# THE RIVERFRONT SITE
# NEW HAVEN, FRANKLIN COUNTY, MISSOURI

CERCLIS ID: MOD981720246

## Baseline Risk Assessment
## Operable Unit 1 (OU1) – Front Street

Prepared for the Superfund Division
U.S. Environmental Protection Agency, Region VII

Prepared by:

Missouri Department of Health and Senior Services
Section for Environmental Public Health
930 Wildwood Drive, P.O. Box 570
Jefferson City, Missouri 65102

January 2003

# THE RIVERFRONT SITE
# NEW HAVEN, FRANKLIN COUNTY, MISSOURI

## Operable Unit 1 – Front Street Baseline Risk Assessment

## Table of Contents

# List of Tables and Figures

# Appendices

Appendix A – Sample Results and COC Spreadsheets for Groundwater – Well Sampling
Appendix B – Sample Results and COC Spreadsheets for Groundwater – Borehole Sampling
Appendix C – Sample Results and COC Spreadsheets for Surface Soil Sampling
Appendix D – Sample Results and COC Spreadsheets for SubSurface Soil Sampling
Appendix E - Calculation Worksheets

**Baseline Risk Assessment**
**Operable Unit 1 (OU1) – Front Street**
**The Riverfront Site, New Haven, Franklin County, Missouri**

## 1.0 INTRODUCTION

### 1.1 Overview

The U.S. Environmental Protection Agency (EPA) requested that the Missouri Department of Health and Senior Services (MDHSS) perform a risk assessment of the Riverfront Superfund Site, New Haven, Missouri. The Riverfront Site has been found to be contaminated with tetrachloroethene (PCE) and other volatile organic compounds (VOCs). As PCE was found to have affected the town's public water supply, the site was added to the National Priorities List in December 2000. In order to better manage response actions for the Riverfront Site, which encompasses multiple contaminant source locations across the New Haven area and is influenced by a diverse and dynamic hydrogeology, EPA has delineated a number of sub-areas or "Operable Units," that allow a focused analysis of localized contaminated media and exposure pathways. This MDHSS risk assessment addresses one of these sub-areas of the Riverfront Site – the Front Street Operable Unit (OU1). Maps developed by the U.S. Geological Survey (USGS) showing the location of New Haven, Missouri, and the locations of the Riverfront Site Operable Units are presented as Figures 1 and 2, respectively.

This assessment is based on sampling results obtained during investigations conducted by the USGS, the principle investigator for the Expanded Site Investigation/Remedial Investigation (ESI/RI) (2001) and Remedial Investigation (RI) (2002) of the Riverfront Site. USGS's objective has been to characterize the extent and magnitude of contamination at each of the Riverfront operable units. A draft RI report for OU1 and OU3 was issued in July 2002. MDHSS was provided with the laboratory sampling results collected from the Riverfront Site and in the vicinity of OU1. This assessment will evaluate risks that may result from human exposure to contaminated groundwater, and contaminated surface and subsurface soils.

### 1.2 Riverfront Site

Missouri Department of Natural Resources (MDNR) investigations at this site began in 1986 when PCE was detected in the two New Haven public water supply wells at levels exceeding EPA's Maximum Contaminant Level (MCL) for PCE of 5 μg/L. One of the wells (W1) was removed from service within the next few years due to other water quality problems. The other well (W2), however, was removed from service in 1993 when PCE concentrations were detected at 140 μg/L. Installation of two additional public water supply wells has reduced the potential for human exposure to PCE in the New Haven area. However, subsequent investigations by EPA, MDNR, and the USGS have identified multiple locations of solvent disposal in the area. These investigations also have established that contaminants have migrated through soils and groundwater beyond the initial source areas, creating additional potential for human exposure.

### 1.3 OU1 Site Background

Early MDNR investigations of the contaminated city wells identified several potential source locations scattered in and around the city of New Haven, one of which was the Front Street property. This property is fairly close (within 700 feet) to both former public water supply wells. EPA investigations have established that at least two of the former businesses occupying the

Front Street building may have used and disposed of chlorinated solvents, including PCE, on the property.

The Front Street building, which has been the target of intensive USGS environmental sampling in OU1, is the location of a former repair, machining, and manufacturing facility where PCE, a constituent of chlorinated solvents, was used and disposed of on-site. Historical aerial photography of the New Haven downtown district indicate that the Front Street building was initially built in the post-World War II era and was expanded through the mid-1960's. The building has had several owners over the course of its use. Contaminant concentrations beneath the Front Street building generally increase toward the east end of the facility, suggesting that the building was expanded over areas of the property that had previously received surface disposal of solvents and possibly other VOCs.

Multiple areas of contaminated soil and groundwater lie adjacent to and beneath the Front Street building. Analysis of data from USGS monitoring wells, GeoProbe boreholes, and tree core samples suggests that a plume of contaminated groundwater emanates from this property and extends to the northeast, possibly emerging in the Missouri River. The plume appears to lie predominantly in the shallow alluvial aquifer that borders the river, and possibly in the underlying bedrock aquifer. This shallow groundwater plume varies spatially and temporally with seasonal fluctuations in the level of the Missouri River. The plume underlies at least one and perhaps two of the residences to the north and adjacent to the Front Street building. Full characterization of the shallow plume has not been possible due to access restrictions in the area.

While conducting the Expanded Site Inspection, USGS unexpectedly discovered that PCE was diffusing into a short section of the city water distribution system that lay adjacent to the Front Street building and led to nearby public restrooms and the city's dog pen. In July 2000, EPA conducted a time-critical removal action to replace the polyethylene water pipeline with a steel line. Significant concentrations of contaminated soils were excavated along the water line, resulting in the removal of 762 tons of contaminated soil, up to 8 feet deep in some excavation cells. The location of this removal action is shown in a map developed by the USGS and is presented as Figure 3. During the removal action, USGS conducted additional sampling of surface and sub-surface soils south of the Front Street building, the analysis of which indicated that this area of OU1 contained large (tens to hundreds of thousands of parts per billion) concentrations of PCE and other VOCs. Because the excavation was within 300 feet of a flood-protection levee, the U.S. Army Corps of Engineers (US ACE) restricted excavation depths to less than 8 feet. These restrictions ensure the integrity of the levee foundation.

## 1.4 Site Description

The Riverfront Site Front Street Operable Unit (OU1) is located in the downtown district of New Haven, Missouri, which has as its north city limit the Missouri River. Features of OU1 are depicted in a map developed by the USGS and presented as Figure 4. New Haven is about 50 miles west of St. Louis on Missouri Highway 100 between Washington and Hermann, the latter a popular east-central Missouri tourist destination. The site can be found on the New Haven, Missouri USGS 7.5' Quadrangle Map at latitude 38 degrees 36 minutes 50 seconds North and 91 degrees 12 minutes 52 seconds West.

The New Haven downtown district lies in the Missouri River floodplain, but is protected by a U.S. Army Corps of Engineers' levee. The U.S. Census Bureau placed the April 2000 City of New Haven population at 1,867. Land uses in the downtown district are residential, light industrial,

commercial, and recreational. The New Haven Area Chamber of Commerce promotes community growth emphasizing small town charm as well as recreation and entertainment opportunities, such as the historic downtown district, antique shops, a walking trail atop the flood levee, a river public access point, and an annual festival marking the area's significance in the nineteenth century Missouri River steamboat trade.

The Front Street Operable Unit (OU1) lies at the northeast corner of the intersection of Front and Cottonwood Streets in downtown New Haven. The approximately 2-acre site consists of a one-story building, a loading dock, and a sparsely vegetated lot. The Front Street Building is primarily of metal construction with a concrete floor and was developed as a series of add-ons extending to the east of the original cinder block building. At present, the building lies slightly below the level of Front Street, and water tends to pool along the south and east edges.

An unoccupied commercial/light industrial building lies to the north of the Front Street building, the fronts of the two buildings facing Cottonwood Street. Two occupied residences lie to the northeast of this unoccupied building and are accessed by a lane at the end of Cottonwood Street that runs roughly parallel to Front Street. The back yards of both of these residences join the northern boundary of the Front Street lot, separated by a narrow alley where surface water runs through a concrete drain. A municipal storm water drop box is sited near the northeast corner of the Front Street building at the end of this alley. The eastern-most residence has a fence separating it from the Front Street property. The New Haven wastewater treatment facility lies approximately 500 feet to the east of OU1 beyond the levee. The New Haven City Utilities storage shed lies across Front Street to the south of OU1.

EPA's time critical removal action in July 2000 resulted in the excavation of a corridor of contaminated soils up to 8 feet deep just outside of the south side of the Front Street building along a New Haven city water service line. Following the installation of clean fill in the excavations, the disturbed areas along Front Street were resurfaced, and compacted gravel was placed over the excavated areas next to the building.

## 1.5 Scope of the Risk Assessment

A Baseline Risk Assessment (BRA) evaluates human health risks from hypothetical exposures to sampled contaminated environmental media if no final remedial action were taken at the site. The BRA provides the basis for taking action and identifies contaminants and exposure pathways to be addressed by remedial action.

This risk assessment used sampling results obtained during site investigations and sampling events conducted by the USGS under the ESI/RI and RI between February 1999 and March 2002. This assessment examined risks that may result from human exposure to contaminated groundwater, surface soils, and subsurface soils. Additionally, USGS supplied MDHSS with sediment and surface water samples from the Missouri River; however, these were dropped from the OU1 analysis, as they did not contain significant detections of site-related contaminants.

Based on the site conceptual model presented in the Work Plan for the Remedial Investigation of the New Haven Public Water Supply Site, New Haven, Missouri, prepared by the USGS (USGS, 2000b), potential health risks of OU1 contaminants were evaluated under current and possible future land-use scenarios. MDHSS' site assessment evaluated the potential for current and future health impacts of OU1 contaminants on receptors inhabiting, employed at, or visiting the Front Street area, within and outside the boundaries of OU1. Current human receptors that

may be exposed to OU1 contaminants include industrial workers potentially exposed to contaminated groundwater through the use of a shallow alluvial well in the downtown district and possible youth trespassers exposed to contaminated surface soils in and around the Front Street building. There is no data with which to assess risks from possibly contaminated soils to nearby residents whose property lies within the apparent pathway of the shallow plume. Future human receptors that may be chronically exposed to OU1 contaminants include residents potentially exposed to contaminated groundwater and surface soils and recreational visitors exposed to contaminated surface soils. Additionally, the possibility exists for current and/or future occupational workers to be exposed to OU1 contaminated surface soils. Also, due to elevated levels of chlorinated solvents in subsurface soils, current or future construction/utility workers may be temporarily exposed to excavated subsurface soils. Surface soil is considered to range from a depth of 0-2 feet, subsurface soils from a depth of greater than 2 feet.

As indicated above, investigations by EPA, MDNR, and USGS have established that PCE and other volatile organic contaminants have migrated through soils and groundwater in the vicinity of OU1, creating multiple human exposure points, including the subsurface vapor intrusion of volatilized contaminants into indoor air. Based on the volatility and toxicity of PCE and related compounds, MDHSS believes there is a potential for risks from chemical vapors that may migrate from the subsurface into current or future overlying buildings at this site. Vapors may originate from contaminated soils or groundwater. MDHSS is awaiting completion of post-RI indoor and ambient air sampling results to evaluate applicability of these data to a quantitative assessment of total risk generated by site contaminants. Therefore, the subsurface vapor intrusion into indoor air pathway will not be assessed in this report.

## 2.0 POTENTIAL CONTAMINANTS OF CONCERN (COC)

### 2.1 Source Residuals

The primary contaminants at the Riverfront Site - Front Street OU1 are PCE, TCE, and their respective degradation or breakdown products. The degradation/breakdown products detected in environmental media at OU1 include cis-1,2-dichloroethene, trans-1,2-dichloroethene, 1,2-dichloroethene (total), 1,1-dichloroethylene, 1,1,1-trichloroethane and vinyl chloride. Other volatile organic compounds (VOCs) at OU1 include benzene, toluene, ethylbenzene, and xylenes; semi-volatile organic compounds (SVOCs) include benzo(a)pyrene and other polycyclic aromatic hydrocarbons (PAHs), as well as a number of organochlorine pesticides and pesticide degradation/breakdown products. A number of inorganics have been identified at the site, including arsenic, lead, and mercury. No polychlorinated biphenyls (PCBs) were detected in sampled OU1 environmental media.

This report does not exclude constituents from risk calculations based on whether inorganic samples taken from OU1 are related to natural background or have an anthropogenic origin. In line with recent guidance for risk characterization (EPA, 2001a), this assessment retains detected constituents that exceed risk-based screening concentrations and may be attributable to natural background. In particular, arsenic has not been excluded from risk calculations, and whether risks posed by arsenic (or any other constituent attributable to natural background) warrant remedial action will not be addressed in this document. However, a comparison and discussion of site concentrations to background concentrations of arsenic is included in Section 6.0 (Uncertainties).

A quantitative evaluation of the hazards and risks that result from exposure to lead will not be conducted in this assessment as site soils generally do not exceed the screening level for lead, which is 400 mg/kg (EPA, 1994b). MDHSS has determined that although sampling results indicate that hot-spot areas of lead contaminated soils do exist in the vicinity of OU1 and adjacent to the Riverfront building, the site does not require further site-specific assessment with EPA's Integrated Exposure Uptake Biokinetic Model (IEUBK) (Pub. # 9285.7-15-2, PB93-963511). Explanatory details on this determination are presented in the Section 6.0 (Uncertainties).

## 2.2 Data Collection and Evaluation

This assessment used the sampling results collected between February 1999 and March 2002 for groundwater taken in the vicinity of the Riverfront site as well as surface and subsurface soils beneath, adjacent to, and in the vicinity of the Front Street building. The various samples were tested for either one or a combination of the following: VOCs, SVOCs, PCBs, and inorganics.

Sampling locations were selected during investigations and sampling events performed by the USGS. Alluvial system and bedrock monitoring wells, including a shallow hand-dug well that predated the Riverfront investigations, were located in proximity to the Front Street building and City Well W2, also in the downtown district. Borehole and soil samples were collected both randomly and with the goal of sampling outside of the pre-1960 building footprint. Two soil samples taken from areas that were later excavated during the removal action were dropped from analysis, as the contaminant concentrations reported in the summer of 2000 were not reflective of current conditions. These two samples are OU1-SO-EPA-P-25 taken on 7/11/00 and OU1-SO-EPA-CELL 5 taken 8/14/00.

QA/QC measures were incorporated into USGS's methods and procedures to help ensure quality, precision, accuracy, and completeness of data and analysis. Field and laboratory quality checks were incorporated into sample collection and analysis procedures as part of the QA/QC measures. Field quality checks were implemented into the sample collection procedures to minimize the potential for interference or introduction of contaminants during sample collection and processing, storage, transport, and equipment decontamination, and included collection of blank and duplicate samples among other measures. Laboratory quality checks were implemented to ensure laboratory systems operated within acceptable guidelines and to minimize or document the occurrence of laboratory contamination and variability in analytical results, and included method blanks among other measures.

Only those samples with corresponding supporting documentation, including custody records and field notes, were included in quantitative analysis. MDHSS reviewed and analyzed QA/QC measures associated with each of these samples to ensure quality data, and determined that all data were acceptable for quantitative analysis with the following exceptions:

Methylene chloride was dropped from further consideration due to the fact that it is considered a common laboratory contaminant and additionally was only detected in two groundwater samples whose associated method blanks were contaminated with this constituent at reportable levels.

Acetone was retained as a COC, but individual results were dropped from analysis for three subsurface soil samples, due to the fact that it is considered a common laboratory contaminant

and the associated method blanks for the three results dropped were contaminated with this constituent at reportable levels.

Constituents with detectable concentrations for each media were retained as COCs, with the exception of methylene chloride as noted above. A complete listing of the COCs is presented in Table 1. Sample results for each media along with spreadsheets demonstrating the COC selection and determination of final concentrations are attached to this document as Appendices: Appendix A presents the groundwater well samples; Appendix B presents the groundwater borehole samples; Appendix C presents the surface soil samples; and Appendix D presents the subsurface soil samples.

### 2.2.1 Groundwater

#### Groundwater Sampling Methods

Groundwater samples were obtained from 8 monitoring wells established around the putative source at the Riverfront Front Street building and from 13 GeoProbe boreholes adjacent to and beneath the building. During MDHSS' review of groundwater data, it was noted that samples taken from the monitoring wells were substantially different from borehole samples. For example, 17 chemical constituents were detected in the monitoring well samples whereas only six contaminants were detected in the borehole samples. In addition, it was observed that for some contaminants, the maximum detected values between the two data sets differed by up to two orders of magnitude. MDHSS believes that this difference likely is related to the necessity of the laboratory having to dilute a significant number of the borehole samples during analysis, a dilution effect having already occurred within the screened area of the monitoring wells. Presented in Figure 5 is a comparison of the maximum detected values for groundwater in well sampling versus borehole sampling. MDHSS has concluded that data from the borehole samples does not represent exposures that could potentially occur via a public or private well.

Due to the marked dissimilarities between these two data, MDHSS determined that it would be more informative to conduct two separate groundwater risk calculations, one based on the monitoring well samples and the other based on the borehole samples. Although combining these data sets may have produced a legitimate representation of groundwater conditions, there would have been a loss of information that could be valuable to interpretation of potential site risks.

#### Groundwater Exposure Point Concentration (EPC)

USGS's investigations have considerably reduced the level of uncertainty regarding the direction of groundwater flow in the downtown district, the level of communication between aquifers, and the likely boundaries of the plume. However, based on data available to date, a boundary between shallow and deep flow systems has not been determined, and there exists a potential for shallow ground water, and any contaminants dissolved within it, to move downward into the deep flow system. This possible connectivity provides the rationale for calculating the groundwater EPC by combining groundwater data from multiple depths, and from all samples for which there was at least one detection of a site contaminant.

In order to estimate the groundwater EPC representative of possible contaminant intake, comparison was made between the 95% upper confidence limit (UCL) of each mean contaminant value and the maximum detected value. In absence of sufficient data to statistically calculate the UCL, the maximum detected value was chosen as representative.

Groundwater concentrations for COCs detected in well and borehole sampling are presented in Tables 2a-b and 3, respectively.

2.2.2 Soils

In order to estimate the surface and subsurface soil concentrations representative of possible contaminant intake, comparison was made between the 95% upper confidence limit (UCL) of each mean contaminant value and the maximum detected value. In absence of sufficient data to statistically calculate the UCL, the maximum detected value was chosen as representative.

Surface and subsurface soil concentrations for COCs are presented in Tables 4 and 5, respectively.

## 3.0 EXPOSURE ASSESSMENT

3.1 Exposure Setting during MDHSS Site Visits

MDHSS staff conducted three site visits to the Riverfront Site – July 2000, June 2001 and March 2002. MDHSS staff observations relevant to this risk assessment include the following:

- Poor site drainage: Pools of water from recent precipitation events observed on two occasions occurring on both sides of Front Street adjacent to and east of the Front Street and New Haven City Utilities buildings.
- The eastern-most portion of the Front Street Site lot is covered with gravel, only partially vegetated, and littered with trash and debris.
- The New Haven downtown district is a mixed residential/commercial/recreational land use; the zoning classification for OU1 site is currently "Light Industrial."
- The levee serves as a local recreational attraction: Pedestrians use the levee walking trail that encloses OU1 to the north and east; picnic tables and benches have been placed alongside the trail. In addition, the levee is the site of a local landmark – an old railroad caboose.
- The downtown district, west of OU1, is comprised of a small commercial district oriented toward recreational activities, which includes a locally popular restaurant, an artisan's shop and a bait-and-tackle shop. On one occasion, staff observed an occupied houseboat being serviced by a marine-and-harbor service vehicle moored upstream from the public river access point.
- Two occupied residences lie immediately north of OU1, separated from the Front Street building by a narrow alley. Additionally, evidence was observed of children living at or frequenting these two homes.

## 3.2 Exposure Pathways

Exposure to contaminants is defined as the contact of a receptor with a contaminant. For exposure to occur, there must be a source of contaminant (for example, contaminated water or soil), a receptor (a person), and a mechanism or pathway for contaminants to reach the receptor (such as ingestion of, or dermal contact with, contaminated media, or inhalation of particulates or vapors from contaminated media). Contaminated media at OU1 include groundwater and surface and subsurface soils.

Contaminants may be transported from a site to secondary media (surface and subsurface soils, ambient and indoor air, groundwater, surface water, and sediments) through several processes, including leaching of contaminants to groundwater from soil or surface water, recharge of surface water from contaminated groundwater, and migration or erosion of contaminated soil particles to air or surface water. Several potential exposure pathways may exist for each contaminated media. For OU1 these pathways include:

Groundwater

- drinking water ingestion during occupational activities
- drinking water ingestion, and dermal contact and inhalation risk from showering for residents

Surface and Subsurface Soils

- incidental ingestion of contaminated surface soils may occur during trespassing, residential, occupational, or recreational activities; and incidental ingestion of contaminated subsurface soils may occur during construction/utility worker activities
- dermal contact with surface soil may occur during trespassing, residential, occupational, or recreational activities; and dermal contact with subsurface soil may occur during construction/utility worker activities
- inhalation of contaminants may occur from particulates liberated into the air or vapors released from surface soil during trespassing, residential, occupational, or recreational activities; and inhalation of contaminants may occur from particulates liberated into the air or vapors released from subsurface soil during construction/utility worker activities

As indicated in Section 1.5, Scope of the Risk Assessment, this assessment will not include a quantitative analysis of human exposure to plume contaminants that may occur when PCE and other volatile organic compounds vaporize and seep into building foundations. This exposure pathway certainly has the potential to be a completed pathway; however, MDHSS is awaiting completion of post-RI basement, building interior, and ambient air sampling results to evaluate the applicability of available data to a quantitative assessment of total risk generated by site contaminants.

## 3.3 Exposure Scenarios

Current Occupational Exposures to Groundwater

At present, a small number of occupational workers are potentially exposed to contaminated groundwater via a PCE contaminated well in use at a fertilizer manufacturing plant in the downtown district. When USGS drew a water sample from the industrial well, a plant employee reported that the water was not used for human consumption; however, investigators did not observe any controls that prevent workers drinking from this well. The exposure concentration

for this scenario consists of the results of one sample taken from the well on 03/27/01. To calculate risks for a current occupational exposure scenario, MDHSS reduced the ingestion rate of water from 2 liters per day (L/day) to 1 L/day, accounting for workers spending only a portion of their day at the fertilizer manufacturing plant. The remaining exposure assumptions used to calculate intake and risks for the current occupational exposure scenario are detailed in Table 6a.

