Final Report

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

FUDS Property Number G05OH0007
Project Number 33

Prepared for

U.S. Army Corps of Engineers
Contract Number W912PP-09-D-0016
Delivery Order Number CY01

July 2016

Executive Summary

This feasibility study (FS) report was prepared for areas of concern (AOCs) 17, 18, 19, and 103 (the Site) at the former Lockbourne Air Force Base in Columbus, Ohio. Because AOCs 17, 18, 19, and 103 are near one another and have been evaluated together, they are referred to as the Site. The AOCs are identified as Formerly Used Defense Site (FUDS) Property Number G05OH0007, Project Number 33. The FUDS program follows the remedial process outlined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The United States Army Corps of Engineers (USACE) is the lead agency for purposes of implementing the FUDS program in Ohio for the Department of Defense (DOD) and works in coordination with the Ohio Environmental Protection Agency (Ohio EPA).

The Site occupies what had been the central machine shop area of the former Air Force Base, adjacent to the tarmac. Operations at the four buildings likely involved the use of solvents, cleaners, petroleum, oils, and lubricants. There are two buildings within the AOCs: the Aircraft Maintenance Building, or hangar, and a passenger terminal. The remaining areas are grass and pavement covered. The Columbus Regional Airport Authority is the current owner of the property where the AOCs are located.

This FS report describes the development of remedial action objectives to protect human health and the environment, identifies applicable or relevant and appropriate requirements (ARARs) and to-be-considered criteria, and describes the development and evaluation of remedial alternatives to mitigate potential future unacceptable risks from vapor intrusion (VI) of soil gas to indoor air at the Site. Based on the results of the *Final Remedial Investigation Report for Areas of Concern 17/18/19/103 at the Former Lockbourne Air Force Base, Ohio* (CH2M HILL 2015), there are no unacceptable human health or ecological risks to current receptors from exposures to surface soil, total soil, groundwater, or indoor air at the Aircraft Maintenance Building. However, the VI of trichloroethene (TCE) in soil gas to indoor air poses potential future unacceptable indoor air human health risks under the foreseeable future land use (airport), as designated by the property deed. The potential risks are based on estimated future indoor air concentrations using subslab soil gas concentrations measured during the RI at the Aircraft Maintenance Building. DOD will not be responsible for investigating or addressing VI concerns in future buildings at the Site in accordance with the Defense Environmental Restoration Program (DERP) Management Manual 4715.20, Enclosure 3 (DOD 2012). To provide a range of alternatives and for consistency with DERP Management Manual 4715.20 (DOD 2012), one of the remedial alternatives developed for the Site considers residential land use. To evaluate this alternative, human health risk screening was conducted for the residential land use scenario; calculations are included as an appendix to this FS. Based on the risk screening results, TCE in soil gas pose potential future unacceptable human health risks to future hypothetical residents.

The remedial alternatives were developed by combining technology process options, which were retained following an initial screening process. The following four remedial alternatives were retained for detailed evaluation and comparative analysis:

- Alternative 1—No Action
- Alternative 2—Sealing and Monitoring
- Alternative 3—Active Subslab Depressurization
- Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction

This report discusses the detailed analysis of each alternative against NCP criteria, followed by a description of the comparative analysis of the remedial alternatives against one another. Alternative 1, No Action, is included only as a baseline for comparing alternatives, does not meet the statutory requirements of the NCP, and is not a viable remedial action for this site. The remaining three alternatives would be protective of human health and the environment and are expected to comply with ARARs.

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Acronyms and Abbreviations

µg/L	micrograms per liter
AFB	Air Force Base
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cm/s	centimeter per second
COC	chemical of concern
CRAA	Columbus Regional Airport Authority
CVOC	chlorinated volatile organic compound
DCE	dichloroethene
DERP	Defense Environmental Restoration Program
DOD	Department of Defense
ELCR	excess lifetime cancer risk
ERA	ecological risk assessment
FS	feasibility study
FUDS	Formerly Used Defense Site
GRA	general response action
GSR	green and sustainable remediation
HHRA	human health risk assessment
HI	hazard index
HVAC	heating, ventilation, and air conditioning
LUC	land use control
MCL	USEPA drinking water maximum contaminant level
mg/kg	milligrams per kilogram
MIP	membrane interface probe
NCP	National Contingency Plan
O&M	operations and maintenance
Ohio EPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PRG	preliminary remediation goal
RAL	Response Action Level

RAO	remedial action objective
RI	remedial investigation
RIA	Rickenbacker International Airport
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SSD	subslab depressurization
SVE	soil vapor extraction
TBC	to be considered
TCE	trichloroethene
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
UWBZ	upper water-bearing zone
VI	vapor intrusion
VISL	vapor intrusion screening level
VOC	volatile organic compound

SECTION 1

Introduction

This feasibility study (FS) report was prepared for areas of concern (AOCs) 17, 18, 19, and 103 at the former Lockbourne Air Force Base (AFB) in Columbus, Ohio (Figure 1-1). This work was conducted as part of the Formerly Used Defense Site (FUDS) program under United States Army Corps of Engineers (USACE) Contract Number W912PP-09-D-0016, Delivery Order Number CY01. The AOCs are identified as FUDS Property Number G05OH0007, Project Number 33. Because the AOCs are proximate and have been evaluated together, they are referred to collectively as the Site.

1.1 Regulatory Framework

A FUDS is a real property that was owned by, leased to, or otherwise possessed by the United States under Department of Defense (DOD) jurisdiction and transferred from DOD control before October 17, 1986. In accordance with Defense Environmental Restoration Program (DERP) legislation (10 USC 2701 et. seq.), the Secretary of the DOD is authorized to carry out response actions with respect to releases of hazardous substances from active installations and FUDS. The DERP/FUDS program follows the remedial process outlined by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The USACE is the lead agency for purposes of implementing the FUDS program in Ohio for the DOD and works in coordination with the Ohio Environmental Protection Agency (Ohio EPA).

The FS for the Site was performed in accordance with FUDS Program Policy, Engineer Regulation 200-3-1 (USACE 2004), and DERP *Management Manual 4715.20* (DOD 2012), which are consistent with the NCP and Section 120 of CERCLA, as amended by SARA.

1.2 Objective and Approach

The remedial investigation (RI) for the Site identified potential future unacceptable indoor air human health risks from the vapor intrusion (VI) of trichloroethene (TCE) in soil gas to indoor air within the Aircraft Maintenance Building (CH2M HILL 2015). DOD will not be responsible for investigating or addressing VI concerns in future buildings at the Site; however, DOD would provide notice of potential vapor intrusion risks as required in DERP Management Manual 4715.20, Enclosure 3 (DOD 2012). In response to these findings, a FS was recommended to evaluate remedial alternatives to mitigate this exposure pathway. The FS report presents the remedial action objectives (RAOs) developed to protect human health and identifies applicable or relevant and appropriate requirements (ARARs) and to-be-considered criteria. In accordance with the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (United States Environmental Protection Agency [USEPA] 1988), the FS identifies applicable technologies for screening, develops remedial alternatives that will address potential unacceptable risks to human health and comply with identified ARARs, and provides a detailed analysis of developed alternatives.

1.3 Site Setting

Former Lockbourne AFB is located east of Interstate 71 in Franklin and Pickaway Counties (Figure 1-1). The former AFB covers 4,371 acres and is now occupied by the Columbus Regional Airport Authority (CRAA), the 121st Air Refueling Wing of the Ohio Air National Guard, the Ohio Army National Guard, a Naval Reserve Center, and various retail and service businesses. Most of the area south and southeast of the former Lockbourne AFB is rural or agricultural. Residential and commercial/industrial areas border the north side of the former AFB, and the village of Lockbourne is to the west. A corridor of railroad tracks is immediately to the southwest.

The site is part of the Rickenbacker International Airport (RIA), an active joint civil-military airport used primarily as a cargo airport for the City of Columbus and some passenger charter carriers. The airport features parallel 12,000-foot runways and 500,000 square feet of cargo terminal space. The Ohio Air National Guard's 121st Air Refueling Wing also operates out of the airport. The RIA lies within the city limits of metropolitan Columbus, Ohio. Most of the airport complex lies in Franklin County, with a small part to the south in Pickaway County.

The Site is located on property owned by the CRAA (Figure 1-2). The AOCs are adjacent to a broad tarmac that covers an area roughly 1,000 by 2,000 feet. AOCs 17 and 103 are grass and pavement covered. CRAA uses the building at AOC 18 for light aircraft maintenance, including refueling and deicing, and at AOC 19 for a passenger terminal.

1.4 Site History

Lockbourne AFB began as the Northwest Training Center of Army Air Corps in 1942. It was renamed Lockbourne AFB in 1948 and designated Rickenbacker AFB in 1974. In 1980, the base was transferred to the Ohio Air National Guard and renamed the Rickenbacker Air National Guard Base. In 1984, part of the property was transferred to the Rickenbacker Port Authority, and the RIA was established. In 2003, Rickenbacker Port Authority merged with the Columbus Airport Authority, forming the CRAA, which now owns and operates the RIA.

The central machine shop area of the former AFB comprised the Base Engineer's Shop (former Building 530, AOC 17), Base Engineer's Maintenance and Inspection Building (Building 532, AOC 18), Engine Cleaning Building (former Building 535, AOC 19), and Battery Maintenance Facility (former Building 531, AOC 103) (Figure 1-3). Operations at the four buildings likely involved the use of solvents and cleaners (DPRA Incorporated [DPRA] 2010).

Of the four facilities, only the building at AOC 18 (Building 532, the Base Engineer's Maintenance and Inspection Building) remains. It is now known as the Aircraft Maintenance Building or hangar. The building has been occupied by the Rickenbacker Port Authority, Southern Air Transport (a private aircraft supply and maintenance company), Lane Aviation (also a private aircraft supply and maintenance company), and is occupied currently by the CRAA and its tenants, which include Rickenbacker Aviation. These entities historically used Building 532 for aircraft maintenance, refueling, and deicing (DPRA 2010); there is no documentation that a release of chlorinated volatile organic compounds (CVOCs) occurred during their times of use. Products used for aircraft maintenance, refueling, and deicing (such as motor oils, lubricants, cleaning/custodial equipment, fuels, and fuel system icing inhibitors) do not contain chlorinated ethenes. A basewide environmental baseline survey documented hazardous material (paint, grease, deicing fluids, aircraft cleaning fluids, and dry cleaning solvent) storage at Building 532 between 1988 and 1991, when the building was occupied by the Rickenbacker Port Authority (DPRA 2010). At that time, there was also a self-contained parts washer, which contained solvents, in the building. Based on information from the CRAA, the Rickenbacker Port Authority also used oils, custodial/cleaning equipment, urea (granular pavement deicer), and diesel and gasoline fuels. There are no other historical chemical inventories available for the Site. Since late 2012, the CRAA has used the building for aircraft maintenance (see Appendix A).

Former Buildings 530, 535, and 531 were demolished before the Phase I site investigation was conducted (before 1999). There is no documentation to state that the buildings were used by the Ohio Air National Guard during their ownership. There is no documentation to state that the buildings were used by the Ohio Air National Guard during their ownership, though the Ohio Air National Guard may have used former Building 531 for storage (see Appendix A). The RIA passenger charter terminal was constructed over part of the footprint of AOC 19 after the Phase I site investigation (after 2001); see Figure 1-3. During building construction, a passive vapor control system was installed beneath the terminal building footprint as a precautionary measure. The vapor control system consists of a vapor barrier (installed to block the potential

entry of vapors into the building) and a passive venting system (installed to divert subslab vapors to the outdoor air through an exhaust stack west of the terminal building).

1.5 Previous Investigations

Several environmental investigations have been conducted at the former Lockbourne AFB. Previous investigations of particular interest are summarized below.

1.5.1 Phase I Site Investigation

A Phase I site investigation (Shaw 2006) was conducted between 1991 and 2001 to determine whether 21 AOCs, which included AOCs 17, 18, 19, and 103, at the former AFB could be closed out with a determination of "No Department of Defense Action Indicated," whether interim removal actions were required, and whether additional investigations were required. Field activities at the Site included collecting surface soil, subsurface soil, and groundwater samples around the perimeter of Building 532 and former Buildings 530, 531, and 535. Based on the results of the Phase I site investigation, further action was recommended to assess polycyclic aromatic hydrocarbons (PAHs), TCE, and arsenic in soil and volatile organic compounds (VOCs), bis(2-ethylhexyl)phthalate, and metals in groundwater.

1.5.2 Phase II Site Inspection

A Phase II site inspection (GEO Consultants 2011) was conducted in 2010 to further evaluate six AOCs (17, 18, 19, 49, 94, and 103) at the former AFB. The objective of the Phase II site inspection was to collect sufficient soil and groundwater data to supplement the Phase I site investigation data and thereby provide a basis for eliminating AOCs that pose no significant threat to public health or the environment, determining the potential need for removal actions, or characterizing the AOCs for initiation of an RI. Field activities at the Site included subsurface soil and groundwater sample collection, primarily along the southern part of the Site; that is, south of the Aircraft Maintenance Building and passenger terminal and adjacent to the tarmac. A Level I scoping ecological risk assessment (ERA) and human health risk screening were also conducted. The Phase II site inspection report concluded that additional investigation was needed to characterize the nature and extent of PAHs in surface soil, to characterize the nature and extent of chlorinated solvents in soil and groundwater, to evaluate risk of VI into buildings from chlorinated solvents in soil and groundwater, and to conduct a detailed monitored natural attenuation (MNA) study.

1.5.3 Remedial Investigation

An RI (CH2M HILL 2015) was conducted at the Site between 2013 and 2014 to characterize the Site and assess the potential risks to human health and the environment posed by contamination. RI field activities included membrane interface probe (MIP) logging, surface and subsurface soil sampling, groundwater sampling, aquifer slug testing, subslab soil gas and exhaust stack vapor sampling, and air sampling. A human health risk assessment (HHRA) was conducted to evaluate potential human health risks associated with exposure to soil, groundwater, and soil gas. Because FUDS follows the CERCLA process, the current and foreseeable future land use, which is commercial/industrial, based on the property deed, was used to perform the HHRA. The RI report concluded the following:

- VOCs, PAHs, and metals were detected in soil samples at concentrations above their commercial/industrial Federal Regional Screening Levels (RSLs) and background threshold values (if available). However, metals are not considered Site related based on quantitative and qualitative background evaluations; metals are naturally occurring compounds. PAHs in surface soil also are not considered to be the result of the CERCLA-regulated Site release and are attributed to non-CERCLA anthropogenic contributions, such as demolition and resurfacing of parking areas. Because of the significant construction work conducted at the Site over the years, surface soil present when the central machine shop area of the former Lockbourne AFB was operational was likely removed from areas that had elevated PAH concentrations (AOCs 17 and 19). The Aircraft Maintenance Building (AOC 18) is the only building that remains from the original Site layout.

- CVOCs were detected in groundwater, soil gas, and indoor air samples collected at the Site. CVOC concentrations in groundwater were detected above the construction worker screening levels. However, these screening levels are considered to be conservative since they are based on a target excess lifetime cancer risk (ELCR) of 1×10^{-6}, whereas USEPA's acceptable ELCR range is 1×10^{-4} to 1×10^{-6}. To further assess risk to human health, these chemicals were carried forward into the HHRA. Concentrations in indoor air samples did not exceed commercial air screening levels. Therefore, no current risks from exposure to CVOCs in indoor air were identified. CVOC concentrations in the subslab soil gas sample adjacent to the passenger terminal building and in the passive exhaust stack vapor sample were also below applicable vapor intrusion screening levels (VISLs).
- Based on the HHRA, there are no unacceptable human health risks from exposure to chemicals in soil (by ingestion, dermal contact, or inhalation from fugitive emissions to ambient air), in groundwater (by dermal contact or inhalation of emissions in excavations), or in current indoor air at the Aircraft Maintenance Building above USEPA's acceptable risk levels. Therefore, no further action is recommended for these exposure pathways.
- As stated above, there are two building onsite, the passenger terminal building and the Aircraft Maintenance Building. CVOC concentrations in the subslab soil gas sample adjacent to the passenger terminal building and in the passive exhaust stack vapor sample were below VISLs. The exhaust stack is associated with a passive vapor control system that was installed beneath the passenger terminal building footprint. There is no further action recommended for the passenger terminal building. There are potential future unacceptable human health risks from the VI of TCE in soil gas at the Aircraft Maintenance Building. Therefore, a FS was recommended to evaluate remedial alternatives to mitigate the VI exposure pathway.

LEGEND

FORMER LOCKBOURNE AIR FORCE BASE (AFB)

NOTE:

AOC = AREA OF CONCERN.

N

0 20 40 Miles

FIGURE 1-1
FORMER LOCKBOURNE AFB LOCATION MAP

FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO

RDD BALDUR V:\LOCKBOURNE_AFB_434043\MAPFILES\FS_REPORT\FIG1-1_LAFB_LOCATION_MAP_FS15.MXD ET024983 5/12/2015

LEGEND

COLUMBUS REGIONAL AIRPORT AUTHORITY BOUNDARY

LOCATION OF AOCS 17/18/19/103

NOTE:

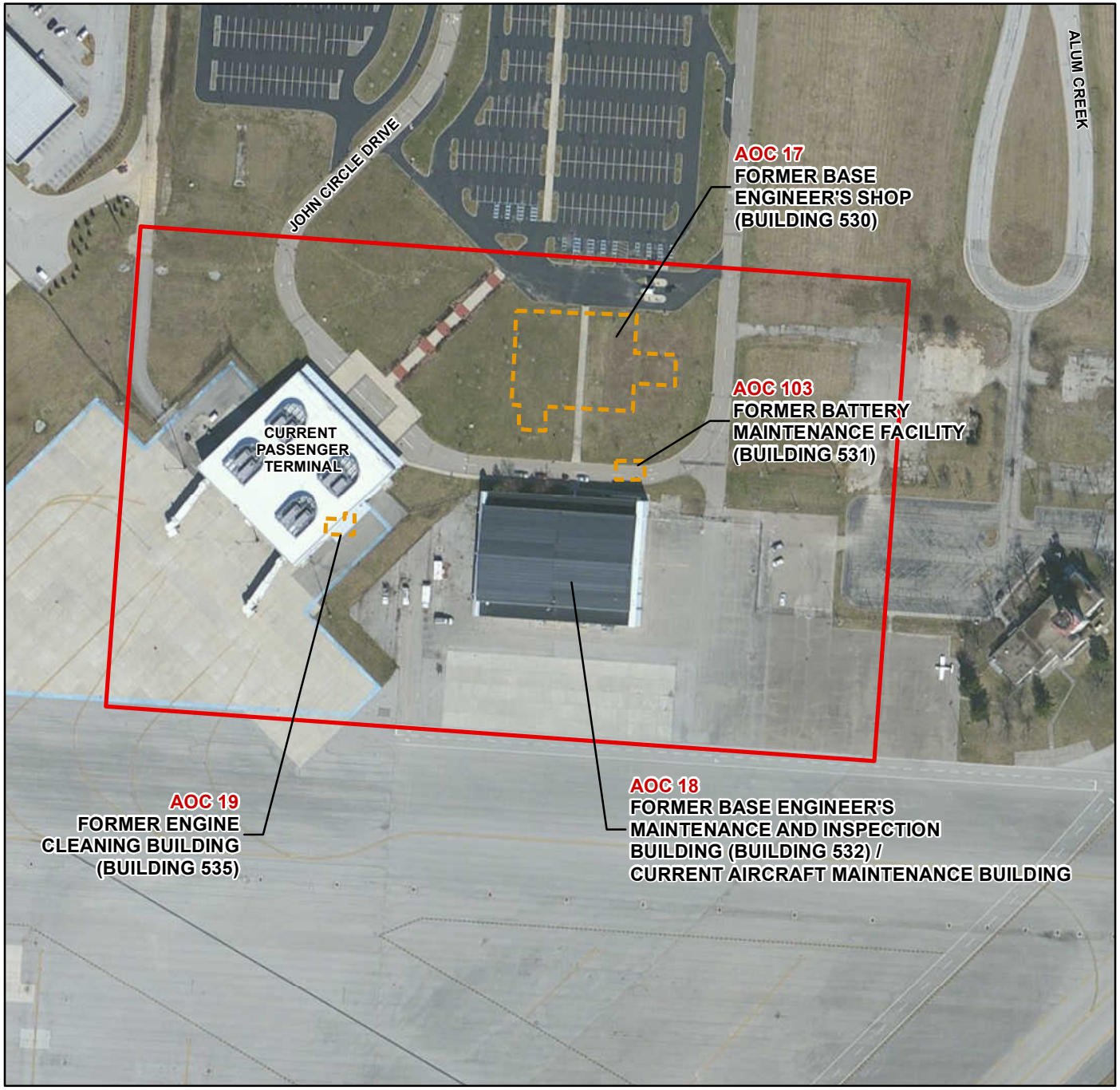
AOC = AREA OF CONCERN.

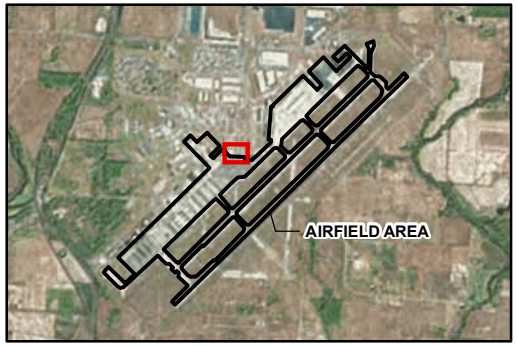
N

0 3,000 6,000 Feet

FIGURE 1-2
AOC LOCATION MAP
FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO

RDD BALDUR V:\LOCKBOURNE_AFB_434043\MAPFILES\FS_REPORT\FIG1-2_AOC_LOCATION_FS15.MXD ET024983 5/12/2015





LEGEND

LOCATION OF AOCS 17/18/19/103

FORMER BUILDING

NOTES:

AOC = AREA OF CONCERN.

SERVICE LAYER CREDITS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY, 25 AUGUST 2013.

0 200 400 Feet

N

FIGURE 1-3
AOCS 17/18/19/103 LAYOUT
FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO

RDD BALDUR V:\LOCKBOURNE_AFB_434043\MAPFILES\FS_REPORT\FIG1-3_LAYOUT_FS15.MXD ET024983 5/12/2015

SECTION 2

Conceptual Site Model

This section summarizes the conceptual site model for the Site, including physical site characteristics and chemical fate and transport. Figure 2-1 provides a graphical depiction of the conceptual site model and supports the discussion in this section.

2.1 Site Physical Characteristics

The Site is covered by pavement, small areas of mowed grass, and two buildings. An active taxiway of the RIA lies to the south of the AOCs. Asphalt parking lots are north and east of the AOCs. Stormwater from paved areas is directed toward and captured by storm sewers but may also run off into the grassy areas within the AOCs and infiltrate before reaching storm sewers. No streams, wetlands, or open water areas are present.

Topography within the Site is relatively flat, and surveys of sampling points showed elevations ranging from 733 to 737 feet above mean sea level. The dominant monthly wind direction is from the west from December through February and from the south from March through November. Wind direction is variable in early spring (March and April). Average monthly wind speeds are highest from late fall through early spring and lightest during the summer months.

The shallow geology consists of an upper till layer overlying a lower gray till layer. Based on soil boring logs, the shallow geology beneath the Site consists mainly of silty clay, sandy clay, and clayey silt, often with trace sand and/or gravel, and with alternating degrees of hardness. The lower gray till was described as a hard silty clay or clayey silt and was encountered between 12 and 15 feet below ground surface (bgs).

Groundwater present within the upper till layer is known as the upper water-bearing zone (UWBZ). The water table typically is encountered 4 to 10 feet bgs. The UWBZ is separated from the underlying intermediate depth aquifer by the lower gray till, which is considered an effective aquitard because of its low hydraulic conductivity and lateral continuity (International Technology Corporation 1998). Based on site-specific slug test data, hydraulic conductivity values for the UWBZ range between 4.0×10^{-5} and 6.8×10^{-4} centimeters per second (cm/s). Hydraulic conductivities as low as 10^{-7} cm/s have been reported for the clays and silts in the UWBZ at the former Lockbourne AFB (International Technology Corporation 1998). Groundwater in the UWBZ generally flows east-southeast at an estimated groundwater velocity of 0.01 foot per day (4 feet per year).

The CRAA has constructed a new traffic control tower for the RIA. The new traffic control tower is just outside the Site boundary.

2.2 Building Characteristics

Two buildings are present within the AOCs: the Aircraft Maintenance Building, or hangar, and a passenger terminal. A building survey was conducted at the Aircraft Maintenance Building in July 2013 as part of the subslab soil gas sampling. An airplane hangar occupies most of the building as a large open space, or clear span. Offices and storage areas are located on two floors along the northern and southern sides of the building. The second floor rooms were unoccupied during the building survey. The first floor office rooms typically have standard doors, whereas the storage rooms have bay doors. Chemicals are stored in a northwest storage room, a northeast storage room, a southern break room, the hangar clear span, and a cleaning storage area. The break room has a fume hood that was used by a previous tenant and is no longer in service. Outdoor air may enter the building at doors and windows. There are two large hangar doors on both the east and west ends of the building for airplane and aircraft service vehicle entry. Exterior doors routinely left open and gaps observed along the bay doors are sources of outdoor air into the building.

The floor, or foundation, of the Aircraft Maintenance Building is concrete slab on grade. The slab had a measured thickness of 7 inches during the RI soil gas probe installations. The slab is covered by tile or carpeting in the majority of office areas along the northern and southern sides of the building. Sealed expansion joints are present across the clear span of the maintenance area. However, two unsealed expansion joints were observed adjacent to the eastern and western interior walls of the building. Cracks in the concrete floor were observed within the clear span area, the southern break room, and a few storage rooms to the north; a greater number of floor cracks were observed on the western half of the building. Six floor drains were identified within the center of the clear span, whereas one floor drain each was observed in the break room, the men's restroom, and the women's restroom.

The Aircraft Maintenance Building includes a multizone heating, ventilation, and air conditioning (HVAC) system. Information obtained from the CRAA indicates that there are five HVAC zones. A new radiant heat system, which draws indoor air out through an exhaust system, was installed in early 2014 for the clear span area of the airport hangar. The main furnace does not have an exterior intake. The offices on the northern and southern sides of the building have heat pumps with fresh-air connections. There are also five air conditioning units along the northern and southern sides of the building.

During building construction, a passive vapor control system was installed beneath the passenger terminal building footprint as a precautionary measure; therefore a building survey was not performed. The vapor control system consists of a vapor barrier (installed to block the potential entry of vapors into the building) and a passive venting system (installed to divert subslab vapors to the outdoor air through an exhaust stack west of the terminal building).

2.3 Land and Water Use

The property deed specifies that the Site property is to be used as an airport (Recorder's Office, Franklin County, Ohio; http://recorderweb.co.franklin.oh.us/pax/). Therefore, the current and most likely future use of the property will be for commercial/industrial purposes. Based on information from the Mid-Ohio Regional Planning Commission, land use within the 0.5-mile radial area includes "airport operation, government, and warehouse." No residential use was identified. Roughly 90 percent of the land within 0.5 mile of the AOCs is within the CRAA property boundary. Since RIA is operational, it contributes to the ambient conditions through commercial/industrial activities, automobile parking and roads, and airplane runway use. Commercial/industrial business operations inside and outside the CRAA property include packaging facilities, distribution (food products, mattresses, and mobile equipment), air cargo logistics and transportation, flight support, and aircraft maintenance. There is also a hotel on the airport property. The government is present in the form of the Air National Guard, Army National Guard, United States Army Reserve, and Navy/Marine Reserve units.

Groundwater in the UWBZ at these AOCs is too shallow to be used for a public water system well (per Ohio Administrative Code 3745-9-05) or private system well (per Ohio Administrative Code 3701-28-10) and is documented to have low well yield because of the limited saturated thickness and low hydraulic conductivity. The UWBZ beneath the Site is wholly contained within 15 feet of the ground surface. While purging monitoring wells for groundwater sample collection during the RI, several wells across the Site would purge dry even at very low yield rates (less than 0.05 gallon per minute). The UWBZ is not currently used as a potable source at the Site or within 0.5 mile of the property, and the deeper sand and gravel aquifer would provide greater yield (Schmidt, 1993). Currently, the Village of Lockbourne receives water from the Franklin County Water Department. The county's largest public water system is the City of Columbus. The City uses surface water from the Griggs and O'Shaughnessy reservoirs for its supply, along with groundwater from the south well field area in southeast Franklin County.

2.4 Chemicals of Concern

Soil, groundwater, subslab vapor, and indoor/outdoor air samples have been collected at the site as part of site investigations (Section 1.5). Risk evaluations were conducted to assess potentially unacceptable risks to

human health and the environment from exposure to the chemicals of concern (COCs). A summary of the HHRA and ERA are discussed in this subsection. The nature and extent and fate and transport of the identified COCs are summarized in the following subsections.

2.4.1 Human Health Risk Assessment Summary

An HHRA was conducted to assess the potential risks from exposure to chemicals in groundwater, soil, soil gas, and indoor air in accordance with USEPA's Office of Solid Waste and Emergency Response Directive 9355.0-30 and the preamble to the 1990 National Oil and Hazardous Substances Pollution Contingency Plan (55 Fed. Reg. 8666-01, 52 (March 8, 1990).

2.4.1.1 Commercial/Industrial Use (Most Likely Future Use)

USEPA's "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (OSWER Directive 9355.0-30) states the following:

> *...the NCP also states that "the assumption of future residential land use may not be justifiable if the probability that the site will support residential use in the future is small." Sites that are surrounded by operating industrial facilities can be assumed to remain as industrial area unless there is an indication that this is not appropriate. Other land uses, such as recreational or agricultural, may be used, if appropriate.*

For the Site, the reasonably foreseeable future land use is the same as its present use (part of the CRAA, an active joint civil-military airport). Therefore, the HHRA evaluated potential human health risks associated with exposure to soil, groundwater, soil gas, and indoor air for commercial/industrial use.

There are no noncarcinogenic hazards exceeding USEPA's threshold hazard index (HI) of 1 or excess lifetime cancer risks (ELCRs) above USEPA's acceptable ELCR range of 1×10^{-4} to 1×10^{-6} for current/future commercial/industrial worker or construction worker exposures to surface soil, total soil, or groundwater. Although current commercial/industrial worker exposures to indoor air concentrations of CVOCs are within USEPA acceptable levels, future estimated indoor air concentrations of TCE at the Aircraft Maintenance Building may pose noncarcinogenic hazards above the USEPA threshold for future commercial/industrial workers due to elevated TCE concentrations in subslab soil gas. Potential ELCRs are within USEPA's target range. There is a high degree of uncertainty in the potential future indoor air risk estimates due to the uncertainty in modeling VI in the Aircraft Maintenance Building (an old airplane hangar with large doors that are frequently opened and tall ceilings). Indoor air concentrations may increase or decrease in the future due to various reasons, including the following:

- Subslab concentrations of TCE above screening levels (that is, TCE in subslab soil gas may serve as a source for indoor air VI)
- Changes in building use, condition, or operation (that is, alterations to the building to facilitate other uses may alter subslab-to-indoor air flow rates or additional cracks in the building slab may increase subslab gas migration into the building)
- Changes in the HVAC system or its operation (that is, changes to the HVAC system or its operations may affect airflow in the building)
- Seasonal variation (that is, changes in outdoor temperature and pressure may alter subslab-to-indoor air flow rates)

As a result, potential future inhalation exposures to TCE in indoor air (via VI) may pose noncarcinogenic hazards above USEPA's threshold of 1 for future commercial/industrial workers at the Aircraft Maintenance Building. The potential ELCR from VI is within USEPA's target risk range of 10^{-4} to 10^{-6}.

2.4.1.2 Residential Use (Hypothetical Future Use)

Although commercial/industrial use is currently dictated by the property deed and the most likely future use of the property, the DERP manual (DOD 2012) states that FS alternatives should address a range of land use scenarios. Therefore, an HHRA was conducted to assess the unlikely future residential use of the property. Potable use of site groundwater was not evaluated since site groundwater from the UWBZ will not be used as a potable water source in the future. The exposure media and exposure points evaluated for a hypothetical residential scenario are presented in Appendix B, Table 1.

The HHRA approach and results for the future hypothetical residential scenario are presented in Appendix B and are summarized below:

- Indoor air (passenger terminal)—exhaust stack vapor data was collected from the passenger terminal's vapor extraction system and evaluated for potential risks to future hypothetical residents. No COCs for indoor air at the passenger terminal were identified.
- Indoor air (Aircraft Maintenance Building)—subslab soil gas data collected from the Aircraft Maintenance Building were evaluated for potential risks to future hypothetical residents. The cumulative ELCR and HI estimates from two chemicals detected in subslab soil gas exceed USEPA's target risk range and noncancer threshold for future residents. One COC (TCE) for indoor air at the Aircraft Maintenance Building was identified for the future hypothetical residents.
- Soil direct contact—soil data collected from the Site were screened for direct contact exposure and evaluated for potential risks to future hypothetical residents. No Site-related COCs for soil direct contact were identified.
- Groundwater potable use—because groundwater from the UWBZ will not be used as a potable water source in the future because of low well yield and current regulations regarding potable well construction, as described in Section 2.3. No Site-related COCs for groundwater potable use were identified.

Although there are no COCs identified for the soil and groundwater based on direct contact, chemicals in vadose zone soil and groundwater are potential sources of the indoor air (Aircraft Maintenance Building) COCs.

2.4.2 Ecological Risk Assessment Summary

A Level I Scoping ERA (GEO Consultants 2011) was conducted to determine (1) if there have been current or past releases at the Site and (2) if there are significant ecological resources, as defined in guidance published by the Ohio EPA (2008). The scoping level ERA is equivalent to the problem formulation, the first step in the ERA process (USEPA 1997). Prior to the Site visit, a literature search was performed. The Ohio Department of Natural Resources showed no records of rare or endangered species within a 1-mile radius of the Site. During the Site visit, no unique areas, geological features, breeding or nonbreeding animal concentrations, champion trees, forests, or wildlife areas were noted. No streams, wetlands, or open water areas or trees were identified at the AOCs. It was therefore concluded that habitat for federally listed species in the area does not exist. In addition, an informal Section 7 consultation was conducted through the U.S. Fish and Wildlife Service web-based evaluation. A "no effect" determination was made because the AOCs are located within developed areas and are not adjacent to native tree and shrub habitat for federally listed species. The Site consists primarily of pavement, two buildings, and small areas of mowed grass. The area is disturbed regularly, and the surrounding area is heavily developed. Therefore, the Level I Scoping ERA concluded that no further ecological investigation of the Site was warranted.

A habitat assessment and visual ecological receptor survey were conducted at the Site during the RI. No aquatic features, sensitive habitats, wetlands, or threatened or endangered species were identified during the survey or within a 0.5-mile radius of the AOCs. The sparse habitat within the AOCs likely would be used for intermittent foraging for birds and possibly small mammals. However, the habitat is not of sufficient size and

lacks sufficient cover to support large local populations. The assessment confirmed the conclusion of the Level I Scoping ERA that habitat for federally listed species in the area does not exist.

2.5 Nature and Extent of COCs

This section focuses on the nature and extent of COCs identified in the risk evaluations. As discussed in Section 2.4, TCE is identified as a COC in soil gas, for its potential to migrate through VI to indoor air under the current and most likely future land use (commercial/industrial) and pose unacceptable risks to human health in indoor air. TCE was identified as a COC in soil gas under the unlikely residential land use, for their potential to migrate to indoor air at concentrations that may pose unacceptable risks to human health. There are no ecological COCs.

As part of the RI, six subslab soil gas samples and six indoor air samples were collected within the Aircraft Maintenance Building. Subslab soil gas samples were collocated with indoor air samples, with the exception of 18SV04 (subslab soil gas) and 18IA04 (indoor air). An exterior soil gas sample was collected adjacent to the eastern side of the passenger terminal, and vapor samples were collected from the exhaust stack that vents vapors from the passenger terminal's passive vapor extraction system (Figure 2-2). Outdoor air samples were collected from an upwind location and adjacent to an exterior air intake on the south side of the Aircraft Maintenance Building.

TCE was detected in subslab soil gas above the commercial VISL in six subslab soil gas samples collected beneath the Aircraft Maintenance Building. The highest concentration was observed at Sample 18SV04, located along the western edge of the hangar area (Figure 2-2); TCE was detected at 99,400 micrograms per cubic meter ($\mu g/m^3$). TCE concentrations (15,800 $\mu g/m^3$) were also observed in the southeast corner of the building, beneath an employee break room (18SV06). There were no TCE exceedances of the commercial/industrial VISL from the soil gas samples collected adjacent to the passenger terminal or at the exhaust stack vapor sample. Although TCE was detected in indoor air samples, concentrations were very low and did not exceed commercial/industrial indoor air screening level. Therefore, no current risks from exposure to vapors in indoor air were identified.

TCE in soil and groundwater may be a potential source of COCs in soil gas. TCE was detected in vadose zone soil samples west and northeast of the Aircraft Maintenance Building (Figure 2-3). The highest concentrations were at soil boring 103SB01 at a concentration of 1.1 J milligrams per kilogram (mg/kg). MIP results indicated that the highest levels of CVOC contamination are present below the water table, between 8 and 14 feet bgs. The highest MIP response was observed in the roadway at former Building 531 (AOC 103) and on the western side of the Aircraft Maintenance Building (AOC 18). Moderately elevated MIP response was observed in the strip of grass between the passenger terminal and the Aircraft Maintenance Building.

TCE was detected in groundwater east of former Building 535 (AOC 19; current passenger terminal location), surrounding and beneath AOC 18 (Aircraft Maintenance Building), and extending towards the northeast the area of former Building 531 (AOC 103) (Figure 2-4). The TCE plume extends to the bottom of the UWBZ (approximately 12 feet bgs) and has an estimated area of 46,800 square feet. The highest concentrations of TCE were detected at temporary point 18GG303 (64 μg/L), adjacent to the western side of the hangar, and at monitoring well 106MW06 (65 μg/L), at AOC 103.

2.6 Fate and Transport of COCs

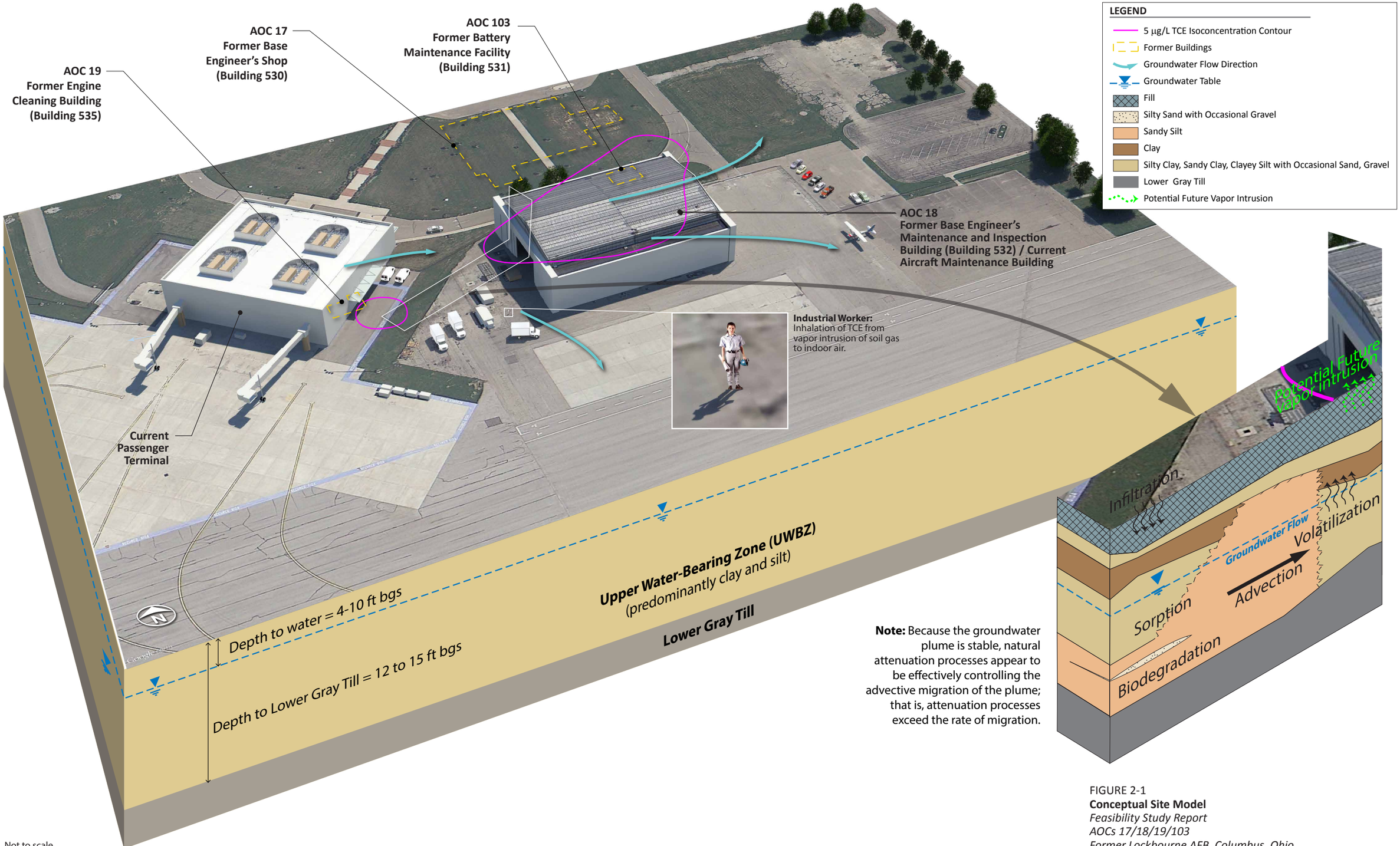
The primary source of the contamination is suspected to be a release of CVOCs on the east side of former Building 535 (AOC 19). Small releases may have also potentially occurred at former Building 531 (AOC 103) and under and around the Aircraft Maintenance Building. Over time, CVOCs in soil have partitioned into infiltrating water from precipitation. However, elevated concentrations of CVOCs in soil are isolated, and most of the Site is covered by impermeable asphalt or concrete, which significantly limits infiltration into the subsurface and potential leaching.

