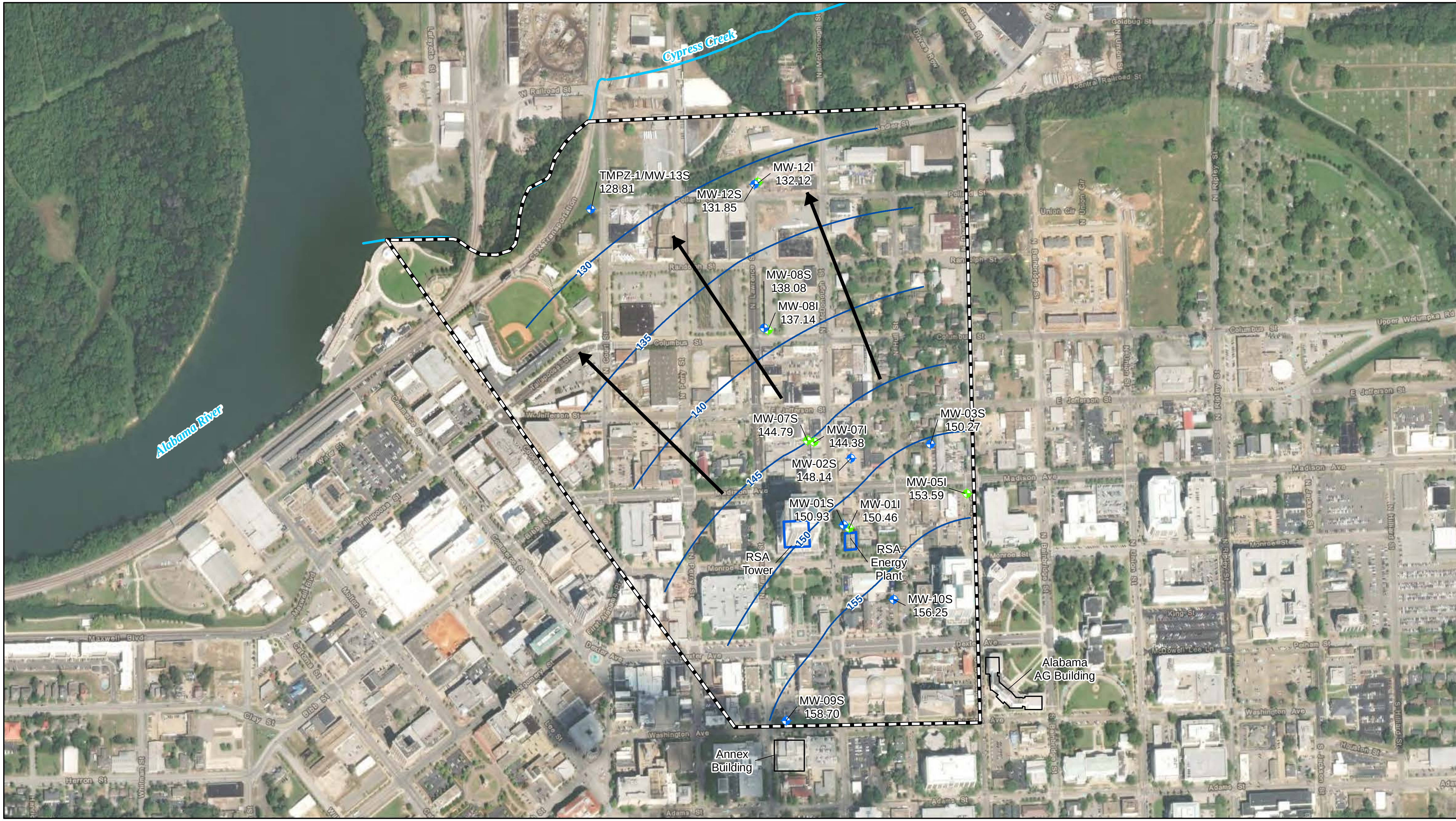


LEGEND

- Site Boundary
- Shallow Monitoring Well
- Deep Monitoring Well
- PCE Plume
- Approximate Extent of Alabama River Influence
- Sand
- Silt and Clay
- Sandy Gravel
- Groundwater Level
- Groundwater Flow Direction
- Vapor Migration

Notes:
1. Not to scale
2. Below surface elements vertically exaggerated for clarity
3. Darker purple color indicates commingled plumes
4. PCE = tetrachloroethene
5. ft AMSL = feet above mean sea level

Figure 1-5
Conceptual Site Model
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project
Montgomery, Alabama



LEGEND

- Shallow Monitoring Well
- Intermediate Monitoring Well
- Shallow Potentiometric Contour
- Generalized Groundwater Flow Direction
- RSA Building
- Site Boundary

Notes:
1. AG - Attorney General
2. RSA - Retirement Systems of Alabama
3. Intermediate wells not used in contouring.
4. Groundwater elevations presented in feet above mean sea level.
5. Reach of Cypress Creek is presented as Reach 4, as defined in Baseline Biological Monitoring Results for the Cypress Creek Aquatic Ecosystem Restoration Feasibility Study (CH2M, 2012).
6. DigitalGlobe Aerial Imagery (September 26, 2017).

N

0 250 500
Feet

FIGURE 1-6
July 2016 Shallow Potentiometric Surface
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project
Montgomery, AL

ch2m

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LEGEND

- Shallow Monitoring Well
- Intermediate Monitoring Well
- Former City Water Supply Well
- RSA Building
- Site Boundary
- Approximate Extent of PCE > 5 µg/L
- Daycare/School
- First Floor Residental
- City
- State
- RSA

Notes:
1. µg/L = micrograms per liter
2. AG = Attorney General
3. RSA = Retirement Systems of Alabama
4. Non-standard areas are commercial/industrial use.
5. DigitalGlobe Aerial Imagery (September 26, 2017).
6. PCE = tetrachloroethene

N

0 250 500
Feet

FIGURE 1-7
Land Use
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project
Montgomery, AL

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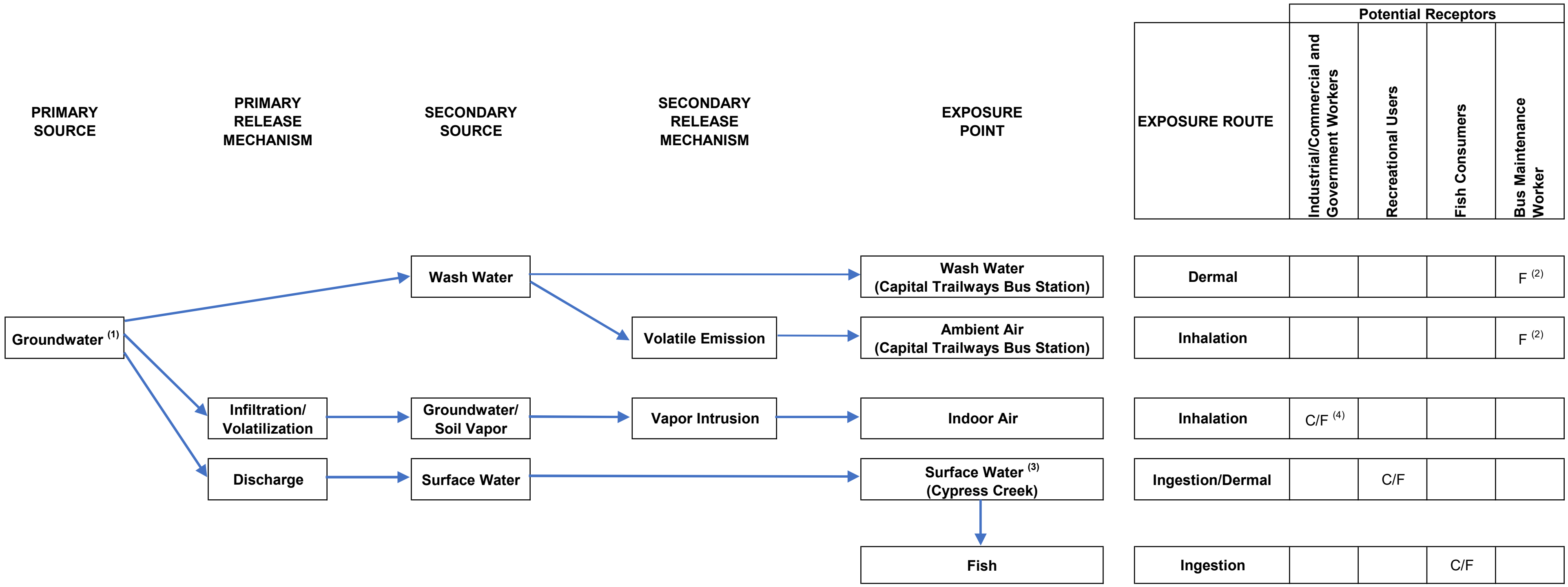


Notes:

(1) Potable use of groundwater is an incomplete pathway under current and future site conditions. The DEAP site is currently served by the Montgomery Water Works and Sanitary Sewer Board. All public water supply wells from the former North Well Field were abandoned and there are no known domestic wells in use at the DEAP site. Additionally, the City enacted an ordinance in 2003 to prohibit future well drilling in the downtown area.