Current Trespasser Exposures

At present, access to surface soil contaminants at OU1 is not limited to trespassers through perimeter fencing, warning signs, or other security measures. In addition, OU1 offers several elements that may be attractive to trespassers year round with evidence that trespassing activities are currently occurring – a secluded alley that leads to a storm drainage opening, debris and trash scattered across a sparsely vegetated lot, a below-grade loading dock, and the site's location in close proximity to the public river access point and the levee walking trail. MDHSS has determined that the evaluation of current exposure scenarios at OU1 should include a youth trespasser.

EPA RAGs guidance does not supply default values for a youth trespasser's activity specific adherence factor of soil-to-skin (AF) or skin surface area (SA). In line with the recommendation in Appendix C: "Soil Pathway," from the RAGs Part E (Dermal) guidance, (EPA, 2001d), MDHSS consulted the Exposure Factors Handbook (EFH) (EPA, 1997a) for activity descriptions that would best represent the soils, exposed body parts, and general activities of a youth trespasser. The Soccer Players #1, described in EFH Table 6-11 (Summary of Field Studies) was chosen as the best representation of the OU1 youth trespasser's activities. Although the age range (Exposure Duration) of the OU1 youth trespasser (age 8 through 15) is slightly longer than the age range reported for the Soccer Players #1, the soils, body parts, and activities are somewhat similar. The Soccer Players #1 group consists of teens playing on partially vegetated ground under moist conditions, wearing long sleeves and shorts or long pants. The OU1 Youth Trespasser would be similarly dressed, and spending time possibly investigating partially buried site debris revealed by incompletely vegetated soils, as well as the adjacent alley, which terminates at the alley's east end in a large storm-water intake pipe. Also, as indicated above, MDHSS staff observed that poor site drainage in the area of OU1 leaves small pools of mud and water, rendering soils wet or moist at least seasonally. Thus, it is projected that the geometric mean weighted soil adherence factor (AF) for the Soccer Player #1, which is 0.04 mg/cm$^2$, would adequately represent site activities.

In addition, MDHSS calculated a skin surface area available for contact of 4,900 cm$^2$ using the information in the table presented in Exhibit C, "Body Part-Specific Surface Area Calculations," page C-3 of RAGs E (EPA, 2001d), assuming a mid-range Soccer Players #1 individual between 13 and 14 years. This surface area derivation is included in the table below. The remaining exposure factors for the youth trespasser are detailed in Table 6b.

Body Part-Specific Surface Area Calculation For the Youth Trespasser

| Body Part | SA Calculation | Totals |
|---|---|---|
| Head | 0.0997 * 1.47 m$^2$ = | 0.146559 |
| Forearms | 0.0545 * 1.47 m$^2$ = | 0.080115 |
| Hands | 0.0511 * 1.47 m$^2$ = | 0.075117 |
| Lower Legs | 0.128 * 1.47 m$^2$ = | 0.18816 |
| OVERALL TOTAL = 0.489951 m$^2$; rounded = 4, 900 cm$^2$ | | |

Future Residential Exposures

USGS was denied access to the potentially contaminated surface and subsurface soils on the residential property that lies within the putative pathway of the shallow groundwater plume. In addition, drinking water is currently supplied to residents by the two new municipal wells that have not been contaminated by PCE. Thus, there is no contaminant concentration data with which to calculate potential risks from exposure to surface soils for a current residential scenario, and additionally, no completed direct-contact pathway exists for a current residential exposure scenario to groundwater. Instead, MDHSS examined a future residential exposure scenario to evaluate risks from exposure to detected contaminant concentrations in surface soils and groundwater. Although the OU1 site is currently zoned as "Light Industrial" by the City of New Haven, it is located within a mixed residential/commercial/recreational area; and therefore, all three of these land uses are also reasonable possibilities for the future.

The future residential scenario incorporates a time-weighted average (TWA) approach to modeling risks to an individual living near the site from birth through adulthood who may be exposed to groundwater or surface soils. The future resident's daily intake of contaminated groundwater includes drinking water ingestion, and dermal contact and inhalation of volatilized contaminants while showering. The future resident's daily intake of contaminated soil includes incidental ingestion, dermal contact, and inhalation of soil particulates or volatiles. The specific exposure assumptions used to calculate intake and risks for the future residential scenario are detailed in Tables 6a and 6b. MDHSS assumed the future resident is not exposed to subsurface soils.

Current or Future Occupational and Future Recreational Exposures to Surface Soils

As indicated above, current land uses surrounding OU1 include commercial and light industrial activities, creating a potential for current occupational exposures. Occupational land uses also are a reasonable future possibility for the site. Given that the area is currently the site of some minor recreational activities, it is also possible that redevelopment of OU1 land could result in increased recreational activities that should be assessed.

The current or future occupational scenario theorizes that a commercial/industrial worker may be exposed to contaminated groundwater or surface soil as a long-term receptor, and may be involved in outdoor maintenance work, indoor/outdoor loading and shipping activities, indoor commercial activities, or office work. The exposure duration and frequency is less than that of a residential receptor, but typical occupational activity levels necessitate a slightly higher soil-to-skin adherence factor. The future recreational visitor may be exposed to contaminated surface soil and is also a long-term scenario, incorporating a time-weighted average approach to an individual who visits the site from birth through adulthood. The visitor scenario does not include exposure to Missouri River surface water and sediments as site contaminants were not detected in sampling results, nor does it consider consumption of fish tissues that may carry contaminant residuals. Specific exposure assumptions used to calculate intake and risks for the current or future occupational worker and future recreational visitor scenario are detailed in Tables 6a and 6b.

Current or Future Construction/Utility Worker Exposures

Although no specific redevelopment project is currently anticipated for the OU1 property or in its vicinity, the site falls within existing utility and transportation infrastructure and would therefore likely be an area subject to current or future excavation during redevelopment activities or utility

repair. Human exposures during construction activities or utility repair would be expected to be short term, although there exists a greater potential for higher contaminant exposure due to increased soil contact during excavation. To reflect this higher level of soil contact, current or future construction/utility worker exposure assumptions include inhalation of contaminated subsurface soil particulates or volatiles, an increased rate of soil ingestion, and slightly higher soil-to-skin adherence factor. Specific exposure assumptions used to calculate intake and risks for the current or future construction/utility worker are presented in Tables 6b.

3.4 Calculation of Contaminant Intake

Intake rates for all contaminants were quantified using pathway-specific equations given in EPA's (1989) Risk Assessment Guidance for Superfund: Volume I (RAGS).

Chemical intakes for the current and future occupational, current trespasser, and current or future construction/utility worker scenarios were calculated using the equations listed below.

Drinking Water Ingestion of Groundwater
Intake (mg/kg-day) = (Cw*IRW*EF*ED) / (BW*AT)

Incidental Ingestion of Soil
Intake (mg/kg-day) = (Cs*CFs*IRS*FI*EF*ED) / (BW*AT)

Dermal Contact with Soil
Dermally Absorbed Dose (mg/kg-day) = (Cs*CFs*SA*AF*ABS*EF*ED) / (BW*AT)

Inhalation of Particulates or Volatiles from Surface Soil
Intake (mg/kg-day) = (Cs*IRA*(1/PEF or 1/VF)*EF*ED) / (BW*AT)

Inhalation of Particulates or Volatiles from Subsurface Soil
Intake (mg/kg-day) = (Cs*IRA*(1/PEF or 1/VF)*EF*ED) / (BW*AT)

Chemical intake for the future residential and recreational scenarios were calculated using the modified equations listed below that take into account a child's exposure by utilizing time-weighted averages for both an adult and a child exposure (EPA 1989).

Drinking Water Ingestion of Groundwater
Intake (mg/kg-day) = [Cw*EF*((IRWa*EDa / BWa)+(IRWc*EDc / BWc))] / AT

Dermal Contact with Groundwater while Showering
Dermally Absorbed Dose (mg/kg-day) =
Cw*CFw*PC*ET*EF*[(SAa*EDa / BWa)+(SAc*EDc / BWc)] / AT

Inhalation of Airborne Particles while Showering
Intake (mg/kg-day) = [Ca*IRA*ET*EF*((EDa / BWa)+(EDc / BWc))] / AT

Incidental Ingestion of Soil
Intake (mg/kg-day) = Cs*CFs*FI*EF*[(IRSa*EDa / BWa)+(IRSc*EDc / BWc)] / AT

Dermal Contact with Soil
Dermally Absorbed Dose (mg/kg-day) =
Cs*CFs*ABS*EF*[(SAa*AFa*EDa / BWa)+(SAc*AFc*EDc / BWc)] / AT

Inhalation of Particulates or Volatiles from Surface Soil
Intake (mg/kg-day) = [Cs*(1/PEF or 1/VF)*EF*((IRAa*EDa / BWa)+(IRAc*EDc / BWc))] / AT

The variable definitions and values for these equations are presented in Tables 6a-b. Calculation worksheets are included as attachments to this document as Appendix E.

## 4.0 TOXICITY ASSESSMENT

### 4.1 Carcinogenic Effects

Slope Factors (SF) are the toxicity values used in assessing carcinogenic effects from exposure. SFs are defined as the plausible upper-bound estimate of the probability of carcinogenic effects per unit intake of a chemical expressed over a lifetime. EPA's Integrated Risk Information System (IRIS) contains many contaminant-specific Oral SFs and Inhalation Unit Risks ($UR_i$). $SF_o$ and $UR_i$ values which are unable to be found on IRIS, may be found in EPA's Health Effects Assessment Summary Tables (HEAST), (EPA, 1997b). If $SF_o$ or $UR_i$ values were not available in IRIS or HEAST, EPA's National Center for Environmental Assessment (NCEA) - Superfund Technical Support Center (STSC) risk assessment issue papers (EPA, 1993-2001) were reviewed to obtain provisional values.

In order to assess carcinogenic effects from dermal exposure, it is necessary to convert oral SFs to absorbed SFs by use of an oral absorption efficiency (OAE) variable. The formula to adjust oral toxicity values to absorbed toxicity values for use in dermal equations is:

$$SF_{oral}\ (mg/kg\text{-}d)^{-1} \div OAE\ (unitless) = SF_{dermal}\ (mg/kg\text{-}d)^{-1}$$

Oral-to-dermal extrapolation is not recommended for volatiles or certain inorganics; therefore, dermal contribution was not calculated for all COCs. For those COCs for which oral-to-dermal extrapolation is appropriate, it is necessary to adjust the dermal intake formulae by use of a dermal absorbance (ABS) variable. When chemical-specific absorption information was unavailable, default variables were used to assess dermal contribution as follows: ABS for SVOCs – 0.1.

To estimate the contribution of inhalation exposure for carcinogenic effects, it is necessary to convert the Inhalation Unit Risks ($UR_i$) to SFs. The formula to adjust these values to toxicity values for use in inhalation equations is:

$$UR_i\ (\mu g/m^3)^{-1} * 70\ (kg) * 1000\ (\mu g/mg) /20\ (m^3/d) = SF_{inhalation}\ (mg/kg\text{-}d)^{-1}$$

COC-specific SF values for each exposure pathway along with the associated target organs, including the OAE and $UR_i$ values utilized for conversion-purposes, to calculate the Carcinogenic Risks for groundwater, surface soil, and subsurface soil are presented in Table 7a, 7b, and 7c, respectively.

Carcinogenic risk could not be calculated for all contaminants of concern due to lack of carcinogenic toxicity information. Those constituents for which information was unavailable for the specified pathways are also presented in the aforementioned tables.

## 4.2 Non-Carcinogenic Effects

References Doses (RfDs) are the toxicity values used in assessing non-carcinogenic effects from exposure. A chronic RfD is defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime. EPA's Integrated Risk Information System (IRIS) contains many contaminant-specific Oral RfDs and Inhalation Reference Concentrations (RfC). $RfD_o$ and RfC values which are unable to be found on IRIS, may be found in EPA's Health Effects Assessment Summary Tables (HEAST), (EPA, 1997b). If $RfD_o$ or RfC values could not be found in IRIS or HEAST, EPA's National Center for Environmental Assessment (NCEA) - Superfund Technical Support Center (STSC) risk assessment issue papers (EPA, 1993-2001) were reviewed to obtain provisional values.

According to RAGS, subchronic exposures are often a concern at Superfund sites, varying in exposure durations of more than 2 weeks to less than 7 years. Subchronic RfDs ($RfD_s$) and subchronic RfCs ($RfC_s$) are the toxicity values used in assessing non-carcinogenic effects from subchronic exposures. Since RfD and RfC values are not available through the IRIS database, subchronic toxicity information used in this risk assessment was obtained from HEAST (EPA, 1997b) and NCEA (EPA, 1993-2001 and EPA, 2002c).

In order to assess non-carcinogenic effects from dermal exposure, it is necessary to convert oral RfDs to absorbed RfDs by use of an oral absorption efficiency (OAE) variable. The formula to adjust oral toxicity values to absorbed toxicity values for use in dermal equations is:

$$RfD_{oral}\ (mg/kg\text{-}d) * OAE\ (unitless) = RfD_{dermal}\ (mg/kg\text{-}d)$$

Oral-to-dermal extrapolation is not recommended for volatiles or certain inorganics; therefore, dermal contribution was not calculated for all COCs. For those COCs for which oral-to-dermal extrapolation is appropriate, it is necessary to adjust the dermal intake formulae by use of a dermal absorbance (ABS) variable. When chemical-specific absorption information was unavailable, default variables were used to assess dermal contribution as follows: ABS for SVOCs – 0.1.

To estimate the contribution of inhalation exposure, it is necessary to convert the Reference Concentrations (RfC) to RfDs. The formula to adjust these values to toxicity values for use in inhalation equations is:

$$RfC\ (mg/m^3) * 20\ (m^3/d) / 70\ (kg) = RfD_{inhalation}\ (mg/kg\text{-}d)$$

COC-specific RfD values for each exposure pathway along with the associated effects of concern, including the OAE and RfC values utilized for conversion-purposes, to calculate the Hazard Index for groundwater, surface soil, and subsurface soil are presented in Table 8a, 8b, and 8c, respectively.

A Hazard Index could not be calculated for all contaminants of concern due to lack of non-carcinogenic toxicity information. Those constituents for which information was unavailable for the specified pathways are also presented in the aforementioned tables.

## 5.0 Risk Characterization

5.1 Carcinogenic Risks

Lifetime excess cancer risks (CR) were calculated for each contaminant in each pathway by multiplying the slope factor (SF) by the Chronic Daily Intake (CDI). Within a pathway, the chemical specific risks were summed to give the total pathway risk. The Total Excess Lifetime Cancer Risk was then determined by summing the total pathway risks. EPA generally considers a total excess lifetime cancer risk for a reasonable maximum exposure that exceeds $10^{-4}$ (1 in 10,000) to be unacceptable. Total excess lifetime cancer risks below $10^{-6}$ (1 in 1,000,000) are considered acceptable.

5.1.1 Current Occupational Worker Exposed to Groundwater Scenario – Carcinogenic Risks

The total excess lifetime cancer risk for the current occupational exposure to groundwater scenario is $7.2 \times 10^{-7}$ (7.2 in 10,000,000), and is presented in Table 9. The entire risk for this scenario is generated through the ingestion of groundwater from an industrial well contaminated with tetrachloroethene, and falls below the $1 \times 10^{-6}$ risk level.

5.1.2 Current Trespasser Exposed to Surface Soil Scenario -- Carcinogenic Risk
The total excess lifetime cancer risk for the current youth trespasser exposed to surface soil exposure scenario is $5.3 \times 10^{-6}$ (5.3 in 1,000,000), and is presented in Table 10. Incidental ingestion of soil is responsible for the largest contribution to excess lifetime cancer risks, followed by inhalation of particulates or volatiles, both of which fall within the range of $10^{-4}$ to $10^{-6}$. Risks from the ingestion of soil are driven by benzo(a)pyrene, and risks from inhalation of particulates or volatiles are driven by tetrachloroethene. Risk contribution for the dermal contact pathway falls below the $1 \times 10^{-6}$ risk level.

5.1.3.a Future Resident Exposed to Groundwater (well samples) Scenario -- Carcinogenic Risk
The total excess lifetime cancer risk for the future residential groundwater (well samples) scenario is $1.7 \times 10^{-3}$ (1.7 in 1000), and is presented in Table 11. Because the risk exceeds $1 \times 10^{-4}$ (1.0 in 10,000), an unacceptable level of cancer risk may exist for a future resident exposed to groundwater from contaminated aquifers underlying OU1 as represented by monitoring well samples. Of the three pathways analyzed in this scenario, ingestion of groundwater is responsible for the largest contribution to excess lifetime cancer risks. This pathway exceeds the $1 \times 10^{-4}$ cancer risk level, calculated at $1.7 \times 10^{-3}$ (1.7 in 1000). Risk contribution from the dermal and inhalation exposure pathways fall within the range of $10^{-4}$ to $10^{-6}$. Vinyl chloride contributed the greatest risk for the ingestion and dermal pathways, followed by trichloroethene and tetrachloroethene. Tetrachloroethene followed by vinyl chloride contributed the greatest risk for the inhalation pathway.

5.1.3.b Future Resident Exposed to Groundwater (borehole samples) Scenario -- Carcinogenic Risk

The total excess lifetime cancer risk for the future residential groundwater (borehole samples) scenario is $1.1 \times 10^{-2}$ (1.1 in 100), and is presented in Table 11. Because the risk exceeds $1 \times 10^{-4}$ (1.0 in 10,000), an unacceptable level of cancer risk may exist for a future resident exposed to groundwater from contaminated aquifers underlying OU1 as represented by borehole samples. Of the three pathways analyzed in this scenario, ingestion of groundwater is responsible for the largest contribution to excess lifetime cancer risks, followed by the dermal exposure pathway. Both of these pathways exceed the $1 \times 10^{-4}$ cancer risk level, with the

ingestion of groundwater pathway risk calculated at $1.0 \times 10^{-2}$ (1 in 100), and the dermal risk at $6.2 \times 10^{-4}$ (6.2 in 10,000). Risk contribution from the inhalation of vapors while showering pathway falls within the range of $10^{-4}$ to $10^{-6}$. Trichloroethene contributed the greatest risk to the ingestion and dermal pathways, followed by tetrachloroethene, vinyl chloride, and benzene. Tetrachloroethene contributed the greatest risk to the inhalation pathway, followed by trichloroethene, benzene, and vinyl chloride.

5.1.4 Future Resident Exposed to Surface Soil – Carcinogenic Risk

The total excess lifetime cancer risk for a future residential scenario exposure to surface soil is $1.2 \times 10^{-4}$ (1.2 in 10,000), and is presented in Table 12. Because the risk exceeds $1 \times 10^{-4}$ (1.0 in 10,000), an unacceptable level of cancer risk may exist for a future resident exposed to surface soils. Of the three pathways analyzed in this scenario, incidental ingestion of soil is responsible for the largest contribution to excess lifetime cancer risks, followed by inhalation of particulates or volatiles and dermal contact with soils, all of which fall within the range of $10^{-4}$ to $10^{-6}$, while combined reach a total cancer risk greater than $1 \times 10^{-4}$. Risks from the ingestion of soil and dermal contact with soil are driven by benzo(a)pyrene, followed by arsenic and benzo(b)fluoranthene. Risks from the inhalation of particulates or volatiles are driven by tetrachloroethene, followed by vinyl chloride and trichloroethene.

5.1.5.a Future Occupational Worker Exposed to Groundwater (well samples) – Carcinogenic Risk

The total excess lifetime cancer risk for the future occupational groundwater (well samples) scenario is $3.1 \times 10^{-4}$ (3.1 in 10,000), and is presented in Table 13. Because the risk exceeds $1 \times 10^{-4}$ (1.0 in 10,000), an unacceptable level of cancer risk may exist for a future commercial or industrial worker exposed to groundwater via ingestion from contaminated aquifers underlying OU1 as represented by monitoring well samples. Vinyl chloride was the contaminant that contributed the highest level of risk for this scenario, followed by trichloroethene, and tetrachloroethene.

5.1.5.b Future Occupational Worker Exposed to Groundwater (borehole samples) – Carcinogenic Risk

The total excess lifetime cancer risk for the future occupational groundwater (borehole samples) scenario is $2.3 \times 10^{-3}$ (2.3 in 1000), and is presented in Table 13. Because the risk exceeds $1 \times 10^{-4}$ (1.0 in 10,000), an unacceptable level of cancer risk may exist for a future commercial or industrial worker exposed to groundwater via ingestion from contaminated aquifers underlying OU1 as represented by borehole samples. Trichloroethene contributed the highest level of risk for this scenario, followed by vinyl chloride, tetrachloroethene, and benzene.

5.1.6 Current or Future Occupational Worker Exposed to Surface Soils – Carcinogenic Risk

The total excess lifetime cancer risk for a current or future occupational scenario exposure to surface soil is $2.9 \times 10^{-5}$ (2.9 in 100,000), and is presented in Table 14. Of the three pathways analyzed in this scenario, inhalation of particulates or volatiles is responsible for the largest contribution to excess lifetime cancer risks, followed by dermal contact with soils and incidental ingestion of soils, all of which fall within the range of $10^{-4}$ to $10^{-6}$. Risks from inhalation of particulates or volatiles are driven by tetrachloroethene, followed by vinyl chloride. Risks from dermal contact with soil and the ingestion of soil are driven by benzo(a)pyrene, followed by arsenic and benzo(b)fluoranthene.

5.1.7 Future Recreational Visitor Exposed to Surface Soil – Carcinogenic Risk

The total excess lifetime cancer risk for a future recreational scenario exposure to surface soil is $2.1 \times 10^{-5}$ (2.1 in 100,000), and is presented in Table 15. Of the three pathways analyzed in this scenario, incidental ingestion of soil is responsible for the largest contribution to excess cancer risks, followed by inhalation of particulates or volatiles and dermal contact with soils, all of which fall within the range of $10^{-4}$ to $10^{-6}$. Risks from the ingestion of soil and dermal contact with soil are driven by benzo(a)pyrene, followed by arsenic, and benzo(b)fluoranthene. Risks from the inhalation of particulates or volatiles pathway are driven by tetrachloroethene.