TCE has high solubility in water, high volatility, and moderate levels of sorption due to the organic carbon content in soil. They can enter the gas phase through volatilization of soil contaminants and aqueous phase contaminants at the water table (groundwater) surface into the unsaturated zone. The contaminants in soil gas tend to remain trapped in the pore space between grains of soil but can migrate out of the soil to the atmosphere or to indoor air in existing or future buildings. The highest detected concentrations in subslab soil gas (18SV04) were adjacent to the western edge of the Aircraft Maintenance Building. Because TCE was also present at higher concentrations along the western side of the building in groundwater, the shallow groundwater may be the source of TCE in soil gas. The proximity of subslab soil gas concentrations (in excess of the commercial/industrial VISLs) to occupied buildings (such as the Aircraft Maintenance Building) presents a potential future VI issue for indoor air.

TCE is subject to degradation by biological and abiotic mechanisms. Under anaerobic conditions, biodegradation typically occurs by reductive dechlorination, a naturally occurring process in which chlorine atoms on a parent CVOC molecule are sequentially replaced with hydrogen. An external electron donor source (such as biodegradable organic co-contaminants or native organic matter) is required for reductive dechlorination to occur. Biotic reductive dechlorination occurs most favorably under strongly reducing conditions between sulfate-reducing and methanogenic conditions. TCE can be aerobically biodegraded via aerobic cometabolism. CVOCs may also be subject to abiotic degradation, mainly mediated by iron-bearing minerals in the subsurface under reducing conditions.

Attenuation of aerobically degraded CVOCs is likely occurring in the soil gas in the vadose zone. Although cis-1,2-dichloroethene (DCE) and vinyl chloride were detected in soil and groundwater adjacent to the Aircraft Maintenance Building, these chemicals were not detected in subslab soil gas samples. Analytical data suggest that TCE is attenuating in soil and groundwater (CH2M HILL 2015). As a result of natural attenuation processes, the groundwater plume at the Site is stable and possibly shrinking.

Concentrations of COCs in indoor air samples were below commercial/industrial air screening levels, indicating that the Aircraft Maintenance Building concrete slab was serving as an effective barrier to VI at the time of the sampling event. Although TCE was detected in the vapor samples collected from the exhaust stack that vents vapors from the passenger terminal's passive vapor extraction system and in the exterior soil gas sample, the concentrations were below applicable VISLs. Therefore, VI from the groundwater plume is not considered a migration pathway of concern at the passenger terminal due to the presence of the passive venting system and the low concentrations of TCE in soil gas.



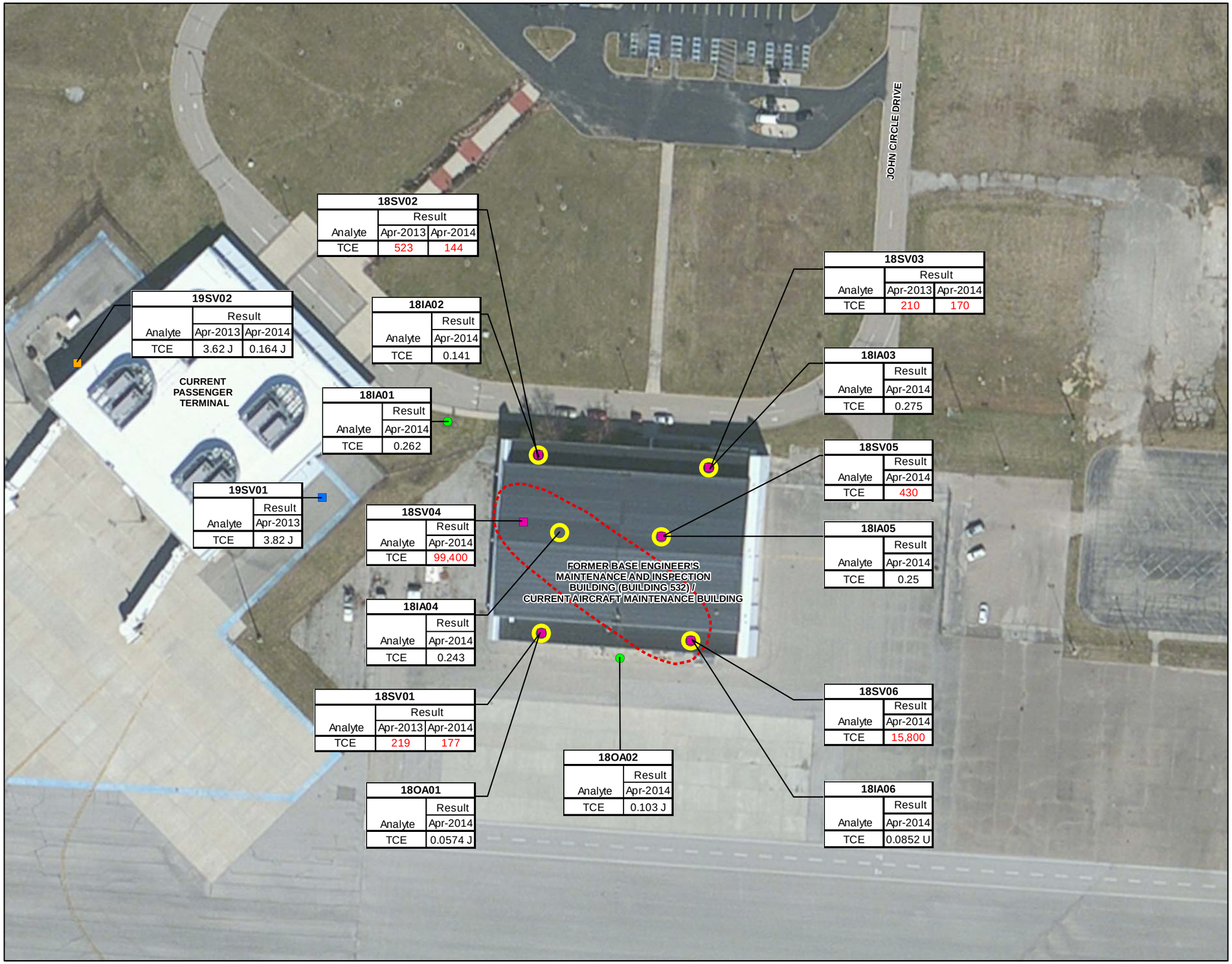
Note: Because the groundwater plume is stable, natural attenuation processes appear to be effectively controlling the advective migration of the plume; that is, attenuation processes exceed the rate of migration.

Not to scale

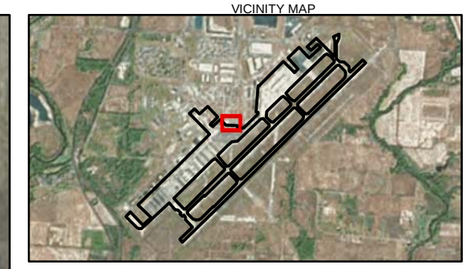
FIGURE 2-1
Conceptual Site Model
Feasibility Study Report
AOCs 17/18/19/103
Former Lockbourne AFB, Columbus, Ohio

CH2MHILL

ES062314050333GNV Lockbourne-AFB_CSM_rev9 07/31/2015 DCD



VICINITY MAP



LEGEND

- RI EXHAUST STACK GAS SAMPLING LOCATION
- RI SUBSLAB SOIL GAS SAMPLING LOCATION
- RI EXTERIOR SOIL GAS SAMPLING LOCATION
- RI OUTDOOR AIR SAMPLING LOCATION
- RI INDOOR AIR SAMPLING LOCATION
- PREVAILING WIND DIRECTION
- ZONE OF HIGH TCE CONCENTRATIONS IN SOIL GAS (10,000 µg/m^3)

NOTES:

RED RESULTS INDICATE TCE CONCENTRATIONS EXCEED THE COMMERCIAL SCREENING LEVEL.

ALL RESULTS ARE IN UNITS OF MICROGRAMS PER CUBIC METER (µg/m^3).

J = THE ANALYTE WAS POSITIVELY IDENTIFIED AT AN APPROXIMATE CONCENTRATION.

RI = REMEDIAL INVESTIGATION.

SOIL GAS SAMPLES AND THE EXHAUST STACK GAS SAMPLE HAVE THE "SV" DESIGNATION IN THEIR SAMPLE IDENTIFICATIONS. INDOOR AIR SAMPLES HAVE THE "IA" DESIGNATION.

SERVICE LAYER CREDITS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY, 25 AUGUST 2013.

TCE = TRICHLOROETHENE.

U = THE ANALYTE WAS NOT DETECTED ABOVE THE LIMIT OF DETECTION.

VISL = VAPOR INTRUSION SCREENING LEVEL.

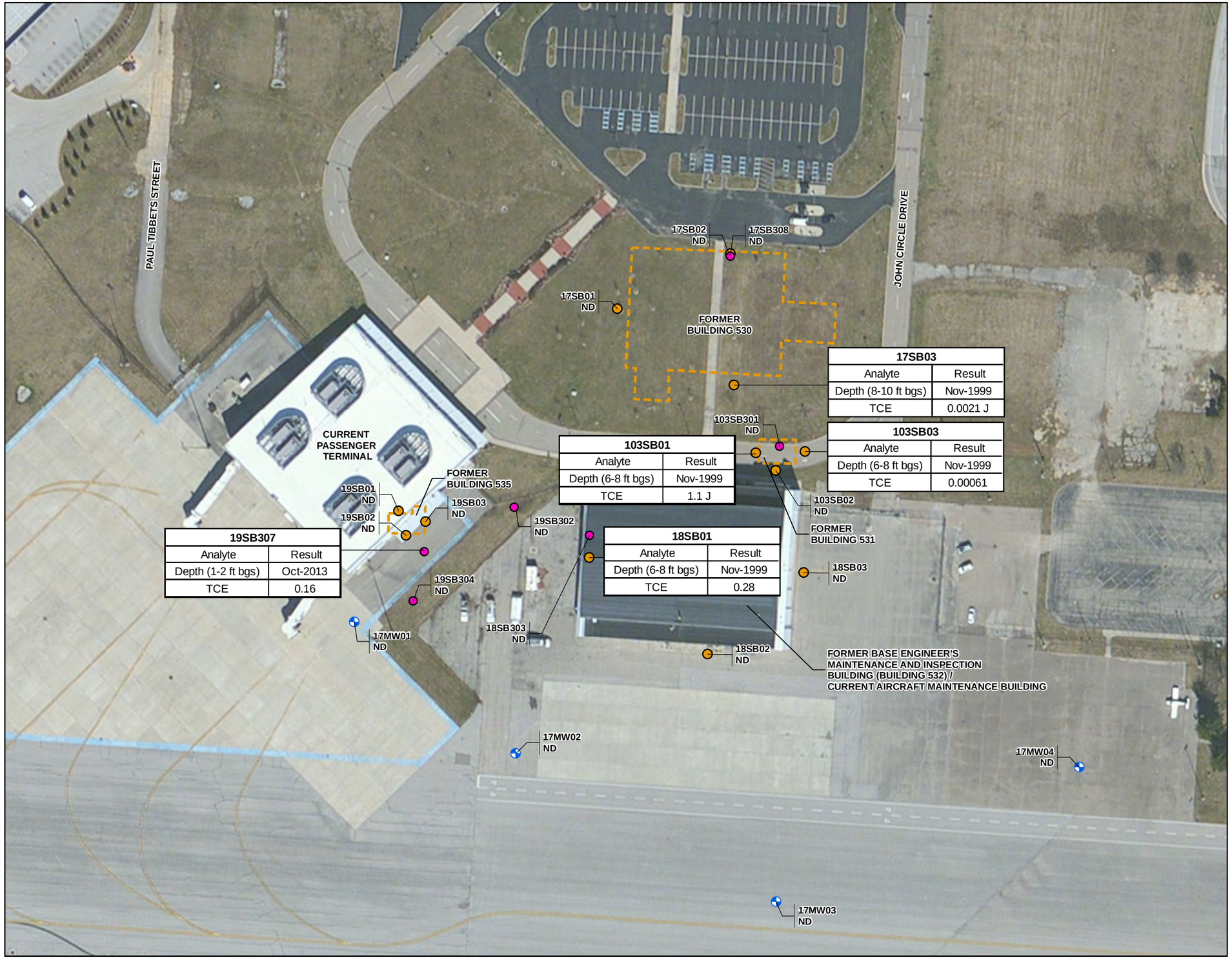
Commercial Screening Levels		
Analyte	VISL for Soil Gas	Indoor/Outdoor Air
TCE	30 µg/m^3	3 µg/m^3

0 80 160 Feet

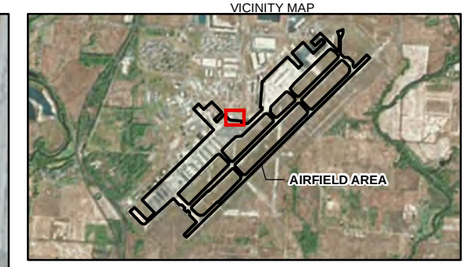
N

FIGURE 2-2
EXCEEDANCES IN SOIL VAPOR AND AIR SAMPLES

FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO



VICINITY MAP



LEGEND

- RI SOIL SAMPLING LOCATION
- PHASE I SI SOIL BORING LOCATION
- PHASE II SI MONITORING WELL LOCATION
- FORMER BUILDING

NOTES:

CHLOROFORM WAS NOT DETECTED IN SOIL.

FT BGS = FEET BELOW GROUND SURFACE.

J = THE ANALYTE WAS POSITIVELY IDENTIFIED AT AN APPROXIMATE CONCENTRATION.

ND =NOT DETECTED.

RI = REMEDIAL INVESTIGATION.

SERVICE LAYER CREDITS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY, 25 AUGUST 2013.

SI = SITE INVESTIGATION.

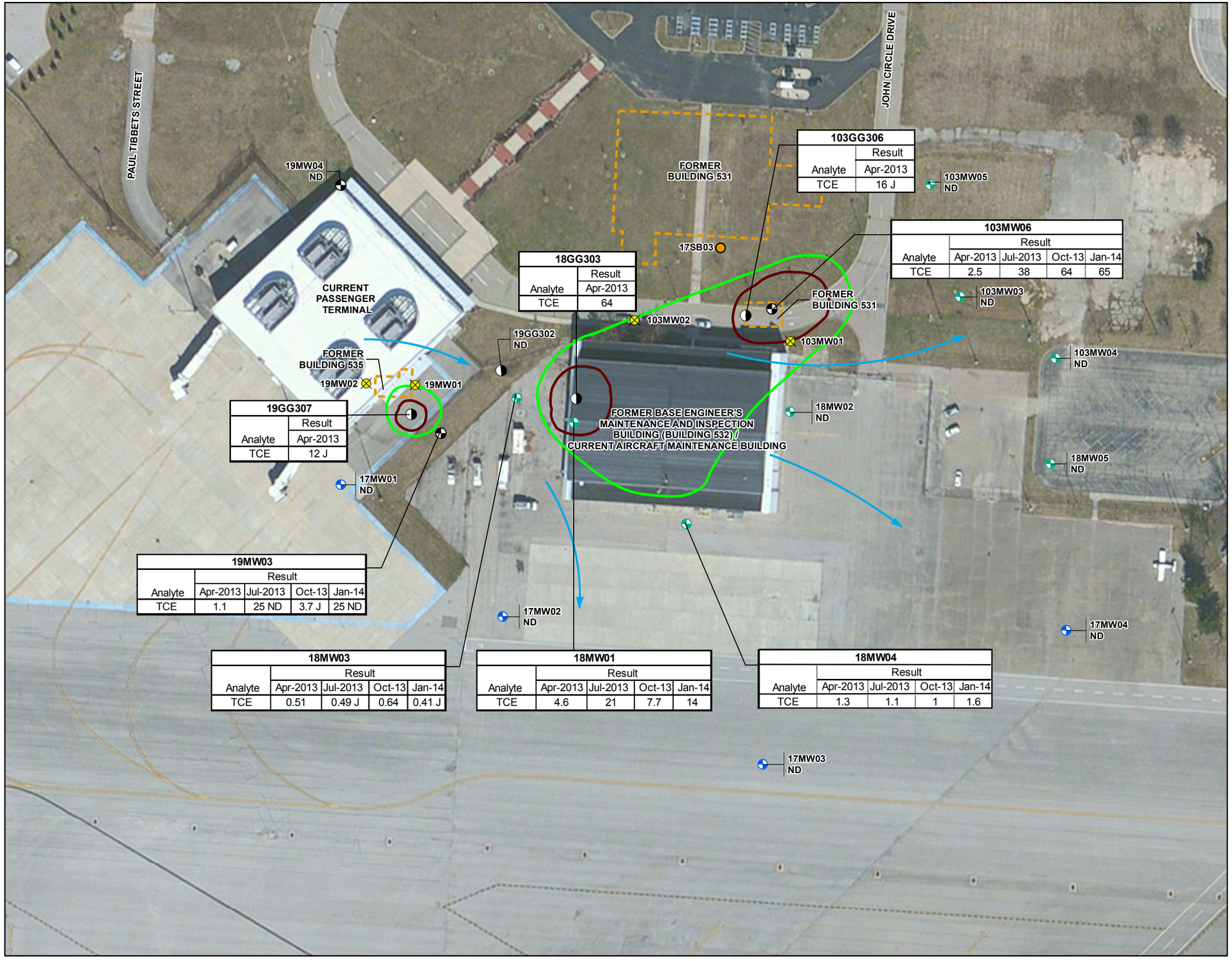
TCE = TRICHLOROETHENE.

TCE CONCENTRATIONS ARE IN UNITS OF MILLIGRAMS PER KILOGRAM (mg/kg).

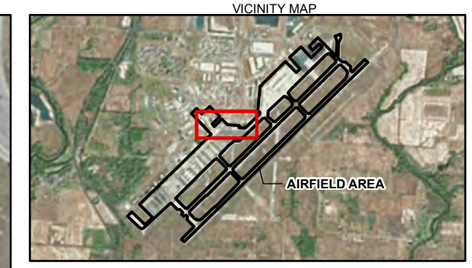
0 100 200 Feet

N

FIGURE 2-3
TCE IN VADOSE ZONE SOIL
FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO



VICINITY MAP



LEGEND

- RI GROUNDWATER SAMPLING LOCATION
- RI MONITORING WELL LOCATION
- PHASE I SI MONITORING WELL LOCATION
- PHASE II SI MONITORING WELL LOCATION
- ABANDONED MONITORING WELL LOCATION
- PHASE I SI SOIL BORING LOCATION
- GROUNDWATER FLOW DIRECTION
- TCE ISOCONCENTRATION CONTOUR (5 µg/L)
- TCE ISOCONCENTRATION CONTOUR (10 µg/L)
- FORMER BUILDING

NOTES:

ABANDONED MONITORING WELLS AND PHASE I SOIL BORING LOCATION 17SB03 ARE SHOWN BECAUSE THEY WERE USED TO HELP DEFINE THE EXTENT OF CONTAMINATION. GROUNDWATER COLLECTED FROM THESE LOCATIONS, WITH THE EXCEPTION OF 103MW01, HAD NO EXCEEDANCES OF SCREENING LEVELS. TCE WAS DETECTED ABOVE SCREENING LEVEL AT 103MW01 IN OCTOBER 2000 (59 J µg/L).

ALL RESULTS ARE IN UNITS OF MICROGRAMS PER LITER (µg/L).

J = THE ANALYTE WAS POSITIVELY IDENTIFIED AT AN APPROXIMATE CONCENTRATION.

ND = NOT DETECTED.

SERVICE LAYER CREDITS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY, 20 AUGUST 2013.

SI = SITE INVESTIGATION.

TCE = TRICHLOROETHENE.

Groundwater Screening Levels

Analyte	Federal Maximum Contaminant Level	Construction Worker Groundwater Screening Level
TCE	5 µg/L	20 µg/L

0 100 200 Feet

N

FIGURE 2-4
TCE IN GROUNDWATER
APRIL 2013 – JANUARY 2014

FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO

SECTION 3

Alternative Development and Evaluation

Future estimated indoor air concentrations of TCE may pose unacceptable risks due to elevated concentrations in subslab soil gas. Therefore, remedial alternatives were developed to address the future VI pathway for commercial/industrial workers. Although considered very unlikely, hypothetical residential land use was also considered during the development of remedial alternatives for consistency with the DERP manual.

In accordance with USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988), the following steps were taken to develop and evaluate remedial alternatives:

1. Identify ARARs
2. Develop RAOs
3. Determine preliminary remediation goals (PRGs) and areas exceeding the PRGs
4. Evaluate COCs against remediation goals
5. Develop general response actions
6. Identify and screen technologies and process options
7. Develop remedial alternatives
8. Perform detailed analysis of remedial alternatives
9. Perform comparative analysis of each alternative's ability to satisfy the evaluation criteria

3.1 Applicable or Relevant and Appropriate Requirements

3.1.1 Overview

CERCLA remedial actions must meet ARARs for selected remedies unless one of the provisions for waiver set forth in the NCP is determined to apply by the lead agency (40 CFR §300.430[f][1][ii][C]). ARARs are defined in the NCP (40 CFR §300.5) as either applicable requirements or relevant and appropriate requirements. Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations similar to those encountered at the CERCLA site that their use is well suited to the particular site. A requirement must be determined to be both relevant and appropriate to be considered an ARAR. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate.

The criteria for determining relevance and appropriateness are listed in 40 C.F.R. § 300.400(g)(2) and are summarized below:

- The purpose of the requirement and the purpose of the CERCLA action
- The medium regulated or affected by the requirement and the medium contaminated or affected at the CERCLA site
- The substances regulated by the requirement and the substances found at the CERCLA site

- The actions or activities regulated by the requirement and the response action contemplated at the CERCLA site
- The existence of variances, waivers, or exemptions of the requirement and their availability for the circumstances at the CERCLA site
- The type of place regulated and the type of place affected by the release or CERCLA action
- The type and size of structure or facility regulated and the type and size of structure or facility affected by the release or proposed in the CERCLA action
- Any consideration of use or potential use of affected resources in the requirement and the use or potential use of the affected resources at the CERCLA site

There are three types of ARARs.

- Chemical-specific ARARs are health-based or risk-based numbers or discharge limitations that restrict chemical concentrations in or discharged to the environment.
- Action-specific ARARs are activity or technology based. These ARARs control remedial activities involving the design or use of certain equipment, or impose specific requirements on discrete actions (e.g., hazardous waste handling, landfill closure, air emission controls).
- Location-specific ARARs are restrictions on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations, and may impose additional constraints on the remedial action because of the location.

Non-promulgated advisories or guidance issued by federal or state governments are not legally binding and do not have the status of ARARs. Such requirements may, however, be useful and are “to be considered” (TBC). TBC requirements (40 C.F.R. § 300.400[g][3]) complement ARARs but do not override them and may be considered along with ARARs in determining the level and implementation of cleanup for the protection of the environment.

Tables 3-1, 3-2, 3-3, and 3-4 list statutes and regulations containing requirements deemed to be potential chemical-specific ARARs, chemical-specific TBC requirements, action-specific ARARs, and location-specific ARARs for the Site, respectively.

3.1.2 Evaluation and Discussion

3.1.2.1 Chemical-Specific

Ohio EPA’s Voluntary Action Program provides generic standards for commercial/industrial indoor air due to VI from environmental media in OAC 3745-300-08(D)(2). These standards are identified as an ARAR only for chemicals that have volatilized from environmental media to indoor air. They are relevant and appropriate requirements because the intent of CERCLA and these rules of the Voluntary Action Program is to protect human health from potential effects caused by releases of TCE to the environment, which have the potential to migrate indoors and cause unacceptable risk to future commercial/industrial workers. Because these rules address the same media (i.e., indoor air), contaminant (i.e., TCE), type of property (i.e., FUDS), and property use (e.g., commercial/industrial use as an airport hangar) as those subject to remediation under this CERCLA action, this ARAR is relevant and appropriate to each alternative.

The USEPA RSLs for Chemical Contaminants at Superfund Sites (USEPA 2015b) provide conservative, risk-based, chemical-specific screening levels for human receptors. RSLs are not promulgated, but are a technical reference. These criteria are TBC in evaluating each alternative.

USEPA Region 9 Interim TCE Indoor Air Response Action Levels (RALs) are criteria identified in a Memorandum to Region 9 Superfund Division staff for use in making site-specific decisions regarding response to TCE vapor intrusion. RALs are not promulgated, but are a technical reference. These criteria are TBC in evaluating each alternative.

USEPA developed a spreadsheet calculator that lists chemicals considered to be volatile and sufficiently toxic through the inhalation pathway; and provides VISLs for indoor air, which are generally recommended, media-specific, risk-based screening-level concentrations. VISLs are not promulgated, but are a reference. These criteria are TBC in evaluating each alternative.

3.1.2.2 Action-Specific

OAC 3745-15-05(C)(5) establishes limit for emissions of hazardous air pollutants (specifically, TCE) to 1 ton per year. Emissions less than this limit are exempt from Ohio Revised Code 3704—Air Pollution Control and rules adopted thereunder. This is requirement is applicable to Alternative 3 described below.

OAC 3745-9-07 and 3723-9-10 contains requirements for well grouting for closure, and for well sealing during the remedial action. This requirement is applicable to Alternatives 2, 3, and 4 since they include well abandonment during the remedial action.

3.1.2.3 Location-Specific

There were no location-specific ARARs or TBCs identified.

3.2 Develop Remedial Action Objectives

RAOs are goals specific to media or operable units for protecting human health and the environment. The identified risks can be associated with current or potential future exposures. RAOs should be as specific as possible but not so specific that the range of alternatives that can be developed is unduly limited. Objectives aimed at protecting human health and the environment should specify (1) COCs, (2) exposure routes and receptors, and (3) an acceptable contaminant level or range of levels for each exposure route (that is, a PRG) (USEPA 1988).

An RAO was developed for the Site in part based on the contaminant levels and exposure pathways found to present potentially unacceptable human health risk determined during the risk evaluations conducted as part of the RI. The RAOs, remediation goals, and remediation strategies developed address constituents posing unacceptable risks. The RAO for the protection of human health and the environment for the Site is:

- Prevent future unacceptable risk from exposure to COC, which is TCE for future commercial/industrial workers at concentrations above 8.8 $\mu g/m^3$ in indoor air within the Aircraft Maintenance Building

3.3 Identify Preliminary Remediation Goals and Areas Exceeding the Preliminary Remediation Goals

PRGs are risk- or ARAR-based chemical-specific concentrations for the COCs and exposure scenarios in the HHRA that contribute to ELCR and non-cancer HI above USEPA-acceptable levels risks. The PRGs address potential exposures associated with the RAO. PRGs are considered preliminary, in that the final remedial goals are defined in the Decision Document once a remedy and target risk level is selected for the site. The PRGs are used to define the extent of contaminated media requiring remedial action.

TCE may pose a risk above USEPA-acceptable levels to future commercial/industrial workers from inhalation of TCE in indoor air at the Aircraft Maintenance Building, based on estimated concentrations using subslab soil gas data. However, indoor air concentrations measured during the RI were within USEPA-acceptable levels. Therefore, under the commercial/industrial use scenario, a PRG was established for future indoor air concentrations, rather than subslab gas concentrations, since indoor air is the environmental medium to which people may be exposed (from inhalation). Subslab gas inhalation is not a direct exposure pathway. The indoor air PRG for potential future inhalation of TCE for commercial/industrial use is 8.8 $\mu g/m^3$. This PRG is based on the lower of a target ELCR of 1×10^{-4} (the upper end of USEPA's target risk range since there is only one indoor air COC for a future commercial/industrial scenario) and target HI of 1. Figure 2-2 shows the extent of TCE concentrations detected in subslab soil gas and indoor air.

TCE may pose risks above USEPA-acceptable levels to future hypothetical residential receptors from inhalation of TCE in indoor air, based on estimated concentrations using subslab soil gas data. Figure 2-2 shows TCE concentrations detected in subslab soil gas and indoor air. Under this unlikely residential scenario, it is assumed that the current deed would be amended, and residential buildings would be constructed. Therefore, soil gas PRGs were established to evaluate the remedial alternative. Because there is evidence of natural reductive dechlorination in soil and groundwater at the Site and the proposed treatment technologies may enhance this process, PRGs were developed for degradation products (1,2-DCE, 1,1-DCE, vinyl chloride, and methylene chloride) as well as for the parent compound (TCE). The soil gas PRGs for residential use (based on the lower of a target ELCR of 1×10^{-5} per chemical since there is more than one soil gas COC for a future hypothetical residential scenario and a noncancer threshold of 1) for the VI pathway are listed in below. Risk-based PRGs could not be developed for cis- or trans-1,2-DCE due to the lack of inhalation toxicity values.

- TCE = 70 $\mu g/m^3$
- cis-1,2-DCE = not available
- trans-1,2-DCE = not available
- 1,1-DCE = 7,000 $\mu g/m^3$
- Vinyl chloride = 56 $\mu g/m^3$

3.4 Develop General Response Actions

After the RAO and PRGs are developed, general response actions (GRAs) are identified to address affected media at the site. As defined in the USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final* (USEPA 1988), GRAs are media-specific actions that satisfy RAOs. Actions for mitigating risk posed by affected media may be applied individually or in combination. Table 3-5 summarizes the GRAs, which were retained for achieving the RAO.

3.5 Identify and Screen Technologies and Process Options

Consistent with USEPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988), before developing remedial alternatives, potentially applicable remedial technologies were identified and screened within each remaining GRA, based on the following criteria:

- **Effectiveness** is the ability of the technology or process option to perform adequately to achieve the remedial objectives alone or as part of an overall system.
- **Implementability** refers to a technology that is effective and workable at a particular project site.
- **Relative cost** is comparative only and is judged similar to the effectiveness criterion. It is used to preclude further evaluation of process options that are very costly where there are other choices that perform similar functions with comparable effectiveness. It includes construction and long-term operation and maintenance costs.

Table 3-6 summarizes the screening process for achieving the RAO at the Site. Technologies and process options considered infeasible based on effectiveness, implementability, and costs are shown in shaded background. Screening was based on professional experience, published sources, and other relevant documentation. The technologies retained following screening include monitoring, passive subslab venting, active subslab depressurization, in situ treatment using enhanced biodegradation, soil vapor extraction (SVE), and inspections to monitor potential changes in land use or the building infrastructure.

3.6 Identify Remedial Alternatives

Remedial alternatives were developed by combining the retained technologies following the screening process presented in Table 3-6. To avoid evaluating an unmanageable number of alternatives, only the most logistically and technically sensible combinations for the given site conditions were carried forward. Four

remedial alternatives were developed: Alternative 1, No Action; Alternative 2, Sealing and Monitoring; Alternative 3, Active Subslab Depressurization; and Alternative 4, Enhanced Biodegradation and Soil Vapor Extraction.

Conceptual designs have been developed for each alternative and are discussed in the subsections below. Specific details of the conceptual designs are provided for this FS to serve as representative examples to estimate order-of-magnitude costs (Appendix C). The actual details would be developed during the remedial design phase and may vary from this FS.

These conceptual details were also used to develop quantitative estimates for the environment impacts associated with each alternative using SiteWise Version 3.0 (NAVFAC 2013). The quantitative metrics calculated by SiteWise include greenhouse gas emissions; energy and water usage; air emissions of criteria pollutants consisting of nitrogen oxides, sulfur oxides, and particulate matter less than 10 micrometers in aerodynamic diameter; and accident risk (that is, risk of injury and risk of fatality). The details of the SiteWise analysis are included in the green and sustainable remediation (GSR) memo, which is provided as Appendix D. Process options within the same remedial technology that achieve the same objectives may be evaluated during the remedial design.

3.6.1 Alternative 1—No Action

Alternative 1 consists of taking no action. The NCP requires that a No Action Alternative be retained throughout the FS process as a baseline for comparison to the other approaches. No action would leave affected soil gas in place and does not monitor potential future impacts to indoor air. No mechanisms would be in place to prevent or control exposure to contaminants or to monitor whether indoor air concentrations increase over time. Lack of active cleanup or controls may allow users to be exposed to contaminants in indoor air if concentrations increase over time due to:

- Changes in building use, condition, or operation (that is, other uses, alterations, or deterioration may alter subslab-to-indoor air soil gas migration)
- HVAC system changes (that is, systems may affect airflow and pressure in the building)
- Seasonal variation (that is, changes in outdoor temperature and pressure may alter subslab-to-indoor air soil vapor migration)

There are no capital or operations and maintenance (O&M) costs for the No Action Alternative.

3.6.2 Alternative 2—Sealing and Monitoring

Alternative 2 consists of sealing of vapor entry points, if any, and routine collection of subslab soil gas and indoor air samples to evaluate how indoor air and subslab soil gas TCE concentrations change over time within the Aircraft Maintenance Building. Alternative 2 is consistent with the current and likely future commercial/industrial use of the Site, based on the property deed. This remedial alternative could also be used in the unlikely event the Site is redeveloped in the future for residential. This alternative allows airport operations to continue at the Site with minimal disruption. Based on the SiteWise evaluation, there would be minimal environmental impacts (Appendix D).

The conceptual design for this alternative is described below only for cost estimating and environmental impact assessment, which are evaluated under the FS detailed and comparative analyses. These conceptual details may vary from the final design, which would be developed during the remedial design phase and address site conditions at the time of the design. For FS purposes, sealing and monitoring for the existing building would be conducted under Alternative 2 and are described in the following subsections. A different sealing and monitoring plan could be used if a new structure (including residential) were built at the Site.

3.6.2.1 Sealing

Prior to initiating monitoring, potential vapor entry points will be identified for sealing. A visual inspection of the entire building would be conducted to identify cracks, building joints, and other building features that could be

potential vapor entry points. A portable HAPSITE gas chromatograph/mass spectrometer (GC/MS) would also be used to identify vapor entry points (such as large cracks or utility penetrations) within the office spaces. The HAPSITE sampling of the office spaces could be used in combination with interior building depressurization (for example, utilization of a blower door to induce negative pressure in the indoor office space and thereby "turn on" vapor intrusion).

Subsequent sealing of vapor entry points could be performed using elastomeric compounds and insulating foam sealants to reduce or prevent TCE from being transported through these vapor entry points. Attempting to identify and seal every potential entry point can be impracticable, and long-term monitoring and maintenance of the seals would be required. However, this approach would address the most obvious and potentially largest points of vapor entry and thereby result in a reduction of indoor air concentrations.

3.6.2.2 Monitoring

TCE concentrations in subslab soil gas and indoor air would be monitored through the collection of subslab soil gas and indoor air samples semiannually for the first two years in the Aircraft Maintenance Building. Samples would be collected in the heating and cooling season to evaluate seasonal variability. Assuming TCE concentrations in indoor air have not increased to exceed the RAO in that time period, sampling would be reduced and would be conducted during the 5-year reviews unless building use changes or construction occurs in a manner that would increase the amount of VI into the building. If indoor air concentrations of TCE remain below the PRG after the second 5-year review (that is, after 10 years), monitoring would be discontinued, and 5-year reviews would include only site inspections. For the FS, it is assumed that 5-year reviews would be conducted for 30 years. If indoor air concentrations during the first two years were observed to increase above the PRGs for two consecutive monitoring periods or two consecutive same-season monitoring periods (that is, during the heating or cooling season), a contingency remedy (such as the depressurization system described in Alternative 3, Section 3.6.3) would be triggered. This contingency would be included in a future Decision Document to avoid future amendment of the remedy. If indoor air concentrations during the 5-year review sampling were observed to increase above the PRGs, then additional rounds of confirmation sampling would be performed and based on the results, and the contingency remedy in Alternative 3 could be implemented.

The subslab soil gas samples would be collected from the existing subslab soil gas probes. The details of the monitoring program, such as the number of samples to be collected, would be provided in the remedial design work plan. The objectives of the monitoring program are as follows:

- Verify that TCE concentrations do not increase to concentrations above PRGs
- Evaluate how subslab soil gas concentrations of TCE change over time; these data would be used for a variety of reasons, such as monitoring for possible increases in reductive degradation daughter products and justifying the termination of indoor air monitoring if subslab soil gas concentrations were to attenuate over time

The NCP requires 5-year Site reviews as long as hazardous substances with the potential to cause risk to human health and the environment remain at the Site. As part of the 5-year review, the USACE would reevaluate the VI pathway, including any potential sources to soil gas (that is, COCs in soil and/or groundwater) and notify property owners of potential risks. Sampling and an evaluation can be conducted as part of the 5-year review to demonstrate that a remedy has met the RAO and 5-year reviews will be discontinued.

Sealing and monitoring only would not address residual subslab vapor sources. However, subslab concentrations would likely naturally attenuate over time due to natural attenuation of the groundwater plume, and subslab soil gas monitoring would be used to track these changes in concentrations. It is assumed that subslab soil gas and indoor air monitoring would be required for 10 years. DOD will not be responsible for investigating or addressing VI concerns in future buildings at the Site; however, DOD will provide notice of potential vapor intrusion risks as required in DERP Management Manual 4715.20, Enclosure 3 (DOD 2012).

As stated above, future 5-year reviews may include additional sampling to evaluate natural attenuation and if possible, no further action.

3.6.2.3 Major Components

The major components of Alternative 2 include the following:

- Identifying and sealing obvious vapor entry points
- Sampling and analyzing soil gas from existing subslab probes
- Sampling and analyzing indoor air
- Performing 5-year reviews, which includes implementing administrative risk management tools and reevaluating the VI pathway

3.6.3 Alternative 3—Active Subslab Depressurization

Under Alternative 3, active subslab depressurization (SSD) would be accomplished using powered mitigation fans or blowers applying negative pressure on the subslab to create a subslab negative pressure field and to extract vapors within the targeted subslab area. The extracted air would be discharged to the atmosphere outside the building, either with or without granular activated carbon treatment of the offgas, depending on the TCE concentrations in the emissions. This alternative allows airport operations to be continued at the Site; however, there would be short-term disruptions during the SSD system construction. Based on the SiteWise evaluation (Appendix D), there would be high environmental impacts. However, if monitoring during system operation indicated that passive, instead of active SSD, could be implemented, then environmental impacts would be significantly lower. Furthermore, if an alternative power source with a low environmental footprint is used (for example, solar), then environmental impacts would also decrease.

The conceptual design for this alternative is described below only for cost estimating and environmental impact assessment, which are evaluated under the FS detailed and comparative analyses. These conceptual details may vary from the final design, which would be developed during the remedial design phase and address site conditions at the time of the design. For purposes of the cost estimate, it is assumed that granular activated carbon treatment would not be required because TCE concentrations would be sufficiently diluted, since subslab soil gas would be pulled from a wide area rather than the areas of highest concentration. Alternative 3 is consistent with the current and likely future commercial/industrial use of the Site, based on the property deed. This remedial alternative could also be used in the unlikely event the Site is redeveloped in the future for residential use.

This technology has been implemented at numerous sites to mitigate the VI pathway. As part of the design process, pre-mitigation diagnostic testing is required to determine the radius of influence of the negative pressure field at a given applied negative pressure and corresponding flow rate and to determine the TCE concentration in the offgas (USEPA 1993 and USEPA 2015a). The negative pressure and flow rate data are then used to select the number of extraction points, their orientation (that is, horizontal or vertical), and blower specifications. As part of diagnostic testing, field tests would be performed over a period of several days, utilizing temporary equipment, to determine the subslab negative pressure field extension, associated flow rates and vacuum, and to estimate potential VOC concentrations in the off-gas. These data would be used to complete the design of the SSD system including fan/blower and pipe sizing, required applied vacuum, number and configuration of SSD extraction nodes, and potential off-gas treatment. Pre-mitigation diagnostic testing would be used to optimize the mitigation system design, reducing both capital and long-term O&M costs. For cost estimating purposes, the following text describes the layout of a subslab depressurization system and monitoring if it is installed under the existing building. A different design could be used if a new structure (including residential) was built at the Site. The system could be a component of construction of the structure or installed after construction depending on potential risk to indoor air.

3.6.3.1 Subslab Depressurization Layout

Vertical or horizontal collection SSD nodes would be installed through or beneath the building slab, respectively, and connected via PVC piping to an exterior vent located above the building roofline. The

purpose of the active SSD system is to intercept the VI pathway by reducing pressure in the subslab environment. A secondary benefit may be to reduce TCE concentrations in the building subslab environment by physically extracting the soil gas and venting it to the atmosphere. For purposes of the cost estimate, SSD nodes are assumed to be installed via horizontal drilling techniques (Figure 3-2).