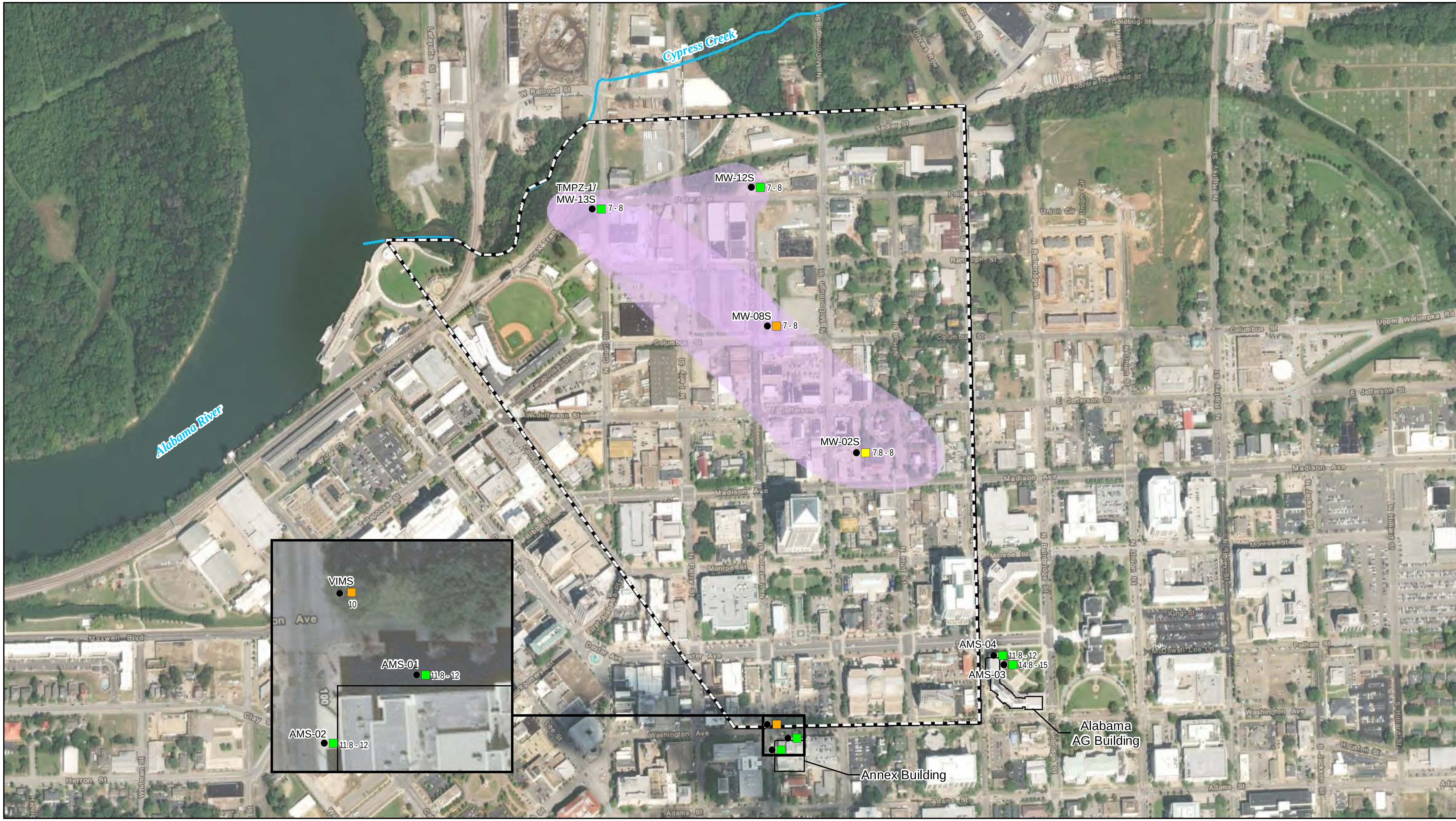
(2) As discussed in Section 1.2.6 of the text, the Capital Trailways well has been decommissioned and it is unlikely to be reconstructed and used in the future. However, per ADEM's request, bus maintenance workers were evaluated under a future exposure scenario.

(3) Potential surface water concentrations were estimated using groundwater concentrations from monitoring well TMPZ-1 and a site-specific attenuation factor.

(4) Potential exposures to indoor air associated with vapor intrusion from groundwater were not evaluated because preference is given to the soil vapor data, which were collected at locations with groundwater concentrations greater than the vapor intrusion screening levels.

C/F - Potentially Complete Pathway under Current and Future Exposure Scenarios
F - Potentially Complete Pathway under Future Exposure Scenario

FIGURE 2-1
Conceptual Exposure Model
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project, Montgomery, Alabama



LEGEND

Soil Vapor VISL Screening Results

- Result Does Not Exceed Commercial VISL
- Result Exceeds Commercial VISL for PCE
- Result Exceeds Commercial VISL for TCE
- Soil Vapor Sample Location
- Approximate Extent of PCE > 5 µg/L
- Site Boundary
- Building

Notes:
1. VISL = EPA vapor intrusion screening level (based on target risk of $1x10^{-5}$ and target hazard quotient of 1) (EPA, 2016)
2. µg/L = micrograms per liter
3. PCE = tetrachloroethene
4. TCE = trichloroethene
5. # - # = the depth interval in feet below ground surface.
6. Soil vapor results compared to commercial VISLs based on lack of first floor residences within the Downtown Environmental Project Alliance plume footprint or near the VIMS.
7. Darker plume shading shows the approximate extent of the commingled portion of the PCE plumes.
8. DigitalGlobe Aerial Imagery (September 26, 2017).

FIGURE 2-2
Shallow Soil Vapor Commercial VISL Results
Risk Assessment/Alternatives Analysis Report
Downtown Environmental Assessment Project
Montgomery, AL

ch2m

Appendix A
Human Health Risk Assessment Tables and Supplemental Information

Appendix A-1
Human Health Risk Assessment Tables

A-1. Potentially Complete Exposure Pathways

Downtown Environmental Assessment Project, Montgomery, Alabama

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor	Exposure Route	Evaluation	Rationale
Current/ Future	Groundwater [1]	Surface Water [2]	Surface Water (Cypress Creek)	Recreational Users	Ingestion, Dermal	Quant	Recreational users could potentially be exposed to site groundwater discharging to surface water in Cypress Creek.
			Fish	Fish Consumers	Ingestion	Quant	Fish consumers could potentially consume fish caught from Cypress Creek.
		Groundwater (Indoor Air)	Buildings Near Groundwater Plume	Industrial/Commercial and Government Workers	Inhalation	None [4]	Workers could inhale volatile constituents in indoor that potentially could migrate from underlying groundwater.
		Soil Vapor (Indoor Air)	Buildings Near Groundwater Plume	Industrial/Commercial and Government Workers	Inhalation	Quant	Workers could inhale volatile constituents in indoor that potentially could migrate from soil vapor.
Future	Groundwater [3]	Wash water	Wash water (Capital Trailways Bus Station)	Bus Maintenance Workers	Dermal, Inhalation	Quant	Future workers potentially could contact wash water from the industrial well while washing vehicles at the bus maintenance facility.