5.1.8 Current or Future Construction/Utility Worker Exposed to Subsurface Soil – Carcinogenic Risk

The total excess lifetime cancer risk for the current or future construction/utility worker scenario is $1.1 \times 10^{-6}$ (1.1 in 1,000,000), and is presented in Table 16. The total risk for this scenario falls just within the range of $10^{-4}$ to $10^{-6}$, while the three pathways taken individually each fall below the $1 \times 10^{-6}$ risk level. Inhalation of particulates or volatiles from subsurface soil is responsible for the largest contribution to excess cancer risks. Tetrachloroethene in subsurface soils was the driver in the inhalation of particulates or volatiles pathway, which contributed the majority of risk in this scenario.

5.2 Noncarcinogenic Effects

Noncancer hazard quotients (HQs) were calculated for each contaminant in each pathway by dividing the Chronic Daily Intake (CDI) by the RfD. The HQ represents the quantitative estimate of noncarcinogenic hazard from exposure to that specific chemical by that specific pathway in that specific media. These contaminant-specific HQs are then summed within an exposure pathway (inhalation of soil, dermal contact with soil, etc.) to determine the pathway hazard index (HI). Each pathway within a media has the same COCs, at the same concentrations, as other pathways in that media, but may differ in the amount of contaminant a receptor may intake depending on the pathway. The pathway HIs are then summed for each media. This would represent the quantitative hazard for exposure to all COCs in that single media. Each media has it's own, possibly different, group of COCs and intakes, and therefore, different hazard indices. The Total Hazard Index was then calculated by summing the hazard indices for each media that the scenario's receptor is assumed to have exposure with. According to RAGS, human health risks may exist when the Total Hazard Index exceeds unity (1.0).

5.2.1 Current Occupational Worker Exposed to Groundwater Scenario -- Hazard Index

The Total Hazard Index for the current occupational scenario is 0.01, and is presented in Table 17. Because the total hazard index is less than 1.0, adverse noncarcinogenic health effects are not expected to occur for current occupational workers who may consume water from an industrial well near OU1.

5.2.2 Current Trespasser Exposed to Surface Soil Scenario -- Hazard Index

The Total Hazard Index for the trespasser scenario is 0.06, and is presented in Table 18. Because the total hazard index is less than 1.0, adverse noncarcinogenic health effects are not expected for current youth trespassers exposed to surface soil.

5.2.3.a Future Resident Exposed to Groundwater (well samples) Scenario -- Hazard Index

The Total Hazard Index for the future residential groundwater (well samples) scenario is 12, and is presented in Table 19. Because the total hazard index is greater than 1.0, there is a potential for adverse noncarcinogenic health effects for residents living on the site who are exposed to groundwater from contaminated aquifers underlying OU1 (as represented by monitoring well samples). Exposure in this scenario occurs via ingestion, and dermal contact and inhalation of vapors while showering. Ingestion exposure to trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, vinyl chloride and tetrachloroethene were the primary drivers resulting in a total pathway Hazard Index greater than 1.0. Of these, only tetrachloroethene did not contribute an individual contaminant Hazard Quotient of at least 1. None of these contaminants contributed an individual contaminant Hazard Quotient greater than 1 in the dermal and inhalation pathways.

5.2.3.b Future Resident Exposed to Groundwater (borehole samples) Scenario -- Hazard Index

The Total Hazard Index for the future residential groundwater (borehole samples) scenario is 192, and is presented in Table 19. Because the total hazard index is greater than 1.0, there is a potential for adverse noncarcinogenic health effects for residents living on the site who are exposed to groundwater from contaminated aquifers underlying OU1 (as represented by borehole samples). Exposure in this scenario occurs via ingestion, and dermal contact and inhalation of vapors while showering. Ingestion exposure to trichloroethene, 1,2-dichloroethene (total), tetrachloroethene, cis-1,2-dichloroethene, and vinyl chloride were the primary drivers to total groundwater (borehole samples) exposure, each of these contributing an individual contaminant Hazard Quotient of at least 1, trichloroethene contributing the greatest part of the hazard with a HQ of 154. For the dermal pathway, trichloroethene and tetrachloroethene contributed individual contaminant Hazard Quotients of 8.7 and 1.4, respectively. No contaminant contributed an individual contaminant Hazard Quotient greater than 1 in the inhalation pathway.

5.2.4 Future Resident Exposed to Surface Soil – Hazard Index

The Total Hazard Index for the future residential surface soil scenario is 0.3, and is presented in Table 20. Because the total hazard index is less than 1.0, adverse noncarcinogenic health effects are not expected to occur for future residents exposed to surface soil.

5.2.5.a Future Occupational Worker Exposed to Groundwater (well samples) – Hazard Index

The Total Hazard Index for the future occupational groundwater (well samples) scenario is 3.0, and is presented in Table 21. Because the total hazard index is greater than 1.0, there is a potential for adverse noncarcinogenic health effects for future occupational workers who may consume water from contaminated aquifers underlying OU1 (as represented by monitoring well samples). Exposure to trichloroethene, 1,2-dichloroethene (total), cis-1,2-dichloroethene, vinyl chloride, and tetrachloroethene were the primary drivers resulting in a total Hazard Index greater than 1.0. Of these, trichloroethene contributed the greatest impact, with an individual Hazard Quotient of 1.6.

5.2.5.b Future Occupational Worker Exposed to Groundwater (borehole samples) – Hazard Index

The Total Hazard Index for the future occupational groundwater (borehole samples) scenario is 51, and is presented in Table 21. Because the total hazard index is greater than 1.0, there is a potential for adverse noncarcinogenic health effects for future occupational workers who may consume water from contaminated aquifers underlying OU1 (as represented by borehole samples). Exposure to trichloroethene, 1,2-dichloroethene (total), tetrachloroethene, and cis-1,2-dichloroethene were the primary drivers resulting in a total Hazard Index greater than 1.0, each of these contributing an individual contaminant Hazard Quotient greater than 1.0.

5.2.6 Current or Future Occupational Worker Exposed to Surface Soils – Hazard Index

The Total Hazard Index for the current or future occupational scenario is 0.08, and is presented in Table 22. Because the total hazard index is less than 1.0, adverse noncarcinogenic health effects are not expected to occur for current or future occupational workers exposed to surface soil.

5.2.7 Future Recreational Visitor Exposed to Surface Soil – Hazard Index

The Total Hazard Index for the future recreational visitor surface soil scenario is 0.06, and is presented in Table 23. Because the total hazard index is less than 1.0, adverse noncarcinogenic health effects are not expected to occur for future recreational visitors exposed to surface soil.

5.2.8 Current or Future Construction/Utility Worker Exposed to Subsurface Soil – Hazard Index

The Total Hazard Index for the subsurface current or future construction/utility worker scenario is 0.05, and is presented in Table 24. Because the total hazard index is below 1.0, adverse noncarcinogenic health effects are not expected to occur for current or future construction/utility workers exposed to subsurface soil.

## 6.0 Uncertainties

The estimation of risk posed by a site is a complex problem and involves making a series of assumptions to determine chemical intake and toxicity. Daily chemical intake is estimated using a variety of variables. Many of the values used for intake variables are 95% upper confidence limits (UCLs) of the mean variable value. This is done to ensure the protection of public health, but it may overestimate the true risk posed by the site.

Most of the toxicity values used to calculate risk are derived from toxicity testing carried out on animals. Interspecies, as well as intraspecies variation adds uncertainty to the toxicity values, thus the true risk posed by the site may be higher or lower than presented in this assessment.

The recovery of contaminants during sample extraction can be less than 100%. This inability to extract all contaminants present at the site may result in an underestimation of the risks posed by the site.

In the modeling of contaminant intake, chemical concentrations in soil and groundwater were assumed to remain constant over time. This is a conservative estimate and is likely to overestimate the true risk posed by the site.

As with any risk assessment, there are several areas of uncertainty specific to this risk assessment. The chemical concentrations in the samples may have been over- or

underestimated. This would result in an over- or underestimation, respectively, of the risk posed by the site.

Sample analysis included detections for total chromium in soils and groundwater at this site. Toxicity information is not available for total chromium, but is available for two forms of this metal, trivalent chromium (chromium III) and the more toxic hexavalent chromium (chromium VI). Due to the inability to analyze for the specific concentrations of each of these forms of chromium, an assumption was made that the toxicity of total chromium that was detected was equal to chromium VI. This is a conservative assumption and very likely overestimates the risk from the site to individuals exposed to chromium. In addition, MDHSS has determined that the toxicity data for technical chlordane (a mixture) is representative of hazards and risks from alpha- and gamma-chlordane; toxicity data for endosulfan is representative of hazards from endosulfan II; and the physical property and toxicity data for xylenes (a mixture) is representative of risks and hazards of m-xylene, o-xylene, and p-xylene.

Two methods were used to obtain groundwater samples from aquifers underlying OU1. Due to marked dissimilarities between the data sets produced by the two sampling methods, MDHSS conducted two separate groundwater risk calculations for the future residential as well as the future occupational scenarios, one based on the monitoring well samples and the other based on the borehole samples. Presented in Figures 6 and 7 are comparison charts for these calculated risks for the Total Excess Cancer Risks and the Total Hazard Indices, respectively. Although combining the data sets may have produced a legitimate representation of groundwater conditions, there would have been a loss of information that could be valuable to interpretation of site risks. It is unknown whether risk calculations based on two separate data sets will result in an overestimation or underestimation of the true risks from exposure to OU1 contaminated groundwater.

Quantitative analysis of arsenic resulted in elevated carcinogenic risks for surface soils; however, further analysis of arsenic shows that site concentrations are within natural background concentrations. The OU1 mean surface soil concentration for arsenic is 7.45 mg/kg, with a maximum detected concentration of 10.7 (Table 4). Site-specific background concentrations were not available; however, comparison was made to two soil studies on background concentrations for Missouri. One study shows natural background levels for Missouri with a geometric mean soil concentration for arsenic of 8.7, with a maximum concentration for Franklin County of 11 (USGS, 1984). The other study shows background levels with a mean concentration for arsenic of 11 and a maximum concentration of 19 for the Missouri River flood plains (USGS, 1998). Comparison of these concentrations to the two studies on Missouri background levels show that site concentrations are all within natural background. Furthermore, all arsenic concentrations from OU1 were less than both the average and the maximum values in post-flood plain sediments deposited on the Missouri River alluvium after the 1993 flood. Therefore, this determination shows that analysis of arsenic may result in an overestimation of the risks posed from the site.

The screening level for lead in soil is 400 mg/kg (EPA, 1994b). The OU1 mean surface soil concentration for lead is 2396.29 mg/kg (Table 4), however, this mean value incorporates at least one sample that appears to be an outlier from the majority of the OU1 surface soil samples, both statistically and in its location in relation to the bulk of OU1 contamination. The surface soil lead concentration for this outlying sample (OU1-SO-TW-F, Lot Number D0J040129-002), which was taken as a borehole sample at a depth of 1.5 to 2 feet during the installation of monitoring well OU1-TW-F, was reported at 11,600 mg/kg. It is important to note this sample location is approximately 100 feet from the Cottonwood Street side of the Front Street building,

and is on the opposite side of the street. A second sample was collected during the installation of well OU1-TW-F at a depth of 6-8 feet, where detected lead concentrations were considerably lower than in the 1.5-2 feet sample at 9 mg/kg. A second outlying sample contained a surface soil concentration for lead of 615 mg/kg (OU1-SO-EPA-P-81, Lot Number D0G140159-006). Although this sample is physically located significantly closer to the Front Street building than OU1-TW-F, relatively high detections of PAHs and metals in this sample may indicate a secondary set of historical activities incidental to the use of chlorinated solvents.

Quantitative analysis of benzo(a)pyrene resulted in elevated carcinogenic risks for surface soils based on a mean surface soil concentration of 3.31 mg/kg (Table 4); however this mean value is calculated based on only two samples with detectable levels that appear to be outliers from the majority of the OU1 surface soil samples. All other surface soil samples were non-detect for benzo(a)pyrene. The maximum surface soil concentration for benzo(a)pyrene for the first outlying sample was reported at 16 mg/kg (OU1-SO-TW-F, Lot Number DOH040129-002). The location of the sample containing the maximum concentration is an outlier in its relation to the bulk of OU1 contamination. Additionally, this is the same sample that contained the high lead concentration noted above, and as stated, the sample was taken as a borehole sample at a depth of 1.5 to 2 feet during the installation of monitoring well OU1-TW-F. Again, it is important to note this sample location is approximately 100 feet from the Cottonwood Street side of the Front Street building, and is on the opposite side of the street. A second sample was collected during the installation of well OU1-TW-F at a depth of 6-8 feet showing benzo(a)pyrene as a non-detect. The second outlier contained a surface soil concentration of .45 mg/kg (OU1-SO-EPA-P-81, Lot Number DOG140159-006). Again, the location of this second outlier for benzo(a)pyrene is also the same location for the second outlier for lead.

If surface soil sample number OU1-TW-F is dropped from the calculation of the mean lead soil concentration, the average soil lead at OU1 would be 213 mg/kg, which is lower than the 400 mg/kg screening level and would suggest that the site does not require additional analysis with USEPA's Integrated Exposure Uptake Biokinetic Model (IEUBK) model (Pub. # 9285.7-15-2, PB93-963511). Also, if this sample were dropped from the calculation of the mean benzo(a)pyrene soil concentration, the average at OU1 would be .24 mg/kg, which would significantly decrease the risk presented in this assessment from benzo(a)pyrene.

Air samples from the basements and building interiors were outside the scope of the ESI and the RI. This lack of data on a likely exposure pathway may result in an underestimation of the risk posed by the site.

## 7.0 Summary

A summary of the final calculated cancer risks and hazard indices for each scenario are presented in Table 25, and demonstrated in Figures 8 and 9, respectively.

This assessment found that unacceptable excess carcinogenic risks and adverse noncarcinogenic health effects are not expected to occur for current occupational workers consuming contaminated groundwater from an industrial well in the New Haven downtown district or from future construction/utility workers exposed to subsurface soils. In addition, adverse noncarcinogenic health effects are not expected to occur for current trespassers, future residents, current or future occupational workers, or future recreational visitors exposed to surface soils.

However, the potential exists for unacceptable excess carcinogenic risks and adverse noncarcinogenic health effects for future residents and future occupational workers who ingest groundwater from contaminated aquifers underlying OU1. Trichloroethene, vinyl chloride, tetrachloroethene, and the other associated solvent breakdown products are largely responsible for these risks, varying according to the parameters of scenario exposure and sampling method. Furthermore, the potential exists for unacceptable excess carcinogenic risks for future residents exposed to surface soils, this risk being driven primarily by benzo(a)pyrene, arsenic, and tetrachloroethene. In addition, calculated carcinogenic risks also were substantial for current trespassers, current or future occupational workers, and future recreational visitors with surface soil contact, these risks being driven by benzo(a)pyrene and arsenic.

Future residents who ingest groundwater from contaminated aquifers underlying OU1 face unacceptable cancer risks. The ingestion pathway followed by the dermal pathway drives carcinogenic risks for the future resident. Risks calculated on well data were driven by vinyl chloride, followed primarily by trichloroethene for the ingestion pathway. Borehole sample risks were driven by trichloroethene, followed by tetrachloroethene, and vinyl chloride for the ingestion and dermal pathways.

In addition, there is a potential for adverse noncarcinogenic health effects for future residents who ingest groundwater from contaminated aquifers underlying OU1. The ingestion pathway drives adverse noncarcinogenic health effects for the future resident based on well sampling. Both the ingestion and dermal pathways drive adverse noncarcinogenic health effects for the future resident based on borehole sampling. Trichloroethene carries the bulk of the hazard, with 1,2-dichloroethene (total), cis-1,2-dichloroethene, vinyl chloride, and tetrachloroethene also making large contributions to the future resident scenario Hazard Quotients.

Future occupational workers who ingest groundwater from contaminated aquifers underlying OU1 face unacceptable cancer risks. Risks calculated on well sampling were driven by vinyl chloride, followed primarily by trichloroethene. Borehole sampling risks were driven by trichloroethene, followed by vinyl chloride and tetrachloroethene.

In addition, there is a potential for adverse noncarcinogenic health effects for future occupational workers who ingest groundwater from contaminated aquifers underlying OU1. Trichloroethene carries the bulk of the hazard, with 1,2-dichloroethene (total), cis-1,2-dichloroethene, vinyl chloride, and tetrachloroethene also making large contributions to the future resident scenario Hazard Quotients.

Future residents exposed to surface soil face unacceptable cancer risks. The ingestion pathway followed by the inhalation of particulates or volatiles and dermal pathways all contribute to carcinogenic risks for the future resident. Risks calculated for ingestion of surface soil and dermal contact with surface soil were driven by benzo(a)pyrene and arsenic; while, risks calculated for inhalation of particulates or volatiles were driven primarily by tetrachloethene.

Current trespassers, current or future occupational workers, and future recreational visitors exposed to contaminated surface soil face excess lifetime carcinogenic risks. Incidental ingestion of soil and dermal contact with soil are driven by benzo(a)pyrene and arsenic once again; while tetrachloroethene and other associated solvent breakdown products drive the risks from inhalation of particulates or volatiles in these scenarios.

Unlike the groundwater exposures, the carcinogenic risks for the future resident, current trespasser, current or future occupational worker, and future recreational visitor discussed above are driven by benzo(a)pyrene and arsenic in addition to tetrachloroethene and the other solvent breakdown products. Substantial uncertainties exist for these scenarios, however, as arsenic has been shown to be attributable to natural background and the benzo(a)pyrene exposure point concentration is driven by two samples that may not be representative of total PAH distribution at OU1.

## 8.0 References


USGS. 1984. *Geochemical Survey of Missouri: Geography of Soil Geochemistry and Classification by Factor Analysis of Missouri Agricultural Soils*. Tidball, Ronald R., Geological Survey Professional Paper: 954-H,I.

EPA. 1989. *Risk Assessment Guidance for Superfund: Volume 1 - Human Health Evaluation Manual, Part A.* Office of Emergency and Remedial Response, Washington, D.C. EPA/540/1-89/002.

EPA. 1991. *Risk Assessment Guidance for Superfund, Volume 1 - Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors*. Office of Emergency and Remedial Response, Washington, D.C. OSWER Directive 9285.6-03.

EPA. 1992. *Guidance for Data Useability in Risk Assessment, Part A*. Office of Emergency and Remedial Response, Washington, D.C. Publication 9285.7-09A.

EPA. 1993-2001. *National Center for Environmental Assessment (NCEA) – Superfund Technical Support Center Risk Assessment Issue Papers for: Benzene* (July 1996); *Benzo(a)pyrene* (Nov. 1994); *Cadmium* (Mar. 1996); *Cobalt* (Sept. 1996); *Dibenzofuran* (April 1993); *Ethylbenzene* (Oct. 1999); *bis(2-Ethylhexyl)phthalate* (Sept. 1995); *Tetrachloroethene* (June 1997 and Dec. 2001); *Tetrahydrofuran* (Oct. 1997); *Toluene* (July 1999); *1,1,1-Trichloroethane* (Aug. 1999); *Trichloroethene* (Feb. 1998); *1,2,4-Trimethylbenzene* (June 1999); and Xylenes (Dec. 1998).

EPA. 1993. *Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons*. Office of Health and Environmental Assessment, Cincinnati, OH. EPA/600/R-93/089.

EPA. 1994a. *Polynuclear Aromatic Hydrocarbons (PAHs) Slope Factors memorandum*. U.S. Environmental Protection Agency Region VII, Kansas City, KS. February 1994.

EPA. 1994b. *Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities*. Office of Solid Waste and Emergency Response, Washington, D.C. OSWER Directive 9355.4-12.

EPA. 1996a. *Soil Screening Guidance: User's Guide*. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R-96/018.

EPA. 1996b. *Soil Screening Guidance: Technical Background Document*. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R95/128.

CRC Press. 1997. *Handbook of Physical Properties of Organic Chemicals*. Howard, P.H. & Meylan W.M. (eds.) CRC Press, Boca Raton, FL.

EPA. 1997a. *Exposure Factors Handbook.* Office of Research and Development, National Center for Environmental Assessment. EPA/600/P-95/002.

EPA. 1997b. *Health Effects Assessment Summary Tables (HEAST).* Office of Research and Development, Office of Emergency and Remedial Response, Washington, D.C. EPA 540/R-97-036.

USGS. 1998. *Physical and Chemical Data on Sediments Deposited in the Missouri and the Mississippi River Flood Plains During the July through August 1993 Flood: Floods in the Upper Mississippi River Basin 1993*. Shalk, G.K., Holmes, R.R., and Johnson, G.P. U.S. Geological Survey Circular 1120-L.

EPA. 2000a. *Standard Default Factors memorandum*. U.S. Environmental Protection Agency Region VII, Kansas City, KS. April 2000.

EPA. 2000b. *U.S. EPA Region 9: Preliminary Remediation Goals (PRGs)*. Available on-line at http://www.epa.gov/region09/waste/sfund/prg/index.htm.

EPA. 2000c. *First and Final Site Progress Report for the Riverfront Site, Franklin County, New Haven, Missouri*. U.S. EPA Region VII. September 2000.

EPA. 2000d. *NPL Site Narrative at Listing: Riverfront, New Haven, Missouri*. EPA Webpage available at http://www.epa.gov/superfund/sites/npl/nar1607.htm

USGS. 2000a. *General Quality-Assurance Project Plan for the Remedial Investigation of the New Haven Public Water Supply Site, New Haven, Missouri*. U.S. Geological Survey, Water Resources Division, Missouri District. Draft, October 2000.

USGS. 2000b. *Workplan for the Remedial Investigation of the New Haven Public Water Supply Site, New Haven, Missouri*. U.S. Geological Survey, Water Resources Division, Missouri District. November 2000.

E & E. 2000. *Removal Assessment and Removal Action: Riverfront Site, New Haven, Missouri*. Ecology & Environment, Inc. October 2000.

USGS. 2001. *Expanded Site Investigation/Remedial Investigation Results for the Riverfront Site, New Haven, Missouri*. U.S. Geological Survey, Water Resources Division, Missouri District. January 2001.

EPA. 2001a. *Guidance for Characterizing Background Chemicals in Soil at Superfund Sites – External Review Draft, June 2001*. Office of Emergency and Remedial Response, Washington, D.C. EPA 540-R-01-003.

