

May 21, 2013

Via E Mail and FedEx

Mr. Mostafa Mehran
Arkansas Department of Environmental Quality
5301 Northshore Drive
North Little Rock, AR 72118-5317

**Re: Whirlpool Corporation, Fort Smith, Arkansas
Revised Risk Management Plan**

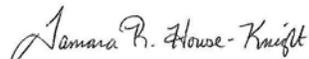
Dear Mr. Mehran:

ENVIRON International Corporation (ENVIRON) has prepared the attached Revised Risk Management Plan (RRMP) in accordance with the Letter of Agreement for ADEQ consideration. This further revised RRMP will replace the Risk Management Plan submitted on November 30, 2012. This RRMP takes into account ADEQ written comments and meetings with ADEQ to develop and implement an active site remedy.

The attached RRMP has also incorporated a revised Human Health Risk Assessment (HHRA) as an appendix. As requested by ADEQ during the March 19, 2013 meeting, the potential off-site drinking water pathway is addressed in this revised HHRA.

If you have any questions or comments please contact me at your earliest convenience.

Sincerely,



Tamara R. House-Knight, PhD
Senior Associate / Toxicologist

cc: Tammie Hynum - ADEQ
Robert Karwowski – Whirlpool Corporation



Revised Risk Management Plan FT. Smith, Arkansas

Prepared for:
Whirlpool Corporation
Benton Harbor, MI

Prepared by:
ENVIRON International Corporation
Little Rock, Arkansas

Date:
November 30, 2012
Revised April 8, 2013
Revised April 24, 2013
Revised May 21, 2013

Project Number:
2131344A

Executive Summary

Starting in 1989, investigations identified trichloroethylene (TCE) in soil and groundwater on the Whirlpool property above applicable screening criteria. No release events were reported during the operational history of the facility. As a result, the TCE is believed to have resulted from multiple small releases over time. The TCE plume, which extends off of the manufacturing site into the residential area, has been characterized and monitored through extensive sampling of groundwater on and off-site. There continues to be, no human health risk from the TCE release.

Interpretation of data collected to date indicates that TCE moved off-site into the residential area north of Ingersoll Avenue. The movement of TCE in the groundwater on-site to off-site was likely intermittent and facilitated by movement of precipitation through soils and into groundwater.

A Human Health Risk Assessment was completed in 2008 and again in 2012 documenting that off-site risk to residents is not present as long as the groundwater is not used for drinking water. All affected properties are connected to the municipal water provided by the City of Fort Smith. Because of that fact, there has been no human exposure to the TCE. Since discovery of the off-site TCE release, a priority for Whirlpool and the Arkansas Department of Environmental Quality (ADEQ) has been the prevention of any human or ecological exposure risk from the release. Early in the investigation process Whirlpool and ADEQ agreed there are no current human or ecological exposure pathways.

We are moving forward to address both on and off-site issues to meet ADEQ requirements and to address the community's concerns in the neighborhood north of Ingersoll Avenue. The holistic solution for the area including the Whirlpool facility incorporates commercial, human health, and ecological elements of which this Revised Risk Management Plan (RRMP) is a part.

The RRMP defines the technical elements of the solution for the on and off-site TCE impacted areas. It is an essential component of the overall solution. In addition, the document defines a multi-component corrective measure to meet United States Environmental Protection Agency (USEPA) drinking water standards in the neighborhood to the north of Ingersoll Avenue and on the Whirlpool property. After ADEQ review and approval, the plan will be submitted for input in a public meeting and during a 30 day written comment period. Whirlpool will address questions raised and/or clarify comments to the ADEQ for consideration in the final approval of the RRMP.

After ADEQ approval, Whirlpool will immediately begin implementation of the corrective measure to treat TCE in groundwater to achieve concentrations less than the USEPA Maximum Contaminant Level (MCL) for TCE in drinking water in the neighborhood and on-site.

Using industry best practices as a model, a combination of 1) off-site targeted in situ (or "in-place") chemical oxidation 2) on-site targeted in situ chemical oxidation 3) on and off-site monitored natural attenuation and 4) on and off-site institutional controls is the most effective and proven remedy to achieve MCLs. (See Figure 7) This corrective measure will remove the largest amount of TCE in the shortest period of time, thereby allowing naturally occurring processes already documented to be present, but currently inhibited by higher concentrations of TCE, to more efficiently decrease the remaining TCE in groundwater to less than MCLs.

Use of institutional controls will eliminate potential for accidental exposure to impacted soil and groundwater until the remedial action criteria are met. When all goals are met, the institutional controls can be retired because they will no longer be needed. These combined corrective measures will substantially reduce risks to human health, mobility, and volume of the source in a shorter period of time than any other single technology.

To meet corrective action objectives including reduction of concentrations of TCE both off and on-site, this RRMP reviews available proven remedial technologies and systematically screens them to identify the best corrective action. The screening process first outlines the individual technologies with a general description of each corrective measure independent of the Whirlpool site conditions (Section 2.6).

The RRMP describes the corrective measure as a stand-alone technology without site specific bias before moving onto the screening steps. The progressive screening steps then evaluate each corrective measure against the known site conditions. Site characteristics which may enhance or limit a corrective action at the site include: the presence of a thick (approximately 20 foot) layer of predominantly clay/silt underlain by a gravelly/sand layer (approximately 5 feet thick); the limited presence of this gravelly/sand layer off-site; a flat, very slow moving groundwater flow between the on-site source area and off-site areas, land uses, the presence of structures, residences, roads, buried utilities and a power substation; and the variable depth of TCE impact below the ground surface across the entire impacted area.

The RRMP then defines the criteria used to further evaluate corrective measures retained from the initial screening process. The criteria used in this secondary corrective measures evaluation include: protection of human health and the environment; short term effectiveness; long term effectiveness; reduction of toxicity, mobility, or volume; implementability, cost, and community acceptance. Only after all of these criteria are reviewed against the technologies is the final remedy chosen which, given the site conditions and constraints, is the highest rated corrective measure based on sound science using proven technologies that is also protective of human health and the environment.

The chosen corrective measure defined by this RRMP includes off-site and on-site chemical oxidation to rapidly reduce the mass of TCE present in the highest concentration areas. The interim measures previously completed have shown that chemical oxidation works effectively to reduce TCE concentrations when applied at the appropriate locations. Due to the nature of on and off-site soils, the oxidant needs to be injected directly into the high concentration areas where the appropriate lithology is present and not rely solely on groundwater movement to disperse the oxidant throughout the plume.

The chosen corrective measure also includes on and off-site monitored natural attenuation. The years of data indicate TCE is being degraded naturally. The targeted, phased, chemical oxidation off and on-site will substantially reduce TCE concentrations. When the high concentration areas of TCE are substantially reduced, natural attenuation can continue to degrade the remaining lower TCE concentrations in groundwater.

For added protection, the chosen corrective measure includes use of institutional controls to legally limit the potential exposure to TCE in the impacted areas while the corrective measure

reduces TCE concentrations to below applicable criteria. The institutional controls provide added protection to everyone in the neighborhood to the north of Ingersoll Ave and on the Whirlpool property while the implementation moves forward.

Contents

	Page
Executive Summary	
1 Introduction	1
1.1 Background and Objectives	1
1.1.1 General Site Description	1
1.1.2 Site Operations	1
1.1.3 Summary of Previous Site Assessments and Risk Evaluations	2
1.2 Objectives and Technical Approach	4
2 Remedy Selection	5
2.1 Introduction and Purpose	5
2.2 Description of Site Conditions	5
2.2.1 On-Site Current Conditions	5
2.2.2 Off-Site Current Conditions	6
2.3 Conceptual Site Model	7
2.3.1 Potential Human Exposure Pathways	7
2.4 Corrective Action Objective	7
2.5 Remedial Action Criteria	7
2.6 Identifying and Screening of Corrective Measures	7
2.6.1 No Action	8
2.6.2 Containment	8
2.6.3 Removal	10
2.6.4 In Situ Treatment	12
2.6.5 Institutional Controls	15
2.6.6 Summary of Corrective Measures Retained for Further Analysis	16
3 Evaluation of Remedy Alternatives	21
3.1 Overall Protection of Human Health and the Environment	21
3.1.1 Monitored Natural Attenuation	21
3.1.2 Enhanced In Situ Biodegradation	21
3.1.3 In Situ Chemical Oxidation	21
3.1.4 Permeable Reactive Barrier	22
3.1.5 Institutional Controls	22
3.2 Short-Term Effectiveness	22
3.2.1 Monitored Natural Attenuation	22
3.2.2 Enhanced In Situ Biodegradation	22
3.2.3 In Situ Chemical Oxidation	23
3.2.4 Permeable Reactive Barrier	23
3.2.5 Institutional Controls	23
3.3 Long-Term Effectiveness	23
3.3.1 Monitored Natural Attenuation	23
3.3.2 Enhanced In Situ Biodegradation	24
3.3.3 In Situ Chemical Oxidation	24
3.3.4 Permeable Reactive Barrier	24

3.3.5	Institutional Controls	24
3.4	Reduction of Toxicity, Mobility, or Volume	24
3.4.1	Monitored Natural Attenuation	24
3.4.2	Enhanced In Situ Biodegradation	24
3.4.3	In Situ Chemical Oxidation	24
3.4.4	Permeable Reactive Barrier	24
3.4.5	Institutional Controls	24
3.5	Implementability	25
3.5.1	Monitored Natural Attenuation	25
3.5.2	Enhanced In Situ Biodegradation	25
3.5.3	In Situ Chemical Oxidation	25
3.5.4	Permeable Reactive Barrier	25
3.5.5	Institutional Controls	26
3.6	Cost	26
3.7	Community Acceptance	27
3.7.1	Monitored Natural Attenuation	27
3.7.2	Enhanced In Situ Biodegradation	27
3.7.3	In Situ Chemical Oxidation	27
3.7.4	Permeable Reactive Barrier	27
3.7.5	Institutional Controls	27
4	Risk Management Plan	28
4.1	Final Remedy Selection	28
4.1.1	Final CSM – Exposure Pathways	30
4.2	Performance Criteria	32
4.2.1	Performance Monitoring	32
4.3	Contingency Plans	33
4.4	Performance Reviews	33
4.4.1	Quarterly	33
4.4.2	Annual Monitoring Report	33
4.4.3	Five-Year Review	34
4.5	Public Involvement Plan	34
4.6	Proposed Schedule and Completion of CAS Program	35
5	References	36

Contents

List of Tables

Table 1:	Corrective Action Measure Summaries
Table 2:	Remedial Alternatives Array / Summary
Table 3a:	Potential Action Specific ARARs- Applicable or Relevant Appropriate Requirements
Table 3b:	Potential Chemical Specific ARARs
Table 3c:	Potential Location Specific ARARs
Table 4:	Cost Summary of Screened Alternatives

List of Figures

Figure 1:	Site Location Map
Figure 2:	Site Layout
Figure 3:	Limits of Impacted Soil Not Saturated
Figure 4:	Limits of CVOCs in Groundwater – Spring 2012
Figure 5:	CSM Scenarios for Potential Human Exposure
Figure 6:	CSM Scenarios for Potential Human Exposure after Remedy Implementation
Figure 7:	Preliminary Conceptual Remedy Layout

List of Appendices

Appendix A:	Human Health Risk Assessment
-------------	------------------------------

Acronyms and Abbreviations

ADEQ	Arkansas Department of Environmental Quality
ARARS	Applicable or Relevant Appropriate Requirements
cis-1,2-DCE	cis-1,2-dichloroethylene
COC	constituent of concern
CSM	conceptual site model
CVOC	chlorinated volatile organic compounds
1,1-DCE	1,1-dichloroethylene
HHRA	human health risk assessment
HI	hazard index
ISCO	in situ chemical oxidation
MCL	maximum contaminant level (USEPA)
MNA	monitored natural attenuation
Off-site	not Whirlpool owned property
On-site	Whirlpool owned property - fenced property as well as property along the north right of way along Ingersoll Ave
OSHA	Occupational Safety and Health Administration
PCE	tetrachloroethylene
RADD	Remedial Action Decision Document
RER	Risk Evaluation Report
RMP	Risk Management Plan
RRMP	Revised Risk Management Plan
TCE	Trichloroethylene
trans-1,2-DCE	trans- 1,2-dichloroethylene
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

1 Introduction

1.1 Background and Objectives

ENVIRON International Corporation (ENVIRON) has prepared this Revised Risk Management Plan (RRMP) on Whirlpool's behalf and at the request of ADEQ. The intent of this RRMP is to assimilate over 15 years of data collected during investigation of the plume and from implementation of interim measures to reduce the impacts of the plume. The RRMP utilizes all data to identify and select a corrective measure that is protective of both human health and the environment.

All investigation activities to date show the TCE impacts to soil and groundwater are limited to the vicinity of the north manufacturing areas and to a limited extent the residential neighborhood to the north. Together the Whirlpool property and the affected residential neighborhood to the north are herein referred to as "the Site". The Whirlpool property extends to the northern right-of-way of Ingersoll Avenue. Based upon investigation activities to date, there is no known impact from TCE to the south, east or west of the current Whirlpool facility boundaries. The delineated TCE impact to the north is limited to groundwater with no known soil impact. The boundary of the impacted groundwater plume has not moved in the past eight years. There has been no pathway of exposure resulting in human impact identified. It is important that the RRMP is designed to continue to assure the community that no pathways to human exposure exist and that none are created in the future.

1.1.1 General Site Description

The Whirlpool Fort Smith site is located at 6400 Jenny Lind Road on the south side of Fort Smith, Arkansas (Figure 1). The site manufactured side-by-side household refrigerators and trash compactors. The site had been operated by Whirlpool for over 45 years and ceased production in June 2012.

The property (approximately 153 acres) consists of the main manufacturing building (approximately 1.3 million square feet), separate warehouse and administrative offices, and undeveloped land (approximately 21 acres) (Figure 2). Additional buildings located on the north side of the property include a water treatment plant and a boiler house. The majority of the property surrounding the buildings consists of concrete or asphalt service roads and parking areas. Some gravel parking areas are also present.

NOTE: In addition to the fenced areas of the property, Whirlpool owns property along the north side of the Ingersoll Road right of way. The fenced property as well as property along the north side of the Ingersoll Road right of way is include in the term "On-Site" for purposes of this RRMP.

1.1.2 Site Operations

The manufacturing processes at the Whirlpool-Fort Smith property involved metal fabricating, plastic thermoforming, and assembly operations. As required by the Resource Conservation and Recovery Act (RCRA), all storage of hazardous waste containers was limited to 90 days or less; no hazardous waste treatment activities were conducted on-site. Constituents in the soil

and groundwater identified during investigations are the result of historical practices prior to 1981, as described below; however, no specific, discreet source for the release of TCE to the environment has been determined or identified during the investigation.

From approximately 1967 to 1981, a vapor degreasing system using trichloroethylene (TCE) was operated in the former degreaser building, which is located near the northwestern corner of the main manufacturing building, west of the boiler house (Figure 2). The degreasing equipment consisted of an open-top TCE tank with a parts rack above the tank and associated process control equipment. The degreasing operations involved placing parts into the parts rack which was positioned over the tank and then heating the TCE tank to create a TCE vapor. The TCE vapor would rise and cover the parts on the parts rack. After the TCE vapor passed above the parts rack, chillers would cool the vapor, causing the vapors to condense and drop back into the TCE tank below the parts rack.

The use of TCE was discontinued in 1981. There are no historical records that document any spills or other release incidents from the degreaser building.

A series of soil and groundwater investigations were conducted starting in 1989 (see section 1.1.3) at the site as part of a project to remove underground storage tanks previously containing fuel oil and heating oil. There was no release of petroleum hydrocarbons from the underground storage tank. However the analytical data showed the presence of TCE and other solvents in groundwater. A series of investigations, including soil sampling to assess the potential source area have been conducted (see section 1.1.3) to define (delineate) affected soil and groundwater. Based on the known historical manufacturing processes and the data from the investigations completed, the primary constituent of concern (COC) is TCE. However, tetrachloroethylene (PCE) and TCE daughter products including cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and vinyl chloride resulting from the natural degradation (natural attenuation) of PCE and TCE have also been documented in monitoring wells.

1.1.3 Summary of Previous Site Assessments and Risk Evaluations

To address the impacts from historical releases, Whirlpool entered into a Letter of Agreement with the Arkansas Department of Environmental Quality (ADEQ), dated July 19, 2002 (ADEQ 2002). Under the Letter of Agreement, Whirlpool is following the United States Environmental Protection Agency's (USEPA's) Corrective Action Strategy, which includes the development of a conceptual site model (CSM), describing environmental conditions at the site. To date, Whirlpool has submitted the following documents to ADEQ as required by Items F and G, of the Letter of Agreement:

Item F – Risk Management Strategy Corrective Action and Reporting Requirements:

- Notice of Intent August, 2002
- Scoping Meeting August, 2002
- RMS Work Plan August, 2002
- Corrective Action Strategy June, 2004

- Corrective Action Strategy Work Plan Addendum August, 2006
- Facility Activities September, 2006
- Risk Evaluation Report June, 2007
- Remedy Selection March, 2008
- Risk Management Plan (RMP) March, 2008
- Annual Groundwater Monitoring Report June, 2012
- Revised Risk Management Plan (RRMP) November 30, 2012
- Revised Risk Management Plan (RRMP) April 8, 2013
- Revised Risk Management Plan (RRMP) April 24, 2013

Item G – Interim/Stabilization Measures:

- Interim Measure Work Plan March, 2008
- Interim Measure Status Report February, 2010
- Interim Measure Status Report July, 2010

Results of the various investigations are included in a series of reports listed below:

- Supplemental Site Investigation, December 2000
- On-Site ChemOx Pilot Study Report, August, 2002
- Conceptual Site Model (CSM) Report, August 2002
- CSM Report Addendum, August 2002
- CAS Work Plan, June 2003
- Off-Site Delineation Phase A (installation and sampling of three off-site wells), July 2003
- Off-Site Delineation Phase B (ten Geoprobe™ borings, membrane interface probe field screening, and installation and sampling of four off-site wells), November 2003
- Interim Status Report and Revised CAS Work Plan, June 2004
- Off-Site Delineation Phase C (seven Geoprobe™ borings and installation and sampling of four off-site wells), November 2004
- Interim Status Report for Off-Site Investigations, March 2005
- Off-Site Delineation Phase D (five Geoprobe™ borings and installation and sampling of four off-site wells), April 2005
- Interim Status Report for Off-Site Investigations, June 2005
- Off-Site Delineation Phase E (installation and sampling of two off-site monitoring wells), April 2006

- Soil Gas Investigation Report (Installation and sampling of two nested soil gas monitoring points) June 2012

In addition to the above reports, a series of annual groundwater monitoring reports have been produced by environmental professionals for Whirlpool since March 2000 documenting the results of semiannual groundwater sampling events. The last semiannual groundwater monitoring event was conducted during September 2012. These reports document the impacted groundwater is predominantly contained within dense subsurface strata and the boundary of impacted groundwater has not grown for over eight years. The off-site impacted groundwater boundary has not changed and no pathways to human exposure have been identified or experienced.

All of these investigations, reports, and monitoring events were used to create a full understanding of the site background, delineate Constituents of Concern (COCs) in soil and groundwater, evaluate potential exposure pathways for the risk assessment, and determine a corrective measure, all of which are detailed in this RRMP.

1.2 Objectives and Technical Approach

An RMP for the site was submitted to ADEQ in March of 2008. At that time, ADEQ approved of the interim measures contained within the RMP. Since that time, Whirlpool completed additional investigations and implemented two interim measure pilot studies (see section 1.1.3.). These activities have provided additional, site specific data that led Whirlpool to re-evaluate the site strategy and associated final remedy defined in the 2008 RMP. Therefore, at the request of ADEQ, ENVIRON International Corporation (ENVIRON) has prepared this RRMP on Whirlpool's behalf. The intent of this RRMP is to assimilate over 15 years of data, with an emphasis on data collected since 2008 from the interim measures, to identify and select a corrective measure that is protective of human health and the environment. The final remedy choice will consider the documented site-specific conditions identified during the on-site chemical oxidation bench scale and pilot studies, off-site interim measures and derived effectiveness determinations based on the data. As required by the Letter of Agreement, the remedy selection process has been conducted "in general accordance with the remedy evaluation standards and general decision factors contained in Chapter IV of the *EPA guidance document entitled RCRA Corrective Action Plan (Final)*, May 1994..." (USEPA 1994).

The objective of this RRMP is to present a current Conceptual Site Model, define remedial action criteria, screen and select a corrective measure (or combination of corrective measures) that will meet the remedial action criteria, establish performance monitoring criteria, and present a schedule for implementation. The Conceptual Site Model (CSM) presented in this RRMP has evolved to incorporate new information available since the previous CSM presented in the *Risk Evaluation Report (RER; 2007)*. Whirlpool did not revise the Risk Evaluation Report as part of this submittal. However, ENVIRON has completed a human health risk assessment (HHRA) that incorporates all site data and is consistent with current risk assessment practices and guidance. The HHRA (2012) is presented as Appendix A.

2 Remedy Selection

2.1 Introduction and Purpose

The purpose of the remedy selection process is to identify and screen potential corrective measures for consideration at the site. The potential corrective measures in this RRMP are hypothetical and listed only by way of performing a complete analysis of remedies. The fact that a potential corrective measure or remedial alternative is listed in this report is not intended to suggest that it is appropriate for implementation at this site. Based on the selection process it stands to reason that many of these "potential corrective measures" are inappropriate for implementation when this site's specific conditions are applied. RMPs subject technologies to a rigorous screening review and evaluation against criteria so that the best corrective measure to implement is determined.

This RRMP evaluates each potential corrective measure for its relative appropriateness and practicability to meet a goal that is protective of human health and the environment. As shown on Figures 3 and 4, impacted soil and groundwater are present within the fenced boundary of the Whirlpool site (on-site¹), and impacted groundwater is present beneath a portion of the residential area north of the site (off-site; north of Ingersoll Avenue). Given the nature of the impacted media and differences in land use, there are variations in hypothetical potentially complete exposure pathways for on-site versus off-site areas (Figure 5). As a result, the RRMP evaluates corrective measure for both on-site and off-site areas.

2.2 Description of Site Conditions

The Conceptual Site Model (CSM) characterizes the site conditions and summarizes the basis for the hypothetical exposure pathways evaluated in the HHRA. Key components of the CSM include actual and potential land use and exposure based on physical, release and risk management profiles on-site and off-site. A summary of the current site conditions is provided below in section 2.2.1.

2.2.1 On-Site Current Conditions

Whirlpool manufactured refrigerators and trash compactors at the site until June 2012. There are currently no on-site manufacturing operations.

Future site activities will be restricted to nonresidential (commercial and/or industrial) uses through restrictive covenants to be recorded with the property deed(s). It is presumed all future uses at the site will be nonresidential.

Based on the data collected to date, the known area of impacted soil is within the property boundaries and security fencing (Figure 3) and thus entirely on-site. Impacted soils, while not heavily impacted, are localized to the area immediately to the west of the former degreaser

¹ In addition to the fenced areas of the property, Whirlpool owns property along the north side of the Ingersoll Road right of way. The fenced property as well as property along the north side of the Ingersoll Road right of way is included in the term "On-Site" for this RRMP.

building where elevated concentrations of TCE were detected in groundwater. The area of impacted soil is an approximately 50 by 250-foot area west of the former degreaser building.

TCE is thought to have migrated through fractures in the silt/clay soil eventually encountering the permeable sand/gravel soil above the shale bedrock which served as a preferential migration pathway for TCE.

The highest impact of TCE in groundwater on-site has been identified at MW-25 near the northwestern corner of the building. Additional higher levels of impact (great than 10 mg/L of TCE) have been identified at ITMW-19. Together these two points currently constitute the heart of the source area on-site.

The groundwater plume extends approximately 1,000 feet to the south southwest from the source and to the north across Ingersoll Avenue (Figure 4). The southern boundary of affected groundwater remains on-site in this direction. There are no known off site groundwater impacts to the east, south or west of the Whirlpool property boundaries.

2.2.2 Off-Site Current Conditions

Land use down-gradient (north) of the site is residential. Residential properties to the north include both single-family and multifamily homes. A recreational facility is located over 500 feet northeast of the Whirlpool property boundary, adjacent to the residential area. No agricultural properties are located in the vicinity of the site. Discussion concerning properties to the east, south and west are not incorporated into the RRMP since they have no impact from the site.

Groundwater with detected concentrations of TCE above USEPA drinking water criteria maximum contaminant levels (MCLs) extends into the residential neighborhood north of the site. There are no known soil or groundwater impacts off-site to the east, west or south. The recreational facility to the northeast is located over 1,000 feet east of the impacted groundwater area. The extent of the off-site groundwater plume is shown on Figure 4. While the transmissive zone is mostly comprised of clayey material, the gravel-containing zone contains some gravel and sandy gravel that varies in thickness from about 6 to 7 feet near the source area on-site and thins to be nonexistent immediately north of Jacobs Avenue as identified on existing boring logs. The higher TCE concentrations in groundwater are generally limited to a gravel-containing portion of the transmissive zone. Additional details on the site geology and hydrogeology are documented in multiple previous reports and work plans (section 1.1.3).

The current understanding of site lithology, contaminant concentration, and groundwater flow pathway together identify that groundwater from the source area (as defined above in 2.2.1) is likely not flowing directly north/northeast into the residential area. However given the flat groundwater elevation of the area around Ingersoll Ave, groundwater may potentially be flowing from the dissolved phase plume (i.e. areas located within the groundwater plume not associated with the source area) northwest of MW-25, past Ingersoll Avenue, and into the residential neighborhood. High precipitation events have the potential to alter this flow path as well as the presence of the groundwater divide just south of Ingersoll Avenue.

All potable water used by the Whirlpool facility and the surrounding area's residents is provided by the municipal water system. There are currently no uses of groundwater within or near the impacted groundwater. However, there is no ordinance or restriction prohibiting groundwater use in the impacted area at this time.

2.3 Conceptual Site Model

2.3.1 Potential Human Exposure Pathways

All potential human exposure pathways are evaluated in the Human Health Risk Assessment (Appendix A). The Human Health Risk Assessment contained within this RRMP validates all previous assertions by the ADEQ and Whirlpool that no exposure risk associated with the TCE release is present.

2.4 Corrective Action Objective

Based on the results from the HHRA, the corrective action objectives for the site are as follows:

- Eliminate or reduce the lateral extent or concentration of the groundwater plume both off-site and on-site.
- Eliminate or reduce the potential for unacceptable risk that may result if there are future changes in land or groundwater uses either off-site or on-site.

2.5 Remedial Action Criteria

As summarized in the HHRA (Appendix A), under current land uses, potential exposures to VOCs detected in on-site soil and off-site groundwater do not present potentially significant risks to the evaluated receptors. However, under current site conditions, potential risks could exist for the routine worker, maintenance worker, and construction worker if exposed to on-site groundwater as presented in the Human Health Risk Assessment (Appendix A).

If wells are installed in the area of impacted off-site groundwater, potentially significant exposures could result from use of the groundwater as a potable source. Therefore, the remedial action criterion for on-site groundwater is to reduce concentrations in groundwater at the source to meet risk limits and reduce or eliminate the source to the off-site groundwater plume which will ultimately reduce the concentrations in off-site groundwater. The remedial action criterion for off-site groundwater is intended to prevent the use of groundwater that has TCE concentrations that exceed the MCLs until those concentrations decrease to levels that are at or below MCLs.

2.6 Identifying and Screening of Corrective Measures

To develop a plan to address the impacted soil and groundwater at the site, multiple corrective measure options were identified. Each corrective measure was evaluated on a screening-level basis to assess whether the measure should be retained for more detailed consideration.

The potential corrective measures are grouped into one of five categories:

1. No Action

2. Containment
3. Removal
4. In Situ (In Place) Treatment
5. Institutional Controls

A description of each category and the specific technologies within the categories are presented below along with the discussion of how the corrective measures were screened. Corrective measures eliminated from further consideration are noted, along with the reasons for their elimination. In general, corrective measures that were eliminated are those which:

- are not currently available commercially;
- have not been proven to be effective on similar COCs;
- have been proven to be less effective than other technologies that could achieve the same results: or
- are technically impracticable due to surface and subsurface conditions, characteristics or uses.

It should be noted that some technologies must be combined to address the site conditions. Table 1 summarizes the technologies considered for each of the above general measures. The general measures are further discussed in the following sections. Table 2 presents an alternatives array to provide a summary overview of corrective measures and associated screening.

2.6.1 No Action

The No Action measure represents a baseline against which other alternatives are compared. This measure would entail continuation of the current groundwater monitoring program but with no remedial activities to address affected soil or groundwater, either on-site or off-site. This measure would not limit risk posed by COCs.

Screening of the No Action Corrective Measure

The No Action measure is screened out from further consideration because it would not address the potential risks associated with affected groundwater if a potable water well were to be installed, either off-site or on-site. No Action will not reduce COC concentrations, control mobility, or reduce the extent of impacted media.

2.6.2 Containment

Containment involves placing a physical barrier to control movement of COCs, thereby providing a means to reduce or eliminate an exposure pathway. Containment technologies can isolate soil and/or groundwater, and are separated into two groups:

- Horizontal barriers (Caps, Covers)
- Vertical barriers (Wall)

2.6.2.1 Horizontal Barriers

Horizontal barriers prevent contact between impacted surface soil and surface water runoff, thereby reducing the potential for COC migration via infiltration into groundwater. The barriers (in the form of caps or covers) may also be engineered to prevent human exposure to impacted soil and to limit vapor migration.

Much of the on-site area where impacted soil is present is currently covered by asphalt and concrete, both are very effective horizontal barriers, thereby capping the contaminated soils to prevent rainwater infiltration that may cause continued leaching of COCs from impacted soils into groundwater. Continued regular maintenance of the existing caps or covers (asphalt and concrete) will reduce the potential for future leaching of COCs from the impacted soil to groundwater. The limited areas where impacted on-site soil is not currently capped or paved (in the northwestern portion of the main building) could be paved to increase the effective surface area of cap/cover. Impacted soil is not present off-site; therefore, applying a horizontal barrier as a corrective measure off-site is unnecessary and will have no benefit.

Horizontal barrier technologies include

- topsoil/clay and vegetative covers;
- asphalt covers;
- concrete covers; and
- soil covers with synthetic/geotextile composite liner.

2.6.2.2 Vertical Barriers

Vertical barriers are typically used to limit or redirect the lateral flow of groundwater from or around an impacted area, to isolate impacted subsurface soil, or to contain an impacted groundwater plume. Such barriers are generally keyed into an existing confining layer. For the Whirlpool site, vertical barriers would have to be keyed into the lower McAllester Shale at a depth of about 35 to 40 feet below ground surface depending on location. Depth to water, depth to the key layer, soil type, and the potential presence of gravel or flowing sand are important data for determining whether a vertical barrier is technically feasible for final design. Prior to final design, a series of geotechnical soil borings would need to be drilled on 20 to 50-foot intervals along the proposed barrier trench centerline to obtain detailed stratigraphic information and other required design data. Compatibility testing may be required to evaluate the impact of COCs on the permeability of the barrier material. Construction of vertical barriers requires a significant surface working area, typically at least 50-ft wide, along the entire length of the barrier which would limit its installed footprint at this site given the location of structures, subsurface utilities, electric power substation and Ingersoll Avenue. A significant material mixing area and staging area(s) would also be needed.

Vertical barrier technologies include

- slurry wall;

- cement-bentonite cutoff wall;
- grout curtain;
- sheet pile wall; and
- interceptor trenches and recovery well systems.

Screening of the Containment Corrective Measure

A containment-based corrective measure would not remove the impacts from the site but would provide protection of human health and the environment by reducing further migration of or exposure to COCs in soil and/or groundwater. Containment technologies are proven, commercially available, and generally readily implemented. Due to the highly intrusive nature of the construction method, residential areas with homes and underground utilities are generally not good candidates for this type of control. Also given the location of the OG&E utility substation, the placement of a vertical barrier on-site is not implementable as the barrier would need to extend into this parcel in order to fully intercept the plume with the appropriate safety factor.

Capping of impacted on-site soil is a feasible option, however it will not reduce or effectively manage the COCs within the source zone as groundwater will continue to move through the subsurface. This option is effective at reducing the amount of surface runoff and precipitation that could contribute to additional groundwater movement. While this option is effective and technically feasible it does not address the mass of contaminants in the source zone and as such is not considered to be an active remedy. An active remedy is required to effectively reduce concentrations and associated risk in a short timeframe, therefore, at this time; this measure is removed from further consideration. This measure may be re-evaluated at a later date after an active remedy has been implemented as this measure may assist in addressing the residuals of the active remedy.

The use of vertical barriers is removed from further consideration because the physical space constraints (buildings, subsurface features, and subsurface utilities, in addition to the OG&E substation parcel) preclude the possibility of ensuring the plume will be fully intercepted on-site. The potential off-site use of a vertical barrier is also not reasonable as not only would it not treat the contaminants but specific off-site properties would need to be obtained in order to fully intercept the plume. Accordingly, vertical barriers would not reduce the risk posed by TCE. Therefore the use of vertical barriers, both on and off-site is removed from further consideration.

2.6.3 Removal

Removal of impacted soil or groundwater involves excavation or collection of the media for treatment or disposal. Removal technologies must be combined with a treatment or disposal technology to form a complete corrective measure. Treatment technologies will be addressed as part of the design specification if this measure is chosen and will not be discussed as part of this RRMP.

Two proven removal technologies were considered as potentially applicable for the Whirlpool site:

2.6.3.1 Soil Excavation

Excavation is a proven technology for direct mass of COC removal and is generally technically feasible for small to moderate soil volumes. Excavation achieves a direct means of reducing the amount of COC mass which could pose a risk to human health or act as a source of COC's to other media (e.g., groundwater). An alternative to mass excavation is targeted area excavations at areas with higher COC concentrations ("hot spots"), if localized high COC concentrations in soil were identified on-site.

2.6.3.2 Groundwater Extraction

Groundwater extraction is a removal technology that is also sometimes applied with a barrier control technology. Groundwater extraction removes groundwater to prevent or control down-gradient migration, which results in removal of dissolved COCs from the impacted transmissive zone. Groundwater extraction is not generally effective in fully restoring groundwater to residential or industrial cleanup standards. However, as an independent corrective measure or when coupled with additional remedial options, it may provide adequate protection from potential exposure pathways.

Groundwater may be extracted using either extraction trenches or extraction wells (including vertical, horizontal, and directionally drilled wells). An extraction trench is an open trench that is designed to collect and convey liquid discharges by gravity flow in a manner similar to a French drain. The trench could be installed in any of three basic configurations:

1. To intercept a plume down-gradient of the leading edge
2. In conjunction with a groundwater cutoff barrier to prevent buildup of groundwater up-gradient of the barrier
3. As a more active withdrawal system where drain(s) are installed within the groundwater plume perpendicular to the direction of groundwater flow.

Like vertical barriers discussed in the previous section, extraction trenches must be keyed into a suitable confining layer. Impacted groundwater can also be extracted from the ground by a system of extraction wells designed to control groundwater flow in a specific area and to remove dissolved and residual COC mass from the impacted transmissive zone. In addition, recovery wells may be used in conjunction with a physical vertical barrier to prevent hydraulic mounding behind the barrier.

Groundwater extraction can reduce dissolved phase concentrations in groundwater.

2.6.3.3 Screening of the Removal Corrective Measure

The removal measure for both soil and groundwater is a proven remedial approach. However, available on-site soil data shows that COCs are not present in concentrations of great concern in soil. The area at the site that would be targeted for soil removal is located between multiple buildings which limit the technical practicability of an active removal action. The presence of groundwater at approximately 10 to 12 feet below ground surface also limits the technical practicability of a removal action due to extensive saturated soil handling, dewatering before disposal. Because soil impacts have not been identified on-site at high TCE concentrations and

various site constraints limit the feasibility and effectiveness of soil removal, it is removed from further consideration.

Groundwater pumping and treatment is the USEPA's presumptive corrective measure for volatile organic carbon (VOC) impacted groundwater. Furthermore, groundwater removal (via pumping and treatment) has the technical ability to reduce COC concentrations within the more transmissive portions of the gravel aquifer, providing near-term protection to off-site residents. However subsurface geological conditions, area hydrogeological characteristics, depth to substantial COC mass, off-site current land use and physical limitations in the residential area limit the ability to install sufficient extraction trench as well as the number of extraction wells that could be installed. Long-term pumping tests conducted during the interim measure indicated the radius of influence of a recovery well and its ability to remove constituent mass in areas outside of the more transmissive portions of the gravel portions aquifer would be low (see section 1.1.3.) Thus, long-term pumping has a low probability of meeting the remedial action criteria. In addition, the presence of substantial buried utilities along Ingersoll Avenue and in the residential area may limit installation and effectiveness of a trench. Therefore, removal via groundwater extraction is removed from further consideration.

2.6.4 In Situ Treatment

In situ (in place) treatment technologies treat the subsurface soil and groundwater to reduce constituent mass and concentrations without removing the impacted media. The technologies and options considered for this measure are below:

- Biological treatments
 - Natural attenuation
 - Enhanced aerobic/anaerobic biodegradation
- Physical/Chemical treatments
 - Vapor extraction or sparging
 - Permeable treatment beds
 - Chemical oxidation
 - Soil flushing

The technologies are described in the following paragraphs.

2.6.4.1 Biological

Natural Attenuation

The term "natural attenuation" is the continuing reliance on naturally occurring subsurface processes to control or prevent migration and/or over time achieve site-specific remediation objectives (USEPA 1989). Natural attenuation processes include a variety of naturally occurring physical, chemical, and biological processes that, under favorable conditions, substantially reduce the mass, toxicity, mobility, volume, or concentration of COCs in soil and/or groundwater. Natural attenuation is effective in reducing the mass of COCs including the off-

site plume. The COC's can be biologically degraded both anaerobically (via reductive dechlorination) or aerobically. Based on site specific data, natural attenuation is occurring and substantiated by site data. Reductive dechlorination of TCE is occurring given the presence of the breakdown components including vinyl chloride. The presence of breakdown components with no indication of incomplete degradation indicates that appropriate subsurface conditions are present that support the natural biodegradation of COCs. This is further discussed in Section 2.6.6 below.

Enhanced Aerobic/Anaerobic Biodegradation

In situ biological treatment includes the addition of nutrients, oxygen, and/or acclimated microbes to enhance the natural degradation processes. Biodegradation in the saturated zone can be used for the remediation of both impacted soil and groundwater. Having the correct site geologic and hydrogeological conditions is very important when considering the use of biodegradation technologies because these conditions determine the extent to which the reducing agents may come into contact with the COCs. Understanding the impact of non-target organic sources, even preferential sources, will have a significant impact on the overall effectiveness of a system.

To implement biodegradation in the saturated zone, a series of wells or trenches is used to inject water containing nutrients, microbes and/or oxygen. The treatment occurs as the water flows with the natural or induced gradient to reach the COCs and aid in reduction. Use of this technology may be limited in areas with clayey soil due to limited flow and reduced contact.

2.6.4.2 Physical/Chemical Treatment

Vapor Extraction or Sparging

Vapor extraction includes application of a vacuum on the subsurface soil to induce volatilization of organic constituents. Volatilization allows for the COC to be removed from the subsurface in its gas phase. This volatilization is accomplished by creating a strong vacuum on a series of vertical or horizontal wells screened in the unsaturated soil zone. For saturated zones and groundwater sparging (stripping) of VOCs in groundwater via wells can also be performed to remove vapors. To enhance overall effectiveness, a low permeability cover may be installed above the treatment area to reduce air bypass. This technology works most efficiently in highly permeable, granular soils.

Permeable Treatment Wall / Beds

Implementation of permeable treatment walls and beds includes the construction of a down-gradient trench filled with a material designed to either adsorb or chemically react with constituents in groundwater. As groundwater passes through the permeable bed, COCs would be treated or removed. Treatment beds include media (e.g. granular zero valent iron, mulch or other proven materials) that create a strong reducing environment to treat chlorinated solvents to nontoxic end products. This technology could potentially be used alone or together with other technologies to control the migration of impacted groundwater.

Chemical Oxidation

In situ chemical oxidation (ISCO) involves decomposition and in situ destruction using chemical oxidation technologies. In contrast to other remedial technologies, reduction in COCs can be seen in short time frames (e.g. weeks or months). Chemical oxidation technologies are predominantly used to address in situ groundwater and soil in the source area saturated zone and capillary fringe.

Understanding the site hydrogeological conditions is very important when considering the use of reduction technologies or chemical oxidation because these conditions often determine the extent to which the chemical oxidants or reducing agents may come into contact with the COCs. Soil reactivity with chemical oxidants or reducing agents is also important when considering the chemical oxidation. Excessive loss of a chemical oxidant or reducing agent because it is reacting with non-target organic compounds preferentially in soil instead of reacting with the COCs, may preclude the use of the technology as an economically viable approach to site remediation due to excessive reagent quantity.

Successful chemical oxidation requires the oxidant come into direct contact with the contaminant. Thus, movement of the oxidant throughout the subsurface is extremely important. Although the transmissive gravel zone (which would be conducive to chemical oxidant movement) exists below ground surface near the former greaser building on-site, it does not extend throughout the residential area north of the site.

Permanganate was evaluated in previous on and off-site interim measure activities which are further discussed in Section 2.6.6.

Soil Flushing

Soil Flushing involves the use of a cosolvent or surfactant where an injection or infiltration process moves the cosolvent or surfactant through the impacted soil with the intent of removing COCs from the soil. The resulting extraction fluids would be recovered after moving through the impacted area (i.e., down-gradient of the impacted area). The recovered fluids may need to be treated prior to discharge and/or reinjection.

Screening of the In Situ Treatment Measure

In situ treatment technologies are proven remediation methods. Implementation of in situ technologies are appropriate for on-site and off-site where a defined transmissive zone, significant mass of TCE is in saturated soils, and groundwater and current land uses or access agreements are present that are compatible with in situ technology systems. Implementation of in situ treatment technologies may be limited off-site (further northeast) due to the tight subsurface soils where the transmissive zone is not present, presence of residential structures, and buried utilities all limiting effective contact of the reactant with the COCs. In situ treatment has the technical ability to rapidly reduce groundwater concentrations of COCs on-site, providing near-term protection to off-site residents. Thus, in situ treatment via enhanced in situ biodegradation and chemical oxidation were retained as corrective measures for further consideration at areas where they could be used to rapidly reduce the highest concentration and total mass of COCs. In areas where tighter soils are present, potentially with intermittent

transmissive layers, horizontal wells may be evaluated for more uniform distribution of substrate/oxidant. In situ Permeable Reactive Barriers were also retained as they could potentially intercept the groundwater plume at one or more off-site locations.

Vapor Extraction/Sparging was not retained as a corrective measure for further evaluation as it has not been shown to be effective in subsurface lithology where clay is a major component. Soil Flushing was also not retained for further evaluation as it requires extraction and control of the cosolvent or surfactant and given the complex lithology the degree of control and extraction required could not be guaranteed.

Natural attenuation as an in situ technology is proven to be effective for target COCs and is retained as a corrective measure for on and off-site. Natural attenuation is effective in reducing the mass of COCs. Based on site specific data, reductive dechlorination of TCE is occurring on and off-site. This is based on the presence of the breakdown indicators including vinyl chloride. The presence of breakdown components indicates that appropriate subsurface conditions are present that support the natural biodegradation of COCs. This is further discussed below in Section 2.6.6.

2.6.5 Institutional Controls

Applying institutional controls as a corrective measure entails implementing legally enforceable restrictions on land use or groundwater use to prevent exposure to impacted media. Institutional controls will not remediate the site (reduce concentrations and/or limit migration). However, by preventing exposure (ingestion, direct contact, etc.), institutional controls are proven to effectively protect human health on a short- and long-term basis. Institutional controls can be applied to both impacted soil and groundwater.

Institutional controls are usually deed recorded wherein a metes and bounds description of impacted media, a description of the impacts (e.g., constituent concentrations and distribution), and all land or groundwater use restrictions are entered into the deed for the impacted property. Institutional controls can be applied via property acquisition, easement, or through the use of a legal covenant.

Other institutional controls include municipal setting designations where a city or other municipal entity establishes a prohibition on the installation of groundwater wells and/or the use of groundwater in an area that is impacted. Municipal setting designations are often instituted in areas that are fully serviced by municipal water supplies and private groundwater wells are not needed or used.

2.6.5.1 Screening of Institutional Control Corrective Measure

The use of institutional controls has been approved by ADEQ and USEPA as a remedial measure on other sites and can readily be applied to impacted areas within the limits of Whirlpool's property. Applying institutional controls such as municipal setting designations and/or deed recordation in the off-site area would require the cooperation and approval of residents, property owners, and/or the City of Fort Smith. Use of institutional controls adds an additional level of exposure protection from incidental ingestion of groundwater from wells not

present today. The institutional control measure is retained as a control measure option to be used in combination with another active corrective measure.

2.6.6 Summary of Corrective Measures Retained for Further Analysis

Some of the corrective measures discussed above were retained, in whole or in part, for potential inclusion. An alternative array summary table is presented in the attached Table 2 which defines inclusion or exclusion of a specific remedy. Remedies which progressed past this first screening step are listed below. In some cases, a given remedial measure should not be implemented as a stand-alone corrective measure or could be applied on a contingency basis, while others could be applied on a broader basis as a component of a corrective action that includes multiple measures.

The remedy alternatives listed below passed the first screening level (see Table 3) and will be further evaluated against the 7 criteria discussed in Section 3. These remedy alternatives include:

1. Monitored Natural Attenuation
2. Enhanced In Situ Biodegradation
3. In Situ Chemical Oxidation
4. Permeable Reactive Barrier
5. Institutional Controls

A description of each remedy alternative is provided below.

2.6.6.1 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) is continuing reliance on naturally occurring subsurface processes to control or prevent migration and/or over time achieve site-specific remediation objectives (USEPA 1989). Natural attenuation processes (the NA of MNA) include a variety of naturally occurring physical, chemical, and biological processes that, under favorable conditions, substantially reduce the mass, toxicity, mobility, volume, or COC concentrations in soil and/or groundwater. Natural attenuation is effective in reducing the mass of COCs including the off-site plume. The COC's can be biologically degraded both anaerobically (via reductive dechlorination) or aerobically.

Monitoring (the M of MNA) is an integral component of the MNA remedy. Long-term monitoring of environmental restoration recognizes that uncertainty is inherent to any cleanup activity and must be managed through data collection and monitoring (US Department of Energy (USDOE) 1997).

MNA relies on source reduction. Similar to other remedial strategies, natural recovery processes can potentially be inhibited or stalled if ongoing sources of contamination are not controlled. Efforts to reduce or eliminate sources contribute to the ongoing natural recovery of the Site.

MNA can be implemented as a sole remedy or as part of a larger remedial strategy incorporating other more intrusive alternatives. For example, institutional and/or engineering controls are commonly employed in conjunction with MNA, such as deed restrictions or physical access restrictions. These controls minimize the potential for disruption of the natural recovery processes. For this purposes of this evaluation, MNA will only be considered for application when coupled with an active remedy.

Evidence Supporting MNA at the Site

Monitored natural attenuation is sustainable if chemical/biochemical processes that transform contaminants to innocuous byproducts, and the availability of energy to drive these processes to completion, are present. Historical and current groundwater quality results were reviewed to evaluate whether natural attenuation processes are present and effectively limiting plume migration.

Since 2005, the TCE concentrations in the wells beyond the extent of the interpreted boundary of impacted groundwater have remained relatively stable, with historical concentrations generally below 0.005 mg/L, suggesting that the impacted groundwater is stable in the off-site area.