Notes:

[1] Potable use of groundwater is an incomplete exposure pathway under current and foreseeable future site conditions. The DEAP site is currently served by the Montgomery Water Works and Sanitary Sewer Board. All public water supply wells from the former North Well Field were abandoned and there are no known domestic wells in use at the DEAP. However, groundwater data were evaluated for a potable use scenario in accordance with the work plan.

[2] Potential surface water concentrations were estimated using groundwater concentrations from monitoring well TMPZ-1 and a site-specific attenuation factor.

[3] The power lines and plumbing connected to the well and the water storage tank that the water was pumped into were removed in February of 2017, rendering the well unusable in its current state (see Appendix B). Capital Trailways has connected to the city water supply and no longer uses groundwater under the DEAP site. However, per ADEM's request, it was conservatively assumed bus maintenance workers could use this well for washing vehicles in the future.

[4] Potential exposures to indoor air associated with vapor intrusion from groundwater will not be evaluated because preference is given to the soil vapor data, which were collected at locations with groundwater concentrations greater than the vapor intrusion screening levels.

A-2. Samples Included in Risk Assessment

Downtown Environmental Assessment Project, Montgomery, Alabama

Medium	Data Grouping	Sample Location	Sample ID	Date Collected	Depth Interval (feet bgs)	Sample Type [1]
Groundwater [2]	Groundwater (Potable Use) [4]	MW-01I	GW-03-0716	7/12/2016	NA	P
		MW-01S	GW-04-0716	7/12/2016	NA	P
		MW-02S	GW-08-0716	7/13/2016	NA	P
		MW-03S	GW-09-0716	7/13/2016	NA	P
			FD01-0716	7/13/2016	NA	FD
		MW-5I	GW-07-0716	7/14/2016	NA	P
			FD02-0716	7/14/2016	NA	FD
		MW-07I	GW-06-0716	7/12/2016	NA	P
		MW-07S	GW-05-0716	7/12/2016	NA	P
		MW-08I	GW-11-0716	7/13/2016	NA	P
		MW-08S	GW-10-0716	7/13/2016	NA	P
		MW-09S	GW-01-0716	7/11/2016	NA	P
		MW-10S	GW-02-0716	7/12/2016	NA	P
		MW-12I	GW-12-0716	7/13/2016	NA	P
		MW-12S	GW-13-0716	7/13/2016	NA	P
	Discharge to Surface Water (Cypress Creek)	TMPZ-1 [5]	GW-014-0716	7/22/2016	NA	P
	Wash water (Capital Trailways Bus Station)	CT-01-S	L891420-03	2/20/2017	NA	P
			L891420-04	2/20/2017	NA	FD
Soil Vapor [3]	County Annex III Building	AMS-01	AMS-01-0916	9/19/2016	11.8 - 12	P
		AMS-02	AMS-02-0916	9/19/2016	11.8 - 12	P
	Alabama AG's Building	AMS-03	AMS-03-0916	9/20/2016	14.8 - 15	P
		AMS-04	AMS-04-0916	9/20/2016	11.8 - 12	P
			AMS-FD-0916	9/20/2016	11.8 - 12	FD
	Vapor Intrusion Monitoring Station (VIMS)	VIMS-10	VIMS-10-0916	9/21/2016	10 - 10	P
	Monitoring Wells/ Temporary Piezometer	MW-12S	SV-MW12-08	9/21/2016	7 - 8	P
		MW-08S	SV-MW08-08	9/22/2016	7 - 8	P
		MW-02S	AMS-MW02-08	9/23/2016	7.8 - 8	P
		TMPZ-1	SV-TMPZ1-08	9/21/2016	8 - 8	P

Notes:

(1) For primary (P) and field duplicate (FD) samples, the maximum detected concentration was used in the evaluation.

(2) Although potential exposures to groundwater are considered incomplete for a potable use scenario, groundwater was compared to the tap water Regional Screening Levels and Maximum Contaminant Levels for informational purposes.

(3) If shallow and deep monitoring points were available from the same location, only the shallow monitoring point was included in the risk assessment.

(4) Although potable use of groundwater is an incomplete exposure pathway under current and foreseeable future site conditions, groundwater data were compared to screening criteria to evaluate a hypothetical potable use scenario, in accordance with the site work plan.

(5) Potential surface water concentrations were estimated using groundwater concentrations from monitoring well TMPZ-1 and a site-specific attenuation factor.

bgs = below ground surface

NA = Not Available/Not Applicable

A-3. Calculation of Cypress Creek Attenuation Factor

Downtown Environmental Assessment Project, Montgomery, Alabama

Plume Thickness (1) (ft)	Discharge Length (2) (ft)	Discharge Area (3) (ft^2)	Discharge Area (3) (cm^2)	Hydraulic Gradient (4) (unitless)	Hydraulic Conductivity (5) (cm/s)	Aquifer Discharge Rate (6) (cm^3/s)	Aquifer Discharge Rate (L/day)	Discharge from Coliseum Blvd. Plume to Cypress Creek(7) (L/day)	Mean Discharge of Alabama River (8) (L/day)	DAF using Cypress Creek discharge	DAF using Alabama River discharge
35	400	14,000	13,006,000	0.008	0.0036	375	32,400	3,324,940	37,677,300,000	103	1,162,880

Notes:

(1) Plume thickness based on distance between the water table (~40 ft bgs at MW-02S) and the point halfway between the bottom screen depth of the deepest well with detected PCE above MCL (MW-02S at 60 ft bgs) and the top of screen for shallowest well where PCE was not detected (MW-07S, at 85 ft bgs), conservatively rounded up to the nearest 5 ft. For example, the plume thickness = (60 ft+((85 ft - 60 ft)/2)) - 40 ft = 32.5 ft, rounded to 35 ft.

(2) Discharge length estimated as the general width of the distal end of the plume measured parallel to the creek, as defined between the non-detect grab groundwater sample data adjacent to the creek shown in Figure 5-2 of the Supplemental Environmental Investigation Report (CH2M, 2017).

(3) Discharge area calculated as rectangular area using the plume thickness and discharge length.

(4) Hydraulic gradient defined as change in head from TMPZ-1 to the closest upgradient well (MW-08S) (9.27 ft) over measured distance between TMPZ-1 and MW-08S (1,161 ft).

(5) Hydraulic conductivity based on geometric mean of hydraulic conductivities determined by slug tests (Data Evaluation Report, Black & Veatch, 2000).

(6) Aquifer Discharge Rate = hydraulic conductivity * hydraulic gradient* discharge area (does not assume retardation of flow from Alabama River porewater exchange)

(7) Assumes the Coliseum Boulevard Plume contribution accounts for all flow in Cypress Creek (data obtained from the Coliseum Boulevard Plume Southwest Treatment Area under NPDES permit AL0081167. The total estimated annual flow, based on the monthly averages, in 2017 for the Discharge Pond was 320.6 million gallons.

(8) Mean discharge obtained from U.S. Geological Survey station 02420000 based on 79 years of record.

DAF - dilution attentuaion factor calculated as the ratio between the discharge of the porewater exchange (from surface water discharge) and groundwater inflow (aquifer discharge)

bgs = below ground surface

ft = feet

ft^2 = square feet

cm^2 = square centimeter

cm^3/s = centimeters cubed per second

L/day = liters per day

cm/s = centimeters per second

A-4. Comparison of Groundwater (TMPZ-1) with Surface Water Standards

Downtown Environmental Assessment Project, Montgomery, Alabama

Well ID	Sample ID	Collection Date	CAS	COPC	Groundwater Result/ Qualifier (µg/L)		Estimated Surface Water Concentration in Cypress Creek[1] (µg/L)		Consumption of Fish Comparison			Consumption of Water and Fish Comparison		
									Surface Water SL[2] (µg/L)		Result > SL	Surface Water SL[2] (µg/L)		Result > SL
TMPZ-1/MW-13S	GW-014-0716	7/22/2016	156-59-2	cis-1,2-DCE	0.874	J	0.00849	J	591	n	No	14	n	No
TMPZ-1/MW-13S	GW-014-0716	7/22/2016	127-18-4	PCE	174		1.69		36	c	No	11	c	No
TMPZ-1/MW-13S	GW-014-0716	7/22/2016	79-01-6	TCE	1.01		0.0098		4.8	c	No	0.66	c	No

Notes:

Only detected concentrations are included on this table.