EPA. 2001b. *Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites – Peer Review Draft (March 2001) and Draft Final (August 2001)*. Office of Emergency and Remedial Response, Washington, D.C. OSWER Directive 9355.4-24.

EPA. 2001c. *Trichloroethylene Health Risk Assessment: Synthesis & Characterization – External Review Draft (August 2001)*. Office of Research and Development, National Center for Environmental Assessment, Washington, D.C. EPA/600/P-01/002A.

EPA. 2001d. *Risk Assessment Guidance for Superfund: Volume 1 – Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment – Interim Review Draft for Public Comment, September 2001*. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/R/99/005.

EPA. 2002a. *CERCLIS Hazardous Waste Sites: Riverfront Site Information*. EPA Webpage available at http://www.epa.gov/superfund/sites/cursites/c3mo/s0702089.htm

EPA. 2002b. *Integrated Risk Information System (IRIS)*. Office of Research and Development, National Center for Environmental Assessment. Available on-line at http://*www.epa.gov/iris/* May-June 2002.

EPA. 2002c. E-mail communication from EPA's National Center for Environmental Assessment (NCEA) providing recommendations for sub-chronic values for Cadmium and Chromium. June 26, 2002.

USGS. 2002a. *The Riverfront Site, New Haven, Missouri: Samples Collected for Laboratory Analysis from February 19, 1999 to December 31, 2001*. U.S. Geological Survey. January 2002.

USGS. 2002b. *Riverfront Superfund Site*. USGS Webpage available at http://missouri.usgs.gov/epa/NH/default.asp

New Haven. 2002. *New Haven Area Chamber of Commerce*. Webpage available at http://www.newhavenmo.com/

# TABLE 1.

COCs at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| Groundwater COCs |
|---|
| Acetone |
| Benzene |
| Chloroform |
| 1,1-Dichloroethene |
| 1,2-Dichloroethene (total) |
| cis-1,2-Dichloroethene |
| trans-1,2-Dichloroethene |
| Methyl tert-butyl ether (MTBE) |
| Tetrachloroethene |
| Tetrahydrofuran |
| Toluene |
| 1,1,1-Trichloroethane |
| Trichloroethene |
| 1,2,4-Trimethylbenzene |
| Vinyl chloride |
| m-Xylene & p-Xylene |
| o-Xylene |

| Surface Soil COCs |
|---|
| Arsenic |
| Barium |
| Cadmium |
| Chromium |
| Cobalt |
| Copper |
| Lead |
| Mercury |
| Molybdenum |
| Nickel |
| Selenium |
| Silver |
| Zinc |
| 1,2-Dichloroethene (total) |
| cis-1,2-Dichloroethene |
| Tetrachloroethene |
| Toluene |
| Trichloroethene |
| Vinyl chloride |
| Xylenes (total) |
| Acenaphthylene |
| Benzo(a)anthracene |
| Benzo(b)fluoranthene |
| Benzo(k)fluoranthene |
| Benzo(g,h,i)perylene |
| Benzo(a)pyrene |
| Chrysene |
| Dibenzofuran |
| bis(2-Ethylhexyl)phthalate |
| Fluoranthene |
| Fluorene |
| Indeno(1,2,3-cd)pyrene |
| Naphthalene |
| Phenanthrene |
| Pyrene |
| alpha-Chlordane |
| gamma-Chlordane |
| 4,4'-DDD |
| 4,4'-DDE |
| 4,4'-DDT |
| Dieldrin |
| Endosulfan II |
| Methoxychlor |

| SubSurface Soil COCs |
|---|
| Arsenic |
| Barium |
| Cadmium |
| Chromium |
| Copper |
| Lead |
| Mercury |
| Nickel |
| Zinc |
| Acetone |
| 2-Butanone (MEK) |
| 1,2-Dichloroethene (total) |
| cis-1,2-Dichloroethene |
| Ethylbenzene |
| Tetrachloroethene |
| Toluene |
| 1,1,1-Trichloroethane |
| Trichloroethene |
| Xylenes (total) |
| gamma-BHC (Lindane) |
| 4,4'-DDD |
| 4,4'-DDE |
| 4,4'-DDT |
| Dieldrin |

# TABLE 2a.

Ground Water Concentrations for COCs in Well Sampling at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | Sample Mean mg/L | Sample Standard Deviation mg/L | 95% UCL mg/L | Minimum Detected Value mg/L | Maximum Detected Value mg/L | **Value Used** 95% UCL -- Maximum Detected mg/L |
|---|---|---|---|---|---|---|---|
| VOCs | Acetone | 0.14 | 0.5 | 0.39 | 0.016 | 0.016 | **0.016** |
| | Benzene | 0.01 | 0.03 | 0.02 | 0.0016 | 0.0016 | **0.0016** |
| | Chloroform | 0.01 | 0.03 | 0.02 | 0.0001 | 0.0001 | **0.0001** |
| | 1,1-Dichloroethene | 0.01 | 0.03 | 0.02 | 0.00016 | 0.00041 | **0.00041** |
| | 1,2-Dichloroethene (total) | 0.3 | 0.32 | 0.61 | 0.013 | 0.63 | **0.61** |
| | cis-1,2-Dichloroethene | 0.24 | 0.59 | 0.43 | 0.00011 | 2.4 | **0.43** |
| | trans-1,2-Dichloroethene | 0.01 | 0.02 | 0.01 | 0.00065 | 0.0214 | **0.01** |
| | Methyl tert-butyl ether (MTBE) | 0.02 | 0.06 | 0.05 | 0.00262 | 0.0071 | **0.0071** |
| | Tetrachloroethene | 0.09 | 0.15 | 0.14 | 0.00059 | 0.67 | **0.14** |
| | Tetrahydrofuran | 0.01 | 0.003 | 0.01 | 0.0123 | 0.0123 | **0.01** |
| | Toluene | 0.01 | 0.03 | 0.02 | 0.00016 | 0.00019 | **0.00019** |
| | 1,1,1-Trichloroethane | 0.01 | 0.03 | 0.02 | 0.00012 | 0.00012 | **0.00012** |
| | Trichloroethene | 0.03 | 0.06 | 0.05 | 0.00019 | 0.28 | **0.05** |
| | 1,2,4-Trimethylbenzene | 0.01 | 0.01 | 0.01 | 0.00023 | 0.00026 | **0.00026** |
| | Vinyl chloride | 0.04 | 0.14 | 0.09 | 0.00027 | 0.63 | **0.09** |
| | m-Xylene & p-Xylene | 0.005 | 0.01 | 0.01 | 0.00026 | 0.00029 | **0.00029** |
| | o-Xylene | 0.005 | 0.01 | 0.01 | 0.0001 | 0.0001 | **0.0001** |

# TABLE 2b.

Ground Water Concentrations for COCs
in Domestic Well Sampling at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | |
|---|---|
| **Sample No.** | **OUX-GW-JS-34 D1C290298-001** |
| Date & Time | 03/27/01 @ 1425 |
| Media | Groundwater |
| Feature | Domestic Well |
| Location | OUX-JS-34 |
| Landowner | Mike Maczuk |
| Temperature/Depth | 15.4C / --300 ft. |
| Dilution | 1 |
| Units | mg/L |

| | | |
|---|---|---|
| VOCs | **Tetrachloroethene** | **0.01** |

# TABLE 3.

Ground Water Concentrations for COCs in Borehole Sampling at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | Sample Mean mg/L | Sample Standard Deviation mg/L | 95% UCL mg/L | Minimum Detected Value mg/L | Maximum Detected Value mg/L | **Value Used** 95% UCL -- Maximum Detected mg/L |
|---|---|---|---|---|---|---|---|
| VOCs | Benzene | 0.05 | 0.08 | 0.08 | 0.16 | 0.34 | **0.08** |
| | 1,2-Dichloroethene (total) | 1.73 | 1.62 | 2.93 | 0.0027 | 3.2 | **2.93** |
| | cis-1,2-Dichloroethene | 0.85 | 1.27 | 1.38 | 0.0017 | 3.1 | **1.38** |
| | Tetrachloroethene | 1.47 | 2.87 | 2.66 | 0.0015 | 11.0 | **2.66** |
| | Trichloroethene | 0.69 | 1.54 | 1.33 | 0.0011 | 5.5 | **1.33** |
| | Vinyl chloride | 0.05 | 0.11 | 0.09 | 0.0036 | 0.41 | **0.09** |

# TABLE 4.

Surface Soil Concentrations for COCs at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | Sample Mean mg/kg | Sample Standard Deviation mg/kg | 95% UCL mg/kg | Minimum Detected Value mg/kg | Maximum Detected Value mg/kg | **Value Used** 95% UCL -- Maximum Detected mg/kg |
|---|---|---|---|---|---|---|---|
| Metals | Arsenic | 6.36 | 2.15 | 7.45 | 4.3 | 10.7 | **7.45** |
| | Barium | 229.17 | 171.68 | 316.05 | 89.8 | 793 | **316.05** |
| | Cadmium | 0.85 | 1.04 | 1.38 | 0.71 | 3.7 | **1.38** |
| | Chromium | 13.34 | 5.41 | 16.08 | 0.35 | 22.9 | **16.08** |
| | Cobalt | 8.9 | 0 | 0 | 8.9 | 8.9 | **8.9** |
| | Copper | 22.61 | 13 | 29.19 | 7.9 | 51.1 | **29.19** |
| | Lead | 895.81 | 2965.03 | 2396.29 | 15.9 | 11600 | **2396.29** |
| | Mercury | 0.18 | 0.11 | 0.24 | 0.069 | 0.39 | **0.24** |
| | Molybdenum | 2.18 | 4.31 | 4.36 | 17.5 | 17.5 | **4.36** |
| | Nickel | 16.11 | 3.52 | 17.95 | 11.8 | 22.7 | **17.95** |
| | Selenium | 8.66 | 30.25 | 23.97 | 1 | 118 | **23.97** |
| | Silver | 1.74 | 4.56 | 4.04 | 18.2 | 18.2 | **4.04** |
| | Zinc | 179.03 | 232.2 | 296.54 | 42.4 | 806 | **296.54** |
| VOCs | 1,2-Dichloroethene (total) | 4.81 | 11.79 | 10.59 | 5.9 | 45 | **10.59** |
| | cis-1,2-Dichloroethene | 4.77 | 11.81 | 10.56 | 0.0032 | 45 | **10.56** |
| | Tetrachloroethene | 17.31 | 34.5 | 34.21 | 0.0087 | 130 | **34.21** |
| | Toluene | 0.32 | 0.54 | 0.59 | 0.38 | 0.38 | **0.38** |
| | Trichloroethene | 1.88 | 4.46 | 4.07 | 0.42 | 17 | **4.07** |
| | Vinyl chloride | 0.66 | 1.13 | 1.21 | 2.4 | 2.4 | **1.21** |
| | Xylenes (total) | 0.33 | 0.54 | 0.6 | 0.54 | 0.54 | **0.54** |
| SVOCs | Acenaphthylene | 0.4 | 0.72 | 0.77 | 0.42 | 0.42 | **0.42** |
| | Benzo(a)anthracene | 0.89 | 2.8 | 2.31 | 11 | 11 | **2.31** |
| | Benzo(b)fluoranthene | 1.19 | 3.82 | 3.12 | 0.63 | 15 | **3.12** |
| | Benzo(k)fluoranthene | 1.5 | 4.85 | 3.95 | 0.87 | 19 | **3.95** |
| | Benzo(g,h,i)perylene | 0.84 | 2.48 | 2.09 | 9.8 | 9.8 | **2.09** |
| | Benzo(a)pyrene | 1.25 | 4.08 | 3.31 | 0.45 | 16 | **3.31** |
| | Chrysene | 1.69 | 5.62 | 4.53 | 1 | 22 | **4.53** |
| | Dibenzofuran | 0.58 | 1.45 | 1.31 | 5.8 | 5.8 | **1.31** |
| | bis(2-Ethylhexyl)phthalate | 0.45 | 0.6 | 0.755 | 0.49 | 1.8 | **0.755** |
| | Fluoranthene | 3.71 | 13.1 | 10.34 | 2.5 | 51 | **10.34** |
| | Fluorene | 0.54 | 1.32 | 1.21 | 5.3 | 5.3 | **1.21** |
| | Indeno(1,2,3-cd)pyrene | 0.81 | 2.41 | 2.025 | 9.5 | 9.5 | **2.025** |
| | Naphthalene | 0.64 | 1.7 | 1.5 | 6.8 | 6.8 | **1.5** |
| | Phenanthrene | 4.05 | 14.65 | 11.46 | 1.4 | 57 | **11.46** |
| | Pyrene | 2.84 | 10.28 | 8.04 | 0.73 | 40 | **8.04** |
| Organochlorine Pesticides | alpha-Chlordane | 0.09 | 0.19 | 0.19 | 0.0043 | 0.0043 | **0.0043** |
| | gamma-Chlordane | 0.09 | 0.19 | 0.19 | 0.0041 | 0.0041 | **0.0041** |
| | 4,4'-DDD | 0.09 | 0.19 | 0.19 | 0.0027 | 0.032 | **0.032** |
| | 4,4'-DDE | 0.11 | 0.19 | 0.2 | 0.23 | 0.23 | **0.2** |
| | 4,4'-DDT | 0.1 | 0.19 | 0.2 | 0.01 | 0.13 | **0.13** |
| | Dieldrin | 0.09 | 0.19 | 0.19 | 0.0032 | 0.023 | **0.023** |
| | Endosulfan II | 0.09 | 0.19 | 0.19 | 0.028 | 0.028 | **0.028** |
| | Methoxychlor | 0.18 | 0.37 | 0.37 | 0.05 | 0.05 | **0.05** |

# TABLE 5.

Sub-Surface Soil Concentrations for COCs at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | Sample Mean mg/kg | Sample Standard Deviation mg/kg | 95% UCL mg/kg | Minimum Detected Value mg/kg | Maximum Detected Value mg/kg | **Value Used** **95% UCL -- Maximum Detected mg/kg** |
|---|---|---|---|---|---|---|---|
| Metals | Arsenic | 5.7 | 1.45 | 6.34 | 4.1 | 8.9 | **6.34** |
| | Barium | 202.85 | 48.12 | 223.94 | 139 | 300 | **223.94** |
| | Cadmium | 0.35 | 0.19 | 0.44 | 0.59 | 1.1 | **0.44** |
| | Chromium | 12.78 | 3.03 | 14.1 | 8.9 | 19.8 | **14.1** |
| | Copper | 13.07 | 4.78 | 15.16 | 3.9 | 25.1 | **15.16** |
| | Lead | 42.47 | 133.1 | 100.8 | 5.6 | 607 | **100.8** |
| | Mercury | 0.04 | 0.06 | 0.07 | 0.043 | 0.27 | **0.07** |
| | Nickel | 15.86 | 3.58 | 17.425 | 10.2 | 22.8 | **17.425** |
| | Zinc | 106.24 | 131.68 | 163.95 | 26.6 | 512 | **163.95** |
| VOCs | Acetone | 3.92 | 22.08 | 10.77 | 0.033 | 0.26 | **0.26** |
| | 2-Butanone (MEK) | 3.69 | 21.3 | 10.05 | 0.052 | 0.052 | **0.052** |
| | 1,2-Dichloroethene (total) | 1.1 | 5.44 | 2.73 | 0.0089 | 5.3 | **2.73** |
| | cis-1,2-Dichloroethene | 0.67 | 2.84 | 1.52 | 0.0089 | 5.3 | **1.52** |
| | Ethylbenzene | 0.93 | 5.4 | 2.55 | 0.012 | 0.012 | **0.012** |
| | Tetrachloroethene | 59.91 | 334.97 | 160.03 | 0.0074 | 2200 | **160.03** |
| | Toluene | 0.93 | 5.4 | 2.54 | 0.011 | 0.086 | **0.086** |
| | 1,1,1-Trichloroethane | 0.93 | 5.4 | 2.55 | 0.017 | 0.017 | **0.017** |
| | Trichloroethene | 0.98 | 5.4 | 2.59 | 0.013 | 1 | **1** |
| | Xylenes (total) | 0.94 | 5.4 | 2.55 | 0.031 | 0.085 | **0.085** |
| Organochlorine Pesticides | gamma-BHC (Lindane) | 0.01 | 0.02 | 0.02 | 0.0068 | 0.0068 | **0.0068** |
| | 4,4'-DDD | 0.01 | 0.02 | 0.02 | 0.0059 | 0.0059 | **0.0059** |
| | 4,4'-DDE | 0.01 | 0.02 | 0.02 | 0.0073 | 0.0091 | **0.0091** |
| | 4,4'-DDT | 0.01 | 0.02 | 0.02 | 0.0035 | 0.0088 | **0.0088** |
| | Dieldrin | 0.01 | 0.02 | 0.02 | 0.013 | 0.013 | **0.013** |

# Table 6a.

## Exposure Variable Values Used To Calculate Intake and Risk Levels for Exposure to Contaminated GroundWater

| | Variable | Unit | Value | References |
|---|---|---|---|---|
| Intake Variables | Cw = Chemical Concentration in Water | mg/L | chemical-specific | |
| | IRW = Water Ingestion Rate | L/day | | |
| | Occupational | | 1 | 1 |
| | IRWa - Residential Adult | | 2 | 1 |
| | IRWc - Residential Child | | 1 | 1 |
| | CFw = Conversion Factor for Water | $L/cm^3$ | 0.001 | 2 |
| | SA = Skin Surface Area Available for Contact | $cm^2$ | | |
| | SAa - Residential Adult | | 18,000 | 3 |
| | SAc - Residential Child | | 6,600 | 3 |
| | PC = Permeability Constant | cm/hour | chemical-specific | |
| | Ca = Air Concentration | $mg/m^3$ | chemical-specific (Cw*K) | |
| | K = Volatilization constant | $L/m^3$ | 0.5 | 1 |
| | IRA = Inhalation Rate | $m^3$/hour | 0.6 | 2 |
| | ET = Exposure Time | hours/day | 0.58 | 3 |
| | EF = Exposure Frequency | days/year | | |
| | Occupational | | 250 | 1 |
| | Residential | | 350 | 1 |
| | ED = Exposure Duration | years | | |
| | Occupational | | 25 | 1 |
| | EDa - Residential Adult | | 24 | 1 |
| | EDc - Residential Child | | 6 | 1 |
| | BW = Body Weight | kg | | |
| | BWa - Adult | | 70 | 1 |
| | BWc - Child | | 15 | 1 |
| | ATc = Averaging Time - carcinogenic | days | 25550 | 1 |
| | ATn = Averaging Time - noncarcinogenic (ED*365) | days | | 1 |
| | Occupational | | 9125 | |
| | Residential | | 10950 | |
| Risk Variables | SF = Slope Factor - carcinogenic | $(mg/kg\text{-}d)^{-1}$ | chemical-specific | |
| | $SF_o$ - Oral | | | |
| | $SF_d$ - Dermal | | | |
| | $SF_i$ - Inhalation | | | |
| | RfD = Reference Dose - noncarcinogenic | mg/kg-d | chemical-specific | |
| | $RfD_o$ - Oral | | | |
| | $RfD_d$ - Dermal | | | |
| | $RfD_i$ - Inhalation | | | |

1 EPA Region VII Standard Default Factors Memorandum (2000) or EPA RAGS Supplemental Guidance: Standard Default Exposure Factors (1991)

2 EPA RAGS, Part A (1989)

3 EPA RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment (2001)

# Table 6b.

## Exposure Variable Values Used To Calculate Intake and Risk Levels for Exposure to Contaminated Soils

| | Variable | Unit | Value | References |
|---|---|---|---|---|
| Intake Variables | Cs = Chemical Concentration in Soil | mg/kg | chemical-specific | |
| | CFs = Conversion Factor for Soils | $10^{-6}$ kg/mg | 0.000001 | 2 |
| | IRS = Soil Ingestion Rate | mg/day | | |
| | Occupational | | 50 | 1 |
| | Construction/Utility Worker | | 330 | 4 |
| | IRSa - Residential Adult | | 100 | 1 |
| | IRSc - Residential Child | | 200 | 1 |
| | Trespasser | | 100 | 1 |
| | Recreational | | time-weighted average of residential adult and child | 1 |
| | FI = Fraction Ingested from Contaminated Source | unitless | 1 | 1 |
| | SA = Skin Surface Area Available for Contact | $cm^2$ | | |
| | Occupational | | 3300 | 1 |
| | Construction/Utility Worker | | 3300 | 4 |
| | SAa - Residential Adult | | 5700 | 1 |
| | SAc - Residential Child | | 2800 | 1 |
| | Trespasser | | 4900 | 3 |
| | Recreational | | time-weighted average of residential adult and child | 1 |
| | AF = Adherence Factor of Soil to Skin | $mg/cm^2$ | | |
| | Occupational | | 0.2 | 1 |
| | Construction/Utility Worker | | 0.2 | 1 |
| | AFa - Residential Adult | | 0.07 | 1 |
| | AFc - Residential Child | | 0.2 | 1 |
| | Trespasser | | 0.04 | 3 |
| | Recreational | | time-weighted average of residential adult and child | 1 |
| | ABS = Absorption Fraction | unitless | chemical-specific | 3 |
| | IRA = Inhalation Rate | $m^3$/day | | |
| | IRAa - Adult | | 20 | 1 |
| | IRAc - Child | | 10 | 1 |
| | Trespasser | | 15 | 5 |
| | Recreational | | time-weighted average of residential adult and child | 1 |
| | PEF = Particulate Emission Factor | $1.316x10^9$ $m^3/kg$ | 1316000000 | 1 |
| | VF = Soil to Air Volatilization Factor | $m^3/kg$ | chemical-specific | 4 |
| | EF = Exposure Frequency | days/year | | |
| | Occupational | | 250 | 1 |
| | Construction/Utility Worker | | 120 | Site-specific |
| | Residential | | 350 | 1 |
| | Trespasser | | 90 | Site-specific |
| | Recreational | | 60 | Site-specific |
| | ED = Exposure Duration | years | | |
| | Occupational | | 25 | 1 |
| | Construction/Utility Worker | | 1 | Site-specific |
| | EDa - Residential Adult | | 24 | 1 |
| | EDc - Residential Child | | 6 | 1 |
| | Trespasser | | 8 | Site-specific |
| | Recreational | | time-weighted average of residential adult and child | 1 |
| | BW = Body Weight | kg | | |
| | BWa - Adult | | 70 | 1 |
| | BWc - Child | | 15 | 1 |
| | Trespasser | | 43 | 6 |
| | Recreational | | time-weighted average of residential adult and child | 1 |
| | ATc = Averaging Time - carcinogenic | days | 25550 | 1 |
| | ATn = Averaging Time - noncarcinogenic | days | (ED*365) | 1 |
| | Occupational | | 9125 | |
| | Construction/Utility Worker | | 365 | |
| | Residential | | 10950 | |
| | Trespasser | | 2920 | |
| | Recreational | | 10950 | |
| Risk Variables | SF = Slope Factor - carcinogenic | $(mg/kg-d)^{-1}$ | chemical-specific | |
| | $SF_o$ - Oral | | | |
| | $SF_d$ - Dermal | | | |
| | $SF_i$ - Inhalation | | | |
| | RfD = Reference Dose - noncarcinogenic | mg/kg-d | chemical-specific | |
| | $RfD_o$ - Oral | | | |
| | $RfD_d$ - Dermal | | | |
| | $RfD_i$ - Inhalation | | | |