Based on the results from the 2011 Fall monitoring event, including samples reported with estimated concentrations ("J" values), TCE was detected in 22 of the 32 off-site monitoring wells sampled. Of these 22 wells with reported concentrations of TCE, cis-1,2-DCE, a primary degradation component of TCE, was reported in 15 samples. Based on the results from the 2012 Spring monitoring event, TCE was detected in 14 of the 14 off-site monitoring wells sampled and cis-1,2-DCE was reported in 11 of these wells with reported concentrations of TCE. Trans-1,2-DCE and vinyl chloride (both potential breakdown products of TCE) were not detected in any of the samples collected from the off-site monitoring wells during both monitoring events at a method detection limit (MDL) of 0.005 mg/L.

Based on the results from the 2012 Fall monitoring event, also including samples reported with estimated concentrations, TCE was detected in 20 of the 32 off-site monitoring wells sampled and cis-1,2-DCE was reported in 18 of these wells with reported concentrations of TCE. With the use of a lower MDL (0.002 mg/L), vinyl chloride was detected in six of these wells, four of the vinyl chloride values reported were estimated ("J" values). The use of a lower MDL was implemented to verify the presence of vinyl chloride, even at low concentrations, which is an indicator that biodegradation is occurring.

The presence of TCE and cis-1,2-DCE, a primary degradation component of TCE, supports that reductive chlorination is occurring at the site. The presence of vinyl chloride reported in samples from off-site wells during the Fall 2012 monitoring event may further support contaminant degradation. It should be noted that lower MDL's for vinyl chloride were used in the Fall of 2012. Detections of vinyl chloride may have been identified in earlier sampling events if lower MDLs had been used. . The presence of vinyl chloride, nitrate, sulfate, and ferrous iron indicates that conditions can support biodegradation.

2.6.6.2 Enhanced In Situ Biodegradation

In situ biological treatment includes the addition of nutrients, oxygen, and/or acclimated microbes to enhance the natural biological degradation processes. To implement biodegradation in the saturated zone, a series of wells or trenches would be used to inject water containing nutrients, microbes and/or oxygen. The treatment occurs as the water flows with the natural or induced gradient to aid microorganisms in the breakdown of contaminants. Use of this technology may be limited in areas with clayey soil due to limited flow and reduced contact.

For the purposes of this evaluation, the enhanced in situ biodegradation remedy alternative includes the injection of a substrate into the groundwater at one or more locations that intercept the plume or treat higher concentrations within the plume. These locations could include either just north of Ingersoll Avenue or at an off-site residential property which intercepts the plume or both. This alternative could also include bioaugmentation in the form of a culture of naturally occurring microorganisms to assist in more rapid degradation. The purpose of this alternative is to assist the MNA option in a more timely and complete breakdown of TCE.

2.6.6.3 In Situ Chemical Oxidation

In situ chemical oxidation (ISCO) involves in situ decomposition and destruction using chemical oxidation technologies. Successful chemical oxidation requires the oxidant to come into direct contact with the contaminant and movement of the oxidant throughout the subsurface is extremely important.

For the purposes of this evaluation, an ISCO remedy alternative would include a phased approach including at least two phases. Phase 1 would include injection at three locations (as shown on Figure 7). The purpose of this phase is to reduce off-site concentrations at Ingersoll Avenue and near IW-77, which will further reduce the amount of COC's continuing to move throughout the plume to the northeast. Another goal of this phase is to further refine the characterization of areas to the west of MW-25 and south of ITMW-19, evaluate the potential for movement in zones other than the transmissive zone, and identifying key components necessary for successful ISCO application onsite, which will limit the potential for back diffusion. As discussed below, back diffusion is likely responsible for previous pilot studies returning to pre-injection TCE levels. Attempting to obtain the appropriate access agreements for further off-site injections will also be a goal of Phase 1. Phase 1 will include injection of an oxidant into the currently identified highest TCE concentrations on-site. Phase 1 will be completed after 3 and 6 month monitoring events have been completed after the first round of injections. Based upon the data gathered during Phase 1, Phase 2 will include additional targeted injections to continue to facilitate source reduction as well as off-site reduction of high concentrations as access agreements are put into place. Phase 2 may also include the completion of additional injection wells. Again 3 and 6 month monitoring events will occur and additional Phases, if necessary, will be evaluated at that time.

This stepwise approach will assist in determining that the correct oxidant is being used at the correct locations and with the correct dosages. Previous bench scale and pilot scale ISCO applications have provided relevant data, however additional evaluation may determine that oxidants other than permanganate could be more effective in treating COCs at the site. This phased approach will also reduce the potential for back diffusion which will lead to a greater

mass reduction both in the source area and in the off-site area. Coupling an active remedy (such as ISCO) with a passive remedy (such as MNA) will contribute toward a remedy that is effective in both the short and long term as well as being protective of human health and the environment.

Evidence Supporting ISCO at the Site

In 2000, a bench scale treatability study was completed to investigate the effectiveness of permanganate for treating site specific soils for chlorinated compounds. In the samples collected from MW-25, which were used for the study, TCE was found at a concentration of 100,000 ug/l, which was representative of site conditions. Testing was then completed to verify that oxidant could destroy the TCE in the site specific sample and total permanganate demand was also determined. The bench scale study was able to reduce TCE concentrations in the sample by almost 100%. A total potassium permanganate demand of 1 to 2.5 g/kg wet weight soils was identified although a comment was included that the concentration of permanganate would most likely need to be increased in the field.

Permanganate was evaluated in an on-site field scale test in 2002. The purpose of this test was to evaluate the use of permanganate for full scale treatment at the site. This test was conducted in the transmissive gravel zone. The soil oxidant demand used for oxidant calculations during this test was less than the oxidant demand identified during the bench scale study, therefore, less than the suggested amount of oxidant was applied during the field scale test. However, the results indicated that ISCO was effective in treating the COCs within the treatment zone and over 20 feet outside the treatment zone in the transmissive gravel portion. After the test was completed, COC concentrations rebounded to pre-test levels which should have been expected given the placement of the test area in relation to the plume. Back diffusion from areas of higher TCE concentration was likely given the flow direction from areas of higher TCE concentrations through the test location.

Permanganate was also evaluated in off-site interim measure activities in April and June of 2009. The objective of this interim measure was to evaluate the effectiveness of using ISCO to treat the core of the offsite plume. Permanganate was applied to eight injection wells and has been, and is currently being, monitored. As evidence of either very slow movement of groundwater or variation in the transmissive layer underneath the residential properties in the area, permanganate was still present in a few off-site monitoring wells during the October 2012 groundwater sampling event. This shows that permanganate is not being uniformly distributed throughout the subsurface to treat impacted groundwater throughout the plume. However based upon the 2010 Interim Measure Status Report, "The analytical data suggest permanganate treatment is very effective within the radius of influence of the injection well". As part of the interim measure, in late 2010 and early 2011, a groundwater extraction well was used to attempt movement of the permanganate through the subsurface; however this effort was only marginally successful due to the tight clays making it impractical for consideration on a larger scale off-site. Therefore, although ISCO may not be effective for treating the entire off-site plume, it could be an effective tool for reducing higher TCE concentration located within the transmissive zone.

Based upon these bench scale and pilot scale studies, it is apparent that ISCO can treat TCE at portions of the site within the transmissive zone, however additional information can aid in determining if a modified approach and/or other oxidant could be more effective than what has currently been attempted.

2.6.6.4 Permeable Reactive Barrier

Implementation of permeable treatment walls and beds would include construction of a down-gradient trench filled with a material designed to either adsorb or chemically react with constituents in groundwater. As groundwater passes through the permeable bed, COCs would be treated or removed. Treatment beds include media (e.g. granular zero-valent iron, mulch or other proven materials) that create a strong reducing environment to treat chlorinated solvents to nontoxic end products. This technology could potentially be used alone or together with other technologies to control the migration of impacted groundwater.

For the purpose of the RMP, the permeable reactive barrier (PRB) remedial alternative which will be evaluated in Section 3 includes the placement of a permeable reactive barrier which will intercept the plume and treat contaminants with zero-valent iron or other reactive media as groundwater moves through the barrier. The use of a PRB on-site is likely limited by the location of the OG&E substation on the northern portion of the Whirlpool property as well as the roadway (Ingersoll Avenue) and accompanying utilities. Therefore, for the purposes of this evaluation the remedy will be assumed to be completed off-site on a residential property. There are a few properties that could be used to implement this remedy and intercept the plume if access were granted by the current property owners.

2.6.6.5 Institutional Controls

Institutional Controls including access and deed restrictions were retained as a remedy alternative for this Site. This alternative would likely be necessary as part of any alternative that would leave material within the affected area above applicable criteria.

One example of institutional controls is the use of groundwater use restrictions, which limit or prohibit certain uses of groundwater which may include limitations or prohibitions on well drilling. The benefits of this type of institutional control is that they are effective in the short as well as the long term and they provide uniform restriction to the specific contaminant throughout the entire area exceeding applicable criteria.

For the purposes of this evaluation, institutional controls would be applied both on and off-site. On-site controls would include restrictions on groundwater use and direct contact. Off-site controls would be in the form of a restriction to prohibit the installation of groundwater wells. Municipal water is available and is being used by all parties affected by groundwater containing TCE above MCLs, however a restriction is necessary to prevent the future installation and use of a well.

3 Evaluation of Remedy Alternatives

This section provides a comparative evaluation of Remedy Alternatives 1 through 5 against the following evaluation criteria:

- Overall protection of human health and the environment
- Short-term effectiveness
- Long-term effectiveness
- Reduction of toxicity, mobility, or volume
- Implementability
- Cost
- Community acceptance

3.1 Overall Protection of Human Health and the Environment

As specified in the National Contingency Plan (NCP), overall protection of human health and the environment is a threshold criterion, in that all alternatives must achieve this criterion to be considered viable. Evaluation of the overall protection of human health and the environment determines whether the alternative achieves adequate short- and long-term protection; describes how site risks are eliminated, reduced, or controlled through natural processes, treatment, engineering, or controls; and describes the extent to which each remedy meets the site goals.

3.1.1 Monitored Natural Attenuation

MNA may only provide protection of public health and the environment in the long term as MNA will reduce contaminant mass and associated risk over time. Short term, MNA may not be able adequately address risk pathways.

3.1.2 Enhanced In Situ Biodegradation

The degree of protectiveness for this alternative depends upon the level of contaminants within the evaluated area. For example, this alternative could be protective at the fringes of the plume where contaminant concentrations are lower, whereas the alternative would likely not be protective in the source area where the highest contaminant concentrations are present. In addition, the ability to access property in appropriate locations could also determine the level of protectiveness.

3.1.3 In Situ Chemical Oxidation

Where ISCO can be applied to the transmissive zone in sufficient quantities, it can provide short-and long-term protection. Therefore, access issues may affect the degree of protectiveness. ISCO can more quickly assist in reducing contaminants of concern and associated risk. Therefore this option could be more protective than some of the other alternatives evaluated.

3.1.4 Permeable Reactive Barrier

This option would provide long-term protection but would not provide short-term protection due to the need for the contaminants to move through the barrier to obtain treatment. Access issues may also limit the protectiveness of this option as a carefully chosen placement of the PRB would be necessary to address full plume interception.

3.1.5 Institutional Controls

Institutional Controls are protective in both the short and long term as these restrictions prohibit access to the contaminants of concern which may pose risk.

3.2 Short-Term Effectiveness

Effectiveness is evaluated based on the ability of the technology or process option to meet the site goals, ensure long-term human health and environmental protection, protect against short-term human and environmental effects during construction, and proven reliability at sites with chemical constituents and conditions similar to those at the Site. Short-term effectiveness also considers safety. Safety is evaluated based on the potential for implementation of a technology or process option to generate higher, different, or unanticipated adverse human health effects or ecological impacts. Projected activities are evaluated for changes such as disruption of baseline sediment geochemical or biological conditions that alter chemical bioavailability, increased erosion, or increased likelihood of offsite migration of contaminated sediment.

Short-term effectiveness includes an evaluation of short-term impacts during the construction and implementation phase. Impacts evaluated include ecological and human risks, potential impacts to the community and site workers during remedy implementation, and time until the remedy is achieved (USEPA 2005). This evaluation determines whether the remedy alternatives negatively impact short-term risks, and whether those risks can be eliminated or controlled through proper remedy selection and best management practices during remedy implementation. Effects of implementation on the community include quality of life impacts, such as noise, odors (vehicles and sediment), and traffic. Impacts to site workers include safety risks during remedy implementation.

3.2.1 Monitored Natural Attenuation

MNA will have limited short-term effectiveness due to the time required for adequate contaminant breakdown to occur. Although MNA does not impact the community the way other intrusive remedies may.

3.2.2 Enhanced In Situ Biodegradation

This alternative will have limited short-term effectiveness due to the time required for adequate contaminant breakdown to occur. Enhanced In Situ Biodegradation will also impact the community due to the intrusive nature of injection and monitoring wells.

3.2.3 In Situ Chemical Oxidation

ISCO is very effective in the short term as compared to other remedies. The short-term reduction of contaminants is higher with this option than with other options reviewed. This option will impact the community due to the intrusive nature of injection and monitoring wells.

3.2.4 Permeable Reactive Barrier

This alternative has limited short-term effectiveness due to the need for impacted groundwater to move through the barrier to receive treatment. This alternative also has greater safety and community implications than other alternatives evaluated.

3.2.5 Institutional Controls

Institutional Controls are very effective in the short term as the risk pathway is no longer viable after restrictions have been put into place. This alternative pose impacts from construction activities the way other alternatives may.

3.3 Long-Term Effectiveness

Long-Term Effectiveness refers to the ability of a remedial option to sustain reliable protection of human health and the environment once remediation goals have been met. This criterion also addresses how residual risk will be mitigated and controlled over time.

Effectiveness is evaluated based on the ability of the technology or process option to meet the site goals, ensure long-term human health and environmental protection, protect against short-term human and environmental effects during construction, and proven reliability at sites with chemical constituents and conditions similar to those at the Site. Effectiveness also considers safety. Safety is evaluated based on the potential for implementation of a technology or process option to generate higher, different, or unanticipated adverse human health effects or ecological impacts. Projected activities are evaluated for changes such as disruption of baseline sediment geochemical or biological conditions that alter chemical bioavailability, increased erosion, or increased likelihood of offsite migration of contaminated sediment.

Long-term effectiveness is a measurement of long-term risk reduction and remedy permanence, including physical stability of the sediment. This criterion determines the adequacy and reliability of sediment remedies and controls to manage human health and ecological risks associated with sediment contaminants (USEPA 2005). Long-term effectiveness is determined by assessing potential residual human health and ecological risks likely to be present after response actions have been employed, and by determining potential future surface sediment chemical concentrations. Remedy permanence is determined by evaluating the physical permanence of the remedy.

3.3.1 Monitored Natural Attenuation

As discussed above in Section 2.6.6 there is evidence that MNA is already occurring both on and off-site. As long as the components necessary for successful biodegradation continue to exist, MNA will continue to be an effective long-term measure.

3.3.2 Enhanced In Situ Biodegradation

Enhanced In Situ Biodegradation, depending upon site conditions/substrate additions/etc, could be effective from 6 months to up to 5 years without re-application of substrate or other media. Over a longer timeframe (potentially from 5 to 20 years) this option would naturally progress to an MNA option.

3.3.3 In Situ Chemical Oxidation

ISCO is protective in the long term by removing the contaminant mass and associated risk in the short term.

3.3.4 Permeable Reactive Barrier

PRB is more effective in the long term than it is in the short term as this remedy requires that the groundwater move through the barrier to receive treatment. Based upon past studies it has been calculated that groundwater moves at a rate of approximately 2 feet per month in the transmissive zone, therefore the time required to achieve site goals would be lengthy.

3.3.5 Institutional Controls

Institutional controls are effective in both the short and the long term.

3.4 Reduction of Toxicity, Mobility, or Volume

The criterion “reduction of toxicity, mobility, or volume” addresses the anticipated efficiency of the remediation alternatives at reducing risks associated with elevated chemical concentrations. This criterion will be evaluated based on historical information regarding the performance of each remedial option via other case studies and scientific calculations.

3.4.1 Monitored Natural Attenuation

MNA reduces the toxicity and mobility of contaminants over time.

3.4.2 Enhanced In Situ Biodegradation

This alternative reduces the toxicity and mobility of contaminants over time as they breakdown. This option provides greater reduction in toxicity and mobility than the MNA option.

3.4.3 In Situ Chemical Oxidation

MNA reduces toxicity, mobility, and volume of contaminants of concern by oxidation. This alternative will provide the greatest mass reduction of the alternatives reviewed.

3.4.4 Permeable Reactive Barrier

This alternative will reduce the toxicity and mobility of contaminants as they move through the treatment barrier. However this option will not reduce the source area mass which will continue to feed the dissolved plume and therefore require treatment over a longer timeframe.

3.4.5 Institutional Controls

Institutional controls do not reduce toxicity, mobility, or volume.

3.5 Implementability

Implementability encompasses both the technical and administrative feasibility of implementing a technology or process option. It incorporates an evaluation of the technical difficulties associated with construction and operation of the remediation system, the reliability of the selected technologies, the ability to implement all facets of the remedial alternative, and challenges associated with process options that support each remedy, such as treatment, storage and disposal services, transportation, and equipment availability. The administrative feasibility of a remedy alternative or technology includes an assessment of the ability to obtain necessary permits and the impact of state and local regulations.

Examples of physical constraints that affect the remedial alternative implementability include:

- Accessibility
- Stability
- Utilities and roadways or railroads
- Depth of contamination
- Thickness and geotechnical properties of the subsurface soils

3.5.1 Monitored Natural Attenuation

MNA is readily implementable.

3.5.2 Enhanced In Situ Biodegradation

Accessibility would be a factor to implementing this option. The correct off-site access agreements would need to be gained to readily implement this alternative as injection of a substrate and/or culture of microorganisms would need to be placed within the plume at various locations to be most effective. The use of this alternative could also be hindered by subsurface lithology, the location of utilities and/or roadways. Lithology would be taken into consideration when designing this remedy so that injections would take place primarily in the transmissive zone.

3.5.3 In Situ Chemical Oxidation

Accessibility would be a factor to implementing this option. The correct off-site access agreements would need to be gained to readily implement this alternative as injection of an oxidant would need to occur within the plume at specific locations to be most effective. The use of this alternative could also be hindered by subsurface lithology, the location of utilities and/or roadways. Lithology would also need to be taken into consideration; however ISCO would be implemented primarily within the transmissive zone.

3.5.4 Permeable Reactive Barrier

Accessibility would be a major factor to implementation of the PRB alternative. Completely intercepting the plume would be required to instituting an effective PRB remedy. Due to access constraints such as the location of the OG&E utility substation, Ingersoll Avenue, utilities along the roadway, as well as the complex geology of the subsurface, the PRB alternative is not

considered implementable on-site. However the PRB remedy could be implemented off-site if the correct access agreements could be obtained.

3.5.5 Institutional Controls

Institutional Controls are readily implementable if community concerns are adequately addressed.

3.6 Cost

Costs are based on engineering judgment, discussions with vendors, and other available information associated with each option. Cost should not be viewed as a proxy for effectiveness. In many cases, more efficient and cost-effective remedies can accomplish the same result or can outperform less efficient, more costly remedies.

The costs of each alternative are estimated with as much accuracy as possible for capital and Operation and Maintenance (O&M). The overall cost for each alternative is the sum of the capital and discounted annual costs. The cost estimates provided have an accuracy of +50 % to -30 %, in compliance with USEPA guidance (USEPA 1988).

Although considered reasonable to provide sufficient detail to compare technology costs, monitoring assumptions (e.g., quantities, frequencies, and durations) are not intended to be prescriptive for the various remedies.

Remedy costs for all screened alternatives are summarized in Table 4. These costs were developed based upon a conceptual level of design at an accuracy of -30% to +50% in accordance with USEPA guidance. Costs are rounded as appropriate.

Remedy costs for Alternatives 1 through 5 are listed below.

Description	Cost (-30%) \$	Cost Estimate (\$)	Cost (+50%) \$
Alternative 1: MNA	\$600,000	\$900,000	\$1,300,000
Alternative 2: Enhanced Bio.	\$1,600,000	\$2,300,000	\$3,400,000
Alternative 3: ISCO	\$2,400,000	\$4,500,000	\$6,800,000
Alternative 4: PRB	\$3,400,000	\$4,800,000	\$7,200,000
Alternative 5: Institutional Controls	\$100,000	\$200,000	\$300,000

Of the evaluated alternatives, Institutional Controls has the lowest cost of approximately \$200,000. Remedy Alternative 4 (PRB) has the highest estimated cost of \$4.8 million.

It should be noted that the remedy cost estimates as stated above and in Table 4 are stand alone cost estimates. It is likely that the chosen alternative will include more than one remedy and as such the cost estimate for the final remedy will alter from those shown above.

3.7 Community Acceptance

This criterion evaluates the issues and concerns that the community may have regarding each remedy alternative. Effects of Remedy implementation on the community include safety issues associated with implementation, which could restrict use of areas in the vicinity of the remediation, and the generation of odors, construction noise, and diesel emissions during remedy implementation.

The State Acceptance criterion is not included in this document. This criterion will be evaluated by ADEQ in preparation of the RAAD.

3.7.1 Monitored Natural Attenuation

MNA has been occurring for years at the site and will likely be accepted by the community when coupled with an active remedy.

3.7.2 Enhanced In Situ Biodegradation

Gaining the access necessary to complete this alternative as a full off-site remedy may limit the community acceptance due to the access agreements required to fully implement this alternative.

3.7.3 In Situ Chemical Oxidation

Quick reduction of contaminant mass which will lead to an overall shorter project timeframe should aid in community acceptance, however gaining the access agreements required to implement this alternative could reduce community acceptance.

3.7.4 Permeable Reactive Barrier

This option is the alternative with the most intrusive construction requirements. Also this option would require gaining access agreements and likely property purchase(s) at distinct parcels. The greater construction requirements would mean a heavier impact on the community in terms of noise and travel throughout the affected area.

3.7.5 Institutional Controls

Institutional controls are generally accepted in communities. However, institutional controls that impact off-site properties may require commercial solutions to garner community acceptance and support.

4 Risk Management Plan

As discussed in Section 2.4, the Corrective Action Objectives for the site include:

- Eliminate or reduce the lateral extent or concentration of the groundwater plume both off-site and on-site.
- Eliminate or reduce the potential for unacceptable risk that may result if there are future changes in land or groundwater uses either off-site or on-site.

These objectives can be further broken down into goals which include:

- Off-Site:
 - Reduce the risk posed by the only viable exposure pathway – drinking water
- On-Site:
 - Reduce contaminant mass (ie. concentration) which will reduce the probability of additional contaminants of concern leaving the property and will reduce on-site risk
 - Reduce other on-site risks posed by contamination (ie. direct contact, etc)

These goals were then reviewed in conjunction with the corrective action objectives to select the final remedy.

4.1 Final Remedy Selection

Based upon the evaluation completed in Section 3, the following alternatives were combined to most effectively address the objectives and goals listed above:

- **ISCO On-Site** within the source area; addresses fast reduction in contaminant mass (thereby reducing risk) while also decreasing the potential for contaminant mass to move off-site into the residential area.
- **ISCO Off-Site** two areas, one north of Ingersoll and the other near IW-77; addresses fast and substantial reduction in contaminant concentration (thereby reducing risk) while also limiting the potential for higher concentrations of concern in groundwater to expand into the larger plume area. Although the area north of Ingersoll (where injections will occur) is owned by Whirlpool it is considered off-site treatment as the injections will primarily benefit downgradient (off-site) properties. The property at and near IW-77 is not owned by Whirlpool. The property owner and Whirlpool have an access agreement in place.
- **MNA** both on and off-site; continues to reduce the contaminant concentrations within the plume as well as allow for a shrinking plume size over time. This remedy alternative when coupled with an active remedy such as ISCO will prove to be effective in both the short and long term.

- **Institutional Controls** both on and off-site (as allowed by property owners); addresses pathway risks by eliminating them.
- **Alternative – Enhanced In Situ Biodegradation** either on or off-site; this remedial technology has been added to the final remedy as an alternative in the instance that MNA appears to be stalling. If Whirlpool and ADEQ agree that additional action will be required beyond MNA after completion of ISCO activities, then this alternative could be used in the portions of the plume which appear to be stalling on the degradation pathway.
- **Potential Future Alternative – Horizontal Barrier (Asphalt Cover)**; this corrective measure may be re-evaluated in the future after implementation of the active (ISCO) remedy as this measure may be effective in addressing residual contaminants on-site.

Due to access issues and the need to purchase specific properties to fully intercept the groundwater plume off-site, the PRB option has been eliminated from further evaluation at this time.

The bulleted combination of technologies will most effectively treat both the off and on-site contaminant issues by reducing contaminant mass, reducing the toxicity and mobility of the contaminant, reducing the potential for contaminant migration, eliminating exposure pathways (when allowable by property owners), and providing for long-term degradation of the lower concentration contaminant plume until the site objectives have been achieved.

In situ treatment of off-site and on-site groundwater will be conducted via in situ chemical oxidation (using an appropriate oxidant²). MNA will then be relied on to address residual COC's after the effectiveness of the in situ chemical oxidation marginalizes. If the natural attenuation process appears to be stalling, then the enhanced biodegradation alternative may be used to jump start the degradation pathway. Institutional controls will be used to limit access to on-site impacted soil and both on-site and off-site groundwater until COC MCL's are consistently met over a period of time. Combining these remedial technologies together will be a more successful remedial strategy than any one strategy could provide as a stand-alone option, especially considering the limitations posed by the site lithology. This final remedy will substantially reduce toxicity, mobility, and volume of the source in a shorter period of time than any other alternative.

Institutional controls will immediately be protective of human health by eliminating the potential for exposure to impacted soil and groundwater. Institutional controls also do not have the issue of incomplete coverage that due to access and transmissivity issues, because the institutional controls will cover the full area of concern. Institutional controls are also readily implemented, providing immediate protection of human health.

The chosen ISCO remedy alternative would include a phased approach including at least two phases. Phase 1 would include injection at three locations (as shown on Figure 7). The purpose of this phase is to reduce off-site concentrations at Ingersoll Avenue and near IW-77,

² Oxidant will be determined by a bench scale treatability study

which will further reduce the amount of COC's continuing to move throughout the plume to the northeast. Another goal of this phase is to further refine the characterization of areas to the west of MW-25 and south of ITMW-19, evaluate the potential for movement in zones other than the transmissive zone, and identifying key components necessary for successful ISCO application onsite, which will limit the potential for back diffusion. As discussed below, back diffusion is likely responsible for previous pilot studies returning to pre-injection TCE levels. Attempting to obtain the appropriate access agreements for further off-site injections will also be a goal of Phase 1. Phase 1 will include injection of an oxidant into the currently identified highest TCE concentrations on-site. Phase 1 will be completed after 3 and 6 month monitoring events have been completed after the first round of injections. Based upon the data gathered during Phase 1, Phase 2 will include additional targeted injections to continue to facilitate source reduction as well as off-site reduction of high concentrations as access agreements are put into place. Phase 2 may also include the completion of additional injection wells. Again 3 and 6 month monitoring events will occur and additional Phases, if necessary, will be evaluated at that time.

This stepwise approach will assist in determining that the correct oxidant is being used at the correct locations and with the correct dosages. This phased approach will also reduce the potential for back diffusion which will lead to a greater mass reduction both in the source area and in the off-site area. Coupling an active remedy (such as ISCO) with a passive remedy (such as MNA) will contribute toward a remedy that is effective in both the short and long term as well as being protective of human health and the environment

Figure 7 outlines the initial concept for injection of oxidants. Based upon current known information injection points would be installed on 10-foot centers screened in the transmissive zone only. Area 1 (on-site) is estimated to be 320 feet by 80 feet, Area 2 (north of Ingersoll Avenue) is estimated to be 210 feet by 20 feet, and Area 3 (near IW-77) is estimated to be 90 feet by 30 feet. The size of the areas and radius of influence information generated during ISCO pilot studies dictate that 256 injection points would be installed in Area 1, and 27 injection points would be installed in Area 3. Additional points may be added depending upon subsurface lithology encountered and the thickness of the transmissive zone at each point. Current data suggests that persulfate may even more effective in treating COCs than permanganate which was previously used; however additional evaluation will be performed prior to injection event(s) to verify this finding. If persulfate is used up to 45,000 pounds of persulfate could be injected into Area 1, up to 7,000 pounds of persulfate could be injected into Area 2, and up to 4,500 pounds of persulfate could be injected into Area 3. All injections would be completed under pressure. To determine the correct pressure breakthrough would be determined then the pressure would be decreased to approximately 3 to 5 psi. If necessary, peroxide could be added to continue to reduce mass following the persulfate injection. Experience of using this approach with similar concentrations of alkenes has achieved up to 99% mass reduction.

4.1.1 Final CSM – Exposure Pathways

The selected final remedy will eliminate all complete exposure pathways associated with impacted on-site and off-site areas (Figure 6). The reduction of source COCs on-site and higher concentration COCs off-site by chemical oxidation and the reduction of on and off-site

COCs via MNA will reduce risks posed by the COCs. Exposure pathways will further be eliminated by developing multiple lines of evidence that off-site vapor intrusion does not pose an unacceptable risk to potential receptors while COCs are being treated. Lastly as an added level of protection not available today exposure pathways will be eliminated both on- and off-site by use of institutional controls such as deed restrictions, restrictive covenants, or a city ordinance.

4.1.1.1 On-Site Groundwater

On-site and off-site groundwater will be treated in-situ with a chemical oxidant to reduce source area concentrations. This action will also affect the off-site groundwater concentrations by reducing the toxicity and volume of COCs moving off-site. Monitored natural attenuation will continue to reduce COCs in the fringe areas on-site during chemical oxidation of higher concentration source areas. After completion of chemical oxidation monitored natural attenuation will address any remaining dissolved COC mass and fringe areas.

Use of on-site groundwater will also be restricted via the use of institutional controls for the entire site. In addition, institutional controls in the form of deed restrictions will be put into place to prohibit groundwater use on-site, require appropriate health and safety precautions be enforced during construction or maintenance activities that involve excavation into impacted groundwater, and require the future building use comply with Occupational Safety and Health Administration (OSHA) requirements and include chlorinated volatile organic compounds (CVOCs) in impacted groundwater as part of the hazard communication program.

Final remedy performance monitoring (Section 3.3.1) includes groundwater and soil vapor monitoring on-site to monitor final remedy effectiveness during the performance monitoring period defined by this RMP.

4.1.1.2 On-Site Soil

On-site soil will be addressed through institutional controls (restrictive covenants) to eliminate access to affected on-site soil. Whirlpool will record restrictive covenants when the property changes ownership. In the interim Whirlpool will continue to operate in accordance with existing site environmental health and safety protocols already in place that address this issue today.

4.1.1.3 Off-Site Groundwater

The selected final remedy includes the treatment of off-site groundwater in-situ with a chemical oxidant to reduce highest concentrations. This action will reduce levels of COCs present in off-site groundwater to limit the potential for migration further off-site towards the northeast end of the current plume while allowing for a more favorable environment for MNA to occur. After completion of chemical oxidation monitored natural attenuation will address any remaining dissolved COC mass and fringe areas.

The selected final remedy also includes proposed off-site institutional controls. Off-site institutional controls can take the form of either deed restrictions, restrictive covenants, or a city ordinance.

Potential off-site vapor intrusion exposure to groundwater-derived vapors meets USEPA risk limits (Appendix A).

Final remedy performance monitoring (Section 3.3.1) includes groundwater and soil vapor monitoring of off-site areas to monitor final remedy effectiveness during the performance monitoring period defined by this RRMP.

4.2 Performance Criteria

The primary elements of the final remedy include source reduction on-site via chemical oxidation, targeted chemical oxidation off-site and monitoring on and off-site for natural attenuation and institutional controls that maintain existing on-site soil restriction, off-site and on-site groundwater restriction,. Performance monitoring will be implemented to ensure the primary elements continue to be protective of human health. Performance monitoring details are presented in the following sections.

4.2.1 Performance Monitoring

4.2.1.1 Institutional Controls

In order to meet obligations associated with restrictive covenants, Whirlpool will record restrictive covenants on the site that will require future owners of the property to adhere to the recorded restrictions. In the interim, Whirlpool will continue to operate in accordance with existing site environmental health and safety protocols already in place. In order to meet obligations associated with the off-site restrictions, Whirlpool will pursue off-site institutional controls after the acceptance of the final remedy by ADEQ in cooperation with residents and the City of Ft Smith.

4.2.1.2 Chemical Oxidation Monitoring

Whirlpool will implement a tiered monitoring program to address chemical reductions completed as part of the on-site and off-site in situ chemical oxidation effort. The final work plan will specify the number of wells to be monitored and frequency of monitoring as these factors are dependent upon the quantity of oxidizing agent used, number of injection points, and frequency of injection event(s). At a minimum, it is expected that monitoring will be completed at the following intervals post injection(s): three months and six months on a phased approach. Additional monitoring will be completed as discussed in the groundwater monitoring discussed in Section 4.2.1.4 below.

4.2.1.3 Soil Gas Monitoring

Whirlpool will implement a program of soil gas monitoring for a five year period on an annual basis to monitor the soil gas concentrations to confirm that groundwater-derived vapors are not migrating and that vapor intrusion continues to be an incomplete pathway. The program will use the existing soil gas sampling points augmented with additional soil gas sampling points to be incorporated into the performance monitoring program. The soil gas monitoring will include analysis of CVOCs that have inhalation toxicity values and where the detected concentration in groundwater exceeds the MCL at or near the soil gas sampling point. The additional soil gas sampling locations will be specified in a final work plan.

4.2.1.4 Monitored Natural Attenuation - Groundwater Monitoring

Whirlpool will implement a program of quarterly groundwater monitoring for a five-year period to verify effectiveness of natural attenuation. If after the first two years, significant trends are

shown to support natural attenuation, a reduction in the monitoring frequency will be discussed with ADEQ. Data will be compiled in annual monitoring reports. A limited number of existing wells will be incorporated into the performance monitoring program. Specific wells to be incorporated into the performance monitoring system will be specified in the final work plan. The groundwater monitoring program will include, in addition to MNA indicators, analysis of the key COCs: TCE, PCE, 1,1-DCE, 1,1-DCA, cis-1,2-DCE and vinyl chloride. Precipitation at the Arkansas River gauging station will also be included in the annual monitoring reports.

4.3 Contingency Plans

If at the end of five years of monitoring, the remedial action criteria are not being met, Whirlpool will implement a revised sampling program and determine how data impact the HHRA that forms the basis for this RMP. Whirlpool will notify ADEQ of any findings that are not in accordance with this RMP within three months of the last annual sampling event.

4.4 Performance Reviews

In accordance with the Letter of Agreement, Whirlpool will complete the following required performance reviews.

4.4.1 Quarterly

Whirlpool will prepare a quarterly remedial action and operation and maintenance status report as required in the Letter of Agreement.

The quarterly status reports will contain the following:

- Description of work completed
- Summaries of all findings in the reporting period
- Summaries of problems encountered during the reporting period and actions taken to address problems
- Deviations from any approved work plans or schedules including justification for any delays with revised projected completion date(s)
- Projected work for the next reporting period

A copy of the quarterly report will be submitted to the City of Ft Smith Board of Directors.

4.4.2 Annual Monitoring Report

Whirlpool will prepare annual performance monitoring reports that summarize the results of the annual groundwater and soil gas monitoring activities. The annual monitoring report will contain the following:

- Summaries of the annual groundwater and soil gas monitoring results with comparisons to remedial action criteria
- Summaries of groundwater level elevation data
- Copies of the laboratory analytical reports

Whirlpool will submit annual monitoring reports with data summaries for current and previous annual submittals.

A copy of the annual report will be submitted to the City of Ft Smith Board of Directors

4.4.3 Five-Year Review

Consistent with the 2005 Arkansas Groundwater Remediation Level Interim Policy, five years after initiating the final corrective measure, Whirlpool will submit a five-year technical review of the status of the Whirlpool site final corrective measure and assess the need for any necessary further actions.

4.5 Public Involvement Plan

As specified in the Letter of Agreement, Whirlpool will seek public comment on the Administrative Record and the proposed corrective measures to be implemented for the Fort Smith site with ADEQ participation. The public involvement plan will consist of

- establishing a local repository for project documents (already completed);
- compiling a copy of the Administrative Record for public access at the repository (already completed);
- providing public notice of the availability of the Administrative Record and a request for comments on the Administrative Record and the proposed corrective measures within 30 days; and
- conduct a public meeting for all residents and city leaders to review and comment on the final corrective measure.

Whirlpool has already establish a local document repository where the public will have access to the Administrative Record (i.e., the collection of documents forming the basis for the final corrective measure). The location of the document repository is the City of Ft Smith Public Library.

Whirlpool has provided a copy of relevant site documents to the repository that will provide the public the basis to understand the selection of the final corrective measure and will update as more documents are published. Whirlpool will work with ADEQ and the City of Ft Smith to place a public notice in a local newspaper advertising the availability of the Administrative Record and asking for public comments on the selection of the final corrective measure. The public will be directed to provide comments to the ADEQ. The public comment period will be for a maximum of 30 calendar days. During the 30-day period, Whirlpool will conduct a public meeting to present the corrective measure and solicit feedback from residents and city leaders. Following receipt of comments and direction from ADEQ, Whirlpool will update the Administrative Record, as necessary. Once the Administrative Record is complete and fully approved, the RMP will be implemented.

4.6 Proposed Schedule and Completion of CAS Program

The RMP implementation schedule is presented below and represents Whirlpools current estimate of the timing for completion of each of the outlined tasks. The schedule reinforces Whirlpools commitment to an efficient, expeditious implementation of the final corrective measure following notification to proceed from the ADEQ.

The schedule will be reviewed on quarterly basis as part of the performance review plan (Section 4.4). Any schedule revisions will be addressed in the quarterly, annual, and five-year reports discussed in previous sections of the RMP.

Activity	Start	End	Comment
Implement Public Involvement Plan	July 1, 2013	October 30, 2013	Includes 30 day comment period, addressing comments with ADEQ, and issuance of RADD
Restricted Covenants / Deed Restrictions developed and Recorded for Whirlpool Property		October 1, 2013 *	* Whirlpool will record restrictive covenants in accordance with Arkansas regulations at the time property(ies) transfer(s) occur.
Prepare and Submit Final Remedy Work Plan To ADEQ	June 1, 2013	August 30, 2013	
Install Additional Soil Gas Sampling Locations	June 1, 2013	August 30, 2013	Assumes ADEQ approval of Work Plan on or before June 30, 2013
Annual Performance (Groundwater / Soil Gas) Monitoring		June 30, 2018	Assumes ADEQ approval of Final Remedy Work Plan on or before June 30, 2013
Quarterly Performance Reports		June 1, 2018	Additional Qtr Performance Reports will be completed as required by ADEQ
Five Year Review		June 1, 2018	Additional 5 Year reviews will be completed as required by ADEQ

5 References

Arkansas Department of Environmental Quality. (ADEQ). 2002. "Letter of Agreement to Implement a Risk Management Strategy Between The Arkansas Department of Environmental Quality and Whirlpool Corporation," July 19.

Environmental Resources Management (ERM). 2007. "Risk Evaluation Report," June 14.

Environmental Resources Management (ERM). 2008. "Risk Management Plan," March 27.

ENVIRON International Corporation (ENVIRON). 2012. "Human Health Risk Assessment (HHRA)," November 30.

United States Environmental Protection Agency (USEPA). 1994. "RCRA Corrective Action Plan (Final)," May.

Tables

TABLE 1

Corrective Action Measures Summaries

Whirlpool Corporation
Fort Smith, Arkansas

General Corrective Action	Remedial Technology	Process Option	Description
NO ACTION	None	No Action	No action, represents base line conditions. Includes semi-annual ground water monitoring.
CONTAINMENT	Horizontal Barriers	Topsoil/Clay and Vegetation	Placement of topsoil/clay and seeding to vegetate
		Asphalt	Placement of asphalt over affected soil
		Concrete	Mixing and placement of concrete over affected soil
		Engineered Soil Cover w/Synthetic Liner	Construction of combination soil cover and synthetic liner
	Vertical Barriers	Slurry Wall	Installation of trench filled with soil/bentonite slurry
		Cement-Bentonite Wall	Installation of trench filled with cement/bentonite slurry
		Grout Curtain	Injection of clay-cement grout into voids where piles were driven and extracted
		Sheet Pile Wall	Construct of containment wall by driving sheet piling
	Interceptor Trenches	Installation of gravel filled trench used to isolate affected area	
REMOVAL	Soil Excavation	Excavation	Excavation - Removing media via backhoe for treatment or disposal
	Ground Water Extraction	Extraction Trenches	Trench, either open or backfilled with porous media, to allow seepage and collection of groundwater and oils
		Extraction Wells	Series of wells to extract impacted groundwater
	TREATMENT - In situ	Biological	Enhanced Aerobic/Anaerobic Biodegradation
Natural Attenuation			Long-term monitoring physical, chemical and biological processes that reduce chemicals of concern naturally
Physical/Chemical		Vapor Extraction	Application of a vacuum on the soil
		Permeable Treatment Beds	Impacted groundwater is intercepted in a downgradient trench filled with materials to treat or absorb the chemicals
		Chemical Oxidation	Saturated soils and groundwater are oxidized by injection of oxidants
		Soil Flushing	A cosolvent or surfactant is used to flood the area
INSTITUTIONAL ACTIONS	Access Restrictions	Deed Recordation	Surveying and filing of deed recordation, restricting groundwater use

**Table 2
Alternatives Array**

Remedial Alternative	RRMP Remedial Alternative Description	Overall Protection of Human Health and the Environment	Compliance with ARAR's	Long Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementability	Cost	Community Acceptance
No Action	Section 2.6.1	Not protective	The No Action alternative would not achieve the chemical-specific ARARs within a reasonable timeframe. As this alternative does not involve RAs, there would be no action-specific or location-specific ARARs.	Not Effective	No Reduction	Not Effective	Readily Implementable	Low	No
Containment - Horizontal Barrier	Section 2.6.2	Minimally protective on-site, as option reduces groundwater flow through source area & restricts direct contact	Does not include any activities that contribute to achieving chemical specific ARARs	Effective with regular maintenance	Reduces mobility due to limiting additional water through the source area, does not reduce toxicity or volume	Limited Effectiveness	Readily Implementable	Low to moderate	Acceptance likely if coupled with additional remedial option
Containment - Vertical Barrier	Section 2.6.2	Protective	Does not include any activities that contribute to achieving chemical specific ARARs	Effective	Reduces mobility of on-site impacts to off-site; no reduction in volume or toxicity	Effective	Not implementable off-site due to the presence of homes/utilities/etc. Implementability would need to be further evaluated on-site due to space constraints and subsurface conditions	Moderate	Potentially acceptable
Removal - Soil	Section 2.6.3	Protective for existing soil contamination	Should achieve chemical specific ARARs for soils for the protection of groundwater. Does not include any activities that contribute directly to achieving chemical specific ARARs for groundwater	Protective of soil issues, does not address high concentrations in groundwater	Reduces volume and potential mobility of soil contamination; does not address existing groundwater concentrations	Minimally effective due to concentrations in groundwater compared to soil	Not readily implementable due to surrounding structures, depth to impacted media, and volume of water table impacted	High	Acceptance likely if coupled with groundwater remedial option
Removal - Groundwater Extraction	Section 2.6.3	Protective	May achieve chemical specific ARARs for groundwater over extended timeframe	Effective only in transmissive portions of the aquifer	Reduces mobility of on-site impacts to off-site; reduction in volume or toxicity off-site over time	Effective only in transmissive portions of the aquifer	Limited implementability off-site due to the presence of homes/utilities/etc. Implementability would need to be further evaluated on-site due to access issues and subsurface conditions	Moderate to high	Potentially acceptable

**Table 2
Alternatives Array**

Remedial Alternative	RRMP Remedial Alternative Description	Overall Protection of Human Health and the Environment	Compliance with ARAR's	Long Term Effectiveness	Reduction of Toxicity, Mobility, or Volume	Short Term Effectiveness	Implementability	Cost	Community Acceptance
In-Situ Treatment: Chemical Oxidation	Section 2.6.4	Protective	Should achieve chemical specific ARARs for groundwater in reasonable timeframe	Effective as reduces source concentrations which in turn will reduce plume	Reduces volume, mobility, and toxicity	Very effective in the short term as the remedy reduces concentrations in a short timeframe	Readily Implementable where access and transmissive zone allows	Moderate to high	Acceptance likely as remedy quickly reduces concentrations
In-Situ Treatment: Permeable Barrier/Bed	Section 2.6.4	Protective	Should achieve chemical specific ARARs for groundwater within barrier/bed and may achieve ARARs for groundwater downgradient of barrier/bed over extended timeframe	Effective	Reduces volume, mobility, and toxicity over time	Minimally effective in the short term due to the need for groundwater to pass through the treatment media and slow associated groundwater movement	Limited implementability off-site based upon need to obtain residential access agreements or purchase properties	Moderate to high	Potentially acceptable, although likely not active enough for community
In-Situ Treatment: Enhanced Biodegradation	Section 2.6.4	Protective	Should achieve chemical specific ARARs for groundwater in reasonable timeframe	Effective as reduces source concentrations which in turn will reduce plume	Reduces volume, mobility, and toxicity	Somewhat effective in the short term, time is required to reduce higher concentrations	Readily Implementable where access and transmissive zone allows however use may be somewhat limited due to high contaminant concentrations	Moderate	Potentially acceptable, although likely not active enough for community
Monitored Natural Attenuation	Section 2.6.4	Protective over time	Should achieve chemical specific ARARs for groundwater over extended timeframe	Effective as concentrations will continue to decrease with time	Reduces volume, mobility, and toxicity	Minimally effective in the short term, time is required to reduce higher concentrations	Readily Implementable	Low to moderate	Potentially acceptable when coupled with active on-site remedy
Institutional Controls: On-Site	Section 2.6.5	Protective	Does not include any activities that contribute to achieving chemical specific ARARs	Effective	No Reduction	Effective	Readily Implementable	Low	Acceptance likely if coupled with additional remedial option
Institutional Controls: Off-Site	Section 2.6.5	Protective	Does not include any activities that contribute to achieving chemical specific ARARs	Effective with enforcement of groundwater well installation ban	No Reduction	Effective	Potentially implementable, further discussions with the City would be warranted	Low	Acceptance likely if coupled with additional remedial option

**TABLE 3a
Potential Action Specific ARARs**

Action	Requirements	Determination	Citation(s)
Activities causing fugitive dust emissions	Establish provisions for any source which has the potential to emit any air contaminant, including dust associated with excavation and construction activities.	ARAR	Arkansas Air Pollution Code ADPC&E Regulation No. 18
Activities causing direct groundwater discharges or storm water runoff from land disturbed by construction activity (disturbance of ≥1 acre of total land)	Implement good construction management techniques (including sediment and erosion controls, vegetative controls, and structural controls) to ensure that storm water discharge does not violate water quality criteria.	ARAR	National Pollutant Discharge Elimination System (NPDES) CWA 40 CFR 122 ADPC&E Regulation No. 6
Generation, storage, treatment, transportation, and disposal of solid waste including RCRA hazardous waste	Establish provisions covering the generation, transportation, treatment, storage, and disposal of hazardous waste and a framework for the management of non-hazardous solid waste. Arkansas requirements may be more stringent as noted in Regulation No. 23 Sections 1-6 and Sections 18-30.	ARAR	Resource Conservation and Recovery Act (RCRA) 40 CFR Part 260-270 ADPC&E Regulation No. 23
Transportation of hazardous materials including hazardous waste	Establish provisions for shippers and transporters of hazardous materials.	ARAR	49 CFR 171 - 180 40 CFR 262
Remedial activities that require use of water treatment prior to discharge to POTW	Pretreatment standards for discharges into POTW. Establish provisions to prohibit discharges of pollutants that may cause pass through or interference.	ARAR	40 CFR 403
Operation of a wastewater treatment system	Certification of Wastewater Utilities Personnel	ARAR	ADPC&E Regulation No. 3
Remedial actions involving discharge of treated groundwater that may affect surface waters.	Establish Water Quality Standards for Surface Waters of the State of Arkansas	ARAR	ADPC&E Regulation No. 2
Remedial actions involving injection of treated water or remedial fluids	Establish provisions for underground injection of fluids for the protection of groundwater resources.	ARAR	ADPC&E Regulation No. 17
Installation or modification of wells	Establish provisions for personnel responsible for installation and modification of water wells.	ARAR	Water Well Construction Act (AWWCC: 096.00) Arkansas Water Well Construction Commission - Water Well Construction Code Rules and Regulations
Practice of geology within the State	Establish provisions for personnel participating in the practice of geology within the State by the State Board of Registration for Professional Geologists.	ARAR	Arkansas Code 17-32-101
Practice of engineering within the State	Establish provisions for personnel participating in the practice of engineering within the State by the State Board of Licensure for Professional Engineers and Professional Surveyors	ARAR	Arkansas Code 17-30-101
Practice of surveying within the State	Establish provisions for personnel participating in the practice of surveying within the State by the State Board of Licensure for Professional Engineers and Professional Surveyors	ARAR	Arkansas Code 17-48-101