(1) Attenuation factor of 103 used to estimate concentration in Cypress Creek (refer to Table 3), based on following equation:

$$C_{SW} = \frac{C_{GW}}{AF}$$

C_{SW} = Concentration in surface water at Cypress Creek (µg/L)

C_{GW} = Concentration in groundwater at TMPZ-1 (µg/L)

AF = Attenuation factor (unitless)

(2) Surface Water Screening Level calculated on Table A-4 Supplement.

µg/L = micrograms per liter

c = carcinogenic

cis-1,2-DCE = cis-1,2-Dichloroethene

COPC = chemical of potential concern

HI = hazard index

J = result is estimated

n = noncarcinogenic

PCE = tetrachloroethene

SL = screening level

TCE = trichloroethene

A-4. Supplement. Calculation of Surface Water Screening Levels

Downtown Environmental Assessment Project, Montgomery, Alabama

Analyte	CAS	RfD_{oral} [1] (mg/kg-day)	CSF_{oral} [1] (1/mg/kg-day)	BCF [2] (L/kg)	RSC [2]	Surface Water SLs - Consumption of Fish [3]			Surface Water SLs - Consumption of Water and Fish[3]		
						SL_{nc} (mg/L)	SL_{ca} (mg/L)	Final SL [4] (µg/L)	SL_{nc} (mg/L)	SL_{ca} (mg/L)	Final SL [4] (µg/L)
cis-1,2-DCE	156-59-2	0.002	NA	1.58	0.2	0.591	NA	591 n	0.014	NA	14 n
PCE	127-18-4	0.006	0.0021	30.6	0.2	0.092	0.036	36 c	0.029	0.011423349	11 c
TCE	79-01-6	0.0005	0.046	10.6	0.2	0.022	0.0048	4.8 c	0.003	0.000656488	0.66 c

Notes:

[1] Source: EPA Integrated Risk Information System, Available online: https://www.epa.gov/iris.

[2] Source: EPA National Recommended Water Quality Criteria: 2002 Human Health Criteria Calculation Matrix. The BCF and RSC for trans-1,2-DCE are used for cis-1,2-DCE.

[3] Surface water screening levels were calculated using Equations 16 through 19, as shown below and as provided in the ADEM Admin. Code r. 335-6-10 (February 2017).

[4] Most conservative value of noncarcinogenic and carcinogenic screening levels selected as final screening level.

µg/L = microgram per liter
c = carcinogenic
cis-1,2-DCE = cis-1,2-Dichloroethene
L/kg = liter per kilogram
mg/kg-day = milligram per kilogram per day
mg/L = milligram per liter
n = noncarcinogenic
NA = Not applicable or not available
PCE = tetrachloroethene
TCE = trichloroethene

Equation 16. - Consumption of water and fish for noncarcinogens

conc. (mg/L) = (HBW x RfD x RSC) / [(FCR x BCF) + WCR]

HBW = Human Body Weight	70 kilograms
RfD = Oral Reference Dose (mg/kg-day)	chemical-specific
FCR = Fish Consumption Rate	0.030 kilogram/day
BCF = Bioconcentration Factor (L/kg)	chemical-specific
RSC = Relative Source Contribution (unitless)	chemical-specific
WCR = Water Consumption Rate	2 liters/day

Equation 17. - Consumption of fish for noncarcinogens

conc. (mg/L) = (HBW x RfD x RSC) / (FCR x BCF)

HBW = Human Body Weight	70 kilograms
RfD = Oral Reference Dose (mg/kg-day)	chemical-specific
FCR = Fish Consumption Rate	0.030 kilogram/day
BCF = Bioconcentration Factor (L/kg)	chemical-specific
RSC = Relative Source Contribution (unitless)	chemical-specific

Equation 18. - Consumption of water and fish for carcinogens

conc. (mg/L) = (HBW x RL) / (CSF x [FCR x BCF + WCR])

HBW = Human Body Weight	70 kilograms
RL = Risk Level	1×10^{-6}
CSF = Oral Cancer Slope Factor (1/mg/kg-day)	chemical-specific
FCR = Fish Consumption Rate	0.030 kilogram/day
BCF = Bioconcentration Factor (L/kg)	chemical-specific
WCR = Water Consumption Rate	2 liters/day

Equation 19. - Consumption of fish for carcinogens

conc. (mg/L) = (HBW x RL) / (CSF x FCR x BCF)

HBW = Human Body Weight	70 kilograms
RL = Risk Level	1×10^{-6}
CSF = Oral Cancer Slope Factor (1/mg/kg-day)	chemical-specific
FCR = Fish Consumption Rate	0.030 kilogram/day
BCF = Bioconcentration Factor (L/kg)	chemical-specific

A-5. Soil Vapor Screening Comparison

Downtown Environmental Assessment Project, Montgomery, Alabama

Location	Sample ID	Collection Date	CAS	COPC	Result/ Qualifier ($\mu g/m^3$)	Commercial VISL (1) ($\mu g/m^3$)	Result > VISL
VIMS	VIMS-10-0916	9/21/2016	156-59-2	cis-1,2-DCE	88.6	NA	NA (2)
			156-60-5	trans-1,2-DCE	2.55	NA	NA (2)
			127-18-4	PCE	99.6	584 n	No
			79-01-6	TCE	13100	29.2 n	Yes
Alabama AG's Building (AMS-03, AMS-04)	AMS-03-0916	9/20/2016	127-18-4	PCE	9.68	584 n	No
	AMS-04-0916	9/20/2016	127-18-4	PCE	9.37	584 n	No
County Annex III Building (AMS-01, AMS-02)	AMS-01-0916	9/19/2016	127-18-4	PCE	14.2	584 n	No
	AMS-02-0916	9/19/2016	127-18-4	PCE	6.28	584 n	No
			79-01-6	TCE	6.67	29.2 n	No
Monitoring Wells/Piezometer (TMPZ-1/MW-13S, MW-12S, MW-08S, MW-02S)	SV-TMPZ1-08	9/21/2016	127-18-4	PCE	3.49	584 n	No
	SV-MW12-08	9/21/2016	127-18-4	PCE	23.3	584 n	No
			79-01-6	TCE	3.56	29.2 n	No
	SV-MW08-08	9/22/2016	127-18-4	PCE	493	584 n	No
			79-01-6	TCE	336	29.2 n	Yes
	AMS-MW02-08	9/23/2016	127-18-4	PCE	4940	584 n	Yes
			79-01-6	TCE	3.21	29.2 n	No

Notes:

A residential VISL was not calculated because no first floor residences were identified within the PCE plume footprint or near the VIMS.

Only detected concentrations are included on this table.

(1) Vapor Intrusion Screening Levels (VISLs) were calculated for a commercial scenario using the EPA's VISL Calculator, https://epa-visl.ornl.gov/cgi-bin/visl_search (EPA, May 2018) and are based on an excess lifetime cancer risk (ELCR) of 1×10^{-6}, hazard quotient (HQ) of 0.1 and default attenuation factor (AF) of 0.03.

(2) VISLs are not available for cis- and trans-1,2-dichloroethene because the inhalation toxicity criteria were withdrawn by EPA.