1 EPA Region VII Standard Default Factors Memorandum (2000) or EPA RAGS Supplemental Guidance: Standard Default Exposure Factors (1991)
2 EPA RAGS, Part A (1989)
3 EPA RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment (2001)
4 EPA Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (March and August 2001)
5 EPA Exposure Factors Handbook (1997)
6 MDHSS Previously Used Value

# TABLE 7a.

Carcinogenic Toxicity Values and Target Organs for COCs in Ground Water at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | Carcinogenic Weight of Evidence Classification | SFo $(mg/kg\text{-}d)^{-1}$ | Reference | OAE unitless | Reference | SFd $(mg/kg\text{-}d)^{-1}$ | URi $(ug/m^3)^{-1}$ | Reference | SFi $(mg/kg\text{-}d)^{-1}$ | Target Organs/Systems |
|---|---|---|---|---|---|---|---|---|---|---|---|
| GroundWater COCs | Acetone | D | | | | | | | | | |
| | Benzene | A | 5.50E-02 | I | 1 | E | 5.50E-02 | 7.80E-06 | I | 2.73E-02 | Blood (leukemia) |
| | Chloroform | B2 | 6.10E-03 | I | 1 | E | 6.10E-03 | 2.30E-05 | I | 8.05E-02 | Cytotoxicity and regenerative cell proliferation in mice livers and kidneys |
| | 1,1-Dichloroethene | C | 6.00E-01 | I | 1 | E | 6.00E-01 | 5.00E-05 | I | 1.75E-01 | Oral: Adrenal pheochromocytomas; Inhalation: Kidney adenocarcinoma |
| | 1,2-Dichloroethene (total) | Not Assessed | | | | | | | | | |
| | cis-1,2-Dichloroethene | D | | | | | | | | | |
| | trans-1,2-Dichloroethene | Not Assessed | | | | | | | | | |
| | Methyl tert-butyl ether (MTBE) | Not Assessed | | | | | | | | | |
| | Tetrachloroethene | C-B2 | 2.07E-02 | N | 1 | E | 2.07E-02 | 3.06E-06 | N | 1.07E-02 | Liver, kidney, and central nervous system |
| | Tetrahydrofuran | C-B2 | 7.60E-03 | N | | | | 1.90E-06 | N | 6.65E-03 | Increase in hepatic tumor incidence of female mice |
| | Toluene | D | | | | | | | | | |
| | 1,1,1-Trichloroethane | D | | | | | | | | | |
| | Trichloroethene | B1 | 4.00E-01 | N | 1 | E | 4.00E-01 | 1.70E-06 | N | 5.95E-03 | Non-Hodgkin's lymphoma, liver and kidney cancer |
| | 1,2,4-Trimethylbenzene | Not Assessed | | | | | | | | | |
| | Vinyl chloride (child) | A | 1.50E+00 | I | 1 | E | 1.50E+00 | 8.80E-06 | I | 3.08E-02 | Liver angiosarcoma and other liver cancers, possibly brain and lung cancers |
| | Vinyl chloride (adult) | A | 7.50E-01 | I | 1 | E | 7.50E-01 | 4.40E-06 | I | 1.54E-02 | Liver angiosarcoma and other liver cancers, possibly brain and lung cancers |
| | m-Xylene & p-Xylene | D | | | | | | | | | |
| | o-Xylene | D | | | | | | | | | |

Carcinogenic Toxicity Values

**Weight of Evidence Classifications**

A - Human Carcinogen, based on sufficient evidence from epidemiological studies

B1 - Probable Human Carcinogen, based on sufficient evidence from animal studies and limited evidence from epidemiological studies

B2 - Probable Human Carcinogen, based on sufficient evidence of animal studies, but inadequate epidemiological data

C - Possible Human Carcinogen

D - Not Classifiable as to Human Carcinogenicity

**Source References**

I - Integrated Risk Information System (IRIS), May-June 2002

H - Health Effects Assessment Summary Tables (HEAST), 1997

N - National Center for Environmental Assessment Risk Assessment Issue Papers

E - Draft RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment, 2001

R - EPA Region VII Standard Default Factors Memorandum, 2000

Not Available/Not Applicable

# TABLE 7b.

Carcinogenic Toxicity Values and Target Organs for COCs in Surface Soils at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | Carcinogenic Weight of Evidence Classification | SFo (mg/kg-d)$^{-1}$ | Reference | OAE unitless | Reference | SFd (mg/kg-d)$^{-1}$ | URi (ug/m$^3$)$^{-1}$ | Reference | SFi (mg/kg-d)$^{-1}$ | Target Organs/Systems |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface Soil COCs | Arsenic | A | 1.50E+00 | I | 1 | E | 1.50E+00 | 4.30E-03 | I | 1.51E+01 | Oral: Multiple internal organs (liver, kidney, lung, and bladder) and skin; Inhalation: Lung |
| | Barium | D | | | | | | | | | |
| | Cadmium | B1 | | | | | | 1.80E-03 | I | 6.30E+00 | Lung, trachea, bronchus |
| | Chromium | A | | | | | | 1.20E-02 | I | 4.20E+01 | Respiratory |
| | Cobalt | Not Assessed | | | | | | | | | |
| | Copper | D | | | | | | | | | |
| | Lead | B2 | | | | | | | | | |
| | Mercury | D | | | | | | | | | |
| | Molybdenum | Not Assessed | | | | | | | | | |
| | Nickel | Not Assessed | | | | | | | | | |
| | Selenium | D | | | | | | | | | |
| | Silver | D | | | | | | | | | |
| | Zinc | D | | | | | | | | | |
| | 1,2-Dichloroethene (total) | Not Assessed | | | | | | | | | |
| | cis-1,2-Dichloroethene | D | | | | | | | | | |
| | Tetrachloroethene | C-B2 | 2.07E-02 | N | | | | 3.06E-06 | N | 1.07E-02 | Liver, kidney, and central nervous system |
| | Toluene | D | | | | | | | | | |
| | Trichloroethene | B1 | 4.00E-01 | N | | | | 1.70E-06 | N | 5.95E-03 | Non-Hodgkin's lymphoma, liver and kidney cancer |
| | Vinyl chloride (child) | A | 1.50E+00 | I | | | | 8.80E-06 | I | 3.08E-02 | Liver angiosarcoma and other liver cancers, possibly brain and lung cancers |
| | Vinyl chloride (adult) | A | 7.50E-01 | I | | | | 4.40E-06 | I | 1.54E-02 | Liver angiosarcoma and other liver cancers, possibly brain and lung cancers |
| | Xylenes (total) | D | | | | | | | | | |
| | Acenaphthylene | D | | | | | | | | | |
| | Benzo(a)anthracene | B2 | 7.30E-01 | N | 1 | E | 7.30E-01 | 8.80E-05 | N | 3.08E-01 | Tumors in mice exposed by gavage; intraperitoneal, subcutaneous or intramuscular injection; and topical application. |
| | Benzo(b)fluoranthene | B2 | 7.30E-01 | N | 1 | E | 7.30E-01 | 8.80E-05 | N | 3.08E-01 | Tumors in mice after lung implantation, intraperitoneal (i.p.) or subcutaneous (s.c.) injection, and skin painting |
| | Benzo(k)fluoranthene | B2 | 7.30E-02 | N | 1 | E | 7.30E-02 | 8.80E-06 | N | 3.08E-02 | Tumors in mice after lung implantation, intraperitoneal (i.p.) or subcutaneous (s.c.) injection, and skin painting |
| | Benzo(g,h,i)perylene | D | | | | | | | | | |
| | Benzo(a)pyrene | B2 | 7.30E+00 | I | 1 | E | 7.30E+00 | 8.80E-04 | N | 3.08E+00 | Forestomach, larynx and esophagus |
| | Chrysene | B2 | 7.30E-03 | N | 1 | E | 7.30E-03 | 8.80E-07 | N | 3.08E-03 | Carcinomas and malignant lymphoma in mice after intraperitoneal injection and skin carcinomas in mice following dermal exposure |
| | Dibenzofuran | D | | | | | | | | | |
| | bis(2-Ethylhexyl)phthalate | B2 | 1.40E-02 | I | 1 | E | 1.40E-02 | 4.00E-06 | N | 1.40E-02 | Liver |
| | Fluoranthene | D | | | | | | | | | |
| | Fluorene | D | | | | | | | | | |
| | Indeno(1,2,3-cd)pyrene | B2 | 7.30E-01 | N | 1 | E | 7.30E-01 | 8.80E-05 | N | 3.08E-01 | Tumors in mice following lung implants, subcutaneous injection and dermal exposure |
| | Naphthalene | C | | | | | | | | | |
| | Phenanthrene | D | | | | | | | | | |
| | Pyrene | D | | | | | | | | | |
| | alpha-Chlordane | B2 | 3.50E-01 | I | 1 | E | 3.50E-01 | 1.00E-04 | I | 3.50E-01 | Hepatocellular carcinoma |
| | gamma-Chlordane | B2 | 3.50E-01 | I | 1 | E | 3.50E-01 | 1.00E-04 | I | 3.50E-01 | Hepatocellular carcinoma |
| | 4,4'-DDD | B2 | 2.40E-01 | I | 1 | E | 2.40E-01 | | | | Increased incidence of lung, liver, and thyroid tumors in mice |
| | 4,4'-DDE | B2 | 3.40E-01 | I | 1 | E | 3.40E-01 | | | | Hepatocellular carcinomas, hepatomas |
| | 4,4'-DDT | B2 | 3.40E-01 | I | 1 | E | 3.40E-01 | 9.70E-05 | I | 3.40E-01 | Liver lesions, and liver tumors, benign and malignant |
| | Dieldrin | B2 | 5.00E-05 | I | 1 | E | 5.00E-05 | 4.60E-03 | I | 1.61E+01 | Liver lesions and liver carcinoma. |
| | Endosulfan II | Not Assessed | | | | | | | | | |
| | Methoxychlor | D | | | | | | | | | |

Carcinogenic Toxicity Values

**Weight of Evidence Classifications**

A - Human Carcinogen, based on sufficient evidence from epidemiological studies

B1 - Probable Human Carcinogen, based on sufficient evidence from animal studies and limited evidence from epidemiological studies

B2 - Probable Human Carcinogen, based on sufficient evidence of animal studies, but inadequate epidemiological data

C - Possible Human Carcinogen

D - Not Classifiable as to Human Carcinogenicity

**Source References**

I - Integrated Risk Information System (IRIS), May-June 2002

H - Health Effects Assessment Summary Tables (HEAST), 1997

N - National Center for Environmental Assessment Risk Assessment Issue Papers

E - Draft RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment, 2001

R - EPA Region VII Standard Default Factors Memorandum, 2000

Not Available/Not Applicable

# TABLE 7c.

Carcinogenic Toxicity Values and Target Organs for COCs in SubSurface Soils at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | Carcinogenic Weight of Evidence Classification | SFo $(mg/kg\text{-}d)^{-1}$ | Reference | OAE unitless | Reference | SFd $(mg/kg\text{-}d)^{-1}$ | URi $(ug/m^3)^{-1}$ | Reference | SFi $(mg/kg\text{-}d)^{-1}$ | Target Organs/Systems |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SubSurface Soil COCs | **Arsenic** | A | 1.50E+00 | I | 1 | E | 1.50E+00 | 4.30E-03 | I | 1.51E+01 | Oral: Multiple internal organs (liver, kidney, lung, and bladder) and skin; Inhalation: Lung |
| | **Barium** | D | | | | | | | | | |
| | **Cadmium** | B1 | | | | | | 1.80E-03 | I | 6.30E+00 | Lung, trachea, bronchus |
| | **Chromium** | A | | | | | | 1.20E-02 | I | 4.20E+01 | Respiratory |
| | **Copper** | D | | | | | | | | | |
| | **Lead** | B2 | | | | | | | | | |
| | **Mercury** | D | | | | | | | | | |
| | **Nickel** | Not Assessed | | | | | | | | | |
| | **Zinc** | D | | | | | | | | | |
| | **Acetone** | D | | | | | | | | | |
| | **2-Butanone (MEK)** | D | | | | | | | | | |
| | **1,2-Dichloroethene (total)** | Not Assessed | | | | | | | | | |
| | **cis-1,2-Dichloroethene** | D | | | | | | | | | |
| | **Ethylbenzene** | D | | | | | | | | | |
| | **Tetrachloroethene** | C-B2 | 2.07E-02 | N | | | | 3.06E-06 | N | 1.07E-02 | Liver, kidney, and central nervous system |
| | **Toluene** | D | | | | | | | | | |
| | **1,1,1-Trichloroethane** | D | | | | | | | | | |
| | **Trichloroethene** | B1 | 4.00E-01 | N | | | | 1.70E-06 | N | 5.95E-03 | Non-Hodgkin's lymphoma, liver and kidney cancer |
| | **Xylenes (total)** | D | | | | | | | | | |
| | **gamma-BHC (Lindane)** | Not Assessed | 1.30E+00 | H | 1 | E | 1.30E+00 | | | | Liver |
| | **4,4'-DDD** | B2 | 2.40E-01 | I | 1 | E | 2.40E-01 | | | | Increased incidence of lung, liver, and thyroid tumors in mice |
| | **4,4'-DDE** | B2 | 3.40E-01 | I | 1 | E | 3.40E-01 | | | | Hepatocellular carcinomas, hepatomas |
| | **4,4'-DDT** | B2 | 3.40E-01 | I | 1 | E | 3.40E-01 | 9.70E-05 | I | 3.40E-01 | Liver lesions, and liver tumors, benign and malignant |
| | **Dieldrin** | B2 | 5.00E-05 | I | 1 | E | 5.00E-05 | 4.60E-03 | I | 1.61E+01 | Liver lesions and liver carcinoma |

Carcinogenic Toxicity Values

**Weight of Evidence Classifications**

A - Human Carcinogen, based on sufficient evidence from epidemiological studies
B1 - Probable Human Carcinogen, based on sufficient evidence from animal studies and limited evidence from epidemiological studies
B2 - Probable Human Carcinogen, based on sufficient evidence of animal studies, but inadequate epidemiological data
C - Possible Human Carcinogen
D - Not Classifiable as to Human Carcinogenicity

**Source References**

I - Integrated Risk Information System (IRIS), May-June 2002
H - Health Effects Assessment Summary Tables (HEAST), 1997
N - National Center for Environmental Assessment Risk Assessment Issue Papers
E - Draft RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment, 2001
R - EPA Region VII Standard Default Factors Memorandum, 2000
Not Available/Not Applicable

# TABLE 8a.

Non-Carcinogenic Toxicity Values and Effects of Concern for COCs in Ground Water at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | RfDo mg/kg-d | Reference | OAE unitless | Reference | RfDd mg/kg-d | RfC mg/m³ | Reference | RfDi mg/kg-d | Effects of Concern |
|---|---|---|---|---|---|---|---|---|---|---|
| Ground Water COCs | Acetone | 1.00E-01 | I | | | | | | | Increase liver and kidney weights and nephrotoxicity |
| | Benzene | 1.00E-01 | N | 1 | E | 1.00E-01 | 6.00E-03 | N | 1.71E-03 | Oral:Hematological and immunological effects; Inhalation: Hematological and/or hematopoietic effects |
| | Chloroform | 1.00E-02 | I | 1 | E | 1.00E-02 | | | | Moderate/marked fatty cyst formation in the liver and SGPT |
| | 1,1-Dichloroethene | 9.00E-03 | I | 1 | E | 9.00E-03 | | | | Hepatic lesions |
| | 1,2-Dichloroethene (total) | 9.00E-03 | H | 1 | E | 9.00E-03 | | | | Hepatic lesions |
| | cis-1,2-Dichloroethene | 1.00E-02 | H | | | | | | | Decreased hematocrit and hemoglobin |
| | trans-1,2-Dichloroethene | 2.00E-02 | I | | | | | | | Increased serum alkaline phosphatase in male mice |
| | Methyl tert-butyl ether (MTBE) | | | | | | 3.00E+00 | I | 8.57E-01 | Increased absolute and relative liver and kidney weights and increased severity of spontaneous renal lesions (females), increased prostration (females), and swollen periocular tissue (males and females) |
| | Tetrachloroethene | 1.00E-02 | I | 1 | E | 1.00E-02 | 6.00E-01 | N | 1.71E-01 | Oral: Hepatotoxicity in mice, weight gain in rats; Inhalation: Renal tubular cell karyomegaly in chronically exposed male and female mice |
| | Tetrahydrofuran | 1.80E-01 | N | | | | 3.00E-01 | N | 8.57E-02 | Hepatic effects in mice |
| | Toluene | 2.00E-01 | I | 1 | E | 2.00E-01 | 4.00E-01 | I | 1.14E-01 | Oral: Changes in liver and kidney weights; Inhalation: Neurological effects |
| | 1,1,1-Trichloroethane | 2.80E-01 | N | 1 | E | 2.80E-01 | 2.20E+00 | N | 6.29E-01 | Oral: Hepatotoxicity; Inhalation: Central nervous system effects in gerbils |
| | Trichloroethene | 3.00E-04 | N | 1 | E | 3.00E-04 | 4.00E-02 | N | 1.14E-02 | Neurotoxicity, immunotoxicity, developmental toxicity, liver toxicity, kidney toxicity, and endocrine effects |
| | 1,2,4-Trimethylbenzene | 5.00E-02 | N | | | | 6.00E-03 | N | 1.71E-03 | Developmental, reproductive, or neurological effects |
| | Vinyl chloride (child) | 3.00E-03 | I | 1 | E | 3.00E-03 | 1.00E-01 | I | 2.86E-02 | Liver cell polymorphism |
| | Vinyl chloride (adult) | 3.00E-03 | I | 1 | E | 3.00E-03 | 1.00E-01 | I | 2.86E-02 | Liver cell polymorphism |
| | m-Xylene & p-Xylene | 2.00E+00 | I | 1 | E | 2.00E+00 | | | | Hyperactivity, decreased body weight and increased mortality (males) |
| | o-Xylene | 2.00E+00 | I | | | | | | | Hyperactivity, decreased body weight and increased mortality (males) |

**Source References**
I - Integrated Risk Information System (IRIS), May-June 2002
H - Health Effects Assessment Summary Tables (HEAST), 1997
N - National Center for Environmental Assessment Risk Assessment Issue Papers
E - Draft RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment, 2001
R - EPA Region VII Standard Default Factors Memorandum, 2000
Not Available/Not Applicable

# TABLE 8b.

Non-Carcinogenic Toxicity Values and Effects of Concern for COCs in Surface Soil at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | RfDo mg/kg-d | Reference | OAE unitless | Reference | RfDd mg/kg-d | RfC mg/m³ | Reference | RfDi mg/kg-d | Effects of Concern |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Soil COCs | Arsenic | 3.00E-04 | I | 1 | E | 3.00E-04 | | | | Keratosis |
| | Barium | 7.00E-02 | I | | | | 5.00E-03 | H | 1.43E-03 | Oral: Increased kidney weight; Inhalation: Fetotoxicity |
| | Cadmium | 1.00E-03 | I | 0.025 | E | 2.50E-05 | 2.00E-04 | N | 5.71E-05 | Proteinuria, nephrotoxicity |
| | Chromium | 3.00E-03 | I | | | | 1.00E-04 | I | 2.86E-05 | Oral: None reported; Inhalation: Pneumocyte toxicity |
| | Cobalt | 6.00E-02 | N | | | | | | | Polycythemia |
| | Copper | | | | | | | | | |
| | Lead | | | | | | | | | |
| | Mercury | | | | | | 3.00E-04 | I | 8.57E-05 | Neurotoxicity |
| | Molybdenum | 5.00E-03 | I | | | | | | | Increased uric acid levels |
| | Nickel | 2.00E-02 | I | | | | | | | Decreased body and organ weights |
| | Selenium | 5.00E-03 | I | | | | | | | Selenosis |
| | Silver | 5.00E-03 | I | | | | | | | Argyria (discoloration of the skin, conjunctiva, and internal organs) |
| | Zinc | 3.00E-01 | I | | | | | | | Anemia, pancreas, and decrease levels of a blood enzyme and HDL cholesterol |
| | 1,2-Dichloroethene (total) | 9.00E-03 | H | | | | | | | Hepatic lesions |
| | cis-1,2-Dichloroethene | 1.00E-02 | H | | | | | | | Decreased hematocrit and hemoglobin |
| | Tetrachloroethene | 1.00E-02 | I | | | | 6.00E-01 | N | 1.71E-01 | Oral: Hepatotoxicity in mice, weight gain in rats; Inhalation: Renal tubular cell karyomegaly in chronically exposed male and female mice |
| | Toluene | 2.00E-01 | I | | | | 4.00E-01 | I | 1.14E-01 | Oral: Changes in liver and kidney weights; Inhalation: Neurological effects |
| | Trichloroethene | 3.00E-04 | N | | | | 4.00E-02 | N | 1.14E-02 | Neurotoxicity, immunotoxicity, developmental toxicity, liver toxicity, kidney toxicity, and endocrine effects |
| | Vinyl chloride (child) | 3.00E-03 | I | | | | 1.00E-01 | I | 2.86E-02 | Liver cell polymorphism |
| | Vinyl chloride (adult) | 3.00E-03 | I | | | | 1.00E-01 | I | 2.86E-02 | Liver cell polymorphism |
| | Xylenes (total) | 2.00E+00 | I | | | | | | | Hyperactivity, decreased body weight and increased mortality (males) |
| | Acenaphthylene | | | | | | | | | |
| | Benzo(a)anthracene | | | | | | | | | |
| | Benzo(b)fluoranthene | | | | | | | | | |
| | Benzo(k)fluoranthene | | | | | | | | | |
| | Benzo(g,h,i)perylene | | | | | | | | | |
| | Benzo(a)pyrene | | | | | | | | | |
| | Chrysene | | | | | | | | | |
| | Dibenzofuran | 4.20E-03 | N | 1 | E | 4.20E-03 | | | | Decrease in absolute organ weight and body length, and kidney abnormalitites |
| | bis(2-Ethylhexyl)phthalate | 2.00E-02 | I | 1 | E | 2.00E-02 | | | | Increased relative liver weight |
| | Fluoranthene | 4.00E-02 | I | 1 | E | 4.00E-02 | | | | Nephropathy, increased liver weights |
| | Fluorene | 4.00E-02 | I | 1 | E | 4.00E-02 | | | | Decreased RBC, packed cell volume and hemoglobin |
| | Indeno(1,2,3-cd)pyrene | | | | | | | | | |
| | Naphthalene | 2.00E-02 | I | 1 | E | 2.00E-02 | 3.00E-03 | I | 8.57E-04 | Nasal effects; hyperplasia & metaplasia in respiratory & olfactory epithelium |
| | Phenanthrene | | | | | | | | | |
| | Pyrene | 3.00E-02 | I | 1 | E | 3.00E-02 | | | | Kidney effects |
| | alpha-Chlordane | 5.00E-04 | I | 1 | E | 5.00E-04 | 7.00E-04 | I | 2.00E-04 | Hepatic necrosis |
| | gamma-Chlordane | 5.00E-04 | I | 1 | E | 5.00E-04 | 7.00E-04 | I | 2.00E-04 | Hepatic necrosis |
| | 4,4'-DDD | | | | | | | | | |
| | 4,4'-DDE | | | | | | | | | |
| | 4,4'-DDT | 5.00E-04 | I | 1 | E | 5.00E-04 | | | | Liver lesions |
| | Dieldrin | 5.00E-05 | I | 1 | E | 5.00E-05 | | | | Liver lesions |
| | Endosulfan II | 6.00E-03 | I | 1 | E | 6.00E-03 | | | | Reduced body weight, glomerulonephrosis |
| | Methoxychlor | 5.00E-03 | I | 1 | E | 5.00E-03 | | | | Excessive loss of litters |