The system could be constructed in phases, so that the piping would be installed first. The system could then be operated in passive mode initially and subslab soil gas concentrations monitored. Operation in this mode may provide sufficient subslab soil gas concentration reductions to mitigate potential future risk from TCE in indoor air. The powered mitigation fan or blower could be added in the future to provide additional extraction and depressurization, if needed. Operation of the system in passive mode would significantly reduce O&M costs. For purposes of the cost estimates, operation in active mode is assumed.

As part of system installation, a portable HAPSITE gas chromatograph/mass spectrometer would be used to identify vapor entry points (such as large cracks or utility penetrations) within the office spaces. Sealing could be performed using elastomeric compounds and insulating foam sealants to reduce or prevent TCE from being transported through these vapor entry points. Sealing would result in active subslab depressurization being more effective because it reduces short-circuiting between the subslab environment and the occupied space (resulting in a loss of applied vacuum). Attempting to identify and seal every potential entry point can be impracticable, and long-term monitoring of the seals would be required. However, this approach would address the most obvious and potentially largest points of vapor entry/short circuiting.

3.6.3.2 Monitoring

The effectiveness of this alternative would be monitored through collection of field parameters (vacuum, flow, differential pressure measurements) on a quarterly basis. Subslab soil gas and indoor air samples would be collected semiannually for the first two years. Following that time period and assuming the target levels in indoor air were being met, sampling would be discontinued, and system parameters (such as flow rate, vacuum measurements, and differential pressure measurements) would be used to demonstrate effectiveness. The subslab soil gas samples would be collected from the existing subslab soil gas probes. The details of the monitoring program, such as the precise number of subslab soil gas and indoor air samples to be collected, would be provided in the remedial design work plan. Active SSD would provide some subsurface mass removal, but is unlikely to address residual vapor sources. However, TCE in the subsurface would likely naturally attenuate with time. It is conservatively assumed that the system would be in place for 30 years; however subslab TCE concentrations may naturally attenuate below concentrations that pose risks to indoor air in a shorter timeframe, and system operation and 5-year reviews could be discontinued.

As with Alternative 2, 5-year site reviews would be conducted as long as hazardous substances remain at the Site with the potential to cause risk to human health and environment. As part of the 5-year review, the USACE would reevaluate the VI pathway, including any potential sources to soil gas (that is, COCs in soil and/or groundwater) and notify property owners of potential risks. DOD will not be responsible for investigating or addressing VI concerns in future buildings at the Site; however, DOD will provide notice of potential vapor intrusion risks as required in DERP Management Manual 4715.20, Enclosure 3 (DOD 2012).

3.6.3.3 Major Components

Major components of the alternative include the following:

- Designing diagnostic testing and the mitigation system
- Identifying and sealing obvious vapor entry points
- Installing an active subslab depressurization system
- Performing quarterly O&M activities
- Sampling and analyzing indoor air and subslab soil gas
- Performing 5-year reviews, which includes implementing administrative risk management tools and reevaluating the VI pathway

3.6.4 Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction

Under Alternative 4, TCE in soil and groundwater would be treated or removed to reduce the contaminant mass that is the potential source of vapors to subslab gas and subsequently to indoor air. Soil and groundwater treatment would shorten the remediation timeframe and need for extended long-term monitoring, maintenance, and reviews. A HAPSITE investigation and building sealing would be implemented in a similar manner to Alternative 2, for added protection during the remedial action.

Vadose zone soil gas contamination would be removed in situ using SVE. Groundwater would be treated in situ with a suitable substrate to enhance biological reductive dechlorination. The Site groundwater data collected during the RI suggest that biological reductive dechlorination is occurring. The substrate injection would accelerate that process within the UWBZ. However, reductive degradation products (such as cis-1,2-DCE, vinyl chloride, and methylene chloride) might be produced during the degradation process. Methane, which is a degradation product of the reducing reaction methanogenesis, can also be a potential concern. Since these chemicals are also volatile, their potential impacts on VI would need to be considered and accounted for in the remediation and monitoring plan. The SVE system would help remove these degradation products from the vadose zone and provide additional protection. This technology has been implemented at numerous sites with CVOCs. This alternative assumes that the Site would be remediated to allow for the hypothetical residential land use. Based on the SiteWise evaluation (Appendix D), there would be moderate environmental impacts.

The conceptual design for this alternative is described below only for cost estimating and environmental impact assessment, which are evaluated under the FS detailed and comparative analyses. These conceptual details may vary from the final design, which would be developed during the remedial design phase and address site conditions at the time of the design.

3.6.4.1 SVE System

SVE applies a vacuum system in the subsurface to remove soil vapors and COCs sorbed to vadose zone soil. Air is pulled through the vadose zone using vertical or horizontal wells, volatilizing the contamination, which is then removed from the subsurface. An offgas system can be used to treat vapors before they are emitted to the atmosphere. Prior to SVE installation, a subslab soil gas monitoring event would be conducted to refine the extent of soil gas concentrations above the remediation goals at the time of the remedial action. It is assumed that three new soil gas monitoring points would be installed around the exterior of the hangar (Figure 3-2). Soil gas samples (three exterior building samples and six interior building samples) would be analyzed for COCs and degradation parameters.

For FS conceptual design purposes, it is assumed that the SVE system would operate for 5 years. Horizontal soil vapor extraction wells (installed using directional drilling methods), as opposed to vertical, are recommended to reduce impact to the site operations. Horizontal wells would also eliminate the need for access manways and conveyance piping inside the building and are generally less intrusive. The wells would be installed within an approximately 15,000-square-foot area defined by the highest soil gas concentrations (Figure 2-2). Given that there were only relatively moderate TCE concentrations detected in groundwater (maximum TCE concentration of 65 μg/L), it is assumed that the high subslab soil gas concentrations observed at 18SVO4 and 18SVO6 are associated with residual vadose zone contamination, which warrants treatment under this alternative.

Because of the limited extent of the target treatment area, it is assumed that a pilot study would not be conducted. As such, the actual remedial design would incorporate flexibility to allow for uncertainties due to the lack of a pilot study. For FS purposes, it is assumed that the SVE system would be composed of two blind-end horizontal directional drilled SVE wells installed parallel to each other. Assuming an average depth to water of 6.5 feet bgs, each horizontal well would be installed to an approximate depth of 5.5 feet bgs and be approximately 300 feet long with 180 feet of slotted pipe. SVE extraction wells generally cannot be installed at depths shallower than 4 to 5 feet bgs. If the water table were to rise to the depth of the extraction system, the SVE wells could become ineffective. Local precipitation and operation of the blower

could cause the water table to rise, or mound, to undesirable levels. The system would also include an SVE blower mounted in an enclosed trailer with exterior mounted vapor phase granular activated carbon to offgas treatment. During the performance monitoring period, the continued need for offgas treatment would be reevaluated.

For FS conceptual design purposes, the radius of influence for the horizontal SVE wells would be dependent on vertical leakage at the surface, the depth to water, and the ability to draw soil vapor through the vadose zone without excessive water table lift. Given that the building slab for the hangar would restrict leakage, the radius of influence could be 40 feet or greater in the horizontal direction, based on experience at other sites. However, to avoid excessive lift of the shallow water table, it is assumed that the radius of influence under Alternative 4 would be less than 40 feet. Because the zone of elevated soil gas concentrations does not appear to be very wide (approximately 70 feet), a substantial radius of influence is not considered necessary.

3.6.4.2 Enhanced Biodegradation

Enhanced biodegradation can be implemented via biostimulation with or without bioaugmentation. Biostimulation involves adding a suitable carbon substrate (soluble or insoluble, also known as slow-releasing) to the subsurface. The introduced substrate serves multiple purposes, such as depleting competing electron acceptors to create strongly reducing conditions and providing an electron donor source for reductive dechlorination. The substrate may also include nutrients, such as phosphorus, nitrogen, yeast extract, and vitamin B_{12}, which are desirable for the growth of the dechlorinating bacteria. Because reductive dechlorination is most effective at neutral or near neutral pH, a buffering agent may be introduced if the aquifer's natural buffering capacity is low.

Bioaugmentation is conducted using a microbial culture, frequently one containing *Dehalococcoides*, to "jump start" the biodegradation process and prevent reductive dechlorination from stalling. Bioaugmentation is recommended at the Site because the microbial population detected during the RI was very low (below 10 cells per milliliter). Additionally, bioaugmentation would help prevent accumulation of reductive dechlorination daughter products, which could also pose potential human health risks from VI if concentrations were to increase. cis-1,2-DCE and vinyl chloride, which are TCE reductive degradation products, were not detected in subslab soil gas samples collected beneath the Aircraft Maintenance Building and were present below their VISLs in the soil gas sample adjacent to the passenger terminal during the April 2013 RI monitoring event.

For the FS evaluation and cost estimating purposes, the use of Anaerobic BioChem (ABC)-CH4, a commercial soluble substrate for enhanced reductive dechlorination, was selected. However, another substrate may later be selected in the remedial design phase. ABC-CH4 contains a variety of carbon donors (such as glycerin, lactic acid, and fatty acids) for fast and slow release to groundwater, nutrients, a pH buffer, and a methanogen inhibitor. The methanogen inhibitor limits the production of methane during the reductive dechlorination process to prevent potential safety issues, which would be particularly desirable if the Aircraft Maintenance Building is still present during the injection. A soluble substrate was selected since it may be more easily broken down and available for reductive dechlorinating bacteria given the slow groundwater flow rate at the site. A number of commercial bioaugmentation cultures are available to enhance degradation of chloroethenes.

Target Treatment Zone. For FS conceptual design purposes, it is assumed that enhanced biodegradation would be conducted over a zone with COC concentrations above their MCLs in groundwater. However, the target treatment zone would be further refined during the design phase and consider any additional VI data. TCE was identified as a COC under the residential use scenario. The MCL is 5 µg/L.

The initial injection would be conducted over the approximately 46,800-square-foot area with TCE groundwater concentrations above the MCL (Figure 3-2).

Prior to substrate injection, a baseline groundwater monitoring event would be conducted to confirm the magnitude and extent of contamination at the time of the remedial action. It is assumed that four new groundwater monitoring wells would also be installed to be used for future performance monitoring (Figure 3-2). Groundwater from 19 new and existing wells would be analyzed for COCs, degradation products, and geochemical parameters.

Enhanced biodegradation may result in the production of reductive degradation products (such as cis-1,2-DCE, vinyl chloride, and methylene chloride). If these degradation products were to accumulate in soil gas at concentrations that could pose potential unacceptable risks (see Section 3.3), then future injections would be conducted to address those chemicals in groundwater as well. Following are MCLs for reductive degradation products:

- cis-1,2-DCE = 70 µg/L
- trans-1,2-DCE = 100 µg/L
- 1,1-DCE = 7 µg/L
- Vinyl chloride = 2 µg/L
- Methylene chloride = 5 µg/L

Injection. For FS cost-estimating purposes, it is assumed that enhanced biodegradation substrate delivery would be completed through high-pressure direct-push technology rod injection and that fracture-specific technologies would not be required. However, some fracturing of the subsurface media may occur during the injection process. Because of the high clay and silt content of the UWBZ, only a 5-foot radius of influence is assumed. Injection wells are not recommended because the Aircraft Maintenance Building may still be operational during the injections, and wells throughout the building would likely hinder the property owner's activities.

Prior to full-scale implementation, a pilot test would be conducted to verify the achievable injection ROI in the UWBZ. The potential for daylighting would also be evaluated. One injection point would be advanced upgradient of each of the following monitoring wells 19MW01, 18MW01, and 106MW06 (Figure 3-2). Groundwater from the existing wells would be evaluated with a water quality meter to assess whether the ROI was met.

For the full-scale implementation, injections would be implemented along multiple transects set approximately 30 feet apart to obtain mass reduction. Along each transect, injection points would be placed at 10-foot centers, for a total of 134 injection points. The injection would be conducted over a vertical interval of 5 to 12 feet bgs, or the approximate depth of the lower gray till, at each point. Because ABC-CH4 is a soluble substrate, it may be further distributed within the treatment zone by diffusion and dispersion. However, there is high uncertainty as to radius of influence and the distribution of the substrate in the aquifer, particularly given the high silt and clay content of the UWBZ.

Approximately 9,660 gallons of diluted AB-CH4 solution (approximately 72 gallons per injection point) would be injected into the treatment zone. This solution volume is based on 17,000 pounds of substrate at approximately 8.8 pounds per gallon and a dilution factor of 5. To avoid daylighting of the substrate, it is assumed that only eight injection points could be completed per day. The higher injection pressures may require a specialized slurry pump. It is assumed that water for the injection solution would be obtained from an approved location on the airport property. After sufficient reducing conditions are established, approximately 1 liter of *Dehalococcoides* microbial culture would be injected with nitrogen gas at each of the 80 direct-push technology points.

For FS cost-estimating purposes, it was assumed that four additional injections would be conducted at 1-year intervals (for a total of 5 injections over the remedial action). Additional biostimulation and bioaugmentation injections are included to address the production of reductive degradation products, which may create potential future VI risks, due to enhanced biodegradation and to meet remedial goals in a timely manner. Additionally, ABC-CH4 is not as persistent as typical slow-release substrates. Additional

injections would also facilitate mixing in the aquifer, which may be beneficial given the slow groundwater flow rate at the site. The latter injections may be offset from the initial injection transects to achieve a greater distribution of the substrate. Performance monitoring data would be used to confirm the need for additional injections, which may be needed given the clay and silt geology.

3.6.4.3 Monitoring

Performance monitoring of the enhanced bioremediation injections would be conducted to evaluate the effectiveness of the treatment technology. For FS cost-estimating purposes, it was assumed that quarterly groundwater sampling would be conducted following each injection for 5 years and then one additional year to confirm that there is no rebound in contamination concentrations (for a total of 6 years). It is assumed that groundwater from 10 wells would be analyzed for COCs, degradation products, and geochemical parameters. The actual groundwater monitoring plan, including the number of monitoring wells, sample parameters, and sample frequency, would be developed during the remedial design phase. This plan would consider the results of the baseline monitoring event. During the remedy implementation, the monitoring plan would be reviewed periodically and optimized as needed to reflect changes in site conditions and the fate and transport of the COCs at the Site.

Soil gas and air sampling would also be conducted to monitor the performance of the remedy. Subslab soil gas and air monitoring would be conducted quarterly for the first 5 years to monitor daughter product generation. Soil gas and air sampling would continue at an annual frequency for an estimated 5 years following the injections to document whether soil gas concentrations had attenuated following treatment. If the building is no longer present during the remedial action, then soil gas concentrations would also be used to estimate indoor air concentrations, to assess if concentrations had decreased below residential remedial goals. As with Alternatives 2 and 3, 5-year reviews would be completed as long as hazardous substances remain at the Site with the potential to cause risk to human health and the environment. As appropriate, property owners will be notified of potential risks as part of the 5-year reviews. DOD will not be responsible for investigating or addressing VI concerns in future buildings at the Site; however, DOD will provide notice of potential vapor intrusion risks as required in DERP Management Manual 4715.20, Enclosure 3 (DOD 2012).

3.6.4.4 Major Components

Major components of the alternative include the following:

- Installing three new soil gas monitoring points for refinement of high COC concentrations in soil gas
- Performing baseline soil gas sampling and analysis
- Installing horizontal vapor extraction system over a zone with residual vadose zone contamination to remove contaminants from soil and soil gas
- Injecting enhanced bioremediation substrate (biostimulation) over the target treatment zone to create reducing conditions and an electron-donor supply
- Injecting microbial culture (bioaugmentation) to further enhance degradation rates and prevent accumulation of daughter products
- Installing four new monitoring wells for performance monitoring
- Performing baseline and quarterly sampling and analysis of existing and/or new monitoring wells
- Performing sampling and analysis of indoor air and soil gas for performance monitoring
- Performing 5-year reviews, which includes implementing administrative risk management tools and reevaluating the VI pathway

3.7 Detailed Analysis of Remedial Alternatives

The detailed analysis of alternatives presents the information needed to compare the remedial alternatives. Detailed analysis of alternatives consists of a detailed evaluation of each alternative against the evaluation criteria, followed by a comparative evaluation.

3.7.1 Evaluation Criteria

The evaluation criteria allow comparison of the relative performance of the alternatives and provide a means for identifying their relative advantages and disadvantages. In accordance with the NCP, remedial actions must accomplish the following:

- Be protective of human health and the environment
- Attain ARARs or provide grounds for invoking a waiver of ARARs that cannot be achieved
- Be cost effective
- Use permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element

Provisions of the NCP require that each alternative be evaluated against nine criteria listed in 40 CFR 300.430(e)(9). These criteria were published in the *Federal Register* for March 8, 1990 (55 *FR* 8666), to provide grounds for comparison of the relative performance of the alternatives and to identify their advantages and disadvantages. This approach is intended to provide sufficient information to adequately compare the alternatives and to select the most appropriate alternative for implementation at the Site as a remedial action. The seven criteria evaluated in this FS are the following:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Two other criteria—state acceptance and community acceptance—will be evaluated following public comment on the selected remedy, as described in the Proposed Plan. The extent to which alternatives are evaluated depends on the available data and the number and types of alternatives analyzed. The detailed analysis includes total present worth of the alternatives, consisting of capital costs and operation, maintenance, and monitoring costs. The detailed analyses and costs are described below.

The above criteria can be grouped into three types of evaluation criteria: threshold, balancing, and modifying. Threshold criteria must be met by a particular alternative for it to be eligible for selection as a remedial action. The two threshold criteria are overall protection of human health and the environment and compliance with ARARs. If ARARs cannot be met, a waiver may be obtained when one of the six exceptions listed in the NCP occurs (see 40 CFR 300.430 [f][1][ii][C][1 to 6]).

The five balancing criteria weigh the trade-offs among alternatives. The five balancing criteria are:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

The modifying criteria are community and state acceptance. These are evaluated following public comment and are used to modify the selection of the recommended alternative. Community and state acceptance are not addressed in the FS but will be addressed in the Proposed Plan for the site.

3.7.1.1 Threshold Criteria

Threshold criteria are standards an alternative must meet to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—the alternative must meet them or it is unacceptable. If ARARs cannot be met, the NCP specifies criteria for a potential waiver.

Overall Protection of Human Health and the Environment. Protectiveness is the main requirement that remedial actions must meet under CERCLA. It is an assessment of whether each alternative achieves and maintains adequate protection of human health and the environment. A remedy is protective if it eliminates, reduces, or controls current and potential risks posed by the Site through each exposure pathway.

Compliance with ARARs. Compliance with ARARs is a statutory requirement of remedy selection. This criterion is used to determine whether the selected alternative would meet the federal and state ARARs identified in Tables 3-1, 3-3, and 3-4. The compliance of each alternative with chemical- and action-specific ARARs is discussed. There are no applicable location-specific ARARs for the Site. Section 3.1 contains a discussion of potential ARARs for the Site.

3.7.1.2 Balancing Criteria

Balancing criteria are used to weigh tradeoffs between alternatives. They represent the standards upon which the detailed evaluation and comparative analysis of alternatives are based. A high rating on one balancing criterion generally can offset a low rating on another.

Long-term Effectiveness and Permanence. Long-term effectiveness and permanence reflect CERCLA's emphasis on remedies that will protect human health and the environment in the long term. Under this criterion, results of a remedial alternative are evaluated in terms of the risk remaining at the site after response objectives are met. The primary focus of the evaluation is the extent and effectiveness of the actions or controls that may be required to manage the risk posed by treatment residuals or untreated wastes.

Factors to be considered and addressed are magnitude of residual risk, adequacy of controls, and reliability of controls. Magnitude of residual risk is the assessment of the risk remaining from untreated waste or treatment residuals after remediation. Adequacy and reliability of controls is the evaluation of the controls that can be used to manage treatment residuals or untreated wastes that remain at a site.

Reduction of Toxicity, Mobility, or Volume through Treatment. This criterion addresses the statutory preference for remedies that employ treatment to reduce the toxicity, mobility, or volume of the hazardous substances. That preference is satisfied when treatment is used to reduce the principal threats at a site significantly by destroying toxic chemicals or reducing the total mass or total volume of affected media. This criterion is specific to evaluating only how the treatment reduces the toxicity, mobility, and volume. It does not pertain to containment actions, such as capping.

Short-term Effectiveness. This criterion addresses short-term impacts of the remedial alternatives on human health and the environment during the construction and implementation activities. Short-term impacts include protection of community (risks include dust, increased traffic, odor, or air-quality impacts), protection of workers during remedial actions (risks from heavy equipment, machinery, and transportation), environmental impacts (such as greenhouse gas emissions, criteria pollutant emissions, destruction of habitats, and consumption of resources), and time until remedial response actions are achieved. To help assess potential environmental and social impacts (in terms of accident risks) of each remedial alternative,

SiteWise Version 3.0 (NAVFAC 2013) was used to conduct a quantitative sustainability analysis; additional details are provided in Appendix D.

Implementability. The technical and administrative feasibility of executing an alternative and the availability of services and materials required during its implementation must be considered.

Cost. For the detailed cost analysis of alternatives, the expenditures required to complete each measure are estimated in terms of both capital and annual O&M costs. Given these values, a present-worth calculation for each alternative was calculated for comparison based on a real discount rate of 1.4 percent up to a 30-year operation period. The discount rate is based on the 2015 Discount Rates for the federal Office of Management and Budget Circular No. A-94 (2015). The cost estimates in this section provide an accuracy of -30 percent to +50 percent in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (USEPA 2000).

3.7.1.3 Modifying Criteria

Modifying criteria are used to modify the selection of the recommended alternative.

State Acceptance. This criterion pertains to the technical and administrative issues and concerns the state may have regarding the alternatives. Ohio EPA's comments on the FS report and also on the Proposed Plan will factor into state acceptance of the recommended alternative.

Community Acceptance. This criterion pertains to the issues and concerns the public may have regarding the alternatives. This is not addressed in this report but will be addressed upon receipt of comments on the Proposed Plan and documented in the remedy decision document.

3.7.2 Remedial Alternatives Evaluation

Table 3-7 provides a detailed evaluation of each remedial alternative against the first seven NCP criteria.

3.8 Comparative Analysis of Remedial Alternatives

Following the detailed analysis of the retained remedial alternatives, it was necessary to compare how well each alternative satisfied the seven evaluation criteria described above. The other two criteria (state and community acceptance will be evaluated as part of the public comment period. Table 3-7 presents the detailed analysis of how well each alternative achieves (or does not) the RAO and the seven criteria based on professional judgment. This approach is intended to compare the alternatives and to select the most appropriate alternative for implementation at the Site as a remedial action. Following the detailed analysis, numerical ratings were assigned to the alternatives for each of the seven criteria on a scale of 1 to 4, with 1 being the lowest for a comparative analysis. The scores were then summarized to determine an overall score for each alternative. The alternative with the highest score best satisfies the seven criteria. Table 3-8 summarizes the comparative analysis results for remedial alternatives.

Based on the comparison of alternatives using the NCP criteria, all alternatives except Alternative 1 would provide future protection of human health and the environment and are expected to comply with ARARs. The HHRA did not identify current risks to human health under the current land use. Alternative 4 is considered to have the greatest long-term effectiveness, permanence, and reduction of toxicity, mobility, and volume through treatment because it actively treats the largest area of the alternatives. Alternative 3 would provide only limited active treatment within the targeted subslab area, whereas Alternative 2 would include no active treatment. Five-year reviews and monitoring, as necessary, would be conducted until the RAO is met. On the contrary, Alternative 4 is considered to have the lowest short-term effectiveness and implementability. To meet residential remedial goals within a reasonable timeframe, remedial actions would be highly disruptive to the airport. Alternative 3 would have the largest quantitative environmental footprint but limited impacts to airport operations compared to Alternative 4. In comparison, Alternative 2 would result in minimal disruptions to the airport and have a small environmental footprint. Costs are highest for Alternative 4, followed by Alternative 3, due to capital installation costs and long-term O&M.

A decision analysis tool, which weights the NCP criteria, was used to create graphical representations of the alternatives (except No Action) against the NCP criteria to facilitate the analysis. The details of the analysis are provided in Appendix E. In general, NCP criteria that were considered to be the most important for identifying the differences between the alternatives were weighted high; these include long-term effectiveness and permanence, short-term effectiveness, and implementability. Because the alternatives must meet the threshold criteria, the overall protection of human health and the environment and compliance with ARARs criterion were weighted lower. As described above, sustainability or GSR is considered because it is part of the short-term effectiveness criteria evaluation. Figure 3-3 presents a graphical representation of the overall alternative rankings. Figure 3-4 presents a graphical representation of the balancing criteria ranking for each alternative to reflect its increased level of detail. Based on the alternatives scoring process and decision analysis, Alternative 2 provides the best overall balance of the seven criteria considered. Alternative 2 will meet the RAO by sealing vapor entry points and monitoring TCE concentrations in indoor air. Monitoring would allow for trends to be identified, prior to exceedances of the RAO.

TABLE 3-1

Potential Chemical-specific ARARs

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

	ARARs	Description of Regulation	Comments
Federal ARARs			
None.			
State ARARs			
1	OAC 3745-300-08(D)(2) Voluntary Action Program—Generic Numerical Standards	Generic standards for commercial/industrial indoor air due to vapor intrusion from environmental media. Standards apply to indoor air only for chemicals that have volatilized from environmental media to indoor air.	**Relevant and appropriate.**

TABLE 3-2

Potential Chemical-specific To-be-considered Requirements

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

	To-be-considered Criteria	Description of Regulation	Comments
Federal To-be-considered			
1	Regional Screening Levels (RSLs)	USEPA RSLs for Chemical Contaminants at Superfund Sites (November 2015). Industrial air RSLs provide conservative, risk-based, chemical-specific screening levels for human receptors. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm	RSLs are not promulgated but are a technical reference.
2	Interim Rapid Action Levels (RALs)	USEPA Region 9 Interim TCE Indoor Air RALs.	RALs are not promulgated but are a technical reference.
3	Vapor Intrusion Screening Levels (VISLs)	USEPA developed a spreadsheet calculator that lists chemicals considered to be volatile and sufficiently toxic through the inhalation pathway; and provides VISLs for indoor air, which are generally recommended, media-specific, risk-based screening-level concentrations. http://www.epa.gov/oswer/vaporintrusion/documents/VISL-Calculator.xlsm	VISLs are not promulgated but are a reference.
State To-be-considered			
None.			

Note: The VISLs include the indoor air RSLs, plus the soil gas and groundwater VISLs. However, the VISL table does not always contain the most current RSLs. Therefore, both TBCs are provided in this table.

TABLE 3-3

Potential Action-specific ARARs

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

	ARARs	Description of Regulation	Comments
State ARARs			
1	OAC 3745-15-05(C)(5) Air pollution control—de minimis air contaminant exemption	Establishes limit for emissions of hazardous air pollutants (specifically, TCE) to 1 ton per year. Emissions less than this limit are exemption from Ohio Revised Code 3704—Air Pollution Control and rules adopted thereunder.	**Applicable.**
2	OAC 3745-9-07 and 3723-9-10 Water well standards	Requirements for well grouting for closure, and for well sealing during the remedial action. Wells closed after the response is complete are not subject to these requirements.	**Applicable.**

Note: Potential state action-specific ARAR 1 would apply only to Alternative 3 (Active Subslab Depressurization).

TABLE 3-4

Potential Location-specific ARARs

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

ARARs	Description of Regulation	Comments
None.		

TABLE 3-5

General Response Actions Retained for the Site

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

GRA	Approach to Achieving the RAO
No Action	A baseline alternative will be evaluated because it is required by CERCLA, but no action will not achieve the RAO because no measures are in place to confirm that indoor air concentrations do not increase over time.
Monitoring	Establishes a program with appropriately identified locations to monitor subslab and indoor air concentrations and/or chemical plumes and degradation. Monitoring does not reduce subslab concentrations. However, monitoring can satisfy the RAO by confirming that indoor air concentrations remain below the target levels and that subslab concentrations remain stable. It may also be used in conjunction with other GRAs to satisfy the RAO.
Containment	Creates a barrier between the building subslab and indoor air. Although contaminants in soil and groundwater can also be addressed via containment, this GRA is not applicable for this media at the Site. The concrete surface cover and building already provide a horizontal barrier to soil. Groundwater containment typically consist of vertical barriers, which would not hinder volatilization to soil gas.
In situ treatment	Involves treating contaminants in the original source area without removing the soil or groundwater. Examples of in situ treatment technologies for soil include solidification/stabilization, soil vapor extraction, and thermal desorption. Examples of in situ treatment technologies for groundwater include chemical oxidation, chemical reduction, permeable reactive barriers, air sparging, steam flushing, enhanced bioremediation, anaerobic bioremediation, natural attenuation, and phytoremediation. In situ treatment would satisfy the RAO if used in conjunction with other GRAs to limit exposure during the time it takes for the in situ treatment to meet remedial goals.
Removal	Removes vapor phase contaminants from the subslab by physical extraction. Removes soil contaminants by excavation; however, this is not a feasible option given that a building is present over the target treatment area. Removes groundwater contaminants by groundwater extraction.
Land use controls (LUCs)	Uses physical (such as, engineering), legal, and/or administrative mechanisms to limit access or exposure to the contaminated media. LUCs include CERCLA institutional controls (legal and administrative). LUCs are typically used in conjunction with other GRAs to meet the RAO. Administrative LUCs include activities such as restricting groundwater use through land-use, deed, or access restrictions. A system of approvals may be set up to require a permit for various activities (such as excavation or installation of wells). Engineering controls physically limit access or land use on a property or exposure to contaminated media through engineered structures.

TABLE 3-6
Technology and Process Option Screening
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Remedial Technology	Process Options	Descriptions	Treated Compounds	Limitations	Effectiveness	Implementability	Relative Cost Range	Screening Comment
No Action								
None	None	No action	None	No action does not achieve the RAO.	None	Implementable	Low	Required by CERCLA for comparison.
Institutional Controls								
Administrative restrictions or engineering controls	Land use controls	Land use controls are used to restrict property use and other intrusive activities.	None	USACE does not own property.	Moderate. Can be effective at protecting human health receptors given proper enforcement.	Low to moderate because the government no longer owns the property; requires the current owner to implement many of the controls. Also requires working with the regulators. Legal aspects could require extended timeframe.	Low	The property deed specifies that the Site property is to be used as an airport indefinitely. Therefore, controls are retained only in the form of inspections or notifications until remedial goals are met.
Indoor Air								
Monitoring	Monitoring	Long-term monitoring is implemented to record site conditions and subslab and indoor air concentrations.	None	Does not reduce subslab soil gas concentrations. Could result in exposure if VOC concentrations exceed target levels.	Moderate	Implementable	Low	Will confirm whether indoor air concentrations of VOCs remain below target levels long-term. However, additional action may be required if VOC concentrations increase in indoor air. Will be a component of each remedial alternative.
Identifying and sealing vapor entry points	Vapor-resistant elastomeric compounds and expansive foam products	Entry points are located using a portable GC/MS (for example, HAPSITE) and sealed using vapor-resistant materials.	None	Impractical to locate and seal all vapor entry points. Requires periodic maintenance. Does not reduce subslab soil gas concentrations of VOCs. Could result in exposure if VOC concentrations exceed target levels.	Can reduce indoor air concentrations by preventing vapors from entering indoor air through the most obvious entry points. Can also be used in conjunction with other technologies, including passive venting and active subslab depressurization to reduce short circuiting and increase the subslab effectiveness (radius of influence).	Implementable	Low	Will be part of each alternative considered in order to increase remedy effectiveness. However, will not be considered a stand-alone alternative due to limitations in identifying all entry points.
Floor sealing	Chemical-resistant sealing	Interior building floor surfaces are sealed using a chemical-resistant sealant to prevent vapors from migrating to indoor air from subslab soil gas through floor cracks and other imperfections in the concrete. Can also be used in combination with passive venting and active depressurization to enhance effectiveness.	None	Does not reduce subslab soil gas concentrations of VOCs. Could result in exposure if VOC concentrations exceed target levels.	High	Not readily implementable due to high degree of disruption of building use (see screening comments).	High	Requires removal of all furniture and floor coverings for installation. Access to the building must be restricted during installation. Requires maintenance in high-traffic areas. Not typically used as a stand-alone remedy. Eliminated for future consideration because it would result in significant disruption to building activities and high cost compared to other sealing methods.

TABLE 3-6
Technology and Process Option Screening
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Remedial Technology	Process Options	Descriptions	Treated Compounds	Limitations	Effectiveness	Implementability	Relative Cost Range	Screening Comment
Passive Venting								
	Vertical or horizontal soil gas collection points	Installation of vertical or horizontal soil gas collection points through the building slab. Piping is installed such that the collected soil gas is vented to the atmosphere.	VOCs	Does not result in predictable, continuing subslab depressurization.	High	Implementable	Moderate	Retained for consideration as an intermediate step to active depressurization.
Active Subslab Depressurization								
	Vertical or horizontal soil gas collection points	Application of a vacuum to cut off the VI pathway by creating a negative pressure field beneath the slab and preventing vapor entry to indoor spaces. The soil gas collection points can be used to enhance the capture zone and removal of subslab soil gas.	VOCs	Increased operation and maintenance is required compared to passive venting.	High. Because soil gas would be actively removed from targeted areas, this technology is considered to be somewhat more effective than passive venting alone.	Implementable	High	Commonly used to cut off the VI pathway and remove contaminant concentrations from subslab soil gas. Retained due to high level of effectiveness and implementability.
Soil and Groundwater								
Monitoring	Monitoring	Regular monitoring and data evaluation to assess effectiveness of natural and/or active treatment processes. Monitoring may be necessary to demonstrate that contaminant concentrations and/or mass continue to decrease and document whether potentially toxic transformation products are created at levels that are a threat to human health or the environment.	None	Does not reduce subslab soil gas concentrations. Could result in exposure if VOC concentrations exceed target levels.	Low to moderate. Effective at verifying COC concentrations at the site, but remedial timeframe may be long.	High. No construction activities would be conducted. Therefore, there would be limited disruption to the site.	Low. Costs include monitoring and are dependent on frequency and number of sampling points.	Retained for use alone or with other technologies. Monitoring is required to evaluate active treatment performance.
In Situ Treatment: Chemical								
	In situ chemical oxidation (ISCO)	Injection of oxidant such as hydrogen peroxide or permanganate to chemically oxidize the organic contaminants to nontoxic end products.	VOCs	Silt and clay geology limits distribution of oxidants in the subsurface. Daylighting may occur during injection, particularly due to shallowness of the UWBZ. ISCO may temporarily mobilize some inorganics. Natural oxygen demand of the clay and silt of the UWBZ is high, based on natural oxidant demand testing during the RI.	Moderate. Quickly creates oxidizing conditions in subsurface. Demonstrated effectiveness on COCs. Requires good contact between contaminants and reagent.	Low to moderate. Most suitable for source area treatment. Short-term risks to field workers and the environment from the chemicals onsite. Distribution in the subsurface may be limited. Would require numerous injection points beneath the building, which will negatively impact airport operations	Moderate to high. More cost-effective for source treatment.	Not retained due to the high oxidant demand and limitation of the site geologic setting.

TABLE 3-6
Technology and Process Option Screening
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Remedial Technology	Process Options	Descriptions	Treated Compounds	Limitations	Effectiveness	Implementability	Relative Cost Range	Screening Comment
	In situ chemical reduction (ISCR)	Reducing agents (e.g., ZVI) are added into the subsurface via hydraulic/pneumatic fracturing or high pressure injection to promote abiotic *in situ* reduction.	VOCs	Silt and clay geology limits distribution of ISCR reagents in the subsurface. Daylighting may occur during injection, particularly due to shallowness of the UWBZ. Reducing agents (such as, zero valent iron) are typically in a solid form, further limiting distribution. That is, the solid agent tends to stay only in the area that it was placed either through injection or mixing. The shallowness of the UWBS and the proximity of contamination to Aircraft Maintenance Building limit fracturing capabilities. Enhanced reductive environment may temporarily mobilize some inorganics.	Moderate. A long-lived technology with demonstrated effectiveness on COCs. Abiotic reactions occur quickly. Requires good contact between contaminants and reagent.	Moderate. Most suitable for source area treatment. Application via soil mixing would provide the best distribution of solid reagents but would not be implementable due to the proximity to the Aircraft Maintenance Building. Injection (likely through hydraulic or pneumatic fracturing) needs specialized vendor.	Moderate to high. Injection technique is only available from specialized vendor.	Not retained since it is unlikely that adequate distribution would be achieved at the site given the use of a solid reagent and inability to use fracturing or soil mixing as application methods. A solid reagent tends to stay in the area that it is placed and does not migrate with groundwater flow. The current infrastructure, which includes an operational building, inhibits the use of fracturing or soil mixing.
In Situ Treatment: Physical								
	Air sparging/soil vapor extraction	Air injected into groundwater through a system of wells or horizontal perforated pipes to volatize target contaminants. May be combined with soil vapor extraction to collect CVOCs in the vadose zone.	VOCs	Silt and clay geology limits distribution of injected air in the subsurface. Technology may increase VI risks by volatilizing COCs in groundwater into soil gas. Vacuum extraction may be difficult since the vadose zone is thin. Requires long-term O&M.	Moderate to low. Sparging will be limited by the low permeability geology. Vapor extraction will be limited by the shallow and thin vadose zone.	Moderate. Would require installing of numerous sparge wells and piping and equipment for extraction system. This would increase short term risks to workers.	Moderate to high. More cost-effective for source treatment.	Air sparging is not retained since the technology will likely increase COC concentrations in soil gas. Soil vapor extraction is retained because it would remove contaminants from soil and soil gas and could also be implemented even if the Aircraft Maintenance Building remains in place.
	Solidification/Stabilization	Solidifying or stabilizing agents are mixed with contaminated soil to physically or chemically bind contaminants.	VOCs	Soil beneath building cannot be effectively mixed. Effectiveness for VOCs may be minimal; leachability testing would be required to assess.	Low. Technology design will be limited by the current infrastructure. Long-term effectiveness may decrease over time if site is not maintained.	Low. Technology equipment and infrastructure may hinder airport activities. Runoff of contaminated media during soil mixing presents a short-term risk to the environment.	Moderate. More cost-effective for source treatment.	Not retained since it will not be feasible to effectively mix the soil if the Aircraft Maintenance Building remains in place. Technology may have minimal effectiveness for VOCs.
	Heating	The subsurface is heated using hot water/steam injection or six phase/radio frequency (electrical resistive heating) to enhance volatilization of contaminants. The volatilized contaminants rise to the unsaturated zone and are removed by vacuum extraction and treated.	VOCs	Heating of subsurface will likely exacerbate VI risks by increasing vapor concentrations in soil gas. Current buildings would likely limit locations for treatment. Vacuum extraction may be difficult since the vadose zone is thin.	Moderate. Technology design may be limited by the current infrastructure. Vapor extraction will be limited by the shallow and thin vadose zone.	Low to moderate. Would require heavy construction. This would increase short term risks to workers. Technology equipment and infrastructure may hinder airport activities.	High. More cost-effective for source treatment.	Not retained since the technology will likely increase COC concentrations in soil gas.

TABLE 3-6
Technology and Process Option Screening
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Remedial Technology	Process Options	Descriptions	Treated Compounds	Limitations	Effectiveness	Implementability	Relative Cost Range	Screening Comment
In Situ Treatment: Biological								
	Enhanced bioremediation	Anaerobic—use of an electron donor (hydrogen-releasing compound, vegetable oil, or molasses) to promote anaerobic biodegradation of organic compounds (biostimulation). Also may involve the use of nutrients and engineered bacterial cultures to promote biodegradation (bioaugmentation). Aerobic—stimulation of indigenous microorganisms to aerobically degrade the contamination by injecting nutrients, oxygen, substrates, or engineered microorganisms. Degradation may be metabolic and/or cometabolic processes.	VOCs	Silt and clay geology limits distribution of the enhanced bioremediation substrate. Daylighting may occur during injection, particularly due to shallowness of the UWBZ. Enhanced reductive dechlorination produces daughter products that may create additional VI risks. Enhanced aerobic cometabolism can be difficult to sustain.	Moderate to high. Proven to be effective for the COCs at this site. Injection of soluble substrates may achieve greater radius of influence than slow-release (nonsoluble) substrates.	Moderate to low. Distribution in the subsurface may be limited. Will require numerous injection points which will negatively impact airport operations.	Moderate. Typically considered a cost-effective alternative. However, numerous injections and injection points would be required to shorten the remediation timeframe. Bioaugmentation culture would be used to avoid accumulation of daughter products.	Enhanced anaerobic bioremediation technology retained due to its demonstrated effectiveness on site COCs and its relatively low cost compared to other in situ technologies. Enhanced bioremediation substrates can be injected using standard injection methods. Although distribution may be limited in the fine-grained geology, the use of a soluble substrate can increase the radius of influence as the substrate migrates with groundwater flow. Aerobic bioremediation was not retained because there is current evidence that reductive dechlorination is occurring at the site, and therefore anaerobic degradation is considered to be more synergistic with existing conditions. Additionally, aerobic cometabolism of TCE may be difficult to maintain.
	Phytoremediation	Use of plants to remove, stabilize, or destroy contaminants in shallow soil or groundwater.	VOCs	Not compatible with current and likely future use as an airport. Currently, site is covered predominantly by impervious buildings, roads, and taxiway.	Moderate to high. Proven to be effective for the COCs at this site, and contamination is shallow. However, the remediation timeframe may be long.	Low. There are very limited to no areas available for vegetative growth within the target treatment area.	Moderate. Costs would include planting, tilling, and operation and maintenance of vegetative cover.	Not retained due to its incompatibility with site use.
Removal: Groundwater Collection								
	Pump and Treat	Groundwater is extracted and treated in an ex-situ treatment system. Extraction system can be designed to achieve hydraulic containment (to prevent off-site migration of contaminants) or for hotspot treatment.	VOCs	Silt and clay geology limits volume of extracted groundwater. Groundwater would need to be treated before disposal. Requires long-term O&M.	Low to Moderate for area treatment (contaminant mass removal). Proven to be effective for the COCs at this site. The rate of contaminant mass removal tends to decrease as concentrations decrease, resulting in long timeframe to achieve low cleanup goals. Operation and maintenance of system results in high carbon footprint.	Low to moderate. Extraction beneath the building may be difficult. Would require heavy construction. This would increase short term risks to workers.	High. More cost-effective for barrier treatment.	Not retained because pump and treat has been shown to be ineffective particularly in a low permeability environment, the location of extraction wells would be limited by current infrastructure, and it would likely result in substantial long-term O&M.