$\mu g/m^3$ = microgram per cubic meter

cis-1,2-DCE = cis-1,2-dichloroethene

COPC = chemical of potential concern

n = noncarcinogenic

PCE = tetrachloroethene

TCE = trichloroethene

trans-1,2-DCE = trans-1,2-dichloroethene

VIMS = Vapor Intrusion Monitoring System

VISL = Vapor Intrusion Screening Level

A-6. Groundwater Screening Comparison for Wash Water (Capital Trailways Bus Station)

Downtown Environmental Assessment Project, Montgomery, Alabama

Well ID	Sample ID	Collection Date	CAS	COPC	Result [MDL] [(1)]/ Qualifier (µg/L)		Modified Tap Water RSL [(2)] (µg/L)		MDL > Modified Tap Water RSL
CT-01-S	L891420-03	2/20/2017	156-59-2	cis-1,2-DCE	0.26	U	36	n	No
CT-01-S	L891420-03	2/20/2017	156-60-5	trans-1,2-DCE	0.396	U	360	n	No
CT-01-S	L891420-03	2/20/2017	127-18-4	PCE	0.372	U	6.1	n	No
CT-01-S	L891420-03	2/20/2017	79-01-6	TCE	0.398	U	0.396	n	Yes
CT-01-S	L891420-03	2/20/2017	75-01-4	Vinyl Chloride	0.259	U	0.154	c	Yes

Notes:

No constituents were detected in the samples collected from CT-01-S; therefore, only non-detect concentrations are included on this table.

(1) Non detected results were reported to MDL.

(2) Source: Modified EPA Regional Screening Level (RSL) that includes dermal and inhalation pathways only (based on May, 2018 RSL table). Modified tap water RSLs are based on an excess lifetime cancer risk (ELCR) of 1 x 10^{-6} and hazard index (HI) of 0.1. Refer to Table 6 Supplement for the Modified tap water RSL calculations.

µg/L = microgram per liter

c = carcinogenic

cis-1,2-DCE = cis-1,2-dichloroethene

COPC = chemical of potential concern

n = noncarcinogenic

MDL = method detection limit

PCE = tetrachloroethene

RSL = Regional Screening Level

TCE = trichloroethene

trans-1,2-DCE = trans-1,2-Dichloroethene

U = non-detect result

A-6. Supplement. Calculation of Modified Tap Water RSLs

Downtown Environmental Assessment Project, Montgomery, Alabama

Analyte	CAS	Carcinogenic Modified Tap Water RSL [1] (TR = 1 x 10^{-6})			Noncarcinogenic Modified Tap Water RSL [1] (THI = 0.1)			Final Modified Tap Water RSL [2]	
		Dermal SL	Inhalation SL	Dermal + Inhalation SL	Dermal SL	Inhalation SL	Dermal & Inhalation SL		
cis-1,2-DCE	156-59-2	NA	NA	NA	36	NA	36	36	n
trans-1,2-DCE	156-60-5	NA	NA	NA	360	NA	360	360	n
PCE	127-18-4	65	22	16	23	8.3	6.1	6.1	n
TCE	79-01-6	7.4	0.96	0.85	6.9	0.42	0.396	0.396	n
Vinyl Chloride	75-01-4	0.28	0.34	0.154	89	21	17	0.154	c

Notes:

Units are microgram(s) per liter (µg/L)

Source: EPA Regional Screening Level (May, 2018), based on an excess lifetime cancer risk (ELCR) of 1 x 10^{-6} and hazard index (HI) of 0.1.

(1) Modified tap water RSLs were calculated based on dermal and inhalation screening levels, as follows:
Carcinogenic Modified Tap Water RSL (µg/L) = 1/(1/Dermal SL) & (1/Inhalation SL)
Noncarcinogenic Modified Tap Water RSL (µg/L) = 1/(1/Dermal SL) + (1/Inhalation SL)

(2) Most conservative value of noncarcinogenic and carcinogenic screening levels selected as final screening level.

cis-1,2-DCE = cis-1,2-dichloroethene
PCE = tetrachloroethene
RSL = Regional Screening Level
SL = screening level
TCE = trichloroethene
THI = target hazard index
TR - target risk
trans-1,2-DCE = trans-1,2-Dichloroethene

A-7. Groundwater Screening Comparison (Site-Wide)

Downtown Environmental Assessment Project, Montgomery, Alabama

Station ID	Sample ID	Collection Date	CAS	COPC	Result/ Qualifier (µg/L)		Screening Level [1] (µg/L)			Screening Result	
							Tap water RSL		MCL	Result > Tap water RSL	Result > MCL
MW-01S	GW-04-0716	7/12/2016	127-18-4	PCE	1.56		4.1	n	5	No	No
MW-02S	GW-08-0716	7/13/2016	127-18-4	PCE	34.1		4.1	n	5	Yes	Yes
MW-03S	GW-09-0716	7/13/2016	127-18-4	PCE	6.27		4.1	n	5	Yes	Yes
MW-03S	GW-09-0716	7/13/2016	79-01-6	TCE	0.566	J	0.28	n	5	Yes	No
MW-05I	GW-07-0716	7/14/2016	127-18-4	PCE	0.595	J	4.1	n	5	No	No
MW-08S	GW-10-0716	7/13/2016	127-18-4	PCE	78.4		4.1	n	5	Yes	Yes
MW-08S	GW-10-0716	7/13/2016	79-01-6	TCE	0.599	J	0.28	n	5	Yes	No
MW-09S	GW-01-0716	7/11/2016	79-01-6	TCE	0.567	J	0.28	n	5	Yes	No
MW-12S	GW-13-0716	7/13/2016	156-59-2	cis-1,2-DCE	0.268	J	3.6	n	70	No	No
MW-12S	GW-13-0716	7/13/2016	127-18-4	PCE	58.9		4.1	n	5	Yes	Yes
MW-12S	GW-13-0716	7/13/2016	79-01-6	TCE	0.414	J	0.28	n	5	Yes	No
TMPZ-1/MW-13S	GW-014-0716	7/22/2016	156-59-2	cis-1,2-DCE	0.874	J	3.6	n	70	No	No
TMPZ-1/MW-13S	GW-014-0716	7/22/2016	127-18-4	PCE	174		4.1	n	5	Yes	Yes
TMPZ-1/MW-13S	GW-014-0716	7/22/2016	79-01-6	TCE	1.01		0.28	n	5	Yes	No

Notes:

Only detected concentrations are included on this table.

[1] Source: EPA Regional Screening Level (RSL) table (May, 2018). Tap water RSLs are based on an excess lifetime cancer risk (ELCR) of 1×10^{-6} and hazard index (HI) of 0.1.

µg/L = microgram per liter

cis-1,2-DCE = cis-1,2-dichloroethene

COPC = chemical of potential concern

J = result is estimated

MCL = EPA Maximum Contaminant Level

n = noncarcinogenic

PCE = tetrachloroethene

RSL = Regional Screening Level

TCE = trichloroethene

A-8. Estimated Risks and Hazards for Soil Vapor-to-Indoor Air

Downtown Environmental Assessment Project, Montgomery, Alabama

Medium	Location	Sample ID	COC	Calculated Indoor Air Concentration [(1)] (µg/m^3)	Commercial Scenario [(1)]	
					IELCR	**HQ**
Soil Vapor-to-Indoor Air	VIMS	VIMS-10-0916	TCE	393	1.E-04	45
	Monitoring Well (MW-08S)	SV-MW08-08	TCE	10.08	3.E-06	1
	Monitoring Well (MW-02S)	AMS-MW02-08	PCE	148	3.E-06	0.8

Notes:

[(1)] The indoor air concentrations, ELCRs, and HQs were estimated using the EPA's VISL Calculator, https://epa-visl.ornl.gov/cgi-bin/visl_search (EPA, May 2018).

µg/m^3 = microgram(s) per cubic meter

COC = chemical of concern

IELCR = individual excess lifetime cancer risk

HI = hazard index

HQ = hazard quotient

PCE = tetrachloroethene

TCE = trichloroethene

VIMS = Vapor Intrusion Monitoring System

A-9. Estimated Risks and Hazards for Wash Water (Capital Trailways Bus Station)
Downtown Environmental Assessment Project, Montgomery, Alabama

Medium	Station ID	Collection Date	CAS	COPC	Result [MDL] [(1)]/ Qualifier (µg/L)		Modified Tap Water Carcinogenic RSL [(2)] (µg/L)	Modified Tap Water Noncarcinogenic RSL [(2)] (µg/L)	IELCR [(3)]	HI [(3)]
Wash Water (Capital Trailways Bus Station)	CT-01-S	2/20/2017	79-01-6	TCE	0.398	U	0.85	3.96	5.E-07	0.1
	CT-01-S	2/20/2017	75-01-4	Vinyl Chloride	0.259	U	0.15	170	2.E-06	0.002
								Total IELCR/HI (CT-01-S)	**2.E-06**	**0.1**

Notes:

No constituents were detected in the samples collected from CT-01-S; therefore, only non-detect concentrations were included in the risk calculations.