**Source References**

I - Integrated Risk Information System (IRIS), May-June 2002
H - Health Effects Assessment Summary Tables (HEAST), 1997
N - National Center for Environmental Assessment Risk Assessment Issue Papers
E - Draft RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment, 2001
R - EPA Region VII Standard Default Factors Memorandum, 2000
Not Available/Not Applicable

# TABLE 8c.

Non-Carcinogenic Toxicity Values and Effects of Concern for COCs in SubSurface Soil at Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | | RfDo mg/kg-d | Reference | OAE unitless | Reference | RfDd mg/kg-d | RfC mg/m³ | Reference | RfDi mg/kg-d | Effects of Concern |
|---|---|---|---|---|---|---|---|---|---|---|
| SubSurface COCs | Arsenic | 3.00E-04 | H | 1 | E | 3.00E-04 | | | | Hyperpigmentation, keratosis, and possible vascular complications |
| | Barium | 7.00E-02 | H | | | | 5.00E-04 | H | 1.43E-04 | Oral: Increased blood pressure; Inhalation: Fetotoxicity |
| | Cadmium | 1.00E-03 | N | 0.025 | E | 2.50E-05 | 9.00E-04 | N | 2.57E-04 | Oral: Proteinuria; Inhalation: Increased renal cortical cadmium concentration |
| | Chromium | 3.00E-03 | N | | | | 1.00E-04 | N | 2.86E-05 | Oral: None reported; Inhalation: Pneumocyte toxicity |
| | Copper | | | | | | | | | |
| | Lead | | | | | | | | | |
| | Mercury | | | | | | 3.00E-04 | H | 8.57E-05 | Neurotoxicity |
| | Nickel | 2.00E-02 | H | | | | | | | Decreased body and organ weights |
| | Zinc | 3.00E-01 | H | | | | | | | Decreased blood enzyme |
| | Acetone | 1.00E+00 | H | | | | | | | Increased liver and kidney weights, nephrotoxicity |
| | 2-Butanone (MEK) | 2.00E+00 | H | | | | 1.00E+00 | H | 2.86E-01 | Decreased fetal birth weight |
| | 1,2-Dichloroethene (total) | 9.00E-03 | H | | | | | | | Hepatic lesions |
| | cis-1,2-Dichloroethene | 1.00E-01 | H | | | | | | | Decreased hematocrit and hemoglobin |
| | Ethylbenzene | 1.00E-01 | N | | | | 1.00E+00 | N | 2.86E-01 | Oral: Liver and kidnery lesions in rats; Inhalation: Changes in absolute and relative weights of liver and kidney in rats and lungs of mice |
| | Tetrachloroethene | 1.00E-01 | H | | | | | | | Hepatotoxicity |
| | Toluene | 2.00E+00 | H | | | | 9.23E-01 | N | 2.64E-01 | Oral: Altered liver and kidney weight in rats; Inhalation: Central Nervous System effects |
| | 1,1,1-Trichloroethane | 2.80E+00 | N | | | | 2.20E+01 | N | 6.29E+00 | Oral: Hepatotoxicity; Inhalation: Central nervous system effects in gerbils |
| | Trichloroethene | | | | | | | | | |
| | Xylenes (total) | 4.00E-01 | N | | | | | | | Developmental toxicity |
| | gamma-BHC (Lindane) | 3.00E-03 | H | 1 | E | 3.00E-03 | | | | Liver and kidney toxicity |
| | 4,4'-DDD | | | | | | | | | |
| | 4,4'-DDE | | | | | | | | | |
| | 4,4'-DDT | 5.00E-04 | H | 1 | E | 5.00E-04 | | | | Liver lesions |
| | Dieldrin | 5.00E-05 | H | 1 | E | 5.00E-05 | | | | Liver lesions |

**Source References**

I - Integrated Risk Information System (IRIS), May-June 2002
H - Health Effects Assessment Summary Tables (HEAST), 1997
N - National Center for Environmental Assessment Risk Assessment Issue Papers
E - Draft RAGS, Part E: Supplemental Guidance for Dermal Risk Assessment, 2001
R - EPA Region VII Standard Default Factors Memorandum, 2000
Not Available/Not Applicable

# TABLE 9.

Carcinogenic Risks Calculated for Current Occupational Exposure
to Contaminated Groundwater from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK |
|---|---|
| | Drinking Water Ingestion |
| Tetrachloroethene | 7.24E-07 |
| **TOTAL CARCINOGENIC RISK FOR CURRENT OCCUPATIONAL SCENARIO** | 7.2E-07 |

# TABLE 10.

Carcinogenic Risks Calculated for Current Trespasser Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 7.33E-07 | 4.31E-08 | 8.38E-10 |
| Barium | | | |
| Cadmium | | | 6.47E-11 |
| Chromium | | | 5.04E-09 |
| Cobalt | | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | |
| Molybdenum | | | |
| Nickel | | | |
| Selenium | | | |
| Silver | | | |
| Zinc | | | |
| 1,2-Dichloroethene (total) | | | |
| cis-1,2-Dichloroethene | | | |
| Tetrachloroethene | 4.65E-08 | | 1.32E-06 |
| Toluene | | | |
| Trichloroethene | 1.07E-07 | | 6.73E-08 |
| Vinyl chloride (child) | 1.19E-07 | | 3.64E-07 |
| Xylenes (total) | | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | 1.10E-07 | 2.81E-08 | 5.31E-12 |
| Benzo(b)fluoranthene | 1.49E-07 | 3.81E-08 | 7.19E-12 |
| Benzo(k)fluoranthene | 1.89E-08 | 4.81E-09 | 9.08E-13 |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | 1.58E-06 | 4.04E-07 | 7.62E-11 |
| Chrysene | 2.17E-09 | 5.53E-10 | 1.04E-13 |
| Dibenzofuran | | | |
| bis(2-Ethylhexyl)phthalate | 6.93E-10 | 1.36E-10 | 7.89E-14 |
| Fluoranthene | | | |
| Fluorene | | | |
| Indeno(1,2,3-cd)pyrene | 9.69E-08 | 2.47E-08 | 4.66E-12 |
| Naphthalene | | | |
| Phenanthrene | | | |
| Pyrene | | | |
| alpha-Chlordane | 9.86E-11 | 7.73E-12 | 1.12E-14 |
| gamma-Chlordane | 9.40E-11 | 7.37E-12 | 1.07E-14 |
| 4,4'-DDD | 5.03E-10 | 9.86E-11 | |
| 4,4'-DDE | 4.54E-09 | 8.89E-10 | |
| 4,4'-DDT | 2.90E-09 | 1.70E-10 | 3.30E-13 |
| Dieldrin | 7.54E-14 | 1.48E-14 | 2.77E-12 |
| Endosulfan II | | | |
| Methoxychlor | | | |
| **Pathway Carcinogenic Risks** | 3.0E-06 | 5.4E-07 | 1.8E-06 |
| **TOTAL CARCINOGENIC RISK FOR CURRENT TRESPASSER SCENARIO** | 5.3E-06 | | |

Not Available - lacks toxicity values

# TABLE 11.

Carcinogenic Risks Calculated for Future Residential Exposure
to Contaminated Groundwater from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK | | | | | |
|---|---|---|---|---|---|---|
| | Well Water Sampling | | | Borehole Sampling | | |
| | Drinking Water Ingestion | Dermal Contact | Inhalation | Drinking Water Ingestion | Dermal Contact | Inhalation |
| Acetone | | | | | | |
| Benzene | 1.31E-06 | 9.24E-08 | 7.73E-08 | 6.67E-05 | 4.71E-06 | 3.94E-06 |
| Chloroform | 9.07E-09 | 2.90E-10 | 1.43E-08 | | | |
| 1,1-Dichloroethene | 3.66E-06 | 2.07E-07 | 1.27E-07 | | | |
| 1,2-Dichloroethene (total) | | | | | | |
| cis-1,2-Dichloroethene | | | | | | |
| trans-1,2-Dichloroethene | | | | | | |
| Methyl tert-butyl ether (MTBE) | | | | | | |
| Tetrachloroethene | 4.20E-05 | 6.52E-06 | 2.58E-06 | 8.22E-04 | 1.28E-04 | 5.05E-05 |
| Tetrahydrofuran | 8.37E-07 | | 8.72E-08 | | | |
| Toluene | | | | | | |
| 1,1,1-Trichloroethane | | | | | | |
| Trichloroethene | 3.01E-04 | 1.70E-05 | 5.33E-07 | 7.92E-03 | 4.48E-04 | 1.40E-05 |
| 1,2,4-Trimethylbenzene | | | | | | |
| Vinyl chloride (child) | 7.18E-04 | 1.54E-05 | 2.56E-06 | 7.78E-04 | 1.67E-05 | 2.78E-06 |
| Vinyl chloride (adult) | 6.15E-04 | 1.80E-05 | 1.10E-06 | 6.67E-04 | 1.95E-05 | 1.19E-06 |
| m-Xylene & p-Xylene | | | | | | |
| o-Xylene | | | | | | |
| **Pathway Carcinogenic Risks** | 1.7E-03 | 5.7E-05 | 7.1E-06 | 1.0E-02 | 6.2E-04 | 7.2E-05 |
| **TOTAL CARCINOGENIC RISK FOR FUTURE RESIDENTIAL SCENARIO** | 1.7E-03 | | | 1.1E-02 | | |

Not Available - lacks toxicity values

# TABLE 12.

Carcinogenic Risks Calculated for Future Residential Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 1.75E-05 | 1.66E-06 | 1.27E-08 |
| Barium | | | |
| Cadmium | | | 9.79E-10 |
| Chromium | | | 7.63E-08 |
| Cobalt | | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | |
| Molybdenum | | | |
| Nickel | | | |
| Selenium | | | |
| Silver | | | |
| Zinc | | | |
| 1,2-Dichloroethene (total) | | | |
| cis-1,2-Dichloroethene | | | |
| Tetrachloroethene | 1.11E-06 | | 1.99E-05 |
| Toluene | | | |
| Trichloroethene | 2.55E-06 | | 1.02E-06 |
| Vinyl chloride (child) | 1.99E-06 | | 5.51E-06 |
| Vinyl chloride (adult) | 4.26E-07 | | 2.75E-06 |
| Xylenes (total) | | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | 2.64E-06 | 1.08E-06 | 8.04E-11 |
| Benzo(b)fluoranthene | 3.57E-06 | 1.47E-06 | 1.09E-10 |
| Benzo(k)fluoranthene | 4.51E-07 | 1.85E-07 | 1.37E-11 |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | 3.78E-05 | 1.55E-05 | 1.15E-09 |
| Chrysene | 5.18E-08 | 2.13E-08 | 1.58E-12 |
| Dibenzofuran | | | |
| bis(2-Ethylhexyl)phthalate | 1.65E-08 | 5.22E-09 | 1.19E-12 |
| Fluoranthene | | | |
| Fluorene | | | |
| Indeno(1,2,3-cd)pyrene | 2.31E-06 | 9.50E-07 | 7.05E-11 |
| Naphthalene | | | |
| Phenanthrene | | | |
| Pyrene | | | |
| alpha-Chlordane | 2.36E-09 | 2.98E-10 | 1.70E-13 |
| gamma-Chlordane | 2.25E-09 | 2.84E-10 | 1.62E-13 |
| 4,4'-DDD | 1.20E-08 | 3.80E-09 | |
| 4,4'-DDE | 1.08E-07 | 3.42E-08 | |
| 4,4'-DDT | 6.92E-08 | 6.55E-09 | 4.99E-12 |
| Dieldrin | 1.80E-12 | 5.68E-13 | 4.18E-11 |
| Endosulfan II | | | |
| Methoxychlor | | | |
| **Pathway Carcinogenic Risks** | 7.1E-05 | 2.1E-05 | 2.9E-05 |
| **TOTAL CARCINOGENIC RISK FOR FUTURE RESIDENTIAL SCENARIO** | **1.2E-04** | | |

Not Available - lacks toxicity values

# TABLE 13.

Carcinogenic Risks Calculated for Future Occupational Exposure
to Contaminated Groundwater from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK | |
|---|---|---|
| | Well Water Sampling | Borehole Sampling |
| | Drinking Water Ingestion | Drinking Water Ingestion |
| Acetone | | |
| Benzene | 3.08E-07 | 1.57E-05 |
| Chloroform | 2.13E-09 | |
| 1,1-Dichloroethene | 8.60E-07 | |
| 1,2-Dichloroethene (total) | | |
| cis-1,2-Dichloroethene | | |
| trans-1,2-Dichloroethene | | |
| Methyl tert-butyl ether (MTBE) | | |
| Tetrachloroethene | 9.86E-06 | 1.93E-04 |
| Tetrahydrofuran | 1.97E-07 | |
| Toluene | | |
| 1,1,1-Trichloroethane | | |
| Trichloroethene | 7.07E-05 | 1.86E-03 |
| 1,2,4-Trimethylbenzene | | |
| Vinyl chloride (adult) | 2.29E-04 | 2.48E-04 |
| m-Xylene & p-Xylene | | |
| o-Xylene | | |
| **TOTAL CARCINOGENIC RISK FOR FUTURE OCCUPATIONAL SCENARIO** | 3.1E-04 | 2.3E-03 |

Not Available - lacks toxicity values

# TABLE 14.

Carcinogenic Risks Calculated for Current or Future Occupational Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 1.95E-06 | 7.74E-07 | 5.96E-09 |
| Barium | | | |
| Cadmium | | | 4.60E-10 |
| Chromium | | | 3.59E-08 |
| Cobalt | | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | |
| Molybdenum | | | |
| Nickel | | | |
| Selenium | | | |
| Silver | | | |
| Zinc | | | |
| 1,2-Dichloroethene (total) | | | |
| cis-1,2-Dichloroethene | | | |
| Tetrachloroethene | 1.24E-07 | | 9.35E-06 |
| Toluene | | | |
| Trichloroethene | 2.84E-07 | | 4.78E-07 |
| Vinyl chloride (adult) | 1.58E-07 | | 1.29E-06 |
| Xylenes (total) | | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | 2.94E-07 | 5.05E-07 | 3.78E-11 |
| Benzo(b)fluoranthene | 3.98E-07 | 6.84E-07 | 5.11E-11 |
| Benzo(k)fluoranthene | 5.04E-08 | 8.64E-08 | 6.46E-12 |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | 4.22E-06 | 7.25E-06 | 5.42E-10 |
| Chrysene | 5.78E-09 | 9.92E-09 | 7.42E-13 |
| Dibenzofuran | | | |
| bis(2-Ethylhexyl)phthalate | 1.85E-09 | 2.44E-09 | 5.61E-13 |
| Fluoranthene | | | |
| Fluorene | | | |
| Indeno(1,2,3-cd)pyrene | 2.58E-07 | 4.43E-07 | 3.31E-11 |
| Naphthalene | | | |
| Phenanthrene | | | |
| Pyrene | | | |
| alpha-Chlordane | 2.63E-10 | 1.39E-10 | 7.99E-14 |
| gamma-Chlordane | 2.51E-10 | 1.32E-10 | 7.62E-14 |
| 4,4'-DDD | 1.34E-09 | 1.77E-09 | |
| 4,4'-DDE | 1.21E-08 | 1.60E-08 | |
| 4,4'-DDT | 7.72E-09 | 3.06E-09 | 2.34E-12 |
| Dieldrin | 2.01E-13 | 2.65E-13 | 1.97E-11 |
| Endosulfan II | | | |
| Methoxychlor | | | |
| **Pathway Carcinogenic Risks** | 7.8E-06 | 9.8E-06 | 1.1E-05 |
| **TOTAL CARCINOGENIC RISK FOR CURRENT OR FUTURE OCCUPATIONAL SCENARIO** | 2.9E-05 | | |

Not Available - lacks toxicity values

# TABLE 15.

Carcinogenic Risks Calculated for Future Recreational Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 3.00E-06 | 2.84E-07 | 2.17E-09 |
| Barium | | | |
| Cadmium | | | 1.68E-10 |
| Chromium | | | 1.31E-08 |
| Cobalt | | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | |
| Molybdenum | | | |
| Nickel | | | |
| Selenium | | | |
| Silver | | | |
| Zinc | | | |
| 1,2-Dichloroethene (total) | | | |
| cis-1,2-Dichloroethene | | | |
| Tetrachloroethene | 1.90E-07 | | 3.41E-06 |
| Toluene | | | |
| Trichloroethene | 4.36E-07 | | 1.75E-07 |
| Vinyl chloride (child) | 3.40E-07 | | 9.44E-07 |
| Vinyl chloride (adult) | 7.30E-08 | | 4.72E-07 |
| Xylenes (total) | | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | 4.52E-07 | 1.86E-07 | 1.38E-11 |
| Benzo(b)fluoranthene | 6.12E-07 | 2.51E-07 | 1.86E-11 |
| Benzo(k)fluoranthene | 7.73E-08 | 3.17E-08 | 2.36E-12 |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | 6.49E-06 | 2.66E-06 | 1.98E-10 |
| Chrysene | 8.88E-09 | 3.65E-09 | 2.71E-13 |
| Dibenzofuran | | | |
| bis(2-Ethylhexyl)phthalate | 2.84E-09 | 8.95E-10 | 2.05E-13 |
| Fluoranthene | | | |
| Fluorene | | | |
| Indeno(1,2,3-cd)pyrene | 3.97E-07 | 1.63E-07 | 1.21E-11 |
| Naphthalene | | | |
| Phenanthrene | | | |
| Pyrene | | | |
| alpha-Chlordane | 4.04E-10 | 5.10E-11 | 2.92E-14 |
| gamma-Chlordane | 3.85E-10 | 4.86E-11 | 2.78E-14 |
| 4,4'-DDD | 2.06E-09 | 6.51E-10 | |
| 4,4'-DDE | 1.86E-08 | 5.87E-09 | |
| 4,4'-DDT | 1.19E-08 | 1.12E-09 | 8.55E-13 |
| Dieldrin | 3.09E-13 | 9.74E-14 | 7.17E-12 |
| Endosulfan II | | | |
| Methoxychlor | | | |
| **Pathway Carcinogenic Risks** | 1.2E-05 | 3.6E-06 | 5.0E-06 |
| **TOTAL CARCINOGENIC RISK FOR FUTURE RECREATIONAL SCENARIO** | **2.1E-05** | | |

Not Available - lacks toxicity values

# TABLE 16.

Carcinogenic Risks Calculated for Current or Future Construction/Utility Worker Exposure
to Contaminated Sub-Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | CARCINOGENIC RISK | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 2.10E-07 | 1.26E-08 | 9.72E-11 |
| Barium | | | |
| Cadmium | | | 2.80E-12 |
| Chromium | | | 6.04E-10 |
| Copper | | | |
| Lead | | | |
| Mercury | | | |
| Nickel | | | |
| Zinc | | | |
| Acetone | | | |
| 2-Butanone (MEK) | | | |
| 1,2-Dichloroethene (total) | | | |
| cis-1,2-Dichloroethene | | | |
| Ethylbenzene | | | |
| Tetrachloroethene | 7.35E-08 | | 8.40E-07 |
| Toluene | | | |
| 1,1,1-Trichloroethane | | | |
| Trichloroethene | 8.86E-09 | | 2.26E-09 |
| Xylenes (total) | | | |
| gamma-BHC (Lindane) | 1.96E-10 | 1.57E-11 | |
| 4,4'-DDD | 3.14E-11 | 6.27E-12 | |
| 4,4'-DDE | 6.85E-11 | 1.37E-11 | |
| 4,4'-DDT | 6.62E-11 | 3.97E-12 | 3.05E-15 |
| Dieldrin | 1.44E-14 | 2.88E-15 | 2.13E-13 |
| **Pathway Carcinogenic Risks** | 2.9E-07 | 1.3E-08 | 8.4E-07 |
| **TOTAL CARCINOGENIC RISK FOR CURRENT OR FUTURE CONSTRUCTION/UTILITY WORKER SCENARIO** | **1.1E-06** | | |