Key:
ADPC&E = Arkansas Department of Pollution Control and Ecology
ARAR = Applicable or relevant and appropriate regulation
AWWCC = Arkansas Water Well Construction Commission
CFR = Code of Federal Regulations
CWA = Clean Water Act

**TABLE 3b
Potential Chemical Specific ARARs**

Requirements	Determination	Citation(s)
Provides maximum contaminant levels (MCLs) for public drinking water supplies.	ARAR	Safe Drinking Water Act 40 CFR Part 141
Establishes methods and requirements for states in the development of ambient water quality criteria for the protection of aquatic organisms and/or the protection of human health in surface water.	ARAR	Federal Ambient Water Quality Criteria CWA 40 CFR Part 131
Establishes provisions covering USEPA permitting requirements, and establishes toxicity characteristics for hazardous waste.	ARAR	Resource Conservation and Recovery Act (RCRA) 40 CFR Part 260-270 ADPC&E Regulation No. 23
Establish Water Quality Standards for Surface Waters of the State of Arkansas	ARAR	ADPC&E Regulation No. 2
Enables Arkansas Natural Resources Commission to designate critical ground water use areas, establishes the authority for ground water withdrawals, establishes ground water rights, establishes fees, and establishes a mechanism for local ground water management. The Strategy outlines water quality criteria for groundwater. Arkansas has adopted the recommended standards for drinking water as promulgated in the SDWA.	ARAR	Groundwater Protection and Management Program Arkansas Water Plan and Ground Water Protection and Management Act (Act 154, 1991)
Establishes framework for determining ground water remediation levels on a case-by-case basis.	TBC	ADEQ Ground Water Remediation Level Interim Policy and Technical Guidance
USEPA risk-based tools for evaluating and cleaning up contaminated sites.	TBC	USEPA Regional Screening Levels
USEPA Region 4 screening values associated with a low probability of unacceptable risks to ecological receptors.	TBC	Region 4 Ecological Screening Values

Key:

ARAR = Applicable or relevant and appropriate regulation
 CFR = Code of Federal Regulations
 CWA = Clean Water Act
 TBC = To be considered

**TABLE 3c
Potential Location Specific ARARs**

Requirements	Determination	Citation(s)
The purpose of this act is to conserve endangered, threatened, and rare species of wildlife and plants. This regulation prohibits federal agencies from jeopardizing habitat for endangered or threatened species.	ARAR	Endangered Species Act 16 USC 1531-1544, 50 CFR 200, 50 CFR 402
Regulates action involving construction of facilities or management of property in wetlands to avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	ARAR	Wetlands Protection [Executive Order 11990] 40 CFR 6.302, Appendix A
Regulates actions that will occur in floodplain to avoid adverse effects due to flooding.	ARAR	Federal Floodplain Management [Executive Order 11988] 40 CFR 6.302, Appendix A
Requires federal agencies to take into account the effect of any federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places. Provides for protection, enhancement, and preservation of sites with archeological or historical significance.	ARAR	National Historic Preservation Act [Executive Order 11593] 40 CFR 6.301(b)
Enables Arkansas Natural Resources Commission to designate critical ground water use areas, establishes the authority for ground water withdrawals, establishes ground water rights, establishes fees, and establishes a mechanism for local ground water management. The Act states that no waste shall be placed in a manner that can potentially pollute the "Waters of the State."	ARAR	Groundwater Protection and Management Program Arkansas Water Plan and Ground Water Protection and Management Act (Act 154, 1991)

Key:

ARAR = Applicable or relevant and appropriate regulation
 CFR = Code of Federal Regulations
 CWA = Clean Water Act

Table 4
Cost Summary of Screened Alternatives

Corrective Action Option	Summary Of Corrective Action Option	Cost (-30%) ¹	Cost (\$) ¹	Cost (+50%) ¹
No Action	The No Action measure is a baseline against which other alternatives are compared.	\$0	\$0	\$0
Horizontal Containment (Asphalt Cover)	This measure is an asphalt cover over the affected soil area. It includes area grading, placement of a stone base and asphalt cover and routine inspection / maintenance for a period of 20 years.	\$400,000	\$600,000	\$800,000
Vertical Containment (Slurry Wall)	The Slurry Wall measure includes removal of surface concrete and debris located within the planned work area, pre-design subsurface work, excavation of the trench and placement of bentonite slurry into the trench. A cap would then be placed over the trench to complete slurry wall construction. A 20 year monitoring period is also included.	\$1,500,000	\$2,100,000	\$2,300,000
Soil Excavation & Disposal	This measure includes providing subsurface stability for the surrounding site structures by placing sheetpile around the working area. The top (unsaturated) soil would be removed and stockpiled onsite to be used as backfill. This soil is assumed to be "clean" for the purposes of the cost estimate. The removal of the saturated soil (from top of groundwater to till) is assumed to be hazardous for the purposes of this cost estimate and will be disposed of as such. This measure also includes dewatering and placing backfill to bring the excavation back to surrounding topography.	\$6,700,000	\$9,500,000	\$14,300,000
Groundwater Extraction (Pump & Treat)	The Groundwater Extraction measure includes construction of an on-site pump and treat system, and operation and maintenance of the system for a 20 year period. This option includes collection of groundwater samples on a semi-annual basis for a period of 20 years.	\$2,300,000	\$3,200,000	\$4,800,000
Monitored Natural Attenuation (MNA)	The Monitored Natural Attenuation measure includes sampling for COCs as well as attenuation parameters over a period of 20 years. The first five years includes semi-annual sampling, with a decreasing number of wells being sampled per year. Years 6 through 19 include annual sampling events of approximately 30 wells each. Year 20 includes a final round of quarterly sampling	\$600,000	\$900,000	\$1,300,000
Enhanced In-Situ Biodegradation	This measure includes collecting pre-design information (including a pilot study), obtaining permits, injection of a substrate at up to 20 injection wells, and pre and post injection sampling events.	\$1,600,000	\$2,300,000	\$3,400,000
Permeable Reactive Barrier	This measure includes collecting pre-design information, (including subsurface investigation), bench scale testing / screening, excavation of the trench, and placement of suitable reactive material for COCs. This option includes collection of groundwater samples on a semi-annual basis for a period of 20 years.	\$3,400,000	\$4,800,000	\$7,200,000

¹ This cost estimate has been developed based upon a conceptual level design at an accuracy of -30% to +50%, in accordance with USEPA guidance. Costs are rounded as appropriate.

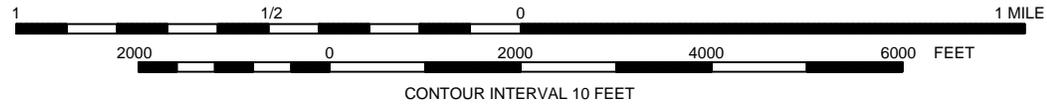
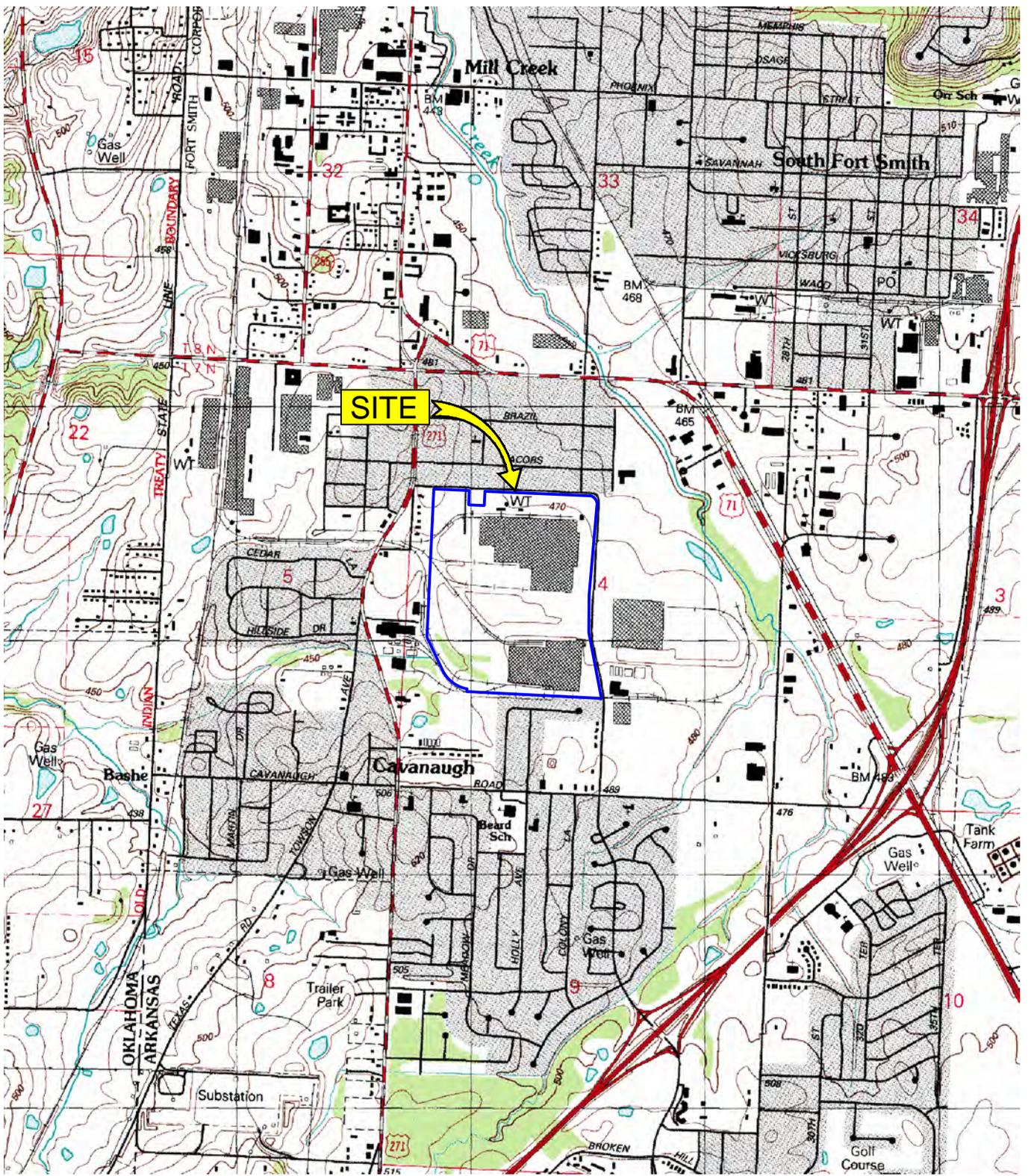
Table 4
Cost Summary of Screened Alternatives

Corrective Action Option	Summary Of Corrective Action Option	Cost (-30%)¹	Cost (\$) ¹	Cost (+50%)¹
In-Situ Chemical Oxidation	This measure includes collecting pre-design information, installation of up to 350 points (mixture of injection points and monitoring points), installation of oxidant, and pre and post injection sampling events.	\$2,400,000	\$4,500,000	\$6,800,000
Institutional Controls	The Institutional Controls measure includes preparing a work plan, meeting with the public/City/ADEQ, survey of on and off site properties, and preparation of deed restrictions including legal review.	\$100,000	\$200,000	\$300,000

¹ This cost estimate has been developed based upon a conceptual level design at an accuracy of -30% to +50%, in accordance with USEPA guidance. Costs are rounded as appropriate.

Figures

L:\Loop Project Files\00_CAD FILES\21\Whirlpool Risk Mgmt Plan & Remedy 21-31344A\01_Site Location Map.dwg



SOURCE: U.S.G.S. 7.5 minute series (topographic)
 South Fort Smith, Arkansas Quadrangle, 1997



LEGEND	
	APPROXIMATE PROPERTY BOUNDARY



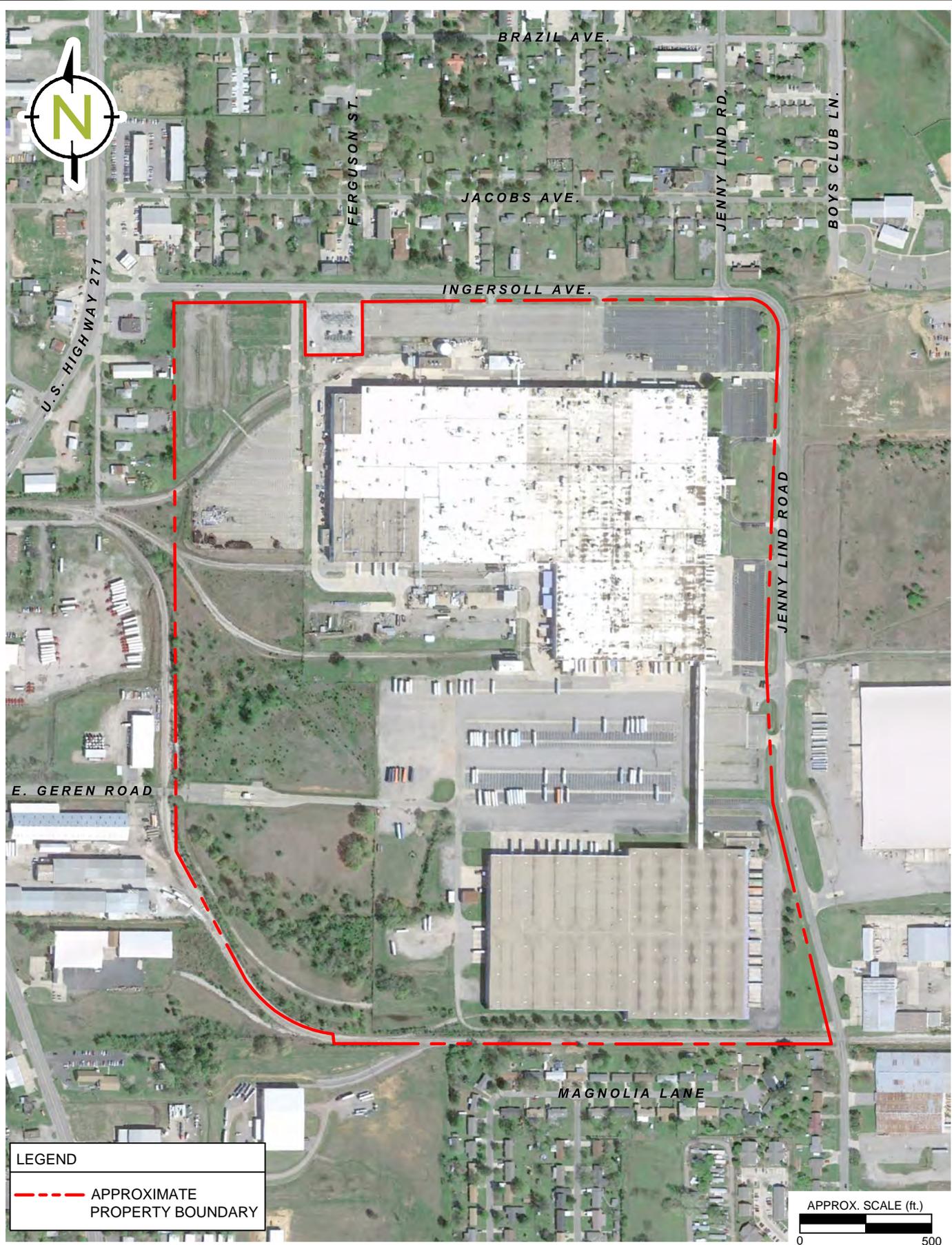
DRAFTED BY: ELS

DATE: 11/8/12

SITE LOCATION MAP
 WHIRLPOOL CORPORATION
 6400 SOUTH JENNY LIND ROAD
 FORT SMITH, ARKANSAS

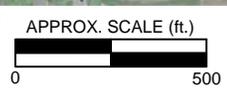
FIGURE
1

21-31344A



LEGEND

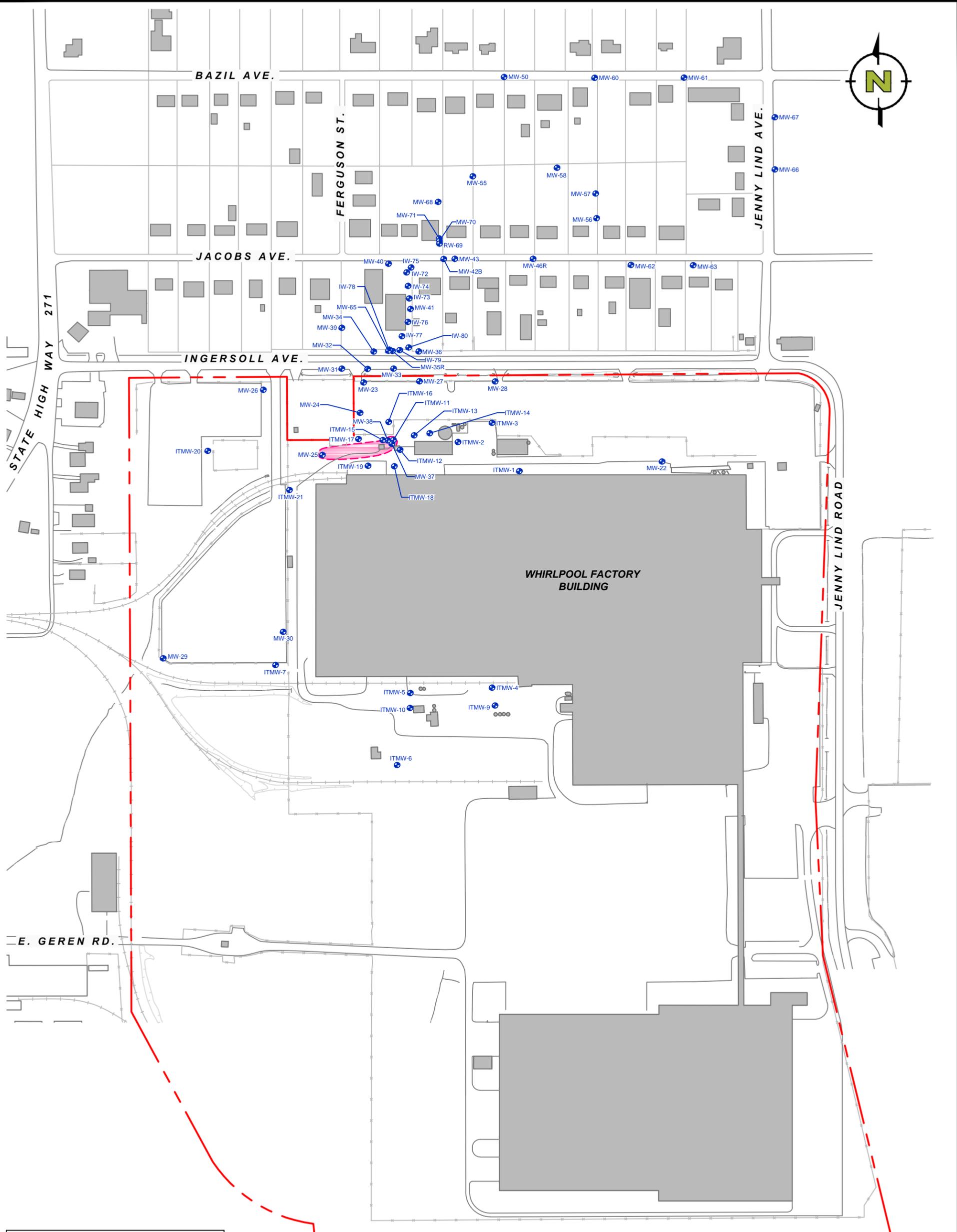
--- APPROXIMATE PROPERTY BOUNDARY



AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO. PHOTO TAKEN MARCH 2012.

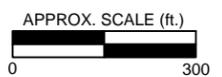
L:\Loop Project Files\00_CAD FILES\21\Whirlpool Risk Mgmt Plan & Remedy 21-31344A\02_Site Layout.dwg

	<p align="center">SITE LAYOUT WHIRLPOOL CORPORATION 6400 JENNY LIND ROAD FORT SMITH, ARKANSAS</p>	<p align="center">FIGURE 2</p>
		<p align="center">21-31344A</p>
<p>DRAFTED BY: ELS</p>	<p>DATE: 11/8/12</p>	



LEGEND

- - - APPROXIMATE PROPERTY BOUNDARY
- - - LIMITS OF IMPACTED SOIL
- - - RAILROAD TRACK
- MONITORING WELL LOCATION



Note: Limits of soil impact were based upon approximation provided by ERM in the 2008 Risk Management Plan.

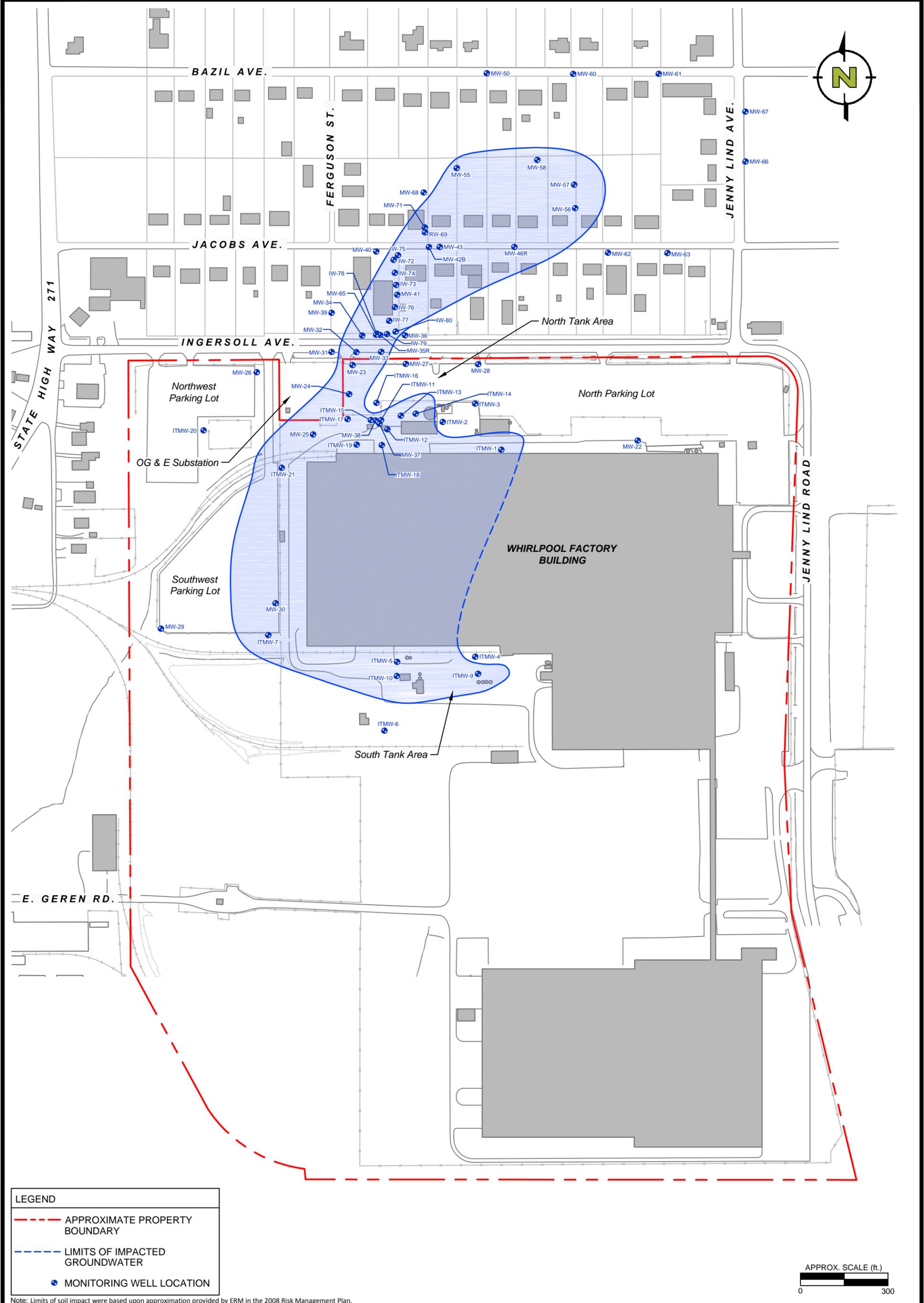
ENVIRON

DRAFTED BY: ELS/CKN DATE: 11/27/12

LIMITS OF IMPACTED SOIL
 WHIRLPOOL CORPORATION
 6400 JENNY LIND ROAD
 FORT SMITH, ARKANSAS

FIGURE
3

21-31344A



LEGEND

- - - APPROXIMATE PROPERTY BOUNDARY
- - - LIMITS OF IMPACTED GROUNDWATER
- MONITORING WELL LOCATION

APPROX. SCALE (ft.)
 0 300

Note: Limits of soil impact were based upon approximation provided by ERM in the 2008 Risk Management Plan.



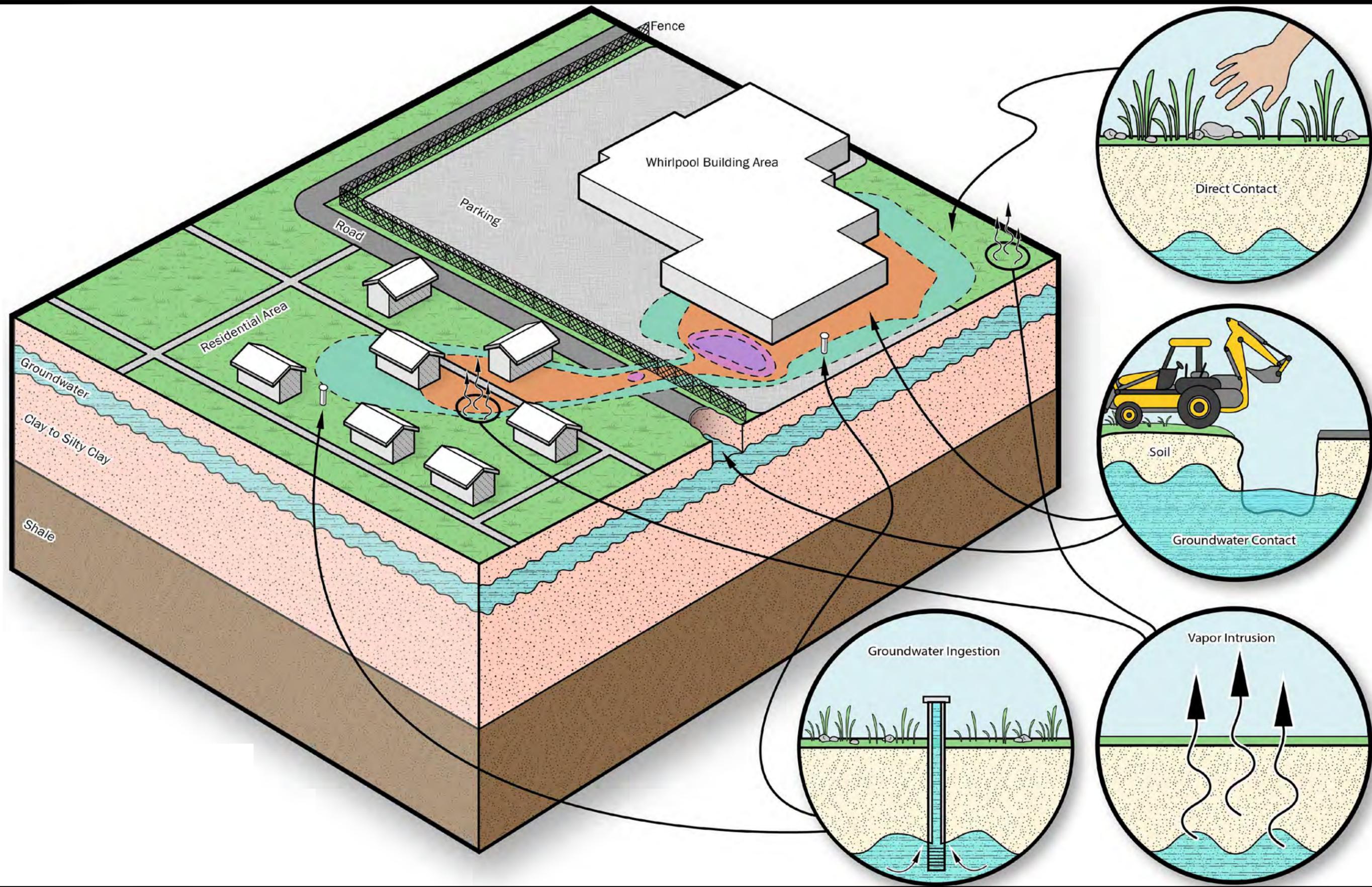
DRAFTED BY: ELS DATE: 11/16/12

LIMITS OF IMPACTED GROUNDWATER - FALL 2012
 WHIRLPOOL CORPORATION
 6400 JENNY LIND ROAD
 FORT SMITH, ARKANSAS

FIGURE 4

21-31344A

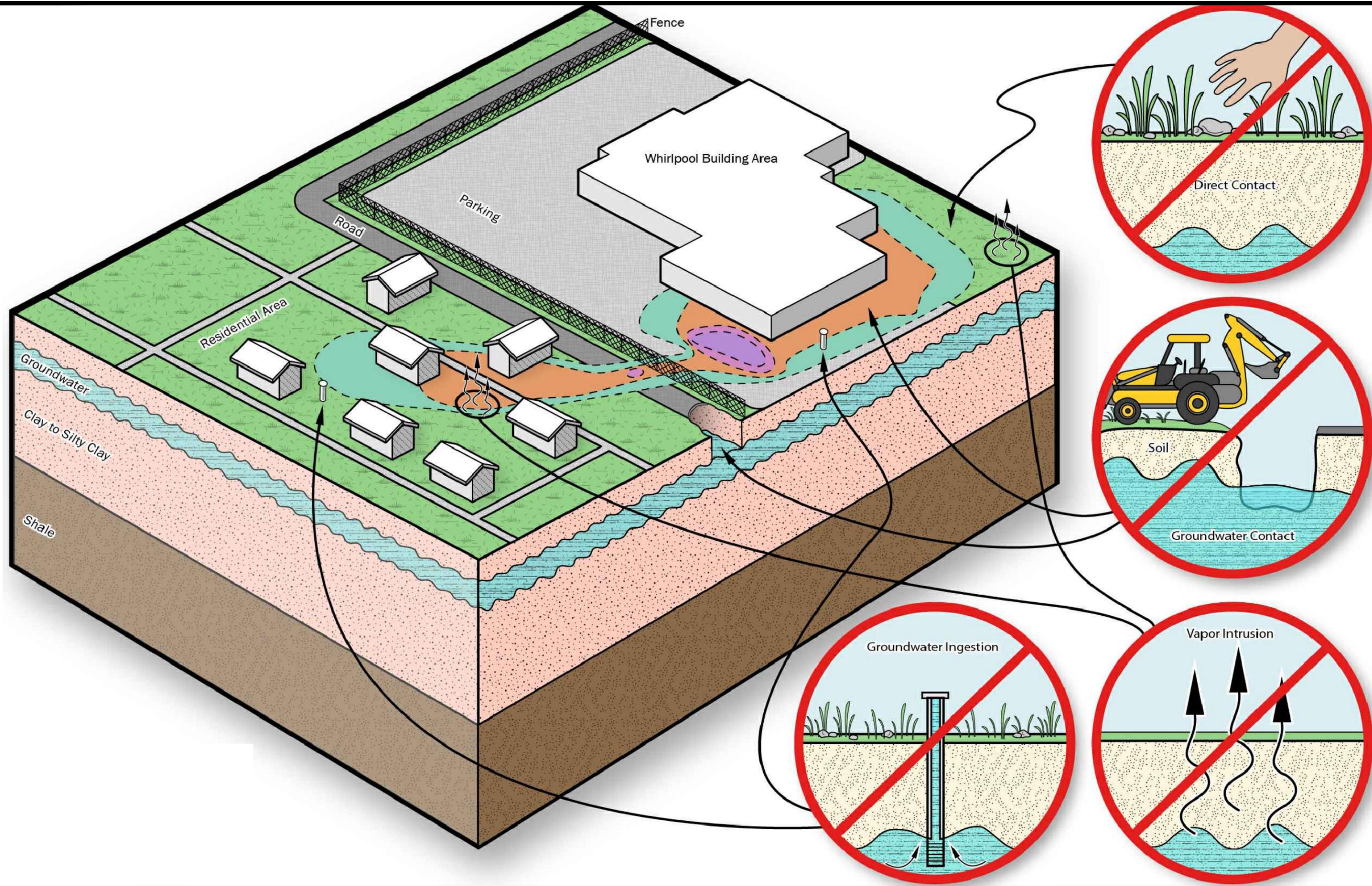
L:\Loop Project Files\00_CAD FILES\21Whirlpool Risk Mgmt Plan & Remedy 21-31344A\05_CSM Scenarios for Potential Human Exposure.dwg



CSM SCENARIOS FOR POTENTIAL HUMAN EXPOSURE
 WHIRLPOOL CORPORATION
 6400 JENNY LIND ROAD
 FORT SMITH, ARKANSAS

FIGURE 5
 21-31344A

L:\Loop Project Files\00_CAD FILES\21Whirlpool Risk Mgmt Plan & Remedy 21-31344A\06_CSM Scenarios for Potential Human Exposure After Remedy Implementation.dwg



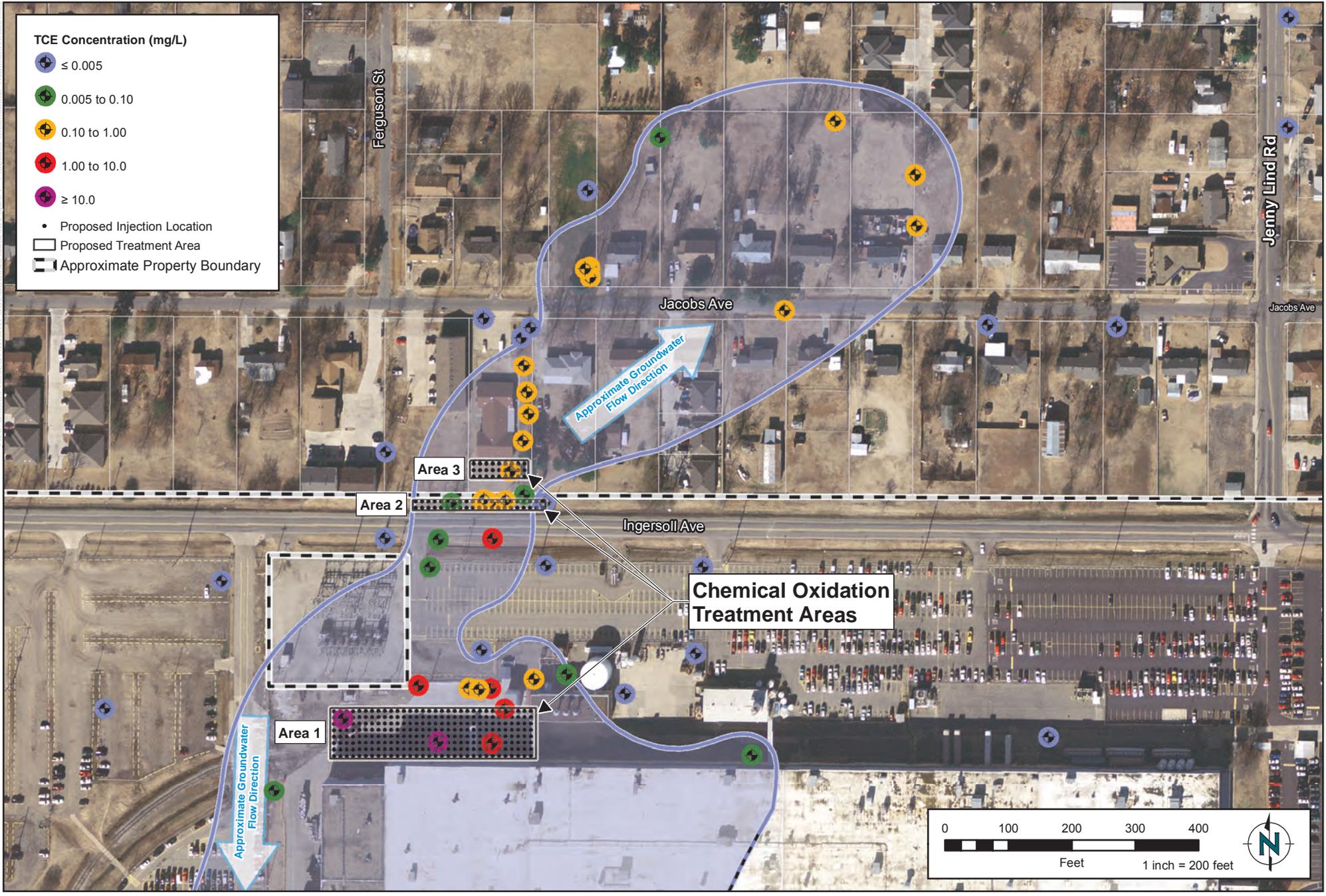
CSM SCENARIOS FOR POTENTIAL HUMAN EXPOSURE AFTER REMEDY IMPLEMENTATION

WHIRLPOOL CORPORATION
 6400 JENNY LIND ROAD
 FORT SMITH, ARKANSAS

FIGURE

6

FILE: D:\GIS\PROJ\ENVIRON\LEGACY\2012\20120520\20120520_Figure 7 - Proposed Groundwater Treatment Areas.mxd



DRAFTED BY: KTS DATE: 05/20/2013

PROPOSED GROUNDWATER TREATMENT AREAS AND FALL 2012 GROUNDWATER RESULTS

Whirlpool Facility - Fort Smith, Arkansas

Figure 7

PROJECT: 2131344A

Appendix A

Human Health Risk Assessment (HHRA)



Revised Risk Management Plan
Appendix A -
Human Health Risk Assessment
Whirlpool Fort Smith Facility
6400 Jenny Lind Avenue
Fort Smith, Arkansas

Prepared for:
Whirlpool Corporation
Benton Harbor, Michigan

Prepared by:
ENVIRON International Corporation
Princeton, New Jersey

Date:
November 2012
Revised April 2013

Project Number:
21-31344A



Contents

	Page
1 Introduction	1
2 Data Collection and Preparation	1
3 Exposure Assessment	2
3.1 Conceptual Site Model	2
3.2 Exposure Concentrations	3
3.2.1 Soil	3
3.2.2 Groundwater	3
3.2.3 Soil Gas	4
3.3 Fate and Transport Models	4
3.3.1 Soil and Groundwater Vapor Intrusion	4
3.3.2 Vapor Emission from Exposed Soil	6
3.3.3 Groundwater Volatilization into Outdoor Air	7
3.3.4 Dust Emission	8
3.3.5 Air Dispersion	9
3.4 Exposure Factors	9
4 Toxicity Values	10
5 Physical and Chemical Parameters	10
6 Risk Estimation	10
6.1 Cancer Risk and Noncancer Hazard Index	10
6.2 Estimating Risks to On-Site Routine Workers	11
6.2.1 Contact with Outdoor Soil	11
6.2.2 Soil Volatilization into Indoor Air	12
6.2.3 Groundwater Volatilization into Indoor Air	13
6.2.4 Groundwater Volatilization into Outdoor Air	13
6.3 Estimating Risks to On-Site Maintenance Workers	13
6.3.1 Contact with Soil	13
6.3.2 Groundwater Contact	14
6.4 Estimating Risks to On-Site Construction Workers	15
6.4.1 Contact with Soil	15
6.4.2 Groundwater Contact	15
6.5 Estimating Risks to Off-Site Residents	15
6.5.1 Inhalation of Soil-Derived Vapors and Particulates	15
6.5.2 Groundwater Volatilization into Indoor Air	16
6.5.3 Groundwater Volatilization into Outdoor Air	16
6.5.4 Groundwater Use	17
6.6 Estimating Risks to Off-Site Routine Workers	17
6.6.1 Inhalation of Soil-Derived Vapors and Particulates	17
6.6.2 Groundwater Volatilization into Indoor Air	17

6.6.3	Groundwater Volatilization into Outdoor Air	17
6.6.4	Groundwater Use	18
6.7	Estimating Risks to Off-Site Maintenance Workers	18
6.7.1	Groundwater Contact	18
6.8	Uncertainty Analysis	18
6.8.1	Exposure Concentrations	18
6.8.2	Fate and Transport Models	19
6.8.3	Exposure Factors	20
6.8.4	Toxicity Values	21
6.8.5	Risk Characterization	21
7	Summary and Conclusions	22
8	References	23

List of Figures

- Figure 1: Site Location Map
- Figure 2: Sample Location Map

List of Tables

- Table 1: Conceptual Site Model – Scenarios for Potential Human Exposure
- Table 2: Upper-Bound Cumulative Risk Estimates for On-Site Soil
- Table 3: Upper-Bound Cumulative Risk Estimates for Groundwater
- Table 4: Evaluation of TCE in Soil Gas
- Table 5: Evaluation of PCE in Soil Gas
- Table 6: Groundwater Screening Summary

List of Attachments

- Attachment 1: Risk Calculation Inputs
- Attachment 2: Routine Worker Risk Calculations
- Attachment 3: Maintenance Worker Risk Calculations
- Attachment 4: Construction Worker Risk Calculations
- Attachment 5: Off-Site Resident Risk Calculations

1 Introduction

This human health risk assessment evaluates the potential health significance of data for soil, groundwater, and soil gas that were collected at and around the Whirlpool facility in Fort Smith, Arkansas (site) to support remedy selection per the letter of agreement (LOA) with the Arkansas Department of Environmental Quality (ADEQ), dated July 19, 2002. The site and adjacent properties are shown on **Figure 1**. As discussed in the Revised Risk Management Plan (ENVIRON 2012), the risk assessment uses these data to quantify risks from reasonable maximum exposures (RME) to soil, groundwater, and soil gas under current and reasonably expected future land and groundwater use at and the site.

The methods and assumptions used in the risk assessment are consistent with United States Environmental Protection Agency (USEPA) human health risk assessment guidance. The results of the risk assessment are compared to the acceptable risk limits used by Arkansas Department of Environmental Quality (ADEQ 2005) to identify where a release of hazardous substances from the site may cause reasonable maximum exposures to be significant enough to warrant remediation. The scope of the human health risk assessment is summarized in the conceptual site model (CSM) presented in **Table 1**, which is based on current and reasonably anticipated land use at the site. The CSM identifies the potentially exposed populations, the environmental media to which they could be exposed, and the potential routes of exposure. These exposure scenarios are discussed further in Section 3.

The remainder of this report is organized as follows:

- Section 2 discusses the preparation of data used in the risk assessment.
- Section 3 discusses the scenarios for potential human exposure that are evaluated in the risk assessment.
- Section 4 discusses the toxicity values used in the risk calculations.
- Section 5 discusses the physical and chemical parameters used in the risk calculations.
- Section 6 discusses the significance of the risk estimates for the potential exposures discussed in Section 3. Uncertainties associated with the risk estimates are also discussed in this section.
- Section 7 summarizes the findings and conclusions of the risk assessment.

2 Data Collection and Preparation

All valid soil, groundwater, and soil gas data collected at and around the site to support remedy selection were considered for use in the risk assessment. The locations where these data were collected are shown on **Figure 2**.

The following procedures, which are based on USEPA's Risk Assessment Guidance (RAGS) Part A (USEPA 1989), were used to prepare the data for quantitative assessment of RME risks:

- Concentrations qualified as not detected (i.e., U or UJ-qualified data) are evaluated as non-detects.
- The concentrations of 1,3-dichloropropene (total) and xylenes (total) in a sample are the sums of the concentrations of the detected isomers and half the quantitation limits of isomers not detected in the sample but detected in the same matrix at the site. If no isomer is detected in a sample, the chemical is considered to be not detected in the sample.

As a conservative assumption, all concentrations of chemicals are assumed to be site-related. All detected chemicals are included in the risk assessment, regardless of their detection frequency.

3 Exposure Assessment

3.1 Conceptual Site Model

The site is an industrial facility located at 6400 Jenny Lind Avenue, Fort Smith, Arkansas. The site has been operated by Whirlpool for over 35 years to manufacture household appliances. The site is approximately 150 acres and includes the main manufacturing building, adjoining warehouse and administrative offices, manufacturing support buildings, and approximately 20 acres of undeveloped land. The majority of the on-site area surrounding the buildings is covered with concrete, asphalt, or gravel for parking.

The area north of the site is residential and the areas east, south, and west of the site are industrial/commercial. The nearest residence is located to the north, adjacent to the site.

The site and the surrounding area are connected to a municipal water supply and there is no known use of groundwater within or near the area of impacted groundwater. Currently, there is no ordinance or restriction that would prohibit use of groundwater in the impacted area.

The scenarios for potential human exposure under current and potential future conditions at and around the site are summarized in the conceptual site model (CSM) on **Table 1**. The receptors and potential pathways included for quantitative evaluation in the risk assessment are as follows:

- On-Site Routine Workers
 - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during outdoor activities; inhalation of vapors in indoor air
 - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air
- On-Site Maintenance Workers
 - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during smaller-scale surface and subsurface maintenance activities
 - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale subsurface maintenance activities that encounter groundwater

- On-Site Construction Workers
 - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during larger-scale/short-term (i.e., 1 year) construction activities
 - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during larger-scale/short-term (i.e., 1 year) subsurface construction activities that encounter groundwater
- Off-Site Residents
 - Soil –inhalation of wind-blown vapors and particulates from on-site soil
 - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or dermal contact with groundwater
- Off-Site Routine Workers
 - Soil – inhalation of vapors and particulates from on-site soil during off-site outdoor activities
 - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or dermal contact with groundwater
- Off-Site Maintenance Workers
 - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale/shorter duration subsurface maintenance activities that encounter groundwater

3.2 Exposure Concentrations

3.2.1 Soil

Risk estimates for RME are conservatively estimated in this risk assessment by first using the maximum detected concentrations at any depth from the available soil data to calculate upper-bound estimates of cumulative cancer and noncancer risks. If these upper-bound estimates of RME risks do not exceed the acceptable risk levels, i.e., cumulative site-related cancer risk of 10^{-4} and noncancer HI of 1, then further calculations such as 95% upper confidence limits (95% UCLs) on the mean are not necessary. The use of maximum detected concentrations, rather than 95% UCLs, for the chemicals evaluated in this risk assessment introduces more conservatism than necessary for RME estimates because it assumes constant, simultaneous worst case exposure to all detected chemicals, when the RME generally would not have all chemicals at worst case concentrations at all times.