(1) Non detected results were reported to MDL.

(2) Calculation of modified tap water RSLs is provided on Table 6 Supplement.

(3) Excess lifetime cancer risk and hazard index were estimated using a ratio approach:

$$IELCR = \frac{C_{GW}}{RSL_c} \times TR \qquad HI = \frac{C_{GW}}{RSL_n} \times THI$$

Where:
IELCR = Individual Excess Lifetime Cancer Risk
HI = Hazard Index
C_{GW} = Concentration (non-detect results based on MDL) in groundwater at CT-01-S (µg/L)
RSL_c = Modified Tap Water Carcinogenic RSL, based on cancer risk of 1 x 10^{-6} (µg/L)
RSL_n = Modified Tap Water Non-carcinogenic RSL, based on hazard index of 1 (µg/L)
TR = Target Risk of 1 x 10^{-6}
THI = Target Hazard Index of 1

µg/L = microgram per liter
COPC = chemical of potential concern
IELCR = individual excess lifetime cancer risk
MDL = method detection limit
HI = hazard index
RSL = Regional Screening Level
TCE = trichloroethene
U = non-detect result

Appendix A-2
Human Health Risk Assessment Data

Appendix A-2. Analytical Data Used in Risk Assessment

Downtown Environmental Assessment Project, Montgomery, Alabama

Matrix	Station ID	Sample ID	Collection Date	COPC	Detect	Result	Qualifier	Result	Sample Type	Upper Depth (feet)	Lower Depth (feet)	Method
Water	MW-03S	FD01-0716	13-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	FD	NA	NA	8260B
Water	MW-03S	FD01-0716	13-Jul-16	PCE	Yes	6.02		µg/L	FD	NA	NA	8260B
Water	MW-03S	FD01-0716	13-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	FD	NA	NA	8260B
Water	MW-03S	FD01-0716	13-Jul-16	TCE	Yes	0.442	J	µg/L	FD	NA	NA	8260B
Water	MW-03S	FD01-0716	13-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	FD	NA	NA	8260B
Water	MW-05I	FD02-0716	14-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	FD	NA	NA	8260B
Water	MW-05I	FD02-0716	14-Jul-16	PCE	Yes	0.573	J	µg/L	FD	NA	NA	8260B
Water	MW-05I	FD02-0716	14-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	FD	NA	NA	8260B
Water	MW-05I	FD02-0716	14-Jul-16	TCE	No	0.398	U	µg/L	FD	NA	NA	8260B
Water	MW-05I	FD02-0716	14-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	FD	NA	NA	8260B
Water	MW-09S	GW-01-0716	11-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-09S	GW-01-0716	11-Jul-16	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	MW-09S	GW-01-0716	11-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-09S	GW-01-0716	11-Jul-16	TCE	Yes	0.567	J	µg/L	P	NA	NA	8260B
Water	MW-09S	GW-01-0716	11-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	TMPZ-1/MW-13S	GW-014-0716	22-Jul-16	cis-1,2-DCE	Yes	0.874	J	µg/L	P	NA	NA	8260B
Water	TMPZ-1/MW-13S	GW-014-0716	22-Jul-16	PCE	Yes	174		µg/L	P	NA	NA	8260B
Water	TMPZ-1/MW-13S	GW-014-0716	22-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	TMPZ-1/MW-13S	GW-014-0716	22-Jul-16	TCE	Yes	1.01		µg/L	P	NA	NA	8260B
Water	TMPZ-1/MW-13S	GW-014-0716	22-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-10S	GW-02-0716	12-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-10S	GW-02-0716	12-Jul-16	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	MW-10S	GW-02-0716	12-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-10S	GW-02-0716	12-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-10S	GW-02-0716	12-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-01I	GW-03-0716	12-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-01I	GW-03-0716	12-Jul-16	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	MW-01I	GW-03-0716	12-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-01I	GW-03-0716	12-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-01I	GW-03-0716	12-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-01S	GW-04-0716	12-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-01S	GW-04-0716	12-Jul-16	PCE	Yes	1.56		µg/L	P	NA	NA	8260B
Water	MW-01S	GW-04-0716	12-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-01S	GW-04-0716	12-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-01S	GW-04-0716	12-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-07S	GW-05-0716	12-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-07S	GW-05-0716	12-Jul-16	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	MW-07S	GW-05-0716	12-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B

Appendix A-2. Analytical Data Used in Risk Assessment

Downtown Environmental Assessment Project, Montgomery, Alabama

Matrix	Station ID	Sample ID	Collection Date	COPC	Detect	Result	Qualifier	Result	Sample Type	Upper Depth (feet)	Lower Depth (feet)	Method
Water	MW-07S	GW-05-0716	12-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-07S	GW-05-0716	12-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-07I	GW-06-0716	12-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-07I	GW-06-0716	12-Jul-16	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	MW-07I	GW-06-0716	12-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-07I	GW-06-0716	12-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-07I	GW-06-0716	12-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-05I	GW-07-0716	14-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-05I	GW-07-0716	14-Jul-16	PCE	Yes	0.595	J	µg/L	P	NA	NA	8260B
Water	MW-05I	GW-07-0716	14-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-05I	GW-07-0716	14-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-05I	GW-07-0716	14-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-02S	GW-08-0716	13-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-02S	GW-08-0716	13-Jul-16	PCE	Yes	34.1		µg/L	P	NA	NA	8260B
Water	MW-02S	GW-08-0716	13-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-02S	GW-08-0716	13-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-02S	GW-08-0716	13-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-03S	GW-09-0716	13-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-03S	GW-09-0716	13-Jul-16	PCE	Yes	6.27		µg/L	P	NA	NA	8260B
Water	MW-03S	GW-09-0716	13-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-03S	GW-09-0716	13-Jul-16	TCE	Yes	0.566	J	µg/L	P	NA	NA	8260B
Water	MW-03S	GW-09-0716	13-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-08S	GW-10-0716	13-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-08S	GW-10-0716	13-Jul-16	PCE	Yes	78.4		µg/L	P	NA	NA	8260B
Water	MW-08S	GW-10-0716	13-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-08S	GW-10-0716	13-Jul-16	TCE	Yes	0.599	J	µg/L	P	NA	NA	8260B
Water	MW-08S	GW-10-0716	13-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-08I	GW-11-0716	13-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-08I	GW-11-0716	13-Jul-16	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	MW-08I	GW-11-0716	13-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-08I	GW-11-0716	13-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-08I	GW-11-0716	13-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-12I	GW-12-0716	13-Jul-16	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	MW-12I	GW-12-0716	13-Jul-16	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	MW-12I	GW-12-0716	13-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-12I	GW-12-0716	13-Jul-16	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	MW-12I	GW-12-0716	13-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	MW-12S	GW-13-0716	13-Jul-16	cis-1,2-DCE	Yes	0.268	J	µg/L	P	NA	NA	8260B

Appendix A-2. Analytical Data Used in Risk Assessment
Downtown Environmental Assessment Project, Montgomery, Alabama