Not Available - lacks toxicity values

# TABLE 17.

Non-Carcinogenic Risks Calculated for Current Occupational Exposure
to Contaminated Groundwater from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX |
|---|---|
| | Drinking Water Ingestion |
| Tetrachloroethene | 0.01 |
| **TOTAL HAZARD INDEX FOR CURRENT OCCUPATIONAL SCENARIO** | **0.01** |

Not Available - lacks toxicity values

# TABLE 18.

Non-Carcinogenic Risks Calculated for Current Trespasser Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 0.01 | 0.001 | |
| Barium | 0.003 | | 0.00001 |
| Cadmium | 0.001 | 0.0001 | 0.000002 |
| Chromium | 0.003 | | 0.00004 |
| Cobalt | 0.0001 | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | 0.0000002 |
| Molybdenum | 0.0005 | | |
| Nickel | 0.001 | | |
| Selenium | 0.003 | | |
| Silver | 0.0005 | | |
| Zinc | 0.001 | | |
| 1,2-Dichloroethene (total) | 0.001 | | |
| cis-1,2-Dichloroethene | 0.001 | | |
| Tetrachloroethene | 0.002 | | 0.01 |
| Toluene | 0.000001 | | 0.0001 |
| Trichloroethene | 0.01 | | 0.01 |
| Vinyl chloride (child) | 0.0002 | | 0.004 |
| Xylenes (total) | 0.0000002 | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | | | |
| Benzo(b)fluoranthene | | | |
| Benzo(k)fluoranthene | | | |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | | | |
| Chrysene | | | |
| Dibenzofuran | 0.0002 | 0.00003 | |
| bis(2-Ethylhexyl)phthalate | 0.00002 | 0.000004 | |
| Fluoranthene | 0.0001 | 0.00004 | |
| Fluorene | 0.00002 | 0.000004 | |
| Indeno(1,2,3-cd)pyrene | | | |
| Naphthalene | 0.00004 | 0.00001 | 0.0000001 |
| Phenanthrene | | | |
| Pyrene | 0.0002 | 0.00004 | |
| alpha-Chlordane | 0.000005 | 0.0000004 | 0.000000001 |
| gamma-Chlordane | 0.000005 | 0.0000004 | 0.000000001 |
| 4,4'-DDD | | | |
| 4,4'-DDE | | | |
| 4,4'-DDT | 0.0001 | 0.00001 | |
| Dieldrin | 0.0003 | 0.0001 | |
| Endosulfan II | 0.000003 | 0.000001 | |
| Methoxychlor | 0.00001 | 0.000001 | |
| **Pathway Non-Carcinogenic Risks** | 0.04 | 0.001 | 0.02 |
| **TOTAL HAZARD INDEX FOR CURRENT TRESPASSER SCENARIO** | **0.06** | | |

Not Available - lacks toxicity values

# TABLE 19.

Non-Carcinogenic Risks Calculated for Future Residential Exposure
to Contaminated Groundwater from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX | | | | | |
|---|---|---|---|---|---|---|
| | Well Water Sampling | | | Borehole Sampling | | |
| | Drinking Water Ingestion | Dermal Contact | Inhalation | Drinking Water Ingestion from Borehole Sampling | Dermal Contact | Inhalation |
| Acetone | 0.01 | | | | | |
| Benzene | 0.001 | 0.00004 | 0.004 | 0.03 | 0.002 | 0.2 |
| Chloroform | 0.0003 | 0.00001 | | | | |
| 1,1-Dichloroethene | 0.002 | 0.0001 | | | | |
| 1,2-Dichloroethene (total) | 2.4 | 0.1 | | 11.3 | 0.4 | |
| cis-1,2-Dichloroethene | 1.5 | | | 4.8 | | |
| trans-1,2-Dichloroethene | 0.02 | | | | | |
| Methyl tert-butyl ether (MTBE) | | | 0.00003 | | | |
| Tetrachloroethene | 0.5 | 0.1 | 0.003 | 9.2 | 1.4 | 0.1 |
| Tetrahydrofuran | 0.001 | | 0.0004 | | | |
| Toluene | 0.00003 | 0.000005 | 0.00001 | | | |
| 1,1,1-Trichloroethane | 0.00001 | 0.000001 | 0.000001 | | | |
| Trichloroethene | 5.8 | 0.3 | 0.02 | 154.1 | 8.7 | 0.5 |
| 1,2,4-Trimethylbenzene | 0.0002 | | 0.001 | | | |
| Vinyl chloride | 1 | 0.03 | 0.01 | 1.1 | 0.03 | 0.01 |
| m-Xylene & p-Xylene | 0.00001 | 0.000001 | | | | |
| o-Xylene | 0.000002 | | | | | |
| **Pathway Non-Carcinogenic Risks** | 11 | 0.5 | 0.04 | 181 | 11 | 0.8 |
| **TOTAL HAZARD INDEX FOR FUTURE RESIDENTIAL SCENARIO** | 12 | | | 192 | | |

Not Available - lacks toxicity values

# TABLE 20.

Non-Carcinogenic Risks Calculated for Future Residential Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 0.1 | 0.01 | |
| Barium | 0.02 | | 0.0001 |
| Cadmium | 0.01 | 0.001 | 0.00001 |
| Chromium | 0.02 | | 0.0001 |
| Cobalt | 0.001 | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | 0.000001 |
| Molybdenum | 0.003 | | |
| Nickel | 0.003 | | |
| Selenium | 0.02 | | |
| Silver | 0.003 | | |
| Zinc | 0.004 | | |
| 1,2-Dichloroethene (total) | 0.004 | | |
| cis-1,2-Dichloroethene | 0.004 | | |
| Tetrachloroethene | 0.01 | | 0.03 |
| Toluene | 0.00001 | | 0.0003 |
| Trichloroethene | 0.05 | | 0.03 |
| Vinyl chloride | 0.001 | | 0.01 |
| Xylenes (total) | 0.000001 | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | | | |
| Benzo(b)fluoranthene | | | |
| Benzo(k)fluoranthene | | | |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | | | |
| Chrysene | | | |
| Dibenzofuran | 0.001 | 0.0004 | |
| bis(2-Ethylhexyl)phthalate | 0.0001 | 0.00004 | |
| Fluoranthene | 0.001 | 0.0004 | |
| Fluorene | 0.0001 | 0.00005 | |
| Indeno(1,2,3-cd)pyrene | | | |
| Naphthalene | 0.0003 | 0.0001 | 0.0000005 |
| Phenanthrene | | | |
| Pyrene | 0.001 | 0.0004 | |
| alpha-Chlordane | 0.00003 | 0.000004 | 0.00000001 |
| gamma-Chlordane | 0.00003 | 0.000004 | 0.00000001 |
| 4,4'-DDD | | | |
| 4,4'-DDE | | | |
| 4,4'-DDT | 0.001 | 0.0001 | |
| Dieldrin | 0.002 | 0.001 | |
| Endosulfan II | 0.00002 | 0.00001 | |
| Methoxychlor | 0.00004 | 0.00001 | |
| **Pathway Non-Carcinogenic Risks** | 0.2 | 0.01 | 0.08 |
| **TOTAL HAZARD INDEX FOR FUTURE RESIDENTIAL SCENARIO** | **0.3** | | |

Not Available - lacks toxicity values

# TABLE 21.

Non-Carcinogenic Risks Calculated for Future Occupational Exposure
to Contaminated Groundwater from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX | |
|---|---|---|
| | Well Water Sampling | Borehole Sampling |
| | Drinking Water Ingestion | Drinking Water Ingestion |
| Acetone | 0.002 | |
| Benzene | 0.0002 | 0.01 |
| Chloroform | 0.0001 | |
| 1,1-Dichloroethene | 0.0004 | |
| 1,2-Dichloroethene (total) | 0.7 | 3.2 |
| cis-1,2-Dichloroethene | 0.4 | 1.4 |
| trans-1,2-Dichloroethene | 0.01 | |
| Methyl tert-butyl ether (MTBE) | | |
| Tetrachloroethene | 0.1 | 2.6 |
| Tetrahydrofuran | 0.0004 | |
| Toluene | 0.00001 | |
| 1,1,1-Trichloroethane | 0.000004 | |
| Trichloroethene | 1.6 | 43.4 |
| 1,2,4-Trimethylbenzene | 0.0001 | |
| Vinyl chloride (adult) | 0.3 | 0.3 |
| m-Xylene & p-Xylene | 0.000001 | |
| o-Xylene | 0.0000005 | |
| **TOTAL HAZARD INDEX FOR FUTURE OCCUPATIONAL SCENARIO** | **3** | **51** |

Not Available - lacks toxicity values

# TABLE 22.

Non-Carcinogenic Risks Calculated for Current or Future Occupational Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 0.01 | 0.005 | |
| Barium | 0.002 | | 0.00003 |
| Cadmium | 0.001 | 0.0004 | 0.000004 |
| Chromium | 0.003 | | 0.0001 |
| Cobalt | 0.0001 | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | 0.0000004 |
| Molybdenum | 0.0004 | | |
| Nickel | 0.0004 | | |
| Selenium | 0.002 | | |
| Silver | 0.0004 | | |
| Zinc | 0.0005 | | |
| 1,2-Dichloroethene (total) | 0.001 | | |
| cis-1,2-Dichloroethene | 0.001 | | |
| Tetrachloroethene | 0.002 | | 0.01 |
| Toluene | 0.000001 | | 0.0002 |
| Trichloroethene | 0.01 | | 0.02 |
| Vinyl chloride (adult) | 0.0002 | | 0.01 |
| Xylenes (total) | 0.0000001 | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | | | |
| Benzo(b)fluoranthene | | | |
| Benzo(k)fluoranthene | | | |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | | | |
| Chrysene | | | |
| Dibenzofuran | 0.0002 | 0.0002 | |
| bis(2-Ethylhexyl)phthalate | 0.00002 | 0.00002 | |
| Fluoranthene | 0.0001 | 0.0002 | |
| Fluorene | 0.00001 | 0.00003 | |
| Indeno(1,2,3-cd)pyrene | | | |
| Naphthalene | 0.00004 | 0.0001 | 0.0000003 |
| Phenanthrene | | | |
| Pyrene | 0.0001 | 0.0002 | |
| alpha-Chlordane | 0.000004 | 0.000002 | 0.000000003 |
| gamma-Chlordane | 0.000004 | 0.000002 | 0.000000003 |
| 4,4'-DDD | | | |
| 4,4'-DDE | | | |
| 4,4'-DDT | 0.0001 | 0.0001 | |
| Dieldrin | 0.0002 | 0.0003 | |
| Endosulfan II | 0.000002 | 0.000003 | |
| Methoxychlor | 0.000005 | 0.00001 | |
| **Pathway Non-Carcinogenic Risks** | 0.03 | 0.01 | 0.04 |
| **TOTAL HAZARD INDEX FOR CURRENT OR FUTURE OCCUPATIONAL SCENARIO** | **0.08** | | |

Not Available - lacks toxicity values

# TABLE 23.

Non-Carcinogenic Risks Calculated for Future Recreational Exposure
to Contaminated Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 0.02 | 0.001 | |
| Barium | 0.003 | | 0.00001 |
| Cadmium | 0.001 | 0.0001 | 0.000001 |
| Chromium | 0.003 | | 0.00003 |
| Cobalt | 0.0001 | | |
| Copper | | | |
| Lead | | | |
| Mercury | | | 0.0000001 |
| Molybdenum | 0.001 | | |
| Nickel | 0.001 | | |
| Selenium | 0.003 | | |
| Silver | 0.001 | | |
| Zinc | 0.001 | | |
| 1,2-Dichloroethene (total) | 0.001 | | |
| cis-1,2-Dichloroethene | 0.001 | | |
| Tetrachloroethene | 0.002 | | 0.004 |
| Toluene | 0.000001 | | 0.00005 |
| Trichloroethene | 0.01 | | 0.006 |
| Vinyl chloride | 0.0003 | | 0.003 |
| Xylenes (total) | 0.0000002 | | |
| Acenaphthylene | | | |
| Benzo(a)anthracene | | | |
| Benzo(b)fluoranthene | | | |
| Benzo(k)fluoranthene | | | |
| Benzo(g,h,i)perylene | | | |
| Benzo(a)pyrene | | | |
| Chrysene | | | |
| Dibenzofuran | 0.0002 | 0.0001 | |
| bis(2-Ethylhexyl)phthalate | 0.00002 | 0.00001 | |
| Fluoranthene | 0.0002 | 0.0001 | |
| Fluorene | 0.00002 | 0.00001 | |
| Indeno(1,2,3-cd)pyrene | | | |
| Naphthalene | 0.00005 | 0.00002 | 0.0000001 |
| Phenanthrene | | | |
| Pyrene | 0.0002 | 0.0001 | |
| alpha-Chlordane | 0.00001 | 0.000001 | 0.000000001 |
| gamma-Chlordane | 0.00001 | 0.000001 | 0.000000001 |
| 4,4'-DDD | | | |
| 4,4'-DDE | | | |
| 4,4'-DDT | 0.0002 | 0.00002 | |
| Dieldrin | 0.0003 | 0.0001 | |
| Endosulfan II | 0.000003 | 0.000001 | |
| Methoxychlor | 0.00001 | 0.000002 | |
| **Pathway Non-Carcinogenic Risks** | 0.04 | 0.002 | 0.01 |
| **TOTAL HAZARD INDEX FOR FUTURE RECREATIONAL SCENARIO** | **0.06** | | |

Not Available - lacks toxicity values

# TABLE 24.

Non-Carcinogenic Risks Calculated for Current or Future Construction/Utility Worker Exposure
to Contaminated Sub-Surface Soil from Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| | HAZARD INDEX | | |
|---|---|---|---|
| | **Incidental Ingestion** | **Dermal Contact** | **Inhalation** |
| Arsenic | 0.03 | 0.002 | |
| Barium | 0.005 | | 0.0001 |
| Cadmium | 0.001 | 0.0001 | 0.0000001 |
| Chromium | 0.007 | | 0.00004 |
| Copper | | | |
| Lead | | | |
| Mercury | | | 0.0000001 |
| Nickel | 0.001 | | |
| Zinc | 0.001 | | |
| Acetone | 0.0000004 | | |
| 2-Butanone (MEK) | 0.00000004 | | 0.000001 |
| 1,2-Dichloroethene (total) | 0.0005 | | |
| cis-1,2-Dichloroethene | 0.00002 | | |
| Ethylbenzene | 0.0000002 | | 0.000001 |
| Tetrachloroethene | 0.002 | | |
| Toluene | 0.0000001 | | 0.00001 |
| 1,1,1-Trichloroethane | 0.00000001 | | 0.0000001 |
| Trichloroethene | | | |
| Xylenes (total) | 0.0000003 | | |
| gamma-BHC (Lindane) | 0.000004 | 0.0000003 | |
| 4,4'-DDD | | | |
| 4,4'-DDE | | | |
| 4,4'-DDT | 0.00003 | 0.000002 | |
| Dieldrin | 0.0004 | 0.0001 | |
| **Pathway Non-Carcinogenic Risks** | 0.05 | 0.002 | 0.0002 |
| **TOTAL HAZARD INDEX FOR CURRENT OR FUTURE CONSTRUCTION/UTILITY WORKER SCENARIO** | **0.05** | | |

Not Available - lacks toxicity values

# TABLE 25.

Summary of Calculated Risks for Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

| Scenario | Media | Total Excess Cancer Risk | Total Hazard Index |
|---|---|---|---|
| Current Occupational | GROUNDWATER | 7.2E-07 | 0.01 |
| Current Trespasser | SURFACE SOIL | 5.3E-06 | 0.06 |
| Future Residential | GROUNDWATER (based on well sampling) | 1.7E-03 | 12 |
| Future Residential | GROUNDWATER (based on borehole sampling) | 1.1E-02 | 192 |
| Future Residential | SURFACE SOIL | 1.2E-04 | 0.3 |
| Future Occupational | GROUNDWATER (based on well sampling) | 3.1E-04 | 3 |
| Future Occupational | GROUNDWATER (based on borehole sampling) | 2.3E-03 | 51 |
| Current or Future Occupational | SURFACE SOIL | 2.9E-05 | 0.08 |
| Future Recreational | SURFACE SOIL | 2.1E-05 | 0.06 |
| Current or Future Construction/Utility Worker | SUBSURFACE SOIL | 1.1E-06 | 0.05 |

**FIGURE 1.**
Location of New Haven, Missouri

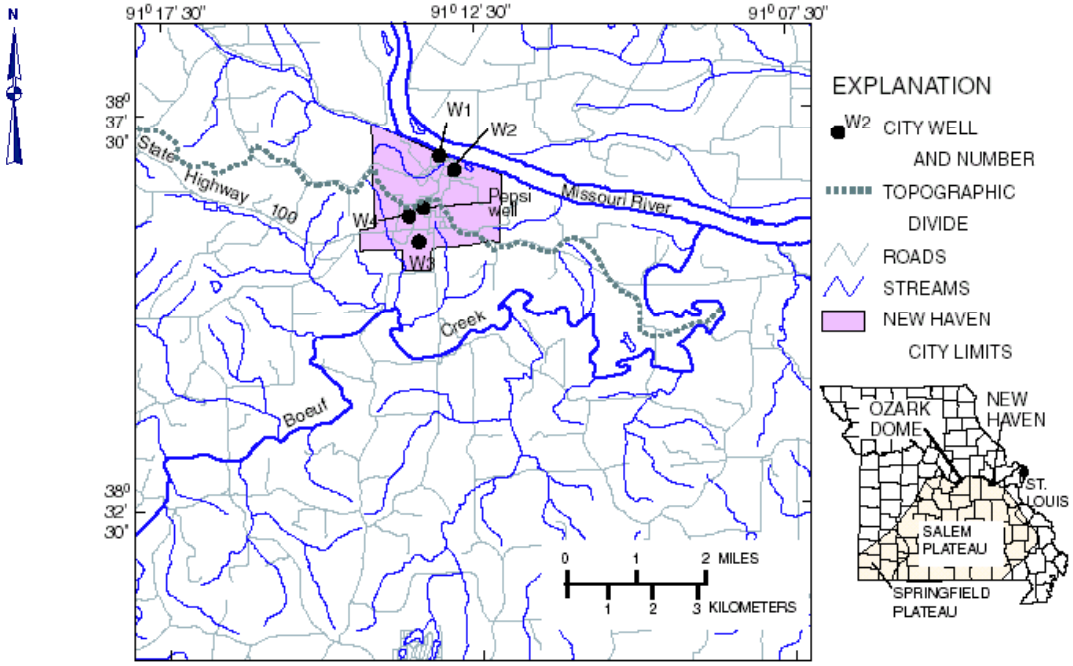


**FIGURE 2.**
Locations of the Riverfront Site Operable Units

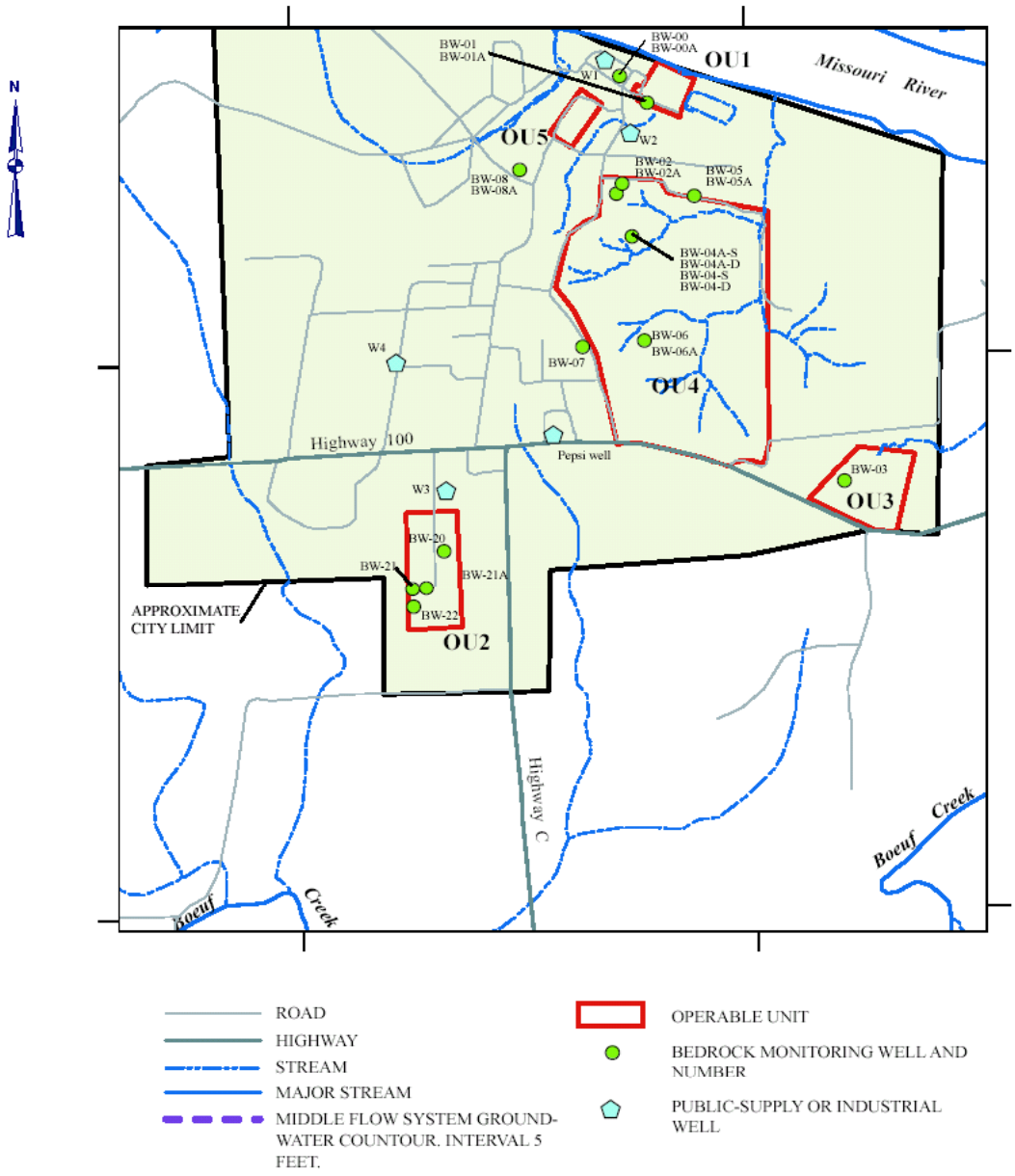
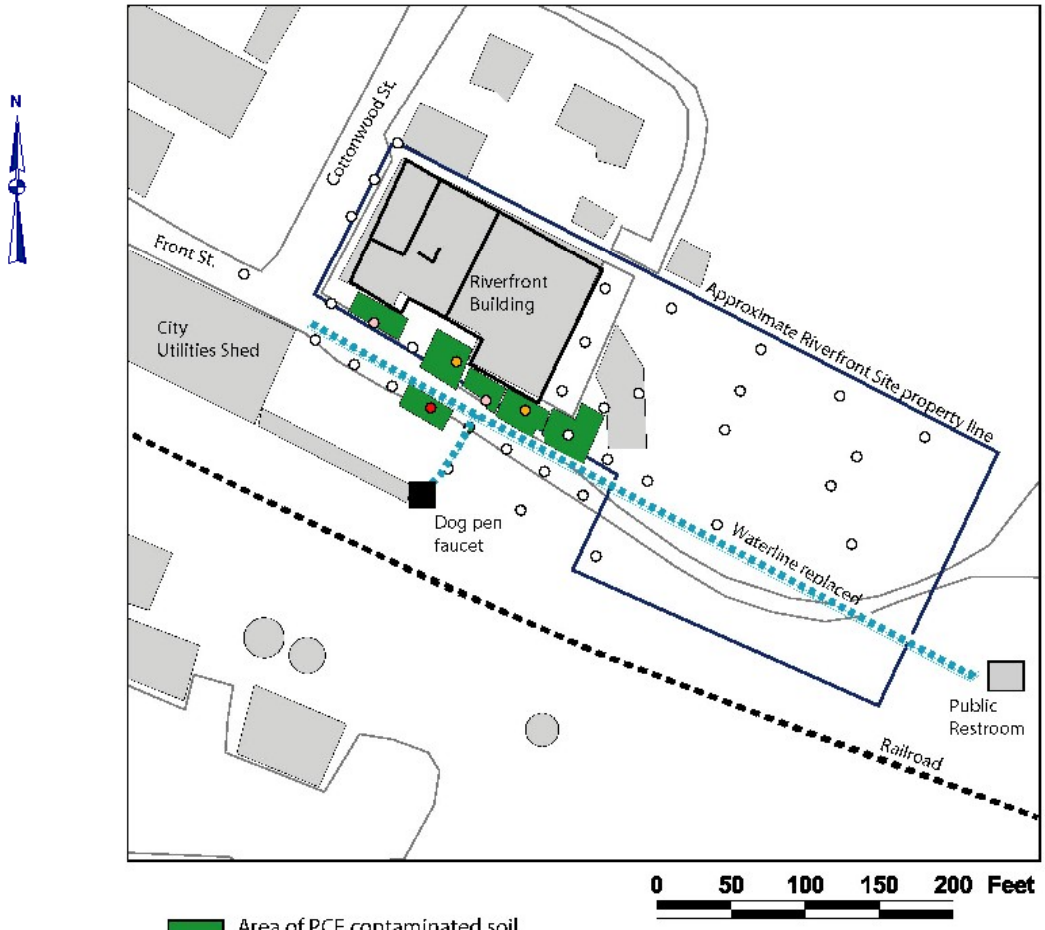