Notes:

Shaded technologies are screened from further consideration in the development of remedial alternatives.

Effectiveness is the ability to perform as part of an overall alternative that can meet the RAO under conditions and limitations that exist onsite.

Implementability is the likelihood that the process could be implemented under the physical, regulatory, technical, and schedule constraints.

Relative cost is for comparative purposes only and it is judged relative to the other processes and technologies that perform similar functions.

TABLE 3-7
Detailed Evaluation of Remedial Alternatives
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Sealing and Monitoring	Alternative 3 Active Subslab Depressurization	Alternative 4 Enhanced Biodegradation and Soil Vapor Extraction
Overall Protection to Human Health and the Environment				
Protection of human health and the environment	Does not provide future protection of human health and the environment.	Will meet the RAO by verifying that TCE concentrations do not exceed target levels. Although unlikely, there is the potential for short-term risks to workers conducting the remedial activities from transportation and sampling activities. Alternative is consistent with the likely future industrial/commercial use of property, based on the property deed.	Will meet the RAO by disconnecting the VI pathway and potentially reducing subslab TCE concentrations. Alternative is consistent with the likely future commercial/industrial use of property, based on the property deed.	Will meet the RAO by removing COCs in soil and degrading COCs in groundwater, thereby reducing soil gas concentrations. Controls, which are within the limits of the USACE, should be maintained to prevent residential use until remedial goals are met.
Compliance with ARARs				
Chemical-specific and action-specific ARARs	Not in compliance.	Compliant	Compliant	Compliant
Long-term Effectiveness and Permanence				
Magnitude of residual risk	Does not address future risk from soil gas to indoor air if building conditions change.	Addresses future risk from soil gas to indoor air by verifying that TCE concentrations in indoor air do not exceed target level. Risks may also gradually reduce through natural attenuation of COCs in soil gas; however, source mass remains.	Addresses future risk from soil gas to indoor air by creating a negative pressure barrier between the subslab and indoor air and verifying that TCE concentrations in indoor air do not exceed target levels. May also reduce TCE concentrations in subslab soil gas by extraction and natural attenuation processes; however, source mass remains.	Addresses future risk from soil gas to indoor air by irreversible removal or degradation of COCs in soil and groundwater that may be a source to soil gas and by verifying that TCE concentrations in indoor air do not exceed target levels. Risks may also gradually reduce through natural attenuation of COCs in subsurface.

TABLE 3-7
Detailed Evaluation of Remedial Alternatives
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Sealing and Monitoring	Alternative 3 Active Subslab Depressurization	Alternative 4 Enhanced Biodegradation and Soil Vapor Extraction
Adequacy and reliability of controls	None	Monitoring and sealing technology is reliable; potential for short-term risks to workers implementing the remedial action; 5-year reviews needed until TCE levels do not pose potential future risk to human health and the environment.	Reliable technology; monitoring will verify TCE concentrations in indoor air remain below target levels; 5-year reviews needed until levels do not pose potential risk to human health and the environment.	Reliable technology; monitoring will verify COC concentrations in indoor air remain below target levels. Monitoring, inspections, and 5-year reviews needed until levels do not pose potential risk to human health and the environment.
Potential environmental impacts of remedial action	None	None.	Small amount of concrete debris and/or soil cuttings generated during drilling will be managed in accordance with state and federal requirements. Offsite disposal would result in a loss of landfill space.	None.
Reduction of Toxicity, Mobility, or Volume through Treatment				
Treatment processes used and materials treated	None	No active treatment. A reduction in the volume of COCs may occur by passive natural attenuation processes.	Volume of COCs in subslab soil gas reduced by extraction and venting to the atmosphere.	Volume, extent, and concentration of COCs in soil and groundwater that may be a source to soil gas will be reduced by enhanced biodegradation and SVE. As a result, migration (or mobility) of COCs into soil gas will decrease. The volume and concentration (and therefore, toxicity) of COCs in soil gas will also reduce. Bioaugmentation will help complete dechlorination.
Amount of hazardous material destroyed or treated	None	None	Some mass removal is expected. However, the rate of removal is expected to be slow because the zone of influence does not extend deep into the vadose zone. Treatment area would include the aircraft maintenance building footprint.	Soil treatment area would include zone with TCE soil gas concentrations above 10,000 $\mu g/m^3$. Groundwater treatment area would include dissolved contamination within footprint of TCE plume at concentrations above the MCL.

TABLE 3-7
Detailed Evaluation of Remedial Alternatives
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Sealing and Monitoring	Alternative 3 Active Subslab Depressurization	Alternative 4 Enhanced Biodegradation and Soil Vapor Extraction
Expected reduction in toxicity, mobility, or volume of the waste	None	None	Reduction of TCE concentration in indoor air and subslab soil gas expected due to extraction of vapors beneath the hangar. Does not address potential residual vadose zone impacts.	Reduction of COC concentrations in soil gas expected due to removal from vapor extraction and enhanced biodegradation of groundwater plume.
Irreversibility of treatment	None	None	Permanent extraction of some mass; however, considered to be minor since the bulk of vadose zone impacts will remain in place.	SVE would permanently remove COCs in soil and soil gas. Enhanced biodegradation would permanently degrade COCs in groundwater that may be a source to soil gas.
Type and quantity of residuals that will remain following treatment	TCE in subslab soil gas and potential residual vadose zone impacts will not be addressed.	TCE in subslab soil gas and potential residual vadose zone impacts will not be addressed.	TCE in subslab soil gas is expected to be reduced; however, potential residual vadose zone impacts will not be addressed.	COCs will be degraded via enhanced bioremediation. Therefore, residuals remaining after treatment would be considered minimal. However, concentrations of reductive degradation products may temporarily increase during treatment. SVE would help to remove COCs and degradation products from subsurface.
Statutory preference for treatment	No	No	Yes	Yes
Short-Term Effectiveness				

TABLE 3-7
Detailed Evaluation of Remedial Alternatives
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Sealing and Monitoring	Alternative 3 Active Subslab Depressurization	Alternative 4 Enhanced Biodegradation and Soil Vapor Extraction
Protection of workers during remedial action	Protective. There would be no actions that would impact the workers.	Potential COC exposure to field staff addressed through air monitoring and PPE.	Potential COC exposure, exposure to soils/dust during drilling addressed through air monitoring and PPE. Physical hazards addressed through engineering controls and PPE.	Potential COC exposure during well drilling, SVE construction, and sampling. Potential exposure to enhanced biodegradation substrate during injections; risks addressed through air monitoring and PPE. Relatively high risks of lost time and accidents to workers from handling and transporting bioremediation substrates, from drilling, and from SVE construction.
Protection of the community during remedial action	Protective. There would be no actions that would impact the community.	Protective. There would be minimal to no impacts to the community.	Protective. Construction equipment and travel would create moderate nuisances (such as traffic, noise, and dust).	Protective. Construction equipment and travel would create moderate nuisances (such as, traffic, noise, and dust) during each of the multiple injections.
Potential environmental impacts of remedial action	None	Relatively low potential impacts. Long-term monitoring requires years of trips to the site. Low GHG and total energy footprint from transportation to and from the site. No loss of beneficial reuse of land.	Relatively high potential impacts. Long-term monitoring and system maintenance require years of trips to the site, and operation of active depressurization system requires significant energy, resulting in high GHG, total energy, and air emissions. However, if active depressurization is determined to not be necessary, then environmental impacts may be significantly lower. No loss of beneficial reuse of land.	Moderate potential impacts. Moderate GHG, total energy, air emissions, and water consumption primarily from direct-push technology injections. Some impacts also attributed to monitoring over time. Reducing concentrations to residential levels will result in a potential gain in the beneficial reuse of land.

TABLE 3-7
Detailed Evaluation of Remedial Alternatives
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Sealing and Monitoring	Alternative 3 Active Subslab Depressurization	Alternative 4 Enhanced Biodegradation and Soil Vapor Extraction
Time until protection is achieved	No response action would be conducted, and protection of the site is not expected.	No unacceptable risks to current receptors from indoor air. Monitoring would be conducted to ensure protection. Estimated duration for 5-year reviews is 30 years.	System construction anticipated to be completed within approximately four weeks. Monitoring would be conducted to ensure protection. Estimated duration for 5-year reviews and operation and maintenance is 30 years.	Since there are no unacceptable risks to current receptors from indoor air, protection would be achieved as long as residential use is restricted and monitoring is conducted. Estimated remediation timeframe to meet residential goals is 10 years.
Implementability				
Technical feasibility	Feasible.	Feasible. The alternative (sealing of vapor points and sampling subslab soil gas and indoor air) is easily implementable and maintainable. If needed, indoor air mitigation (Alternative 3) is also implementable and maintainable.	Feasible. The alternative (sealing of vapor points, installing an active subslab depressurization system, and sampling subslab soil gas and indoor air) is implementable and maintainable.	Feasible. The alternative (injecting substrates and microbial cultures, installing a vapor extraction system and sampling groundwater, subslab soil gas, and indoor air) are implementable. However, conducting injections and installing an effective vapor extraction system in tight formations can be difficult.
Reliability of technology	Requires no implementation. No potential for schedule delays.	Reliable. Includes only monitoring and sealing of vapor entry points and therefore, would be less subject to schedule delays.	Reliable. Construction of piping and blowers for subslab depressurization system may be subject to schedule delays.	Reliable technologies; however, they have a high degree of uncertainty for this Site. The quantity of injection points and difficulty of injecting into silt and clay geology will increase the potential for schedule delays. Because of the water table is shallow, there is the risk that it may rise during precipitation events or during SVE blower operation, and intercept the SVE wells, causing them to be ineffective.

TABLE 3-7
Detailed Evaluation of Remedial Alternatives
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Evaluation Criteria	Alternative 1 No Action	Alternative 2 Sealing and Monitoring	Alternative 3 Active Subslab Depressurization	Alternative 4 Enhanced Biodegradation and Soil Vapor Extraction
Administrative feasibility	Unlikely to get approval from necessary agencies.	Feasible.	Feasible. Construction activities would need to be coordinated with the CRAA.	Feasible. Activities would need to be coordinated with the CRAA. Injections and construction activities within the Aircraft Maintenance Building may be subject to airport operations.
Availability of services, equipment, and materials	N/A	Services and materials are available and are easily implementable.	Services and materials are available and are easily implementable.	Services and materials are available from multiple venders. Water availability is a potential issue.
Cost				
Capital cost	$0	$200,000	$831,000	$1,815,000
Present worth	$0	$385,000	$1,915,000	$3,598,000
Period of analysis (years)	30[a]	30	30	10
Capital and present worth	$0	$585,000	$2,746,000	$5,413,000

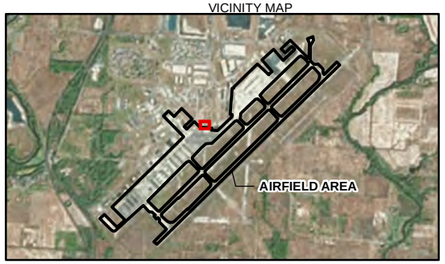
CRAA, Columbus Regional Airport Authority; GHG, greenhouse gas; PPE, personal protective equipment.
[a] Based on USEPA, 2000, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA 540-R-00-002).
[b] Cost estimate is provided in Appendix C.

TABLE 3-8
Comparative Analysis Results
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

	Alternative			
Criterion	**1**	**2**	**3**	**4**
Overall protection of human health and the environment	1	4	4	4
Compliance with ARARs	1	4	4	4
Long-term effectiveness and permanence	1	2	3	4
Reduction of toxicity, mobility, or volume through treatment	1	1	2	4
Short-term effectiveness	3	3	2	1
Implementability	4	4	2	1
Cost	4	4	2	1
Total Score	**15**	**22**	**21**	**19**

1—poor 2—satisfactory 3—good 4—excellent

VICINITY MAP



LEGEND

- HORIZONTAL SSD LATERAL
- PROPOSED EQUIPMENT LOCATION
- FORMER BUILDING

NOTES:

SERVICE LAYER CREDITS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY
25 AUGUST 2015.

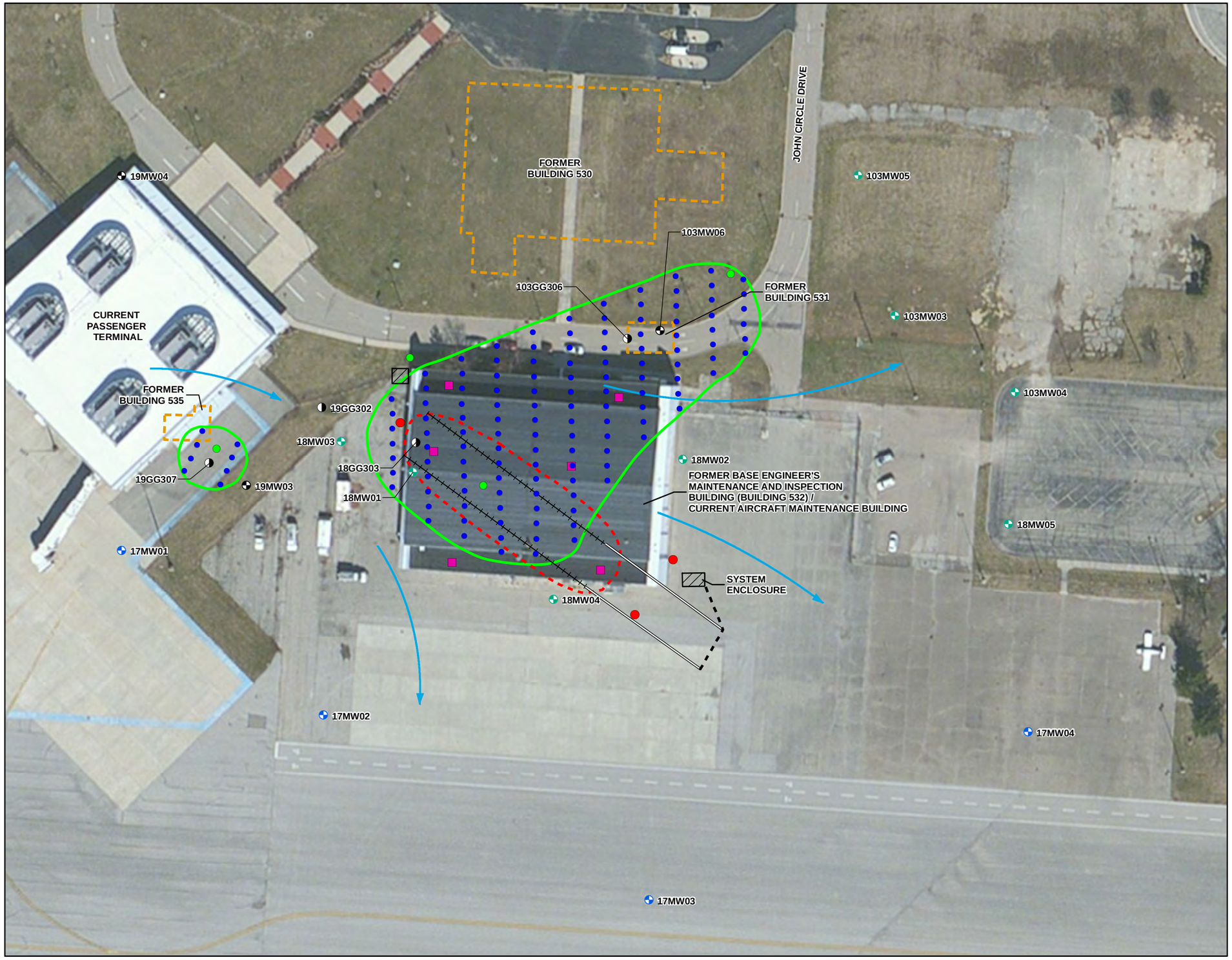
SUBSLAB DEPRESSURIZATION (SSD) LATERALS ARE ASSUMED TO BE INSTALLED VIA HORIZONTAL DRILLING TECHNIQUES.

THE FEASIBILITY STUDY CONCEPTUAL DESIGN ASSUMES THAT ONE NODE WILL BE MANIFOLDED ONTO EACH LATERAL.

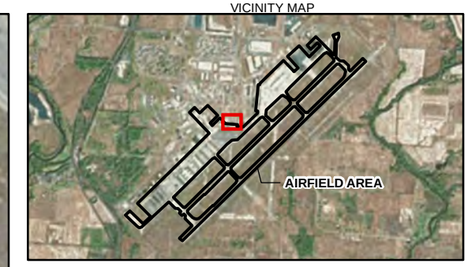
0 40 80 Feet

N

FIGURE 3-1
ALTERNATIVE 3 LAYOUT
ACTIVE SUBSLAB DEPRESSURIZATION
FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO



VICINITY MAP



LEGEND

- PROPOSED INJECTION LOCATION
- PROPOSED MONITORING WELL LOCATION
- PROPOSED SOIL GAS SAMPLE LOCATION
- RI SUBSLAB SOIL GAS SAMPLING LOCATION
- RI GROUNDWATER SAMPLING LOCATION
- RI MONITORING WELL LOCATION
- PHASE I SI MONITORING WELL LOCATION
- PHASE II SI MONITORING WELL LOCATION
- SVE WELL SCREEN
- SVE WELL RISER
- CONVEYANCE PIPING TRENCH
- TCE ISOCONCENTRATION CONTOUR (5 µg/L)
- GROUNDWATER FLOW DIRECTION
- ZONE OF HIGH TCE CONCENTRATIONS IN SOIL GAS (10,000 µg/m^3)
- SYSTEM ENCLOSURE
- FORMER BUILDING

NOTES:

µg/L = MICROGRAMS PER LITER.

DPT INJECTION POINTS ARE ASSUMED TO HAVE A RADIUS OF INFLUENCE OF 5 FEET AND ARE SET AT 10-FOOT CENTERS.

HORIZONTAL SVE WELLS WOULD BE INSTALLED WITH BLIND COMPLETION; 120 FEET OF PROXIMAL RISER, 150 FEET OF SLOTTED PIPE.

INJECTION LOCATIONS ARE PRESUMED.

RI = REMEDIAL INVESTIGATION.

SERVICE LAYER CREDITS: SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEX, GETMAPPING, AEROGRID, IGN, IGP, SWISSTOPO, AND THE GIS USER COMMUNITY, 20 AUGUST 2013.

SI = SITE INVESTIGATION.

TCE = TRICHLORETHENE.

0 80 160 Feet

N

FIGURE 3-2
ALTERNATIVE 4 LAYOUT
ENHANCED BIODEGRADATION AND SOIL VAPOR EXTRACTION
FEASIBILITY STUDY REPORT
AOCS 17/18/19/103
FORMER LOCKBOURNE AFB, COLUMBUS, OHIO

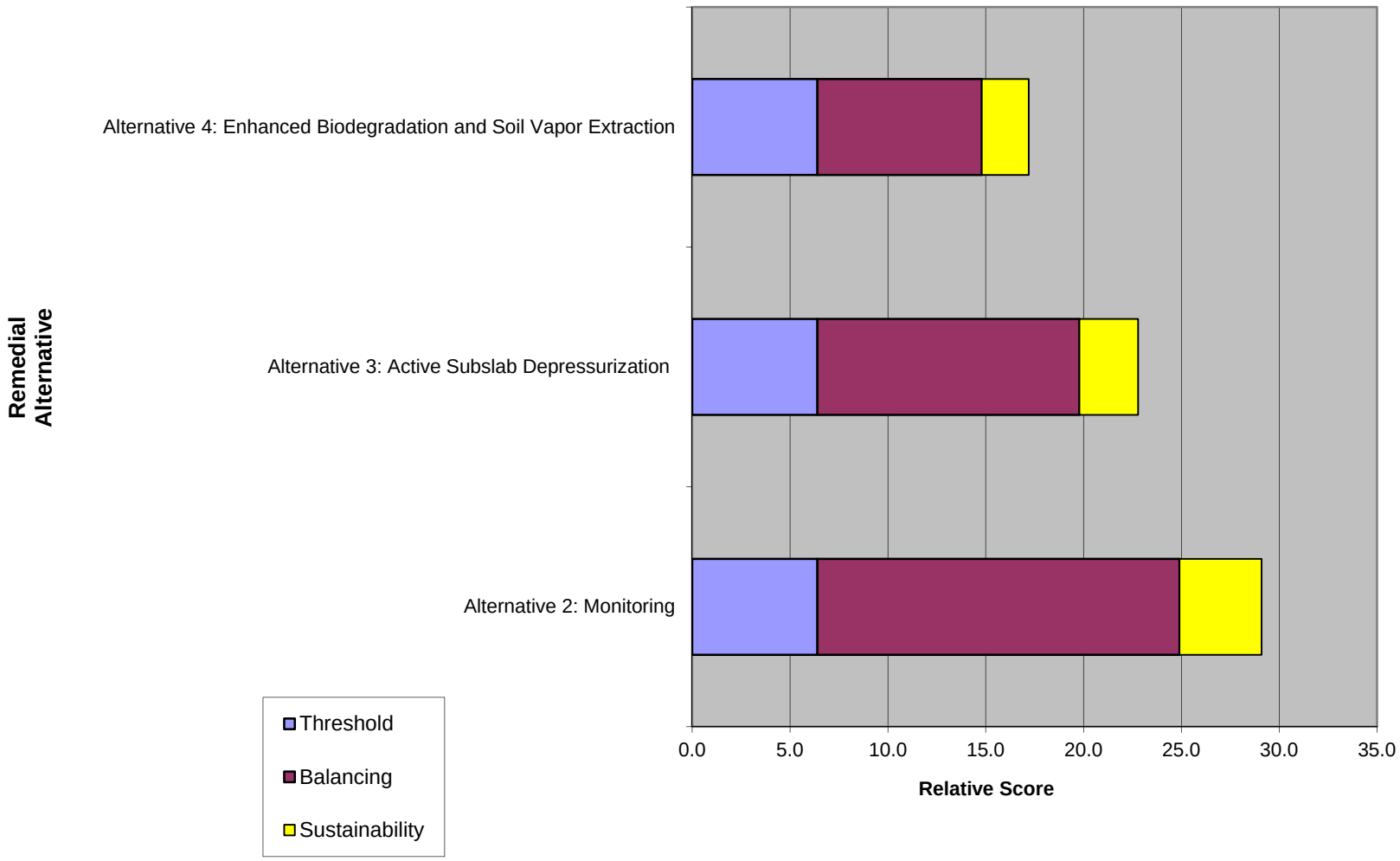


Figure 3-3
Overall Comparative Analysis Ranking
Feasibility Study Report
AOCs 17/18/19/103
Former Lockbourne AFB, Columbus, Ohio

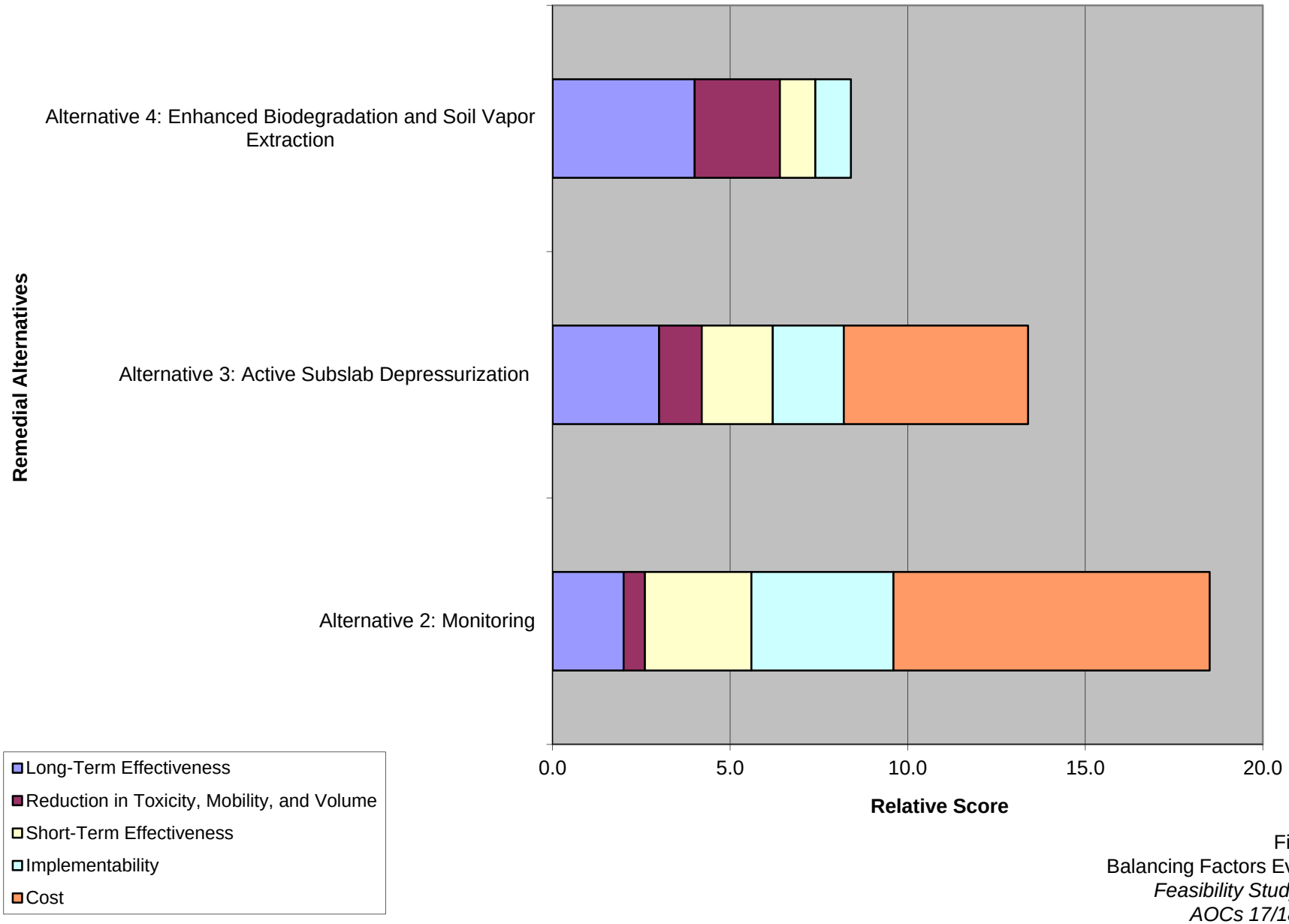


Figure 3-4
Balancing Factors Evaluation
Feasibility Study Report
AOCs 17/18/19/103
Former Lockbourne AFB, Columbus, Ohio

SECTION 4

Green and Sustainable Remediation

GSR practices in accordance with DERP Management Manual 4715.20, Enclosure 3, Section 6(d) (DOD 2012) were incorporated into the FS. The GSR memorandum (Appendix D) was developed to present GSR activities evaluated and implemented as part of this investigation and reporting phase. Previous GSR memorandums were prepared as part of the work planning and investigation phases. The memorandum in Appendix D will be updated following the proposed plan/decision document phases as part of the current USACE contract. The GSR memo will also be revised during the remedial design and remedial action phases, as applicable, under future contracts. The GSR practices employ the following strategies throughout the remedial process:

- Use natural resources and energy efficiently.
- Reduce negative impacts on the environment.
- Minimize or eliminate pollution at its source.
- Reduce waste to the greatest extent possible.

The GSR strategy for the project includes implementing sustainability considerations through best management practices and environmental footprint evaluations. The memorandum identifies the numerous best management practices implemented during the FS, which include evaluation of the environmental footprints of the proposed remedial alternatives. By considering social, economic, and environmental impacts (both positive and negative), a more holistic view of the alternatives can be evaluated during the remedy selection process.

SECTION 5

Summary and Conclusions

An FS was prepared for AOCs 17/18/19/103 to evaluate remedial alternatives to address potential unacceptable risks to human health. The HHRAs concluded that there is no current risk and that VI of COCs in soil gas to indoor air is the only exposure pathway that poses potential future risks. Based on measured soil gas concentrations, TCE was identified as a COC for future commercial/industrial workers at the Aircraft Maintenance Building and for hypothetical, and unlikely, future residential receptors. Because indoor air concentrations measured during the RI were within USEPA-acceptable levels under the commercial/industrial use scenario, there are no risks to current site workers. To address the VI exposure pathway and facilitate alternative evaluation, an RAO was developed and ARARs and to-be-considered criteria were identified.

Following an initial screening process of treatment technologies, four remedial alternatives were retained for detailed evaluation and comparative analysis against the NCP criteria:

- Alternative 1—No Action
- Alternative 2—Sealing and Monitoring
- Alternative 3—Active Subslab Depressurization
- Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction

Alternative 1 (No Action) was retained only for baseline comparison, in accordance with NCP, and does not meet statutory requirements. The remaining three alternatives would be protective of human health and the environment and are expected to comply with ARARs. Alternatives 2 and 3 are consistent with the future land use of the Site (as an airport) based on the property deed; however, these two alternatives can be implemented for residential land use as well. Alternative 4 is protective of the unlikely residential land use. It is assumed that the airport property deed would remain in place until residential remedial goals were met. Therefore, the alternatives would require only inspections to monitor potential changes in the building infrastructure. Land ownership and the property deed would be verified during the CERCLA Five-year Review process and, if needed, potential impacts on remedial alternatives would be evaluated.

Alternative 2 would have the lowest costs, the greatest short-term effectiveness, and the greatest implementability. Because it would cause minimal disruptions to the Site, it is considered to be the most compatible with current airport operations. There would be no loss of beneficial reuse. While indoor air concentrations measured during the RI were below levels that might pose unacceptable risks, sealing vapor entry points would provide protection against future VI. Although no active treatment component would be employed, natural attenuation of contaminants in the subsurface would likely occur and act to reduce COC concentrations.

Alternative 3 would temporarily impact airport operations during SSD system construction; however, there would be no loss in beneficial reuse of the Site overall. This alternative would result in relatively high costs and low short-term effectiveness, compared to Alternative 2. This alternative would have the highest greenhouse gas and criteria air pollutant emissions, as well as the highest energy footprint due to long-term O&M. However, SSD would provide some active treatment by extracting vapors from a limited area. Therefore, the remediation timeframe may be shortened.

Although Alternative 4 would result in the highest degree of contaminant reductions through treatment and a gain in beneficial land reuse (residential), it would also result in the lowest short-term effectiveness. This alternative would create substantial disruptions to the Site, if it is to remain an airport. If the technology continues to improve, horizontal injection wells, instead of vertical points, should be considered to limit these disruptions. Due to the injections and SVE construction work, this Alternative 4 has the highest accident risks and moderate greenhouse gas and criteria air pollutant emissions and energy use. The

production of methane and other degradation products may pose additional short-term risks to workers; however, the SVE system may address this concern. Regarding implementability, there is high uncertainty for the radius of influence for the injection points, the effectiveness/uniformity of the substrate injections, and effectiveness of the SVE system, given the low permeability geology and shallow water table. Alternative 4 would also have the highest costs.

Upon finalization of the FS report, in coordination with the Ohio EPA, a proposed plan will be prepared in accordance with CERCLA and FUDS guidance documents. The proposed plan will summarize the RI activities conducted at the Site and their results, as well as the remedial alternatives evaluated in this FS. Recommendations on the preferred remedial alternative will be made in the proposed plan. A decision document will be drafted after receiving and addressing public comments on the proposed plan. The decision document will summarize the RI results, present the remedial alternatives evaluated in the FS, and describe the selected remedy.

SECTION 6

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Appendix A
Communication with Paul Kennedy of Columbus Regional Airport Authority

From: Paul Kennedy <pkennedy@ColumbusAirports.com>
Sent: Tuesday, December 23, 2014 3:33 PM
To: Swoveland Chapman, Tiffany/STL
Cc: Joshua.Vanbogaert@usace.army.mil
Subject: RE: AOC 17/18/19/103 Remedial Investigation Report - Site Historical Use

Hi. The contact for Lane Aviation is Steve Evans. His email is:
sevans@laneaviation.com<mailto:sevans@laneaviation.com>. 614 237-3747

CRAA (named Rickenbacker Port Authority at that time) was in the building from ~ 1986 to ~ 1995. This was the airfield maintenance function, consisting of vehicle parking, material storage, vehicle maintenance, and offices.

Typical chemicals used in the authority operation:

Motor oils

Hydraulic oils

Antifreeze

Lubricants (like WD-40)

Cleaning/custodial equipment (windex, bleach, dish soap)

Urea (granular pavement deicer)

Self-contained parts washer from Safety Kleen. Standard solvent. http://www.safety-kleen.com/File%20Library/pdfs_chemistry_specs/SK_PartsCleaningSolventChemistries.pdf

Vehicle fuels (diesel and gasoline)

The CRAA reoccupied the building in October 2012. In this function we use it as offices, equipment storage, and as aircraft storage. Tenants may do light maintenance from time to time; including adding motor oil to engines.

Typical chemicals in this operation include:

Motor oils

Lubricants (like WD-40)

Cleaning/custodial equipment (windex, bleach, dish soap)

Fuels (diesel, Jet-A, 100LL AVGAS)

Fuel System Icing Inhibitor (FSII); one brand is Prist

From: Tiffany.SwovelandChapman@CH2M.com [mailto:Tiffany.SwovelandChapman@CH2M.com]
Sent: Friday, December 19, 2014 3:13 PM
To: Paul Kennedy
Cc: Joshua.Vanbogaert@usace.army.mil
Subject: AOC 17/18/19/103 Remedial Investigation Report - Site Historical Use

Hi Paul - are you around next week for a teleconference with Josh and I regarding site use of AOCs 17/18/19/103 (i.e., hangar and new terminal area)? USACE have questions regarding site historical use that arose as part of their review of our remedial investigation report. Josh can find information regarding DoD historical use for us to add, but we would like to get information from you regarding airport use or property use since DoD left. In lieu of a call, if you have any documents of historical use for this area, that would work also. If you are free for a call, let me know when and I'll send a call-in number.

Best Regards,

Tiffany

Tiffany Swoveland Chapman

Project Manager

Environmental and Nuclear Services

CH2M HILL
300 Hunter Avenue, Suite 305
St. Louis, Missouri 63124
Direct 314.335.3044
Fax 414.454.8728
Mobile 314.805.6993
www.ch2mhill.com<http://www.ch2mhill.com/>

From: Paul Kennedy <pkennedy@ColumbusAirports.com>
Sent: Monday, January 05, 2015 3:12 PM
To: Swoveland Chapman, Tiffany/STL
Cc: Joshua.Vanbogaert@usace.army.mil; Goodson, Bob/DFW
Subject: RE: Former Lockbourne AFB AOCs Teleconference Summary 23 December 2014
Attachments: RE: AOC 17/18/19/103 Remedial Investigation Report - Site Historical Use

Hi

A few corrections (see also the attached email):

RPA (later to be called CRAA after 2003) was in the building ~1986 to~1995 Sothern Air Transport ~1995 to ~ 2001
~2001 Lane Aviation to October 2012.
Oct 2012 to present = CRAA

We don't currently have a parts washer in the building.

RPA had a self contained parts washer. Not sure what Southern Air had, but would assume they did have something for parts washing.

Building 531 not at all used by RPA. All RPA activities confined to 532.

Prior to ~1986 no civilians occupied 532.

UPS operated from portable job trailers near the current passenger terminal (535 vicinity?) No one occupied 535 that I know.

-----Original Message-----
From: Tiffany.SwovelandChapman@CH2M.com [mailto:Tiffany.SwovelandChapman@CH2M.com]
Sent: Monday, December 29, 2014 11:43 AM
To: Paul Kennedy
Cc: Joshua.Vanbogaert@usace.army.mil; Bob.Goodson@CH2M.com
Subject: Former Lockbourne AFB AOCs Teleconference Summary 23 December 2014

Hi Paul - As you know, a teleconference was held on 23 December 2014, to discuss historic use of AOCs 17/18/19/103 at the former Lockbourne AFB. Below is a list of attendees and a summary of the discussion. Following the teleconference, we received your email with the Lane contact, rough dates of Building 532 ownership, and chemical use - thank you. Based on this follow-up information, I understand that Building 532 was Southern Air Transport in 1980s-1986, then CRAA 1986-1995, Lane 1995-2012, then back to CRAA 2012-present. Is this correct? Can you confirm that CRAA does not have a parts cleaner currently? I see that CRAA had one initially based on your follow-up email, but I thought that you indicated that Southern Air Transport had that self-contained unit. Do you know if Southern Air Transport did parts cleaning? I can ask the Lane contact about a parts cleaner. Also, I got the feeling that Southern Air Transport did heavier maintenance. Can you confirm this? Lastly, can you confirm that the information in the below summary is correct and add any more information regarding use of this area that I may have missed or you have since recalled? Thanks for your help!

Attendees:
USACE: Josh Van Bogaert/COR
CRAA: Paul Kennedy/Manager, Energy and Environment CH2M HILL: Bob Goodson/Senior Technical Consultant and Tiffany Swoveland Chapman/Project Manager

In response to Office of Counsel (OC) comments on the draft remedial investigation report, USACE and CH2M HILL representatives met with CRAA to request information regarding historical use of AOCs 17/18/19/103. Paul Kennedy/CRAA has worked at CRAA since 1993. The below information is based on Paul's recollections and verbal information passed on to him; there are no written documents or records on site use and chemical inventories.

- Building 531: ANG/CRAA stored de-icing trucks and materials including the storage of urea for de-icing
- Building 532 (hangar): In the 1980s, Southern Air Transport and CRAA occupied the building for light aircraft maintenance and company operations. The building was used for office space, storage, and work shop. There was an associated storage tank(s) for fuel. There likely was a small parts washer that was self-contained and disposed of by a waste management entity (e.g., SafetyKleen). Other products besides fuels and possibly solvents included janitorial cleaners (e.g., glass cleaner, bleach) and oils/lubricants (e.g., motor and hydraulic). Southern Air Transport went out of business and the building was vacant for a period. Lane Aviation leased the building in the late 1990s for the same uses as Southern Air Transport although we do not have information on parts cleaning. Lane Aviation is still in business at another location and Paul will forward contact information.
- Building 535 was demolished for construction of the existing passenger terminal that was constructed in 2001. The building was occupied by UPS at one time, but were relocated for demolition and construction of the terminal.

Best Regards,
Tiffany

Tiffany Swoveland Chapman
Project Manager
Environmental and Nuclear Services

CH2M HILL
300 Hunter Avenue, Suite 305
St. Louis, Missouri 63124
Direct 314.335.3044
Fax 414.454.8728
Mobile 314.805.6993
www.ch2mhill.com

Appendix B
Human Health Risk Assessment—Residential Land Use

Human Health Risk Assessment for Residential Land Use, Former Lockbourne Air Force Base, Areas of Concern 17/18/19/103, Columbus, Ohio

The current and future commercial/industrial use is dictated by the property deed for AOCs 17/18/19/103 (the Site) and is the most likely future use of the property; therefore, the remedial investigation evaluated potential risk to commercial/industrial land use. The DERP manual (DOD 2012) states that feasibility study alternatives should address a range of land use scenarios. Therefore, a human health risk assessment (HHRA) was conducted to assess a residential scenario for the Site. The overall approach for the HHRA follows USEPA's *Risk Assessment Guidance for Superfund (RAGS),* Parts A, D, E, and F (USEPA 1989, 2001, 2004, 2009).

The HHRA evaluated potential human health risks associated with exposure to soil and indoor air (using soil gas data). Soil gas is expected to be impacted as a result of VOCs in site groundwater and vadose zone sources under the Aircraft Maintenance Building. Groundwater is not used as a potable source onsite. Groundwater in the upper water bearing zone (UWBZ) at the Site is too shallow to be used for a drinking water resource and is documented to have low well yield because of the limited saturated thickness and low hydraulic conductivity; contamination does not extend offsite. Therefore, potable use of groundwater was not evaluated for the residential scenario.

B.1. Data Evaluation

B.1.1 Data Used in the HHRA

The analytical data used in the HHRA consist of soil samples collected during the Phase I site investigation, the Phase II site inspection, and the remedial investigation (RI) (in November 1999, May 2001, November 2010, and April and October 2013). Soil samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals.