3.2.2 Groundwater

To assess potential exposures to groundwater under current and future conditions on- and off-site, the highest detected concentration for each chemical from all monitoring wells sampled since 2008, i.e., the past five (5) years, were used to calculate upper-bound estimates of cumulative cancer and noncancer risks representative of current conditions. On-site and off-site groundwater data from the last ten years of semi-annual groundwater monitoring conducted under the LOA, indicate the plume boundary, defined by concentrations in groundwater that are higher than the Federal maximum contaminant level (MCL), is not expanding and that concentrations of trichloroethene (TCE) in groundwater are not increasing, although some

contaminant mass may have been re-distributed following the permanganate injections in 2009. Groundwater data from 2012 show that concentrations of TCE have further decreased by at least a factor of 2.4 from the maximum concentrations detected during the last five years. As discussed above, the use of maximum detected concentrations introduces more conservatism than necessary for RME estimates.

3.2.3 Soil Gas

Soil gas data were collected in May 2012 from two locations that are between 30 and 80 feet away from nearby groundwater wells, as shown on **Figure 2**, to confirm the results of the groundwater vapor intrusion risk calculations discussed in Section 3.3.1. The evaluation of the soil gas data and potential uncertainties in the groundwater vapor intrusion risk estimates are discussed in Section 6.8.2.

3.3 Fate and Transport Models

The following models are used in the risk assessment to estimate exposure concentrations for the exposure scenarios discussed in Section 3.1. These models are used by USEPA and state regulatory agencies for screening level analysis. The following are descriptions of the models.

3.3.1 Soil and Groundwater Vapor Intrusion

Indoor air concentrations resulting from soil or groundwater vapor intrusion into a building are estimated using the following relationships described by Johnson and Ettinger (1991), which USEPA recommends for screening level evaluations (USEPA 2004a):

$$C_{building} = \alpha C_{source}$$

where C_{source} is the source vapor concentration, and α is an attenuation coefficient that is given by the following equation:

$$\alpha = \frac{\left[\frac{D_T^{eff} A_B}{Q_{building} L_T} \right] \exp\left(\frac{Q_{soil} L_{crack}}{D^{crack} A_{crack}} \right)}{\exp\left(\frac{Q_{soil} L_{crack}}{D^{crack} A_{crack}} \right) + \left[\frac{D_T^{eff} A_B}{Q_{building} L_T} \right] + \left[\frac{D_T^{eff} A_B}{Q_{soil} L_T} \right] \left[\exp\left(\frac{Q_{soil} L_{crack}}{D^{crack} A_{crack}} \right) - 1 \right]}$$

Derivation of this equation and definition of the equation parameters can be found in Johnson and Ettinger's 1991 journal article, and therefore, are not repeated here.

The effective diffusion coefficient term D_T^{eff} in the equation for the attenuation coefficient (α) is calculated based on a "silty clay" soil, the predominant unsaturated soil type at and around the site. The soil-water profile in the vadose zone is estimated using the van Genuchten soil-water retention equation with default water retention parameters appropriate for silty clay (USEPA 2004a).

The distance between on-site groundwater and the foundation of a slab-on-grade building (L_T) is estimated to be approximately 3.5 m, which is the difference between the typical depth to

groundwater on-site of 3.7 m (12 ft) and a conservatively assumed building foundation thickness of 15 cm. The cracks in the building foundation are conservatively assumed to be filled with dry sand. The remaining parameters in the equation for the attenuation coefficient (α), which relate to building characteristics, are based on USEPA values for assessing chronic vapor intrusion into residential buildings (USEPA 2004a and 2012a) and default values presented in the Michigan Department of Environmental Quality technical support document for assessing chronic vapor intrusion into commercial buildings (MDEQ 1998)¹. Residential structures surrounding the Site have not been observed to have basements and as such, evaluation of vapor intrusion into structures with basements was not performed. The rationale for these inputs is discussed in the USEPA guidance and MDEQ guidance, and therefore, is not repeated here.

The source vapor concentration (C_{source}) for a chemical in soil is calculated from the chemical's concentration in soil (C_{soil}), as follows:

$$C_{source} = C_{soil} \left(\frac{K_d}{H} + \frac{\theta_w}{\rho_b H} + \frac{\theta_a}{\rho_b} \right)^{-1}$$

where K_d is the equilibrium-partitioning coefficient, H is the Henry's law constant (adjusted to the estimated subsurface temperature in the Fort Smith, Arkansas area of 16.7 °C (USEPA 2004a)), θ_w is the water-filled soil porosity, ρ_b is the soil bulk density, and θ_a is the air-filled soil porosity.

The soil vapor intrusion risk calculations included a mass balance check to ensure that the assumed mass of a chemical infiltrating into the building over the assumed exposure period does not exceed an upper-bound estimate of the chemical's mass in the vadose zone soil underlying the building. The upper-bound estimate of the chemical's mass in the vadose zone soil was conservatively estimated using the highest concentration of the chemical from any depth in soil at the site and assuming that this concentration represents the concentration in soil from ground surface to the water table. The attenuation coefficient α_{ML} used in the mass balance check is given by the following equation:

$$\alpha_{ML} = \left(\frac{\rho_b \cdot K_d}{H} + \frac{\theta_w}{H} + \theta_a \right) \cdot \left(\frac{A_B \cdot \Delta H}{Q_{building} \cdot ED} \right)$$

where A_B is the area of the building footprint, ΔH is the contaminant thickness (the distance between water table and a building foundation (L_{T-gw})), and $Q_{building}$ is the air flow rate through the building. These parameters are shown in **Attachment 2** and **Attachment 5**.

The source vapor concentration for a chemical in groundwater is calculated from the chemical's concentration in groundwater (C_{gw}), as follows:

¹ Factors for assessing this pathway for commercial/industrial buildings, including assumptions regarding building characteristics, are not available from ADEQ or USEPA.

$$C_{source} = C_{gw} \cdot H$$

The computation of the single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 2**. The cumulative risk and HI estimates for vapor intrusion from soil and groundwater are summarized on **Table 2** and **Table 3**, respectively.

In assessing the significance of releases, potential exposure of routine workers to chemicals in soil and groundwater via potential vapor intrusion is also evaluated by dividing the highest estimated concentrations of chemicals in indoor air resulting from vapor intrusion by occupational indoor air standards, and then summing the resulting ratios. This approach is consistent with the approach described in Occupational Safety and Health Administration (OSHA) regulations at 29 CFR 1910.1000(d)(2)(i) for assessing compliance with inhalation exposure limits for a mixture of air contaminants, which uses an equivalent exposure for the mixture (E_m) given by the following:

$$E_m = \sum_i \frac{C_{building,i}}{L_i}$$

where $C_{building,i}$ and L_i are the indoor air concentration (calculated as described above) and exposure limit for chemical i , respectively. Exposure is within acceptable limits when E_m does not exceed 1. In applying this approach to assess the significance of contributions from vapor intrusion to indoor air exposures, the contribution to E_m due to vapor intrusion should be much less than 1 (e.g., less than 0.01).

The exposure limits L_i in the above equation are the permissible exposure limits (PELs) established by OSHA (OSHS 2007), threshold limit values (TLVs) recommended by the American Conference of Government Industrial Hygienists (ACGIH 2005) for chemicals without PELs, or NIOSH recommended exposure limits (RELs) for chemicals without a PEL or TLV. The inhalation limits for chemicals evaluated in the risk assessment are shown in **Attachment 1**.

3.3.2 Vapor Emission from Exposed Soil

The potential exposure of outdoor receptors (i.e., routine workers and residents) to vapors that are emitted from soil are assessed based on the normalized average vapor flux J_v of a chemical from unsaturated soil. The average flux is conservatively estimated using an unsteady-state model derived by Jury et al. (1983). This model conservatively assumes that volatile chemicals are present in the soil to a finite depth. The equation for J_v is given by:

$$J_v = \frac{C_{s,0}}{T} \left(2 \left(\exp\left(\frac{-Z_1^2}{4D_E T}\right) - \exp\left(\frac{-Z_2^2}{4D_E T}\right) \right) \sqrt{\frac{D_E T}{\pi}} - Z_1 \operatorname{erfc}\left(\frac{Z_1}{2\sqrt{D_E T}}\right) + Z_2 \operatorname{erfc}\left(\frac{Z_2}{2\sqrt{D_E T}}\right) \right)$$

where:

$$D_E = \frac{D_G H + D_L}{\rho_b K_d + \theta_w + \theta_a H}$$

$$D_G = D_{air} \cdot \frac{\theta_a^{10/3}}{n^2}$$

$$D_L = D_{water} \cdot \frac{\theta_w^{10/3}}{n^2}$$

where ρ_b is the soil dry bulk density, D_E is the effective diffusion coefficient in soil, T is the averaging period, D_G is the gas-phase diffusion coefficient, H is the Henry's law constant, D_L is the liquid-phase diffusion coefficient, K_d is the soil-water distribution coefficient, θ_w is water-filled porosity, θ_a is the air-filled porosity, D_{air} is the diffusion coefficient in air, n is the soil porosity, D_{water} is the diffusion coefficient in water and Z_1 and Z_2 are the top and bottom depths of the soil contamination. Derivation of this equation can be found in the Jury et al. 1983 journal article and therefore, is not repeated here. Finite depth volatilization models are also discussed in the Soil Screening Guidance (USEPA 1996). Soil parameters used in this assessment were obtained from USDA's ROSETTA Model V1.0 (1999); parameters for silty clay were selected as representative of the soil observed in the site. The values for chemical-specific parameters and soil parameters for calculating J_v are included in **Attachment 2**.

3.3.3 Groundwater Volatilization into Outdoor Air

Potential exposures to vapor emissions from groundwater that migrate through the vadose zone into outdoor air are assessed using a normalized average vapor flux (J) of a chemical from groundwater, which is calculated by using the steady-state diffusion equation in one-dimension with a constant source concentration and the maximum concentration gradient, as follows:

$$J = D_e \cdot \frac{C_{source}}{L}$$

where D_e is the effective diffusion coefficient of the chemical in the vapor phase, C_{source} is the vapor concentration in equilibrium with the groundwater concentration, and L is the distance from groundwater to the ground surface.

The effective diffusion coefficient for the vapor phase is calculated as follows:

$$D_e = D_v + \frac{D_w}{H}$$

where D_v is the gas phase diffusion coefficient, D_w is the liquid phase diffusion coefficient, and H is the Henry's law constant (adjusted to a subsurface temperature of 16.7°C). The gas and

liquid-phase diffusion coefficients are calculated using the Millington-Quirk tortuosity model, as follows:

$$D_v = D_{air} \cdot \frac{\theta_a^{10/3}}{\theta_t^2}$$

$$D_w = D_{water} \cdot \frac{\theta_w^{10/3}}{\theta_t^2}$$

where D_{air} is the diffusion coefficient in air, D_{water} is the diffusion coefficient in water, θ_a is the air-filled soil porosity, θ_w is the water-filled soil porosity, and θ_t is the total soil porosity. The values of the porosities used in these calculations are the same as those discussed in Section 3.3.1 for calculating vapor flux from silty clay vadose zone soil.

The normalized vapor flux (J_L) of a chemical from exposed groundwater into outdoor air (e.g., in an excavation) is estimated using an overall mass transfer coefficient (K_L) recommended by USEPA (1995):

$$J_L = K_L = \left(\frac{1}{k_l} + \frac{1}{H k_g} \right)^{-1} \left(\frac{m}{10^2 \text{ cm}} \right) \left(\frac{10^3 \text{ L}}{m^3} \right)$$

where H is the Henry's law constant (adjusted to a subsurface temperature of 16.7°C) and k_l and k_g are the liquid-phase and gas-phase mass transfer coefficients given by the following:

$$k_l = \left(\frac{MW_o}{MW} \right)^{0.5} \left(\frac{T}{298 \text{ K}} \right) k_{l,o}$$

$$k_g = \left(\frac{MW_w}{MW} \right)^{0.335} \left(\frac{T}{298 \text{ K}} \right)^{1.005} k_{g,w}$$

where MW , MW_o , and MW_w are the molecular weights of the chemical, oxygen, and water, T is the absolute temperature of the groundwater, $k_{l,o}$ is the liquid-phase mass transfer coefficient for oxygen, and $k_{g,w}$ is the gas-phase mass transfer coefficient for water vapor.

3.3.4 Dust Emission

Potential exposures to particulate emissions from uncovered soil are assessed using a normalized average particulate flux (J_{10}) of a chemical from surface soil. This particulate flux is conservatively estimated using the "unlimited reservoir" model that USEPA has adapted for screening-level analysis of respirable particulate emissions from soil (USEPA 1996). This model assumes that particulate emissions are created by wind erosion. The equation for J_{10} is given by:

$$J_{10,w} = 0.036 \cdot (1 - G) \cdot \left(\frac{u_m}{u_t} \right)^3 \cdot F(x) \frac{g}{m^2 hr} \cdot \frac{hr}{60^2 \text{ sec}} \cdot \frac{10^{-3} kg}{g}$$

where G is fraction of ground/vegetative cover, u_m is the mean annual wind speed at the nearest weather station which is located at Fort Smith, Arkansas (NOAA 2010), u_t is the equivalent threshold wind speed at the anemometer height at which u_m was measured, and $F(x)$ is a function dependent on u_m/u_t . The details of this model can be found in USEPA guidance (1996), and are not repeated here. The values for default parameters recommended in the 1996 USEPA guidance are used in conjunction with the wind speed for Fort Smith, Arkansas.

Emission and dispersion modeling were not used to estimate airborne dust concentrations for excavation activities, because such activities are generally required to ensure that dust does not exceed acceptable levels. Emission of respirable soil particulates during maintenance activities is conservatively set at the former annual average National Ambient Air Quality Standard (NAAQS) for PM_{10} of 50 micrograms per cubic meter ($\mu g/m^3$). The PM_{10} level of $50 \mu g/m^3$ is based on a time weighted average over an exposure frequency of 30 days per year assuming that maintenance workers spend 5 days per year excavating into the subsurface and 25 days per year conducting other activities that do not involve excavation into the subsurface. In the time-weighted average calculation, the 24-hour average NAAQS for PM_{10} of $150 \mu g/m^3$ was used as the maximum PM_{10} concentration for the time spent excavating into the subsurface and a PM_{10} concentration of $1 \mu g/m^3$ was used for the time spent during activities that do not involve excavation. The PM_{10} concentration during non-excavation activities is expected to be less than $1 \mu g/m^3$. It was conservatively assumed that the PM_{10} concentration would be at these limits every day for the entire assumed periods of exposure.

3.3.5 Air Dispersion

Potential exposure of receptors to vapors and particulates in ambient air are estimated based on emission estimates presented above and using the empirical correlations presented in USEPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA 2002). The normalized air concentration (or air dispersion factor, C/Q) is estimated using the empirical equations presented in USEPA's *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites* (USEPA 2002). The calculations are performed, assuming the source area is the area of the site (approximately 150 acres) for routine workers and residents, and a 15 ft by 15 ft excavation for maintenance and construction workers, and using correlation coefficients for Little Rock, Arkansas, which is the closest city for which correlation coefficients are available. Derivation of the equations and definition of the equation parameters for C/Q can be found in Appendix D of the 2002 USEPA Supplemental Soil Screening Guidance, and therefore, are not repeated here.

3.4 Exposure Factors

Standard default exposure factors recommended by USEPA for estimating reasonable maximum exposures are used where available and appropriate. Where standard default exposure factors are not available or not appropriate for an exposure scenario, the evaluation is conducted using similarly conservative exposure factors based on professional judgment. The exposure factors used in the derivation of the risk estimates are presented in **Attachment 1**.

4 Toxicity Values

According to USEPA (2003), the hierarchy of sources for toxicity values used in quantitative risk computations is:

1. Integrated Risk Information System (IRIS);
2. Provisional Peer Reviewed Toxicity Values (PPRTV); and
3. Other Toxicity Values (e.g., historical HEAST, NCEA provisional values and ATSDR).

When a toxicity value is not available from the first two tiers of the hierarchy, other USEPA and non-USEPA sources of toxicity values can be consulted. Route-to-route extrapolation of toxicity values was made following USEPA guidance (USEPA 2004b, 2009). The toxicity values and their sources used in the risk assessment are summarized in **Attachment 1**. For evaluating construction worker exposures, subchronic noncancer toxicity values are used instead of chronic values, since their exposure duration is one year. The toxicity values in **Attachment 1** are current as of October 2, 2012.

5 Physical and Chemical Parameters

The physical and chemical parameters used in the risk assessment are based on the hierarchy USEPA used in the Soil Screening Guidance (USEPA 1996). The values used in the risk assessment and their sources are presented in **Attachment 1**.

6 Risk Estimation

6.1 Cancer Risk and Noncancer Hazard Index

For the ingestion and dermal exposure routes, estimates of cancer risk and noncancer hazard quotient (HQ) are calculated as follows:

$$Risk = LADD \cdot SF$$

$$HQ = \frac{ADD}{RfD}$$

where LADD is the lifetime average daily dose, SF is the cancer slope factor, ADD is the average daily dose, and RfD is the reference dose.

For the inhalation route, the inhalation cancer risk and noncancer HQ are calculated using the chemical concentration in air (C_{air}), as follows:

$$Risk = C_{air} \cdot URF \cdot \frac{ET \cdot ED \cdot EF}{AT_c}$$

$$HQ = \frac{C_{air}}{RfC} \cdot \frac{ET \cdot ED \cdot EF}{AT_{nc}}$$

where URF is the inhalation unit risk, RfC is the reference concentration, ET is the exposure time, EF is the exposure frequency, ED is the exposure duration, AT_c is the averaging time for carcinogens, and AT_{nc} is the averaging time for non-carcinogens.

The potential cancer risk and noncancer effects that may result from exposure to a combination of chemicals is conservatively estimated according to USEPA guidance (1989), as follows:

$$Cumulative\ Risk = \sum_i Risk_i$$

$$HI = \sum_i HQ_i$$

where HI is the hazard index. For chemicals with different and unrelated noncancer health effects, summing their HQs would overestimate the significance of their combined effects. Where such summation of HQs indicates a potential for unacceptable risk, the HQs may be segregated by target organ and/or critical health effects (USEPA 1989).

6.2 Estimating Risks to On-Site Routine Workers

6.2.1 Contact with Outdoor Soil

On-site routine workers could be exposed to outdoor surface soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during routine activities. Risk estimates are calculated using the approach discussed in Section 6.1. The receptor specific calculations are discussed below.

The LADDs for soil ingestion ($LADD_{ing}$) and soil dermal contact ($LADD_{derm}$) are calculated as follows, using the exposures factors for routine worker soil contact shown in **Attachment 1**:

$$LADD_{ing} = C_{soil} \cdot \frac{IR \cdot FC \cdot EF \cdot ED}{BW \cdot AT_c}$$

$$LADD_{derm} = C_{soil} \cdot \frac{SA \cdot AF \cdot ABS_{derm} \cdot FC \cdot EF \cdot ED}{BW \cdot AT_c}$$

where C_{soil} is the concentration of chemicals in soil, IR is the incidental soil ingestion rate, FC is the fraction of soil that is contaminated, BW is the body weight, SA is the exposed skin surface area, AF is the soil-to-skin adherence factor recommended by USEPA (2004b), and ABS_{derm} is the chemical-specific dermal absorption factor recommended by USEPA (2004b).

The ADDs for soil ingestion (ADD_{ing}) and soil dermal contact (ADD_{derm}) are calculated as follows:

$$ADD_{ing} = C_{soil} \cdot \frac{IR \cdot FC \cdot EF \cdot ED}{BW \cdot AT_{nc}}$$

$$ADD_{derm} = C_{soil} \cdot \frac{SA \cdot AF \cdot ABS_{derm} \cdot FC \cdot EF \cdot ED}{BW \cdot AT_{nc}}$$

For the inhalation route, the exposure concentration (EC) for cancer and noncancer risk estimates are calculated using the equations shown in Section 6.1.

The air concentrations (C_{air}) of vapor and particulates from soil are calculated as follows:

$$C_{air} = J \cdot C / Q$$

where the product J·C/Q is an air concentration that is normalized to unit concentration in soil. The J term is the normalized, time-average vapor or particulate flux (discussed in Sections 3.3.4 and 3.3.2, respectively). The C/Q term is a dispersion factor, as discussed in Section 3.3.5.

For exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for routine workers are 1×10^{-8} and 0.004, respectively, as shown in **Table 2**. These risk estimates for potential routine worker exposures do not exceed ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.2.2 Soil Volatilization into Indoor Air

The cancer risk and HQ estimates for vapor intrusion from soil are calculated for hypothetical exposure of routine workers via assumed vapor intrusion from soil using the modeling approach and input parameter values discussed in Section 3.3.1, as follows:

$$Risk = C_{building} \cdot URF \cdot \frac{ET \cdot EF \cdot ED}{AT_c}$$

$$HQ = \frac{C_{building}}{RfC} \cdot \frac{ET \cdot EF \cdot ED}{AT_{nc}}$$

As shown in **Table 2**, the routine worker's upper-bound cumulative cancer risk and noncancer HI estimates for soil vapor intrusion based on the maximum detected concentrations in soil among the sampled locations are 3×10^{-7} and 0.1, respectively, which do not exceed USEPA's cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

The significance of potential exposure via vapor intrusion is also assessed using occupational inhalation limits. As shown on **Table 2**, the sum of the ratios of the estimated indoor air concentrations via vapor intrusion from soil to the occupational indoor air standards is much lower than 1, which shows that vapor intrusion from soil does not result in unacceptable exposure for workplaces subject to these occupational inhalation limits.

6.2.3 Groundwater Volatilization into Indoor Air

The calculation of cancer risk and HQ estimates for exposure of routine workers via assumed vapor intrusion from groundwater is the same as the soil vapor intrusion calculations discussed above, except using source concentrations from on-site groundwater.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for on-site indoor routine worker's exposure to the maximum detected concentrations in on-site groundwater via vapor intrusion are 1×10^{-5} and 3, respectively. The cumulative cancer risk estimate for routine worker exposure to on-site groundwater via inhalation of vapors in indoor air does not exceed ADEQ's risk limit. However, the noncancer HI estimate for routine worker exposure to on-site groundwater via vapor intrusion is above ADEQ's limit. The HI of 3 for potential vapor intrusion from groundwater is largely the result of a TCE concentration of 81 mg/L from a sample collected in 2010. The maximum detected concentration of TCE from on-site monitoring wells in 2012 is 29 mg/L, which corresponds to an HQ of 1.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

The significance of potential exposure via vapor intrusion is also assessed using occupational inhalation limits. As shown on **Table 3**, the sum of the ratios of the estimated indoor air concentrations via vapor intrusion from groundwater using the maximum detected on-site concentrations (calculated as described in Section 3.3.1) to the occupational indoor air standards is much lower than 1, which shows that vapor intrusion from soil does not result in unacceptable exposure for workplaces subject to these occupational inhalation limits.

6.2.4 Groundwater Volatilization into Outdoor Air

On-site routine workers could inhale vapors from groundwater that migrate into outdoor air. The computation of risk and HI for vapor inhalation in outdoor air is analogous to the computations discussed in Section 6.2.1, except the J value is calculated as described in Section 3.3.3.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for outdoor routine worker's exposure to the maximum detected concentrations in on-site groundwater via vapor inhalation are 4×10^{-7} and 0.1, respectively, which do not exceed ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.3 Estimating Risks to On-Site Maintenance Workers

6.3.1 Contact with Soil

On-site maintenance workers could contact unsaturated soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during occasional subsurface activities (e.g., utility maintenance or small scale excavations). The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1, except exposure factors for maintenance workers are used and the airborne dust concentrations are estimated

as discussed in Section 3.3.4. The calculation of the risk and HI for each route of exposure is provided in **Attachment 4**.

For exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for maintenance workers are 1×10^{-9} and 0.001 (**Table 2**), respectively, which meet ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.3.2 Groundwater Contact

Maintenance workers could contact groundwater via incidental ingestion, dermal contact, and inhalation of vapors during occasional subsurface activities (e.g., utility maintenance or small scale excavations) that extend to the groundwater. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1 for routine worker exposures to soil, except the exposure factors are for maintenance workers and the dermal dose, C/Q, and normalized vapor flux are calculated as discussed below.

The LADD and ADD for groundwater dermal contact are calculated as follows:

$$LADD_{derm} = C_{gw} \cdot \frac{SA \cdot EF \cdot ED \cdot FC}{BW \cdot AT_c} \cdot DA$$

$$ADD_{derm} = C_{gw} \cdot \frac{SA \cdot EF \cdot ED \cdot FC}{BW \cdot AT_{nc}} \cdot DA$$

where DA is the chemical-specific dermal absorption dose.

For exposure to the maximum detected concentrations in on-site groundwater, the upper-bound cumulative cancer risk and noncancer HI estimates for maintenance workers are 5×10^{-5} and 30, respectively. The cumulative cancer risk estimate for maintenance worker exposure to on-site groundwater does not exceed ADEQ's risk limits. The noncancer HI estimate for maintenance worker exposure to on-site groundwater is above ADEQ's limit. The HI of 30 for potential inhalation of vapors from exposed groundwater is largely the result of a TCE concentration of 81 mg/L from a sample collected in 2010. The maximum detected concentration of TCE from on-site monitoring wells in 2012 is 29 mg/L at MW-37, which corresponds to a HQ of 10. The detected concentrations of TCE in 2012 from on-site monitoring wells ITMW-17, ITMW-18, ITMW-19, and MW-25 also result in HQs above 1. All other detected concentrations of TCE in 2012 from on-site monitoring wells correspond to HQs less than 1, which meets ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.4 Estimating Risks to On-Site Construction Workers

6.4.1 Contact with Soil

Construction workers could contact unsaturated soil via incidental ingestion, dermal contact, and inhalation of vapors and particulates during construction activities (e.g., site redevelopment). The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.3.1, except the exposure factors for construction workers are used and subchronic noncancer toxicity values are used instead of chronic values. The calculation of the risk and HI for each route of exposure is provided in **Attachment 4**.

For exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for construction workers are 4×10^{-9} and 0.0009 (**Table 2**), respectively, which do not exceed ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.4.2 Groundwater Contact

Construction workers could contact groundwater via incidental ingestion, dermal contact, and inhalation of vapors during construction activities (e.g., site redevelopment) that extend to the groundwater. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.3.2 for maintenance worker exposures to groundwater, except the exposure factors are for construction workers and subchronic noncancer toxicity values are used instead of chronic values.

For exposure to the maximum detected concentrations in on-site groundwater, the upper-bound cumulative cancer risk and noncancer HI estimates for construction workers are 5×10^{-6} and 6, respectively. The cumulative cancer risk estimate for construction worker exposure to on-site groundwater does not exceed ADEQ's risk limit. The noncancer HI estimate for construction worker exposure to on-site groundwater is above ADEQ's limit. The HI of 6 for potential inhalation of vapors from exposed groundwater is largely the result of a TCE concentration of 81 mg/L from a sample collected in 2010. The maximum detected concentration of TCE from on-site monitoring wells in 2012 is 29 mg/L at MW-37, which corresponds to an HQ of 2. The next highest detected concentration of TCE in 2012 from on-site monitoring wells is 18 mg/L, which corresponds to an HQ of 1, which does not exceed ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.5 Estimating Risks to Off-Site Residents

6.5.1 Inhalation of Soil-Derived Vapors and Particulates

Off-site residents could inhale wind-blown vapors and particulates from on-site unsaturated soil. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1 for unsaturated vadose zone soil, except the exposure factors for residents are used.

For carcinogens with a mutagenic mode of action, cancer risk for exposures from 0 to 2 years of age and from 2 to 16 years of age are multiplied by the USEPA-recommended age-dependent adjustment factors (ADAFs), as follows:

$$Inhalation\ Risk = C_{air} \cdot URF \cdot \left(\frac{ET \cdot ED_{0-2} \cdot EF}{AT_c} \cdot ADAF_{0-2} + \frac{ET \cdot ED_{2-16} \cdot EF}{AT_c} \cdot ADAF_{2-16} + \frac{ET \cdot ED_{16-30} \cdot EF}{AT_c} \right)$$

where ED is the value for the identified age-group (**Attachment 1**); ADAF₀₋₂ is 10; and ADAF₂₋₁₆ is 3 (USEPA 2005). For trichloroethene (TCE) the ADAF is applied only to the portion of the toxicity value representative of kidney effects, as explained in USEPA's IRIS toxicological review (USEPA 2011) and applied in USEPA's Regional Screening Levels (USEPA 2012b).

For exposure to the maximum detected concentrations in on-site soil via vapor and particulate inhalation off-site, the upper-bound cumulative cancer risk and noncancer HI estimates for residents are 6x10⁻⁸ and 0.01 (**Table 2**), respectively, which meet cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.5.2 Groundwater Volatilization into Indoor Air

Off-site residents could inhale vapors from groundwater that migrate into indoor air. The computation of risk and HI for vapor intrusion is analogous to the computations discussed in Section 6.2.3, except the C_{air} value is calculated as described in Section 3.3.1. The assumptions used and the calculation of the risk and HI are provided in **Attachment 3**.

For exposure to the maximum detected concentrations in off-site groundwater via vapor intrusion, the upper-bound cumulative cancer risk and noncancer HI estimates for residents are 6x10⁻⁶ and 1 (**Table 3**), respectively, which do not exceed cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 5**.

6.5.3 Groundwater Volatilization into Outdoor Air

Off-site residents could inhale vapors from groundwater that migrate into outdoor air. The computation of risk and HI for vapor inhalation in outdoor air is analogous to the computations discussed in Section 6.5.1, except the C_{air} value is calculated as described in Section 3.3.3.

For exposure to the maximum detected concentrations in off-site groundwater via inhalation of vapor in outdoor air, the upper-bound cumulative cancer risk and noncancer HI estimates for residents are 5x10⁻⁸ and 0.01 (**Table 3**), respectively, which meet cancer risk and HI limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 5**.

6.5.4 Groundwater Use

Off-site residents could ingest or contact groundwater if drinking waterwells are installed in the area of impacted groundwater. These hypothetical future uses, which could include potable or nonpotable uses, were conservatively evaluated by comparing detected concentrations in groundwater to Federal MCLs, which are the permissible levels in public water. As shown on **Table 6**, the maximum detected concentrations of TCE and vinyl chloride in off-site monitoring wells exceed the Federal MCLs. As such, use of groundwater from the impacted off-site area, shown on **Figure 4** of the RRMP, could result in potentially significant exposures.

6.6 Estimating Risks to Off-Site Routine Workers

6.6.1 Inhalation of Soil-Derived Vapors and Particulates

Off-site routine workers residents could inhale wind-blown vapors and particulates from on-site unsaturated soil. The computation of risk and HI for these exposures is analogous to the computations discussed in Section 6.2.1 for unsaturated vadose zone soil.

For off-site exposure to the maximum detected concentrations in on-site soil, the upper-bound cumulative cancer risk and noncancer HI estimates for routine workers are 1×10^{-8} and 0.004, respectively, as shown in **Table 2**. These risk estimates for potential routine worker exposures do not exceed ADEQ's risk limits. The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.6.2 Groundwater Volatilization into Indoor Air

The cancer risk and HQ estimates for vapor intrusion from groundwater are calculated for exposure of routine workers via assumed vapor intrusion from groundwater as discussed above for on-site groundwater.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for off-site indoor routine worker exposure to the maximum detected concentrations in off-site groundwater via vapor intrusion are 2×10^{-7} and 0.06, respectively, which do not exceed ADEQ's cancer risk and HI limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate these upper-bound cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.6.3 Groundwater Volatilization into Outdoor Air

Off-site routine workers could inhale vapors from groundwater that migrate into outdoor air. The computation of risk and HI for vapor inhalation in outdoor air is analogous to the computations discussed in Section 6.2.4, except the C_{air} value is calculated as described in Section 3.3.3.

As shown in **Table 3**, the upper-bound cumulative cancer risk and noncancer HI estimates for off-site outdoor routine worker exposure to the maximum detected concentrations in off-site groundwater via vapor inhalation are 7×10^{-9} and 0.002, respectively, which do not exceed ADEQ's cancer risk and HI limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 2**.

6.6.4 Groundwater Use

Off-site routine workers could ingest or contact groundwater if drinking waterwells are installed in the area of impacted groundwater. These hypothetical future uses would be similar to those evaluated in Section 6.5.4. As shown on **Table 6**, the maximum detected concentrations of TCE and vinyl chloride in off-site monitoring wells exceed the Federal MCLs. As such, use of groundwater from the impacted off-site area, shown on **Figure 4** of the RRMP, could result in potentially significant exposures.

6.7 Estimating Risks to Off-Site Maintenance Workers

6.7.1 Groundwater Contact

Maintenance workers could contact groundwater via incidental ingestion, dermal contact, and inhalation of vapors during occasional subsurface activities (e.g., utility maintenance or small scale excavations) that extend to the groundwater. The computation of risk and HI for these exposures is the same as those discussed in Section 6.3.2.

For exposure to the maximum detected concentrations in off-site groundwater, the upper-bound cumulative cancer risk and noncancer HI estimates for maintenance workers are 9×10^{-7} and 0.5 (**Table 3**), respectively, which do not exceed ADEQ's risk limits.

The single-chemical cancer risk and noncancer HQ estimates, which were summed to estimate the media-specific cumulative cancer risk and noncancer HI, are shown in **Attachment 3**.

6.8 Uncertainty Analysis

6.8.1 Exposure Concentrations

As discussed in Section 3.2.1, all exposure concentrations for soil in this risk assessment are based on the highest concentrations detected at the site; more representative exposure concentrations (i.e., 95% UCLs) are not calculated. This approach streamlines the risk assessment by avoiding calculation of 95% UCLs that would not materially affect risk assessment conclusions. The use of maximum concentrations for all chemicals introduces more conservatism than necessary for RME estimates because it assumes simultaneous worst-case exposure to these chemicals, when the RME generally would not reflect having all chemicals at worst-case concentrations at all times.

Most exposure concentrations that are based on mathematical modeling of chemical transfer from soil or groundwater to air are conservative for the same reasons discussed above, since the model estimates are based on the use of maximum concentrations in soil or groundwater. In addition, the model estimates are conservative because they generally do not account for the reduction of chemical concentrations in the soil or groundwater as chemicals transfer from these media. As a result, risk estimates that are based cross media transfer are more conservative than necessary for RME estimates.

6.8.2 Fate and Transport Models

The groundwater volatilization to indoor air risk estimates for residential exposure are calculated using a central tendency air exchange rate (0.45/hr) identified by USEPA (2012a) and high end inputs for both the groundwater concentration (maximum detected concentration from the last five years) and exposure factors (24 hours of exposure for 350 days/year for 30 years). The combination of these values is believed to give RME risk estimates. The cumulative cancer risk and noncancer HI estimates for residents are 6×10^{-6} and 1, respectively, as discussed in Section 6.5.2 (**Table 3**). These risk estimates meet ADEQ and USEPA cancer risk and HI limits. Using the lower air exchange rate of 0.25/hr recommended as a default by USEPA (2004a) would increase the cumulative cancer risk and noncancer HI estimates for residents to 1×10^{-5} and 2, respectively, which is slightly higher than the HI limit of 1. However, using an air exchange rate that is lower than the central tendency value of 0.45/hr overestimates the exposure concentration (i.e., the indoor air concentration), which according to USEPA risk assessment guidance is supposed to be an estimate of the average concentration to which receptors are exposed (USEPA 1989). Using the lower air exchange rate is particularly unwarranted because it is combined with the highest detected groundwater concentration over the past five years (which is higher than the most recent data and expected future groundwater concentrations). By overestimating the exposure concentration via a combination of a lower than average air exchange rate and higher than average groundwater concentration, the resulting risk estimates are believed to overestimate RME risks, and as such, are not appropriate for determining whether an unacceptable risk exists.

Further, as discussed in Section 3.2.3, soil gas data were collected to confirm that the results of the volatilization to indoor air calculations, discussed in Section 3.3.1. Specifically, data were collected at two locations that are between 30 and 80 feet from nearby groundwater monitoring wells, as shown on **Figure 2**, and from two different depth intervals at each location. Specifically, soil gas sampling locations SV-01 and SV-02 were located near on-site monitoring well MW-33, which had the highest detected concentration of TCE at the property boundary, and soil gas sampling locations SV-03 and SV-04 were located near off-site monitoring well MW-70, which had the highest detected concentration of TCE off-site where access was readily attainable. The measured concentration of TCE in shallow soil gas collected 7 ft bgs (the sample depth closest to building foundation depths), was conservatively combined with USEPA's 95th percentile subslab soil gas attenuation factor of 0.03 (USEPA 2012a) to estimate the potential for significant vapor intrusion into indoor air. As shown of **Table 4**, the TCE concentrations in shallow soil gas would result in acceptable risk estimates for indoor exposure. These risk estimates are believed to be more conservative than necessary because attenuation in the approximately 7 ft of silty clay soil between the soil gas sample depth and subslab depth was ignored. Accounting for such attenuation, which may be substantial (i.e., a factor of 10 or more based on observed attenuation between the deep and shallow soil gas concentrations), would result in even lower risk estimates than those shown in **Table 4**.

The cancer risk and HQ from groundwater vapor intrusion into a residential building calculated using the most recent concentration of TCE in groundwater at MW-70 (0.33 mg/L) and the approach described in Section 6.5.2 is 1×10^{-6} and 0.3, respectively. The single-chemical risk and HQ from soil gas vapor intrusion into a residential building calculated using the measured shallow soil gas concentration at SV-03 and USEPA's default subslab to indoor air attenuation

factor of 0.03 are 2×10^{-7} and 0.04, respectively. As shown in **Table 4**, the conservatively calculated risks from shallow soil gas are at least 6 times lower than the risks estimated by the groundwater vapor intrusion model. Therefore, the approach described in Section 6.5.2 results in risk estimates that are overly conservative. The degree of model overestimation is particularly large when considering the fact that the risk estimates based on the shallow soil gas data shown in **Table 4** may be 10 times too high because they ignore the soil gas attenuation between the shallow soil gas sample and the slab of the building, as discussed above. As shown in **Table 4**, the same evaluation was performed for on-site locations MW-33 and SV-01, which conservatively assumed groundwater and soil gas concentrations at these locations were to migrate off-site with no attenuation. The results of this evaluation are similar to those discussed above, except the overestimation of residential vapor intrusion risk by the groundwater vapor intrusion model relative to the estimates based on soil gas is even greater.

As discussed in Section 1.1.2 of the Revised Risk Management Plan, TCE is the predominant contaminant at the Site and was detected in groundwater at significantly greater concentrations and frequency than tetrachloroethene (PCE). However, PCE was reported in the deep soil gas sample collected on-site at SV-02. The measured concentration of PCE in deep soil gas collected 15 ft bgs, was conservatively combined with USEPA's 95th percentile subslab soil gas attenuation factor of 0.03 (USEPA 2012a) to estimate the potential for significant vapor intrusion into residential indoor air. As shown on **Table 5**, the PCE concentrations in deep soil gas would result in acceptable risk estimates for residential indoor exposure. These risk estimates are believed to be more conservative than necessary because attenuation in the approximately 15 ft of silty clay soil between the soil gas sample depth and subslab depth was ignored. Accounting for such attenuation, which may be substantial (i.e., a factor of 100 or more based on observed attenuation for TCE), would result in even lower risk estimates than those shown in **Table 5**. These risk estimates are consistent with the groundwater volatilization to indoor air risk estimates that show PCE risks are insignificant compared to those calculated for TCE.

These results indicate that the model used to evaluate the potential for significant vapor intrusion from groundwater is conservative. Measured soil gas concentrations indicate that the modeling approach in Section 6.5.2 over-predicts exposure risks from groundwater.

6.8.3 Exposure Factors

Most of the exposures in the risk assessment were evaluated using factors, presented in **Attachment 1**, that are high-end (i.e., 90th to 95th percentile) estimates of the magnitude, frequency, and duration of potential exposures. When several such high-end factors are multiplied, the resulting estimates of dose will be higher than the 90th percentile of the distribution of exposures in the potentially exposed population and could be higher than the exposure to the maximally exposed individual, particularly when such exposure factors are combined with exposure concentrations that are based on maximum concentrations.

6.8.4 Toxicity Values

RfDs and RfCs used in the risk assessment typically incorporate several safety factors² to account for uncertainties in their derivation, which in combination often result in overall uncertainty factors of 1,000 or more. Furthermore, for many chemicals, there is scientific debate about the validity of these RfDs and RfCs, and the association of these doses and concentrations to potential adverse health consequences (USEPA 1995, USEPA 1989). The use of such RfDs and RfCs in the risk evaluation could introduce uncertainty, including overstating, the resultant estimate of noncancer effects.

Oral SFs and URFs used in the risk assessment represent 95% upper confidence bounds on the probability of getting cancer over a lifetime per unit dose. As recognized by USEPA, there is significant scientific evidence that some of the SFs and URFs may be overly conservative and may ignore the potential existence of threshold doses (USEPA 2005a). The use of such SFs and URFs in the risk evaluation could introduce uncertainty, including overstating, the resultant cancer risk estimates.

The dermal toxicity values used in the risk assessment are oral toxicity values that were extrapolated to the dermal route without chemical-specific judgment regarding whether such extrapolation might be appropriate for a particular chemical. This is an appropriately conservative approach, which is also the current state of the practice, to ensure that potential risk via the dermal route is not overlooked (USEPA 2004b). However, some chemicals might exhibit different degrees of toxicity for the dermal route relative to the oral route. For such chemicals, the extrapolation approach used in the risk evaluation could introduce uncertainty to the resultant risk estimates.

The use of surrogate toxicity values was applied conservatively to ensure that potential risk to these detected chemicals is not overlooked. However, some chemicals might exhibit different degrees of toxicity than their surrogate chemicals. For such chemicals, the extrapolation approach used in the risk evaluation could introduce uncertainty to the resultant risk estimates.

6.8.5 Risk Characterization

The summation of cancer risks and HQs for multiple chemicals is based on USEPA guidance (1989) to assume dose additivity, which means that chemicals in a mixture are assumed to have no synergistic or antagonistic interactions and each chemical has the same mode of action and elicits the same health effects. In general, this approach can introduce uncertainty. However, the majority of the cumulative cancer risk and HI estimates in this risk assessment are dominated by contributions from no more than a few chemicals, so that the cumulative risk estimates are nearly the same as those for the few key chemicals.

² According to USEPA, safety factors between 3 and 10,000 may be included depending on the source studies (USEPA. *Reference Dose (RfD): Description and Use in Health Risk Assessments, Background Document 1A* March 15, 1993).

7 Summary and Conclusions

The risk assessment evaluated the significance of potential exposure for the following receptors and potential pathways identified for current and potential future land use and groundwater use described in **Table 1**:

- On-Site Routine Workers
 - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during outdoor activities; inhalation of vapors in indoor air
 - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air
- On-Site Maintenance Workers
 - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during smaller-scale surface and subsurface maintenance activities
 - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale subsurface maintenance activities that encounter groundwater
- On-Site Construction Workers
 - Soil – incidental ingestion, dermal contact, and inhalation of vapors and particulates during larger-scale/short-term (i.e., 1 year) construction activities
 - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during larger-scale/short-term (i.e., 1 year) subsurface construction activities that encounter groundwater
- Off-Site Residents
 - Soil –inhalation of wind-blown vapors and particulates from on-site soil
 - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or contact if water use wells are installed in the area of impacted groundwater
- Off-Site Routine Workers
 - Soil – inhalation of vapors and particulates from on-site soil during off-site outdoor activities
 - Groundwater – inhalation of vapors in outdoor air; inhalation of vapors in indoor air; and ingestion or contact if water use wells are installed in the area of impacted groundwater
- Off-Site Maintenance Workers
 - Groundwater – incidental ingestion, dermal contact, and inhalation of vapors during smaller-scale/shorter duration subsurface maintenance activities that encounter groundwater

The significance of potential exposure to chemicals in soil, groundwater, and soil gas was evaluated for each of these exposures. As discussed in Sections 6.2 to 6.5, the risk estimates using maximum detected concentrations for all chemicals meet cancer risk and noncancer HI levels of 1×10^{-4} and 1, respectively, for exposure to on-site soil and off-site groundwater under current land and groundwater uses. Under current on-site land and groundwater uses, the risk

estimates using maximum detected concentrations for all chemicals in on-site groundwater meet USEPA's cancer risk level of 1×10^{-4} and exceed USEPA's noncancer HI level of 1 for maintenance worker and construction worker contact and routine worker vapor intrusion. In the hypothetical scenario in which drinking water wells are installed in the area of impacted off-site groundwater, potentially significant exposures could result from use of the groundwater.