Matrix	Station ID	Sample ID	Collection Date	COPC	Detect	Result	Qualifier	Result	Sample Type	Upper Depth (feet)	Lower Depth (feet)	Method
Water	MW-12S	GW-13-0716	13-Jul-16	PCE	Yes	58.9		µg/L	P	NA	NA	8260B
Water	MW-12S	GW-13-0716	13-Jul-16	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	MW-12S	GW-13-0716	13-Jul-16	TCE	Yes	0.414	J	µg/L	P	NA	NA	8260B
Water	MW-12S	GW-13-0716	13-Jul-16	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	CT-01-S	L891420-03	20-Feb-17	cis-1,2-DCE	No	0.26	U	µg/L	P	NA	NA	8260B
Water	CT-01-S	L891420-03	20-Feb-17	trans-1,2-DCE	No	0.396	U	µg/L	P	NA	NA	8260B
Water	CT-01-S	L891420-03	20-Feb-17	PCE	No	0.372	U	µg/L	P	NA	NA	8260B
Water	CT-01-S	L891420-03	20-Feb-17	TCE	No	0.398	U	µg/L	P	NA	NA	8260B
Water	CT-01-S	L891420-03	20-Feb-17	Vinyl Chloride	No	0.259	U	µg/L	P	NA	NA	8260B
Water	CT-01-S	L891420-04	20-Feb-17	cis-1,2-DCE	No	0.26	U	µg/L	FD	NA	NA	8260B
Water	CT-01-S	L891420-04	20-Feb-17	trans-1,2-DCE	No	0.396	U	µg/L	FD	NA	NA	8260B
Water	CT-01-S	L891420-04	20-Feb-17	PCE	No	0.372	U	µg/L	FD	NA	NA	8260B
Water	CT-01-S	L891420-04	20-Feb-17	TCE	No	0.398	U	µg/L	FD	NA	NA	8260B
Water	CT-01-S	L891420-04	20-Feb-17	Vinyl Chloride	No	0.259	U	µg/L	FD	NA	NA	8260B
Soil Vapor	AMS-01	AMS-01-0916	19-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-01	AMS-01-0916	19-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-01	AMS-01-0916	19-Sep-16	PCE	Yes	14.2		µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-01	AMS-01-0916	19-Sep-16	TCE	No	2.14	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-01	AMS-01-0916	19-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-02	AMS-02-0916	19-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-02	AMS-02-0916	19-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-02	AMS-02-0916	19-Sep-16	PCE	Yes	6.28		µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-02	AMS-02-0916	19-Sep-16	TCE	Yes	6.67		µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-02	AMS-02-0916	19-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-03	AMS-03-0916	20-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	14.8	15	TO-15
Soil Vapor	AMS-03	AMS-03-0916	20-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	14.8	15	TO-15
Soil Vapor	AMS-03	AMS-03-0916	20-Sep-16	PCE	Yes	9.68		µg/m3	P	14.8	15	TO-15
Soil Vapor	AMS-03	AMS-03-0916	20-Sep-16	TCE	No	2.14	U	µg/m3	P	14.8	15	TO-15
Soil Vapor	AMS-03	AMS-03-0916	20-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	14.8	15	TO-15
Soil Vapor	AMS-04	AMS-04-0916	20-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-04-0916	20-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-04-0916	20-Sep-16	PCE	Yes	9.37		µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-04-0916	20-Sep-16	TCE	No	2.14	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-04-0916	20-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-FD-0916	20-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	FD	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-FD-0916	20-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	FD	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-FD-0916	20-Sep-16	PCE	Yes	9.18		µg/m3	FD	11.8	12	TO-15
Soil Vapor	AMS-04	AMS-FD-0916	20-Sep-16	TCE	No	2.14	U	µg/m3	FD	11.8	12	TO-15

Appendix A-2. Analytical Data Used in Risk Assessment

Downtown Environmental Assessment Project, Montgomery, Alabama

Matrix	Station ID	Sample ID	Collection Date	COPC	Detect	Result	Qualifier	Result	Sample Type	Upper Depth (feet)	Lower Depth (feet)	Method
Soil Vapor	AMS-04	AMS-FD-0916	20-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	FD	11.8	12	TO-15
Soil Vapor	TMPZ-1/MW-13S	SV-TMPZ1-08	21-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	8	8	TO-15
Soil Vapor	TMPZ-1/MW-13S	SV-TMPZ1-08	21-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	8	8	TO-15
Soil Vapor	TMPZ-1/MW-13S	SV-TMPZ1-08	21-Sep-16	PCE	Yes	3.49		µg/m3	P	8	8	TO-15
Soil Vapor	TMPZ-1/MW-13S	SV-TMPZ1-08	21-Sep-16	TCE	No	2.14	U	µg/m3	P	8	8	TO-15
Soil Vapor	TMPZ-1/MW-13S	SV-TMPZ1-08	21-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	8	8	TO-15
Soil Vapor	VIMS-10	VIMS-10-0916	21-Sep-16	cis-1,2-DCE	Yes	88.6		µg/m3	P	10	10	TO-15
Soil Vapor	VIMS-10	VIMS-10-0916	21-Sep-16	trans-1,2-DCE	Yes	2.55		µg/m3	P	10	10	TO-15
Soil Vapor	VIMS-10	VIMS-10-0916	21-Sep-16	PCE	Yes	99.6		µg/m3	P	10	10	TO-15
Soil Vapor	VIMS-10	VIMS-10-0916	21-Sep-16	TCE	Yes	13100		µg/m3	P	10	10	TO-15
Soil Vapor	VIMS-10	VIMS-10-0916	21-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	10	10	TO-15
Soil Vapor	MW-12S	SV-MW12-08	21-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	7	8	TO-15
Soil Vapor	MW-12S	SV-MW12-08	21-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	7	8	TO-15
Soil Vapor	MW-12S	SV-MW12-08	21-Sep-16	PCE	Yes	23.3		µg/m3	P	7	8	TO-15
Soil Vapor	MW-12S	SV-MW12-08	21-Sep-16	TCE	Yes	3.56		µg/m3	P	7	8	TO-15
Soil Vapor	MW-12S	SV-MW12-08	21-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	7	8	TO-15
Soil Vapor	MW-08S	SV-MW08-08	22-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	7	8	TO-15
Soil Vapor	MW-08S	SV-MW08-08	22-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	7	8	TO-15
Soil Vapor	MW-08S	SV-MW08-08	22-Sep-16	PCE	Yes	493		µg/m3	P	7	8	TO-15
Soil Vapor	MW-08S	SV-MW08-08	22-Sep-16	TCE	Yes	336		µg/m3	P	7	8	TO-15
Soil Vapor	MW-08S	SV-MW08-08	22-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	7	8	TO-15
Soil Vapor	MW-02S	AMS-MW02-08	23-Sep-16	cis-1,2-DCE	No	1.59	U	µg/m3	P	7.8	8	TO-15
Soil Vapor	MW-02S	AMS-MW02-08	23-Sep-16	trans-1,2-DCE	No	1.59	U	µg/m3	P	7.8	8	TO-15
Soil Vapor	MW-02S	AMS-MW02-08	23-Sep-16	PCE	Yes	4940		µg/m3	P	7.8	8	TO-15
Soil Vapor	MW-02S	AMS-MW02-08	23-Sep-16	TCE	Yes	3.21		µg/m3	P	7.8	8	TO-15
Soil Vapor	MW-02S	AMS-MW02-08	23-Sep-16	Vinyl Chloride	No	1.02	U	µg/m3	P	7.8	8	TO-15

Notes:
cis-1,2-DCE = cis-1,2-Dichloroethene
COPC = chemical of potential concern
FD = Field Duplicate
J = result is estimated
P = Primary
NA = Not Applicable
PCE = Tetrachloroethene
TCE = Trichloroethene
trans-1,2-DCE = trans-1,2-Dichloroethene
U = Not detected
µg/L = microgram per liter
µg/m3 = microgram per cubic meter

Appendix A-3
Human Health Risk Assessment
VISL Calculator Worksheets

Site-specific VISL Results
Commercial Equation Inputs

*** Inputted values different from Commercial defaults are highlighted.**
Output generated 03MAY2018:21:39:32

Variable	Commercial Air Default Value	Value
AF_{gw} (Attenuation Factor Groundwater) unitless	0.001	0.001
AF_{ss} (Attenuation Factor Sub-Slab) unitless	0.03	0.03
AT_w (averaging time - composite worker)	365	365
ED_w (exposure duration - composite worker) yr	25	25
EF_w (exposure frequency - composite worker) day/yr	250	250
ET_w (exposure time - composite worker) hr	8	8
THQ (target hazard quotient) unitless	0.1	0.1
LT (lifetime) yr	70	70
TR (target risk) unitless	1.0E-06	1.0E-06