Soil samples collected from discrete depths between 0 feet and the depth to groundwater (4 to 10 feet bgs; average 7 feet bgs), termed "total soil," were used in the HHRA. Because future invasive activities may disturb soil in the shallow subsurface and bring current subsurface soil to the ground surface where future contact may occur, soil samples collected from the ground surface to the depth to groundwater were used to evaluate potential future soil scenarios.

Soil gas samples collected from the exhaust of the passive vapor extraction system in April 2013 and January 2014 from the passenger terminal vapor extraction system, an exterior soil gas sample collected in April 2013 near the passenger terminal, and subslab soil gas samples collected from the Aircraft Maintenance Building in April 2013 and April 2014 were used in the HHRA.

B.1.2 Chemicals of Potential Concern

Chemicals of potential concern (COPCs) are the chemicals that are carried through the quantitative human health risk process. The COPCs are those chemicals that have the greatest potential to cause adverse human health effects if receptors come into contact with Site media.

The detected constituents were screened following the procedures described below. The maximum detected concentration of each constituent in soil was compared to the screening levels discussed below to identify the COPCs. If the maximum detected concentration exceeded the screening level, the constituent was selected as a COPC. The COPC screening is presented in Tables 1-1 through 1-3, in Attachment 1. A detected chemical that has no RSL was compared with an RSL for a surrogate chemical based on structural or functional similarities, if such information and values were available.

Subslab Gas/Exterior Soil Gas/Exhaust Stack Gas

The residential vapor intrusion screening levels (VISLs) for soil gas are the target residential soil gas concentrations obtained from the VISL calculator (USEPA 2014). When multiple VISLs were available (both carcinogenic- and noncarcinogenic-based VISLs), the lower value was selected as the final VISL for that chemical. The carcinogenic-based VISLs are based on a target carcinogenic risk of 1×10^{-6} and the noncarcinogenic-based VISLs are based on a target hazard index (HI) of 1, which is consistent with the Department of Defense (DOD) *Vapor Intrusion Handbook* (Tri-Service Environmental Risk Assessment Workgroup 2009).

Soil gas VISLs were not available in the VISL calculator for hexachlorobutadiene; it is not identified as a volatile chemical in USEPA's RSL table. Based on the definition of volatiles in the DOD *Vapor Intrusion Handbook* (Tri-Service Environmental Risk Assessment Workgroup 2009), however, hexachlorobutadiene is considered volatile. Target indoor air concentrations were available from USEPA's RSL table (USEPA 2015). Therefore, residential target soil gas concentrations were calculated for hexachlorobutadiene using the following equation (USEPA 2014):

$$C_{soil-gas} = \frac{C_{target,\,ia}}{AF_{ss}}$$

where:

$C_{soil-gas}$ = Target soil gas concentration [micrograms per cubic meter (µg/m^3)]
$C_{target,\,ia}$ = Target indoor air concentration (µg/m^3)
AF_{ss} = Attenuation factor (ratio of indoor air concentration to sub-slab or soil gas concentration; USEPA default value is 0.1)

For chemicals without soil gas VISLs and inhalation toxicity values, VISLs for identified surrogate chemicals were used, as presented in Attachment 1, Tables 1-1 and 1-2.

Soil

Soil data were compared to USEPA RSLs (USEPA, 2015) for residential contact with soil to identify COPCs. The RSLs were based on a target excess lifetime cancer risk (ELCR) of 1×10^{-6} and target HI of 0.1. In the case of lead, the RSL [400 milligrams per kilogram (mg/kg)] is based on the Integrated Exposure Uptake Biokinetic (IEUBK) Model. The RSL for hexavalent chromium (the more toxic form of chromium) was conservatively used for screening total chromium results since an RSL is not available for total chromium. When multiple RSLs were available (such as carcinogenic, noncarcinogenic, and soil saturation-based RSLs), the lowest value was selected as the final screening level for that chemical. When a tabulated RSL was not available for a chemical, the RSL for an appropriate surrogate (if available) was used as presented in Attachment 1, Table 1-3.

B.1.3 Results of COPC Screening

The results of the COPC screening process for soil gas and soil are presented in Tables 1-1 through 1-3 of Attachment 1.

Soil Gas (Passenger Terminal Area)

Three VOCs were identified as COPCs in soil gas for potential future indoor air exposures: benzene, chloroform, and vinyl chloride (Table 1-1 of Attachment 1).

Chloroform in site groundwater is attributable to "background" activities and is not considered a Site-related chemical at DOD sites. The most common source for chloroform in urban groundwater is chlorinated water releases. Chloroform is likely present in site groundwater as a result of chlorinated water from various sources including irrigation, washdown water, and/or leaking water lines. Storm sewers leak and typically receive irrigation runoff, and many floor drains leak.

Soil Gas (Aircraft Maintenance Building Area)

Two VOCs were identified as COPCs in soil gas for potential future indoor air exposures: chloroform and TCE (Table 1-2 of Attachment 1).

As discussed above, chloroform in site groundwater is attributable to "background" activities and is not considered a Site-related chemical at DOD sites.

Total Soil

Seven metals, eight polycyclic aromatic hydrocarbons (PAHs), one SVOC, and three VOC were identified as COPCs in total soil for potential direct contact exposures: aluminum, arsenic, chromium, cobalt, iron, manganese, thallium, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene, dibenzofuran, cis-1,2-dichloroethene, TCE, and vinyl chloride (Table 1-3 of Attachment 1).

As discussed in Section 4.2.3 of the RI report (CH2M HILL 2015), arsenic, total chromium, and thallium concentrations in subsurface soil cannot be distinguished from background levels. Although the central tendency comparison indicated thallium in subsurface soil at the Site may be above background levels, this metal is still considered to be naturally occurring and not Site related. Based on the historical Site use, a release of metals is not expected. Current PAH concentrations are attributed to resurfacing of the adjacent parking lot over more recent years and not a CERCLA release. Chemicals which were detected in total soil above residential RSLs were retained as COPCs and carried forward in the HHRA.

B.2. Risk and Hazard Estimates

Following identification of COPCs, ELCRs, and HIs for soil gas were estimated using USEPA's VISL calculator tool (USEPA 2014). By selecting the Sub-slab or Exterior Soil Gas Concentration to Indoor Air Concentration worksheets, forward risk calculations were performed.

ELCRs and HIs for soil were estimated using USEPA's RSL calculator. By selecting the "risk output" option, forward risk calculations were performed.

Exposure intake assumptions used in risk estimates are discussed below.

B.2.1 Exposure Point Concentrations

The maximum detected concentrations of COPCs in soil gas and total soil were used as exposure point concentrations.

B.2.2 Exposure Factors

A reasonable maximum exposure scenario was quantified for future hypothetical residents (USEPA 1989). The exposure factors used in the intake calculations for residents are the default values provided in the VISL calculator and RSL calculator tools.

B.2.3 Toxicity Assessment

Toxicity values are provided in the RSL calculator and follow USEPA's hierarchy of sources (USEPA 2003).

B.2.4 Soil Gas (Passenger Terminal) Risk Estimates and COCs

A summary of soil gas risks estimates for soil gas COPCs and only the two Site-related soil gas COPCs for the passenger terminal is provided as Table B-1. Forward risk calculator outputs for COPCs are provided in Attachment 1, Table 1-4, while risk calculator outputs for only Site-related soil gas COPCs are provided in Attachment 1, Table 1-5. As noted on the summary table and calculator output tables, the ELCR of 6×10^{-6} and maximum target organ HI of 0.01 are within USEPA's acceptable risk range and less than USEPA's HI threshold. As a result, no chemicals of concern (COCs) were identified for soil gas at the Passenger Terminal for residential land use.

For the two Site-related soil gas COPCs, an ELCR of 5×10^{-6} and HI of 0.01 were calculated, which are within USEPA's acceptable risk range and below USEPA's target threshold. As a result, no Site-related soil gas COCs for potential direct contact exposures were identified for residential land use.

B.2.5 Soil Gas (Aircraft Maintenance Building) Risk Estimates and COCs

A summary of soil gas risk estimates for soil gas COPCs and only the one Site-related soil gas COPCs for the Aircraft Maintenance Hangar is provided as Table B-1. Forward risk calculator outputs for all COPCs are provided in Attachment 1, Table 1-7. As noted on the summary table and calculator output tables, the ELCR of 2×10^{-2} and maximum target organ HI of 4,766 exceed USEPA's acceptable risk range and HI threshold. As a result, chloroform and TCE were identified as soil gas COCs for the Aircraft Maintenance Building for residential land use. Soil gas is expected to be impacted as a result of VOCs in groundwater and a vadose zone source underneath the Aircraft Maintenance Building.

For the one Site-related soil COPC (i.e., TCE), an ELCR of 2×10^{-2} and HI of 4,766 were calculated, which exceed USEPA's acceptable risk range and HI threshold. As a result, TCE was identified as soil gas COC for the Aircraft Maintenance Building for residential land use.

B.2.6 Soil Risk Estimates and COCs

A summary of total soil risks for soil COPCs and only the three Site-related soil COPCs is provided as Table B-1. Forward risk calculator outputs for all soil COPCs are provided in Attachment 1, Table 1-6, while risk calculator outputs for only Site-related soil COPCs are provided in Attachment 1, Table 1-7. As noted on the summary table and calculator output tables, the ELCR of 3×10^{-3} and HI of 3 for all soil COPCs exceed the USEPA's acceptable risk range and HI threshold. Benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, arsenic, and thallium were identified as soil COCs for residential land use.

However, for the three Site-related soil COCs, an ELCR of 5×10^{-5} and HI of 0.6 were calculated, which are within USEPA's acceptable risk range and below USEPA's target threshold. As a result, no Site-related soil COCs for potential direct contact exposures were identified for residential land use.

B.3. References

Department of Defense (DOD). 2012. *Defense Environmental Restoration Program (DERP) Management.* Manual Number 4715.20. March.

Tri-Service Environmental Risk Assessment Workgroup. 2009. *Department of Defense Vapor Intrusion Handbook*. January.

U.S. Environmental Protection Agency (USEPA). 1989. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A).* Office of Emergency and Remedial Response. PA/540/1-89/002. December.

U.S. Environmental Protection Agency (USEPA). 2001. *Risk Assessment Guidance for Superfund (RAGS); Volume I - Human Health Evaluation Manual (Part D, Standardized Planning, Reporting and Review of Superfund Risk Assessments)*. Final. December.

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U.S. Environmental Protection Agency (USEPA). 2009. *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment).* EPA-540-R-070-002. OSWER 9285.7.82. January.

U.S. Environmental Protection Agency (USEPA). 2014. *USEPA's Vapor Intrusion Screening Levels Calculator Version 3.2.* Available online at http://www.epa.gov/oswer/vaporintrusion/guidance.html. May.

U.S. Environmental Protection Agency (USEPA). 2015. Regional Screening Levels for Chemical Contaminants at Superfund Sites. January. Available online at http://www.epa.gov/region9/superfund/prg/.

TABLE B-1
Summary of Human Health Risk Estimates and Chemicals of Concern
Feasibility Study
AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Scenario Time Frame	Receptor Population	Medium	Exposure Medium	Exposure Point	Risks and COCs[a]			
					ELCR	HI[b]	ELCR-Based COCs	HI-Based COCs
Future	Resident	Soil Gas (Passenger Terminal) - All COPCs	Indoor Air	Indoor Air at residences near the Passenger Terminal	6E-06	0.01	None	None
		Soil Gas (Passenger Terminal) - Site-Related COPCs	Indoor Air	Indoor Air at residences near the Passenger Terminal	5E-06	0.01	None	None
		Soil Gas (Aircraft Maintenance Building) - All COPCs	Indoor Air	Indoor Air at residences near the Aircraft Maintenance Building	2E-02	4766	Chloroform, Trichloroethylene	Trichloroethylene
		Soil Gas (Aircraft Maintenance Building) - Site-Related COPCs	Indoor Air	Indoor Air at residences near the Aircraft Maintenance Building	2E-02	4766	Trichloroethylene	Trichloroethylene
		Soil - All COPCs	Soil and Ambient Air	Total Soil (0-8 ft)	3E-03	3	Benz(a)anthracene, benzo(a)pyrene, benzo(a)fluoranthene, dibenz(a,h)anthracene	Arsenic, thallium (effects on skin)
		Soil - Site-Related COPCs	Soil and Ambient Air	Total Soil (0-8 ft)	5E-05	0.6	None	None

Notes
ELCR = Excess Lifetime Cancer Risk
HQ/HI = Hazard Quotient/Hazard Index

[a]Chemicals of Concern (COCs) were identified in the following manner:
Cancer: If the receptor ELCR exceeds 1 × 10-4, COCs were identified as individual chemicals with an ELCR greater than 1 × 10-4 for the environmental medium driving the risk.
Non-Cancer: If a target organ HI exceeds 1, COCs were identified as chemicals with an individual HQ greater than 0.1 contributing to the target organ HI exceeding 1 for the environmental medium driving the risk.
[b]The HI presented in the table is the highest HI associated with any target organ for the receptor/exposure route.

Attachment 1
COPC Screening Tables

ATTACHMENT 1, TABLE 1-1
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Scenario Timeframe: Future
Medium: Soil Gas (Passenger Terminal)
Exposure Medium: Indoor Air (Resident)

Exposure Point	CAS Number	Chemical	Minimum Concentration Qualifier	Maximum Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3)	Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Selection or Deletion (4)
Indoor Air at residences near the Passenger Terminal (Vapor Intrusion via Soil Gas)	71-55-6	1,1,1-Trichloroethane	3.64E-02 J	5.07E+00 J	µg/m3	19SV01	2 / 3	0.232 - 0.232	5.07E+00	NA	5.2E+04 nc	NA	NA	No	BSL
	120-82-1	1,2,4-Trichlorobenzene	1.56E-01 J	1.56E-01 J	µg/m3	19SV02	1 / 3	0.316 - 0.319	1.56E-01	NA	2.1E+01 nc	NA	NA	No	BSL
	95-63-6	1,2,4-Trimethylbenzene	5.40E-01	3.06E+00 J	µg/m3	19SV01	3 / 3	-	3.06E+00	NA	7.3E+01 nc	NA	NA	No	BSL
	95-50-1	1,2-Dichlorobenzene	2.46E-01	2.46E-01	µg/m3	19SV02	1 / 3	0.256 - 0.258	2.46E-01	NA	2.1E+03 nc	NA	NA	No	BSL
	107-06-2	1,2-Dichloroethane	6.83E-02 J	6.83E-02 J	µg/m3	19SV02	1 / 3	0.172 - 0.174	6.83E-02	NA	1.1E+00 ca	NA	NA	No	BSL
	78-87-5	1,2-Dichloropropane	3.67E-02 J	3.67E-02 J	µg/m3	19SV02	1 / 3	0.196 - 0.198	3.67E-02	NA	2.8E+00 ca	NA	NA	No	BSL
	108-67-8	1,3,5-Trimethylbenzene	1.75E-01	1.69E+00 J	µg/m3	19SV01	3 / 3	-	1.69E+00	NA	5.2E+01 nc	NA	NA	No	BSL
	541-73-1	1,3-Dichlorobenzene	4.26E-02 J	4.26E-02 J	µg/m3	19SV02	1 / 3	0.256 - 0.258	4.26E-02	NA	2.6E+00 ca	NA	NA	No	BSL
	106-46-7	1,4-Dichlorobenzene	4.69E-01 J	5.52E-01	µg/m3	19SV02	2 / 3	0.258 - 0.258	5.52E-01	NA	2.6E+00 ca	NA	NA	No	BSL
	71-43-2	Benzene	4.65E-01	3.93E+00 J	µg/m3	19SV01	2 / 3	0.868 - 0.868	3.93E+00	NA	3.6E+00 ca	NA	NA	Yes	ASL
	100-44-7	Benzyl Chloride	2.53E-01	2.53E-01	µg/m3	19SV02	1 / 3	0.22 - 0.222	2.53E-01	NA	5.7E-01 ca	NA	NA	No	BSL
	74-83-9	Bromomethane	1.18E+00 J	5.77E+00 J	µg/m3	19SV02	3 / 3	-	5.77E+00	NA	5.2E+01 nc	NA	NA	No	BSL
	56-23-5	Carbon Tetrachloride	3.28E-01	3.18E+00 J	µg/m3	19SV01	3 / 3	-	3.18E+00	NA	4.7E+00 ca	NA	NA	No	BSL
	108-90-7	Chlorobenzene	9.97E-02 J	9.97E-02 J	µg/m3	19SV02	1 / 3	0.196 - 0.198	9.97E-02	NA	5.2E+02 nc	NA	NA	No	BSL
	75-00-3	Chloroethane	1.34E-01 J	1.06E+00 J	µg/m3	19SV01	2 / 3	0.112 - 0.112	1.06E+00	NA	1.0E+05 nc	NA	NA	No	BSL
	67-66-3	Chloroform	1.08E-01 J	1.79E+00 J	µg/m3	19SV01	3 / 3	-	1.79E+00	NA	1.2E+00 ca	NA	NA	Yes	ASL
	74-87-3	Chloromethane	3.21E-01 J	6.20E-01 J	µg/m3	19SV02	3 / 3	-	6.20E-01	NA	9.4E+02 nc	NA	NA	No	BSL
	156-59-2	Cis-1,2-Dichloroethene	9.11E+00 J	9.11E+00 J	µg/m3	19SV01	1 / 3	0.0879 - 0.169	9.11E+00	NA	NA	NA	NA	No	NTX
	75-71-8	Dichlorodifluoromethane	1.82E+00 J	3.09E+00 J	µg/m3	19SV02	3 / 3	-	3.09E+00	NA	1.0E+03 nc	NA	NA	No	BSL
	100-41-4	Ethylbenzene	4.73E-01	4.09E+00 J	µg/m3	19SV01	3 / 3	-	4.09E+00	NA	1.1E+01 ca	NA	NA	No	BSL
	76-13-1	Freon 113	7.03E-01	2.51E+00 J	µg/m3	19SV01	2 / 3	0.326 - 0.326	2.51E+00	NA	3.1E+05 nc	NA	NA	No	BSL
	87-68-3	Hexachlorobutadiene	5.82E-02 J	5.82E-02 J	µg/m3	19SV02	1 / 3	0.448 - 0.453	5.82E-02	NA	1.3E+00 ca	NA	NA	No	NTX
	1330-20-7	m,p-Xylenes	1.55E+00 J	8.44E+00 J	µg/m3	19SV02	3 / 3	-	8.44E+00	NA	1.0E+03 nc	NA	NA	No	BSL
	75-09-2	Methylene Chloride	2.66E-01	5.27E-01 J	µg/m3	19SV01	3 / 3	-	5.27E-01	NA	1.0E+03 ca	NA	NA	No	BSL
	95-47-6	O-Xylene	7.02E-01	4.18E+00 J	µg/m3	19SV02	3 / 3	-	4.18E+00	NA	1.0E+03 nc	NA	NA	No	BSL
	100-42-5	Styrene	1.14E+00	1.31E+01 J	µg/m3	19SV02	2 / 3	0.183 - 0.183	1.31E+01	NA	1.0E+04 nc	NA	NA	No	BSL
	127-18-4	Tetrachloroethene	1.81E-01	1.35E+00 J	µg/m3	19SV01	3 / 3	-	1.35E+00	NA	1.1E+02 ca	NA	NA	No	BSL
	108-88-3	Toluene	2.05E+00	2.06E+01 J	µg/m3	19SV02	3 / 3	-	2.06E+01	NA	5.2E+04 nc	NA	NA	No	BSL
	79-01-6	Trichloroethene	1.64E-01 J	3.82E+00 J	µg/m3	19SV01	3 / 3	-	3.82E+00	NA	4.8E+00 ca	NA	NA	No	BSL
	75-69-4	Trichlorofluoromethane	1.21E+00 J	1.58E+02 J	µg/m3	19SV02	3 / 3	-	1.58E+02	NA	7.3E+03 nc	NA	NA	No	BSL
	75-01-4	Vinyl Chloride	5.95E+00 J	5.95E+00 J	µg/m3	19SV01	1 / 3	0.0567 - 0.109	5.95E+00	NA	1.7E+00 ca	NA	NA	Yes	ASL

(1) Maximum detected concentration is used for screening.
(2) Background values not available.
(3) Regional Screening Levels for Residential Air (January 2015) based on the USEPA default AF = 0.1 (USEPA, 2004) to account for soil gas to indoor air.
Concentrations based on an ELCR = $1x10^{-6}$ or an HQ = 1.
The SL for 1,2,3-Trimethylbenzene was used as the SL for 1,3,5-Trimethylbenzene.
The SL for 1,4-Dichlorobenzene was used as the SL for 1,3-Dichlorobenzene.
The SL for m-Xylenes was used as the SL for m,p-Xylenes.
(4) Rationale Codes
Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)
No Toxicity value (NTX)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
ca = Carcinogenic
nc = Noncarcinogenic
NA = Not available
SL = Screening Level
AF = Attenuation Factor
ELCR = excess lifetime cancer risk
HQ = Hazard Quotient
J = Analyte was detected, but should be considered an estimated value.
µg/m3 = microgram per cubic meter

ATTACHMENT 1, TABLE 1-2
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Scenario Timeframe: Future
Medium: Soil Gas (Aircraft Maintenance Building)
Exposure Medium: Indoor Air (Resident)

Exposure Point	CAS Number	Chemical	Minimum Concentration Qualifier		Maximum Concentration Qualifier		Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Selection or Deletion (4)
Indoor Air at residences near the Aircraft Maintenance Building (Vapor Intrusion via Soil Gas)	71-55-6	1,1,1-Trichloroethane	2.77E+00	J	6.44E+00	J	µg/m3	18SV03	2 / 3	5.33 - 5.33	6.44E+00	NA	5.2E+04	nc	NA	NA	No	BSL
	95-63-6	1,2,4-Trimethylbenzene	4.45E+00	J	1.51E+01		µg/m3	18SV03	2 / 3	5.55 - 5.55	1.51E+01	NA	7.3E+01	nc	NA	NA	No	BSL
	108-67-8	1,3,5-Trimethylbenzene	8.90E+00		8.90E+00		µg/m3	18SV03	1 / 3	4.8 - 5.55	8.90E+00	NA	5.2E+01	nc	NA	NA	No	BSL
	71-43-2	Benzene	1.27E+00	J	1.27E+00	J	µg/m3	18SV03	1 / 3	3.12 - 3.61	1.27E+00	NA	3.6E+00	ca	NA	NA	No	BSL
	67-66-3	Chloroform	1.94E+00	J	4.01E+02	J	µg/m3	18SV04	4 / 9	3.79 - 124	4.01E+02	NA	1.2E+00	ca	NA	NA	Yes	ASL
	75-71-8	Dichlorodifluoromethane	2.41E+00	J	2.62E+00	J	µg/m3	18SV03	3 / 3	-	2.62E+00	NA	1.0E+03	nc	NA	NA	No	BSL
	100-41-4	Ethylbenzene	1.37E+00	J	3.36E+00	J	µg/m3	18SV03	3 / 3	-	3.36E+00	NA	1.1E+01	ca	NA	NA	No	BSL
	1330-20-7	M,P-Xylenes	5.12E+00	J	8.61E+00	J	µg/m3	18SV03	3 / 3	-	8.61E+00	NA	1.0E+03	nc	NA	NA	No	BSL
	75-09-2	Methylene Chloride	1.48E+00	J	7.42E+00		µg/m3	18SV02	3 / 3	-	7.42E+00	NA	1.0E+03	ca	NA	NA	No	BSL
	95-47-6	O-Xylene	2.16E+00	J	4.11E+00	J	µg/m3	18SV03	3 / 3	-	4.11E+00	NA	1.0E+03	nc	NA	NA	No	BSL
	127-18-4	Tetrachloroethene	4.35E+00	J	2.12E+01		µg/m3	18SV03	2 / 3	6.62 - 6.62	2.12E+01	NA	1.1E+02	ca	NA	NA	No	BSL
	108-88-3	Toluene	1.80E+00	J	8.63E+00		µg/m3	18SV03	3 / 3	-	8.63E+00	NA	5.2E+04	nc	NA	NA	No	BSL
	79-01-6	Trichloroethene	1.44E+02		9.94E+04		µg/m3	18SV04	9 / 9	-	9.94E+04	NA	4.8E+00	ca	NA	NA	Yes	ASL
	75-69-4	Trichlorofluoromethane	3.37E+00	J	1.28E+01		µg/m3	18SV03	2 / 3	5.49 - 5.49	1.28E+01	NA	7.3E+03	nc	NA	NA	No	BSL

(1) Maximum detected concentration is used for screening.
(2) Background values not available.
(3) Regional Screening Levels for Residential Air (January 2015) based on the USEPA default AF = 0.1 (USEPA, 2004) to account for soil gas to indoor air.
Concentrations based on an ELCR = $1x10^{-6}$ or an HQ = 1.
The SL for 1,2,3-Trimethylbenzene was used as the SL for 1,3,5-Trimethylbenzene.
The SL for m-Xylenes was used as the SL for m,p-Xylenes.
(4) Rationale Codes Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
ca = Carcinogenic
nc = Noncarcinogenic
NA = Not available .
SL = Screening Level
AF = Attenuation Factor
ELCR = excess lifetime cancer risk
HQ = Hazard Quotient
J = Analyte was detected, but should be considered an estimated value.
µg/m3 = microgram per cubic meter

ATTACHMENT 1, TABLE 1-3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil and Ambient Air (Resident)

Exposure Point	CAS Number	Chemical	Minimum Concentration Qualifier	Maximum Concentration Qualifier	Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Selection or Deletion (4)
Total Soil (0-8 ft)	7429-90-5	Aluminum	3.1E+03 J	1.4E+04 J	mg/kg	18SB02	16 / 18	0 - 0	1.4E+04	NA	7.7E+03	nc	NA	NA	Yes	ASL
	7440-38-2	Arsenic	5.8E+00 J	4.7E+01 J	mg/kg	18SB03	16 / 18	0 - 0	4.7E+01	NA	6.7E-01	cR	NA	NA	Yes	ASL
	7440-39-3	Barium	5.3E+01	1.5E+02	mg/kg	19SB01	16 / 18	0 - 0	1.5E+02	NA	1.5E+03	nc	NA	NA	No	BSL
	7440-41-7	Beryllium	3.0E-01	6.5E-01	mg/kg	18SB02	5 / 18	0 - 0.63	6.5E-01	NA	1.6E+01	nc	NA	NA	No	BSL
	7440-43-9	Cadmium	5.4E-01 J	1.0E+00 J	mg/kg	17MW02	4 / 14	0 - 0.63	1.0E+00	NA	7.0E+00	nc	NA	NA	No	BSL
	7440-70-2	Calcium	3.0E+03	2.0E+05	mg/kg	19SB02	16 / 18	0 - 0	2.0E+05	NA	NA		NA	NA	No	NUT
	7440-47-3	Chromium	6.2E+00 J	1.8E+01 J	mg/kg	18SB02	16 / 18	0 - 0	1.8E+01	NA	3.0E-01	ca	NA	NA	Yes	ASL
	7440-48-4	Cobalt	6.9E+00 J	2.7E+01 J	mg/kg	18SB03	14 / 18	0 - 5.5	2.7E+01	NA	2.3E+00	nc	NA	NA	Yes	ASL
	7440-50-8	Copper	8.6E+00 J	4.4E+01 J	mg/kg	18SB03	16 / 18	0 - 0	4.4E+01	NA	3.1E+02	nc	NA	NA	No	BSL
	7439-89-6	Iron	6.9E+03 J	3.7E+04	mg/kg	19SB01	16 / 18	0 - 0	3.7E+04	NA	5.5E+03	nc	NA	NA	Yes	ASL
	7439-92-1	Lead	6.6E+00	2.2E+01 J	mg/kg	18SB03	16 / 18	0 - 0	2.2E+01	NA	4.0E+02	L	NA	NA	No	BSL
	7439-95-4	Magnesium	2.2E+03 J	4.7E+04 J	mg/kg	19SB02	16 / 18	0 - 0	4.7E+04	NA	NA		NA	NA	No	NUT
	7439-96-5	Manganese	1.6E+02	1.4E+03 J	mg/kg	17MW02	16 / 18	0 - 0	1.4E+03	NA	1.8E+02	nc	NA	NA	Yes	ASL
	7439-97-6	Mercury	1.9E-02 J	2.5E-02 J	mg/kg	17MW02	4 / 14	0 - 0.13	2.5E-02	NA	2.3E+00	nc	NA	NA	No	BSL
	7440-02-0	Nickel	1.2E+01 J	6.4E+01 J	mg/kg	18SB03	16 / 18	0 - 0	6.4E+01	NA	1.5E+02	nc	NA	NA	No	BSL
	7440-09-7	Potassium	6.1E+02	2.7E+03 J	mg/kg	103SB03	16 / 18	0 - 0	2.7E+03	NA	NA		NA	NA	No	NUT
	7782-49-2	Selenium	6.6E-01	2.6E+00 J	mg/kg	17MW02	3 / 18	0 - 0.99	2.6E+00	NA	3.9E+01	nc	NA	NA	No	BSL
	7440-23-5	Sodium	7.1E+01	7.9E+01	mg/kg	17MW01	4 / 14	0 - 626	7.9E+01	NA	NA		NA	NA	No	NUT
	7440-28-0	Thallium	7.0E-01 J	1.5E+00	mg/kg	103SB03	3 / 14	0 - 1.3	1.5E+00	NA	7.8E-02	nc	NA	NA	Yes	ASL
	7440-62-2	Vanadium	1.3E+01 J	3.5E+01 J	mg/kg	18SB02	16 / 18	0 - 0	3.5E+01	NA	3.9E+01	nc	NA	NA	No	BSL
	7440-66-6	Zinc	2.5E+01 J	1.5E+02 J	mg/kg	18SB03	16 / 18	0 - 0	1.5E+02	NA	2.3E+03	nc	NA	NA	No	BSL
	90-12-0	1-Methylnaphthalene	1.3E-01 J	1.6E-01 J	mg/kg	17SB308	2 / 2	-	1.6E-01	NA	1.7E+01	ca	NA	NA	No	BSL
	91-57-6	2-Methylnaphthalene	9.1E-04 J	2.4E+00 J	mg/kg	17SB02	6 / 20	0 - 0.42	2.4E+00	NA	2.3E+01	nc	NA	NA	No	BSL
	83-32-9	Acenaphthene	3.1E-02	8.9E+00 J	mg/kg	17SB02	5 / 6	0.42 - 0.42	8.9E+00	NA	3.5E+02	nc	NA	NA	No	BSL
	208-96-8	Acenaphthylene	2.9E-02	3.1E-02 J	mg/kg	17SB308	2 / 6	0 - 19	3.1E-02	NA	3.5E+02	nc	NA	NA	No	BSL
	120-12-7	Anthracene	5.6E-02 J	2.2E+01	mg/kg	17SB02	5 / 6	0.42 - 0.42	2.2E+01	NA	1.7E+03	nc	NA	NA	No	BSL
	56-55-3	Benzo(a)Anthracene	4.7E-01	3.2E+01	mg/kg	17SB02	5 / 6	0.42 - 0.42	3.2E+01	NA	1.5E-01	ca	NA	NA	Yes	ASL
	50-32-8	Benzo(a)Pyrene	1.6E-03 J	2.7E+01	mg/kg	17SB02	6 / 20	0 - 0.42	2.7E+01	NA	1.5E-02	ca	NA	NA	Yes	ASL
	205-99-2	Benzo(b)Fluoranthene	6.2E-04 J	3.7E+01	mg/kg	17SB02	10 / 20	0 - 0.42	3.7E+01	NA	1.5E-01	ca	NA	NA	Yes	ASL
	191-24-2	Benzo(g,h,i)Perylene	2.8E-03 J	1.7E+01	mg/kg	17SB02	9 / 20	0 - 0.42	1.7E+01	NA	1.7E+02	nc	NA	NA	No	BSL
	207-08-9	Benzo(k)Fluoranthene	9.1E-04 J	1.4E+01	mg/kg	17SB02	6 / 20	0 - 0.42	1.4E+01	NA	1.5E+00	ca	NA	NA	Yes	ASL
	117-81-7	bis(2-ethylhexyl)phthalate	8.3E-02	1.4E-01	mg/kg	19SB01	2 / 14	0 - 1.2	1.4E-01	NA	3.8E+01	ca	NA	NA	No	BSL
	86-74-8	Carbazole	2.4E-01 J	1.3E+01	mg/kg	17SB02	3 / 4	0.42 - 0.42	1.3E+01	NA	NA		NA	NA	No	NTX
	218-01-9	Chrysene	1.1E-03 J	3.3E+01	mg/kg	17SB02	7 / 20	0 - 0.42	3.3E+01	NA	1.5E+01	ca	NA	NA	Yes	ASL
	53-70-3	Dibenzo(a,h)Anthracene	8.7E-04 J	4.2E+00 J	mg/kg	17SB02	7 / 20	0 - 0.42	4.2E+00	NA	1.5E-02	ca	NA	NA	Yes	ASL
	132-64-9	Dibenzofuran	1.7E-01 J	9.3E+00 J	mg/kg	17SB02	3 / 4	0.42 - 0.42	9.3E+00	NA	7.2E+00	nc	NA	NA	Yes	ASL
	206-44-0	Fluoranthene	7.9E-04 J	9.8E+01	mg/kg	17SB02	7 / 20	0 - 0.42	9.8E+01	NA	2.3E+02	nc	NA	NA	No	BSL
	86-73-7	Fluorene	5.2E-02	1.3E+01	mg/kg	17SB02	5 / 6	0.42 - 0.42	1.3E+01	NA	2.3E+02	nc	NA	NA	No	BSL
	193-39-5	Indeno(1,2,3-cd)Pyrene	2.5E-03 J	1.9E+01	mg/kg	17SB02	6 / 20	0 - 0.42	1.9E+01	NA	1.5E-01	ca	NA	NA	Yes	ASL
	85-01-8	Phenanthrene	9.1E-04 J	1.0E+02	mg/kg	17SB02	6 / 20	0 - 0.42	1.0E+02	NA	1.7E+03	nc	NA	NA	No	BSL
	129-00-0	Pyrene	1.1E-03 J	7.8E+01	mg/kg	17SB02	7 / 20	0 - 0.42	7.8E+01	NA	1.7E+02	nc	NA	NA	No	BSL
	75-35-4	1,1-Dichloroethene	6.8E-02	6.8E-02	mg/kg	19SB307	1 / 23	0 - 0.059	6.8E-02	NA	2.3E+01	nc	NA	NA	No	BSL

ATTACHMENT 1, TABLE 1-3
OCCURRENCE, DISTRIBUTION AND SELECTION OF CHEMICALS OF POTENTIAL CONCERN
AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil and Ambient Air (Resident)

Exposure Point	CAS Number	Chemical	Minimum Concentration Qualifier		Maximum Concentration Qualifier		Units	Location of Maximum Concentration	Detection Frequency	Range of Detection Limits	Concentration Used for Screening (1)	Background Value (2)	Screening Toxicity Value (3)		Potential ARAR/TBC Value	Potential ARAR/TBC Source	COPC Flag	Rationale for Selection or Deletion (4)
	95-63-6	1,2,4-Trimethylbenzene	4.2E-02	J	5.0E+00	J	mg/kg	103SB301	2 / 5	0.025 - 0.025	5.0E+00	NA	5.8E+00	nc	NA	NA	No	BSL
	108-67-8	1,3,5-Trimethylbenzene	1.1E-03	J	3.4E-02	J	mg/kg	19SB307	2 / 7	0.0016 - 0.025	3.4E-02	NA	7.8E+01	nc	NA	NA	No	BSL
	78-93-3	2-Butanone	1.1E-03	J,S	5.5E-02		mg/kg	18SB02	4 / 23	0 - 0.25	5.5E-02	NA	2.7E+03	nc	NA	NA	No	BSL
	67-64-1	Acetone	3.5E-03		2.4E+01		mg/kg	18SB01	9 / 23	0 - 0.29	2.4E+01	NA	6.1E+03	nc	NA	NA	No	BSL
	75-15-0	Carbon Disulfide	2.5E-02	J	2.5E-02	J	mg/kg	17MW04	1 / 19	0 - 0.059	2.5E-02	NA	7.7E+01	nc	NA	NA	No	BSL
	74-87-3	Chloromethane	3.4E-02	J	1.5E-01	J	mg/kg	103SB301	2 / 19	0 - 0.12	1.5E-01	NA	1.1E+01	nc	NA	NA	No	BSL
	156-59-2	cis-1,2-Dichloroethene	1.5E-03		4.1E+01		mg/kg	19SB307	8 / 23	0 - 0.025	4.1E+01	NA	1.6E+01	nc	NA	NA	Yes	ASL
	100-41-4	Ethylbenzene	8.8E-03	J	2.1E-01	J	mg/kg	17MW04	5 / 23	0 - 0.059	2.1E-01	NA	5.8E+00	ca	NA	NA	No	BSL
	98-82-8	Isopropylbenzene	1.1E-02	J	2.2E+00	J	mg/kg	103SB301	2 / 9	0.0016 - 0.025	2.2E+00	NA	1.9E+02	nc	NA	NA	No	BSL
	75-09-2	Methylene Chloride	6.7E-04		2.7E-02		mg/kg	103SB01	13 / 23	0 - 0.063	2.7E-02	NA	3.5E+01	nc	NA	NA	No	BSL
	91-20-3	Naphthalene	3.5E-04	J	7.0E+00	J	mg/kg	17SB02	7 / 24	0 - 0.42	7.0E+00	NA	3.8E+00	ca	NA	NA	Yes	ASL
	104-51-8	n-Butylbenzene	4.1E-02	J	1.0E+01		mg/kg	103SB301	2 / 5	0.025 - 0.025	1.0E+01	NA	1.1E+02	sat	NA	NA	No	BSL
	103-65-1	n-Propylbenzene	1.2E-02	J	4.8E+00	J	mg/kg	103SB301	2 / 9	0.0016 - 0.025	4.8E+00	NA	2.6E+02	sat	NA	NA	No	BSL
	95-47-6	o-Xylene	1.9E-03	J	2.1E-02	J	mg/kg	103SB301	5 / 9	0.0016 - 0.025	2.1E-02	NA	6.5E+01	nc	NA	NA	No	BSL
	99-87-6	p-Isopropyltoluene	3.1E-02	J	5.6E-01	J	mg/kg	103SB301	2 / 9	0.0016 - 0.025	5.6E-01	NA	1.9E+02	nc	NA	NA	No	BSL
	135-98-8	sec-Butylbenzene	1.9E-02	J	7.7E+00	J	mg/kg	103SB301	3 / 5	0.025 - 0.025	7.7E+00	NA	1.5E+02	sat	NA	NA	No	BSL
	100-42-5	Styrene	4.6E-04		4.6E-04		mg/kg	19SB02	1 / 9	0.0055 - 0.025	4.6E-04	NA	6.0E+02	nc	NA	NA	No	BSL
	98-06-6	tert-Butylbenzene	2.1E-02	J	1.9E-01	J	mg/kg	103SB301	2 / 5	0.021 - 0.025	1.9E-01	NA	1.8E+02	sat	NA	NA	No	BSL
	108-88-3	Toluene	1.1E-03		3.4E-02	J	mg/kg	19SB307	10 / 23	0 - 0.059	3.4E-02	NA	4.9E+02	nc	NA	NA	No	BSL
	156-60-5	trans-1,2-Dichloroethene	2.2E-02	J	4.1E-01		mg/kg	19SB307	3 / 23	0 - 0.059	4.1E-01	NA	1.6E+02	nc	NA	NA	No	BSL
	79-01-6	Trichloroethene	6.1E-04		1.1E+00	J	mg/kg	103SB01	5 / 23	0 - 0.025	1.1E+00	NA	4.1E-01	nc	NA	NA	Yes	ASL
	75-01-4	Vinyl Chloride	1.7E-02	J	3.1E+00		mg/kg	19SB307	2 / 23	0 - 0.12	3.1E+00	NA	5.9E-02	ca	NA	NA	Yes	ASL
	XYLENE	Xylenes, Total	9.9E-04	J	2.2E-03		mg/kg	103SB02	6 / 18	0 - 0.059	2.2E-03	NA	5.8E+01	nc	NA	NA	No	BSL

(1) Maximum detected concentration is used for screening.
(2) Background values not available.
(3) Regional Screening Levels for Residential Soil (January 2015) based on an ELCR = $1x10^{-6}$ or an HQ = 0.1.

The SL for Acenaphthene was used as the SL for Acenaphthylene.
The SL for Pyrene was used as the SL for Benzo(g,h,i)perylene.
The SL for Anthracene was used as the SL for Phenanthrene.
The SL for Isopropylbenzene was used as the SL for p-Isopropyltoluene.
The SL for Chromium(VI) was used as the SL for Chromium.
The SL for Mercuric Chloride was used as the SL for Mercury.

(4) Rationale Codes: Selection Reason: Above Screening Levels (ASL)
Deletion Reason: Below Screening Level (BSL)
No Toxicity Information (NTX)
Essential Nutrient (NUT)

COPC = Chemical of Potential Concern
ARAR/TBC = Applicable or Relevant and Appropriate Requirement/ To Be Considered
c = Carcinogenic
n = Noncarcinogenic
L = Adult lead model
R = Relative bioavailability incorporated
sat = Soil saturation

NA = Not available
SL = Screening Level
ELCR = excess lifetime cancer risk
HQ = Hazard Quotient

J = Analyte was detected, but should be considered an estimated value.