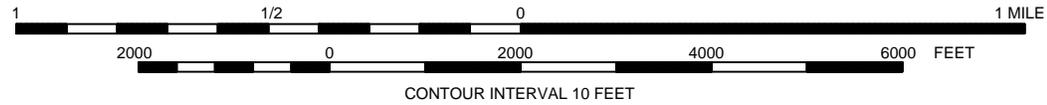
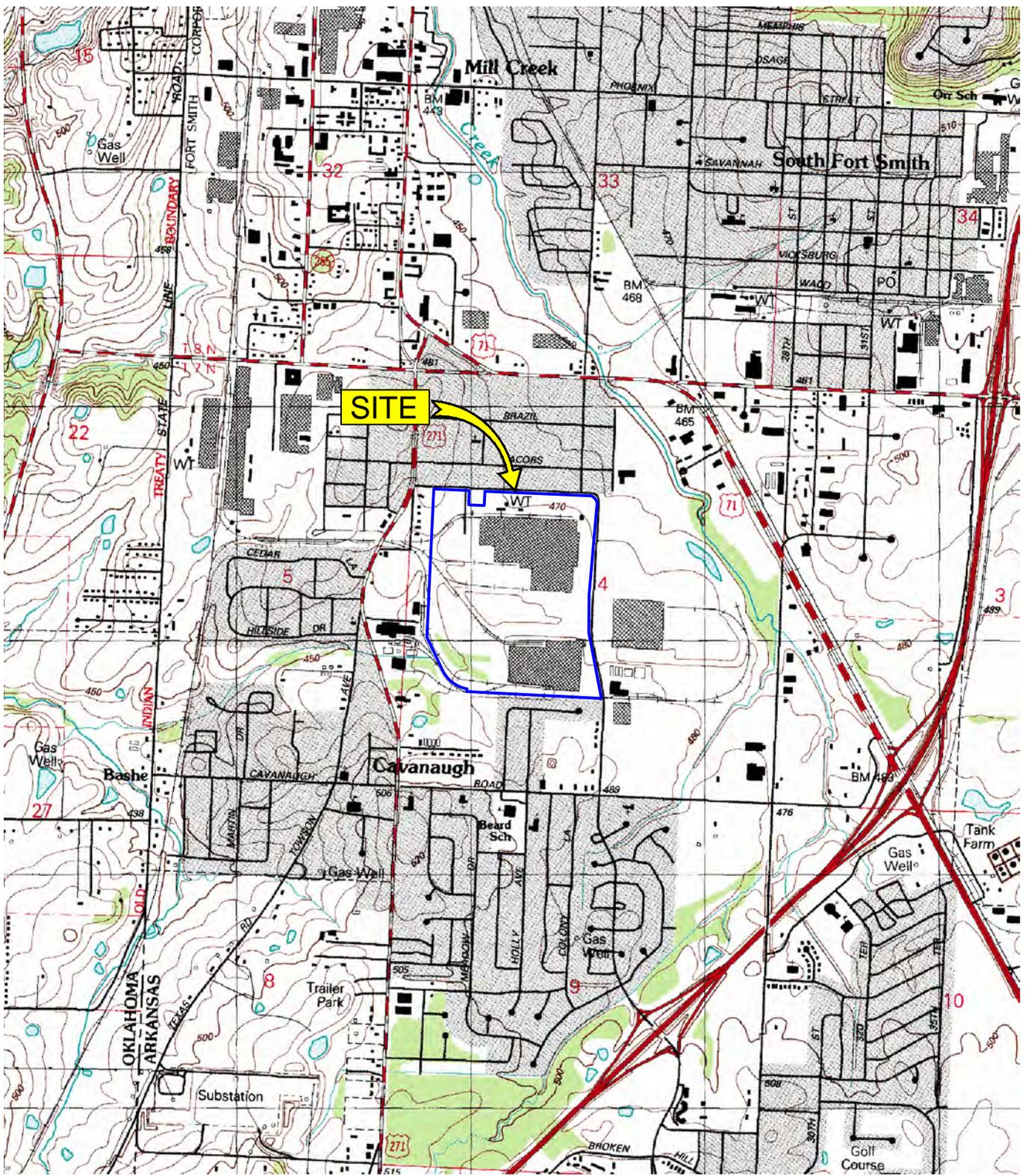
8 References

- American Conference of Governmental Industrial Hygienists (ACGIH). 2005. 2005 TLVs and BEIs, Threshold Limit Values for Chemical Substances and Physical Agents, Biological Exposure Indices. ISBN: 1-882417-40-2.
- Arkansas Department of Environmental Quality (ADEQ). 2005. Ground Water Remediation Level Interim Policy and Technical Guidance. Memorandum from Marcus Devine, Director, to Ellen Carpenter, Legal Division Chief. July 12.
- ENVIRON International Corporation (ENVIRON). 2012. Revised Risk Management Plan, Ft. Smith, Arkansas. November.
- Johnson, P. C., and R. A. Ettinger. 1991. Heuristic model for predicting the intrusion rate of contaminant vapors into buildings. *Environ. Sci. Technol.* 25(8):1445-1452.
- Jury, W.A, W.F. Spencer and W.J. Farmer. 1983. Behavior Assessment Model for Trace Organics in Soil: I. Model Description. *J. Environ. Qual.* 12(4):448-64.
- Michigan Department of Environmental Quality (MDEQ). 1998. Environmental Response Division. Part 201, Generic Groundwater and Soil Volatilization to Indoor Air Inhalation Criteria: Technical Support Document. August 31.
- Occupational Safety and Health Standards — Toxic and Hazardous Substances, Title 29 Code of Federal Regulations, Pt. 1910 Subpart Z. 2007 ed.
- Stanek, Edward J. III et al. 1997. Soil Ingestion in Adults—Results of a Second Pilot Study. *Ecotoxicology and Environmental Safety.* Volume 36. Pages 249-257. April.
- Song, S., Ramacciotti, F., Schnorr, B., Bock, M., Stubbs, C. 2011. "Evaluation of EPA's Empirical Attenuation Factors Database." *EM, Air & Waste Management Association.* February; 16-21.
- United States Environmental Protection Agency (USEPA). 1989. Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual. Washington, DC. EPA/540-1-89-002. OSWER Directive 9285.7 01a. December.
- United States Environmental Protection Agency (USEPA). 1989. Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund. Vol. I, Human Health Evaluation Manual. Washington, D.C. EPA/540-1-89-002. OSWER Directive 9285.7-01a. December.
- United States Environmental Protection Agency (USEPA). 1995. Office of Air Quality Planning and Standards. Guidelines for predictive baseline emissions estimation procedures for Superfund Sites, ASF-21. EPA-451/R-96-001. November.

- United States Environmental Protection Agency (USEPA). 1996. Office of Solid Waste and Emergency Response (OSWER). Soil Screening Guidance: Technical Background Document, 2nd Ed. EPA/540/R95/128. May.
- United States Environmental Protection Agency (USEPA). 2002. Office of Solid Waste and Emergency Response. Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. Washington, DC. OSWER Directive 9355.4-24. December.
- United States Environmental Protection Agency (USEPA). 2003. Office of Solid Waste and Emergency Response (OSWER). Human Health Toxicity Values in Superfund Risk Assessments. OSWER Directive 92857.7-53. December.
- United States Environmental Protection Agency (USEPA). 2004a. User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings. Office of Emergency and Remedial Response, Washington D.C., February.
- United States Environmental Protection Agency (USEPA) 2004b. Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R/99/005. September.
- United States Environmental Protection Agency (USEPA). 2005. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. USEPA/630/R 03/003F. March.
- United States Environmental Protection Agency (USEPA). 2009. Office of Emergency and Remedial Response. Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment). USEPA/540/R/070/002. January.
- United States Environmental Protection Agency (USEPA). 2011. Toxicological Review of Trichloroethylene. September.
- United States Environmental Protection Agency (USEPA). 2012a. EPA's Vapor Intrusion Database: Evaluation and Characterization of Attenuation Factors for Chlorinated Volatile Organic Compounds and Residential Buildings. Office of Emergency and Remedial Response, Washington D.C. EPA 530-R-10-002. March.
- United States Environmental Protection Agency (USEPA). 2012b. Regional Screening Levels. May.

Figures

L:\Loop Project Files\00_CAD FILES\21\Whirlpool Risk Mgmt Plan & Remedy 21-31344A\01_Site Location Map.dwg



SOURCE: U.S.G.S. 7.5 minute series (topographic)
 South Fort Smith, Arkansas Quadrangle, 1997



LEGEND	
	APPROXIMATE PROPERTY BOUNDARY

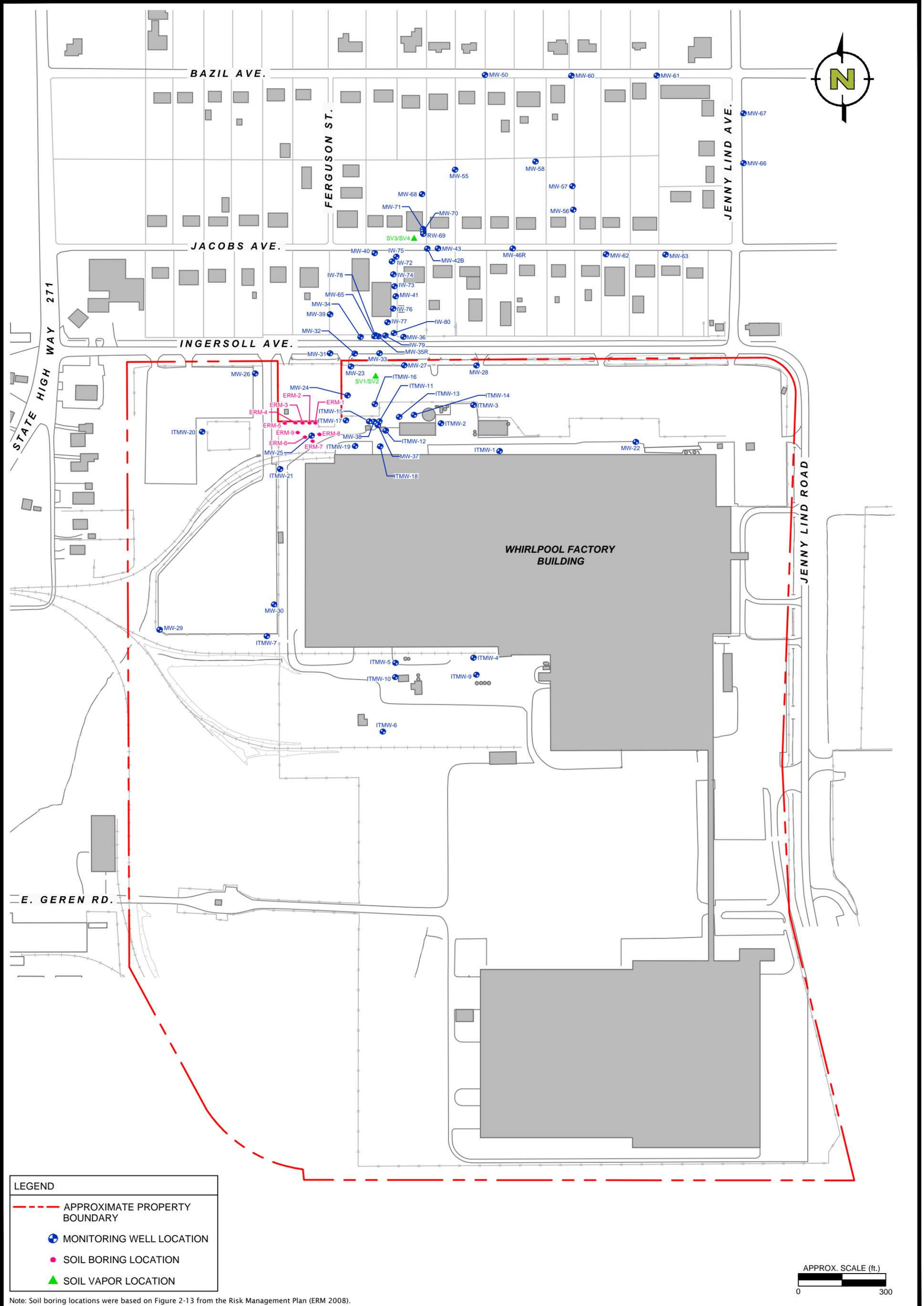


SITE LOCATION MAP
 WHIRLPOOL CORPORATION
 6400 SOUTH JENNY LIND ROAD
 FORT SMITH, ARKANSAS

FIGURE
1

DRAFTED BY: ELS DATE: 11/8/12

21-31344A



Tables

**Table 1: Conceptual Site Model - Scenarios for Potential Human Exposure
Whirlpool: Fort Smith Facility, Fort Smith, Arkansas**

Receptor Population	Exposure Medium	Exposure Route	Potential Current Exposure?	Potential Future Exposure?	Comments	
On-Site						
Routine Workers	surface soil	incidental ingestion of and dermal contact with surface soil	Yes	Yes	Exposure to surface soil through incidental ingestion and dermal contact is possible in areas without ground cover or where ground cover may be removed. Exposure through inhalation of vapors from constituents that could volatilize and migrate into indoor or outdoor air is also possible.	
		inhalation of soil-derived vapors and airborne particulates (wind erosion) in outdoor air	Yes	Yes		
		inhalation of soil-derived vapors that migrate through building foundations into indoor air	Yes	Yes		
	subsurface soil	inhalation of soil-derived vapors in outdoor air	Yes	Yes		
		inhalation of soil-derived vapors that migrate through building foundations into indoor air	Yes	Yes		
	groundwater	ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for drinking water	No	No		Potable water in Ft. Smith is obtained from the municipality. There are no production wells currently on Site. Potential exposure of routine workers to groundwater-derived vapors that migrate through cracks in building foundations into indoor air is possible in areas where contaminated groundwater is present.
		incidental ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for purposes other than drinking water	No	No		
		inhalation of groundwater-derived vapors in outdoor air	Yes	Yes		
		inhalation of groundwater-derived vapors that migrate through building foundations into indoor air	Yes	Yes		
Maintenance Workers	surface and subsurface soil	incidental ingestion of and dermal contact with soil; inhalation of soil-derived vapors and airborne particulates in work-space air	Yes	Yes	Exposure to soil and groundwater during occasional excavations to the depth of existing or planned utilities is possible. The average depth to water at the Site is approximately 12 feet bgs.	
	groundwater	incidental ingestion of and dermal contact with exposed groundwater; inhalation of vapors from exposed groundwater in work-space air	Yes	Yes		
Construction Workers	surface and subsurface soil	incidental ingestion of and dermal contact with soil; inhalation of soil-derived vapors and airborne particulates in work-space air	Yes	Yes	Exposure to soil and groundwater is possible where redevelopment of the site could occur.	
	groundwater	incidental ingestion of and dermal contact with exposed groundwater; inhalation of vapors from exposed groundwater in work-space air	Yes	Yes		
Residents	various	various	No	No	The Site is zoned for commercial/industrial uses.	
Off-Site						
Residents	surface and subsurface soil	inhalation of soil-derived vapors and airborne particulates (wind erosion) in outdoor air	Yes	Yes	Off-Site exposure via inhalation of airborne vapors and dust from exposed on-Site soil is possible.	
	groundwater	ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for drinking water	No	No	Potable water in Fort Smith is obtained from the municipality.	
		incidental ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for purposes other than drinking water	No	No		
		inhalation of groundwater-derived vapors in outdoor air	Yes	Yes		
		inhalation of groundwater-derived vapors that migrate through building foundations into indoor air	Yes	Yes	Exposure via inhalation of vapors that could volatilize and migrate into outdoor or indoor air is possible where contaminated groundwater has migrated off-Site.	
Routine Workers	surface and subsurface soil	inhalation of soil-derived vapors and airborne particulates (wind erosion) in outdoor air	Yes	Yes	Off-Site exposure via inhalation of airborne vapors and dust from exposed on-Site soil is possible.	
	groundwater	ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for drinking water	No	No	Potable water in Fort Smith is obtained from the municipality.	
		incidental ingestion of and dermal contact with groundwater and inhalation of groundwater-derived vapors during use of groundwater for purposes other than drinking water	No	No		
		inhalation of groundwater-derived vapors in outdoor air	Yes	Yes		
		inhalation of groundwater-derived vapors that migrate through building foundations into indoor air	Yes	Yes		
Maintenance Workers	groundwater	incidental ingestion of and dermal contact with exposed groundwater; inhalation of vapors from exposed groundwater in work-space air	Yes	Yes	Exposure via incidental ingestion, dermal contact, and inhalation of vapors is possible in excavations extending to groundwater in areas where contaminated groundwater has migrated off-site.	

Table 2: Upper-Bound Cumulative Risk Estimates for On-Site Soil Whirlpool, Fort Smith, Arkansas				
Receptor	Exposure Type	Risk	HI	Occupational
On-Site Routine Worker	Direct contact	1E-08	4E-03	NA
On-Site Routine Worker	Vapor intrusion to indoor air	3E-07	1E-01	2E-06
On-Site Maintenance Worker	Direct contact	1E-09	1E-03	NA
On-Site Construction Worker	Direct contact	4E-09	9E-04	NA
Off-Site Resident	Vapor and particulate inhalation	6E-08	1E-02	NA
Off-Site Routine Worker	Vapor and particulate inhalation	1E-08	4E-03	NA
Notes:				
1. None of the cumulative cancer risk and HI estimates are in excess of ADEQ's risk limits (1E-4 and 1, respectively).				
2. Cumulative cancer risk and HI estimates are calculated using the maximum detected concentrations from onsite locations from any depth.				
3. NA = Not applicable. Occupational air standards are only applicable for routine worker vapor intrusion exposures.				

**Table 3: Upper-Bound Cumulative Risk Estimates for Groundwater
Whirlpool, Fort Smith, Arkansas**

Receptor	Exposure Type	On-Site			Off-Site	
		Risk	HI	Occupational	Risk	HI
Routine Worker	Vapor intrusion to indoor air	1E-05	3E+00	8E-04	2E-07	6E-02
Routine Worker	Vapor inhalation in outdoor air	4E-07	1E-01	NA ⁴	7E-09	2E-03
Maintenance Worker	Direct contact	5E-05	3E+01	NA ⁴	9E-07	5E-01
Construction Worker	Direct contact	5E-06	6E+00	NA ⁴	NA ⁴	NA ⁴
Resident	Vapor intrusion to indoor air	NA ³	NA ³	NA ⁴	6E-06	1E+00
Resident	Vapor inhalation in outdoor air	NA ³	NA ³	NA ⁴	5E-08	1E-02
Notes:						
1. Cumulative cancer risk and HI estimates in excess of ADEQ's risk limits (1E-4 and 1, respectively) are shaded in bold.						
2. Cumulative cancer risk and HI estimates are calculated using the maximum detected concentrations from all wells and sample dates.						
3. NA = Not applicable. Receptor is not reasonably expected to be present in this area.						
4. NA = Not applicable. Occupational air standards are only applicable for routine worker vapor intrusion exposures.						

**Table 4: Evaluation of TCE in Soil Gas
Whirlpool, Fort Smith, Arkansas**

		Soil Gas			Groundwater			
Sample Location	Sample Depth (ft)	TCE Concentration (mg/m ³)	Risk (2)	HQ (2)	Nearby Monitoring Well	Most Recent TCE Concentration (mg/L)	Risk (3)	HQ (3)
SV01	7	ND (4.1E-5)	3E-09	6E-04	MW-33	1.00E+00	4E-06	8E-01
SV02	15	2.27E-01	-- ⁴	-- ⁴			-- ⁴	-- ⁴
SV03	7	2.90E-03	2E-07	4E-02	MW-70	3.30E-01	1E-06	3E-01
SV04	12	3.98E-02	-- ⁴	-- ⁴			-- ⁴	-- ⁴
Notes:								
1. ND = Non-detect.								
2. Residential risk and HQ are calculated using USEPA's default attenuation factor for subslab gas to indoor air of 0.03.								
3. Residential risk and HQ are calculated using the approach described in Section 6.5.2 of the report.								
4. Risk and HQ estimates are calculated only for concentrations of TCE in shallow soil gas.								

Table 5: Evaluation of PCE in Soil Gas Whirlpool, Fort Smith, Arkansas				
Sample Location	Sample Depth (ft)	PCE Concentration (mg/m³)	Risk (1)	HQ (1)
SV02	15	1.1E-01	3E-07	8E-02
Note:				
1. Residential risk and HQ are calculated using USEPA's default attenuation factor for subslab gas to indoor air of 0.03.				

**Table 6: Groundwater Screening Summary
Whirlpool, Fort Smith, Arkansas**

Area	Chem Group	Chemical	CASRN	Meas Basis	Carc Class	Analyzed	Detected	Min Detected (mg/L)	Max Detected (mg/L)	MCL FED (mg/L)	Ratio of Maximum Concentration to MCL
On-Site	VOC	Acetone	67-64-1	T	ID	194	17	2.70E-03	1.99E-01		
On-Site	VOC	Benzene	71-43-2	T	A	194	5	6.60E-04	6.53E-02	5.0E-03	1.3E+01
On-Site	VOC	Bromodichloromethane	75-27-4	T	B2	194	3	5.42E-02	6.79E-02	8.0E-02	8.5E-01
On-Site	VOC	Bromoform	75-25-2	T	B2	194	3	4.43E-02	7.67E-02	8.0E-02	9.6E-01
On-Site	VOC	Bromomethane	74-83-9	T	ID	194	3	4.74E-02	6.13E-02		
On-Site	VOC	2-Butanone	78-93-3	T	ID	194	3	9.87E-02	1.06E-01		
On-Site	VOC	Carbon Disulfide	75-15-0	T		194	3	3.59E-02	6.52E-02		
On-Site	VOC	Carbon Tetrachloride	56-23-5	T	LC	194	3	5.89E-02	6.69E-02	5.0E-03	1.3E+01
On-Site	VOC	Chlorobenzene	108-90-7	T	D	194	7	1.20E-03	6.86E-02	1.0E-01	6.9E-01
On-Site	VOC	Chloroethane	75-00-3	T	LC	194	3	4.80E-02	7.23E-02		
On-Site	VOC	Chloroform	67-66-3	T	B2	194	33	9.40E-04	6.64E-02	8.0E-02	8.3E-01
On-Site	VOC	Chloromethane	74-87-3	T	D	194	3	4.21E-02	9.00E-02		
On-Site	VOC	Dibromochloromethane	124-48-1	T	C	194	3	4.82E-02	7.13E-02	8.0E-02	8.9E-01
On-Site	VOC	1,1-Dichloroethane	75-34-3	T	SC	194	36	1.60E-03	6.59E-02		
On-Site	VOC	1,2-Dichloroethane	107-06-2	T	B2	194	4	1.20E-03	6.61E-02	5.0E-03	1.3E+01
On-Site	VOC	1,1-Dichloroethene	75-35-4	T	C	194	76	2.20E-03	2.50E-01	7.0E-03	3.6E+01
On-Site	VOC	1,2-Dichloroethene (total)	540-59-0	T		194	130	1.40E-03	1.00E+01	1.00E-02	1.4E+02
On-Site	VOC	cis-1,2-Dichloroethene	156-59-2	T	ID	194	132	1.40E-03	1.00E+01	7.0E-02	1.4E+02
On-Site	VOC	trans-1,2-Dichloroethene	156-60-5	T	ID	194	27	8.90E-04	5.99E-02	1.0E-01	6.0E-01
On-Site	VOC	1,2-Dichloropropane	78-87-5	T	B2	194	3	6.03E-02	6.52E-02	5.0E-03	1.3E+01
On-Site	VOC	1,3-Dichloropropene (total)	542-75-6	T	B2	194	3	1.05E-01	1.42E-01		
On-Site	VOC	Ethyl Benzene	100-41-4	T	D	194	8	1.50E-03	6.89E-02	7.0E-01	9.8E-02
On-Site	VOC	2-Hexanone	591-78-6	T	ID	194	6	4.80E-03	1.20E-01		
On-Site	VOC	4-Methyl-2-pentanone	108-10-1	T	ID	194	3	1.02E-01	1.20E-01		
On-Site	VOC	Methylene Chloride	75-09-2	T	LC	194	27	2.20E-03	3.10E-01	5.0E-03	6.2E+01
On-Site	VOC	Styrene	100-42-5	T		194	4	5.70E-04	6.83E-02	1.0E-01	6.8E-01
On-Site	VOC	1,1,2,2-Tetrachloroethane	79-34-5	T	LC	194	3	5.78E-02	6.40E-02		
On-Site	VOC	Tetrachloroethene	127-18-4	T	LC	194	45	1.20E-03	7.67E-02	5.0E-03	1.5E+01
On-Site	VOC	Toluene	108-88-3	T	ID	194	17	1.10E-03	6.54E-02	1.0E+00	6.5E-02
On-Site	VOC	1,1,1-Trichloroethane	71-55-6	T	ID	194	11	5.70E-03	1.10E-01	2.0E-01	5.5E-01
On-Site	VOC	1,1,2-Trichloroethane	79-00-5	T	C	194	12	1.20E-03	6.59E-02	5.0E-03	1.3E+01
On-Site	VOC	Trichloroethene	79-01-6	T	HC	194	153	1.60E-03	8.10E+01	5.0E-03	1.6E+04
On-Site	VOC	Vinyl Chloride	75-01-4	T	A	194	45	1.00E-03	2.50E+00	2.0E-03	1.3E+03
On-Site	VOC	Xylenes (total)	1330-20-7	T	ID	194	8	2.70E-03	1.99E-01	1.0E+01	2.0E-02
Off-Site	VOC	Acetone	67-64-1	T	ID	253	17	4.00E-03	8.50E-02		
Off-Site	VOC	Bromoform	75-25-2	T	B2	253	4	4.40E-03	2.40E-02	8.0E-02	3.0E-01
Off-Site	VOC	2-Butanone	78-93-3	T	ID	253	1	9.50E-02	9.50E-02		
Off-Site	VOC	1,2-Dichloroethane	107-06-2	T	B2	252	1	3.00E-03	3.00E-03	5.0E-03	6.0E-01
Off-Site	VOC	1,1-Dichloroethene	75-35-4	T	C	252	22	1.00E-03	4.20E-03	7.0E-03	6.0E-01
Off-Site	VOC	1,2-Dichloroethene (total)	540-59-0	T		253	111	1.40E-03	4.10E-02	7.0E-02	5.9E-01
Off-Site	VOC	cis-1,2-Dichloroethene	156-59-2	T	ID	253	113	1.40E-03	4.10E-02	7.0E-02	5.9E-01
Off-Site	VOC	4-Methyl-2-pentanone	108-10-1	T	ID	253	1	4.00E-03	4.00E-03		
Off-Site	VOC	Trichloroethene	79-01-6	T	HC	253	166	1.60E-03	1.60E+00	5.0E-03	3.2E+02
Off-Site	VOC	Vinyl Chloride	75-01-4	T	A	253	4	1.10E-03	3.00E-03	2.0E-03	1.5E+00
Notes:											
Summary includes data from all monitoring wells sampled since 2008 (i.e., the past 5 years).											
Only constituents detected in each area are shown.											
The criteria for 1,2-Dichloroethene (total) are the criteria provided by the agency for cis-1,2-Dichloroethene.											
The concentrations for the 1,3-Dichloropropene isomers (cis and trans) were summed before comparing to the criteria for 1,3-Dichloropropene (total).											
The concentrations for the Xylene isomers (m/p and o) were summed before comparing to the criteria for Xylenes (total).											
Ratios of concentration to the criteria greater than 1 are shaded in bold.											
Chem Group - chemical group											
Meas Basis - measured basis; T = total, D = dissolved											
Carc Class - USEPA Weight-of-Evidence Cancer Classification											

Attachment 1

Risk Calculation Inputs

Contents:

- Toxicity Values
- Physical and Chemical Properties
- Occupational Inhalation Limits
- High-End Exposure Factors
- Detected Source Concentrations

**Attachment 1: Toxicity Values
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Classification		ADAF		SF _{oral} (mg/kg/d) ¹			SF _{dermal} (mg/kg/d) ¹			URF (mg/m ³) ¹			RfD _{oral} (mg/kg/d)				RfD _{dermal} (mg/kg/d)				RfC (mg/m ³)				SRfD _{oral} (mg/kg/d)				SRfD _{dermal} (mg/kg/d)				SRfC (mg/m ³)					
			Group	Ref	Y/N	f _{ing}	f _{inh}	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	Value	UF	Ref	Notes	
VOC	Acetone	67-64-1	ID	1	N										9.0E-01	1,000	1		9.0E-01	1,000	125	104	3.1E+01	100	129	111	2.0E+00	100	129	111	2.0E+00	100	125	104	3.1E+01	100	129	111			
VOC	Benzene	71-43-2	A	1	N			5.5E-02	1	68	5.5E-02	125	104	7.8E-03	1	60	4.0E-03	300	1	4.0E-03	300	125	104	3.0E-02	300	1	1.0E-02	100	126		1.0E-02	100	125	104	9.0E-02	100	1	110			
VOC	Bromodichloromethane	75-27-4	B2	1	N			6.2E-02	1		6.2E-02	125	104		2.0E-02	1,000	1		2.0E-02	1,000	125	104			126	90	2.0E-02	1,000	1	62	2.0E-02	1000	125	104	2.0E-02	300	126	90			
VOC	Bromoform	75-25-2	B2	1	N			7.9E-03	1		7.9E-03	125	104	1.1E-03	1		2.0E-02	1,000	1	2.0E-02	1,000	125	104			126	90	3.0E-02	100	126		3.0E-02	100	125	104			126	90		
VOC	Bromomethane	74-83-9	ID	126	N										1.4E-03	1,000	1		1.4E-03	1,000	125	104	5.0E-03	100	1		5.0E-03	300	126		5.0E-03	300	125	104	1.0E-01	30	126				
VOC	2-Butanone	78-93-3	ID	1	N										6.0E-01	1,000	1		6.0E-01	1,000	125	104	5.0E+00	300	1		2.0E+00	1,000	2		2.0E+00	1000	125	104	5.0E+00	300	1	62			
VOC	Carbon Disulfide	75-15-0			N										1.0E-01	100	1		1.0E-01	100	125	104	7.0E-01	30	1		1.0E-01	100	2	2	1.0E-01	100	125	104	7.0E-01	30	2	2			
VOC	Carbon Tetrachloride	56-23-5	LC	1	N			7.0E-02	1		7.0E-02	125	104	6.0E-03	1		4.0E-03	1,000	1	4.0E-03	1,000	125	104	1.0E-01	100	1	1.0E-02	300	1	110	1.0E-02	300	125	104	1.9E-01	30	129	111			
VOC	Chlorobenzene	108-90-7	D	1	N										2.0E-02	1,000	1		2.0E-02	1,000	125	104	5.0E-02	1,000	126		7.0E-02	300	126		7.0E-02	300	125	104	5.0E-01	100	126				
VOC	Chloroethane	75-00-3	LC	126	N				126	90		125	104		1.0E-01	3,000	126	116	1.0E-01	3,000	125	104	1.0E+01	300	1		1.0E-01	3,000	126		1.0E-01	3000	125	104	1.0E+01	300	1	62			
VOC	Chloroform	67-66-3	B2	1	N			1.9E-02	135		1.9E-02	125	104	2.3E-02	1		1.0E-02	1,000	1	1.0E-02	1,000	125	104	5.0E-02	100	117		1.0E-01	100	129	111	1.0E-01	100	125	104	5.0E-02	100	117			
VOC	Chloromethane	74-87-3	D	1	N																		9.0E-02	1,000	1											4.1E-01	300	129	111		
VOC	Dibromochloromethane	124-48-1	C	1	N			8.4E-02	1		8.4E-02	125	104		2.0E-02	1,000	1		2.0E-02	1,000	125	104			126	90	7.0E-02	300	126		7.0E-02	300	125	104			126	90			
VOC	1,1-Dichloroethane	75-34-3	SC	126	N				126	90		125	104		2.0E-01	3,000	126		2.0E-01	3,000	125	104	5.0E-01	1,000	2	3	2.0E+00	300	126		2.0E+00	300	125	104	5.0E+00	100	2	3			
VOC	1,2-Dichloroethane	107-06-2	B2	1	N			9.1E-02	1		9.1E-02	125	104	2.6E-02	1		6.0E-03	10,000	126	6.0E-03	10,000	125	104	7.0E-03	3,000	126		2.0E-02	3,000	126		2.0E-02	3000	125	104	7.0E-02	300	126			
VOC	1,1-Dichloroethene	75-35-4	C	1	N										5.0E-02	100	1		5.0E-02	100	125	104	2.0E-01	30	1		5.0E-02	100	1	62	5.0E-02	100	125	104	2.0E-01	30	1	62			
VOC	1,2-Dichloroethene (total)	540-59-0			N										2.0E-03	3,000	1	133	2.0E-03	3,000	125	104			1	90, 133	2.0E-02	300	1	110, 133	2.0E-02	300	125	104			126	90, 133			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1	N										2.0E-03	3,000	1		2.0E-03	3,000	125	104			1	90	2.0E-02	300	1	110	2.0E-02	300	125	104			126	90			
VOC	trans-1,2-Dichloroethene	156-60-5	ID	1	N										2.0E-02	3,000	1		2.0E-02	3,000	125	104			1	90	2.0E-01	300	1	110	2.0E-01	300	125	104			1	90			
VOC	1,2-Dichloropropane	78-87-5	B2	2	N			3.6E-02	139		3.6E-02	125	104		9.0E-02	1,000	129	111	9.0E-02	1,000	125	104	4.0E-03	300	1		7.0E-02	1,000	129	111	7.0E-02	1000	125	104	1.3E-02	100	1	110			
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1	N			1.0E-01	1	77	1.0E-01	125	104	4.0E-03	1		3.0E-02	100	1	3.0E-02	100	125	104	2.0E-02	30	1	4.0E-02	100	129	111	4.0E-02	100	125	104	3.6E-02	30	129	111			
VOC	Ethyl Benzene	100-41-4	D	1	N										1.0E-01	1,000	1		1.0E-01	1,000	125	104	1.0E+00	300	1		1.0E-01	1,000	1	62	1.0E-01	1000	125	104	9.0E+00	100	126				
VOC	2-Hexanone	591-78-6	ID	1	N										5.0E-03	1,000	1		5.0E-03	1,000	125	104	3.0E-02	3,000	1		5.0E-03	1,000	1	62	5.0E-03	1000	125	104	3.0E-01	300	1	110			
VOC	4-Methyl-2-pentanone	108-10-1	ID	1	N												1	90			125	104	3.0E+00	300	1											125	104	3.0E+00	300	1	62
VOC	Methylene Chloride	75-09-2	LC	1	Y	1	1	2.0E-03	1	159	2.0E-03	125	104	1.0E-05	1	159	6.0E-03	30	1	6.0E-03	30	125	104	6.0E-01	30	1	6.0E-02	100	2	2	6.0E-02	100	125	104	1.0E+00	90	129	111			
VOC	Styrene	100-42-5			N										2.0E-03	1,000	1	6	2.0E-03	1,000	125	104	1.0E+00	30	1		2.0E-01	1,000	1	6, 62	2.0E-01	1000	125	104	3.0E+00	10	2				
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	1	N			2.0E-01	1		2.0E-01	125	104		1	90	2.0E-02	1,000	1	2.0E-02	1,000	125	104		1	90	5.0E-02	300	1		5.0E-02	300	125	104			126	90			
VOC	Tetrachloroethene	127-18-4	LC	1	N			2.1E-03	1		2.1E-03	125	104	2.6E-04	1		6.0E-03	1,000	1	6.0E-03	1,000	125	104	4.0E-02	1,000	1	1.0E-01	100	2		1.0E-01	100	125	104	4.0E-02	1,000	1	62			
VOC	Toluene	108-88-3	ID	1	N										8.0E-02	3,000	1		8.0E-02	3,000	125	104	5.0E+00	10	1		8.0E-01	300	1	110	8.0E-01	300	125	104	5.0E+00	10	126				
VOC	1,1,1-Trichloroethane	71-55-6	ID	1	N										2.0E+00	1,000	1		2.0E+00	1,000	125	104	5.0E+00	100	1		7.0E+00	300	1		7.0E+00	300	125	104	5.0E+00	100	1				
VOC	1,1,2-Trichloroethane	79-00-5	C	1	N			5.7E-02	1		5.7E-02	125	104	1.6E-02	1		4.0E-03	1,000	1	4.0E-03	1,000	125	104	2.0E-04	3,000	126	114	4.0E-03	1,000	126		4.0E-03	1000	125	104	2.0E-03	300	126	114		
VOC	Trichloroethene	79-01-6	HC	1	Y	0.202	0.2439	4.6E-02	1	159	4.6E-02	125	104	4.1E-03	1	159	5.0E-04	1,000	1	5.0E-04	1,000	125	104	2.0E-03	100	1		5.0E-04	1,000	1	62	5.0E-04	1000	125	104	5.4E-01	300	129	111		
VOC	Vinyl Chloride	75-01-4	A	1	N			7.2E-01	1	78	7.2E-01	125	104	4.4E-03	1	79	3.0E-03	30	1	3.0E-03	30	125	104	1.0E-01	30	1		3.0E-03	30	1	62	3.0E-03	30	125	104	1.0E-01	30	1	62		
VOC	Xylenes (total)	1330-20-7	ID	1	N										2.0E-01	1,000	1		2.0E-01	1,000	125	104	1.0E-01	300	1		2.0E-01	1,000	1	110	2.0E-01	1000	125	104	3.0E-01	100	1	110			

**Attachment 1: Physical and Chemical Properties
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	MW (g/mole)			K _{ow} (unitless)			K _{oc} (L/kg)			H (unitless)				s (mg/L)			VP (mm Hg)				D _{air} (m ² /d)			D _{water} (m ² /d)			K _p (cm/hr)				ABS ₃ (unitless)			FA (unitless)			ΔH _v (cal/mol)			T _c (Kelvin)			T _b (Kelvin)			HENRY Ref Temp (°C)
			Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Adjusted*	Ref	Notes	Value	Ref	Notes	Value	Adjusted	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes	Value	Ref	Notes		
VOC	Acetone	67-64-1	5.8E+01	50.1		5.8E-01	44		5.8E-01	44	82	1.6E-03	1.1E-03	44	1.0E+06	44		2.3E+02	1.6E+02	50.1	92	1.1E+00	44	9.8E-05	44	5.2E-04	44	115	62	62	1.0E+00	62	114	6.96E+03	44	118	3.29E+02	44	118	5.62E+02	44	118	3.53E+02	44	118	2.5E+01		
VOC	Benzene	71-43-2	7.8E+01	50.1		1.3E+02	44		5.8E+01	44	111	2.3E-01	1.6E-01	44	1.8E+03	44		9.5E+01	6.4E+01	50.1	92	7.6E-01	44	8.5E-05	44	1.5E-02	44	115	62	62	1.0E+00	62	7.34E+03	44	118	5.62E+02	44	118	3.63E+02	44	118	2.5E+01						
VOC	Bromodichloromethane	75-27-4	1.6E+02	50.1		1.3E+02	44		5.5E+01	44	111	6.6E-02	4.5E-02	44	6.7E+03	44		5.0E+01	3.3E+01	50.1	92	2.6E-01	44	9.2E-05	44	4.7E-03	44	115	62	62	1.0E+00	62	7.80E+03	44	118	5.86E+02	44	118	3.63E+02	44	118	2.5E+01						
VOC	Bromoform	75-25-2	2.5E+02	50.1		2.2E+02	44		8.7E+01	44	111	2.2E-02	1.3E-02	44	3.1E+03	44		5.5E+00	3.3E+00	50.1	92	1.3E-01	44	8.9E-05	44	2.2E-03	44	115	62	62	1.0E+00	62	9.48E+03	44	118	6.96E+02	44	118	4.22E+02	44	118	2.5E+01						
VOC	Bromomethane	74-83-9	9.5E+01	50.1		1.5E+01	44		1.0E+01	44	111	2.6E-01	2.0E-01	44	1.5E+04	44		1.6E+03	1.2E+03	50.1	92	6.3E-01	44	1.0E-04	44	2.8E-03	44	115	62	62	1.0E+00	62	5.71E+03	44	118	4.67E+02	44	118	2.77E+02	44	118	2.5E+01						
VOC	2-Butanone	78-93-3	7.2E+01	50.1		1.9E+00	69		2.0E+00	69	111	2.3E-03	2.0E-03	50.1	92, 123	2.2E+05	50.2		9.5E+01	6.4E+01	50.1	92	7.0E-01	69	8.5E-05	69	9.6E-04	69	115	62	62	1.0E+00	62	7.48E+03	70		5.37E+02	70		3.53E+02	70		2.0E+01					
VOC	Carbon Disulfide	75-15-0	7.6E+01	50.1		1.0E+02	44		4.6E+01	44	111	1.2E+00	9.3E-01	44	1.2E+03	44		3.6E+02	2.6E+02	50.1	92	9.0E-01	44	8.6E-05	44	1.2E-02	44	115	62	62	1.0E+00	62	6.39E+03	44	118	5.52E+02	44	118	3.19E+02	44	118	2.5E+01						
VOC	Carbon Tetrachloride	56-23-5	1.5E+02	50.1		5.4E+02	44		1.7E+02	44	111	1.3E+00	8.8E-01	44	7.9E+02	44		1.2E+02	7.9E+01	50.1	92	6.7E-01	44	7.6E-05	44	1.4E-02	44	115	62	62	1.0E+00	62	7.13E+03	44	118	5.57E+02	44	118	3.50E+02	44	118	2.5E+01						
VOC	Chlorobenzene	108-90-7	1.1E+02	50.1		7.2E+02	44		2.2E+02	44	111	1.5E-01	9.8E-02	44	4.7E+02	44		1.2E+01	7.5E+00	50.1	92	6.3E-01	44	7.5E-05	44	2.9E-02	44	115	62	62	1.0E+00	62	8.41E+03	44	118	6.32E+02	44	118	4.05E+02	44	118	2.5E+01						
VOC	Chloroethane	75-00-3	6.5E+01	50.1		2.7E+01	69		1.6E+01	69	111	3.6E-01	3.3E-01	50.1	92, 123	5.7E+03	50.1	92	1.0E+03	7.6E+02	50.1	92	2.3E+00	69	9.9E-05	69	6.1E-03	69	115	62	62	1.0E+00	62	5.88E+03	70		4.60E+02	70		2.85E+02	70		2.0E+01					
VOC	Chloroform	67-66-3	1.2E+02	50.1		8.3E+01	44		4.0E+01	44	111	1.5E-01	1.1E-01	44	7.9E+03	44		2.0E+02	1.4E+02	50.1	92	9.0E-01	44	8.6E-05	44	6.3E-03	44	115	62	62	1.0E+00	62	6.99E+03	44	118	5.36E+02	44	118	3.34E+02	44	118	2.5E+01						
VOC	Chloromethane	74-87-3	5.0E+01	50.1		8.3E+01	69		4.0E+01	69	111	3.6E-01	3.3E-01	50.1	92, 123	5.3E+03	50.1	92	4.3E+03	3.4E+03	50.1	92	1.1E+00	69	5.6E-05	69	1.5E-02	69	115	62	62	1.0E+00	62	5.11E+03	70		4.16E+02	70		2.49E+02	70		2.0E+01					
VOC	Dibromochloromethane	124-48-1	2.1E+02	50.1		1.5E+02	44		6.3E+01	44	111	3.2E-02	2.4E-02	44	2.6E+03	44		4.9E+00	3.5E+00	50.1	92	1.7E-01	44	9.1E-05	44	2.9E-03	44	115	62	62	1.0E+00	62	5.90E+03	44	118	4.16E+02	44	118	4.16E+02	44	118	2.5E+01						
VOC	1,1-Dichloroethane	75-34-3	9.9E+01	50.1		6.2E+01	44		3.1E+01	44	111	2.3E-01	1.7E-01	44	5.1E+03	44		2.3E+02	1.6E+02	50.1	92	6.4E-01	44	9.1E-05	44	6.7E-03	44	115	62	62	1.0E+00	62	6.90E+03	44	118	5.23E+02	44	118	3.31E+02	44	118	2.5E+01						
VOC	1,2-Dichloroethane	107-06-2	9.9E+01	50.1		3.0E+01	44		1.7E+01	44	111	4.0E-02	2.7E-02	44	8.5E+03	44		7.9E+01	5.2E+01	50.1	92	9.0E-01	44	8.6E-05	44	4.1E-03	44	115	62	62	1.0E+00	62	7.64E+03	44	118	5.61E+02	44	118	3.57E+02	44	118	2.5E+01						
VOC	1,1-Dichloroethene	75-35-4	9.7E+01	50.1		1.3E+02	44		5.8E+01	44	111	1.1E+00	8.1E-01	44	2.3E+03	44		6.0E+02	4.4E+02	50.1	92	7.8E-01	44	9.0E-05	44	1.2E-02	44	115	62	62	1.0E+00	62	6.25E+03	44	118	5.76E+02	44	118	3.05E+02	44	118	2.5E+01						
VOC	1,2-Dichloroethene (total)	540-59-0	9.7E+01	50.1	133	7.2E+01	44	133	3.6E+01	44	133, 111	1.7E-01	1.2E-01	44	133	3.5E+03	44	133	2.0E+02	1.4E+02	50.1	92, 133	6.4E-01	44	9.8E-05	44	7.7E-03	44	133, 115	62	62	1.0E+00	62	117	7.19E+03	44	118, 133	5.44E+02	44	118, 133	3.34E+02	44	118, 133	2.5E+01				
VOC	cis-1,2-Dichloroethene	156-59-2	9.7E+01	50.1		7.2E+01	44		3.6E+01	44	111	1.7E-01	1.2E-01	44	3.5E+03	44		2.0E+02	1.4E+02	50.1	92	6.4E-01	44	9.8E-05	44	7.7E-03	44	115	62	62	1.0E+00	62	7.19E+03	44	118	5.44E+02	44	118	3.34E+02	44	118	2.5E+01						
VOC	trans-1,2-Dichloroethene	156-60-5	9.7E+01	50.1		1.2E+02	44		5.2E+01	44	111	3.9E-01	2.8E-01	44	6.3E+03	44		3.3E+02	2.4E+02	50.1	92	6.1E-01	44	1.0E-04	44	1.1E-02	44	115	62	62	1.0E+00	62	114	6.72E+03	44	118	5.17E+02	44	118	3.21E+02	44	118	2.5E+01					
VOC	1,2-Dichloropropane	78-87-5	1.1E+02	50.1		9.3E+01	44		4.3E+01	44	111	1.2E-01	7.8E-02	44	2.8E+03	44		5.2E+01	3.4E+01	50.1	92	6.8E-01	44	7.5E-05	44	7.4E-03	44	115	62	62	1.0E+00	62	7.59E+03	44	118	5.72E+02	44	118	3.70E+02	44	118	2.5E+01						
VOC	1,3-Dichloropropene (total)	542-75-6	1.1E+02	50.1		1.0E+02	44		4.6E+01	44	111	7.3E-01	4.8E-01	44	2.8E+03	44		3.4E+01	2.2E+01	50.1	92	5.4E-01	44	8.6E-05	44	7.9E-03	44	115	62	62	1.0E+00	62	7.90E+03	44	118	5.87E+02	44	118	3.81E+02	44	118	2.5E+01						
VOC	Ethyl Benzene	100-41-4	1.1E+02	50.1		1.4E+03	44		3.7E+02	44	111	3.2E-01	2.0E-01	44	1.7E+02	44		9.6E+00	8.1E+00	50.1	92	6.5E-01	44	6.7E-05	44	4.8E-02	44	115	62	62	1.0E+00	62	8.50E+03	44	118	6.17E+02	44	118	4.09E+02	44	118	2.5E+01						
VOC	2-Hexanone	591-78-6	1.0E+02	50.1		2.4E+01	39		1.5E+01	39	111	3.8E-03	3.2E-03	68	1.8E+04	39		1.2E+01	9.8E+00	50.1	92	7.4E-01	52	7.6E-05	52	3.5E-03	39	115	62	62	1.0E+00	62	114										2.5E+01					
VOC	4-Methyl-2-pentanone	108-10-1	1.0E+02	50.1		1.5E+01	62		1.0E+01	62	111	5.6E-03	4.7E-03	50.1	92, 123	1.9E+04	39		2.0E+01	1.2E+01	50.1	92	6.5E-01	40	6.7E-05	40	2.7E-03	62	115	62	62	1.0E+00	62	8.24E+03	70		5.71E+02	70		3.90E+02	70		2.0E+01					
VOC	Methylene Chloride	75-09-2	8.5E+01	50.1		1.8E+01	44		1.2E+01	44	111	9.0E-02	6.6E-02	44	1.3E+04	44		4.3E+02	3.1E+02	50.1	92	8.7E-01	44	1.0E-04	44	3.5E-03	44	115	62	62	1.0E+00	62	6.71E+03	44	118	5.10E+02	44	118	3.13E+02	44	118	2.5E+01						
VOC	Styrene	100-42-5	1.0E+02	50.1		8.7E+02	44		7.8E+02	44	82	1.1E-01	7.0E-02	44	3.1E+02	44		6.1E+00	3.7E+00	50.1	92	6.1E-01	44	6.9E-05	44	3.6E-02	44	115	62	62	1.0E+00	62	8.74E+03	44	118	6.36E+02	44	118	4.18E+02	44	118	2.5E+01						
VOC	1,1,2,2-Tetrachloroethane	79-34-5	1																																													

**Attachment 1: Occupational Inhalation Limits
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Occupational Inhalation Limits		
			Value (mg/m ³)	Ref	Note
VOC	Acetone	67-64-1	2.4E+03	97	
VOC	Benzene	71-43-2	3.2E+00	97	368
VOC	Bromodichloromethane	75-27-4			
VOC	Bromoform	75-25-2	5.0E+00	97	426
VOC	Bromomethane	74-83-9	3.9E+00	47	
VOC	2-Butanone	78-93-3	5.9E+02	97	
VOC	Carbon Disulfide	75-15-0	6.2E+01	97	
VOC	Carbon Tetrachloride	56-23-5	6.3E+01	97	
VOC	Chlorobenzene	108-90-7	3.5E+02	97	
VOC	Chloroethane	75-00-3	2.6E+03	97	
VOC	Chloroform	67-66-3	4.9E+01	47	
VOC	Chloromethane	74-87-3	2.1E+02	97	
VOC	Dibromochloromethane	124-48-1			
VOC	1,1-Dichloroethane	75-34-3	4.0E+02	97	
VOC	1,2-Dichloroethane	107-06-2	2.0E+02	97	
VOC	1,1-Dichloroethene	75-35-4	2.0E+01	47	
VOC	1,2-Dichloroethene (total)	540-59-0	7.9E+02	97	
VOC	cis-1,2-Dichloroethene	156-59-2	7.9E+02	97	409
VOC	trans-1,2-Dichloroethene	156-60-5	7.9E+02	97	409
VOC	1,2-Dichloropropane	78-87-5	3.5E+02	97	
VOC	1,3-Dichloropropene (total)	542-75-6	4.5E+00	47	
VOC	Ethyl Benzene	100-41-4	4.4E+02	97	
VOC	2-Hexanone	591-78-6	4.1E+02	97	
VOC	4-Methyl-2-pentanone	108-10-1	4.1E+02	97	
VOC	Methylene Chloride	75-09-2	8.7E+01	97	
VOC	Styrene	100-42-5	4.3E+02	97	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	3.5E+01	97	426
VOC	Tetrachloroethene	127-18-4	6.8E+02	97	
VOC	Toluene	108-88-3	7.5E+02	97	
VOC	1,1,1-Trichloroethane	71-55-6	1.9E+03	97	
VOC	1,1,2-Trichloroethane	79-00-5	4.5E+01	97	426
VOC	Trichloroethene	79-01-6	5.4E+02	97	
VOC	Vinyl Chloride	75-01-4	2.6E+00	97	368
VOC	Xylenes (total)	1330-20-7	4.4E+02	97	
References:					
47	American Conference of Government Industrial Hygienists. 2012. 2012 TLVs and BEIs. ISBN: 978-1-607260-48-6.				
97	Occupational Safety and Health Standards — Toxic and Hazardous Substances, Title 29 Code of Federal Regulations, Pt. 1910 Subpart Z. 2007 ed.				
Notes:					
368	Complex criterion; source document review required.				
409	ENVIRON used 1,2-Dichloroethene (total) [CASRN 540-59-0] value from the indicated reference as a surrogate.				
426	Skin Designation assigned; wear appropriate PPE.				