Commercial Vapor Intrusion Screening Levels (VISL)
User's Guide Variable References

Output generated 03MAY2018:21:39:32

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source? (C_{vp} > $C_{i,a}$,Target?)	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source? (C_{hc} > $C_{i,a}$,Target?)	Target Indoor Air Concentration (TCR=1E-06 or THQ=0.1) MIN($C_{ia,c}$,$C_{ia,nc}$) (µg/m^3)	Toxicity Basis
Tetrachloroethylene	127-18-4	Yes	Yes	Yes	Yes	1.75E+01	NC
Trichloroethylene	79-01-6	Yes	Yes	Yes	Yes	8.76E-01	NC

Chemical	Target Sub-Slab and Exterior Soil Gas Concentration (TCR=1E-06 or THQ=0.1) C_{sg},Target (µg/m^3)	Target Groundwater Concentration (TCR=1E-06 or THQ=0.1) C_{gw},Target (µg/L)	Is Target Groundwater Concentration < MCL? (C_{gw} < MCL?)	Pure Phase Vapor Concentration C_{vp} (25 ° C) (\µg/m^3)	Maximum Groundwater Vapor Concentration C_{hc} (\µg/m^3)	Temperature for Maximum Groundwater Vapor Concentration (° C)	Lower Explosive Limit LEL (% by volume)
Tetrachloroethylene	5.84E+02	2.42E+01	No (5)	1.65E+08	1.49E+08	25	
Trichloroethylene	2.92E+01	2.18E+00	Yes (5)	4.88E+08	5.15E+08	25	8.00

Chemical	LEL Ref	Inhalation Unit Risk (ug/m^3)$^{-1}$	IUR Ref	Chronic RfC (mg/m^3)	Chronic RfC Ref	Mutagenic Indicator	Carcinogenic VISL TCR=1E-06 $C_{ia,c}$ (µg/m^3)	Noncarcinogenic VISL THQ=0.1 $C_{ia,nc}$ (µg/m^3)
Tetrachloroethylene		2.60E-07	I	4.00E-02	I		4.72E+01	1.75E+01
Trichloroethylene	CRC89	4.10E-06	I	2.00E-03	I	Mut	2.99E+00	8.76E-01

Chemical Properties
Output generated 03MAY2018:21:39:32

Chemical	CAS Number	Does the chemical meet the definition for volatility? (HLC>1E-5 or VP>1)	Does the chemical have inhalation toxicity data? (IUR and/or RfC)	MW (g/mol)	MW Ref	Vapor Pressure VP (mm Hg)	VP Ref	Pure Component Water Solubility S (mg/L)	S Ref
Tetrachloroethylene	127-18-4	Yes	Yes	165.83	PHYSPROP	1.85E+01	PHYSPROP	2.06E+02	PHYSPROP
Trichloroethylene	79-01-6	Yes	Yes	131.39	PHYSPROP	6.90E+01	PHYSPROP	1.28E+03	PHYSPROP

Chemical	MCL (ug/L)	Henry's Law Constant @25° C (atm-m^3/mole)	Henry's Law Constant (unitless)	H`& HLC Ref	Henry's Law Constant Used in Calcs (unitless)	Air Diffusivity D_{ia} (cm^2/s)	D_{ia} Ref	Water Diffusivity D_{iw} (cm^2/s)	D_{iw} Ref	Normal Boiling Point T_{boil} (K)
Tetrachloroethylene	5	1.77E-02	7.24E-01	PHYSPROP	7.24E-01	5.05E-02	WATER9 (U.S. EPA, 2001)	9.46E-06	WATER9 (U.S. EPA, 2001)	394.45
Trichloroethylene	5	9.85E-03	4.03E-01	PHYSPROP	4.03E-01	6.87E-02	WATER9 (U.S. EPA, 2001)	1.02E-05	WATER9 (U.S. EPA, 2001)	360.35

Chemical	BP Ref	Critical Temperature T_{crit} (K)	T_{crit} Ref	Enthalpy of vaporization at the normal boiling point Δ$H_{v,b}$ (cal/mol)	Δ$H_{v,b}$ Ref	Organic Carbon Partition Coefficient K_{oc} (cm3/g)	K_{oc} Ref	Lower Explosive Limit LEL (% by volume)	LEL Ref
Tetrachloroethylene	PHYSPROP	6.20E+02	YAWS	8288.00	Weast	94.94	EPI		
Trichloroethylene	PHYSPROP	5.71E+02	YAWS	7505.00	Weast	60.7	EPI	8.00	CRC89

<h2>Inhalation Unit Risk Toxicity Metadata</h2>

Chemical	CASNUM	Inhalation Unit Risk (µg/m^{3})$^{-1}$	Toxicity Source	EPA Cancer Classification	Inhalation Unit Risk Tumor Type	Inhalation Unit Risk Target Organ	Inhalation Unit Risk Species
Tetrachloroethylene	127-18-4	2.60E-07	IRIS	likely to be carcinogenic in humans by all routes of exposure	Hepatocellular adenomas or carcinomas	liver	mouse
Trichloroethylene	79-01-6	4.10E-06	IRIS	carcinogenic to humans	Renal cell carcinoma, non-Hodgkin's lymphoma, and liver tumors	Kidney, Liver	human

Inhalation Unit Risk Method	Inhalation Unit Risk Route	Inhalation Unit Risk Treatment Duration	Inhalation Unit Risk Study Reference	Inhalation Unit Risk Notes
Multistage model with linear extrapolation from the point of departure (BMCL10), followed by extrapolation to humans using the PBPK model of Chiu and Ginsberg (2011)	NA	NA	JISA 1993	NA
LEC01	NA	NA	Charbotel et al. 2006, EPA 2011, Raaschou-Nielsen et al. 2003	NA

<h2>Inhalation Chronic Toxicity Metadata</h2>

Chemical	CASNUM	Chronic Inhalation Reference Concentration (mg/m³)	Toxicity Source	Inhalation Chronic Reference Concentration Basis	Inhalation Chronic Reference Concentration Confidence Level	Inhalation Chronic Reference Concentration Critical Effect	Inhalation Chronic Reference Concentration Target Organ	Inhalation Chronic Reference Concentration Modifying Factor
Tetrachloroethylene	127-18-4	0.04	IRIS	LOAEL3: Multiple	medium	Neurotoxicity (color vision) (reaction time, cognitive effects)	Nervous System	1
Trichloroethylene	79-01-6	0.002	IRIS	LOAEL (HEC99): 0.19 mg/m3	High	Decreased thymus weight in female B6C3F1 mice (immunotoxicity)	Thymus	1

Inhalation Chronic Reference Concentration Uncertainty Factor	Inhalation Chronic Reference Concentration Species	Inhalation Chronic Reference Concentration Route	Inhalation Chronic Reference Concentration Study Duration	Inhalation Chronic Reference Concentration Study Reference	Inhalation Chronic Reference Concentration Notes
1000	human	NA	NA	Echeverria et al. (1995) and Cavalleri et al. (1994)	NA
100	mice	NA	NA	Keil et al. 2009	NA

Appendix B
Correspondence from Capitol Trailways Regarding Discontinued Use of Water Supply Well

CAPITAL - COLONIAL - SOUTHERN
TRAILWAYS

520 North Court St.

Montgomery, AL. 36104

February 14, 2018

Mrs. Ashley Mastin

Alabama Department of Environmental Management

P.O. Box 301463

Montgomery, Al. 36130-1463

The well that is located at the Capital Trailways 520 North Court Street Montgomery, Alabama 36104 is no longer in use. The well was deactivated and taken out of service in February of 2017. Power lines and plumbing connected to the well have been removed and the water storage tank that the water was pumped into has also been removed. Capital Trailways has connected to the city water supply and will continue to wash our buses with the city water supply. The well was used only for washing buses and will not be used in any capacity in the future.

Regards,

Tom Fletcher

Tom Fletcher
President of Capital/Colonial Trailways