Units: mg/kg = milligram per kilogram

ATTACHMENT 1, TABLE 1-4

OSWER VAPOR INTRUSION ASSESSMENT (RESIDENT - TERMINAL), ALL CHEMICALS OF POTENTIAL CONCERN (COPCs)

Sub-slab or Exterior Soil Gas Concentration to Indoor Air Concentration (SGC-IAC) Calculator Version 3.3.1, May 2014 RSLs

AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR_SG	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ_SG	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)

CAS	Chemical Name	Site Sub-slab or Exterior Soil Gas Concentration	Calculated Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard	Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
		Csg	Cia	CR	HQ	IUR		RfC		
		(ug/m^3)	(ug/m^3)			(ug/m^3)$^{-1}$		(mg/m^3)		i
71-43-2	Benzene	3.9E+00	3.93E-01	**1.1E-06**	1.3E-02	7.80E-06	I	3.00E-02	I	
67-66-3	Chloroform	1.8E+00	1.79E-01	**1.5E-06**	1.8E-03	2.30E-05	I	9.80E-02	A	
75-01-4	Vinyl Chloride	6.0E+00	5.95E-01	**3.6E-06**	5.7E-03	4.40E-06	I	1.00E-01	I	VC

ATTACHMENT 1, TABLE 1-5

OSWER VAPOR INTRUSION ASSESSMENT (RESIDENT - TERMINAL), SITE-RELATED CHEMICALS OF POTENTIAL CONCERN (COPCs)

Sub-slab or Exterior Soil Gas Concentration to Indoor Air Concentration (SGC-IAC) Calculator Version 3.3.1, May 2014 RSLs

AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR_SG	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ_SG	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)

CAS	Chemical Name	Site Sub-slab or Exterior Soil Gas Concentration	Calculated Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Csg	Cia	CR	HQ
		(ug/m^3)	(ug/m^3)		
71-43-2	Benzene	3.9E+00	3.93E-01	**1.1E-06**	1.3E-02
75-01-4	Vinyl Chloride	6.0E+00	5.95E-01	**3.6E-06**	5.7E-03

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
7.80E-06	I	3.00E-02	I	
4.40E-06	I	1.00E-01	I	VC

ATTACHMENT 1, TABLE 1-6

OSWER VAPOR INTRUSION ASSESSMENT (RESIDENT - HANGAR), ALL CHEMICALS OF POTENTIAL CONCERN (COPCs)

Sub-slab or Exterior Soil Gas Concentration to Indoor Air Concentration (SGC-IAC) Calculator Version 3.3.1, May 2014 RSLs

AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR_SG	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ_SG	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)

CAS	Chemical Name	Site Sub-slab or Exterior Soil Gas Concentration	Calculated Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Csg	Cia	CR	HQ
		(ug/m^3)	(ug/m^3)		
67-66-3	Chloroform	4.0E+02	4.01E+01	**3.3E-04**	3.9E-01
79-01-6	Trichloroethylene	9.9E+04	9.94E+03	**2.1E-02**	**4.8E+03**

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
2.30E-05	I	9.80E-02	A	
see note	I	2.00E-03	I	TCE

ATTACHMENT 1, TABLE 1-7

OSWER VAPOR INTRUSION ASSESSMENT (RESIDENT - HANGAR), SITE-RELATED CHEMICALS OF POTENTIAL CONCERN (COPCs)

Sub-slab or Exterior Soil Gas Concentration to Indoor Air Concentration (SGC-IAC) Calculator Version 3.3.1, May 2014 RSLs

AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR_SG	1.00E-06	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ_SG	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)

CAS	Chemical Name	Site Sub-slab or Exterior Soil Gas Concentration	Calculated Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Csg	Cia	CR	HQ
		(ug/m^3)	(ug/m^3)		
79-01-6	Trichloroethylene	9.9E+04	9.94E+03	**2.1E-02**	**4.8E+03**

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
see note	I	2.00E-03	I	TCE

ATTACHMENT 1, TABLE 1-8

Resident Risk for Soil for all Chemicals of Potential Concerns (COPCs)

AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Chemical	Ingestion SF (mg/kg-day)$^{-1}$	SFO Ref	Inhalation Unit Risk (ug/m^3)$^{-1}$	IUR Ref	Chronic RfD (mg/kg-day)	Chronic RfD Ref	Chronic RfC (mg/m^3)	Chronic RfC Ref	GIABS	ABS	RBA	Volatilization Factor (m^3/kg)	Soil Saturation Concentration (mg/kg)	Particulate Emission Factor (m^3/kg)	Concentration (mg/kg)	Ingestion Risk TR=1.0E-6	Dermal Risk TR=1.0E-6	Inhalation Risk TR=1.0E-6	Carcinogenic Risk TR=1.0E-6	Ingestion Risk Child HQ=1	Dermal Risk Child HQ=1	Inhalation Risk Child HQ=1	Noncarcinogenic Risk Child HI=1	Ingestion Risk Adult HQ=1	Dermal Risk Adult HQ=1	Inhalation Risk Adult HQ=1	Noncarcinogenic Risk Adult HI=1
Aluminum	-		-		1.00E+00	P	5.00E-03	P	1	-	1	-	-	1.36E+09	14300	-	-	-	-	0.183	-	0.00202	0.185	0.0171	-	0.00202	0.0192
Arsenic, Inorganic	1.50E+00	I	4.30E-03	I	3.00E-04	I	1.50E-05	C	1	0.03	0.6	-	-	1.36E+09	46.9	0.0000607	0.00000927	5.28E-08	0.00007	1.2	0.161	0.00221	1.36	0.112	0.0237	0.00221	0.138
Benz[a]anthracene	7.30E-01	W	1.10E-04	C	-		-		1	0.13	1	-	-	1.36E+09	32	0.000153	0.0000565	2.55E-09	0.000209	-	-	-	-	-	-	-	-
Benzo[a]pyrene	7.30E+00	I	1.10E-03	C	-		-		1	0.13	1	-	-	1.36E+09	27	0.00129	0.000477	2.16E-08	0.00176	-	-	-	-	-	-	-	-
Benzo[b]fluoranthene	7.30E-01	W	1.10E-04	C	-		-		1	0.13	1	-	-	1.36E+09	37	0.000176	0.0000654	2.95E-09	0.000242	-	-	-	-	-	-	-	-
Benzo[k]fluoranthene	7.30E-02	W	1.10E-04	C	-		-		1	0.13	1	-	-	1.36E+09	14	0.00000667	0.00000247	1.12E-09	0.00000915	-	-	-	-	-	-	-	-
Chromium(III), Insoluble Salts	-		-		1.50E+00	I	-		0.013	-	1	-	-	1.36E+09	18.2	-	-	-	-	0.000155	-	-	0.000155	0.0000145	-	-	0.0000145
Chrysene	7.30E-03	W	1.10E-05	C	-		-		1	0.13	1	-	-	1.36E+09	33	0.00000157	0.000000583	2.63E-10	0.00000216	-	-	-	-	-	-	-	-
Cobalt	-		9.00E-03	P	3.00E-04	P	6.00E-06	P	1	-	1	-	-	1.36E+09	26.9	-	-	6.34E-08	6.34E-08	1.15	-	0.00316	1.15	0.107	-	0.00316	0.111
Dibenz[a,h]anthracene	7.30E+00	W	1.20E-03	C	-		-		1	0.13	1	-	-	1.36E+09	4.2	0.0002	0.0000742	3.66E-09	0.000274	-	-	-	-	-	-	-	-
Dibenzofuran	-		-		1.00E-03	S	-		1	0.03	1	1.96E+05	-	1.36E+09	9.3	-	-	-	-	0.119	0.0096	-	0.128	0.0111	0.00141	-	0.0126
Dichloroethylene, 1,2-cis-	-		-		2.00E-03	I	-		1	-	1	2.50E+03	2.37E+03	1.36E+09	41	-	-	-	-	0.262	-	-	0.262	0.0246	-	-	0.0246
Indeno[1,2,3-cd]pyrene	7.30E-01	W	1.10E-04	C	-		-		1	0.13	1	-	-	1.36E+09	19	0.0000906	0.0000336	1.52E-09	0.000124	-	-	-	-	-	-	-	-
Iron	-		-		7.00E-01	P	-		1	-	1	-	-	1.36E+09	37100	-	-	-	-	0.678	-	-	0.678	0.0635	-	-	0.0635
Manganese (Non-diet)	-		-		2.40E-02	S	5.00E-05	I	0.04	-	1	-	-	1.36E+09	1440	-	-	-	-	0.767	-	0.0203	0.787	0.0719	-	0.0203	0.0922
Naphthalene	-		3.40E-05	C	2.00E-02	I	3.00E-03	I	1	0.13	1	4.63E+04	-	1.36E+09	7	-	-	0.00000183	0.00000183	0.00447	0.00156	0.0483	0.0543	0.00042	0.00023	0.0483	0.0489
Thallium (Soluble Salts)	-		-		1.00E-05	S	-		1	-	1	-	-	1.36E+09	1.5	-	-	-	-	1.92	-	-	1.92	0.18	-	-	0.18
Trichloroethylene	4.60E-02	I	4.10E-06	I	5.00E-04	I	2.00E-03	I	1	-	1	2.21E+03	6.92E+02	1.36E+09	1.1	0.000000125	-	0.00000104	0.00000117	0.0281	-	0.239	0.267	0.00264	-	0.239	0.241
Vinyl Chloride	7.20E-01	I	4.40E-06	I	3.00E-03	I	1.00E-01	I	1	-	1	9.56E+02	3.92E+03	1.36E+09	3.1	0.000033	-	0.0000194	0.0000523	0.0132	-	0.0311	0.0443	0.00124	-	0.0311	0.0323
**Total Risk/HI*	-		-		-		-		-	-	-	-	-	-	-	*2.E-03*	*7.E-04*	*2.E-05*	*3.E-03*	*6*	*0.2*	*0.3*	*7*	*0.6*	*0.03*	*0.3*	*1.0*

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ATTACHMENT 1, TABLE 1-9

Resident Risk for Soil for all Site-Related Chemicals of Potential Concerns (COPCs)

AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Chemical	Ingestion SF (mg/kg-day)$^{-1}$	SFO Ref	Inhalation Unit Risk (ug/m^3)$^{-1}$	IUR Ref	Chronic RfD (mg/kg-day)	Chronic RfD Ref	Chronic RfC (mg/m^3)	Chronic RfC Ref	GIABS	ABS	RBA	Volatilization Factor (m^3/kg)	Soil Saturation Concentration (mg/kg)	Particulate Emission Factor (m^3/kg)	Concentration (mg/kg)	Ingestion Risk TR=1.0E-6	Dermal Risk TR=1.0E-6	Inhalation Risk TR=1.0E-6	Carcinogenic Risk TR=1.0E-6	Ingestion Risk Child HQ=1	Dermal Risk Child HQ=1	Inhalation Risk Child HQ=1	Noncarcinogenic Risk Child HI=1	Ingestion Risk Adult HQ=1	Dermal Risk Adult HQ=1	Inhalation Risk Adult HQ=1	Noncarcinogenic Risk Adult HI=1
Dichloroethylene, 1,2-cis-	-		-		2.00E-03	I	-		1	-	1	2.50E+03	2.37E+03	1.36E+09	41	-	-	-	-	0.262	-	-	0.262	0.0246	-	-	0.0246
Trichloroethylene	4.60E-02	I	4.10E-06	I	5.00E-04	I	2.00E-03	I	1	-	1	2.21E+03	6.92E+02	1.36E+09	1.1	0.000000125	-	0.00000104	0.00000117	0.0281	-	0.239	0.267	0.00264	-	0.239	0.241
Vinyl Chloride	7.20E-01	I	4.40E-06	I	3.00E-03	I	1.00E-01	I	1	-	1	9.56E+02	3.92E+03	1.36E+09	3.1	0.000033	-	0.0000194	0.0000523	0.0132	-	0.0311	0.0443	0.00124	-	0.0311	0.0323
**Total Risk/HI*	-		-		-		-		-	-	-	-	-	-	-	*3.E-05*	-	*2.E-05*	*5.E-05*	*3.E-01*	-	*3.E-01*	*6.E-01*	*3.E-02*	-	*3.E-01*	*3.E-01*

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Appendix C
Cost Estimates for Remedial Alternatives

APPENDIX C—COST ESTIMATES

Summary of Cost Analysis

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Alternatives		Alternative 1 No Action	Alternative 2 Sealing and Monitoring			Alternative 3 Active Subslab Depressurization			Alternative 4 Enhanced Biodegradation and Soil Vapor Extraction		
Alternative Evaluation Timeframe		0 years	30 years			30 years			10 years		
			-30%	**Estimate**	*+50%*	*-30%*	**Estimate**	*+50%*	*-30%*	**Estimate**	*+50%*
Total Implementation Costs		**$0**	*$140,000*	$200,000	*$300,000*	*$582,000*	$831,000	*$1,247,000*	*$1,271,000*	$1,815,000	*$2,723,000*
Present Value of Future Costs	Discount Rate of 1.4% (OMB, 2014)	**$0**	*$270,000*	$385,000	*$578,000*	*$1,341,000*	$1,915,000	*$2,873,000*	*$2,519,000*	$3,598,000	*$5,397,000*
Grand Total Present Value	**Discount Rate of 1.4% (OMB, 2014)**	**$0**	***$410,000***	**$585,000**	***$878,000***	***$1,923,000***	**$2,746,000**	***$4,120,000***	***$3,790,000***	**$5,413,000**	***$8,120,000***

Notes and References:

● The "Real" Discount Rate used to calculate the Present Value cost is 1.4% for a timeframe of 30 years per the Office of Management and Budget (OMB), Circular A-94, Appendix C, Revised December 2014, "Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis" for Calendar Year 2014

The Real Discount Rates are a forecast of real interest rates from which the inflation premium has been removed and based on the economic assumptions from the December 2014 Budget Baseline. These real rates are to be used for discounting constant-dollar flows, as is often required in cost-effectiveness analysis.

● USEPA. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* . OSWER Directive 9355.3-01. EPA/540/G-89/004. October.

● USEPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* . With the U.S. Army Corps of Engineers. OSWER 9355.0-75. EPA 540-R-00-002. July

● The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during the Remedial Design phase. This is a Class 4 order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost (per USEPA 1988 and 2000).

TABLE C-1

Cost Estimate for Alternative 1—No Action

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

No Action

Cost =	**$0**

TABLE C-2
Cost Estimate for Alternative 2—Monitoring
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
IMPLEMENTATION COST					
Work Plan for Indoor Air Monitoring					
Work Plan for semi-annual sampling for Year 1 and 2 and 5-Year Review Sampling	1	each	$25,000	$25,000	Pre-Draft, Draft, Draft Final, & Final. Includes Scoping sessions. Recent similar project.
HAPSITE Investigation					
Labor, ODCs, travel	1	each	$32,500	$32,500	Pricing per recent project similar in nature
Report	1	each	$15,000	$15,000	Report to include Sealing work
Entry Point Sealing					
Equipment and Subcontractor					
Mobilization and Site Setup	1	LS	$5,000	$5,000	Pricing per recent project similar in nature
Labor - 3-man Crew	50	Hours	$200	$10,000	Average Labor Rate for 3 person crew -$200/hr; 5 days, 10-hr days
Elastomeric Polymer	100	Tube	$8	$800	Per recent vendor estimate
Misc Materials	1	LS	$2,000	$2,000	Based on historical pricing
Travel and Per Diem	15	day	$162	$2,430	Lodging and Per diem of $162/day/person
Vehicles for crew (2)	5	day	$250	$1,250	Vehicles for Crew (2 each @ $125/day with fuel)
Subtotal				***$93,980***	
Contingency	*25%*			*$23,495*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$117,475***	
Project Management	*10%*			*$11,748*	*USEPA 2000, Exhibit 5-8 on p.5-13, <$100k*
Remedial Design	*20%*			*$23,495*	*USEPA 2000, Exhibit 5-8 on p.5-13, <$100k*
Construction Management	*15%*			*$17,621*	*USEPA 2000, Exhibit 5-8 on p.5-13, <$100k*
Overhead	*15%*			*$17,621*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$11,748*	*USEPA 2000, Exhibit 5-3 on p.5-8*
			Total Implementation Cost	**$199,708**	
FUTURE COSTS (30 years)					
5-Year Reviews (Years 5, 10, 15, 20, 25, and 30)					
5-Year Review - Includes LUC Inspections	6	each	$14,000	$84,000	5YR review conducted once every 5 years. Includes pre-draft, draft, draft final, final, fact sheet, and public notices.
Subtotal				***$84,000***	
Contingency	*25%*			*$21,000*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$105,000***	
Project Management	*8%*			*$8,400*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$15,750*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$15,750*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$10,500*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal				***$155,400***	
Subtotal Annual Cost (at Years 5, 10… and 30)			**$25,900**		Calculated from future costs/6 total years
Subtotal Future Cost				**$155,400**	
Present Value *(1.4%)* ***of Future Cost of 5YRs***	*30*	*year*	*1.4%*	***$122,699***	
Air Monitoring					
Months 6, 12, 18, and 24					Semi-Annual Sampling for first 2 years
Labor, ODCs, Travel	4	event	$8,000	$32,000	6 IA samples, 6 subslab samples, 1 OA samples
Lab & Data Validation	4	each	$5,039	$20,155	See lab & DV backup sheets
Equipment	4	event	$3,600	$14,400	Based on recent project similar in nature.
Report	4	each	$8,000	$32,000	Based on historical pricing
Subtotal				***$98,555***	
Contingency	*25%*			*$24,639*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$123,193***	
Project Management	*8%*			*$9,855*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$18,479*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$18,479*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$12,319*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$91,163.04***		Calculated from future costs/2 total years
Subtotal Future Cost				***$182,326***	
Present Value *(1.4%)* ***of Future Cost of Air Sampling Years 1-2***			*1.4%*	***$178,567***	

TABLE C-2

Cost Estimate for Alternative 2—Monitoring

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
Air Monitoring					
Years 5 and 10					1 Sample Event every 5 years
Labor, ODCs, Travel	2	event	$8,000	$16,000	6 IA samples, 6 subslab samples, 1 OA samples
Lab & Data Validation	2	each	$5,039	$10,077	See lab & DV backup sheets
Equipment	2	event	$3,600	$7,200	Based on recent project similar in nature.
Report	2	each	$8,000	$16,000	Based on historical pricing.
Subtotal				***$49,277***	
Contingency	*25%*			*$12,319*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$61,597***	
Project Management	*10%*			*$6,160*	*USEPA 2000, Exhibit 5-8 on p.5-13, <$100k*
Technical Support	*15%*			*$9,239*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$9,239*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$6,160*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost (at Years 5 and 10)			***$46,197.49***	***$92,395***	Calculated from future costs/2 total years
Subtotal Future Cost				***$92,395***	
Present Value *(1.4%)* ***of Future Cost of Air Sampling Years 5-10***			*1.4%*	***$83,296***	
Total Present Value of Future Costs			**1.4%**	**$384,563**	Y2015 PV calculated for 30-yrs-future-cost using 1.4% Real Discount Rate per Office of Management and Budget (2014).

Other Notes and References:

● The "Real" Discount Rate used to calculate the Present Value cost is 1.4% for a timeframe of 30 years per the Office of Management and Budget (OMB), Circular A-94, Appendix C, Revised December 2014, "Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis" for Calendar Year 2015.

● USEPA. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. OSWER Directive 9355.3-01. EPA/540/G-89/004. October.

● USEPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. With the U.S. Army Corps of Engineers. OSWER 9355.0-75. EPA 540-R-00-002. July.

● The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during Baseline Sampling and the Remedial Design phase. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost (per USEPA 1988 and 2000).

TABLE C-3

Cost Estimate for Alternative 3—Active Depressurization

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
IMPLEMENTATION COST					
UFP-SAP & Remedial Action Work Plan					
Diagnostic Testing Plan and Remedial Action Work Plan	1	each	$60,000	$60,000	Pre-Draft, Draft, Draft Final, & Final. Includes Scoping sessions. Recent similar project.
Diagnostic Testing					
Labor	100	Hours	$200	$20,000	2 people, 5, 10-hr days including travel; Average labor rate $200
Misc Materials	1	LS	$6,000	$6,000	Based on Historical pricing
Travel and Per Diem	10	day	$162	$1,620	Lodging and Per diem of $162/day/person
HAPSITE Investigation					
Labor, ODCs, Travel	1	each	$32,500	$32,500	Pricing per recent project similar in nature.
Entry Point Sealing					
Equipment and Subcontractor					
Mobilization and Site Setup	1	LS	$5,000	$5,000	Pricing per recent project similar in nature.
Labor - 3-man Crew	50	Hours	$200	$10,000	Average Labor Rate for 3 man crew -$200/hr; 5 days, 10-hr days
Elastomeric Polymer	100	Tube	$8	$800	Per recent vendor estimate
Misc Materials	1	LS	$2,000	$2,000	Based on historical pricing
Travel and Per Diem	15	day	$162	$2,430	Lodging and Per diem of $162/day/person
Vehicles for crew (2)	5	day	$250	$1,250	Vehicles for Crew (2 each @ $125/day with fuel)
Active Depressurization System Installation					
Equipment and Subcontractor					
Mobilization and Site Setup	1	LS	$15,000	$15,000	Pricing per recent project similar in nature.
Utility Location	1	LS	$4,500	$4,500	Engineer's Estimate
Drilling for Soil Gas Collection Points	40	each	$3,000	$120,000	Installed Horizontally every 20 feet beneath offices. No depressurization in bay area.
Blower	2	LS	$4,500	$9,000	Based on historical pricing
Blower Installation	2	LS	$5,000	$10,000	Includes mounting and electrical connections
Bollard Installation	12	each	$800	$9,600	Based on historical pricing
Piping Installation	1,000	LF	$65	$65,000	Pricing per recent project similar in nature.
Travel and Per Diem	45	day	$162	$7,290	3-man crew for 15 days
Vehicles for crew (2)	15	day	$250	$3,750	Vehicles for Crew (2 each @ $125/day with fuel)
Electrical - Installation of meter	1	LS	$4,650	$4,650	RSMeans #26-27-13.10 (3670)
Construction Report	1	each	$50,000	$50,000	Draft and Final Construction Completion Report
Subtotal				***$440,390***	
Contingency	*25%*			*$110,098*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$550,488***	
Project Management	*6%*			*$33,029*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Remedial Design	*12%*			*$66,059*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Construction Management	*8%*			*$44,039*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Overhead	*15%*			*$82,573*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$55,049*	*USEPA 2000, Exhibit 5-3 on p.5-8*
			Total Implementation Cost	**$831,236**	
5-Year Reviews (Years 5, 10, 15, 20, 25, and 30)					
5-Year Review - Includes LUC Inspections	6	each	$14,000	$84,000	5YR review conducted once every 5 years. Includes pre-draft, draft, draft final, final, fact sheet, and public notices.
Subtotal				***$84,000***	
Contingency	*25%*			*$21,000*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$105,000***	
Project Management	*8%*			*$8,400*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$15,750*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$15,750*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$10,500*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal				***$155,400***	
Subtotal Annual Cost (at Years 5, 10… and 30)			**$25,900**		Calculated from future costs/6 total years
Subtotal Future Cost				**$155,400**	
Present Value *(1.4%)* ***of Future Cost of 5YRs***	*30*	*year*	*1.4%*	***$122,699***	

TABLE C-3
Cost Estimate for Alternative 3—Active Depressurization
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
Air Monitoring					
Months 6, 12, 18, and 24					Semi-Annual Sampling for first 2 years
Labor, ODCs, Travel	4	event	$8,000	$32,000	6 IA samples, 6 subslab samples, 1 OA samples
Lab & Data Validation	4	each	$5,039	$20,155	See lab & DV backup sheets
Equipment	4	event	$3,600	$14,400	Based on recent project similar in nature.
Report	4	each	$8,000	$32,000	Based on historical pricing
Subtotal				***$98,555***	
Contingency	*25%*			*$24,639*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$123,193***	
Project Management	*8%*			*$9,855*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$18,479*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$18,479*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$12,319*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$91,163.04***		Calculated from future costs/2 total years
Subtotal Future Cost				***$182,326***	
Present Value *(1.4%)* ***of Future Cost of Air Sampling Years 1-2***			*1.4%*	***$178,567***	
Quarterly O&M					Years 1 to 30; The overall power draw is expected to be small compared to the overall building power requirements.
Labor, ODCs, Travel	120	event	$6,000	$720,000	Equipment Inspection, Differential Pressure Measurements
Report	30	each	$7,000	$210,000	Annual Report
Electrical - Electricity use for SSDS System (per year/30 years)	1,200,000	kwh	$0.10	$120,000	Based on recent electrical quote for similar project
Subtotal				***$1,050,000***	
Contingency	*25%*			*$262,500*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$1,312,500***	
Project Management	*8%*			*$105,000*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$196,875*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$196,875*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$131,250*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$64,750.00***		Calculated from future costs-no blower/30 total years
Subtotal Future Cost - No Blower Replacement				***$1,942,500***	
Equipment	6	event	$6,000	$36,000	Includes Blower replacement 1 every 5 Years
Subtotal Future Cost				***$1,978,500***	
Present Value *(1.4%)* ***of Future Cost of Quarterly O&M Years 1-30***			*1.4%*	***$1,613,293.88***	*Blower Replacement not Discounted*
Total Present Value of All Future Costs			**1.4%**	**$1,914,561**	Y2015 PV calculated for 30-yrs-future-cost using 1.4% Real Discount Rate per Office of Management and Budget (2014).

Other Notes and References:

● The "Real" Discount Rate used to calculate the Present Value cost is 1.4% for a timeframe of 30 years per the Office of Management and Budget (OMB), Circular A-94, Appendix C, Revised December 2014, "Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis" for Calendar Year 2015.

● USEPA. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. OSWER Directive 9355.3-01. EPA/540/G-89/004. October.

● USEPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. With the U.S. Army Corps of Engineers. OSWER 9355.0-75. EPA 540-R-00-002. July.

● The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during Baseline Sampling and the Remedial Design phase. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost (per USEPA 1988 and 2000).

TABLE C-4
Cost Estimate for Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Assumptions:
(1) Two blind-end horizontal directional drilled SVE wells installed to an approximate depth of 6 feet bgs. Each well is 300 feet long with 180 feet of slotted pipe
(2) Vapor extraction via horizontal, directionally drilled well (4-inch HDPE) and SVE blower mounted in enclosed trailer, with exterior mounted vapor phase granular activated carbon (VGAC). Target flow rate is 0.5 CFM per linear foot of slotted pipe, or 90 cfm per well (180 cfm total).

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
UFP-SAP & Remedial Action Work Plan					
Diagnostic Testing Plan and Remedial Action Work Plan	1	each	$100,000	$100,000	Pre-Draft, Draft, Draft Final, & Final. Includes Scoping sessions. Recent similar project and professional judgement. Includes permitting, QMP, and HASP.
HAPSITE Investigation					Same as Alternative 2
Labor, ODCs, Travel	1	each	$32,500	$32,500	Pricing per recent project similar in nature.
Report	1	each	$15,000	$15,000	Report to include Sealing work
Entry Point Sealing					Same as Alternative 2
Equipment and Subcontractor					
Mobilization and Site Setup	1	LS	$5,000	$5,000	Pricing per recent project similar in nature.
Labor - 3-man Crew	50	Hours	$200	$10,000	Average Labor Rate for 3 man crew -$200/hr; 5 days, 10-hr days
Elastomeric Polymer	100	Tube	$8	$800	Pricing per recent vendor estimate
Misc Materials	1	LS	$2,000	$2,000	Based on historical pricing
Travel and Per Diem	15	day	$162	$2,430	Lodging and Per diem of $162/day/person
Utility Location	1	LS	$4,500	$4,500	Engineer's Estimate
Monitoring Well Installation					4 new monitoring wells
Drilling Mobilization	1	LS	$900	$900	TTL Assoc estimate from RI
Coring	4	EA	$90	$360	TTL Assoc estimate from RI
Continuous soil samples (soil boring logging)	60	LF	$19	$1,140	TTL Assoc estimate from RI; 4 wells
Drill/Install monitoring wells to 15 ft bgs (including all materials)	60	LF	$38	$2,280	TTL Assoc estimate from RI; 4 wells
Decon	1	LS	$600	$600	TTL Assoc estimate from RI
Drums	8	Ea	$40	$320	TTL Assoc estimate from RI
IDW Management	1	LS	$1,000	$1,000	TTL Assoc estimate from RI
Well Development	4	EA	$255	$1,020	TTL Assoc estimate from RI
Engineer/Geologist	60	Hours	$100	$6,000	Engineer's Estimate
Travel and Per Diem	6	day	$162	$972	Engineer/Geologist oversight
Vehicle for crew (1)	6	Day	$125	$750	Vehicle for Crew (1 each @ $125/day with fuel)
Survey	1	LS	$2,600	$2,600	Luis G. Riancho & Associates, Inc. estimate from RI
Baseline Groundwater and Soil Gas Monitoring Event					19 monitoring wells; 9 soil gas points
Engineer/Geologist, 2-person crew, 5 days	100	Hours	$100	$10,000	Engineer's Estimate
Travel and Per Diem, 2-person crew, 5 days	10	day	$162	$1,620	Engineer/Geologist oversight
Field Equipment (includes installation of new gas probes)	1	LS	$2,000	$2,000	Engineer's Estimate
Vehicle rental and fuel	5	DY	$125	$625	Engineer's estimate
Consumable supplies	5	DY	$50	$250	Engineer's estimate
Analytical (groundwater and soil gas)	1	LS	$6,060	$6,060	Assume similar to RI lab costs; VOCs, VFAs, geochemical
Data Validation and Database	1	LS	$38,400	$38,400	Assume similar to RI costs (~30 samples)- Critigen; Assume database set-up
DPT Injection					134 Injection points
Subcontractor Pre-submittals	1	EACH	$3,060	$3,060	Communication from ARS Technologies (May 2015)
Pilot Study					Injection 3 injection points from vendor estimates
Drilling Mobilization	1	EACH	$3,995	$3,995	Communication from Vironex (May 2015)
Coring	3	EA	$90	$270	TTL Assoc estimate from RI
DPT Injection (2-driller crew)	1	Days	$5,500	$5,500	~8 points per day plus setup, decon. Communication from Vironex (May 2015)
Biostimulation Substrate (ABC-CH4)	380	LBS	$1.70	$646	Communication from Provectus Environmental (May 2015)
Substrate (freight)	1	EACH	$250	$250	Assume 1/10 of total shipping estimate
Engineer/Geologist	12	Hours	$100	$1,200	Engineer's Estimate
Travel and Per Diem	2	day	$162	$324	Engineer/Geologist oversight
Full-Scale Injection					
Drilling Mobilization	1	EACH	$3,995	$3,995	Communication from Vironex (May 2015)
Coring	134	EA	$90	$12,060	TTL Assoc estimate from RI
DPT Injection (2-driller crew)	20	Days	$5,500	$110,000	~8 points per day plus setup, decon. Communication from Vironex (May 2015)
Biostimulation Substrate (ABC-CH4)	16620	LBS	$1.70	$28,254	Communication from Provectus Environmental (May 2015)
Substrate (freight)	1	EACH	$2,500	$2,500	Communication from Provectus Environmental (May 2015)
Bioaugmentation culture (SDC-9)	80	L	$170	$13,600	Communication from JRW Bioremediation LLC (Jan. 2013)
Bioaugmentation culture (freight)	1	EACH	$1,500	$1,500	Communication from JRW Bioremediation LLC (Jan. 2013)
Engineer/Geologist	160	Hours	$100	$16,000	Engineer's Estimate
Travel and Per Diem	20	day	$162	$3,240	Engineer/Geologist oversight

TABLE C-4
Cost Estimate for Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Assumptions:
(1) Two blind-end horizontal directional drilled SVE wells installed to an approximate depth of 6 feet bgs. Each well is 300 feet long with 180 feet of slotted pipe
(2) Vapor extraction via horizontal, directionally drilled well (4-inch HDPE) and SVE blower mounted in enclosed trailer, with exterior mounted vapor phase granular activated carbon (VGAC). Target flow rate is 0.5 CFM per linear foot of slotted pipe, or 90 cfm per well (180 cfm total).

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
SVE Construction					
Mobilization/Demobilization	1	LS	$30,000	$30,000	Directed Technologies Drilling Estimate
Pre-Construction Subsurface Utility Location	1	LS	$7,500	$7,500	Engineer's Estimate
Site-Specific Training	1	LS	$3,200	$3,200	Assume 8-hr training required; 4 man crew
Temporary Facilities (trailer, three 30 yd roll-offs, Baker tank, temp fence)	3	WK	$3,500	$10,500	Similar projects; assume 3 week duration
Two biosparge wells, 300 ft blind end, total 600 ft	600	LF	$145.00	$87,000	Directed Technologies Drilling Estimate
350 ft blind end HDD (materials)	600	LF	$18	$10,800	Directed Technologies Drilling Estimate
SVE Blower with 8' x 20' trailer and basic manifold and telemetry	1	LS	$115,000	$115,000	Onion Equipment Estimate
Two, 2000# VGAC beds with connecting hose, sample ports, etc.	1	LS	$18,500	$18,500	Onion Equipment Estimate
Waste management (assume four 30 yd roll boxes and Baker tank for liquids)	1	LS	$25,000	$25,000	Engineer's Estimate
Electrical power drop and final connections	1	LS	$35,000	$35,000	Engineer's Estimate; Assumes 480 V, 3 ph, 150 A service is readily available after installation of new pole mounted transformers and no more than two power poles
Electrical - Installation of meter	1	LS	$4,650	$4,650	RSMeans #26-27-13.10 (3670)
Minor trenching and conveyance piping	1	LS	$25,000	$25,000	Engineer's Estimate
SVE trailer installation (assume basic tie downs and grounding only, no concrete pad)	1	LS	$7,500	$7,500	Engineer's Estimate
SVE trailer delivery and three days start-up assistance	1	LS	$12,500	$12,500	Onion Equipment Estimate
O&M Manual	1	LS	$3,000	$3,000	Onion Equipment Estimate
Miscellaneous Parts and Materials	1	LS	$5,000.00	$5,000	Engineer's Estimate
Surveying	1	LS	$4,500	$4,500	Engineer's Estimate
Engineer/Geologist	120	Hours	$100	$12,000	Similar projects; assume 3 week duration (5 working days/week)
Travel and Per Diem	15	day	$162	$2,430	Engineer/Geologist oversight
Construction Report	1	each	$50,000	$50,000	Draft and Final Construction Completion Report
Subtotal				***$924,601***	
Contingency	*30%*			*$277,380*	*USEPA 2000, pp. 5-10 & 5-11 (15% Scope + 15% Bid)*
Subtotal				***$1,201,981***	
Project Management	*6%*			*$72,119*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Remedial Design	*12%*			*$144,238*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Construction Management	*8%*			*$96,159*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Overhead	*15%*			*$180,297*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$120,198*	*USEPA 2000, Exhibit 5-3 on p.5-8*
			Total Implementation Cost	**$1,814,992**	
5-Year Reviews (Years 5 and 10)					
5-Year Review - Includes LUC Inspections	2	each	$14,000	$28,000	5YR review conducted once every 5 years. Includes pre-draft, draft, draft final, final, fact sheet, and public notices.
Subtotal				***$28,000***	
Contingency	*25%*			*$7,000*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$35,000***	
Project Management	*8%*			*$2,800*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$5,250*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$5,250*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$3,500*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal				***$51,800***	
Subtotal Annual Cost (at Years 5 and 10)			**$25,900**		Calculated from future costs/2 total years
5YR Total Future Cost				**$51,800**	
Present Value *(1.4%)* ***of Future Cost of 5YRs***	*30*	*year*	*1.4%*	***$46,699***	
DPT Re-Injection (Years 2 through 5)					Assume starts after 1 year of performance monitoring
Utility	4	event	$4,500	$18,000	Assume same as capital costs
DPT Injection	4	event	$206,394	$825,576	Assume same as capital costs
Subtotal				***$843,576***	
Contingency	*30%*			*$253,073*	*USEPA 2000, pp. 5-10 & 5-11 (15% Scope + 15% Bid)*
Subtotal				***$1,096,649***	
Project Management	*6%*			*$65,799*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Technical Support	*15%*			*$164,497*	*USEPA 2000, p.5-14*
Construction Management	*8%*			*$87,732*	*USEPA 2000, Exhibit 5-8 on p.5-13, $500k -$2M*
Overhead	*15%*			*$164,497*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$109,665*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$422,210***		Calculated from future costs/4 total years
Subtotal Future Cost				***$1,688,839***	
Present Value *(1.4%)* ***of Re-Injection Years 2-5***			*1.4%*	***$1,608,822***	

TABLE C-4
Cost Estimate for Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction
Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Assumptions:
(1) Two blind-end horizontal directional drilled SVE wells installed to an approximate depth of 6 feet bgs. Each well is 300 feet long with 180 feet of slotted pipe
(2) Vapor extraction via horizontal, directionally drilled well (4-inch HDPE) and SVE blower mounted in enclosed trailer, with exterior mounted vapor phase granular activated carbon (VGAC). Target flow rate is 0.5 CFM per linear foot of slotted pipe, or 90 cfm per well (180 cfm total).

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
Quarterly Groundwater Monitoring (Years 1 through 6)					
Engineer/Geologist, 2-person crew	1440	Hours	$100	$144,000	3 days/ event, 10 hour days; 4 events for 6 years
Travel and Per Diem, 2-person crew	144	day	$162	$23,328	3 days/event; 4 events for 6 years
Field Equipment	24	LS	$1,500	$36,000	Engineer's Estimate; 4 events for 6 years
Vehicle rental and fuel	72	DY	$125	$9,000	Engineer's estimate
Consumable supplies	72	DY	$50	$3,600	Engineer's estimate
Analytical (10 wells plus QA/QC)	24	LS	$2,330	$55,920	Assume similar to RI lab costs; VOCs, VFAs, geochemical
Data Validation (10 wells plus QA/QC)	24	LS	$1,020	$24,480	Assume similar to RI costs - Critigen
Annual Report	6	each	$7,000	$42,000	Based on historical pricing
Subtotal				***$338,328***	
Contingency	*25%*			*$84,582*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$422,910***	
Project Management	*8%*			*$33,833*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$63,437*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$63,437*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$42,291*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$104,317.80***		Calculated from future costs/6 total years
Subtotal Future Cost				***$625,907***	
Present Value *(1.4%)* ***of Future Cost of Quarterly monitoring Years 1-6***			*1.4%*	***$596,347***	
SVE O&M (Years 1 through 5)					
Monthly O&M Labor + Travel	60	events	$1,650	$99,000	Engineer's Estimate; 12 events/year
Quarterly "Heavy" Maintenance	20	events	$2,850	$57,000	Engineer's Estimate; 4 events/year
O&M Supplies	5	LS	$5,000	$25,000	
Electrical - Electrical usage for SVE System (per year/5 years)	500,000	kwh	$0.10	$50,000	Based on recent Electrical quote for similar project
Subtotal				***$231,000***	
Contingency	*25%*			*$57,750*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$288,750***	
Project Management	*8%*			*$23,100*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$43,313*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$43,313*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$28,875*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$85,470***		Calculated from future costs/5 total years
Subtotal Future Cost				***$427,350***	
Present Value *(1.4%)* ***of Future Cost of O&M Years 1-5***			*1.4%*	***$409,972***	
Air Monitoring (Years 1 through 5)					Quarterly Sampling for first 5 years (to monitor daughter product generation)
Labor, ODCs, Travel	20	event	$8,000	$160,000	6 IA samples, 6 subslab samples, 1 OA samples
Lab & Data Validation	20	each	$5,039	$100,773	See lab & DV backup sheets
Equipment	20	event	$3,600	$72,000	Based on recent project similar in nature.
Report	10	each	$8,000	$80,000	Assume Semiannual frequency; Based on historical pricing
Subtotal				***$412,773***	
Contingency	*25%*			*$103,193*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$515,967***	
Project Management	*8%*			*$41,277*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$77,395*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$77,395*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$51,597*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$152,726.08***		Calculated from future costs/5 total years
Subtotal Future Cost				***$763,630***	
Present Value *(1.4%)* ***of Future Cost of Air Sampling Years 1-5***			*1.4%*	***$732,577***	
Air Monitoring (Years 6 through 10)					1 Sample Event every year
Labor, ODCs, Travel	5	event	$8,000	$40,000	6 IA samples, 6 subslab samples, 1 OA samples
Lab & Data Validation	5	each	$5,039	$25,195	See lab & DV backup sheets
Equipment	5	event	$3,600	$18,000	Based on recent project similar in nature.
Report	5	each	$8,000	$40,000	Based on historical pricing
Subtotal				***$123,195***	
Contingency	*25%*			*$30,799*	*USEPA 2000, pp. 5-10 & 5-11 (10% Scope + 15% Bid)*
Subtotal				***$153,994***	
Project Management	*8%*			*$12,320*	*USEPA 2000, Exhibit 5-8 on p.5-13, $100k-$500k*
Technical Support	*15%*			*$23,099*	*USEPA 2000, p.5-14*
Overhead	*15%*			*$23,099*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Profit	*10%*			*$15,399*	*USEPA 2000, Exhibit 5-3 on p.5-8*
Subtotal Annual Cost			***$45,582.15***		Calculated from future costs/5 total years
Subtotal Future Cost				***$227,911***	
Present Value *(1.4%)* ***of Future Cost of Air Sampling Years 6-10***			*1.4%*	***$203,960***	

TABLE C-4

Cost Estimate for Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction

Feasibility Study for AOCs 17/18/19/103, Former Lockbourne Air Force Base, Ohio

Assumptions:

(1) Two blind-end horizontal directional drilled SVE wells installed to an approximate depth of 6 feet bgs. Each well is 300 feet long with 180 feet of slotted pipe

(2) Vapor extraction via horizontal, directionally drilled well (4-inch HDPE) and SVE blower mounted in enclosed trailer, with exterior mounted vapor phase granular activated carbon (VGAC). Target flow rate is 0.5 CFM per linear foot of slotted pipe, or 90 cfm per well (180 cfm total).