**Attachment 1: High-End Exposure Factors
Whirlpool, Fort Smith, Arkansas**

		Resident Age 0-2	Resident Age 2-6	Resident Age 6-16	Resident Age 16-30	Routine Worker	Maintenance Worker	Construction Worker	
Soil Ingestion									
Ingestion Rate (mg/d)	IR					50 b	100 f	200 f	f
Conversion Factor (kg/mg)	CF					1E-06	1E-06	1E-06	
Fraction Contacted (unitless)	FC					1.0 f	1.0 f	1.0 f	f
Exposure Frequency (d/yr)	EF					250 b	30 f	250 b	b
Exposure Duration (yr)	ED					25 b	10 e	1 f	f
Body Weight (kg-bw)	BW					70 a	70 a	70 a	a
Averaging Time, carc (d)	AT _c					25,550 a	25,550 a	25,550 a	a
Averaging Time, noncarc (d)	AT _{nc}					9,125 a	3,650 a	365 a	a
Intake, carc (kg-soil/kg-bw per d)						1.75E-07	1.68E-08	2.80E-08	
Soil Dermal Contact									
Adherence Factor (mg/cm ²)	AD					0.2 c	0.2 c	0.2 c	c
Skin Surface Area (cm ² /d)	SA					3,300 c	3,300 c	3,300 c	c
Conversion Factor (kg/mg)	CF					1E-06	1E-06	1E-06	
Fraction Contacted (unitless)	FC					1.0 f	1.0 f	1.0 f	f
Exposure Frequency (d/yr)	EF					250 b	30 f	250 b	b
Exposure Duration (yr)	ED					25 b	10 e	1 f	f
Body Weight (kg-bw)	BW					70 a	70 a	70 a	a
Averaging Time, carc (d)	AT _c					25,550 a	25,550 a	25,550 a	a
Averaging Time, noncarc (d)	AT _{nc}					9,125 a	3,650 a	365 a	a
Outdoor Air Inhalation of Vapor and Particulates									
Exposure Time (h/d)	ET	24	24	24	24 d	8 d	8 d	8 d	d
Exposure Frequency (d/yr)	EF	0	0	0	0 b	250 b	30 f	250 b	b
Exposure Duration (yr)	ED	0	0	0	0 b	25 b	10 e	1 f	f
Averaging Time, carc (h)	AT _c	613,200	613,200	613,200	613,200 a	613,200 a	613,200 a	613,200 a	a
Averaging Time, noncarc (h)	AT _{nc}	0	0	0	0 a	219,000 a	87,600 a	8,760 a	a
Incidental Groundwater Ingestion									
Drinking Rate (L/hr per event)	DR						0.005 f	0.005 f	f
Exposure Time (h)	ET						2 f	2 f	f
Exposure Frequency (d/yr)	EF						5 f	5 f	f
Exposure Duration (yr)	ED						10 e	1 f	f
Body Weight (kg-bw)	BW						70 a	70 a	a
Averaging Time, carc (d)	AT _c						25,550 a	25,550 a	a
Averaging Time, noncarc (d)	AT _{nc}						3,650 a	365 a	a
Groundwater Dermal Contact									
Event Time (hr)	t						2 f	2 f	f
Skin Surface Area (cm ²)	SA						3,300 c	3,300 c	c
Events per Day (event/d)	EV						1 f	1 f	f
Exposure Frequency (d/yr)	EF						5 f	5 f	f
Exposure Duration (yr)	ED						10 e	1 f	f
Body Weight (kg)	BW						70 a	70 a	a
Averaging Time, cancer (days)	AT _c						25,550 a	25,550 a	a
Averaging Time, noncancer (days)	AT _{nc}						3,650 a	365 a	a
Groundwater Outdoor Vapor Inhalation									
Exposure Time (h/d)	ET	0	0	0	0 d	0 d	8 d	8 d	d
Exposure Frequency (d/yr)	EF	0	0	0	0 b	0 b	5 f	5 f	f
Exposure Duration (yr)	ED	2	4	10	14 b	0 b	10 e	1 f	f
Averaging Time, carc (h)	AT _c	613,200	613,200	613,200	613,200 a	613,200 a	613,200 a	613,200 a	a
Averaging Time, noncarc (h)	AT _{nc}	262,800	262,800	262,800	262,800 a	0 a	87,600 a	8,760 a	a
Groundwater Indoor Vapor Inhalation									
Exposure Time (hours/day)	ET	24	24	24	24 d	8 d			
Exposure Frequency (d/yr)	EF	350	350	350	350 b	250 b			
Exposure Duration (yr)	ED	2	4	10	14 b	25 b			
Averaging Time, carc (hours)	AT _c	613,200	613,200	613,200	613,200 a	613,200 a			
Averaging Time, noncarc (hours)	AT _{nc}	262,800	262,800	262,800	262,800 a	219,000 a			
Soil Indoor Vapor Inhalation									
Exposure Time (hours/day)	ET					8 d			
Exposure Frequency (d/yr)	EF					250 b			
Exposure Duration (yr)	ED					25 b			
Averaging Time, carc (hours)	AT _c					613,200 a			
Averaging Time, noncarc (hours)	AT _{nc}					219,000 a			

References:

- a. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A) Interim Final (EPA 1989).
- b. Standard default exposure factors. OSWER Directive 9285.6-03 (EPA 1991).
- c. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual: Part E, Supplemental Guidance for Dermal Risk Assessment (EPA 2004).
- d. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual: Part F, Supplemental Guidance for Inhalation Risk Assessment (EPA 2009).
- e. The 90th to 95th percentile job tenure for workers in construction (Burmester 2000).
- f. Based on professional judgment and site-specific considerations discussed in the text.
- g. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens (USEPA 2005).

**Attachment 1: Detected Source Concentrations
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Carc Class	Groundwater Concentration (On-Site) (mg/L)	Groundwater Concentration (Off-Site) (mg/L)	Soil Concentration (mg/kg)	SV1 (mg/m ³)	SV2 (mg/m ³)	SV3 (mg/m ³)	SV4 (mg/m ³)
VOC	Acetone	67-64-1	ID	1.99E-01	8.50E-02	ND	NA	NA	NA	NA
VOC	Benzene	71-43-2	A	6.53E-02	ND	ND	NA	NA	NA	NA
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	ND	ND	NA	NA	NA	NA
VOC	Bromoform	75-25-2	B2	7.67E-02	2.40E-02	ND	NA	NA	NA	NA
VOC	Bromomethane	74-83-9	ID	6.13E-02	ND	ND	NA	NA	NA	NA
VOC	2-Butanone	78-93-3	ID	1.06E-01	9.50E-02	ND	NA	NA	NA	NA
VOC	Carbon Disulfide	75-15-0		6.52E-02	ND	ND	NA	NA	NA	NA
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	ND	ND	NA	NA	NA	NA
VOC	Chlorobenzene	108-90-7	D	6.86E-02	ND	ND	NA	NA	NA	NA
VOC	Chloroethane	75-00-3	LC	7.23E-02	ND	ND	NA	NA	NA	NA
VOC	Chloroform	67-66-3	B2	6.64E-02	ND	ND	NA	NA	NA	NA
VOC	Chloromethane	74-87-3	D	9.00E-02	ND	ND	NA	NA	NA	NA
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	ND	ND	NA	NA	NA	NA
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	ND	ND	NA	NA	NA	NA
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	3.00E-03	ND	NA	NA	NA	NA
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	4.20E-03	ND	NA	NA	NA	NA
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	4.10E-02	1.20E-02	NA	NA	NA	NA
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	4.10E-02	1.20E-02	NA	NA	NA	NA
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	ND	ND	NA	NA	NA	NA
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	ND	ND	NA	NA	NA	NA
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	ND	ND	NA	NA	NA	NA
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	ND	ND	NA	NA	NA	NA
VOC	2-Hexanone	591-78-6	ID	1.20E-01	ND	ND	NA	NA	NA	NA
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	4.00E-03	ND	NA	NA	NA	NA
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	ND	7.00E-03	NA	NA	NA	NA
VOC	Styrene	100-42-5		6.83E-02	ND	ND	NA	NA	NA	NA
VOC	1,1,1,2-Tetrachloroethane	79-34-5	LC	6.40E-02	ND	ND	NA	NA	NA	NA
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	ND	ND	NA	1.1E-01	NA	NA
VOC	Toluene	108-88-3	ID	6.54E-02	ND	ND	NA	NA	NA	NA
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	ND	ND	NA	NA	NA	NA
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	ND	ND	NA	NA	NA	NA
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.60E+00	1.86E-01	ND	2.3E-01	2.9E-03	4.0E-02
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	3.00E-03	ND	NA	NA	NA	NA
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	ND	ND	NA	NA	NA	NA

Notes:

ND - Not Detected.

NA - Not Analyzed.

Attachment 2

Routine Worker Risk Calculations

Contents:

- Vapor Flux from Soil to Outdoor Air
- Soil PM10 Emission from Wind Erosion
- Cancer Risk Calculations for Exposure of On-Site Routine Workers to On-Site Soil
- Hazard Index Calculations for Exposure of On-Site Routine Workers to On-Site Soil
- Cancer Risk Calculations for Exposure of Off-Site Routine Workers to On-Site Soil
- Hazard Index Calculations for Exposure of Off-Site Routine Workers to On-Site Soil

- Soil Moisture Profile for Comm/Ind Building (Slab-on-Grade)
- Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Subsurface Soil
- Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
- Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Soil Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
- Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
- Vapor Intrusion Contribution to Occupational Inhalation Exposure Limits Calculations for On-Site Routine Workers Exposure in a Comm/Ind Building (Slab-on-Grade)
- Cancer Risk and Hazard Index Calculations for Off-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)

- Vapor Flux to Outdoor Air from Groundwater
- Cancer Risk and Hazard Index Calculations for Exposure of On-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air
- Cancer Risk and Hazard Index Calculations for Exposure of Off-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air

**Attachment 2: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	K _{oc} (L/kg)	H (unitless)	D _{air} (m ² /d)	D _{water} (m ² /d)	R _L (unitless)	D _G (m ² /d)	D _L (m ² /d)	D _E (m ² /d)	Infinite J _v (kg/m ² -s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J _v (kg/m ² -s)	J _v (kg/m ² -s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	1.58E-06	0.00E+00	4.48E-03	1.58E-06	1.58E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	9.63E-06	0.00E+00	2.18E+00	5.08E-06	5.08E-06
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	3.14E-06	0.00E+00	3.82E-01	2.97E-06	2.97E-06
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	1.31E-06	0.00E+00	3.38E-04	1.31E-06	1.31E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	1.14E-05	0.00E+00	2.39E+00	5.27E-06	5.27E-06
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	1.58E-06	0.00E+00	4.54E-03	1.58E-06	1.58E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	2.32E-05	0.00E+00	3.02E+00	5.84E-06	5.84E-06
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	1.56E-05	0.00E+00	2.72E+00	5.57E-06	5.57E-06
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	5.04E-06	0.00E+00	1.14E+00	4.01E-06	4.01E-06
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	2.66E-05	0.00E+00	3.10E+00	5.91E-06	5.91E-06
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	9.18E-06	0.00E+00	2.11E+00	5.02E-06	5.02E-06
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	1.70E-05	0.00E+00	2.79E+00	5.64E-06	5.64E-06
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	1.94E-06	0.00E+00	3.05E-02	1.93E-06	1.93E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	9.77E-06	0.00E+00	2.20E+00	5.10E-06	5.10E-06
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	5.14E-06	0.00E+00	1.17E+00	4.05E-06	4.05E-06
VOC	1,1-Dichloroethene	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	1.99E-05	0.00E+00	2.92E+00	5.75E-06	5.75E-06
VOC	1,2-Dichloroethene (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	8.21E-06	0.00E+00	1.95E+00	4.86E-06	4.86E-06
VOC	cis-1,2-Dichloroethene	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	8.21E-06	0.00E+00	1.95E+00	4.86E-06	4.86E-06
VOC	trans-1,2-Dichloroethene	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	1.14E-05	0.00E+00	2.40E+00	5.28E-06	5.28E-06
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	6.76E-06	0.00E+00	1.65E+00	4.56E-06	4.56E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	1.39E-05	0.00E+00	2.61E+00	5.47E-06	5.47E-06
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	6.11E-06	0.00E+00	1.48E+00	4.38E-06	4.38E-06
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	1.81E-06	0.00E+00	1.76E-02	1.81E-06	1.81E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	2.01E-06	0.00E+00	4.02E-02	2.00E-06	2.00E-06
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	7.90E-06	0.00E+00	1.90E+00	4.81E-06	4.81E-06
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	2.61E-06	0.00E+00	1.83E-01	2.54E-06	2.54E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	1.99E-06	0.00E+00	3.77E-02	1.98E-06	1.98E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	1.19E-05	0.00E+00	2.44E+00	5.32E-06	5.32E-06
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	7.87E-06	0.00E+00	1.89E+00	4.80E-06	4.80E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	1.35E-05	0.00E+00	2.58E+00	5.45E-06	5.45E-06
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	3.77E-06	0.00E+00	6.44E-01	3.39E-06	3.39E-06
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	9.57E-06	0.00E+00	2.17E+00	5.07E-06	5.07E-06

**Attachment 2: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	K_{oc} (L/kg)	H (unitless)	D_{air} (m ² /d)	D_{water} (m ² /d)	R_L (unitless)	D_G (m ² /d)	D_L (m ² /d)	D_E (m ² /d)	Infinite J_v (kg/m ² -s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J_v (kg/m ² -s)	J_v (kg/m ² -s)
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	2.48E-05	0.00E+00	3.06E+00	5.88E-06	5.88E-06
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	5.65E-06	0.00E+00	1.34E+00	4.24E-06	4.24E-06
Notes:	Soil bulk density	kg/L	ρ_b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ_w	0.32											
	Soil air-filled porosity	L/L-soil	θ_a	0.17											
	Soil organic carbon fraction	unitless	f_{oc}	0.002											
	Averaging period (Exposure Duration)	year	T	25											
		days	T	9125											
		s	T	7.9E+08											
	Molar Gas Constant	L-mmHg/ mole-°K	R	62.411											
	Temperature	°C	Temp	16.7											
		K	Temp	289.7											
	Clean soil above source	m	Z₁	0.00											
	Bottom of source depth	m	Z₂	3.66											

Attachment 2: Soil PM10 Emission from Wind Erosion Whirlpool, Fort Smith, Arkansas			
Unlimited Reservoir Model			
Aerodynamic particle size multiplier			0.036
Ground cover fraction		G	0.5
Mode of aggregate size distribution	mm		0.50
Threshold friction velocity	m/s	u'_t	0.50
Correction factor			1.25
Corrected friction velocity	m/s	u*_t	0.6252
Roughness height	m	z₀	0.005
Anemometer height	m		10.0
Friction velocity at anemometer height	m/s	u_t	11.9
Mean annual wind speed	mph	u_m	7.6
Mean annual wind speed	m/s	u_m	3.40
u _m /u _t			0.286
x = 0.886 u _t /u _m			3.10
F(x)			0.003
Annual average PM₁₀ flux	kg-soil/m ² -s	J_{10,w}	3.93E-13

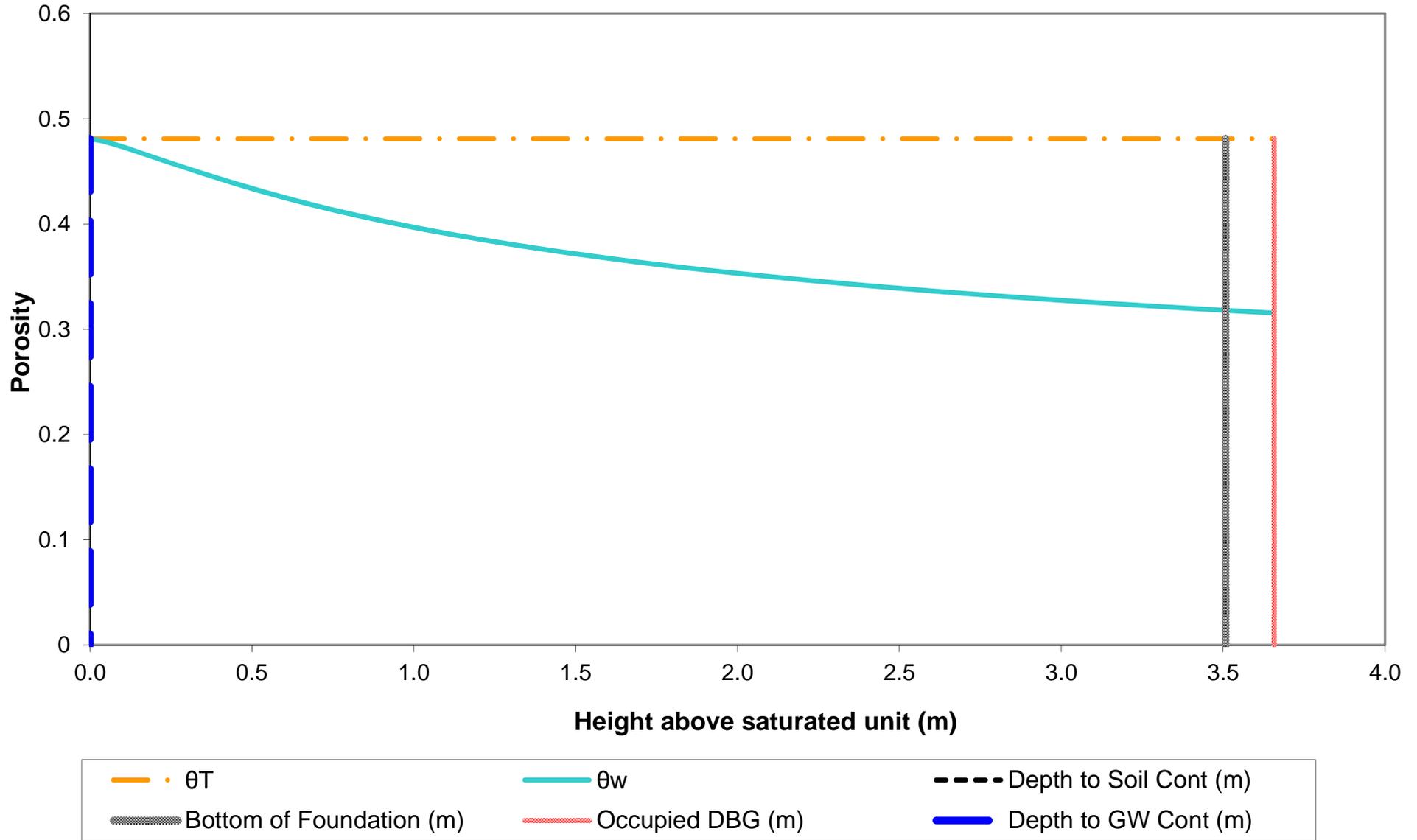
**Attachment 2: Cancer Risk Calculations for Exposure of On-Site Routine Workers to On-Site Soil
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{soil} (mg/kg)	Soil Ingestion			Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes	
					LADD (mg/kg/d)	SF _{oral} (mg/kg/d) ⁻¹	Risk	ABS _{derm}	LADD (mg/kg/d)	SF _{derm} (mg/kg/d) ⁻¹	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	Risk	
VOC	Acetone	67-64-1	ID																
VOC	Benzene	71-43-2	A											7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2																
VOC	Bromoform	75-25-2	B2											1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID																
VOC	2-Butanone	78-93-3	ID																
VOC	Carbon Disulfide	75-15-0																	
VOC	Carbon Tetrachloride	56-23-5	LC											6.0E-03			6.0E-03		
VOC	Chlorobenzene	108-90-7	D																
VOC	Chloroethane	75-00-3	LC																
VOC	Chloroform	67-66-3	B2											2.3E-02			2.3E-02		
VOC	Chloromethane	74-87-3	D																
VOC	Dibromochloromethane	124-48-1	C																
VOC	1,1-Dichloroethane	75-34-3	SC																
VOC	1,2-Dichloroethane	107-06-2	B2											2.6E-02			2.6E-02		
VOC	1,1-Dichloroethene	75-35-4	C																
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	2.10E-09								1.98E-06				1.60E-13		
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	2.10E-09								1.98E-06				1.60E-13		
VOC	trans-1,2-Dichloroethene	156-60-5	ID																
VOC	1,2-Dichloropropane	78-87-5	B2																
VOC	1,3-Dichloropropene (total)	542-75-6	B2																
VOC	Ethyl Benzene	100-41-4	D											4.0E-03			4.0E-03		
VOC	2-Hexanone	591-78-6	ID																
VOC	4-Methyl-2-pentanone	108-10-1	ID																
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.22E-09	2.0E-03	2.4E-12						1.14E-06	1.0E-05	9.3E-13	9.35E-14	1.0E-05	7.6E-20	3.4E-12
VOC	Styrene	100-42-5																	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC																
VOC	Tetrachloroethene	127-18-4	LC											2.6E-04			2.6E-04		
VOC	Toluene	108-88-3	ID																
VOC	1,1,1-Trichloroethane	71-55-6	ID																
VOC	1,1,2-Trichloroethane	79-00-5	C											1.6E-02			1.6E-02		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.25E-08	4.6E-02	1.5E-09						3.21E-05	4.1E-03	1.1E-08	2.48E-12	4.1E-03	8.3E-16	1.2E-08
VOC	Vinyl Chloride	75-01-4	A											4.4E-03			4.4E-03		
VOC	Xylenes (total)	1330-20-7	ID																
Cumulative Risk:							1E-09							1E-08			8E-16		1E-08
Notes:																			
The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).																			
This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.																			

**Attachment 2: Cancer Risk Calculations for Exposure of Off-Site Routine Workers to On-Site Soil
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{soil} (mg/kg)	Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes
					C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	Risk
VOC	Acetone	67-64-1	ID								
VOC	Benzene	71-43-2	A			7.8E-03			7.8E-03		
VOC	Bromodichloromethane	75-27-4	B2								
VOC	Bromofom	75-25-2	B2			1.1E-03			1.1E-03		
VOC	Bromomethane	74-83-9	ID								
VOC	2-Butanone	78-93-3	ID								
VOC	Carbon Disulfide	75-15-0									
VOC	Carbon Tetrachloride	56-23-5	LC			6.0E-03			6.0E-03		
VOC	Chlorobenzene	108-90-7	D								
VOC	Chloroethane	75-00-3	LC								
VOC	Chloroform	67-66-3	B2			2.3E-02			2.3E-02		
VOC	Chloromethane	74-87-3	D								
VOC	Dibromochloromethane	124-48-1	C								
VOC	1,1-Dichloroethane	75-34-3	SC								
VOC	1,2-Dichloroethane	107-06-2	B2			2.6E-02			2.6E-02		
VOC	1,1-Dichloroethene	75-35-4	C								
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	1.98E-06			1.60E-13			
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	1.98E-06			1.60E-13			
VOC	trans-1,2-Dichloroethene	156-60-5	ID								
VOC	1,2-Dichloropropane	78-87-5	B2								
VOC	1,3-Dichloropropene (total)	542-75-6	B2			4.0E-03			4.0E-03		
VOC	Ethyl Benzene	100-41-4	D								
VOC	2-Hexanone	591-78-6	ID								
VOC	4-Methyl-2-pentanone	108-10-1	ID								
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.14E-06	1.0E-05	9.3E-13	9.35E-14	1.0E-05	7.6E-20	9.3E-13
VOC	Styrene	100-42-5									
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC								
VOC	Tetrachloroethene	127-18-4	LC			2.6E-04			2.6E-04		
VOC	Toluene	108-88-3	ID								
VOC	1,1,1-Trichloroethane	71-55-6	ID								
VOC	1,1,2-Trichloroethane	79-00-5	C			1.6E-02			1.6E-02		
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.21E-05	4.1E-03	1.1E-08	2.48E-12	4.1E-03	8.3E-16	1.1E-08
VOC	Vinyl Chloride	75-01-4	A			4.4E-03			4.4E-03		
VOC	Xylenes (total)	1330-20-7	ID								
			Cumulative Risk:				1E-08			8E-16	1E-08
Notes:											
The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).											
This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.											

Attachment 2: Soil Moisture Profile for Comm/Ind Building (Slab-on-Grade) Whirlpool, Fort Smith, Arkansas



**Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Subsurface Soil
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	D _{air} (m ² /day)	D _{water} (m ² /day)	H (unitless)	D _{crack} (m ² /day)	D _{eff} ^T (m ² /day)	α _{so}	K _{oc} (L/kg)	K _d (L/kg)	C _{s, vap} (kg-soil/m ³)	α _{ML}	α	C _{bdg} (kg-soil/m ³)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.91E-02	8.26E-05	5.81E-01	1.16E-03	4.91E+00	9.22E-04	8.26E-05	4.05E-04
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	7.74E-03	8.25E-05	5.82E+01	1.16E-01	4.34E+02	1.04E-05	1.04E-05	4.53E-03
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	2.80E-03	8.23E-05	5.51E+01	1.10E-01	1.29E+02	3.52E-05	3.52E-05	4.53E-03
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.94E-03	8.22E-05	8.70E+01	1.74E-01	3.29E+01	1.38E-04	8.22E-05	2.70E-03
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	6.41E-03	8.25E-05	1.05E+01	2.10E-02	7.30E+02	6.20E-06	6.20E-06	4.53E-03
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	1.96E-03	1.12E-01	1.12E-02	8.25E-05	2.00E+00	3.99E-03	8.35E+00	5.42E-04	8.25E-05	6.89E-04
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	9.09E-03	8.25E-05	4.59E+01	9.19E-02	2.14E+03	2.11E-06	2.11E-06	4.53E-03
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	6.82E-03	8.25E-05	1.74E+02	3.48E-01	1.29E+03	3.50E-06	3.50E-06	4.53E-03
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	6.45E-03	8.25E-05	2.20E+02	4.41E-01	1.43E+02	3.17E-05	3.17E-05	4.53E-03
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	3.25E-01	3.76E-01	2.37E-02	8.26E-05	1.62E+01	3.25E-02	1.08E+03	4.20E-06	4.20E-06	4.53E-03
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	9.16E-03	8.25E-05	3.97E+01	7.94E-02	3.33E+02	1.36E-05	1.36E-05	4.53E-03
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	1.10E-02	8.25E-05	3.97E+01	7.94E-02	9.52E+02	4.75E-06	4.75E-06	4.53E-03
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	2.08E-03	8.22E-05	6.26E+01	1.25E-01	6.64E+01	6.82E-05	6.82E-05	4.53E-03
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	6.53E-03	8.25E-05	3.13E+01	6.27E-02	5.29E+02	8.56E-06	8.56E-06	4.53E-03
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	9.38E-03	8.25E-05	1.75E+01	3.50E-02	1.02E+02	4.44E-05	4.44E-05	4.53E-03
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	7.87E-03	8.25E-05	5.82E+01	1.16E-01	1.83E+03	2.47E-06	2.47E-06	4.53E-03
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.51E-03	8.25E-05	3.56E+01	7.12E-02	3.75E+02	1.21E-05	1.21E-05	4.53E-03
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	6.51E-03	8.25E-05	3.56E+01	7.12E-02	3.75E+02	1.21E-05	1.21E-05	4.53E-03
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.80E-02	6.21E-03	8.25E-05	5.22E+01	1.04E-01	7.64E+02	5.93E-06	5.93E-06	4.53E-03
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	6.92E-03	8.25E-05	4.35E+01	8.70E-02	2.39E+02	1.89E-05	1.89E-05	4.53E-03
VOC	1,3-Dichloropropene (total)	542-75-6	5.41E-01	8.64E-05	4.83E-01	8.68E-02	5.49E-03	8.25E-05	4.59E+01	9.19E-02	1.27E+03	3.56E-06	3.56E-06	4.53E-03
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	6.58E-03	8.25E-05	3.67E+02	7.35E-01	2.06E+02	2.19E-05	2.19E-05	4.53E-03
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	9.76E-03	8.25E-05	1.48E+01	2.97E-02	1.24E+01	3.65E-04	8.25E-05	1.02E-03
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	7.92E-03	8.25E-05	1.05E+01	2.10E-02	1.87E+01	2.42E-04	8.25E-05	1.54E-03
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	8.97E-03	8.25E-05	1.17E+01	2.34E-02	2.52E+02	1.80E-05	1.80E-05	4.53E-03
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.84E-02	6.30E-03	8.25E-05	7.77E+02	1.55E+00	3.93E+01	1.15E-04	8.25E-05	3.24E-03
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.84E-02	6.95E-03	8.25E-05	9.35E+01	1.87E-01	2.09E+01	2.17E-04	8.25E-05	1.72E-03
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.98E-02	6.30E-03	8.25E-05	1.56E+02	3.12E-01	8.17E+02	5.54E-06	5.54E-06	4.53E-03
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	7.64E-03	8.25E-05	1.80E+02	3.61E-01	2.94E+02	1.54E-05	1.54E-05	4.53E-03
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	6.83E-03	8.25E-05	1.10E+02	2.20E-01	9.75E+02	4.64E-06	4.64E-06	4.53E-03
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	7.11E-03	8.25E-05	5.03E+01	1.01E-01	7.27E+01	6.23E-05	6.23E-05	4.53E-03
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	6.93E-03	8.25E-05	1.68E+02	3.35E-01	4.80E+02	9.43E-06	9.43E-06	4.53E-03

**Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Subsurface Soil
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	D _{air} (m ² /day)	D _{water} (m ² /day)	H (unitless)	D _{crack} (m ² /day)	D _{eff} ^T (m ² /day)	α _{so}	K _{oc} (L/kg)	K _d (L/kg)	C _{s, vap} (kg-soil/m ³)	α _{ML}	α	C _{bdlg} (kg-soil/m ³)
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	9.27E-03	8.25E-05	1.85E+01	3.69E-02	2.41E+03	1.88E-06	1.88E-06	4.53E-03
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.85E-03	8.25E-05	3.86E+02	7.71E-01	1.69E+02	2.67E-05	2.67E-05	4.53E-03
Notes:	Soil and Building Characteristics			Crack	Vadose (below floor to 6")	Deep Vadose (6" to bottom of contaminant)								
	SCS Soil texture class			Sand	Silty Clay	Silty Clay								
	Bulk density	kg/L	ρ _b	1.66		1.38								
	Total porosity	L/L-soil	θ _T	0.375	0.481	0.481								
	Water-filled porosity	L/L-soil	θ _w	0.054	0.319	0.319								
	Air-filled porosity	L/L-soil	θ _a	0.321	0.162	0.162								
	Organic carbon fraction	unitless	f _{oc}			0.002								
	Residual saturation	L/L-soil	θ _r	0.053										
	Hydraulic conductivity	cm/s	K	7.4E-03										
	Dynamic viscosity of water	g/cm-s	μ _w	0.01307										
	Density of water	g/cm ³	ρ _w	1.0										
	Gravitational acceleration	cm/s ²	g	980.7										
	Intrinsic permeability	cm ²	k	9.9E-08										
	Relative saturation	unitless	S _e	0.004										
	van Genuchten N	unitless	N	1.32										
	van Genuchten M	unitless	M	0.243										
	Relative air permeability	unitless	k _{rg}	0.998										
	Permeability to vapor	cm ²	k _v	9.9E-08										
	Distance from building foundation to source	m	L _{T-soil}	0.001										
	Bldg foundation thickness	m	L _{crack}	0.15										
	Bldg foundation length	m		19.29										
	Bldg foundation width	m		19.29										
	Bldg occupied height	m		2.44										
	Bldg occupied volume	m ³		907.93										
	Occupied depth below ground	m		0.0										
	Bldg area for vapor intrusion	m ²	A _B	372.1										
	Ratio of A _{crack} to A _B		η	1E-04										
	Area of cracks	m ²	A _{crack}	3.86E-02										
	Air exchange rate	hour ⁻¹	ach	2.0										
	Building ventilation rate	m ³ /day	Q _{bdlg}	4.36E+04										
	Pressure difference between outdoors-indoors	kg/m-s ²	ΔP	1.0										
	Viscosity of air	kg/m-s	μ _a	1.8E-05										
	Crack length (bldg perimeter)	m	X _{crack}	77.16										
	Crack depth below ground	m	Z _{crack}	0.15										
	Crack radius	m	r _{crack}	5E-04										
	Soil gas flow rate into bldg	m ³ /day	Q _{soil}	3.60E+00										
	Averaging period	d	T	9.13E+03										
	Contaminant thickness	m	ΔH	3.5066										

**Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	D _{air} (m ² /day)	D _{water} (m ² /day)	H (unitless)	D _{crack} (m ² /day)	D _{eff} ^T (m ² /day)	α _{soil}	α _{slab}	α _∞	C _{bdg} (L-water/m ³)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.87E-02	3.55E-01	8.26E-05	2.93E-05	3.34E-05
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	8.00E-04	2.30E-02	8.26E-05	1.90E-06	3.02E-04
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	1.06E-03	3.02E-02	8.26E-05	2.50E-06	1.11E-04
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.64E-03	4.60E-02	8.26E-05	3.80E-06	5.08E-05
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	7.29E-04	2.10E-02	8.26E-05	1.74E-06	3.49E-04
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	1.96E-03	1.12E-01	1.00E-02	2.28E-01	8.26E-05	1.89E-05	3.70E-05
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	2.87E-04	8.39E-03	8.26E-05	6.93E-07	6.42E-04
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	2.47E-04	7.22E-03	8.26E-05	5.96E-07	5.26E-04
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	9.16E-04	2.63E-02	8.26E-05	2.17E-06	2.12E-04
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	3.25E-01	3.76E-01	8.68E-04	2.50E-02	8.26E-05	2.06E-06	6.70E-04
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	1.09E-03	3.11E-02	8.26E-05	2.57E-06	2.76E-04
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	4.51E-04	1.31E-02	8.26E-05	1.08E-06	3.61E-04
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	1.26E-03	3.58E-02	8.26E-05	2.96E-06	7.05E-05
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	7.58E-04	2.18E-02	8.26E-05	1.80E-06	2.99E-04
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	2.34E-03	6.44E-02	8.26E-05	5.32E-06	1.46E-04
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	3.06E-04	8.93E-03	8.26E-05	7.37E-07	5.97E-04
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.55E-04	2.74E-02	8.26E-05	2.26E-06	2.68E-04
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.55E-04	2.74E-02	8.26E-05	2.26E-06	2.68E-04
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.80E-02	5.85E-04	1.70E-02	8.26E-05	1.40E-06	3.94E-04
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	1.07E-03	3.06E-02	8.26E-05	2.53E-06	1.98E-04
VOC	1,3-Dichloropropene (total)	542-75-6	5.41E-01	8.64E-05	4.83E-01	8.68E-02	3.62E-04	1.06E-02	8.26E-05	8.72E-07	4.21E-04
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	5.64E-04	1.63E-02	8.26E-05	1.35E-06	2.76E-04
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	6.82E-03	1.67E-01	8.26E-05	1.38E-05	4.47E-05
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	4.77E-03	1.23E-01	8.26E-05	1.02E-05	4.80E-05
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	1.56E-03	4.39E-02	8.26E-05	3.62E-06	2.39E-04
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.84E-02	1.04E-03	2.97E-02	8.26E-05	2.45E-06	1.73E-04
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.84E-02	3.27E-03	8.79E-02	8.26E-05	7.26E-06	6.35E-05
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.98E-02	3.34E-04	9.74E-03	8.26E-05	8.04E-07	3.95E-04
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	6.83E-04	1.97E-02	8.26E-05	1.63E-06	2.94E-04
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	3.56E-04	1.04E-02	8.26E-05	8.58E-07	4.27E-04
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	2.06E-03	5.71E-02	8.26E-05	4.72E-06	1.15E-04
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	5.13E-04	1.49E-02	8.26E-05	1.23E-06	3.54E-04
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	3.37E-04	9.84E-03	8.26E-05	8.12E-07	7.31E-04

**Attachment 2: Normalized Indoor Air Concentration in a Comm/Ind Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	D _{air} (m ² /day)	D _{water} (m ² /day)	H (unitless)	D _{crack} (m ² /day)	D _{eff} ^T (m ² /day)	α _{soil}	α _{slab}	α _∞	C _{bdg} (L-water/m ³)
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.77E-04	1.95E-02	8.26E-05	1.61E-06	2.80E-04
Notes:	Crack Soil and Building Characteristics			Crack Soil							
	SCS Soil texture class			Sand							
	Bulk density	kg/L	ρ _b	1.66							
	Total porosity	L/L-soil	θ _T	0.375							
	Water-filled porosity	L/L-soil	θ _w	0.054							
	Air-filled porosity	L/L-soil	θ _a	0.321							
	Residual saturation	L/L-soil	θ _r	0.053							
	Hydraulic conductivity	cm/s	K	7.4E-03							
	Dynamic viscosity of water	g/cm-s	μ _w	0.01307							
	Density of water	g/cm ³	ρ _w	1.0							
	Gravitational acceleration	cm/s ²	g	980.7							
	Intrinsic permeability	cm ²	k	9.9E-08							
	Relative saturation	unitless	S _e	0.004							
	van Genuchten N	unitless	N	1.321							
	van Genuchten M	unitless	M	0.243							
	Relative air permeability	unitless	k _{rg}	0.998							
	Permeability to vapor	cm ²	k _v	9.89E-08							
	Distance from building foundation	m	L _{T-gw}	3.51							
	Bldg foundation thickness	m	L _{crack}	0.15							
	Bldg foundation length	m		19.29							
	Bldg foundation width	m		19.29							
	Bldg occupied height	m		2.44							
	Bldg occupied volume	m ³		907.93							
	Occupied depth below ground	m		0.0							
	Bldg area for vapor intrusion	m ²	A _B	372.1							
	Ratio of A _{crack} to A _B		η	1E-04							
	Area of cracks	m ²	A _{crack}	4E-02							
	Air exchange rate	hour ⁻¹	ach	2.00							
	Building ventilation rate	m ³ /day	Q _{bdg}	4.36E+04							
	Pressure difference between	kg/m-s ²	ΔP	1.0							
	Viscosity of air	kg/m-s	μ _a	1.8E-05							
	Crack length (bldg perimeter)	m	X _{crack}	77.16							
	Crack depth below ground	m	Z _{crack}	0.15							
	Crack radius	m	r _{crack}	5E-04							
	Soil gas flow rate into bldg	m ³ /day	Q _{soil}	3.60							

**Attachment 2: Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Soil Vapor Intrusion
into a Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Carc Class	C _{soil} (mg/kg)	C _{bdlg} (kg-soil/m ³)	C _{air} (mg/m ³)	Cancer		Noncancer	
							URF (m ³ /mg)	Risk	RfC (mg/m ³)	HQ
VOC	Acetone	67-64-1	ID		4.05E-04				3.1E+01	
VOC	Benzene	71-43-2	A		4.53E-03		7.8E-03		3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2		4.53E-03					
VOC	Bromoform	75-25-2	B2		2.70E-03		1.1E-03			
VOC	Bromomethane	74-83-9	ID		4.53E-03				5.0E-03	
VOC	2-Butanone	78-93-3	ID		6.89E-04				5.0E+00	
VOC	Carbon Disulfide	75-15-0			4.53E-03				7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC		4.53E-03		6.0E-03		1.0E-01	
VOC	Chlorobenzene	108-90-7	D		4.53E-03				5.0E-02	
VOC	Chloroethane	75-00-3	LC		4.53E-03				1.0E+01	
VOC	Chloroform	67-66-3	B2		4.53E-03		2.3E-02		5.0E-02	
VOC	Chloromethane	74-87-3	D		4.53E-03				9.0E-02	
VOC	Dibromochloromethane	124-48-1	C		4.53E-03					
VOC	1,1-Dichloroethane	75-34-3	SC		4.53E-03				5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2		4.53E-03		2.6E-02		7.0E-03	
VOC	1,1-Dichloroethene	75-35-4	C		4.53E-03				2.0E-01	
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	4.53E-03	5.43E-05				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	4.53E-03	5.43E-05				
VOC	trans-1,2-Dichloroethene	156-60-5	ID		4.53E-03					
VOC	1,2-Dichloropropane	78-87-5	B2		4.53E-03				4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2		4.53E-03		4.0E-03		2.0E-02	
VOC	Ethyl Benzene	100-41-4	D		4.53E-03				1.0E+00	
VOC	2-Hexanone	591-78-6	ID		1.02E-03				3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID		1.54E-03				3.0E+00	
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	4.53E-03	3.17E-05	1.0E-05	2.6E-11	6.0E-01	1.2E-05
VOC	Styrene	100-42-5			3.24E-03				1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC		1.72E-03					
VOC	Tetrachloroethene	127-18-4	LC		4.53E-03		2.6E-04		4.0E-02	
VOC	Toluene	108-88-3	ID		4.53E-03				5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID		4.53E-03				5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C		4.53E-03		1.6E-02		2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.86E-01	4.53E-03	8.42E-04	4.1E-03	2.8E-07	2.0E-03	9.6E-02
VOC	Vinyl Chloride	75-01-4	A		4.53E-03		4.4E-03		1.0E-01	
VOC	Xylenes (total)	1330-20-7	ID		4.53E-03				1.0E-01	
							Cumulative Risk:	3E-07	HI:	1E-01

**Attachment 2: Cancer Risk and Hazard Index Calculations for On-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Carc Class	C _{gw} (mg/L)	C _{bdg} (L-water/m ³)	C _{air} (mg/m ³)	Cancer		Noncancer	
							URF (m ³ /mg)	Risk	RfC (mg/m ³)	HQ
VOC	Acetone	67-64-1	ID	1.99E-01	3.34E-05	6.65E-06			3.1E+01	4.9E-08
VOC	Benzene	71-43-2	A	6.53E-02	3.02E-04	1.97E-05	7.8E-03	1.3E-08	3.0E-02	1.5E-04
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.11E-04	7.55E-06				
VOC	Bromoform	75-25-2	B2	7.67E-02	5.08E-05	3.89E-06	1.1E-03	3.5E-10		
VOC	Bromomethane	74-83-9	ID	6.13E-02	3.49E-04	2.14E-05			5.0E-03	9.8E-04
VOC	2-Butanone	78-93-3	ID	1.06E-01	3.70E-05	3.92E-06			5.0E+00	1.8E-07
VOC	Carbon Disulfide	75-15-0		6.52E-02	6.42E-04	4.18E-05			7.0E-01	1.4E-05
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	5.26E-04	3.52E-05	6.0E-03	1.7E-08	1.0E-01	8.0E-05
VOC	Chlorobenzene	108-90-7	D	6.86E-02	2.12E-04	1.45E-05			5.0E-02	6.6E-05
VOC	Chloroethane	75-00-3	LC	7.23E-02	6.70E-04	4.85E-05			1.0E+01	1.1E-06
VOC	Chloroform	67-66-3	B2	6.64E-02	2.76E-04	1.84E-05	2.3E-02	3.4E-08	5.0E-02	8.4E-05
VOC	Chloromethane	74-87-3	D	9.00E-02	3.61E-04	3.25E-05			9.0E-02	8.2E-05
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	7.05E-05	5.03E-06				
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	2.99E-04	1.97E-05			5.0E-01	9.0E-06
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.46E-04	9.65E-06	2.6E-02	2.0E-08	7.0E-03	3.1E-04
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	5.97E-04	1.49E-04			2.0E-01	1.7E-04
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	2.68E-04	2.68E-03				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	2.68E-04	2.68E-03				
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	3.94E-04	2.36E-05				
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.98E-04	1.29E-05			4.0E-03	7.4E-04
VOC	1,3-Dichloropropane (total)	542-75-6	B2	1.42E-01	4.21E-04	5.99E-05	4.0E-03	2.0E-08	2.0E-02	6.8E-04
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	2.76E-04	1.90E-05			1.0E+00	4.3E-06
VOC	2-Hexanone	591-78-6	ID	1.20E-01	4.47E-05	5.36E-06			3.0E-02	4.1E-05
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	4.80E-05	5.75E-06			3.0E+00	4.4E-07
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	2.39E-04	7.41E-05	1.0E-05	6.0E-11	6.0E-01	2.8E-05
VOC	Styrene	100-42-5		6.83E-02	1.73E-04	1.18E-05			1.0E+00	2.7E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	6.35E-05	4.06E-06				
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	3.95E-04	3.03E-05	2.6E-04	6.4E-10	4.0E-02	1.7E-04
VOC	Toluene	108-88-3	ID	6.54E-02	2.94E-04	1.92E-05			5.0E+00	8.8E-07
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	4.27E-04	4.69E-05			5.0E+00	2.1E-06
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.15E-04	7.56E-06	1.6E-02	9.9E-09	2.0E-04	8.6E-03
VOC	Trichloroethene	79-01-6	HC	8.10E+01	3.54E-04	2.87E-02	4.1E-03	9.6E-06	2.0E-03	3.3E+00
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	7.31E-04	1.83E-03	4.4E-03	6.6E-07	1.0E-01	4.2E-03
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	2.80E-04	5.58E-05			1.0E-01	1.3E-04
							Cumulative Risk:	1E-05	HI:	3E+00