**FIGURE 3.**

Location of U.S. EPA Removal Action in OU1, July 2000




Area of PCE contaminated soil removed by the U.S. EPA

Soil boring conducted before the water-line removal action. Color indicates degree of PCE contamination

- Lowest
- Small
- Moderate
- Highest

**FIGURE 4.**
Features of the Riverfront Site OU1 in downtown, New Haven, Missouri

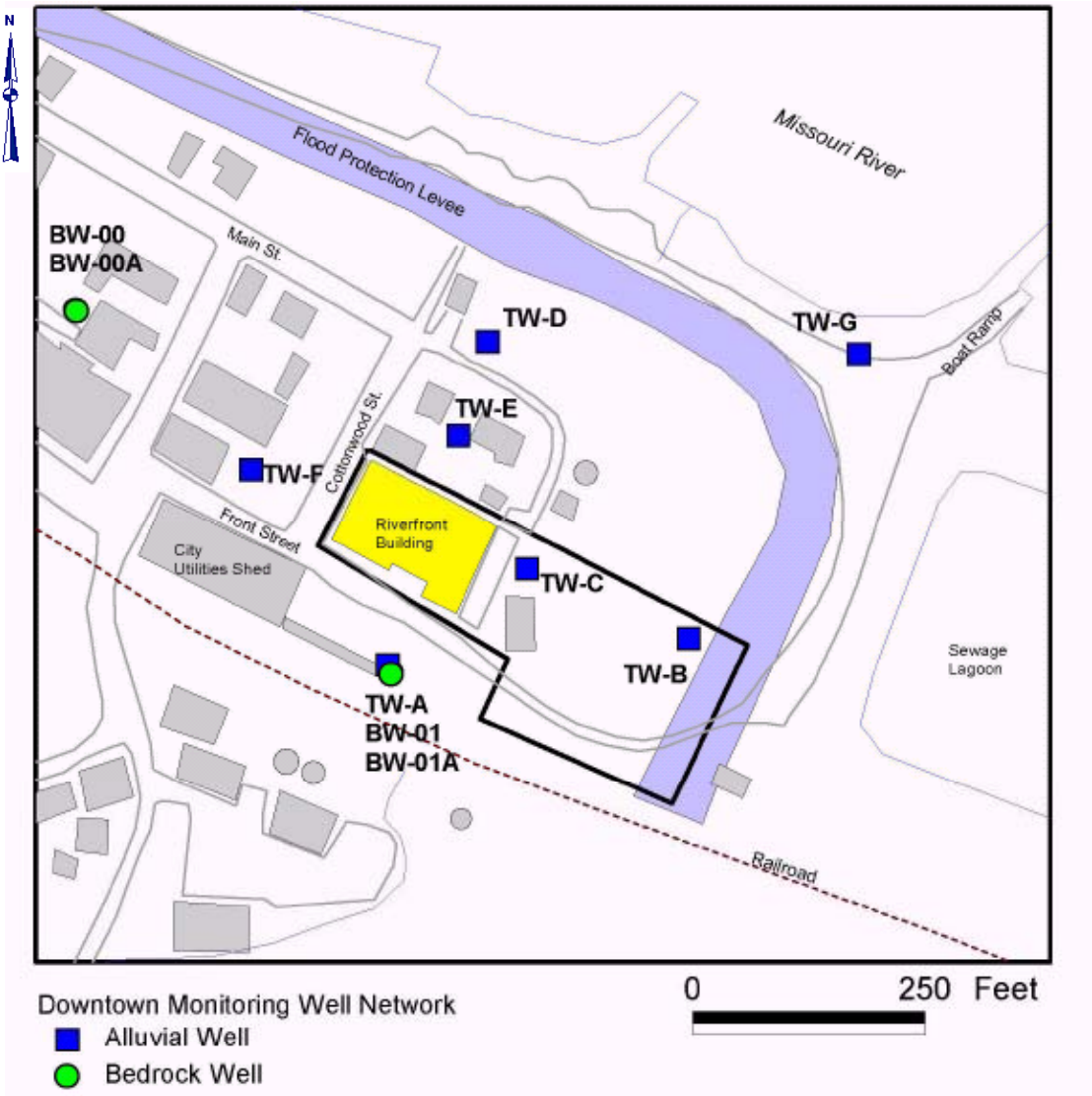
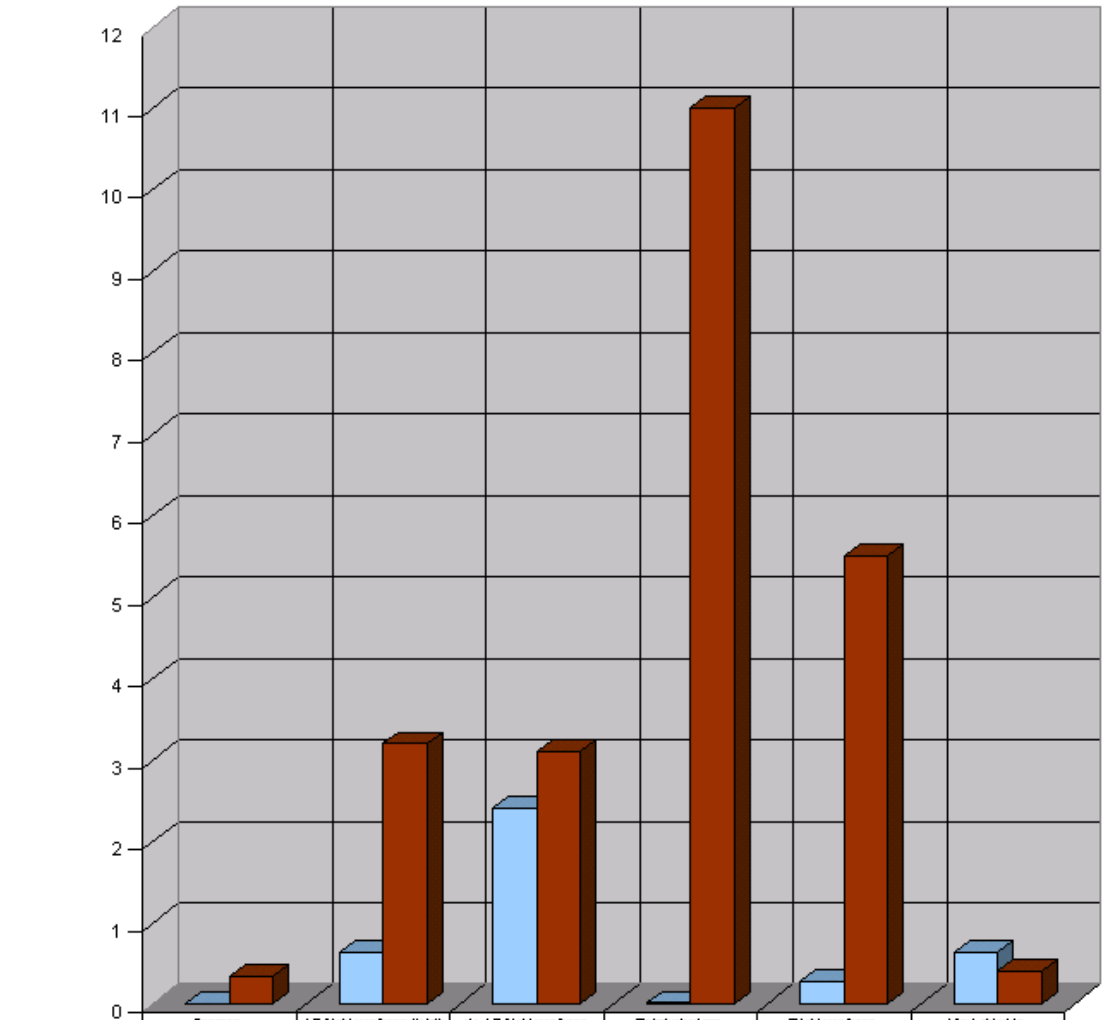


**FIGURE 5.**

Comparison of Maximum Detected Values for Groundwater
Well Sampling vs. Borehole Sampling
Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri



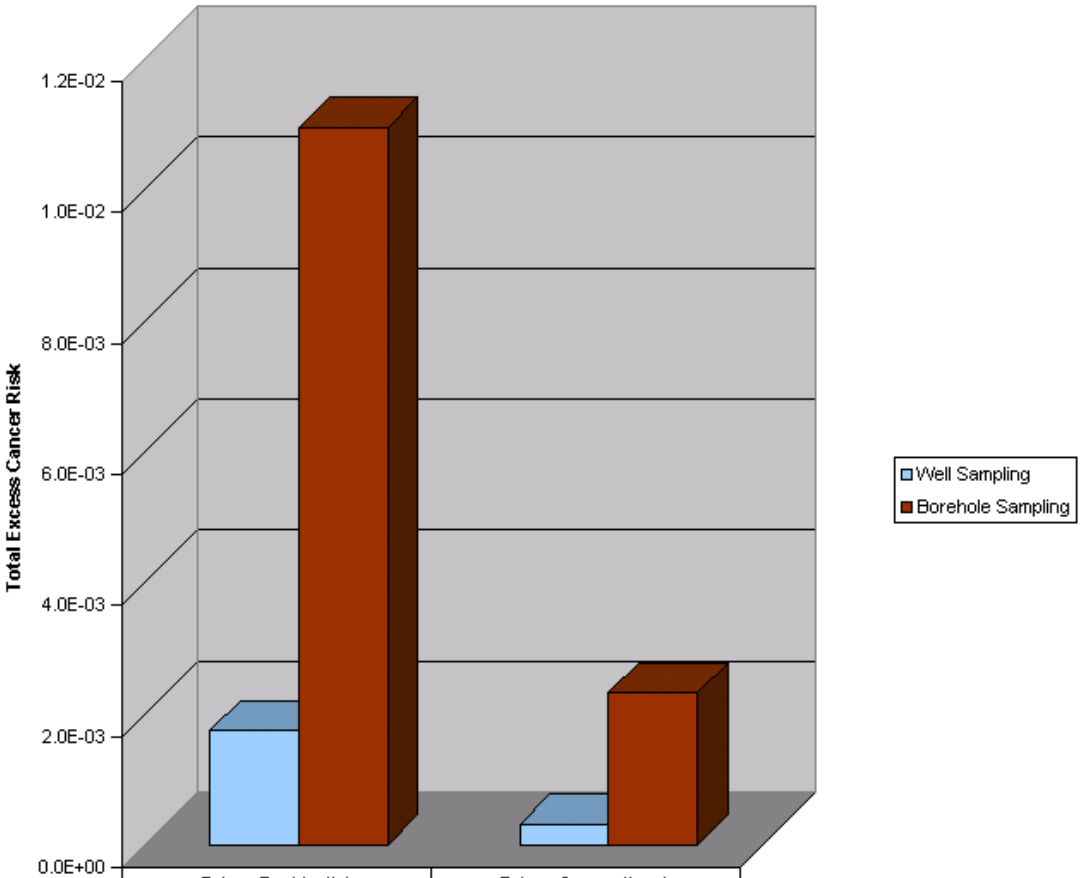

| | Benzene | 1,2-Dichloroethene (total) | cis-1,2-Dichloroethene | Tetrahydrofuran | Trichloroethene | Vinyl chloride |
|---|---|---|---|---|---|---|
| Well Sampling | 0.0016 | 0.63 | 2.4 | 0.0123 | 0.28 | 0.63 |
| Borehole Sampling | 0.34 | 3.2 | 3.1 | 11 | 5.5 | 0.41 |

**FIGURE 6.**

Comparison of Total Excess Cancer Risk for Groundwater based on Well Sampling vs. Borehole Sampling for the Future Residential and Occupational Scenarios

Operable Unit 1 - Front Street

The Riverfront Site, New Haven, Franklin County, Missouri



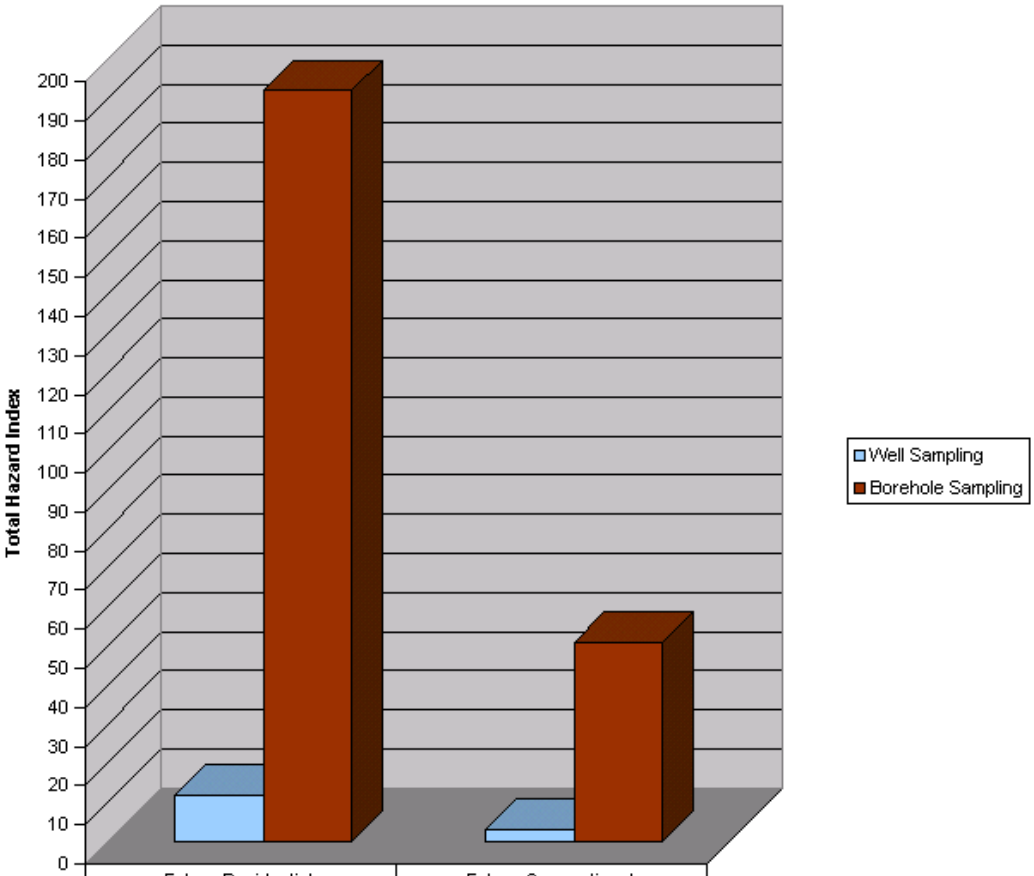

| | Future Residential | Future Occupational |
|---|---|---|
| Well Sampling | 1.7E-03 | 3.1E-04 |
| Borehole Sampling | 1.1E-02 | 2.3E-03 |

**FIGURE 7.**

Comparison of Total Hazard Index for Groundwater based on Well Sampling vs. Borehole Sampling for the Future Residential and Occupational Scenarios

Operable Unit 1 - Front Street

The Riverfront Site, New Haven, Franklin County, Missouri




| | Future Residential | Future Occupational |
|---|---|---|
| Well Sampling | 12 | 3 |
| Borehole Sampling | 192 | 51 |

**FIGURE 8.**

Summary of Total Excess Cancer Risks
Operable Unit 1 - Front Street
The Riverfront Site, New Haven, Franklin County, Missouri

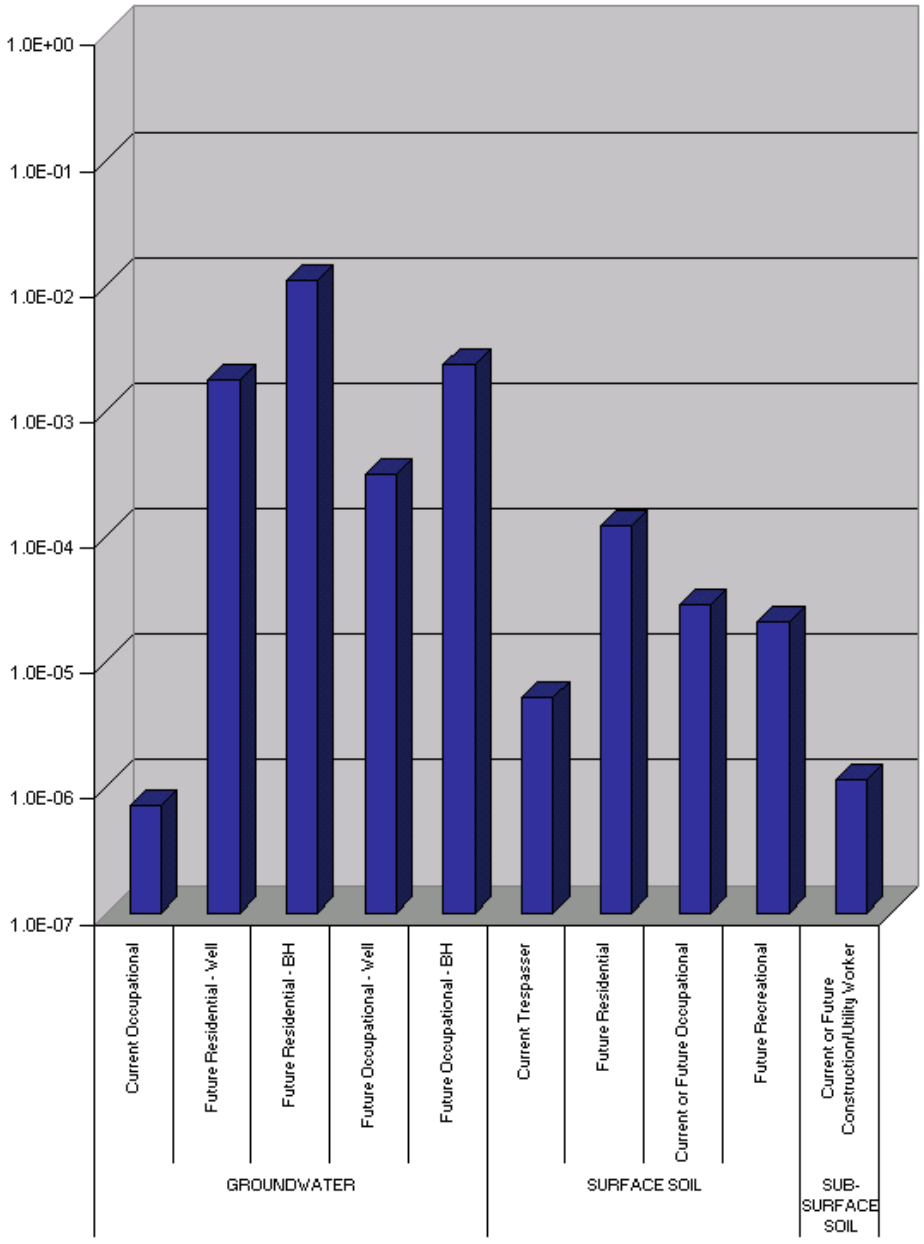


**FIGURE 9.**

Summary of Hazard Indices

Operable Unit 1 - Front Street

The Riverfront Site, New Haven, Franklin County, Missouri