Item/Activity	Qty	Unit	Unit Cost	Cost	Notes & Comments
Total Present Value of All Future Costs			**1.4%**	**$3,598,377**	Y2015 PV calculated for 30-yrs-future-cost using 1.4% Real Discount Rate per Office of Management and Budget (2014).

Other Notes and References:

● The "Real" Discount Rate used to calculate the Present Value cost is 1.4% for a timeframe of 30 years per the Office of Management and Budget (OMB), Circular A-94, Appendix C, Revised December 2014, "Discount Rates for Cost Effectiveness, Lease Purchase, and Related Analysis" for Calendar Year 2015.

● USEPA. 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. OSWER Directive 9355.3-01. EPA/540/G-89/004. October.

● USEPA. 2000. *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*. With the U.S. Army Corps of Engineers. OSWER 9355.0-75. EPA 540-R-00-002. July.

● The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternative. Changes in the cost elements are likely to occur as a result of new information and data collected during Baseline Sampling and the Remedial Design phase. This is an order-of-magnitude engineering cost estimate that is expected to be within –30 to +50 percent of the actual project cost (per USEPA 1988 and 2000).

Appendix D
Green and Sustainable Remediation Memorandum

Green and Sustainable Remediation, Former Lockbourne Air Force Base, Areas of Concern 17/18/19/103, Columbus, Ohio

This memorandum identifies and evaluates progress in incorporating green and sustainable remediation (GSR) practices into Delivery Order Number CY01 for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) activities at areas of concern (AOCs) 17, 18, 19, and 103 at the Former Lockbourne Air Force Base (AFB) in Columbus, Ohio. AOCs 17, 18, 19, and 103 are near one another and thus are being evaluated as one site. The former AFB is part of the Formerly Used Defense Site (FUDS) program. The delivery order was awarded under Contract Number W912PP-09-D-0016 and includes the remedial investigation (RI), feasibility study (FS), proposed plan, decision document, and public involvement activities. GSR practices continue to be evaluated in future United States Army Corps of Engineers (USACE) contracts for remedial design and remedial action of AOCs 17/18/19/103, if applicable.

The site description and history are provided in the RI report, and a summary is provided in the FS report.

The project stakeholders are provided in Table D-1.

TABLE D-1
Project Stakeholders

Responsible Affiliation	Name	Phone Number	Procedure
USACE project manager	Valerie Doss	502-315-6108	Primary point of contact (POC) for USACE with Ohio EPA, CRAA, stakeholders, and the community.
USACE contracting officer's representative and technical project manager	Josh Van Bogaert	502-315-6333	Primary POC for USACE contractor (CH2M HILL) regarding contractual and technical issues.
CRAA manager, energy and environment	Paul Kennedy	614-239-3347	Primary POC for CRAA; can delegate communication to other internal or external POCs.
Ohio EPA remediation project manager	Fred Myers	614-728-3830	Primary POC for Ohio EPA; can delegate communication to other internal or external POCs.
Community	Not applicable	Not applicable	Provide input to USACE.

D.1. Purpose

Pursuant to the Department of Defense (DOD) *Defense Environmental Restoration Program Management* manual (DOD, 2012), GSR employs the following strategies throughout the remedial process:

- Uses natural resources and energy efficiently
- Reduces negative impacts on the environment
- Minimizes or eliminates pollution at its source
- Reduces waste to the greatest extent possible

The manual instructs DOD to consider and implement GSR opportunities in all phases of remediation when feasible, and to ensure the use of GSR remediation practices where practicable based on economic and social benefits and costs. In the FS phase, remedial alternatives will be evaluated to ensure they are efficient; are environmentally, economically, and fiscally sound; consider sustainable practices; and reduce the footprint of remediation systems in the environment.

This memorandum identifies GSR practices and documentation thereof for this delivery order for the FS phase. There are three overall types of project tasks to consider GSR implementation: reporting, fieldwork, and remedial alternative development and evaluation. For this FS phase, the focus includes reporting and remedial alternative development and evaluation. There is no fieldwork during the FS phase of this project. To better integrate GSR considerations, this memorandum will be updated as GSR practices are implemented.

D.2. Green and Sustainable Remediation Strategy

The GSR strategy for the project includes implementing sustainability considerations through best management practices (BMPs) and footprint evaluations. The BMPs that are planned, and progress made toward implementing those BMPs, are provided below. The environmental footprint of proposed remedial alternatives has been evaluated as part of the FS. Figure 1 depicts the GSR decision logic for CERCLA activities.

D.2.1 Best Management Practices

BMPs are actions or considerations that are expected to improve the environmental, social, or economic aspects of the remedial process. As with other industries or activities, BMPs for GSR have been developed that apply to soil, sediment, and groundwater remediation activities. Improvements for GSR can be achieved by considering BMPs and implementing those that apply to the project-specific remedial process or potentially implementing alternate GSR practices identified while considering BMPs (USACE 2011).

Consideration of BMPs requires knowledge of the remedial activities and site conditions to determine which are applicable and appropriate. BMPs are divided into the following categories:

A. Planning
B. Characterization or Remedy Approach
C. Energy/Emissions: Transportation
D. Energy/Emissions: Equipment Use
E. Materials and Offsite Services
F. Water Resource Use
G. Waste Generation, Disposal, and Recycling
H. Land Use, Ecosystems, and Cultural Resources
I. Safety and Community
J. Other Site-specific BMPs

Table D-2 (at the end of this appendix) lists the BMPs planned for components of the project and the progress made toward implementing them. Components of the project include reporting, field work, and remedial alternative development and evaluation. The categories presented in Table D-2 are consistent with those presented in the BMP checklists in USACE's (2012) *Evaluation of Consideration and Incorporation of Green and Sustainable Remediation Practices in Army Environmental Remediation* and consist of BMP description, evaluation status, implementations status, and value evaluation. See the notes to Table D-2 for BMPs deemed applicable but not evaluated.

Table D-2 lists BMPs deemed applicable to the project. The following BMPs (not included in Table D-2) are not currently applicable but would apply to subsequent remedial design and remedial action activities:

- BMP B-7: Consider use of existing site structures/infrastructure or mobilization of temporary structures versus new construction.
- BMP D-5: Use variable frequency drives on motors (e.g., pumps, blowers), or replace oversized motors with properly sized motors.
- BMP D-6: Identify options for generating renewable energy for direct use in the remedial alternatives and/or for alternate use at or near the project site.

- BMP D-7: Consider purchase of renewable energy certificates (RECs) to offset emissions from the remedial activities. The memorandum "Department of the Army Policy for Renewable Energy Credits" (May 24, 2012) states "the Army shall not purchase RECs solely to meet Federal renewable energy goals." It is possible, however, that project teams might in some cases consider the purchase of RECs to address concerns of one or more stakeholders at a specific site.
- BMP D-8: Design/modify housing required for aboveground treatment components for energy efficiency.
- BMP D-9: For remedies that involve groundwater or air extraction, optimize extraction to reduce flow rates (potentially beneficial with respect to energy use, materials usage, water resources, waste disposal, etc.).
- BMP D-10: Consider pulsing for extraction or injection (or both) of water or air to maximize mass removal per unit of time or energy, by extracting higher concentrations.
- BMP D-11: Run electrical equipment during times of lower electric demand if possible (this does not reduce energy use but could lower cost and also can lower stress on the energy grid during periods of peak demand).
- BMP E-4: Identify opportunities for using by-products or "waste" materials from local sources in place of refined chemicals or materials.
- BMP E-5: Reduce demand on publicly owned treatment works.
- BMP F-2: Preferentially use less refined water resources when feasible.
- BMP G-2: Segregate excavated soil in planned staging areas so that "clean" material can be deposited onsite or reused rather than transported for offsite disposal.
- BMP H-1: Minimize erosion and soil transport to surface water bodies.
- BMP H-4: Minimize drawdown of the water table in sensitive areas such as wetlands or areas subject to subsidence.

Table D-3 summarizes BMP applicability and implementation as the project currently stands.

D.3. Environmental Footprint

The term "environmental footprint" refers to the quantification of GSR parameters such as amount of energy used, amount of greenhouse gases emitted, and amount of potable water consumed. The environmental footprint has been evaluated as part of the FS and will be revised as needed for the decision document, for remedial alternatives with active treatment and remedy selection. The environmental footprint for these alternatives was calculated using SiteWise version 3.0 (NAVFAC 2013). The SiteWise evaluation is included as Attachment 1. U.S. Environmental Protection Agency (USEPA) has not provided official guidance on the role of GSR footprint analyses in CERCLA FSs. However, USEPA does support the new ASTM Greener Cleanup Standard (ASTM E-2893), which includes an option of performing "quantitation." USEPA was involved in the development of the standard and are currently training their staff in its application. The standard provides a section on how footprint analysis results can be used in evaluating alternatives.

The results from the SiteWise analysis is provided in Attachment 1. The environmental footprints calculated by SiteWise were used to quantitatively compare the alternatives, and a relative impact of high, medium, or low was assigned to each alternative based on its performance against the other alternatives. The tool assigns a ranking of "high" to the highest footprint in each category and assigns the rankings of other alternatives based on the difference in the data between alternatives. Alternative 2 had low environmental footprints and accident risks. Alternative 3 had comparatively high environmental footprints but low accident risks. Operating the depressurization system contributed to almost all of the environmental and water use footprints for this alternative. Alternative 4 had medium environmental footprints and high

accident risks which were primarily associated with the equipment use component during soil vapor extraction operations and enhanced biodegradation injections.

D.4. References

DOD (Department of Defense). 2012. *Defense Environmental Restoration Program (DERP) Management.* Manual Number 4715.20. March.

NAVFAC (Naval Facilities Engineering Command). 2013. *SiteWise Version 3 User's Guide*. July.

USACE. 2011. *Process for Consideration and Incorporation of Process of Green and Sustainable Remediation (GSR) Practices in Army Environmental Remediation*. Prepared by Tetra Tech EC, Inc. May.

USACE. 2012. *Evaluation of Consideration and Incorporation of Green and Sustainable Remediation Practices in Army Environmental Remediation.* August. http://www.fedcenter.gov/Documents/index.cfm?id=22322&pge_prg_id=27392.

TABLE D-2
Summary of Best Management Practices

Phase	BMP Number	Project Task	BMP Description	Evaluation Status (A, P, E, Null)	Implementation Status (FI, PI, NY, Null)	Value Evaluation	Notes	Completion/ Revision Date
Planning	BMP A-1	Reports/ Documents	Develop a culture of green and sustainable remediation (GSR) within the project team and encourage GSR ideas from project staff, and review similar projects from other sites for possible transfer/adoption of GSR ideas	E	FI	Cost Increase	Chartered project team on GSR as part of fieldwork planning during field charter teleconferences held on March 27 and April 1. Assigned GSR subject matter expert (Paul Favara/CH2M HILL) to support the project and project team. Leveraged GSR ideas and implementation from similar projects as discussed on field charters.	April 2012
Planning	BMP A-1	Fieldwork	Develop a culture of GSR within the project team and encourage GSR ideas from project staff, and review similar projects from other sites for possible transfer/adoption of GSR ideas	E	FI	Cost Increase	Chartered project team on GSR during field charters held on March 27 and April 1. GSR activities were documented in a GSR table following the field event.	January 2014
Planning	BMP A-1	Alternatives	Develop a culture of GSR within the project team and encourage GSR ideas from project staff, and review similar projects from other sites for possible transfer/adoption of GSR ideas	E	NY	Cost Savings	Chartered project team on GSR; GSR subject matter expert supporting the project and project team; Leverage GSR ideas and implementation from similar projects.	December 2015
Planning	BMP A-2	Reports/ Documents	Incorporate a section on GSR in project meetings, work plans, and reports	P	PI	TBD	Remedial investigation/feasibility study work plan, remedial investigation report, and feasibility study report included section on GSR. Agenda for project meetings, as appropriate, included GSR as topic. Future project meetings and reporting will include GSR topics, as appropriate. Used paper containing at least 30 percent postconsumer fiber for work plans and reports. Used double sided printing for work plan and reports. Printers and copiers used for producing work plan and reports was Energy Star compliant or better.	Throughout delivery order
Planning	BMP A-2	Fieldwork	Incorporate a section on GSR in project meetings, work plans, and reports	null	null	null	Not considered applicable to field activities. BMP is addressed in reports/documents.	null
Planning	BMP A-2	Alternatives	Incorporate a section on GSR in project meetings, work plans, and reports	E	NY	Cost Savings	Work plans and reports associated with planning and implementation of the remedy will include GSR considerations.	December 2015
Planning	BMP A-3	Reports/ Documents	Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations	E	FI	Cost Increase	Identified list of key stakeholders as part of work planning activities. Identify list of key stakeholders during public involvement activities.	April 2013
Planning	BMP A-3	Fieldwork	Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations	E	FI	Cost Increase	Identified list of key stakeholders (USACE and CH2M HILL) and discussed in field charters held March 27 and April 1.	April 2014
Planning	BMP A-3	Alternatives	Identify and periodically update a list of key stakeholders and their concerns with respect to GSR considerations	E	NY	Cost Neutral	Identified list of key stakeholders.	December 2015
Planning	BMP A-4	Reports/ Documents	Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling	null	null	null	Not considered applicable to reporting. BMP addressed under fieldwork.	null
Planning	BMP A-4	Fieldwork	Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling	E	null	null	Considered seasons when scheduling field activities, but not practical due to overall project schedule and associated funding.	null
Planning	BMP A-4	Alternatives	Schedule activities for appropriate seasons and/or time of day to reduce delays caused by weather conditions and fuel needed for heating or cooling	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, remedial action activities will be scheduled for appropriate seasons and/or time of day to reduce delays caused by weather conditions. Reduced delays caused by weather conditions will reduce costs.	December 2015
Planning	BMP A-5	Reports/ Documents	Prepare, store, and distribute documents electronically	P	PI	Cost Savings	Distribute additional reports/documents electronically. Specifically, CH2M HILL files of final reports are limited to the project manager's office. The remaining CH2M HILL team accesses project documents (e.g., Background Memorandum, Work Plans) as electronic files. Also, USACE requested some versions of documents electronically only.	Throughout delivery order
Planning	BMP A-5	Fieldwork	Prepare, store, and distribute documents electronically	E	FI	Cost Savings	Field work photographs and field notes have been distributed to the project team for review rather than shipping or photocopying files for review. Digital photographs were used rather than film and film development. Field files and equipment have been stored at the closest CH2M HILL office (Dayton, OH) rather than sending back to the project manager for storage. Field documents including soil boring logs, monitoring well construction diagrams, and groundwater sampling forms are scanned shared among offices digitally. No hard copies of the field book are generated.	April 2014
Planning	BMP A-5	Alternatives	Prepare, store, and distribute documents electronically	E	NY	Cost Savings	Distribute additional reports/documents electronically.	December 2015
Planning	BMP A-6	Reports/ Documents	Utilize teleconferences rather than meetings when feasible	P	PI	TBD	Used teleconference for internal project meetings and project meetings with stakeholders to discuss documents. Field charters were held by teleconference since the project team is located in various offices. Used teleconference for internal project meetings and project meetings with stakeholders to discuss investigation findings and resolve comments on reports/documents. Teleconferences are held with USACE monthly.	Throughout delivery order
Planning	BMP A-6	Fieldwork	Use teleconferences rather than meetings when feasible	E	FI	Cost Savings	Used teleconference for internal project meetings and project meetings with stakeholders to discuss investigation findings. Meetings to discuss vapor intrusion sample locations were held with USACE. Further coordination with CRAA was completed by e-mail. Coordination activities include sample locations and field schedule.	Throughout delivery order
Planning	BMP A-6	Alternatives	Use teleconferences rather than meetings when feasible	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, will use teleconferences rather than in-person meetings when feasible which will reduce travel costs.	December 2015

TABLE D-2
Summary of Best Management Practices

Phase	BMP Number	Project Task	BMP Description	Evaluation Status (A, P, E, Null)	Implementation Status (FI, PI, NY, Null)	Value Evaluation	Notes	Completion/ Revision Date
Planning	BMP A-7	Reports/ Documents	Incorporate GSR specifications into solicitations and contracts	null	null	null	Not considered applicable for report and document preparation activities, since subcontractor scope is limited to third-party data validation and graphics. BMP is addressed under fieldwork.	null
Planning	BMP A-7	Fieldwork	Incorporate GSR specifications into solicitations and contracts	E	FI	Cost Neutral	Included language into subcontracts (investigation-derived waste (IDW) waste) solicitation for subcontractor to consider incorporate sustainable practices into their services.	April 2014
Planning	BMP A-7	Alternatives	Incorporate GSR specifications into solicitations and contracts	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, will incorporate GSR specification into contractor/subcontractor solicitations and contracts. Examples of GSR specifications include no idling of equipment, utilizing local staff and subcontractors, use vehicles that use alternative fuel options, and use alternative power sources (e.g., solar).	December 2015
Planning	BMP A-8	Reports/ Documents	Integrate schedules to allow resource sharing and fewer days of field mobilization	null	null	null	Not considered applicable to reporting. BMP addressed under fieldwork.	null
Planning	BMP A-8	Fieldwork	Integrate schedules to allow resource sharing and fewer days of field mobilization	E	FI	Cost Savings	Reviewed scope of field investigation and field resources to maximize field efficiencies. Scope of investigation was presented in the project work plan. Specifically, an iterative approach to vapor intrusion evaluations was implemented. Additional sampling was justified only after initial sampling results indicated that vapor intrusion needed to be evaluated further. Soil sampling, groundwater sampling, and/or vapor intrusion sampling were scheduled during the same event to minimize trips and staff hours. Field staff from the Midwest region were used.	April 2014
Planning	BMP A-8	Alternatives	Integrate schedules to allow resource sharing and fewer days of field mobilization	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, will sequence implementation of selected remedy to allow resource sharing and fewer days of field mobilization which will reduce costs.	December 2015
Planning	BMP A-9	Reports/ Documents	Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals	E	FI	Cost Neutral	Identified realistic end-use of the site during preparation of work plan. The risk assessment exposure pathways are based on current and foreseeable future uses. The most conservative exposure pathways were not selected, which could cause unnecessary efforts and an increased carbon footprint to address risks that aren't applicable. The feasibility study report presented the preliminary remediation goals based on current and foreseeable future uses.	May 2015
Planning	BMP A-9	Fieldwork	Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals	null	null	null	Not considered applicable for fieldwork activities. BMP is addressed under reports/documents and development of alternatives.	null
Planning	BMP A-9	Alternatives	Tailor the remedy cleanup goals such that they are appropriate for anticipated end-use of the property, rather than assuming a more conservative exposure scenario with more stringent cleanup goals	E	FI	Cost Neutral	Reevaluated realistic end-use of the site was proposed in the feasibility study report.	December 2015
Planning	BMP A-10	Reports/ Documents	Conduct thorough review of project documents and historical records to minimize required scope of investigation.	null	null	null	Not considered applicable for report and document preparation activities. BMP is addressed under fieldwork.	null
Planning	BMP A-10	Fieldwork	Conduct thorough review of project documents and historical records to minimize required scope of investigation.	E	FI	Cost Savings	Reviewed existing project documents and historical records to minimize required scope of investigation. Scope of investigation was presented in the project work plan. Additional sampling was only conducted based on results of smaller, initial investigation.	April 2014
Planning	BMP A-10	Alternatives	Conduct thorough review of project documents and historical records to minimize required scope of investigation.	E	NY	Cost Savings	Review existing project documents and historical records to minimize required scope of sampling as part of the remedy. Scope of sampling will be presented in a work plan.	December 2015
Planning	BMP A-11	Reports/ Documents	Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented	P	PI	Cost Savings	A habitat assessment was conducted at AOC 94 during the upland sandpiper breeding season to evaluate the presence or absence of habitat and the presence or absence of breeding individuals. If the results of the habitat assessment determined that additional work is warranted, a screening-level ERA would be conducted at AOC 94 to conservatively evaluate the potential for adverse ecological effects from site contamination in surface soil. However, based on results, the potential for risk to ecological receptors were eliminated from further evaluation.	December 2013
Planning	BMP A-11	Fieldwork	Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented	null	null	null	Not considered applicable since this project task is not a work plan, proposed plan, or decision document. BMP is addressed under reports/documents and development of alternatives.	null
Planning	BMP A-11	Alternatives	Use language in work plans, proposed plans, and decision documents that maximizes flexibility to allow GSR recommendations to be implemented	E	NY	Cost Savings[a]	Incorporate flexibility in feasibility study and decision document to allow GSR recommendations to be implemented. If Alternative 2, 3, or 4 is selected, maximize flexibility to allow GSR recommendations to be implemented.	December 2015
Characterization or Remedy Approach	BMP B-1	Reports/ Documents	Develop and routinely update a conceptual site model (CSM) to use as a basis for making remedial process decisions	E	FI	Cost Savings	Developed preliminary CSM for work plan. Updated CSM following evaluation of data collected during from the remedial investigation.	July 2014

TABLE D-2
Summary of Best Management Practices

Phase	BMP Number	Project Task	BMP Description	Evaluation Status (A, P, E, Null)	Implementation Status (FI, PI, NY, Null)	Value Evaluation	Notes	Completion/ Revision Date
Characterization or Remedy Approach	BMP B-1	Fieldwork	Develop and routinely update a CSM to use as a basis for making remedial process decisions	E	FI	Cost Savings	Updated CSM, as applicable, during fieldwork based on visual observations and real-time qualitative data (e.g., vapor intrusion sampling). The initial vapor intrusion investigation was limited to 2 to 3 samples per building. Based on the initial results, only one building needed additional sampling. Also, selected soil sample locations based on the CSM updated following the Triad investigation using membrane interface probe technologies.	April 2014
Characterization or Remedy Approach	BMP B-1	Alternatives	Develop and routinely update a CSM to use as a basis for making remedial process decisions	E	FI	Cost Savings	Updated CSM, as applicable, during Feasibility Study.	December 2015
Characterization or Remedy Approach	BMP B-2	Reports/ Documents	Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project	null	null	null	Not considered applicable for reports/documents. BMP addressed under fieldwork.	null
Characterization or Remedy Approach	BMP B-2	Fieldwork	Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project	E	FI	Cost Savings	MIP technology was used to collect real-time qualitative data to refine the understanding of the horizontal and vertical distribution of the highest chlorinated volatile organic compound (CVOC)-concentration areas. The use of the MIP optimized the locations of permanent monitoring wells and supports the tenets of Triad investigations. The use of MIP avoided the need to install as many monitoring wells, which resulted in a reduction of roughly 50% fuel usage (avoids emissions of greenhouse gas [GHG], nitrogen oxides [NOx], sulfur oxides [SOx], particulate matter [PM]), IDW of soil cuttings from an 8-inch bore hole, and labor reduction, which helped to avoid potential accidents, as there is a correlation between hours worked and injury potential. Groundwater sampling used past sampling events to evaluate monitoring wells that can be purged dry according to the groundwater sampling SOP due to low recharge rates. By using past groundwater sampling records, the monitoring wells that were immediately purged dry reduced labor hours in comparison to low flow sampling.	April 2014
Characterization or Remedy Approach	BMP B-2	Alternatives	Perform regular optimization evaluations to improve efficiency of current or planned actions and/or develop alternative remedial approaches that might shorten remedy duration or otherwise improve the net environmental benefit of the remedy, including use of any methodologies, such as TRIAD (www.triadcentral.org), systematic planning (technical project planning), value engineering studies, and remedial system evaluations, expected to optimize the planning and/or execution of the project	E	NY	Cost Savings[a]	If Alternative 2 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. A decrease in concentrations will be used to justify termination of indoor air monitoring if subslab soil gas concentrations were to attenuate over time. Termination of monitoring will reduce costs. If Alternative 3 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. Following that time period and assuming the target levels in indoor air were being met, monitoring will be discontinued, and system parameters (such as flow rate, vacuum measurements, and differential pressure measurements) will be used to demonstrate effectiveness, resulting in a cost savings. If Alternative 4 is selected, subslab soil gas and air monitoring would be conducted quarterly for the first 5 years to monitor daughter product generation. Soil gas and air sampling would continue at an annual frequency for an estimated 5 years following the injections to document whether soil gas concentrations had attenuated following treatment. Monitoring will be used to assess if concentrations have decreased below residential remedial goals and triggering termination of monitoring, resulting in a cost savings.	December 2015
Characterization or Remedy Approach	BMP B-3	Reports/ Documents	Use appropriate characterization or remedy approach based on site conditions	null	null	null	Not considered applicable to reporting and document production activities as this is a non-field task. BMP addressed under fieldwork.	null
Characterization or Remedy Approach	BMP B-3	Fieldwork	Use appropriate characterization or remedy approach based on site conditions	E	FI	Cost Savings	Developed preliminary CSM during work planning. Updated CSM following evaluation of data collected during from the remedial investigation fieldwork.	April 2014
Characterization or Remedy Approach	BMP B-3	Alternatives	Use appropriate characterization or remedy approach based on site conditions	E	FI	Cost Savings	Used appropriate remedy approach based on site conditions, as applicable, during Feasibility Study.	December 2015
Characterization or Remedy Approach	BMP B-4	Reports/ Documents	Establish decision points to trigger a change from one technology to another or from one remedy alternative to another	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null

TABLE D-2
Summary of Best Management Practices

Phase	BMP Number	Project Task	BMP Description	Evaluation Status (A, P, E, Null)	Implementation Status (FI, PI, NY, Null)	Value Evaluation	Notes	Completion/ Revision Date
Characterization or Remedy Approach	BMP B-4	Fieldwork	Establish decision points to trigger a change from one technology to another or from one remedy alternative to another	E	FI	Cost Savings	Evaluated real-time qualitative data in the field to confirm that field technology is meeting project objectives. Used hollow-stem auger, which generates less IDW and has cost savings compared to other drilling technologies. Further, a Triad approach was used before drilling.	April 2013
Characterization or Remedy Approach	BMP B-4	Alternatives	Establish decision points to trigger a change from one technology to another or from one remedy alternative to another	E	NY	Cost Savings[a]	If Alternative 2 is selected and if indoor air concentrations during the first two years of monitoring were observed to increase above the PRGs for two consecutive monitoring periods or two consecutive same-season monitoring periods, a contingency remedy (such as the depressurization system described in Alternative 3) will be triggered. This contingency would be included in a future Decision Document to avoid future amendment of the remedy. If Alternative 3 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. Following that time period and assuming the target levels in indoor air were being met, monitoring would be discontinued and removed as a component of the remedy. System parameters (such as flow rate, vacuum measurements, and differential pressure measurements) would be used to demonstrate effectiveness after termination of monitoring, resulting in a cost savings. If Alternative 4 is selected, subslab soil gas and air monitoring would be conducted quarterly for the first 5 years to monitor daughter product generation. Soil gas and air sampling would continue at an annual frequency for an estimated 5 years following the injections to document whether soil gas concentrations had attenuated following treatment. Monitoring will be used to assess if concentrations have decreased below residential remedial goals. If concentrations decrease below residential remedial goals, monitoring would be discontinued and removed as a component of the remedy, resulting in a cost savings.	December 2015
Characterization or Remedy Approach	BMP B-5	Reports/ Documents	Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization)	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Characterization or Remedy Approach	BMP B-5	Fieldwork	Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization)	E	FI	Cost Savings	Sampling efforts were developed and focused to meet objectives of the site characterization and remedy evaluations during the work planning activities.	April 2014
Characterization or Remedy Approach	BMP B-5	Alternatives	Focus sampling efforts to meet objectives of the specific remedial phase (e.g., sampling during O&M should be focused on evaluating remedy performance and not on thorough plume characterization)	E	NY	Cost Savings[a]	If Alternative 2 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. A decrease in concentrations will be used to justify termination of indoor air monitoring if subslab soil gas concentrations were to attenuate over time. Termination of monitoring will reduce costs. If Alternative 3 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. Following that time period and assuming the target levels in indoor air were being met, monitoring would be discontinued, and system parameters (such as flow rate, vacuum measurements, and differential pressure measurements) would be used to demonstrate effectiveness, resulting in a cost savings. If Alternative 4 is selected, subslab soil gas and air monitoring would be conducted quarterly for the first 5 years to monitor daughter product generation. Soil gas and air sampling would continue at an annual frequency for an estimated 5 years following the injections to document whether soil gas concentrations had attenuated following treatment. Monitoring will be used to assess if concentrations have decreased below residential remedial goals and warrant termination of monitoring. If concentrations decrease below residential remedial goals, monitoring would be discontinued, resulting in a cost savings.	December 2015
Characterization or Remedy Approach	BMP B-6	Reports/ Documents	Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts	null	null	null	Not considered applicable to reporting activities as this is a non-field task. BMP addressed under fieldwork.	null
Characterization or Remedy Approach	BMP B-6	Fieldwork	Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts	E	FI	Cost Savings	MIP technology was used to collect real-time qualitative data to refine the understanding of the horizontal and vertical distribution of the highest CVOC-concentration areas; MIP borings were based on the preliminary CSM and the Triad approach (systematic planning,	April 2013
Characterization or Remedy Approach	BMP B-6	Alternatives	Consider real-time measurements and dynamic work plans to reduce mobilizations and improve effectiveness of investigation efforts	E	NY	Cost Savings	Consider applicable technologies to during implementation of the remdy. For example, no purge groundwater sampling.	December 2015
Characterization or Remedy Approach	BMP B-8	Reports/ Documents	Establish project-specific decision points to limit extent of remediation	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null

TABLE D-2
Summary of Best Management Practices

Phase	BMP Number	Project Task	BMP Description	Evaluation Status (A, P, E, Null)	Implementation Status (FI, PI, NY, Null)	Value Evaluation	Notes	Completion/ Revision Date
Characterization or Remedy Approach	BMP B-8	Fieldwork	Establish project-specific decision points to limit extent of remediation	E	FI	Cost Savings	Evaluated vapor intrusion data collected in 2013 to develop data quality objectives and scope for additional vapor intrusion sampling to identify limits of contamination and potential human health risks.	April 2014
Characterization or Remedy Approach	BMP B-8	Alternatives	Establish project-specific decision points to limit extent of remediation	E	NY	Cost Savings[a]	If Alternative 2 or 3 is selected, potential vapor entry points will be identified for sealing to reduce or prevent TCE from being transported through these vapor entry points. This would address the most obvious and potentially largest points of vapor entry and thereby result in a reduction of indoor air concentrations, minimizing the frequency of monitoring which will reduce costs. If Alternative 3 is selected, pre-mitigation diagnostic testing will be conducted to determine the radius of influence of the negative pressure field at a given applied negative pressure and corresponding flow rate and to determine the TCE concentration in the off gas. These data would be used to optimize the design of the active subslab depressurization system including fan/blower and pipe sizing, required applied vacuum, and number and configuration of active subslab depressurization extraction nodes. Pre-mitigation diagnostic testing would be used to optimize the mitigation system design, reducing both capital and long-term O&M costs. If Alternative 4 is selected, prior to soil vapor extraction system installation, a subslab soil gas monitoring event would be conducted to refine the extent of soil gas concentrations above the remediation goals at the time of the remedial action. These data would be used to optimize the soil vapor excavation system, reducing capital and long-term O&M costs.	December 2015
Characterization or Remedy Approach	BMP B-9	Reports/ Documents	Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Characterization or Remedy Approach	BMP B-9	Fieldwork	Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)	E	FI	Cost Neutral	Relocated a subset of soil boring locations due to a subsurface anomaly detected with GPR during the utility locate. Subsurface anomaly potentially represented buried concrete.	April 2013
Characterization or Remedy Approach	BMP B-9	Alternatives	Consider leaving in place structures whose removal is not necessary (i.e., foundations, underground pillars, etc.)	E	FI	Cost Savings	If Alternative 2, 3, or 4 is selected, the remedy will include leaving in place structures.	December 2015
Energy /Emissions: Transportation	BMP C-1	Reports/ Documents	Reduce the number of trips for personnel	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Energy /Emissions: Transportation	BMP C-1	Fieldwork	Reduce the number of trips for personnel	E	FI	Cost Savings	Local (Dayton, OH) staff were used for the field events based on early planning. In addition, the field escort has remained consistent to avoid multiple trips to the site for background checks and screening and escort training.	April 2014
Energy /Emissions: Transportation	BMP C-1	Alternatives	Reduce the number of trips for personnel	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. A decrease in concentrations will be used to justify termination of indoor air monitoring if subslab soil gas concentrations were to attenuate over time. Termination of monitoring will reduce the number of trips for personnel to the site and reduce costs.	December 2015
Energy /Emissions: Transportation	BMP C-2	Reports/ Documents	Reduce the number of trips and/or volume for transported materials, equipment, or waste	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Energy /Emissions: Transportation	BMP C-2	Fieldwork	Reduce the number of trips and/or volume for transported materials, equipment, or waste	E	FI	Cost Savings	Used previously installed vapor sampling ports for additional event, rather than abandoning as part of initial sampling event. The use of a low flow sampling approach avoids higher volumes of purge water management associated with traditional well purging approaches. Used shared groundwater sampling equipment rather than equipment dedicated to the Lockbourne project resulting in reduced shipping costs. Drums used for IDW containment were transported with the drilling equipment or purchased locally to minimize distance to be transported.	April 2014
Energy /Emissions: Transportation	BMP C-2	Alternatives	Reduce the number of trips and/or volume for transported materials, equipment, or waste	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. A decrease in concentrations will be used to justify termination of indoor air monitoring if subslab soil gas concentrations were to attenuate over time. Termination of monitoring will reduce the number of trips transporting materials and equipment to and from the site and will reduce costs.	December 2015
Energy /Emissions: Transportation	BMP C-3	Reports/ Documents	Reduce trip lengths	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Energy /Emissions: Transportation	BMP C-3	Fieldwork	Reduce trip lengths	E	FI	Cost Savings	Use locally produced supplies during remedial investigation. For example, field supplies such as trash bags, water, paper towels, etc. were purchased locally rather than transported to the site.	April 2014

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Phase	BMP Number	Project Task	BMP Description	Evaluation Status (A, P, E, Null)	Implementation Status (FI, PI, NY, Null)	Value Evaluation	Notes	Completion/ Revision Date
Energy /Emissions: Transportation	BMP C-3	Alternatives	Reduce trip lengths	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, trade and construction services will be utilized from the local community minimizing mobilization and demobilization distances which will reduce costs.	December 2015
Energy /Emissions: Transportation	BMP C-4	Reports/ Documents	Use alternate fuels or other options for transportation when possible	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Energy /Emissions: Transportation	BMP C-4	Fieldwork	Use alternate fuels or other options for transportation when possible	E	null	null	Vehicles and subcontractor equipment was gasoline or diesel powered. Alternative modes of transportation were not available.	April 2014
Energy /Emissions: Transportation	BMP C-4	Alternatives	Use alternate fuels or other options for transportation when possible	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, alternative fuel options for truck and equipment will be evaluated. If implemented, select alternative fuel options will reduce fuel costs.	December 2015
Energy /Emissions: Equipment Use	BMP D-1	Reports/ Documents	Consider and implement approaches to minimize engine idle times	null	null	null	Not considered applicable to reporting and document production activities as this is a non-field task. BMP addressed under fieldwork.	null
Energy /Emissions: Equipment Use	BMP D-1	Fieldwork	Consider and implement approaches to minimize engine idle times	E	FI	Cost Savings	Engines were shut off during non-use. This included drill rigs and support vehicles. Alternative fuel vehicles were not available for use by the subcontractors.	April 2014
Energy /Emissions: Equipment Use	BMP D-1	Alternatives	Consider and implement approaches to minimize engine idle times	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, engine idling will not be allowed during remedial action activities. This requirements will be written into solicitations and contracts with contractor/subcontractors. Eliminating engine idling will reduce fuel consumption and reduce costs.	December 2015
Energy /Emissions: Equipment Use	BMP D-2	Reports/ Documents	Ensure peak operating efficiency of equipment to reduce energy use and emissions	P	PI	Cost Neutral	Printers and copiers used for producing documents were Energy Star compliant or better. Documents produced include the remedial investigation/feasibility study work plan, background memorandum, vapor intrusion work plan, habitat assessment memorandum, remedial investigation report, and feasibility study report.	Throughout delivery order
Energy /Emissions: Equipment Use	BMP D-2	Fieldwork	Ensure peak operating efficiency of equipment to reduce energy use and emissions	E	FI	Cost Savings	Field team shut off engines when not in use. Groundwater sampling and air monitoring equipment consisted of battery operated instruments and pumps rather than electrical equipment that required the use of a generator. Battery powered equipment was charged during night time/off peak hours.	April 2014
Energy /Emissions: Equipment Use	BMP D-2	Alternatives	Ensure peak operating efficiency of equipment to reduce energy use and emissions	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, equipment used during the remedial action will be calibrated and/or maintained regularly to ensure peak operating efficiencies to reduce energy use and costs.	December 2015
Energy /Emissions: Equipment Use	BMP D-3	Reports/ Documents	Use alternate fuel options for equipment when possible	null	null	null	Not considered applicable to reporting and document production activities as this is a non-field task. BMP addressed under fieldwork.	null
Energy /Emissions: Equipment Use	BMP D-3	Fieldwork	Use alternate fuel options for equipment when possible	E	FI	Cost Savings	Utilized battery operated pumps for groundwater sampling rather than electrical pumps that required the use of generators.	April 2014
Energy /Emissions: Equipment Use	BMP D-3	Alternatives	Use alternate fuel options for equipment when possible	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, contractor/subcontractor will use alternative fuel options for equipment where possible. If Alternative 3 is selected, implementation of an alternative power source (solar) with a low environmental footprint for active subslab depressurization will be evaluated. If implemented, an alternative power source (such as solar) will reduce power requirements long-term, resulting in a cost savings.	December 2015
Energy /Emissions: Equipment Use	BMP D-4	Reports/ Documents	Select appropriate equipment and/or power source for the job	null	null	null	Not considered applicable to preparation of reports and documents since equipment, other than printers, is not used.	null
Energy /Emissions: Equipment Use	BMP D-4	Fieldwork	Select appropriate equipment and/or power source for the job	E	FI	Cost Neutral	Appropriate tools and equipment for fieldwork were evaluated during work planning phase and implemented. The equipment and tools were discussed and re-evaluated as part of the two field work charters. Battery operated tools were available and used for tasks that required mobile equipment, such as groundwater sampling. Electrical equipment, including air pumps were used during the vapor intrusion sampling where access to site electricity was readily available.	April 2014
Energy /Emissions: Equipment Use	BMP D-4	Alternatives	Select appropriate equipment and/or power source for the job	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, job-specific equipment and power sources will be used rather than an overly-conservative specified equipment and power requirements that are more costly.	December 2015
Materials and Offsite Services	BMP E-1	Reports/ Documents	Use materials that are made from recycled materials	P	PI	Cost Neutral	Used paper containing at least 30 percent postconsumer fiber for reports.	Throughout delivery order
Materials and Offsite Services	BMP E-1	Fieldwork	Use materials that are made from recycled materials	E	null	null	Use of recycled materials during the field investigation was not identified as being practical based on the limited amount of materials planned for use. In addition, specifications for materials limit use of recycled materials.	null
Materials and Offsite Services	BMP E-1	Alternatives	Use materials that are made from recycled materials	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, recycled materials will be used when feasible.	December 2015
Materials and Offsite Services	BMP E-2	Reports/ Documents	Optimize the amount of materials used	P	PI	Cost Savings	Used double-sided printing for reports.	Throughout delivery order