**Attachment 2: Cancer Risk and Hazard Index Calculations for Off-Site Routine Workers due to Groundwater Vapor Intrusion into a Comm/Ind Building (Slab-on-Grade)
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Carc Class	C _{gw} (mg/L)	C _{bdg} (L-water/m ³)	C _{air} (mg/m ³)	Cancer		Noncancer	
							URF (m ³ /mg)	Risk	RfC (mg/m ³)	HQ
VOC	Acetone	67-64-1	ID	8.50E-02	3.34E-05	2.84E-06			3.1E+01	2.1E-08
VOC	Benzene	71-43-2	A		3.02E-04		7.8E-03		3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2		1.11E-04					
VOC	Bromoform	75-25-2	B2	2.40E-02	5.08E-05	1.22E-06	1.1E-03	1.1E-10		
VOC	Bromomethane	74-83-9	ID		3.49E-04				5.0E-03	
VOC	2-Butanone	78-93-3	ID	9.50E-02	3.70E-05	3.52E-06			5.0E-01	1.6E-07
VOC	Carbon Disulfide	75-15-0			6.42E-04				7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC		5.26E-04		6.0E-03		1.0E-01	
VOC	Chlorobenzene	108-90-7	D		2.12E-04				5.0E-02	
VOC	Chloroethane	75-00-3	LC		6.70E-04				1.0E+01	
VOC	Chloroform	67-66-3	B2		2.76E-04		2.3E-02		5.0E-02	
VOC	Chloromethane	74-87-3	D		3.61E-04				9.0E-02	
VOC	Dibromochloromethane	124-48-1	C		7.05E-05					
VOC	1,1-Dichloroethane	75-34-3	SC		2.99E-04				5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	1.46E-04	4.38E-07	2.6E-02	9.3E-10	7.0E-03	1.4E-05
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	5.97E-04	2.51E-06			2.0E-01	2.9E-06
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	2.68E-04	1.10E-05				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	2.68E-04	1.10E-05				
VOC	trans-1,2-Dichloroethene	156-60-5	ID		3.94E-04					
VOC	1,2-Dichloropropane	78-87-5	B2		1.98E-04				4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2		4.21E-04		4.0E-03		2.0E-02	
VOC	Ethyl Benzene	100-41-4	D		2.76E-04				1.0E+00	
VOC	2-Hexanone	591-78-6	ID		4.47E-05				3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	4.80E-05	1.92E-07			3.0E+00	1.5E-08
VOC	Methylene Chloride	75-09-2	LC		2.39E-04		1.0E-05		6.0E-01	
VOC	Styrene	100-42-5			1.73E-04				1.0E+00	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC		6.35E-05					
VOC	Tetrachloroethene	127-18-4	LC		3.95E-04		2.6E-04		4.0E-02	
VOC	Toluene	108-88-3	ID		2.94E-04				5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID		4.27E-04				5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C		1.15E-04		1.6E-02		2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.60E+00	3.54E-04	5.67E-04	4.1E-03	1.9E-07	2.0E-03	6.5E-02
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	7.31E-04	2.19E-06	4.4E-03	7.9E-10	1.0E-01	5.0E-06
VOC	Xylenes (total)	1330-20-7	ID		2.80E-04				1.0E-01	
							Cumulative Risk:	2E-07	HI:	6E-02

**Attachment 2: Vapor Flux to Outdoor Air from Groundwater
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	H (unitless)	D_{eff}^T (m ² /day)	J (L/m ² -s)	C_{air} (L/m ³)
VOC	Acetone	67-64-1	1.14E-03	1.87E-02	6.75E-08	1.78E-06
VOC	Benzene	71-43-2	1.59E-01	8.31E-04	4.18E-07	1.10E-05
VOC	Bromodichloromethane	75-27-4	4.45E-02	1.09E-03	1.53E-07	4.03E-06
VOC	Bromoform	75-25-2	1.34E-02	1.65E-03	6.97E-08	1.84E-06
VOC	Bromomethane	74-83-9	2.01E-01	7.57E-04	4.81E-07	1.27E-05
VOC	2-Butanone	78-93-3	1.96E-03	1.01E-02	6.27E-08	1.65E-06
VOC	Carbon Disulfide	75-15-0	9.26E-01	2.99E-04	8.76E-07	2.31E-05
VOC	Carbon Tetrachloride	56-23-5	8.82E-01	2.57E-04	7.17E-07	1.89E-05
VOC	Chlorobenzene	108-90-7	9.77E-02	9.49E-04	2.93E-07	7.73E-06
VOC	Chloroethane	75-00-3	3.25E-01	9.04E-04	9.30E-07	2.45E-05
VOC	Chloroform	67-66-3	1.07E-01	1.13E-03	3.85E-07	1.01E-05
VOC	Chloromethane	74-87-3	3.33E-01	4.70E-04	4.95E-07	1.30E-05
VOC	Dibromochloromethane	124-48-1	2.38E-02	1.28E-03	9.66E-08	2.55E-06
VOC	1,1-Dichloroethane	75-34-3	1.66E-01	7.86E-04	4.12E-07	1.09E-05
VOC	1,2-Dichloroethane	107-06-2	2.74E-02	2.41E-03	2.09E-07	5.52E-06
VOC	1,1-Dichloroethene	75-35-4	8.10E-01	3.18E-04	8.15E-07	2.15E-05
VOC	1,2-Dichloroethene (total)	540-59-0	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	cis-1,2-Dichloroethene	156-59-2	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	trans-1,2-Dichloroethene	156-60-5	2.81E-01	6.08E-04	5.41E-07	1.43E-05
VOC	1,2-Dichloropropane	78-87-5	7.82E-02	1.11E-03	2.75E-07	7.25E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.83E-01	3.76E-04	5.75E-07	1.52E-05
VOC	Ethyl Benzene	100-41-4	2.04E-01	5.86E-04	3.78E-07	9.98E-06
VOC	2-Hexanone	591-78-6	3.23E-03	6.91E-03	7.07E-08	1.86E-06
VOC	4-Methyl-2-pentanone	108-10-1	4.71E-03	4.85E-03	7.23E-08	1.91E-06
VOC	Methylene Chloride	75-09-2	6.60E-02	1.61E-03	3.36E-07	8.87E-06
VOC	Styrene	100-42-5	7.04E-02	1.08E-03	2.40E-07	6.32E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.74E-03	3.35E-03	9.26E-08	2.44E-06
VOC	Tetrachloroethene	127-18-4	4.90E-01	3.47E-04	5.39E-07	1.42E-05
VOC	Toluene	108-88-3	1.80E-01	7.10E-04	4.05E-07	1.07E-05
VOC	1,1,1-Trichloroethane	71-55-6	4.97E-01	3.71E-04	5.83E-07	1.54E-05
VOC	1,1,2-Trichloroethane	79-00-5	2.43E-02	2.12E-03	1.63E-07	4.29E-06
VOC	Trichloroethene	79-01-6	2.88E-01	5.33E-04	4.86E-07	1.28E-05
VOC	Vinyl Chloride	75-01-4	9.00E-01	3.51E-04	9.99E-07	2.63E-05
VOC	Xylenes (total)	1330-20-7	1.73E-01	7.02E-04	3.85E-07	1.02E-05
	Parameters					
	Depth to groundwater	m	DTW	3.66		
	Dispersion coefficient	(kg/m ³) / (kg/m ² /s)	C/Q	26.4		

Attachment 2: Cancer Risk and Hazard Index Calculations for Exposure of On-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air Whirlpool, Fort Smith, Arkansas

Chem Group	Chemical	CASRN	Carc Class	C _{GW} (mg/L)	C _{air} (mg/m ³)	Cancer		Noncancer	
						URF (m ³ /mg)	Risk	RfC (mg/m ³)	HQ
VOC	Acetone	67-64-1	ID	1.99E-01	3.54E-07			3.1E+01	2.6E-09
VOC	Benzene	71-43-2	A	6.53E-02	7.19E-07	7.8E-03	4.6E-10	3.0E-02	5.5E-06
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	2.74E-07				
VOC	Bromoform	75-25-2	B2	7.67E-02	1.41E-07	1.1E-03	1.3E-11		
VOC	Bromomethane	74-83-9	ID	6.13E-02	7.78E-07			5.0E-03	3.6E-05
VOC	2-Butanone	78-93-3	ID	1.06E-01	1.75E-07			5.0E+00	8.0E-09
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.51E-06			7.0E-01	4.9E-07
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.26E-06	6.0E-03	6.2E-10	1.0E-01	2.9E-06
VOC	Chlorobenzene	108-90-7	D	6.86E-02	5.30E-07			5.0E-02	2.4E-06
VOC	Chloroethane	75-00-3	LC	7.23E-02	1.77E-06			1.0E+01	4.1E-08
VOC	Chloroform	67-66-3	B2	6.64E-02	6.74E-07	2.3E-02	1.3E-09	5.0E-02	3.1E-06
VOC	Chloromethane	74-87-3	D	9.00E-02	1.17E-06			9.0E-02	3.0E-06
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.82E-07				
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	7.16E-07			5.0E-01	3.3E-07
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	3.65E-07	2.6E-02	7.7E-10	7.0E-03	1.2E-05
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	5.37E-06			2.0E-01	6.1E-06
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	9.79E-05				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	9.79E-05				
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	8.55E-07				
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	4.73E-07			4.0E-03	2.7E-05
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	2.16E-06	4.0E-03	7.0E-10	2.0E-02	2.5E-05
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	6.88E-07			1.0E+00	1.6E-07
VOC	2-Hexanone	591-78-6	ID	1.20E-01	2.24E-07			3.0E-02	1.7E-06
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	2.29E-07			3.0E+00	1.7E-08
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	2.75E-06	1.0E-05	2.2E-12	6.0E-01	1.0E-06
VOC	Styrene	100-42-5		6.83E-02	4.31E-07			1.0E+00	9.9E-08
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.56E-07				
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	1.09E-06	2.6E-04	2.3E-11	4.0E-02	6.2E-06
VOC	Toluene	108-88-3	ID	6.54E-02	6.99E-07			5.0E+00	3.2E-08
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	1.69E-06			5.0E+00	7.7E-08
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	2.83E-07	1.6E-02	3.7E-10	2.0E-04	3.2E-04
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.04E-03	4.1E-03	3.5E-07	2.0E-03	1.2E-01
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	6.59E-05	4.4E-03	2.4E-08	1.0E-01	1.5E-04
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	2.02E-06			1.0E-01	4.6E-06
						Cumulative Risk:		4E-07	HI: 1E-01
Note:	The dispersion coefficient to outdoor air (C/Q) is 11.6 (kg/m3) / (kg/m2/s).								

**Attachment 2: Cancer Risk and Hazard Index Calculations for Exposure of Off-Site Routine Workers to Groundwater-derived Vapors in Outdoor Air
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Carc Class	C _{GW} (mg/L)	C _{air} (mg/m ³)	Cancer		Noncancer	
						URF (m ³ /mg)	Risk	RfC (mg/m ³)	HQ
VOC	Acetone	67-64-1	ID	8.50E-02	1.51E-07			3.1E+01	1.1E-09
VOC	Benzene	71-43-2	A			7.8E-03		3.0E-02	
VOC	Bromodichloromethane	75-27-4	B2						
VOC	Bromoform	75-25-2	B2	2.40E-02	4.41E-08	1.1E-03	4.0E-12		
VOC	Bromomethane	74-83-9	ID					5.0E-03	
VOC	2-Butanone	78-93-3	ID	9.50E-02	1.57E-07			5.0E+00	7.2E-09
VOC	Carbon Disulfide	75-15-0						7.0E-01	
VOC	Carbon Tetrachloride	56-23-5	LC			6.0E-03		1.0E-01	
VOC	Chlorobenzene	108-90-7	D					5.0E-02	
VOC	Chloroethane	75-00-3	LC					1.0E+01	
VOC	Chloroform	67-66-3	B2			2.3E-02		5.0E-02	
VOC	Chloromethane	74-87-3	D					9.0E-02	
VOC	Dibromochloromethane	124-48-1	C						
VOC	1,1-Dichloroethane	75-34-3	SC					5.0E-01	
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	1.66E-08	2.6E-02	3.5E-11	7.0E-03	5.4E-07
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	9.03E-08			2.0E-01	1.0E-07
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	4.01E-07				
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	4.01E-07				
VOC	trans-1,2-Dichloroethene	156-60-5	ID						
VOC	1,2-Dichloropropane	78-87-5	B2					4.0E-03	
VOC	1,3-Dichloropropene (total)	542-75-6	B2			4.0E-03		2.0E-02	
VOC	Ethyl Benzene	100-41-4	D					1.0E+00	
VOC	2-Hexanone	591-78-6	ID					3.0E-02	
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	7.63E-09			3.0E+00	5.8E-10
VOC	Methylene Chloride	75-09-2	LC			1.0E-05		6.0E-01	
VOC	Styrene	100-42-5						1.0E+00	
VOC	1,1,1,2-Tetrachloroethane	79-34-5	LC						
VOC	Tetrachloroethene	127-18-4	LC			2.6E-04		4.0E-02	
VOC	Toluene	108-88-3	ID					5.0E+00	
VOC	1,1,1-Trichloroethane	71-55-6	ID					5.0E+00	
VOC	1,1,2-Trichloroethane	79-00-5	C			1.6E-02		2.0E-04	
VOC	Trichloroethene	79-01-6	HC	1.60E+00	2.05E-05	4.1E-03	6.9E-09	2.0E-03	2.3E-03
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	7.90E-08	4.4E-03	2.8E-11	1.0E-01	1.8E-07
VOC	Xylenes (total)	1330-20-7	ID					1.0E-01	
						Cumulative Risk:	7E-09	HI:	2E-03
Note:	The dispersion coefficient to outdoor air (C/Q) is 11.6 (kg/m3) / (kg/m2/s).								

Attachment 3

Maintenance Worker Risk Calculations

Contents:

- Vapor Flux from Soil to Outdoor Air
- Cancer Risk Calculations for Exposure of On-Site Maintenance Workers to Soil
- Hazard Index Calculations for Exposure of On-Site Maintenance Workers to Soil

- Nonsteady State Dermal Absorption from Water
- Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations
- Cancer Risk Calculations for Exposure of On-Site Maintenance Workers to Groundwater in Excavations
- Hazard Index Calculations for Exposure of On-Site Maintenance Workers to Groundwater in Excavations
- Cancer Risk Calculations for Exposure of Off-Site Maintenance Workers to Groundwater in Excavations
- Hazard Index Calculations for Exposure of Off-Site Maintenance Workers to Groundwater in Excavations

**Attachment 3: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	K _{oc} (L/kg)	H (unitless)	D _{air} (m ² /d)	D _{water} (m ² /d)	R _L (unitless)	D _G (m ² /d)	D _L (m ² /d)	D _E (m ² /d)	Infinite J _v (kg/m ² -s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J _v (kg/m ² -s)	J _v (kg/m ² -s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	2.50E-06	0.00E+00	1.17E-06	2.50E-06	2.50E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	1.52E-05	0.00E+00	1.47E+00	1.09E-05	1.09E-05
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	4.97E-06	0.00E+00	3.74E-02	4.95E-06	4.95E-06
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	2.07E-06	0.00E+00	2.32E-09	2.07E-06	2.07E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	1.80E-05	0.00E+00	1.75E+00	1.17E-05	1.17E-05
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	2.50E-06	0.00E+00	1.20E-06	2.50E-06	2.50E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	3.66E-05	0.00E+00	2.66E+00	1.38E-05	1.38E-05
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	2.46E-05	0.00E+00	2.21E+00	1.28E-05	1.28E-05
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	7.97E-06	0.00E+00	3.99E-01	7.51E-06	7.51E-06
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	4.20E-05	0.00E+00	2.78E+00	1.41E-05	1.41E-05
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	1.45E-05	0.00E+00	1.39E+00	1.07E-05	1.07E-05
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	2.69E-05	0.00E+00	2.32E+00	1.30E-05	1.30E-05
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	3.06E-06	0.00E+00	1.11E-04	3.06E-06	3.06E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	1.55E-05	0.00E+00	1.49E+00	1.10E-05	1.10E-05
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	8.13E-06	0.00E+00	4.25E-01	7.62E-06	7.62E-06
VOC	1,1-Dichloroethene	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	3.15E-05	0.00E+00	2.51E+00	1.34E-05	1.34E-05
VOC	1,2-Dichloroethene (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	1.30E-05	0.00E+00	1.19E+00	1.02E-05	1.02E-05
VOC	cis-1,2-Dichloroethene	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	1.30E-05	0.00E+00	1.19E+00	1.02E-05	1.02E-05
VOC	trans-1,2-Dichloroethene	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	1.81E-05	0.00E+00	1.76E+00	1.17E-05	1.17E-05
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	1.07E-05	0.00E+00	8.50E-01	9.17E-06	9.17E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	2.19E-05	0.00E+00	2.05E+00	1.24E-05	1.24E-05
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	9.67E-06	0.00E+00	6.82E-01	8.61E-06	8.61E-06
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	2.87E-06	0.00E+00	3.05E-05	2.87E-06	2.87E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	3.18E-06	0.00E+00	2.12E-04	3.18E-06	3.18E-06
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	1.25E-05	0.00E+00	1.12E+00	9.99E-06	9.99E-06
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	4.12E-06	0.00E+00	7.10E-03	4.12E-06	4.12E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	3.15E-06	0.00E+00	1.83E-04	3.15E-06	3.15E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	1.88E-05	0.00E+00	1.82E+00	1.18E-05	1.18E-05
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	1.24E-05	0.00E+00	1.12E+00	9.97E-06	9.97E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	2.14E-05	0.00E+00	2.01E+00	1.23E-05	1.23E-05
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	5.97E-06	0.00E+00	1.18E-01	5.88E-06	5.88E-06
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	1.51E-05	0.00E+00	1.46E+00	1.09E-05	1.09E-05
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	3.92E-05	0.00E+00	2.72E+00	1.39E-05	1.39E-05
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	8.94E-06	0.00E+00	5.60E-01	8.17E-06	8.17E-06
Notes:	Soil bulk density	kg/L	ρ _b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ _w	0.32											
	Soil air-filled porosity	L/L-soil	θ _a	0.17											
	Soil organic carbon fraction	unitless	f _{oc}	0.002											
	Averaging period (Exposure Duration)	year	T	25											
		days	T	9125											
		s	T	7.9E+08											
	Molar Gas Constant	L-mmHg/mole-°K	R	62.411											
	Temperature	°C	Temp	16.7											
		K	Temp	289.7											
	Clean soil above source	m	Z ₁	0.00											
	Bottom of source depth	m	Z ₂	3.66											

**Attachment 3: Cancer Risk Calculations for Exposure of On-Site Maintenance Workers to Soil
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{soil} (mg/kg)	Soil Ingestion			Soil Dermal Contact				Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes	
					LADD (mg/kg/d)	SF _{oral} (mg/kg/d) ⁻¹	Risk	ABS _{derm}	LADD (mg/kg/d)	SF _{derm} (mg/kg/d) ⁻¹	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	Risk	
VOC	Acetone	67-64-1	ID																
VOC	Benzene	71-43-2	A																
VOC	Bromodichloromethane	75-27-4	B2																
VOC	Bromoform	75-25-2	B2																
VOC	Bromomethane	74-83-9	ID																
VOC	2-Butanone	78-93-3	ID																
VOC	Carbon Disulfide	75-15-0																	
VOC	Carbon Tetrachloride	56-23-5	LC																
VOC	Chlorobenzene	108-90-7	D																
VOC	Chloroethane	75-00-3	LC																
VOC	Chloroform	67-66-3	B2																
VOC	Chloromethane	74-87-3	D																
VOC	Dibromochloromethane	124-48-1	C																
VOC	1,1-Dichloroethane	75-34-3	SC																
VOC	1,2-Dichloroethane	107-06-2	B2																
VOC	1,1-Dichloroethene	75-35-4	C																
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	2.01E-10														
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	2.01E-10														
VOC	trans-1,2-Dichloroethene	156-60-5	ID																
VOC	1,2-Dichloropropane	78-87-5	B2																
VOC	1,3-Dichloropropene (total)	542-75-6	B2																
VOC	Ethyl Benzene	100-41-4	D																
VOC	2-Hexanone	591-78-6	ID																
VOC	4-Methyl-2-pentanone	108-10-1	ID																
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.17E-10	2.0E-03	2.3E-13												
VOC	Styrene	100-42-5																	
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC																
VOC	Tetrachloroethene	127-18-4	LC																
VOC	Toluene	108-88-3	ID																
VOC	1,1,1-Trichloroethane	71-55-6	ID																
VOC	1,1,2-Trichloroethane	79-00-5	C																
VOC	Trichloroethene	79-01-6	HC	1.86E-01	3.12E-09	4.6E-02	1.4E-10												
VOC	Vinyl Chloride	75-01-4	A																
VOC	Xylenes (total)	1330-20-7	ID																
Cumulative Risk:																			
Notes:																			
The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).																			
This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.																			
The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS) for PM ₁₀ of 50 ug/m ³ .																			

**Attachment 3: Nonsteady State Dermal Absorption from Water
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	MW (g/mole)	FA (unitless)	K _p (cm/hr)	B (unitless)	τ (hr)	c	b	ts (hr)	DA (L/cm ² -event)
VOC	Acetone	67-64-1	5.8E+01	1.0E+00	5.2E-04	1.5E-03	2.2E-01	3.3E-01	3.0E-01	5.3E-01	1.27E-06
VOC	Benzene	71-43-2	7.8E+01	1.0E+00	1.5E-02	5.0E-02	2.9E-01	3.7E-01	3.3E-01	6.9E-01	3.70E-05
VOC	Bromodichloromethane	75-27-4	1.6E+02	1.0E+00	4.7E-03	2.3E-02	8.7E-01	3.5E-01	3.2E-01	2.1E+00	1.70E-05
VOC	Bromoform	75-25-2	2.5E+02	1.0E+00	2.2E-03	1.3E-02	2.7E+00	3.4E-01	3.1E-01	6.6E+00	1.40E-05
VOC	Bromomethane	74-83-9	9.5E+01	1.0E+00	2.8E-03	1.1E-02	3.6E-01	3.4E-01	3.1E-01	8.6E-01	7.68E-06
VOC	2-Butanone	78-93-3	7.2E+01	1.0E+00	9.6E-04	3.1E-03	2.7E-01	3.4E-01	3.1E-01	6.4E-01	2.42E-06
VOC	Carbon Disulfide	75-15-0	7.6E+01	1.0E+00	1.2E-02	4.2E-02	2.8E-01	3.6E-01	3.3E-01	6.7E-01	3.11E-05
VOC	Carbon Tetrachloride	56-23-5	1.5E+02	1.0E+00	1.4E-02	6.6E-02	7.6E-01	3.8E-01	3.4E-01	1.8E+00	4.84E-05
VOC	Chlorobenzene	108-90-7	1.1E+02	1.0E+00	2.9E-02	1.2E-01	4.5E-01	4.2E-01	3.8E-01	1.1E+00	8.00E-05
VOC	Chloroethane	75-00-3	6.5E+01	1.0E+00	6.1E-03	1.9E-02	2.4E-01	3.5E-01	3.1E-01	5.8E-01	1.49E-05
VOC	Chloroform	67-66-3	1.2E+02	1.0E+00	6.3E-03	2.6E-02	4.9E-01	3.5E-01	3.2E-01	1.2E+00	1.86E-05
VOC	Chloromethane	74-87-3	5.0E+01	1.0E+00	1.5E-02	4.2E-02	2.0E-01	3.6E-01	3.3E-01	4.8E-01	3.58E-05
VOC	Dibromochloromethane	124-48-1	2.1E+02	1.0E+00	2.9E-03	1.6E-02	1.5E+00	3.4E-01	3.1E-01	3.7E+00	1.42E-05
VOC	1,1-Dichloroethane	75-34-3	9.9E+01	1.0E+00	6.7E-03	2.6E-02	3.8E-01	3.5E-01	3.2E-01	9.0E-01	1.83E-05
VOC	1,2-Dichloroethane	107-06-2	9.9E+01	1.0E+00	4.1E-03	1.6E-02	3.8E-01	3.4E-01	3.1E-01	9.0E-01	1.13E-05
VOC	1,1-Dichloroethene	75-35-4	9.7E+01	1.0E+00	1.2E-02	4.4E-02	3.7E-01	3.6E-01	3.3E-01	8.8E-01	3.10E-05
VOC	1,2-Dichloroethene (total)	540-59-0	9.7E+01	1.0E+00	7.7E-03	2.9E-02	3.7E-01	3.5E-01	3.2E-01	8.8E-01	2.07E-05
VOC	cis-1,2-Dichloroethene	156-59-2	9.7E+01	1.0E+00	7.7E-03	2.9E-02	3.7E-01	3.5E-01	3.2E-01	8.8E-01	2.07E-05
VOC	trans-1,2-Dichloroethene	156-60-5	9.7E+01	1.0E+00	1.1E-02	4.0E-02	3.7E-01	3.6E-01	3.3E-01	8.8E-01	2.83E-05
VOC	1,2-Dichloropropane	78-87-5	1.1E+02	1.0E+00	7.4E-03	3.0E-02	4.5E-01	3.5E-01	3.2E-01	1.1E+00	2.12E-05
VOC	1,3-Dichloropropene (total)	542-75-6	1.1E+02	1.0E+00	7.9E-03	3.2E-02	4.4E-01	3.6E-01	3.2E-01	1.1E+00	2.25E-05
VOC	Ethyl Benzene	100-41-4	1.1E+02	1.0E+00	4.8E-02	1.9E-01	4.1E-01	4.7E-01	4.3E-01	9.9E-01	1.27E-04
VOC	2-Hexanone	591-78-6	1.0E+02	1.0E+00	3.5E-03	1.4E-02	3.8E-01	3.4E-01	3.1E-01	9.2E-01	9.75E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.0E+02	1.0E+00	2.7E-03	1.0E-02	3.8E-01	3.4E-01	3.1E-01	9.2E-01	7.32E-06
VOC	Methylene Chloride	75-09-2	8.5E+01	1.0E+00	3.5E-03	1.3E-02	3.1E-01	3.4E-01	3.1E-01	7.5E-01	9.25E-06
VOC	Styrene	100-42-5	1.0E+02	1.0E+00	3.6E-02	1.4E-01	4.0E-01	4.3E-01	4.0E-01	9.7E-01	9.63E-05
VOC	1,1,1,2-Tetrachloroethane	79-34-5	1.7E+02	1.0E+00	6.9E-03	3.4E-02	9.2E-01	3.6E-01	3.2E-01	2.2E+00	2.57E-05
VOC	Tetrachloroethene	127-18-4	1.7E+02	1.0E+00	1.1E-02	5.4E-02	8.9E-01	3.7E-01	3.4E-01	2.1E+00	3.99E-05
VOC	Toluene	108-88-3	9.2E+01	1.0E+00	3.2E-02	1.2E-01	3.5E-01	4.2E-01	3.8E-01	8.3E-01	8.08E-05
VOC	1,1,1-Trichloroethane	71-55-6	1.3E+02	1.0E+00	1.2E-02	5.5E-02	5.9E-01	3.7E-01	3.4E-01	1.4E+00	3.85E-05
VOC	1,1,2-Trichloroethane	79-00-5	1.3E+02	1.0E+00	6.4E-03	2.8E-02	5.9E-01	3.5E-01	3.2E-01	1.4E+00	2.02E-05
VOC	Trichloroethene	79-01-6	1.3E+02	1.0E+00	1.8E-02	7.9E-02	5.7E-01	3.9E-01	3.5E-01	1.4E+00	5.53E-05
VOC	Vinyl Chloride	75-01-4	6.3E+01	1.0E+00	6.9E-03	2.1E-02	2.4E-01	3.5E-01	3.2E-01	5.7E-01	1.69E-05
VOC	Xylenes (total)	1330-20-7	1.1E+02	1.0E+00	5.0E-02	2.0E-01	4.1E-01	4.8E-01	4.4E-01	9.9E-01	1.32E-04
Notes:											
	Event Time	hours	t	2							
	K _p capped at 1 cm/hr (USEPA 1992).										

**Attachment 3: Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	H (unitless)	MW (g/mol)	k_G (cm/s)	k_L (cm/s)	1/K_L (s/cm)	K_L (cm/s)	J_L (L/m ² -s)
VOC	Acetone	67-64-1	1.1E-03	5.8E+01	5.47E-01	1.44E-03	2.30E+03	4.35E-04	4.35E-03
VOC	Benzene	71-43-2	1.6E-01	7.8E+01	4.95E-01	1.24E-03	8.16E+02	1.23E-03	1.23E-02
VOC	Bromodichloromethane	75-27-4	4.5E-02	1.6E+02	3.86E-01	8.59E-04	1.22E+03	8.18E-04	8.18E-03
VOC	Bromoform	75-25-2	1.3E-02	2.5E+02	3.34E-01	6.92E-04	1.67E+03	5.99E-04	5.99E-03
VOC	Bromomethane	74-83-9	2.0E-01	9.5E+01	4.64E-01	1.13E-03	8.97E+02	1.12E-03	1.12E-02
VOC	2-Butanone	78-93-3	2.0E-03	7.2E+01	5.09E-01	1.30E-03	1.77E+03	5.64E-04	5.64E-03
VOC	Carbon Disulfide	75-15-0	9.3E-01	7.6E+01	4.99E-01	1.26E-03	7.96E+02	1.26E-03	1.26E-02
VOC	Carbon Tetrachloride	56-23-5	8.8E-01	1.5E+02	3.95E-01	8.87E-04	1.13E+03	8.85E-04	8.85E-03
VOC	Chlorobenzene	108-90-7	9.8E-02	1.1E+02	4.38E-01	1.04E-03	9.88E+02	1.01E-03	1.01E-02
VOC	Chloroethane	75-00-3	3.3E-01	6.5E+01	5.28E-01	1.37E-03	7.36E+02	1.36E-03	1.36E-02
VOC	Chloroform	67-66-3	1.1E-01	1.2E+02	4.30E-01	1.01E-03	1.02E+03	9.85E-04	9.85E-03
VOC	Chloromethane	74-87-3	3.3E-01	5.0E+01	5.73E-01	1.55E-03	6.51E+02	1.54E-03	1.54E-02
VOC	Dibromochloromethane	124-48-1	2.4E-02	2.1E+02	3.57E-01	7.62E-04	1.43E+03	6.99E-04	6.99E-03
VOC	1,1-Dichloroethane	75-34-3	1.7E-01	9.9E+01	4.57E-01	1.11E-03	9.18E+02	1.09E-03	1.09E-02
VOC	1,2-Dichloroethane	107-06-2	2.7E-02	9.9E+01	4.57E-01	1.11E-03	9.84E+02	1.02E-03	1.02E-02
VOC	1,1-Dichloroethene	75-35-4	8.1E-01	9.7E+01	4.61E-01	1.12E-03	8.98E+02	1.11E-03	1.11E-02
VOC	1,2-Dichloroethene (total)	540-59-0	1.2E-01	9.7E+01	4.61E-01	1.12E-03	9.13E+02	1.09E-03	1.09E-02
VOC	cis-1,2-Dichloroethene	156-59-2	1.2E-01	9.7E+01	4.61E-01	1.12E-03	9.13E+02	1.09E-03	1.09E-02
VOC	trans-1,2-Dichloroethene	156-60-5	2.8E-01	9.7E+01	4.61E-01	1.12E-03	9.03E+02	1.11E-03	1.11E-02
VOC	1,2-Dichloropropane	78-87-5	7.8E-02	1.1E+02	4.38E-01	1.03E-03	9.96E+02	1.00E-03	1.00E-02
VOC	1,3-Dichloropropene (total)	542-75-6	4.8E-01	1.1E+02	4.40E-01	1.04E-03	9.63E+02	1.04E-03	1.04E-02
VOC	Ethyl Benzene	100-41-4	2.0E-01	1.1E+02	4.47E-01	1.07E-03	9.48E+02	1.06E-03	1.06E-02
VOC	2-Hexanone	591-78-6	3.2E-03	1.0E+02	4.56E-01	1.10E-03	1.59E+03	6.29E-04	6.29E-03
VOC	4-Methyl-2-pentanone	108-10-1	4.7E-03	1.0E+02	4.56E-01	1.10E-03	1.38E+03	7.27E-04	7.27E-03
VOC	Methylene Chloride	75-09-2	6.6E-02	8.5E+01	4.82E-01	1.19E-03	8.69E+02	1.15E-03	1.15E-02
VOC	Styrene	100-42-5	7.0E-02	1.0E+02	4.50E-01	1.08E-03	9.59E+02	1.04E-03	1.04E-02
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.7E-03	1.7E+02	3.83E-01	8.49E-04	1.48E+03	6.77E-04	6.77E-03
VOC	Tetrachloroethene	127-18-4	4.9E-01	1.7E+02	3.85E-01	8.54E-04	1.18E+03	8.50E-04	8.50E-03
VOC	Toluene	108-88-3	1.8E-01	9.2E+01	4.69E-01	1.15E-03	8.85E+02	1.13E-03	1.13E-02
VOC	1,1,1-Trichloroethane	71-55-6	5.0E-01	1.3E+02	4.14E-01	9.52E-04	1.05E+03	9.48E-04	9.48E-03
VOC	1,1,2-Trichloroethane	79-00-5	2.4E-02	1.3E+02	4.14E-01	9.52E-04	1.15E+03	8.70E-04	8.70E-03
VOC	Trichloroethene	79-01-6	2.9E-01	1.3E+02	4.16E-01	9.60E-04	1.05E+03	9.52E-04	9.52E-03

**Attachment 3: Normalized Vapor Flux to Outdoor Air from Exposed Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	H (unitless)	MW (g/mol)	k_G (cm/s)	k_L (cm/s)	1/K_L (s/cm)	K_L (cm/s)	J_L (L/m ² -s)
VOC	Vinyl Chloride	75-01-4	9.0E-01	6.3E+01	5.34E-01	1.39E-03	7.21E+02	1.39E-03	1.39E-02
VOC	Xylenes (total)	1330-20-7	1.7E-01	1.1E+02	4.47E-01	1.07E-03	9.50E+02	1.05E-03	1.05E-02
	Molecular Weight of Oxygen	g/mol	MW_{O2}	32					
	Molecular Weight of Water	g/mol	MW_{H2O}	18					
	Temperature	K	Temp	289.7					
	Liquid-phase Mass Transfer Coefficient for Oxygen	cm/s	k_{L,O2}	0.002					
	Gas-Phase Mass Transfer Coefficient for Water Vapor at 25 °C	cm/s	K_{G,H2O}	0.833					
	Dispersion coefficient	(kg/m ³) / (kg/m ² /s)	C/Q	11.6					

**Attachment 3: Hazard Index Calculations for Exposure of On-Site Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{gw} (mg/L)	Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
					ADD (mg/kg/d)	RfD _{oral} (mg/kg/d)	HQ	DA (L/cm ² -event)	ADD (mg/kg/d)	RfD _{derm} (mg/kg/d)	HQ	C _{air} (mg/m ³)	RfC (mg/m ³)	HQ	
VOC	Acetone	67-64-1	ID	1.99E-01	3.89E-07	9.0E-01	4.3E-07	1.27E-06	1.63E-07	9.0E-01	1.8E-07	1.01E-02	3.1E+01	1.5E-06	2.1E-06
VOC	Benzene	71-43-2	A	6.53E-02	1.28E-07	4.0E-03	3.2E-05	3.70E-05	1.56E-06	4.0E-03	3.9E-04	9.29E-03	3.0E-02	1.4E-03	1.8E-03
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.33E-07	2.0E-02	6.6E-06	1.70E-05	7.45E-07	2.0E-02	3.7E-05	6.45E-03			4.4E-05
VOC	Bromoform	75-25-2	B2	7.67E-02	1.50E-07	2.0E-02	7.5E-06	1.40E-05	6.94E-07	2.0E-02	3.5E-05	5.33E-03			4.2E-05
VOC	Bromomethane	74-83-9	ID	6.13E-02	1.20E-07	1.4E-03	8.6E-05	7.68E-06	3.04E-07	1.4E-03	2.2E-04	7.94E-03	5.0E-03	7.2E-03	7.6E-03
VOC	2-Butanone	78-93-3	ID	1.06E-01	2.07E-07	6.0E-01	3.5E-07	2.42E-06	1.66E-07	6.0E-01	2.8E-07	6.94E-03	5.0E+00	6.3E-06	7.0E-06
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.28E-07	1.0E-01	1.3E-06	3.11E-05	1.31E-06	1.0E-01	1.3E-05	9.51E-03	7.0E-01	6.2E-05	7.6E-05
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.31E-07	4.0E-03	3.3E-05	4.84E-05	2.09E-06	4.0E-03	5.2E-04	6.87E-03	1.0E-01	3.1E-04	8.7E-04
VOC	Chlorobenzene	108-90-7	D	6.86E-02	1.34E-07	2.0E-02	6.7E-06	8.00E-05	3.55E-06	2.0E-02	1.8E-04	8.06E-03	5.0E-02	7.4E-04	9.2E-04
VOC	Chloroethane	75-00-3	LC	7.23E-02	1.41E-07	1.0E-01	1.4E-06	1.49E-05	6.95E-07	1.0E-01	6.9E-06	1.14E-02	1.0E+01	5.2E-06	1.4E-05
VOC	Chloroform	67-66-3	B2	6.64E-02	1.30E-07	1.0E-02	1.3E-05	1.86E-05	7.97E-07	1.0E-02	8.0E-05	7.59E-03	5.0E-02	6.9E-04	7.9E-04
VOC	Chloromethane	74-87-3	D	9.00E-02	1.76E-07			3.58E-05	2.08E-06			1.60E-02	9.0E-02	8.1E-04	8.1E-04
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.40E-07	2.0E-02	7.0E-06	1.42E-05	6.53E-07	2.0E-02	3.3E-05	5.79E-03			4.0E-05
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	1.29E-07	2.0E-01	6.4E-07	1.83E-05	7.78E-07	2.0E-01	3.9E-06	8.34E-03	5.0E-01	7.6E-05	8.1E-05
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.29E-07	6.0E-03	2.2E-05	1.13E-05	4.82E-07	6.0E-03	8.0E-05	7.80E-03	7.0E-03	5.1E-03	5.2E-03
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	4.89E-07	5.0E-02	9.8E-06	3.10E-05	5.01E-06	5.0E-02	1.0E-04	3.23E-02	2.0E-01	7.4E-04	8.5E-04
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	1.96E-05	2.0E-03	9.8E-03	2.07E-05	1.34E-04	2.0E-03	6.7E-02	1.27E+00			7.7E-02
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	1.96E-05	2.0E-03	9.8E-03	2.07E-05	1.34E-04	2.0E-03	6.7E-02	1.27E+00			7.7E-02
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	1.17E-07	2.0E-02	5.9E-06	2.83E-05	1.10E-06	2.0E-02	5.5E-05	7.70E-03			6.1E-05
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.28E-07	9.0E-02	1.4E-06	2.12E-05	8.91E-07	9.0E-02	9.9E-06	7.60E-03	4.0E-03	8.7E-03	8.7E-03
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	2.78E-07	3.0E-02	9.3E-06	2.25E-05	2.07E-06	3.0E-02	6.9E-05	1.72E-02	2.0E-02	3.9E-03	4.0E-03
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	1.35E-07	1.0E-01	1.3E-06	1.27E-04	5.64E-06	1.0E-01	5.6E-05	8.44E-03	1.0E+00	3.9E-05	9.6E-05
VOC	2-Hexanone	591-78-6	ID	1.20E-01	2.35E-07	5.0E-03	4.7E-05	9.75E-06	7.56E-07	5.0E-03	1.5E-04	8.77E-03	3.0E-02	1.3E-03	1.5E-03
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	2.35E-07			7.32E-06	5.67E-07			1.01E-02	3.0E+00	1.5E-05	1.5E-05
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	6.07E-07	6.0E-03	1.0E-04	9.25E-06	1.85E-06	6.0E-03	3.1E-04	4.14E-02	6.0E-01	3.2E-04	7.2E-04
VOC	Styrene	100-42-5		6.83E-02	1.34E-07	2.0E-01	6.7E-07	9.63E-05	4.25E-06	2.0E-01	2.1E-05	8.26E-03	1.0E+00	3.8E-05	6.0E-05
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.25E-07	2.0E-02	6.3E-06	2.57E-05	1.06E-06	2.0E-02	5.3E-05	5.03E-03			5.9E-05
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	1.50E-07	6.0E-03	2.5E-05	3.99E-05	1.98E-06	6.0E-03	3.3E-04	7.57E-03	4.0E-02	8.6E-04	1.2E-03
VOC	Toluene	108-88-3	ID	6.54E-02	1.28E-07	8.0E-02	1.6E-06	8.08E-05	3.41E-06	8.0E-02	4.3E-05	8.58E-03	5.0E+00	7.8E-06	5.2E-05
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	2.15E-07	2.0E+00	1.1E-07	3.85E-05	2.74E-06	2.0E+00	1.4E-06	1.21E-02	5.0E+00	1.1E-05	1.3E-05
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.29E-07	4.0E-03	3.2E-05	2.02E-05	8.58E-07	4.0E-03	2.1E-04	6.65E-03	2.0E-04	1.5E-01	1.5E-01
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.59E-04	5.0E-04	3.2E-01	5.53E-05	2.89E-03	5.0E-04	5.8E+00	8.95E+00	2.0E-03	2.0E+01	2.7E+01
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	4.89E-06	3.0E-03	1.6E-03	1.69E-05	2.72E-05	3.0E-03	9.1E-03	4.03E-01	1.0E-01	1.8E-02	2.9E-02
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	3.90E-07	2.0E-01	2.0E-06	1.32E-04	1.70E-05	2.0E-01	8.5E-05	2.44E-02	1.0E-01	1.1E-03	1.2E-03
			Hazard Index:				3E-01				6E+00			2E+01	3E+01

Notes: This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

**Attachment 3: Hazard Index Calculations for Exposure of Off-Site Maintenance Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{gw} (mg/L)	Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
					ADD (mg/kg/d)	RfD _{oral} (mg/kg/d)	HQ	DA (L/cm ² -event)	ADD (mg/kg/d)	RfD _{derm} (mg/kg/d)	HQ	C _{air} (mg/m ³)	RfC (mg/m ³)	HQ	HQ
VOC	Acetone	67-64-1	ID	8.50E-02	1.66E-07	9.0E-01	1.8E-07	1.27E-06	6.98E-08	9.0E-01	7.8E-08	4.29E-03	3.1E+01	6.4E-07	9.0E-07
VOC	Benzene	71-43-2	A			4.0E-03		3.70E-05		4.0E-03			3.0E-02		
VOC	Bromodichloromethane	75-27-4	B2			2.0E-02		1.70E-05		2.0E-02					
VOC	Bromoform	75-25-2	B2	2.40E-02	4.70E-08	2.0E-02	2.3E-06	1.40E-05	2.17E-07	2.0E-02	1.1E-05	1.67E-03			1.3E-05
VOC	Bromomethane	74-83-9	ID			1.4E-03		7.68E-06		1.4E-03			5.0E-03		
VOC	2-Butanone	78-93-3	ID	9.50E-02	1.86E-07	6.0E-01	3.1E-07	2.42E-06	1.48E-07	6.0E-01	2.5E-07	6.22E-03	5.0E+00	5.7E-06	6.2E-06
VOC	Carbon Disulfide	75-15-0				1.0E-01		3.11E-05		1.0E-01			7.0E-01		
VOC	Carbon Tetrachloride	56-23-5	LC			4.0E-03		4.84E-05		4.0E-03			1.0E-01		
VOC	Chlorobenzene	108-90-7	D			2.0E-02		8.00E-05		2.0E-02			5.0E-02		
VOC	Chloroethane	75-00-3	LC			1.0E-01		1.49E-05		1.0E-01			1.0E+01		
VOC	Chloroform	67-66-3	B2			1.0E-02		1.86E-05		1.0E-02			5.0E-02		
VOC	Chloromethane	74-87-3	D					3.58E-05					9.0E-02		
VOC	Dibromochloromethane	124-48-1	C			2.0E-02		1.42E-05		2.0E-02					
VOC	1,1-Dichloroethane	75-34-3	SC			2.0E-01		1.83E-05		2.0E-01			5.0E-01		
VOC	1,2-Dichloroethane	107-06-2	B2	3.00E-03	5.87E-09	6.0E-03	9.8E-07	1.13E-05	2.19E-08	6.0E-03	3.6E-06	3.54E-04	7.0E-03	2.3E-04	2.4E-04
VOC	1,1-Dichloroethene	75-35-4	C	4.20E-03	8.22E-09	5.0E-02	1.6E-07	3.10E-05	8.41E-08	5.0E-02	1.7E-06	5.43E-04	2.0E-01	1.2E-05	1.4E-05
VOC	1,2-Dichloroethene (total)	540-59-0		4.10E-02	8.02E-08	2.0E-03	4.0E-05	2.07E-05	5.48E-07	2.0E-03	2.7E-04	5.21E-03			3.1E-04
VOC	cis-1,2-Dichloroethene	156-59-2	ID	4.10E-02	8.02E-08	2.0E-03	4.0E-05	2.07E-05	5.48E-07	2.0E-03	2.7E-04	5.21E-03			3.1E-04
VOC	trans-1,2-Dichloroethene	156-60-5	ID			2.0E-02		2.83E-05		2.0E-02					
VOC	1,2-Dichloropropane	78-87-5	B2			9.0E-02		2.12E-05		9.0E-02			4.0E-03		
VOC	1,3-Dichloropropene (total)	542-75-6	B2			3.0E-02		2.25E-05		3.0E-02			2.0E-02		
VOC	Ethyl Benzene	100-41-4	D			1.0E-01		1.27E-04		1.0E-01			1.0E+00		
VOC	2-Hexanone	591-78-6	ID			5.0E-03		9.75E-06		5.0E-03			3.0E-02		
VOC	4-Methyl-2-pentanone	108-10-1	ID	4.00E-03	7.83E-09			7.32E-06	1.89E-08			3.38E-04	3.0E+00	5.1E-07	5.1E-07
VOC	Methylene Chloride	75-09-2	LC			6.0E-03		9.25E-06		6.0E-03			6.0E-01		
VOC	Styrene	100-42-5				2.0E-01		9.63E-05		2.0E-01			1.0E+00		
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC			2.0E-02		2.57E-05		2.0E-02					
VOC	Tetrachloroethene	127-18-4	LC			6.0E-03		3.99E-05		6.0E-03			4.0E-02		
VOC	Toluene	108-88-3	ID			8.0E-02		8.08E-05		8.0E-02			5.0E+00		
VOC	1,1,1-Trichloroethane	71-55-6	ID			2.0E+00		3.85E-05		2.0E+00			5.0E+00		
VOC	1,1,2-Trichloroethane	79-00-5	C			4.0E-03		2.02E-05		4.0E-03			2.0E-04		
VOC	Trichloroethene	79-01-6	HC	1.60E+00	3.13E-06	5.0E-04	6.3E-03	5.53E-05	5.71E-05	5.0E-04	1.1E-01	1.77E-01	2.0E-03	4.0E-01	5.2E-01
VOC	Vinyl Chloride	75-01-4	A	3.00E-03	5.87E-09	3.0E-03	2.0E-06	1.69E-05	3.27E-08	3.0E-03	1.1E-05	4.83E-04	1.0E-01	2.2E-05	3.5E-05
VOC	Xylenes (total)	1330-20-7	ID			2.0E-01		1.32E-04		2.0E-01			1.0E-01		
			Hazard Index:				6E-03				1E-01			4E-01	5E-01

Notes:

This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.

Attachment 4

Construction Worker Risk Calculations

Contents:

- Vapor Flux from Soil to Outdoor Air
- Cancer Risk Calculations for Exposure of On-Site Construction Workers to Soil
- Hazard Index Calculations for Exposure of On-Site Construction Workers to Soil

- Cancer Risk Calculations for Exposure of On-Site Construction Workers to Groundwater in Excavations
- Hazard Index Calculations for Exposure of On-Site Construction Workers to Groundwater in Excavations

**Attachment 4: Vapor Flux from Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	K _{oc} (L/kg)	H (unitless)	D _{air} (m ² /d)	D _{water} (m ² /d)	R _L (unitless)	D _G (m ² /d)	D _L (m ² /d)	D _E (m ² /d)	Infinite J _v (kg/m ² -s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J _v (kg/m ² -s)	J _v (kg/m ² -s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	7.90E-06	0.00E+00	0.00E+00	7.90E-06	7.90E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	4.82E-05	0.00E+00	2.93E-02	4.80E-05	4.80E-05
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	1.57E-05	0.00E+00	1.68E-15	1.57E-05	1.57E-05
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	6.53E-06	0.00E+00	0.00E+00	6.53E-06	6.53E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	5.69E-05	0.00E+00	9.03E-02	5.62E-05	5.62E-05
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	7.91E-06	0.00E+00	0.00E+00	7.91E-06	7.91E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	1.16E-04	0.00E+00	9.88E-01	9.60E-05	9.60E-05
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	7.79E-05	0.00E+00	3.69E-01	7.37E-05	7.37E-05
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	2.52E-05	0.00E+00	1.47E-06	2.52E-05	2.52E-05
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	1.33E-04	0.00E+00	1.23E+00	1.03E-04	1.03E-04
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	4.59E-05	0.00E+00	1.97E-02	4.58E-05	4.58E-05
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	8.51E-05	0.00E+00	4.88E-01	7.89E-05	7.89E-05
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	9.68E-06	0.00E+00	0.00E+00	9.68E-06	9.68E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	4.89E-05	0.00E+00	3.28E-02	4.87E-05	4.87E-05
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	2.57E-05	0.00E+00	2.46E-06	2.57E-05	2.57E-05
VOC	1,1-Dichloropropane	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	9.95E-05	0.00E+00	7.29E-01	8.78E-05	8.78E-05
VOC	1,2-Dichloroethene (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	4.11E-05	0.00E+00	6.86E-03	4.10E-05	4.10E-05
VOC	cis-1,2-Dichloroethene	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	4.11E-05	0.00E+00	6.86E-03	4.10E-05	4.10E-05
VOC	trans-1,2-Dichloroethene	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	5.72E-05	0.00E+00	9.37E-02	5.66E-05	5.66E-05
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	3.38E-05	0.00E+00	5.82E-04	3.38E-05	3.38E-05
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	6.93E-05	0.00E+00	2.39E-01	6.71E-05	6.71E-05
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	3.06E-05	0.00E+00	1.08E-04	3.06E-05	3.06E-05
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	9.06E-06	0.00E+00	0.00E+00	9.06E-06	9.06E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	1.00E-05	0.00E+00	0.00E+00	1.00E-05	1.00E-05
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	3.95E-05	0.00E+00	4.51E-03	3.95E-05	3.95E-05
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	1.30E-05	0.00E+00	0.00E+00	1.30E-05	1.30E-05
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	9.96E-06	0.00E+00	0.00E+00	9.96E-06	9.96E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	5.95E-05	0.00E+00	1.17E-01	5.87E-05	5.87E-05
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	3.94E-05	0.00E+00	4.30E-03	3.93E-05	3.93E-05
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	6.77E-05	0.00E+00	2.17E-01	6.58E-05	6.58E-05
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	1.89E-05	0.00E+00	4.84E-11	1.89E-05	1.89E-05
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	4.79E-05	0.00E+00	2.79E-02	4.77E-05	4.77E-05
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	1.24E-04	0.00E+00	1.11E+00	9.95E-05	9.95E-05
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	2.83E-05	0.00E+00	2.27E-05	2.83E-05	2.83E-05
Notes:	Soil bulk density	kg/L	ρ _b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ _w	0.32											
	Soil air-filled porosity	L/L-soil	θ _a	0.17											
	Soil organic carbon fraction	unitless	f _{oc}	0.002											
	Averaging period (Exposure Duration)	year	T	25											
		days	T	9125											
		s	T	7.9E+08											
	Molar Gas Constant	L-mmHg/	R	62.411											
	Temperature	°C	Temp	16.7											
		K	Temp	289.7											
	Clean soil above source	m	Z ₁	0.00											
	Bottom of source depth	m	Z ₂	3.66											

**Attachment 4: Cancer Risk Calculations for Exposure of On-Site Construction Workers to Soil
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{soil} (mg/kg)	Soil Ingestion			Soil Dermal Contact			Soil Vapor Inhalation			Soil Particulate Inhalation			All Routes	
					LADD (mg/kg/d)	SF _{oral} (mg/kg/d) ⁻¹	Risk	ABS _{derm}	LADD (mg/kg/d)	SF _{derm} (mg/kg/d) ⁻¹	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	Risk	Risk
VOC	Acetone	67-64-1	ID															
VOC	Benzene	71-43-2	A															
VOC	Bromodichloromethane	75-27-4	B2															
VOC	Bromoform	75-25-2	B2															
VOC	Bromomethane	74-83-9	ID															
VOC	2-Butanone	78-93-3	ID															
VOC	Carbon Disulfide	75-15-0																
VOC	Carbon Tetrachloride	56-23-5	LC															
VOC	Chlorobenzene	108-90-7	D															
VOC	Chloroethane	75-00-3	LC															
VOC	Chloroform	67-66-3	B2															
VOC	Chloromethane	74-87-3	D															
VOC	Dibromochloromethane	124-48-1	C															
VOC	1,1-Dichloroethane	75-34-3	SC															
VOC	1,2-Dichloroethane	107-06-2	B2															
VOC	1,1-Dichloroethene	75-35-4	C															
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	3.35E-10													
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	3.35E-10													
VOC	trans-1,2-Dichloroethene	156-60-5	ID															
VOC	1,2-Dichloropropane	78-87-5	B2															
VOC	1,3-Dichloropropene (total)	542-75-6	B2															
VOC	Ethyl Benzene	100-41-4	D															
VOC	2-Hexanone	591-78-6	ID															
VOC	4-Methyl-2-pentanone	108-10-1	ID															
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	1.96E-10	2.0E-03	3.9E-13											
VOC	Styrene	100-42-5																
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC															
VOC	Tetrachloroethene	127-18-4	LC															
VOC	Toluene	108-88-3	ID															
VOC	1,1,1-Trichloroethane	71-55-6	ID															
VOC	1,1,2-Trichloroethane	79-00-5	C															
VOC	Trichloroethene	79-01-6	HC	1.86E-01	5.20E-09	4.6E-02	2.4E-10											
VOC	Vinyl Chloride	75-01-4	A															
VOC	Xylenes (total)	1330-20-7	ID															
Cumulative Risk:																		

Notes:

The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).

This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.

The concentration of particulates in the air is assumed to be no more than the former annual National Ambient Air Quality Standards (NAAQS) for PM₁₀ of 50 ug/m³.

**Attachment 4: Hazard Index Calculations for Exposure of On-Site Construction Workers to Groundwater in Excavations
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{gw} (mg/L)	Incidental Ingestion			Dermal Contact				Vapor Inhalation			All Routes
					ADD (mg/kg/d)	RfD _{oral} (mg/kg/d)	HQ	DA (L/cm ² -event)	ADD (mg/kg/d)	RfD _{derm} (mg/kg/d)	HQ	C _{air} (mg/m ³)	RfC (mg/m ³)	HQ	HQ
VOC	Acetone	67-64-1	ID	1.99E-01	3.89E-07	2.0E+00	1.9E-07	1.27E-06	1.63E-07	2.0E+00	8.2E-08	1.01E-02	3.1E+01	1.5E-06	1.8E-06
VOC	Benzene	71-43-2	A	6.53E-02	1.28E-07	1.0E-02	1.3E-05	3.70E-05	1.56E-06	1.0E-02	1.6E-04	9.29E-03	9.0E-02	4.7E-04	6.4E-04
VOC	Bromodichloromethane	75-27-4	B2	6.79E-02	1.33E-07	2.0E-02	6.6E-06	1.70E-05	7.45E-07	2.0E-02	3.7E-05	6.45E-03	2.0E-02	1.5E-03	1.5E-03
VOC	Bromoform	75-25-2	B2	7.67E-02	1.50E-07	3.0E-02	5.0E-06	1.40E-05	6.94E-07	3.0E-02	2.3E-05	5.33E-03			2.8E-05
VOC	Bromomethane	74-83-9	ID	6.13E-02	1.20E-07	5.0E-03	2.4E-05	7.68E-06	3.04E-07	5.0E-03	6.1E-05	7.94E-03	1.0E-01	3.6E-04	4.5E-04
VOC	2-Butanone	78-93-3	ID	1.06E-01	2.07E-07	2.0E+00	1.0E-07	2.42E-06	1.66E-07	2.0E+00	8.3E-08	6.94E-03	5.0E+00	6.3E-06	6.5E-06
VOC	Carbon Disulfide	75-15-0		6.52E-02	1.28E-07	1.0E-01	1.3E-06	3.11E-05	1.31E-06	1.0E-01	1.3E-05	9.51E-03	7.0E-01	6.2E-05	7.6E-05
VOC	Carbon Tetrachloride	56-23-5	LC	6.69E-02	1.31E-07	1.0E-02	1.3E-05	4.84E-05	2.09E-06	1.0E-02	2.1E-04	6.87E-03	1.9E-01	1.7E-04	3.9E-04
VOC	Chlorobenzene	108-90-7	D	6.86E-02	1.34E-07	7.0E-02	1.9E-06	8.00E-05	3.55E-06	7.0E-02	5.1E-05	8.06E-03	5.0E-01	7.4E-05	1.3E-04
VOC	Chloroethane	75-00-3	LC	7.23E-02	1.41E-07	1.0E-01	1.4E-06	1.49E-05	6.95E-07	1.0E-01	6.9E-06	1.14E-02	1.0E+01	5.2E-06	1.4E-05
VOC	Chloroform	67-66-3	B2	6.64E-02	1.30E-07	1.0E-01	1.3E-06	1.86E-05	7.97E-07	1.0E-01	8.0E-06	7.59E-03	5.0E-02	6.9E-04	7.0E-04
VOC	Chloromethane	74-87-3	D	9.00E-02	1.76E-07			3.58E-05	2.08E-06			1.60E-02	4.1E-01	1.8E-04	1.8E-04
VOC	Dibromochloromethane	124-48-1	C	7.13E-02	1.40E-07	7.0E-02	2.0E-06	1.42E-05	6.53E-07	7.0E-02	9.3E-06	5.79E-03			1.1E-05
VOC	1,1-Dichloroethane	75-34-3	SC	6.59E-02	1.29E-07	2.0E+00	6.4E-08	1.83E-05	7.78E-07	2.0E+00	3.9E-07	8.34E-03	5.0E+00	7.6E-06	8.1E-06
VOC	1,2-Dichloroethane	107-06-2	B2	6.61E-02	1.29E-07	2.0E-02	6.5E-06	1.13E-05	4.82E-07	2.0E-02	2.4E-05	7.80E-03	7.0E-02	5.1E-04	5.4E-04
VOC	1,1-Dichloroethene	75-35-4	C	2.50E-01	4.89E-07	5.0E-02	9.8E-06	3.10E-05	5.01E-06	5.0E-02	1.0E-04	3.23E-02	2.0E-01	7.4E-04	8.5E-04
VOC	1,2-Dichloroethene (total)	540-59-0		1.00E+01	1.96E-05	2.0E-02	9.8E-04	2.07E-05	1.34E-04	2.0E-02	6.7E-03	1.27E+00			7.7E-03
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.00E+01	1.96E-05	2.0E-02	9.8E-04	2.07E-05	1.34E-04	2.0E-02	6.7E-03	1.27E+00			7.7E-03
VOC	trans-1,2-Dichloroethene	156-60-5	ID	5.99E-02	1.17E-07	2.0E-01	5.9E-07	2.83E-05	1.10E-06	2.0E-01	5.5E-06	7.70E-03			6.1E-06
VOC	1,2-Dichloropropane	78-87-5	B2	6.52E-02	1.28E-07	7.0E-02	1.8E-06	2.12E-05	8.91E-07	7.0E-02	1.3E-05	7.60E-03	1.3E-02	2.7E-03	2.7E-03
VOC	1,3-Dichloropropene (total)	542-75-6	B2	1.42E-01	2.78E-07	4.0E-02	7.0E-06	2.25E-05	2.07E-06	4.0E-02	5.2E-05	1.72E-02	3.6E-02	2.2E-03	2.2E-03
VOC	Ethyl Benzene	100-41-4	D	6.89E-02	1.35E-07	1.0E-01	1.3E-06	1.27E-04	5.64E-06	1.0E-01	5.6E-05	8.44E-03	9.0E+00	4.3E-06	6.2E-05
VOC	2-Hexanone	591-78-6	ID	1.20E-01	2.35E-07	5.0E-03	4.7E-05	9.75E-06	7.56E-07	5.0E-03	1.5E-04	8.77E-03	3.0E-01	1.3E-04	3.3E-04
VOC	4-Methyl-2-pentanone	108-10-1	ID	1.20E-01	2.35E-07			7.32E-06	5.67E-07			1.01E-02	3.0E+00	1.5E-05	1.5E-05
VOC	Methylene Chloride	75-09-2	LC	3.10E-01	6.07E-07	6.0E-02	1.0E-05	9.25E-06	1.85E-06	6.0E-02	3.1E-05	4.14E-02	1.0E+00	1.8E-04	2.2E-04
VOC	Styrene	100-42-5		6.83E-02	1.34E-07	2.0E-01	6.7E-07	9.63E-05	4.25E-06	2.0E-01	2.1E-05	8.26E-03	3.0E+00	1.3E-05	3.4E-05
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC	6.40E-02	1.25E-07	5.0E-02	2.5E-06	2.57E-05	1.06E-06	5.0E-02	2.1E-05	5.03E-03			2.4E-05
VOC	Tetrachloroethene	127-18-4	LC	7.67E-02	1.50E-07	1.0E-01	1.5E-06	3.99E-05	1.98E-06	1.0E-01	2.0E-05	7.57E-03	4.0E-02	8.6E-04	8.9E-04
VOC	Toluene	108-88-3	ID	6.54E-02	1.28E-07	8.0E-01	1.6E-07	8.08E-05	3.41E-06	8.0E-01	4.3E-06	8.58E-03	5.0E+00	7.8E-06	1.2E-05
VOC	1,1,1-Trichloroethane	71-55-6	ID	1.10E-01	2.15E-07	7.0E+00	3.1E-08	3.85E-05	2.74E-06	7.0E+00	3.9E-07	1.21E-02	5.0E+00	1.1E-05	1.1E-05
VOC	1,1,2-Trichloroethane	79-00-5	C	6.59E-02	1.29E-07	4.0E-03	3.2E-05	2.02E-05	8.58E-07	4.0E-03	2.1E-04	6.65E-03	2.0E-03	1.5E-02	1.5E-02
VOC	Trichloroethene	79-01-6	HC	8.10E+01	1.59E-04	5.0E-04	3.2E-01	5.53E-05	2.89E-03	5.0E-04	5.8E+00	8.95E+00	5.4E-01	7.6E-02	6.2E+00
VOC	Vinyl Chloride	75-01-4	A	2.50E+00	4.89E-06	3.0E-03	1.6E-03	1.69E-05	2.72E-05	3.0E-03	9.1E-03	4.03E-01	1.0E-01	1.8E-02	2.9E-02
VOC	Xylenes (total)	1330-20-7	ID	1.99E-01	3.90E-07	2.0E-01	2.0E-06	1.32E-04	1.70E-05	2.0E-01	8.5E-05	2.44E-02	3.0E-01	3.7E-04	4.6E-04
			Hazard Index:				3E-01				6E+00			1E-01	6E+00
Notes:	This C/Q term is estimated using USEPA's SCREEN3 air dispersion model (USEPA 1995) to estimate maximum 1-hour concentrations at ground level. The source area for maintenance workers is based on a 15 by 15 foot excavation.														

Attachment 5

Off-Site Resident Risk Calculations

Contents:

- Vapor Flux from On-Site Soil to Outdoor Air
- Soil PM10 Emission from Wind Erosion
- Cancer Risk Calculations for Exposure of Residents to On-Site Soil
- Hazard Index Calculations for Exposure of Residents to On-Site Soil

- Soil Moisture Profile for Residential Building (Slab-on-Grade)
- Normalized Indoor Air Concentration in a Residential Building (Slab-on-Grade) due to Vapor Intrusion from Groundwater
- Cancer Risk and Hazard Index Calculations Residents due to Groundwater Vapor Intrusion into a Residential Building (Slab-on-Grade)

- Vapor Flux to Outdoor Air from Groundwater
- Cancer Risk and Hazard Index Calculations for Exposure of Resident to Groundwater-Derived Vapors in Outdoor Air

**Attachment 5: Vapor Flux from On-Site Soil to Outdoor Air
Whirlpool, Fort Smith, Arkansas**

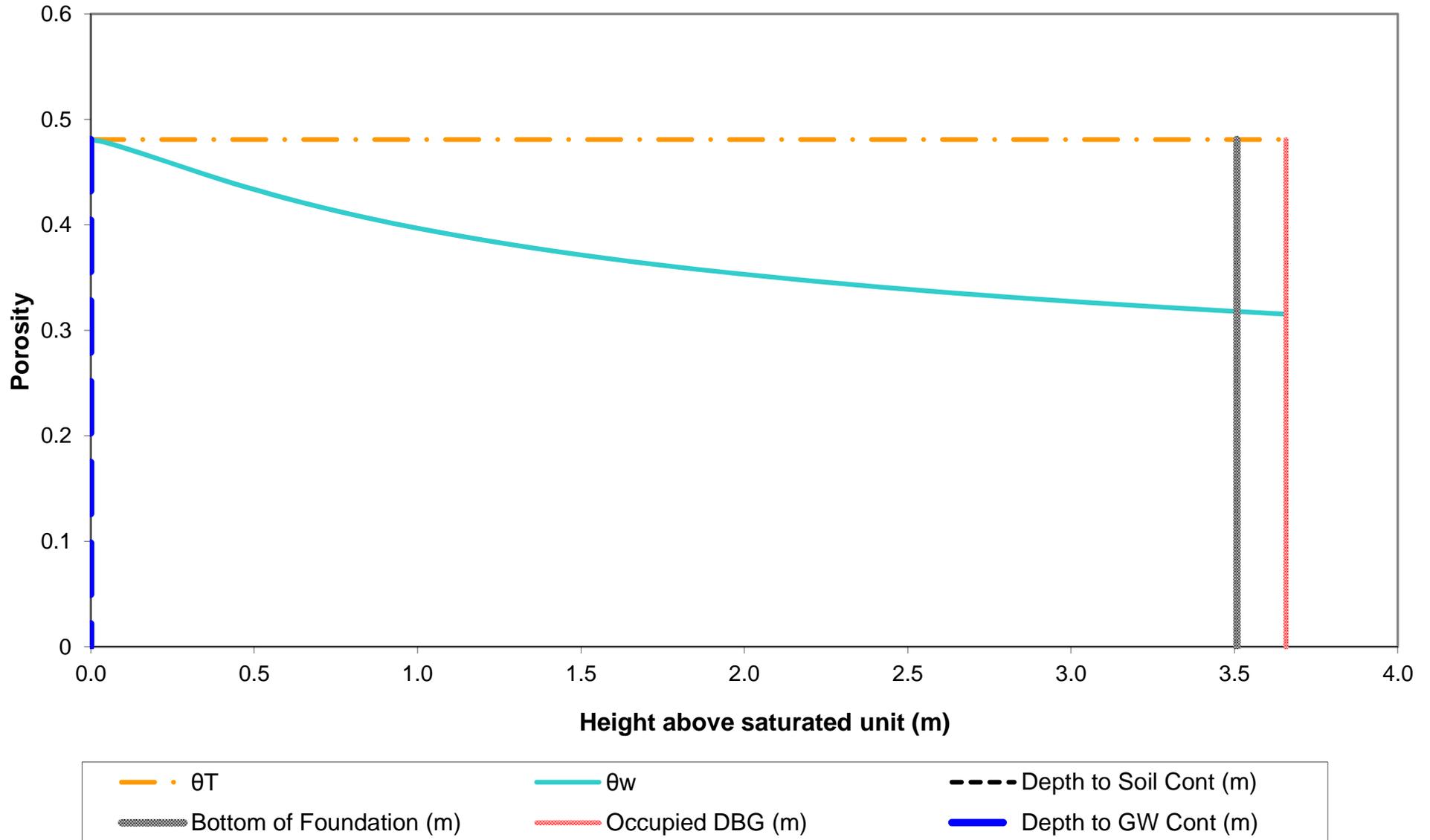
Chem Group	Chemical	CASRN	K _{oc} (L/kg)	H (unitless)	D _{air} (m ² /d)	D _{water} (m ² /d)	R _L (unitless)	D _G (m ² /d)	D _L (m ² /d)	D _E (m ² /d)	Infinite J _v (kg/m ² -s)	Finite depth Z1 ERFC term	Finite depth Z2 ERFC term	Finite J _v (kg/m ² -s)	J _v (kg/m ² -s)
VOC	Acetone	67-64-1	5.81E-01	1.14E-03	1.07E+00	9.85E-05	3.17E-01	1.15E-02	9.10E-06	7.01E-05	1.44E-06	0.00E+00	1.16E-02	1.44E-06	1.44E-06
VOC	Benzene	71-43-2	5.82E+01	1.59E-01	7.60E-01	8.47E-05	5.02E-01	8.19E-03	7.82E-06	2.61E-03	8.79E-06	0.00E+00	2.30E+00	4.32E-06	4.32E-06
VOC	Bromodichloromethane	75-27-4	5.51E+01	4.45E-02	2.57E-01	9.16E-05	4.75E-01	2.77E-03	8.46E-06	2.78E-04	2.87E-06	0.00E+00	5.05E-01	2.65E-06	2.65E-06
VOC	Bromoform	75-25-2	8.70E+01	1.34E-02	1.29E-01	8.90E-05	5.58E-01	1.39E-03	8.22E-06	4.80E-05	1.19E-06	0.00E+00	1.31E-03	1.19E-06	1.19E-06
VOC	Bromomethane	74-83-9	1.05E+01	2.01E-01	6.29E-01	1.05E-04	3.78E-01	6.78E-03	9.65E-06	3.63E-03	1.04E-05	0.00E+00	2.49E+00	4.47E-06	4.47E-06
VOC	2-Butanone	78-93-3	2.00E+00	1.96E-03	6.98E-01	8.47E-05	3.21E-01	7.52E-03	7.82E-06	7.03E-05	1.44E-06	0.00E+00	1.17E-02	1.44E-06	1.44E-06
VOC	Carbon Disulfide	75-15-0	4.59E+01	9.26E-01	8.99E-01	8.64E-05	5.96E-01	9.68E-03	7.98E-06	1.51E-02	2.11E-05	0.00E+00	3.07E+00	4.91E-06	4.91E-06
VOC	Carbon Tetrachloride	56-23-5	1.74E+02	8.82E-01	6.74E-01	7.60E-05	9.41E-01	7.26E-03	7.02E-06	6.81E-03	1.42E-05	0.00E+00	2.80E+00	4.70E-06	4.70E-06
VOC	Chlorobenzene	108-90-7	2.20E+02	9.77E-02	6.31E-01	7.52E-05	9.40E-01	6.79E-03	6.94E-06	7.13E-04	4.60E-06	0.00E+00	1.30E+00	3.49E-06	3.49E-06
VOC	Chloroethane	75-00-3	1.62E+01	3.25E-01	2.34E+00	9.94E-05	4.14E-01	2.52E-02	9.18E-06	1.98E-02	2.43E-05	0.00E+00	3.15E+00	4.96E-06	4.96E-06
VOC	Chloroform	67-66-3	3.97E+01	1.07E-01	8.99E-01	8.64E-05	4.43E-01	9.68E-03	7.98E-06	2.37E-03	8.38E-06	0.00E+00	2.24E+00	4.28E-06	4.28E-06
VOC	Chloromethane	74-87-3	3.97E+01	3.33E-01	1.09E+00	5.62E-05	4.80E-01	1.17E-02	5.19E-06	8.14E-03	1.55E-05	0.00E+00	2.87E+00	4.76E-06	4.76E-06
VOC	Dibromochloromethane	124-48-1	6.26E+01	2.38E-02	1.69E-01	9.07E-05	4.92E-01	1.82E-03	8.38E-06	1.05E-04	1.77E-06	0.00E+00	5.87E-02	1.76E-06	1.76E-06
VOC	1,1-Dichloroethane	75-34-3	3.13E+01	1.66E-01	6.41E-01	9.07E-05	4.29E-01	6.91E-03	8.38E-06	2.68E-03	8.92E-06	0.00E+00	2.32E+00	4.34E-06	4.34E-06
VOC	1,2-Dichloroethane	107-06-2	1.75E+01	2.74E-02	8.99E-01	8.55E-05	3.68E-01	9.68E-03	7.90E-06	7.42E-04	4.69E-06	0.00E+00	1.33E+00	3.53E-06	3.53E-06
VOC	1,1-Dichloroethane	75-35-4	5.82E+01	8.10E-01	7.78E-01	8.99E-05	6.10E-01	8.38E-03	8.30E-06	1.11E-02	1.82E-05	0.00E+00	2.98E+00	4.84E-06	4.84E-06
VOC	1,2-Dichloroethane (total)	540-59-0	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	7.50E-06	0.00E+00	2.09E+00	4.16E-06	4.16E-06
VOC	cis-1,2-Dichloroethane	156-59-2	3.56E+01	1.19E-01	6.36E-01	9.76E-05	4.33E-01	6.85E-03	9.02E-06	1.90E-03	7.50E-06	0.00E+00	2.09E+00	4.16E-06	4.16E-06
VOC	trans-1,2-Dichloroethane	156-60-5	5.22E+01	2.81E-01	6.11E-01	1.03E-04	5.06E-01	6.58E-03	9.49E-06	3.68E-03	1.04E-05	0.00E+00	2.50E+00	4.48E-06	4.48E-06
VOC	1,2-Dichloropropane	78-87-5	4.35E+01	7.82E-02	6.76E-01	7.54E-05	4.48E-01	7.28E-03	6.97E-06	1.28E-03	6.17E-06	0.00E+00	1.79E+00	3.92E-06	3.92E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.59E+01	4.83E-01	5.41E-01	8.64E-05	5.22E-01	5.83E-03	7.98E-06	5.40E-03	1.27E-05	0.00E+00	2.69E+00	4.63E-06	4.63E-06
VOC	Ethyl Benzene	100-41-4	3.67E+02	2.04E-01	6.48E-01	6.74E-05	1.36E+00	6.98E-03	6.22E-06	1.05E-03	5.58E-06	0.00E+00	1.63E+00	3.79E-06	3.79E-06
VOC	2-Hexanone	591-78-6	1.48E+01	3.23E-03	7.45E-01	7.57E-05	3.57E-01	8.02E-03	6.99E-06	9.23E-05	1.65E-06	0.00E+00	3.69E-02	1.65E-06	1.65E-06
VOC	4-Methyl-2-pentanone	108-10-1	1.05E+01	4.71E-03	6.48E-01	6.74E-05	3.45E-01	6.98E-03	6.22E-06	1.13E-04	1.83E-06	0.00E+00	7.41E-02	1.82E-06	1.82E-06
VOC	Methylene Chloride	75-09-2	1.17E+01	6.60E-02	8.73E-01	1.01E-04	3.59E-01	9.40E-03	9.33E-06	1.76E-03	7.22E-06	0.00E+00	2.03E+00	4.11E-06	4.11E-06
VOC	Styrene	100-42-5	7.77E+02	7.04E-02	6.13E-01	6.91E-05	2.47E+00	6.61E-03	6.38E-06	1.91E-04	2.38E-06	0.00E+00	2.69E-01	2.29E-06	2.29E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	9.35E+01	8.74E-03	6.13E-01	6.83E-05	5.75E-01	6.61E-03	6.30E-06	1.11E-04	1.82E-06	0.00E+00	7.02E-02	1.80E-06	1.80E-06
VOC	Tetrachloroethene	127-18-4	1.56E+02	4.90E-01	6.22E-01	7.08E-05	8.27E-01	6.70E-03	6.54E-06	3.98E-03	1.09E-05	0.00E+00	2.54E+00	4.51E-06	4.51E-06
VOC	Toluene	108-88-3	1.80E+02	1.80E-01	7.52E-01	7.43E-05	8.43E-01	8.10E-03	6.86E-06	1.74E-03	7.19E-06	0.00E+00	2.02E+00	4.11E-06	4.11E-06
VOC	1,1,1-Trichloroethane	71-55-6	1.10E+02	4.97E-01	6.74E-01	7.60E-05	7.02E-01	7.26E-03	7.02E-06	5.15E-03	1.24E-05	0.00E+00	2.67E+00	4.61E-06	4.61E-06
VOC	1,1,2-Trichloroethane	79-00-5	5.03E+01	2.43E-02	6.74E-01	7.60E-05	4.58E-01	7.26E-03	7.02E-06	4.00E-04	3.45E-06	0.00E+00	7.93E-01	3.00E-06	3.00E-06
VOC	Trichloroethene	79-01-6	1.68E+02	2.88E-01	6.83E-01	7.86E-05	8.26E-01	7.35E-03	7.26E-06	2.57E-03	8.74E-06	0.00E+00	2.29E+00	4.32E-06	4.32E-06
VOC	Vinyl Chloride	75-01-4	1.85E+01	9.00E-01	9.16E-01	1.06E-04	5.15E-01	9.87E-03	9.81E-06	1.72E-02	2.26E-05	0.00E+00	3.11E+00	4.94E-06	4.94E-06
VOC	Xylenes (total)	1330-20-7	3.86E+02	1.73E-01	6.74E-01	7.56E-05	1.41E+00	7.26E-03	6.98E-06	8.97E-04	5.16E-06	0.00E+00	1.50E+00	3.67E-06	3.67E-06
Notes:	Soil bulk density	kg/L	ρ _b	1.38											
	Soil porosity	L/L-soil	θ	0.48											
	Soil water content	L/L-soil	θ _w	0.32											
	Soil air-filled porosity	L/L-soil	θ _a	0.17											
	Soil organic carbon fraction	unitless	f _{oc}	0.002											
	Averaging period (Exposure Duration)	year	T	25											
		days	T	9125											
		s	T	7.9E+08											
	Molar Gas Constant	L-mmHg/	R	62.411											
	Temperature	°C	Temp	16.7											
		K	Temp	289.7											
	Clean soil above source	m	Z ₁	0.00											
	Bottom of source depth	m	Z ₂	3.66											

Attachment 5: Soil PM10 Emission from Wind Erosion Whirlpool, Fort Smith, Arkansas			
Unlimited Reservoir Model			
Aerodynamic particle size multiplier			0.036
Ground cover fraction		G	0.5
Mode of aggregate size distribution	mm		0.50
Threshold friction velocity	m/s	u'_t	0.50
Correction factor			1.25
Corrected friction velocity	m/s	u*_t	0.6252
Roughness height	m	z₀	0.005
Anemometer height	m		10.0
Friction velocity at anemometer height	m/s	u_t	11.9
Mean annual wind speed	mph	u_m	7.6
Mean annual wind speed	m/s	u_m	3.40
u _m /u _t			0.286
x = 0.886 u _t /u _m			3.10
F(x)			0.003
Annual average PM₁₀ flux	kg-soil/m ² -s	J_{10,w}	3.93E-13

**Attachment 5: Cancer Risk Calculations for Exposure of Residents to On-Site Soil
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	Cancer Class	C _{soil} (mg/kg)	Soil Vapor Inhalation				Soil Particulate Inhalation				All Routes	
					C _{air} (mg/m ³)	URF (m ³ /mg)	f _{inh}	Risk	C _{air} (mg/m ³)	URF (m ³ /mg)	f _{inh}	Risk	Risk	
VOC	Acetone	67-64-1	ID											
VOC	Benzene	71-43-2	A			7.8E-03				7.8E-03				
VOC	Bromodichloromethane	75-27-4	B2											
VOC	Bromoform	75-25-2	B2			1.1E-03				1.1E-03				
VOC	Bromomethane	74-83-9	ID											
VOC	2-Butanone	78-93-3	ID											
VOC	Carbon Disulfide	75-15-0												
VOC	Carbon Tetrachloride	56-23-5	LC			6.0E-03				6.0E-03				
VOC	Chlorobenzene	108-90-7	D											
VOC	Chloroethane	75-00-3	LC											
VOC	Chloroform	67-66-3	B2			2.3E-02				2.3E-02				
VOC	Chloromethane	74-87-3	D											
VOC	Dibromochloromethane	124-48-1	C											
VOC	1,1-Dichloroethane	75-34-3	SC											
VOC	1,2-Dichloroethane	107-06-2	B2			2.6E-02				2.6E-02				
VOC	1,1-Dichloroethene	75-35-4	C											
VOC	1,2-Dichloroethene (total)	540-59-0		1.20E-02	1.70E-06				1.60E-13					
VOC	cis-1,2-Dichloroethene	156-59-2	ID	1.20E-02	1.70E-06				1.60E-13					
VOC	trans-1,2-Dichloroethene	156-60-5	ID											
VOC	1,2-Dichloropropane	78-87-5	B2											
VOC	1,3-Dichloropropene (total)	542-75-6	B2			4.0E-03				4.0E-03				
VOC	Ethyl Benzene	100-41-4	D											
VOC	2-Hexanone	591-78-6	ID											
VOC	4-Methyl-2-pentanone	108-10-1	ID											
VOC	Methylene Chloride	75-09-2	LC	7.00E-03	9.79E-07	1.0E-05	1	1.0E-11	9.35E-14	1.0E-05	1	9.7E-19	1.0E-11	
VOC	Styrene	100-42-5												
VOC	1,1,2,2-Tetrachloroethane	79-34-5	LC											
VOC	Tetrachloroethene	127-18-4	LC			2.6E-04				2.6E-04				
VOC	Toluene	108-88-3	ID											
VOC	1,1,1-Trichloroethane	71-55-6	ID											
VOC	1,1,2-Trichloroethane	79-00-5	C			1.6E-02				1.6E-02				
VOC	Trichloroethene	79-01-6	HC	1.86E-01	2.73E-05	4.1E-03	0.244	6.3E-08	2.48E-12	4.1E-03	0.244	5.7E-15	6.3E-08	
VOC	Vinyl Chloride	75-01-4	A			4.4E-03				4.4E-03				
VOC	Xylenes (total)	1330-20-7	ID											
			Cumulative Risk:					6E-08				6E-15	6E-08	
Notes:														
The dispersion coefficient to outdoor air (C/Q) is 34.0 (kg/m3) / (kg/m2/s).														
This C/Q term is estimated using the empirical correlation in USEPA's Supplemental Soil Screening Guidance (2002), conservatively assuming a source area of 153 acres (the site area) and region-specific meteorological parameters.														
f _{inh} is the fraction of the inhalation toxicity values that USEPA identified as having a mutagenic mode of action.														

Attachment 5: Soil Moisture Profile for Residential Building (Slab-on-Grade) Whirlpool, Fort Smith, Arkansas



**Attachment 5: Normalized Indoor Air Concentration in a Residential Building (Slab on Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	D _{air} (m ² /day)	D _{water} (m ² /day)	H (unitless)	D _{crack} (m ² /day)	D _{eff} ^T (m ² /day)	α _{soil}	α _{slab}	α _∞	C _{bdg} (L-water/m ³)
VOC	Acetone	67-64-1	1.07E+00	9.85E-05	1.14E-03	1.72E-01	1.87E-02	6.80E-02	2.73E-03	1.86E-04	2.12E-04
VOC	Benzene	71-43-2	7.60E-01	8.47E-05	1.59E-01	1.22E-01	8.15E-04	3.17E-03	2.73E-03	8.67E-06	1.38E-03
VOC	Bromodichloromethane	75-27-4	2.57E-01	9.16E-05	4.45E-02	4.13E-02	1.07E-03	4.17E-03	2.73E-03	1.14E-05	5.07E-04
VOC	Bromoform	75-25-2	1.29E-01	8.90E-05	1.34E-02	2.07E-02	1.64E-03	6.37E-03	2.73E-03	1.74E-05	2.33E-04
VOC	Bromomethane	74-83-9	6.29E-01	1.05E-04	2.01E-01	1.01E-01	7.43E-04	2.89E-03	2.73E-03	7.90E-06	1.59E-03
VOC	2-Butanone	78-93-3	6.98E-01	8.47E-05	1.96E-03	1.12E-01	1.01E-02	3.78E-02	2.73E-03	1.03E-04	2.03E-04
VOC	Carbon Disulfide	75-15-0	8.99E-01	8.64E-05	9.26E-01	1.44E-01	2.93E-04	1.14E-03	2.73E-03	3.12E-06	2.89E-03
VOC	Carbon Tetrachloride	56-23-5	6.74E-01	7.60E-05	8.82E-01	1.08E-01	2.52E-04	9.82E-04	2.73E-03	2.68E-06	2.37E-03
VOC	Chlorobenzene	108-90-7	6.31E-01	7.52E-05	9.77E-02	1.01E-01	9.32E-04	3.63E-03	2.73E-03	9.91E-06	9.68E-04
VOC	Chloroethane	75-00-3	2.34E+00	9.94E-05	3.25E-01	3.76E-01	8.86E-04	3.45E-03	2.73E-03	9.42E-06	3.06E-03
VOC	Chloroform	67-66-3	8.99E-01	8.64E-05	1.07E-01	1.44E-01	1.11E-03	4.32E-03	2.73E-03	1.18E-05	1.27E-03
VOC	Chloromethane	74-87-3	1.09E+00	5.62E-05	3.33E-01	1.75E-01	4.61E-04	1.80E-03	2.73E-03	4.90E-06	1.63E-03
VOC	Dibromochloromethane	124-48-1	1.69E-01	9.07E-05	2.38E-02	2.72E-02	1.27E-03	4.94E-03	2.73E-03	1.35E-05	3.21E-04
VOC	1,1-Dichloroethane	75-34-3	6.41E-01	9.07E-05	1.66E-01	1.03E-01	7.72E-04	3.00E-03	2.73E-03	8.21E-06	1.36E-03
VOC	1,2-Dichloroethane	107-06-2	8.99E-01	8.55E-05	2.74E-02	1.44E-01	2.37E-03	9.19E-03	2.73E-03	2.51E-05	6.88E-04
VOC	1,1-Dichloroethene	75-35-4	7.78E-01	8.99E-05	8.10E-01	1.25E-01	3.12E-04	1.22E-03	2.73E-03	3.32E-06	2.69E-03
VOC	1,2-Dichloroethene (total)	540-59-0	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.72E-04	3.78E-03	2.73E-03	1.03E-05	1.22E-03
VOC	cis-1,2-Dichloroethene	156-59-2	6.36E-01	9.76E-05	1.19E-01	1.02E-01	9.72E-04	3.78E-03	2.73E-03	1.03E-05	1.22E-03
VOC	trans-1,2-Dichloroethene	156-60-5	6.11E-01	1.03E-04	2.81E-01	9.81E-02	5.96E-04	2.32E-03	2.73E-03	6.35E-06	1.79E-03
VOC	1,2-Dichloropropane	78-87-5	6.76E-01	7.54E-05	7.82E-02	1.08E-01	1.09E-03	4.24E-03	2.73E-03	1.16E-05	9.07E-04
VOC	1,3-Dichloropropene (total)	542-75-6	5.41E-01	8.64E-05	4.83E-01	8.68E-02	3.69E-04	1.44E-03	2.73E-03	3.93E-06	1.90E-03
VOC	Ethyl Benzene	100-41-4	6.48E-01	6.74E-05	2.04E-01	1.04E-01	5.75E-04	2.24E-03	2.73E-03	6.12E-06	1.25E-03
VOC	2-Hexanone	591-78-6	7.45E-01	7.57E-05	3.23E-03	1.20E-01	6.86E-03	2.61E-02	2.73E-03	7.13E-05	2.31E-04
VOC	4-Methyl-2-pentanone	108-10-1	6.48E-01	6.74E-05	4.71E-03	1.04E-01	4.81E-03	1.84E-02	2.73E-03	5.03E-05	2.37E-04
VOC	Methylene Chloride	75-09-2	8.73E-01	1.01E-04	6.60E-02	1.40E-01	1.58E-03	6.14E-03	2.73E-03	1.68E-05	1.11E-03
VOC	Styrene	100-42-5	6.13E-01	6.91E-05	7.04E-02	9.85E-02	1.06E-03	4.11E-03	2.73E-03	1.12E-05	7.90E-04
VOC	1,1,2,2-Tetrachloroethane	79-34-5	6.13E-01	6.83E-05	8.74E-03	9.85E-02	3.31E-03	1.28E-02	2.73E-03	3.48E-05	3.05E-04
VOC	Tetrachloroethene	127-18-4	6.22E-01	7.08E-05	4.90E-01	9.99E-02	3.40E-04	1.33E-03	2.73E-03	3.63E-06	1.78E-03
VOC	Toluene	108-88-3	7.52E-01	7.43E-05	1.80E-01	1.21E-01	6.97E-04	2.71E-03	2.73E-03	7.41E-06	1.34E-03
VOC	1,1,1-Trichloroethane	71-55-6	6.74E-01	7.60E-05	4.97E-01	1.08E-01	3.64E-04	1.42E-03	2.73E-03	3.87E-06	1.92E-03
VOC	1,1,2-Trichloroethane	79-00-5	6.74E-01	7.60E-05	2.43E-02	1.08E-01	2.09E-03	8.08E-03	2.73E-03	2.21E-05	5.37E-04
VOC	Trichloroethene	79-01-6	6.83E-01	7.86E-05	2.88E-01	1.10E-01	5.23E-04	2.04E-03	2.73E-03	5.57E-06	1.60E-03
VOC	Vinyl Chloride	75-01-4	9.16E-01	1.06E-04	9.00E-01	1.47E-01	3.44E-04	1.34E-03	2.73E-03	3.66E-06	3.30E-03

**Attachment 5: Normalized Indoor Air Concentration in a Residential Building (Slab on Grade) due to Vapor Intrusion from Groundwater
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	D _{air} (m ² /day)	D _{water} (m ² /day)	H (unitless)	D _{crack} (m ² /day)	D _{eff} ^T (m ² /day)	α _{soil}	α _{slab}	α _∞	C _{bdg} (L-water/m ³)
VOC	Xylenes (total)	1330-20-7	6.74E-01	7.56E-05	1.73E-01	1.08E-01	6.90E-04	2.68E-03	2.73E-03	7.34E-06	1.27E-03
Notes:	Crack Soil and Building Characteristics			Crack Soil							
	SCS Soil texture class			Sand							
	Bulk density	kg/L	ρ _b	1.66							
	Total porosity	L/L-soil	θ _T	0.375							
	Water-filled porosity	L/L-soil	θ _w	0.054							
	Air-filled porosity	L/L-soil	θ _a	0.321							
	Residual saturation	L/L-soil	θ _r	0.053							
	Hydraulic conductivity	cm/s	K	7.4E-03							
	Dynamic viscosity of water	g/cm-s	μ _w	0.01307							
	Density of water	g/cm ³	ρ _w	1.0							
	Gravitational acceleration	cm/s ²	g	980.7							
	Intrinsic permeability	cm ²	k	9.9E-08							
	Relative saturation	unitless	S _e	0.004							
	van Genuchten N	unitless	N	3.177							
	van Genuchten M	unitless	M	0.685							
	Relative air permeability	unitless	k _{rg}	0.998							
	Permeability to vapor	cm ²	k _v	9.89E-08							
	Distance from building foundation	m	L _{T-gw}	3.56							
	Bldg foundation thickness	m	L _{crack}	0.1							
	Bldg foundation length	m		10.00							
	Bldg foundation width	m		10.00							
	Bldg occupied height	m		2.44							
	Bldg occupied volume	m ³		244.00							
	Occupied depth below ground	m		0.0							
	Bldg area for vapor intrusion	m ²	A _B	100.0							
	Ratio of A _{crack} to A _B		η	4E-04							
	Area of cracks	m ²	A _{crack}	4E-02							
	Air exchange rate	hour ⁻¹	ach	0.45							
	Building ventilation rate	m ³ /day	Q _{bdg}	2.64E+03							
	Pressure difference between	kg/m-s ²	ΔP	1.0							
	Viscosity of air	kg/m-s	μ _a	1.8E-05							
	Crack length (bldg perimeter)	m	X _{crack}	40							
	Crack depth below ground	m	Z _{crack}	0.10							
	Crack radius	m	r _{crack}	1E-03							
	Soil gas flow rate into bldg	m ³ /day	Q _{soil}	7.20							

**Attachment 5: Vapor Flux to Outdoor Air from Groundwater
Whirlpool, Fort Smith, Arkansas**

Chem Group	Chemical	CASRN	H (unitless)	D_{eff}^T (m ² /day)	J (L/m ² -s)	C_{air} (L/m ³)
VOC	Acetone	67-64-1	1.14E-03	1.87E-02	6.75E-08	1.78E-06
VOC	Benzene	71-43-2	1.59E-01	8.31E-04	4.18E-07	1.10E-05
VOC	Bromodichloromethane	75-27-4	4.45E-02	1.09E-03	1.53E-07	4.03E-06
VOC	Bromoform	75-25-2	1.34E-02	1.65E-03	6.97E-08	1.84E-06
VOC	Bromomethane	74-83-9	2.01E-01	7.57E-04	4.81E-07	1.27E-05
VOC	2-Butanone	78-93-3	1.96E-03	1.01E-02	6.27E-08	1.65E-06
VOC	Carbon Disulfide	75-15-0	9.26E-01	2.99E-04	8.76E-07	2.31E-05
VOC	Carbon Tetrachloride	56-23-5	8.82E-01	2.57E-04	7.17E-07	1.89E-05
VOC	Chlorobenzene	108-90-7	9.77E-02	9.49E-04	2.93E-07	7.73E-06
VOC	Chloroethane	75-00-3	3.25E-01	9.04E-04	9.30E-07	2.45E-05
VOC	Chloroform	67-66-3	1.07E-01	1.13E-03	3.85E-07	1.01E-05
VOC	Chloromethane	74-87-3	3.33E-01	4.70E-04	4.95E-07	1.30E-05
VOC	Dibromochloromethane	124-48-1	2.38E-02	1.28E-03	9.66E-08	2.55E-06
VOC	1,1-Dichloroethane	75-34-3	1.66E-01	7.86E-04	4.12E-07	1.09E-05
VOC	1,2-Dichloroethane	107-06-2	2.74E-02	2.41E-03	2.09E-07	5.52E-06
VOC	1,1-Dichloroethene	75-35-4	8.10E-01	3.18E-04	8.15E-07	2.15E-05
VOC	1,2-Dichloroethene (total)	540-59-0	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	cis-1,2-Dichloroethene	156-59-2	1.19E-01	9.89E-04	3.71E-07	9.79E-06
VOC	trans-1,2-Dichloroethene	156-60-5	2.81E-01	6.08E-04	5.41E-07	1.43E-05
VOC	1,2-Dichloropropane	78-87-5	7.82E-02	1.11E-03	2.75E-07	7.25E-06
VOC	1,3-Dichloropropene (total)	542-75-6	4.83E-01	3.76E-04	5.75E-07	1.52E-05
VOC	Ethyl Benzene	100-41-4	2.04E-01	5.86E-04	3.78E-07	9.98E-06
VOC	2-Hexanone	591-78-6	3.23E-03	6.91E-03	7.07E-08	1.86E-06
VOC	4-Methyl-2-pentanone	108-10-1	4.71E-03	4.85E-03	7.23E-08	1.91E-06
VOC	Methylene Chloride	75-09-2	6.60E-02	1.61E-03	3.36E-07	8.87E-06
VOC	Styrene	100-42-5	7.04E-02	1.08E-03	2.40E-07	6.32E-06
VOC	1,1,2,2-Tetrachloroethane	79-34-5	8.74E-03	3.35E-03	9.26E-08	2.44E-06
VOC	Tetrachloroethene	127-18-4	4.90E-01	3.47E-04	5.39E-07	1.42E-05
VOC	Toluene	108-88-3	1.80E-01	7.10E-04	4.05E-07	1.07E-05
VOC	1,1,1-Trichloroethane	71-55-6	4.97E-01	3.71E-04	5.83E-07	1.54E-05
VOC	1,1,2-Trichloroethane	79-00-5	2.43E-02	2.12E-03	1.63E-07	4.29E-06
VOC	Trichloroethene	79-01-6	2.88E-01	5.33E-04	4.86E-07	1.28E-05
VOC	Vinyl Chloride	75-01-4	9.00E-01	3.51E-04	9.99E-07	2.63E-05
VOC	Xylenes (total)	1330-20-7	1.73E-01	7.02E-04	3.85E-07	1.02E-05
	Parameters					
	Depth to groundwater	m	DTW	3.66		
	Dispersion coefficient	(kg/m ³) / (kg/m ² /s)	C/Q	26.4		