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Materials and Offsite Services	BMP E-2	Fieldwork	Optimize the amount of materials used	E	FI	Cost Savings	Optimized number of groundwater samples to be collected using data from previous sampling events under this investigation. Groundwater sampling tubing was dedicated to each monitoring well during each groundwater sampling event, allowing its reuse throughout the duration of the event. Disposable tubing prevented water use for decontamination, which also resulted in less waste to characterize, transport, and dispose of offsite as special waste. Tubing is disposed of at a nearby facility with other CRAA waste. Down-well tooling and equipment was decontaminated using spray bottles and paper towels rather than 5-gallon buckets of decontamination solutions, reducing IDW volumes. Optimized number of vapor and indoor/outdoor air samples to be collected using data from previous sampling events under this investigation. The initial investigation only included 2 to 3 samples per building. As a result, only one building required additional sampling based on review of the initial data.	April 2014
Materials and Offsite Services	BMP E-2	Alternatives	Optimize the amount of materials used	E	NY	Cost Savings[a]	If Alternative 2 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. A decrease in concentrations will be used to justify termination of indoor air monitoring if subslab soil gas concentrations were to attenuate over time. Termination of monitoring will reduce the amount of equipment and materials used and will reduce costs. If Alternative 3 is selected, monitoring will be conducted to evaluate how subslab soil gas concentrations of TCE change over time. Following that time period and assuming the target levels in indoor air were being met, monitoring will be discontinued, and system parameters (such as flow rate, vacuum measurements, and differential pressure measurements) will be used to demonstrate effectiveness reducing the amount of equipment and materials used, resulting in a cost savings. If Alternative 4 is selected: -Horizontal soil vapor extraction wells will be installed using directional drilling methods, as opposed to vertical wells. Horizontal wells will eliminate the need for access manways and conveyance piping inside the building and are generally less intrusive. -Subslab soil gas and air monitoring would be conducted quarterly for the first 5 years to monitor daughter product generation. Soil gas and air sampling would continue at an annual frequency for an estimated 5 years following the injections to document whether soil gas concentrations had attenuated following treatment. Monitoring will be used to assess if concentrations have decreased below residential remedial goals and triggering termination of monitoring, resulting in reduced equipment and materials used and a cost savings.	December 2015
Materials and Offsite Services	BMP E-3	Reports/ Documents	Use less refined materials when feasible	P	PI	Cost Neutral	Used paper containing at least 30 percent postconsumer fiber for reports.	Throughout delivery order
Materials and Offsite Services	BMP E-3	Fieldwork	Use less refined materials when feasible	E	null	null	Less refined materials were not needed during field work.	null
Materials and Offsite Services	BMP E-3	Alternatives	Use less refined materials when feasible	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, less refined materials will be used when feasible.	December 2015
Water Resource use	BMP F-1	Reports/ Documents	Minimize water consumption	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Water Resource use	BMP F-1	Fieldwork	Minimize water consumption	E	FI	Cost Savings	Optimized number of groundwater samples to be collected using data from previous sampling events under this investigation.	April 2014
Water Resource use	BMP F-1	Alternatives	Minimize water consumption	E	NY	Cost Savings[a]	If Alternative 2 or 3 is selected, water consumption will be minimized through implementation of best management practices during decontamination of equipment used in monitoring activities. If Alternative 4 is selected, water consumption will be minimized through optimization of dilution needed for the enhanced bioremediation substrate and implementation of best management practices during decontamination of equipment used in installing the soil vapor excavation system.	December 2015
Water Resource use	BMP F-3	Reports/ Documents	Use extracted and treated water for beneficial purposes	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Water Resource use	BMP F-3	Fieldwork	Use extracted and treated water for beneficial purposes	null	null	null	Not considered applicable due to the low volume of purge water that will be generated during the fieldwork.	null

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Water Resource use	BMP F-3	Alternatives	Use extracted and treated water for beneficial purposes	E	null	Cost Savings	Groundwater extraction is not applicable to the remedies developed.	December 2015
Water Resource use	BMP F-4	Reports/ Documents	Promote groundwater recharge	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Water Resource use	BMP F-4	Fieldwork	Promote groundwater recharge	null	null	null	Not considered applicable due to the low volume of groundwater purged during the fieldwork.	null
Water Resource use	BMP F-4	Alternatives	Promote groundwater recharge	E	NY	Cost Savings	Groundwater extraction/recharge is not applicable to the remedies developed.	December 2015
Water Resource use	BMP F-5	Reports/ Documents	Maintain water quality by preventing nutrient loading to surface water or groundwater	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Water Resource use	BMP F-5	Fieldwork	Maintain water quality by preventing nutrient loading to surface water or groundwater	E	FI	Cost Neutral	Minimized discharge of detergent wash solutions on ground. For the vapor intrusion investigation, mostly disposable equipment is used due to concerns with cross contamination since the tubing diameter is small. Therefore, decontamination water was not disposed of on the ground.	April 2014
Water Resource use	BMP F-5	Alternatives	Maintain water quality by preventing nutrient loading to surface water or groundwater	E	NY	Cost Savings[a]	If Alternative 2 or 3 is selected, nutrient loading to any surface waters or groundwater will not occur. If Alternative 4 is selected, an enhanced bioremediation substrate will be selected that minimizes nutrient loading to groundwater. Substrate injection quantities and pressures will be optimized to minimize daylighting and nutrient loading to any surface waters.	December 2015
Waste Generation, Disposal, and Recycling	BMP G-1	Reports/ Documents	Minimize drill cuttings and IDW (including personal protection equipment)	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Waste Generation, Disposal, and Recycling	BMP G-1	Fieldwork	Minimize drill cuttings and all other investigation derived waste (including personal protection equipment)	E	FI	Cost Savings	Optimized number of samples to be collected using data from this investigation. See notes above regarding the iterative approach to the sampling. Regarding waste, due to the small diameter tubing, new tubing was used at each location to prevent cross contamination. The waste was disposed of onsite with other waste generated at the facility. Down-well tooling and equipment was decontaminated using spray bottles and paper towels rather than 5-gallon buckets of decontamination solutions, reducing IDW volumes. Direct push sampling methods were used for the background study, installation of temporary monitoring wells, and soil borings for collection of soil samples rather than auger/split-spoon sampling. Direct push sampling reduced soil IDW generation and the amount of bentonite hole plug needed for borehole abandonment.	April 2014
Waste Generation, Disposal, and Recycling	BMP G-1	Alternatives	Minimize drill cuttings and other investigation derived waste (including personal protection equipment)	E	NY	Cost Savings	Will optimize number of samples to be collected using data from previous investigation. Regarding waste, due to the small diameter tubing, new tubing will be used at each location to prevent cross contamination. Down-well tooling and equipment will be decontaminated using spray bottles and paper towels rather than 5-gallon buckets of decontamination solutions, reducing waste volumes. Direct push sampling methods will be used for the injection points rather than augers. Direct push sampling will reduce soil waste generation and the amount of bentonite hole plug needed for borehole abandonment.	December 2015
Waste Generation, Disposal, and Recycling	BMP G-3	Reports/ Documents	Consider onsite treatment and reuse of soil instead of offsite disposal	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Waste Generation, Disposal, and Recycling	BMP G-3	Fieldwork	Consider onsite treatment and reuse of soil instead of offsite disposal	E	null	null	Reuse of soil was evaluated and not deemed practical based on the limited amount of soil IDW that would be generated during the field investigation.	null
Waste Generation, Disposal, and Recycling	BMP G-3	Alternatives	Consider onsite treatment and reuse of soil instead of offsite disposal	E	NY	Cost Savings[a]	If Alternative 2 or 3 is selected, soil excavation and offsite disposal is not applicable to the selected remedy. If Alternative 4 is selected, onsite treatment through soil vapor extraction will be used instead of soil excavation and offsite disposal.	December 2015
Waste Generation, Disposal, and Recycling	BMP G-4	Reports/ Documents	Minimize need to transport and dispose hazardous waste	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Waste Generation, Disposal, and Recycling	BMP G-4	Fieldwork	Minimize need to transport and dispose hazardous waste	E	null	null	Soil and groundwater IDW is classified as nonhazardous.	null

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Waste Generation, Disposal, and Recycling	BMP G-4	Alternatives	Minimize need to transport and dispose hazardous waste	E	NY	Cost Savings	Hazardous waste is not present. Also, the implementation of alternatives will minimize the need for materials that require special handling and disposal. As evaluated, the quantities of such materials will be very small, if used at all.	December 2015
Waste Generation, Disposal, and Recycling	BMP G-5	Reports/ Documents	When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Waste Generation, Disposal, and Recycling	BMP G-5	Fieldwork	When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal	E	FI	Cost Savings	Photoionization detectors (PID) were used for soil screening and air monitoring rather than flame-ionization detectors. This resulted in not needing to use or ship hydrogen.	April 2014
Waste Generation, Disposal, and Recycling	BMP G-5	Alternatives	When possible avoid/minimize use of hazardous/toxic materials that may require special handling or disposal	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, the implementation of the alternative will minimize the need for materials that require special handling and disposal. As evaluated, the quantities of such materials will be very small, if used at all.	December 2015
Waste Generation, Disposal, and Recycling	BMP G-6	Reports/ Documents	Recycle or reuse materials rather than disposing of them	P	PI	TBD	Recycled paper materials were used when practical during reporting tasks.	Throughout delivery order
Waste Generation, Disposal, and Recycling	BMP G-6	Fieldwork	Recycle or reuse materials rather than disposing of them	E	FI	Cost Savings	When applicable, recycled materials were used rather than disposable. Tubing was dedicated to monitoring wells and reused through the duration of individual sampling events. Disposable tubing prevented water use for decontamination, which also resulted in less waste to characterize, transport, and dispose of offsite as special waste. Tubing is disposed of at a nearby facility with other CRAA waste. Equipment such as water level gauges, air monitoring equipment, and vapor sampling equipment were ordered as used equipment from a CH2M HILL warehouse rather than purchasing new equipment. Cardboard boxes and shipping containers were reused rather than disposing of these items.	April 2014
Waste Generation, Disposal, and Recycling	BMP G-6	Alternatives	Recycle or reuse materials rather than disposing of them	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, materials that are used during the remedial action will be recycled or reused when applicable.	December 2015
Land Use, Ecosystems, and Cultural Resources	BMP H-2	Reports/ Documents	Minimize disturbances to land	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Land Use, Ecosystems, and Cultural Resources	BMP H-2	Fieldwork	Minimize disturbances to land	E	FI	Cost Neutral	Many of the sampling locations are located in paved areas. Other locations sampled during the background study were either in maintained grassy areas or cleared farm fields. Work occurred before crop planting, which avoided damage to crops.	April 2014
Land Use, Ecosystems, and Cultural Resources	BMP H-2	Alternatives	Minimize disturbances to land	E	FI	Cost Savings	Impacts of land disturbances during remedial alternative development were considered when developing the remedies. Soil/groundwater excavation was not selected as an appropriate remedy to evaluate further.	December 2015
Land Use, Ecosystems, and Cultural Resources	BMP H-3	Reports/ Documents	Preserve/restore ecosystems to the extent possible	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Land Use, Ecosystems, and Cultural Resources	BMP H-3	Fieldwork	Preserve/restore ecosystems to the extent possible	E	FI	Cost Increase	No disturbance to ecosystems based on field activities occurring in paved areas or inside buildings and due to the limited duration of field event. An evaluation of the habitat suitable for the upland sandpiper of AOC 94 indicated that the upland sandpiper is not present in this area.	April 2014
Land Use, Ecosystems, and Cultural Resources	BMP H-3	Alternatives	Preserve/restore ecosystems to the extent possible	E	FI	Cost Savings	Ecosystems will not be encountered during the remedial action based on remedies developed.	December 2015
Land Use, Ecosystems, and Cultural Resources	BMP H-5	Reports/ Documents	Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Land Use, Ecosystems, and Cultural Resources	BMP H-5	Fieldwork	Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site	E	FI	Cost Neutral	Monitoring wells were constructed of flush-mount construction and soil vapor probes were constructed flush with the flooring to allow reuse of the area.	April 2014

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Land Use, Ecosystems, and Cultural Resources	BMP H-5	Alternatives	Construct wells and other remedial process infrastructure (piping, buildings, etc.) to minimize restrictions to anticipated future use of the site	E	PI	Cost Savings[a]	If Alternative 2 or 3 is selected, the remedy is consistent with the current and likely future commercial/industrial use of the Site, based on the property deed. However, the remedy could also be used in the unlikely event the Site is redeveloped in the future for residential. If Alternative 4 is selected, placement of and optimization of the number of monitoring wells that will be used to monitor performance of enhanced biodegradation was considered during remedial alternative development based on anticipated future use of the site. Optimization of the number of wells reduces costs. Additionally, if Alternative 4 is selected: -Enhanced biodegradation substrate delivery will be completed through high-pressure direct-push technology rod injection. Injection wells will not be used because the Aircraft Maintenance Building may still be operational during the injections, and wells throughout the building would likely hinder the property owner's activities. -Horizontal soil vapor extraction wells (installed using directional drilling methods), as opposed to vertical, will be used to reduce impact to the site operations. Horizontal wells would also eliminate the need for access manways and conveyance piping inside the building and are generally less intrusive.	December 2015
Land Use, Ecosystems, and Cultural Resources	BMP H-6	Reports/ Documents	Preserve/restore cultural resources to the extent possible	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Land Use, Ecosystems, and Cultural Resources	BMP H-6	Fieldwork	Preserve/restore cultural resources to the extent possible	E	FI	Cost Neutral	Prepared field instructions for field staff that include instructions if cultural resources are encountered onsite. However, the sampling for this investigation occurred within the shallow subsurface beneath existing pavement or flooring.	April 2014
Land Use, Ecosystems, and Cultural Resources	BMP H-6	Alternatives	Preserve/restore cultural resources to the extent possible	E	FI	Cost Savings	Cultural resources will not be encountered during the remedial action based on remedies developed.	December 2015
Land Use, Ecosystems, and Cultural Resources	BMP H-7	Reports/ Documents	Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Land Use, Ecosystems, and Cultural Resources	BMP H-7	Fieldwork	Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources	E	FI	Cost Increase	Conducted habitat assessment for AOC 94 to assess the presence or absence of habitat and the presences or absence of the upland sandpiper.	April 2013
Land Use, Ecosystems, and Cultural Resources	BMP H-7	Alternatives	Document sensitive ecological and cultural resources prior to initiating actions that might diminish or destroy those resources	E	FI	Cost Savings	Sensitive ecological and cultural resources is not applicable to the remedies developed.	December 2015
Safety and Community	BMP I-1	Reports/ Documents	Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Safety and Community	BMP I-1	Fieldwork	Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable	E	FI	Cost Neutral	Fieldwork was conducted during daylight hours so light disturbance is not applicable. No odor disturbance was encountered. Vapor sampling purging was contained in tedlar bags and vented to the outside air.	April 2014
Safety and Community	BMP I-1	Alternatives	Minimize and mitigate noise, light and odor disturbance during all phases of the remedial process, to the extent practicable	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, the activities can be completed during standard working hours and would eliminate the need for lighting. Noise and odor disturbance for the remedy are minimal. The limited intrusive site work will occur on airport property. Noise and odor, if any, due to the remedy will be less than standard airport noise and odor disturbances. Limited resources would be needed to monitor and manage noise and odor, thus presenting a cost savings.	December 2015
Safety and Community	BMP I-2	Reports/ Documents	Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Safety and Community	BMP I-2	Fieldwork	Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)	E	FI	Cost Neutral	Dust was not generated during soil or groundwater sampling. Dust generated during the installation of the vapor intrusion ports was collected using a vacuum.	April 2014
Safety and Community	BMP I-2	Alternatives	Minimize dust during construction activities by spraying water or techniques such as laying biodegradable mats, tarps, or materials (already in EM385-1-1)	E	NY	Cost Savings[a]	Evaluated alternatives do not involve earth moving processes and machinery, thus the dust generated with implementing any of the alternatives would not be noticeable above background levels. Limited resources would be needed to address dust mitigation, thus presenting a cost savings.	December 2015
Safety and Community	BMP I-3	Reports/ Documents	Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null

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Safety and Community	BMP I-3	Fieldwork	Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts	E	FI	Cost Neutral	Transportation routes are dictated by the airport. IDW transportation offsite was reviewed to verify that local staff were used.	April 2014
Safety and Community	BMP I-3	Alternatives	Select transportation routes for trucks and heavy equipment that minimize impacts to residential areas to maximize safety and minimize noise and other aesthetic impacts	E	NY	Cost Savings[a]	If Alternative 2, 3, or 4 is selected, estimates of transportation hazards are low since limited equipment is needed to implement the remedy. For the minimal trucks needed, the airport selects the routes while onsite. For offsite portions of the routes, noise and other aesthetic impacts are minimal resulting in preparation of a streamlined transportation plan resulting in a cost savings.	December 2015
Safety and Community	BMP I-4	Reports/ Documents	Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Safety and Community	BMP I-4	Fieldwork	Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells	E	null	null	Not considered applicable due to the low volume of purging during the fieldwork.	null
Safety and Community	BMP I-4	Alternatives	Minimize drawdown of the water table in areas that could impact production rates at supply wells and/or irrigation wells	E	FI	Cost Savings	The proposed remedial alternatives do not include groundwater extraction or implementation of activates where drawdown of the water table could impact production rates at supply wells and/or irrigation wells.	December 2015
Safety and Community	BMP I-5	Reports/ Documents	Minimize amount of time that heavy machinery is needed to enhance safety	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Safety and Community	BMP I-5	Fieldwork	Minimize amount of time that heavy machinery is needed to enhance safety	E	FI	Cost Savings	DPT equipment was used for soil borings instead of standard drilling equipment, resulting in less fuel consumption and less IDW generation.	April 2013
Safety and Community	BMP I-5	Alternatives	Minimize amount of time that heavy machinery is needed to enhance safety	E	NY	Cost Savings[a]	If Alternative 2 or 3 is selected, the use of heavy machinery will be minimized resulting in a less conservative level of protectiveness and fewer resources. If Alternative 4 is selected, heavy machinery hazards for the remedy will be minimized through implementation of best management practices.	December 2015
Safety and Community	BMP I-6	Reports/ Documents	Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Safety and Community	BMP I-6	Fieldwork	Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals	E	FI	Cost Neutral	Used pre-preserved laboratory sample jars for fieldwork.	April 2014
Safety and Community	BMP I-6	Alternatives	Minimize handling of dangerous chemicals by selecting alternate chemicals and/or engineering to minimize contact with chemicals	E	NY	Cost Savings[a]	If Alternative 2 or 3 is selected, the use of dangerous chemicals (sealants) will be minimal. If Alternative 4 is selected, the use of dangerous chemicals (sealants) will be minimal and application of an innocuous enhanced biodegradation substrate to the subsurface poses minimal handling risks when compared to use of other injectable treatments. If Alternative 2, 3, or 4 is selected, the development and implementation of a health and safety plan will limit the potential for negative impacts associated with chemical use. Due to the minimal risks, a less robust health and safety plan will be prepared which will result in a cost savings.	December 2015
Safety and Community	BMP I-7	Reports/ Documents	Contribute to local economy when possible	E	NY	Cost Neutral	Use local newspapers for public notification of proposed plan. Reserve space at local community center for public meetings.	TBD
Safety and Community	BMP I-7	Fieldwork	Contribute to local economy when possible	E	FI	Cost Savings	Field team stayed at local hotels and utilized local restaurants, rather than commuting to the site. Consumable equipment (paper towels, water, etc..) was purchased locally. Drums for groundwater sampling were obtained locally.	April 2014
Safety and Community	BMP I-7	Alternatives	Contribute to local economy when possible	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, trade and construction services will be utilized from the local community which will contribute to the local economy. Using local trade and construction services will present a cost savings due to reduced mobilization and demobilization fees.	December 2015
Safety and Community	BMP I-8	Reports/ Documents	Use onsite construction practices and personal protective equipment (PPE) requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive	null	null	null	Not considered applicable to reporting activities. BMP addressed under fieldwork.	null
Safety and Community	BMP I-8	Fieldwork	Use onsite construction practices and PPE requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive	E	FI	Cost Savings	Identified Health & Safety subject matter expert to appropriately determine field practices and PPE requirements for remedial investigation field work. PPE requirements were communicated to field team in field project instructions.	April 2014
Safety and Community	BMP I-8	Alternatives	Use onsite construction practices and PPE requirements for anticipated exposure scenarios rather than an overly conservative level of protectiveness that is more resource intensive	E	NY	Cost Savings[a]	If Alternative 2, 3 or 4 is selected, USACE will use onsite construction practices and PPE requirements for anticipated exposure scenarios based on site-specific data rather than an overly conservative level of protectiveness that is more resource intensive.	December 2015

Notes:
1. Evaluation Status through the Feasibility Study Report:

TABLE D-2

Summary of Best Management Practices

Phase	BMP Number	Project Task	BMP Description	Evaluation Status (A, P, E, Null)	Implementation Status (FI, PI, NY, Null)	Value Evaluation	Notes	Completion/ Revision Date

A = BMPs that were identified as potentially applying to the project.
E = BMPs that were identified as applicable, practical, and them reviewed for implementation.
P = BMPs that were identified as applicable and practical for the project to implement.
null = not applicable

2. Implementation status through the Feasibility Study Report:
   FI = Fully implemented.
   PI = Partially implemented.
   NY = Not Yet, but expected to be implemented.
   null = Not applicable
3. Value Evaluation consists of qualitative net cost impact over five (5) years with no discounting. Categories include:
   Cost Increase
   Cost Neutral
   Cost Savings
   TBD = To be determined.
   null = Not applicable
4. Subcontract procurement is included under the Fieldwork project task.
5. Includes BMPs deemed applicable to the project. BMPs not included in this table (presented in the memorandum) are not applicable to the current project but may apply to remedial design and remedial action activities.
6. Alternative 1, No Action, was not included in the evaluation.

[a]The United States Army Corps of Engineers (USACE) and its contractors will optimize the selected alternative to meet green and sustainable remediation objectives during the remedial design phase of work and implement the optimized design during the remedial construction and long-term O&M phase of work. Subsequent USACE task orders for the remedial design will include an updated SiteWise assessment of the selected alternative to identify potential additional GSR optimization opportunities that may be identified during the design process as well as completion of a best management practices evaluation that can identify BMPs that will be implemented during the construction and long-term O&M phases of work. USACE prefers to realize the anticipated cost savings designation now, but will be re-evaluated after the remedy is selected and during implementation.

TABLE D-3

Summary of Best Management Practices Applicability and Implementation

	BMP Category								
	A. Planning	**B. Characterization or Remedy Approach**	**C. Energy/ Emissions Transportation**	**D. Energy/ Emissions Equipment Use**	**E. Materials & Offsite Services**	**F. Water Resource Use**	**G. Waste Generation, Disposal, and Recycling**	**H. Land Use, Ecosystems, and Cultural Resources**	**I. Safety and Community**
Total number of BMPs[a]	11	8	4	4	3	4	5	5	8
Applicable BMPs[a]	11	8	4	4	3	4	5	5	8
Practical BMPs[a]	11	8	4	4	3	4	5	5	8
Evaluated BMPs[a]	11	8	4	4	3	4	5	5	8
Null[a]	0	0	0	0	0	0	0	0	0
BMPs Implemented through the Feasibility Study Report Phase (Includes the Most Mature Implementation Status of Reports/Documents, Fieldwork, and Alternatives)[b]									
Fully[b]	8	8	3	4	1	2	3	5	8
Partially[b]	2	0	0	0	2	0	0	0	0
Not yet[b]	1	0	1	0	0	1	2	0	0
Null[b]	0	0	0	0	0	1	0	0	0
Practical BMPs likely to result in cost savings[c]	9	8	4	4	3	4	5	5	8

[a]Total Number of BMPs = Total Number of BMPs listed in Table D-2 under each BMP Category that are carried forward.
Applicable = BMPs listed in Table D-2 that were identified as potentially applying to the project.
Practical = BMPs listed in Table D-2 that were identified as applicable and practical for the project to implement.
Evaluated = BMPs listed in Table D-2 that were identified as applicable, practical, and them reviewed for implementation.
[b]Number of BMPs listed in Table D-2.
[c]Number of BMPs listed in Table D-2 that will result in cost savings.

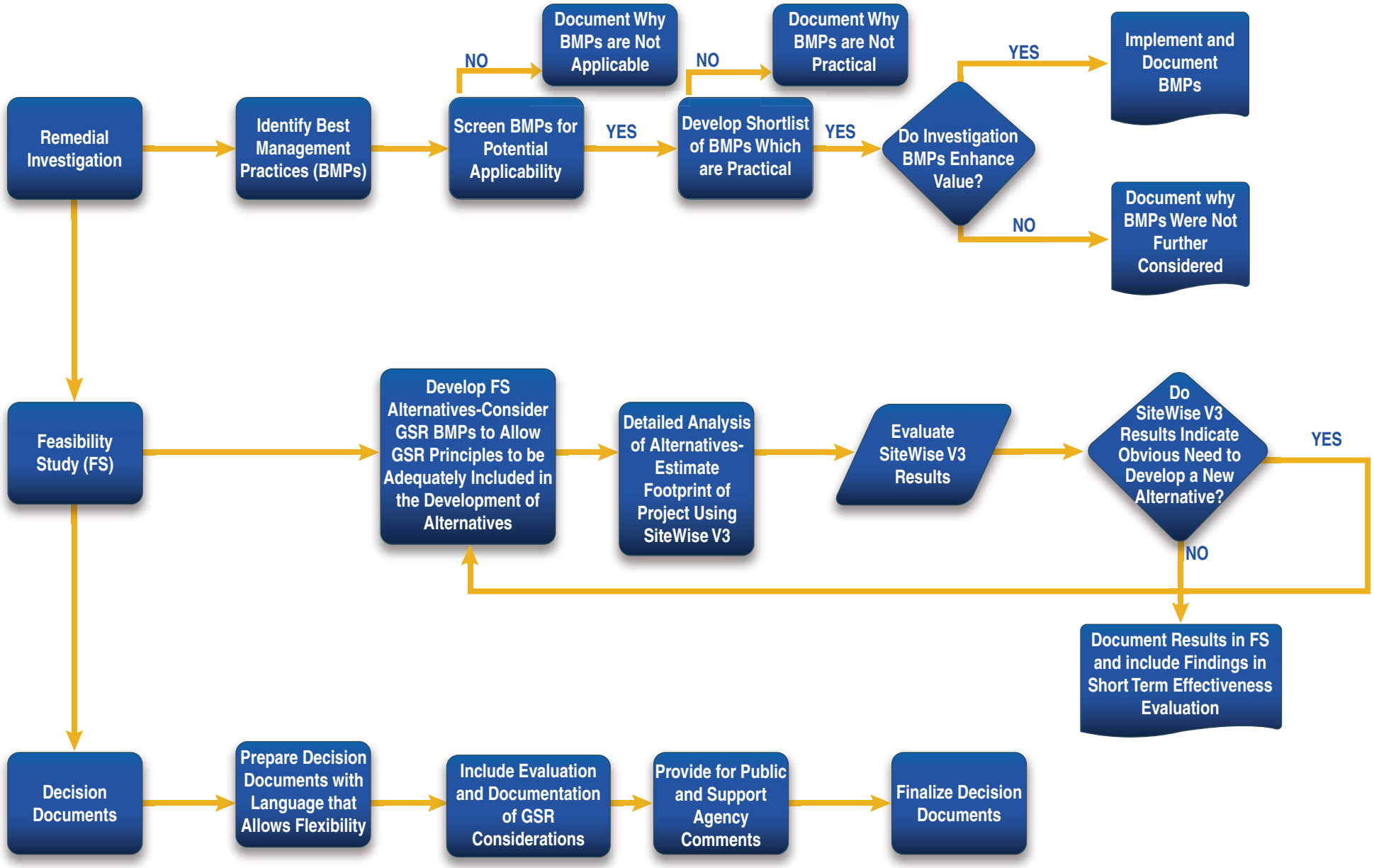


FIGURE 1
GSR Decision Logic
Green and Sustainable Remediation Technical Memorandum
Former Lockbourne, AFB, Columbus, Ohio

Attachment 1
SiteWise Evaluation

The following remedial alternatives were developed to address potential risks to human health and the environment at areas of concern (AOCs) 17, 18, 19, and 103.

- Alternative 1—No Action
- Alternative 2—Sealing and Monitoring
- Alternative 3—Active Subslab Depressurization
- Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction

The purpose of this analysis is to provide a quantitative assessment of the potential environmental and social impact (in terms of accident risks) of each remedial alternative. The sustainability analysis was performed using SiteWise version 3.0 (NAVFAC 2013) for Alternatives 2 through 4. Although the no-action alternative (Alternative 1) has no actions that would impact sustainability, it is not considered a viable alternative and will not be further discussed in this analysis.

Method and Assumptions

The SiteWise tool consists of a series of Excel-based spreadsheets used to conduct a baseline assessment of sustainability metrics. The assessment is carried out using a spreadsheet-based building block approach, where every remedial alternative can be broken down into components for discrete phases of work (such as construction, operation, long-term monitoring), or different systems for more complex remedial actions.

SiteWise uses various emission factors from governmental or non-governmental research sources to determine the environmental impact of each activity. The quantitative metrics calculated by the tool include:

1. Greenhouse gases (GHGs) reported as metric tons of carbon dioxide equivalents (CO_2e), consisting of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)
2. Energy usage (expressed as millions of British thermal units [MMBTU])
3. Water usage (gallons of water)
4. Air emissions of criteria pollutants consisting of metric tons of nitrogen (NO_x), sulfur oxides (SO_x), and particulate matter (PM_{10})
5. Accident risk (risk of injury and risk of fatality)

For the purpose of this discussion, the term footprint will be used to describe the quantified emissions or quantities for each metric. To estimate the sustainability footprint for each removal action alternative, only those elements possessing important sustainability impacts were included in the assessment. A lower footprint indicates lower deleterious impacts to environmental and social metrics, which collectively make up the SiteWise sustainability metrics. Conversely, a higher footprint indicates higher deleterious impacts associated with the SiteWise metrics. The major conclusions of this sustainability analysis are incorporated into the effectiveness criteria evaluation of the FS.

The following is a description of the major activities for each alternative.

- Alternative 2—Sealing and Monitoring (details provided in Table 1)
  - Transportation of personnel and equipment for monitoring activities
  - Onsite labor hours for estimate of accident risks during monitoring activities
- Alternative 3—Active Subslab Depressurization (details provided in Table 2)
  - Production of materials for depressurization system
  - Transportation of personnel, materials, and equipment for depressurization system
  - Equipment use (blowers or powered mitigation fans)
  - Onsite labor hours for estimate of accident risks during installation and monitoring
  - Transportation and disposal of residuals to nonhazardous landfills

- Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction (details provided in Table 3)
  - Production of materials for monitoring and SVE wells and lactate[1] for injections (a total of 5 injection events using direct-push technology [DPT])
  - Transportation of personnel and equipment for well installation and injection and monitoring activities
  - Equipment use for well installation, injections, and operating the SVE system (blowers)
  - Onsite labor hours
  - Transportation and disposal of residuals to nonhazardous landfills

General Assumptions

The specific assumptions made for the individual remedies are presented in Tables 1 through 3. The following general assumptions are used for the SiteWise tool evaluation:

- The complete environmental footprint for production of equipment used, or production of the vehicles used for transportation, is not considered in this analysis.
- Initial transportation to the site varies by activity, oversight and sampling activities are assumed to be performed by employees from the Midwest (average 150 miles one way).
- Nonhazardous landfill is located 45 miles away from the site.
  - The environmental impacts associated with the life cycle of the landfill are not included, as reliable footprint factors are not available for this element of the project. However, the impacts of landfilling waste, with respect to the SiteWise metrics, are considered to be very small compared to those of the other alternative components.
- Negligible waste will be generated during injections and air monitoring.
- The following weights and distance for delivery are used for equipment:
  - DPT rig and tooling—3.5 tons, 500 miles round trip
  - Injection equipment (tanks, hoses, water truck)—15 tons, 500 miles round trip

Results and Conclusions

A comparative analysis for Alternatives 2, 3, and 4 is summarized in Figure 1. Table 4 presents a comparison of the quantitative and relative environmental footprint metrics evaluated for each of the removal action alternatives.

The relative impact is a qualitative assessment of the footprint of each alternative, a rating of high, medium, or low is assigned to each alternative based on its performance against the other alternatives. A “high” impact is least desirable and low impacts are preferred. The tool assigns a ranking of “high” to the highest footprint in each category and assigns the rankings of other alternatives based on the difference in the data between alternatives. In this case, a higher footprint indicates a higher potential for deleterious environmental impacts, therefore, a lower footprint is preferred.

The ranking is based on a 30 percent difference; for example, if the footprints of two alternatives are within 30 percent of each other, they will be given the same rating. Alternative 2 had the lowest relative footprints for the sustainability metrics compared with Alternatives 3 and 4 because it does not involve active remediation, whereas Alternatives 3 and 4 involve active remediation and long-term monitoring. Alternative 3 had the highest footprints in the categories, except accident risks, from electricity use to power the blower for 30 years of operation. Alternative 4 had the highest accident risk footprints because injections and monitoring required more site visits and onsite labor hours.

[1] Emulsified vegetable oil (EVO) was used as a proxy in SiteWise because footprint data for lactate is not available. The footprint is likely an overestimate because lactate is less resource intensive to produce than EVO.

It should be noted that while this analysis compares the environmental footprints of each of the alternatives, the alternatives may differ with respect to other evaluation criteria. Therefore, a comparison of the results of the alternatives needs to be made in the context of the benefits (ARAR compliance, contaminant reduction, site reuse, cost effectiveness, etc.) of each of the alternatives.

The following is a summary of the individual alternatives.

Alternative 2—Sealing and Monitoring

Results are provided in Table 5 and Figure 2. Transportation to and from the site during monitoring events contributed to all of the environmental footprints (GHG, energy, criteria air pollutants) and the majority of the accident risk injury and fatality footprints. Water use was negligible for this alternative.

Alternative 3—Active Depressurization

Results are provided in Table 6 and Figure 3. Operating the depressurization system contributed to almost all of the environmental and water use footprints because the system does not treat the source of indoor air, and it is assumed that it will need to operate indefinitely. However, if monitoring during passive depressurization indicates that there will not be a need for active depressurization, the environmental impacts may be significantly lower. Further, if an alternative power source that has a lower environmental footprint is used (solar, for example), the impacts will also be lower. System installation and O&M contributed 40 to 60 percent of the accident risk footprints from transportation to and from the site and onsite labor hours. Although this alternative does not directly use water onsite, SiteWise includes embedded water from electricity use, which contributed a significant amount to the water consumption footprint for this alternative.

Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction

Results are provided in Table 7 and Figure 4. The equipment use component during SVE operations and additional injections, which is primarily made up of electricity use for the blower, contributed to over 80 percent of the GHG footprint, 70 percent of the energy use footprint, 95 percent of the water use, 75 percent of the NO_X, over 95 percent of the SO_X and PM_{10} footprints, and approximately 30 percent of the accident risk footprints.

The additional injection and SVE operations phase contributed approximately half of the accident risk footprints with initial injection/well installation events and monitoring contributing 20 and 30 percent, respectively.

Uncertainty

The SiteWise tool calculates environmental and risk footprints based on industry averages, published emissions factors, and generalized data sources. The footprint results are not representative of actual emissions and should be used for comparative purposes only.

Water use for consumable manufacturing is not included in this analysis; however, water is most likely used for the manufacture of most materials. As a result, the water use for each alternative may be underestimated, particularly where large volumes of injection materials are used.

The use of EVO in place of lactate may have overestimated the footprint for Alternative 4 because EVO typically requires more energy and resources to manufacture.

Recommendations

The estimates from the SiteWise tool were used to estimate the environmental footprint of the alternatives. Once the alternative is selected, it is recommended that the footprint of the selected alternative be further evaluated in the design phase of the projects to explore opportunities to optimize the environmental footprint of the project and integrate sustainable remediation best practices in the design, construction, and operation of the removal action.

If Alternative 3 is selected, source treatment may be able to reduce the duration the active depressurization system needs to run. The major contributor to the overall footprint was from electricity use to power the blower;

if a green power source, such as solar panels or wind is used, it could significantly reduce the footprint in the long term.

If Alternative 4 is selected, potential best practices may include sourcing injection materials from a company with a lower environmental footprint or commitment to sustainable manufacture. The use of bench-scale testing and tracer tests to get a better understanding of site conditions should be used to optimize the required amount of materials once selected. Similar to Alternative 3, green power sources or reduced electricity use could also reduce the environmental impact of Alternative 4.

If allowed, water used for injections may be sourced from graywater or other alternatives to drinking water.

References

NAVFAC (Naval Facilities Engineering Command). 2013. *SiteWise Version 3 User's Guide*. July.

TABLE 1
Alternative 2—Sealing and Monitoring
Feasibility Study for AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Phase	Assumptions
Sealing and Monitoring	**Initial sampling and crack-sealing event. Semi-annual vapor sampling for 2 years (4 events), sampling every 5 years for 10 years (2 events).**
Labor Hours	270 hours (3 person crew, 5 x 10 hour days per person for initial event, monitoring: 20 hours per event for 6 events) - assume labor type is equivalent to operating engineers
Transportation	
Personnel Transportation - Road	
Initial Sealing Event	3 people, light duty truck, gas powered, driving 300 miles round trip, 3 trips total
Initial Sealing Event	1 vehicle, 2 people, light duty, gas powered truck, driving from Chicago or Dayton (average 300 mile R/T, 6 trips total)

Note: The assumptions provided in this table are based on the FS conceptual design for this alternative. These assumptions are only provided to develop cost estimates and conduct the SiteWise environmental impact assessment, which are used to evaluate the alternatives. The actual design details would be developed during a future remedial design phase.

R/T = round trip

TABLE 2
Alternative 3—Active Depressurization
Feasibility Study for AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Phase	Assumptions
System Installation	**Install piping, soil gas monitoring points, and mitigation fan system (blowers).**
Consumables	Piping - 1,000 linear feet of 2-inch diameter HDPE piping
Labor Hours	450 hours (150 hours per person, 3 person crew) - assume labor type is equivalent to construction laborers
Transportation	
Personnel Transportation - Road	
Installation/Sealing Event	3 people, light duty truck, gas powered, driving 300 miles round trip, 3 trips total
Utility Locate	Assume local travel approx. 25 miles R/T, 2 people, light duty truck, gas powered
Equipment Transportation - Road	Blowers/piping: 1 ton total, shipped 400 miles on a shared load road Drill Rig for soil gas point installation - 5 tons, 400 miles
Equipment Use	Drill Rig - 40 points, 2 hours at each point, DPT rig
Residual Handling	
Residual Disposal	Assume 4 drums generated during vapor sampling point installation (approx. 650 lbs per drum, 1.3 ton), transported to landfill located 100 miles away (one way)
O&M	**Semi-annual vapor sampling for 2 years (4 events), quarterly inspections (local travel) for 30 years**
Labor Hours	560 hours (Monitoring: 20 hours per event for 4 events, inspections - 4 hours per event 120 events) - Operating Engineers
Transportation	
Personnel Transportation - Road	Monitoring: Assume 1 vehicle, 2 people, light duty, gas powered truck, driving from Chicago or Dayton (average 300 mile R/T, 4 trips total) Inspections: Assume 1 vehicle 1 person, light duty, gas powered truck, driving 25 miles round trip, 120 trips
Equipment Use	Mitigation fans powered by two 3 hp blowers operating continuously for 30 years

Note: The assumptions provided in this table are based on the FS conceptual design for this alternative. These assumptions are only provided to develop cost estimates and conduct the SiteWise environmental impact assessment, which are used to evaluate the alternatives. The actual design details would be developed during a future remedial design phase.

R/T = round trip

TABLE 3
Alternative 4—Enhanced Bioremediation and Soil Vapor Extraction
Feasibility Study for AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Phase	Assumptions
Initial injections and SVE system installation	**Initial Injections, install SVE system including horizontal well installation**
Material Production	
Treatment Chemicals and Materials	Monitoring well materials (4 wells, 2-inch diameter, 5 foot screen, 14 feet deep, PVC)
	2,000 gallons soluble lactate substrate (specific gravity = 1.25, 10.4 lb/gal = 20,800 lbs total, 60 percent lactate by weight = 12,480 lbs, proxy EVO for lactate in SiteWise)
	Horizontal well materials (600 total feet, 4-inch HDPE)
Transportation	
Personnel Transportation - Road	
Pilot Injection/well install oversight	2 people, light duty truck, gas powered, 300 miles R/T, 1 trip
Full Scale Injection oversight	2 people, light duty truck, gas powered, 300 miles R/T, 1 trip
Baseline Sampling	2 people, light duty truck, gas powered, 300 miles R/T, 1 trip
Utility Locate	Assume local travel approx. 25 miles R/T, 2 people, light duty truck, gas powered
Survey	Assume local travel approx. 25 miles R/T, 2 people, light duty truck, gas powered
Drilling/Injection Support Crew	3 person crew, heavy duty truck, diesel powered, 1,000 mi R/T (2 trips
Equipment Transportation - Road	
Substrate	20,800 lbs (10.4 tons), transported 500 miles, empty return
Drill Rig Transport	Assume Geoprobe 6610DT or equivalent (5000 lb - 2.5 tons) 1 rig transported using heavy duty diesel truck, tooling adds 1 ton. 500 miles one way, load is 3.5 tons
	HDD rig - 10 tons, transported 500 miles one way, add 10 tons for additional tooling and equipment
Injection Equipment Transport	Assume tanks, pumps, and associated injection equipment weigh a total of 5 tons (500 miles one way)
SVE Equipment Transport	Assume SVE system equipment weights a total of 5 tons (500 miles one way)
Equipment Use	
Drilling/Injection	Well install - DPT equipped with HSA for shallow wells - 4 wells, 6 hours each well
	Assume 1 DPT rig, 134 injection points, 4 points at a time (~34 quads), 3 hours per quad
	Horizontal well install - assume similar impact as hollow stem auger, 2 wells, 30 hours drilling per wel
Residual Handling	
Residual Disposal/Recycling	assume waste is negligible for DPT injections (solid cores)
	20 tons from well install and baseline samples to non-hazardous waste landfill 100 miles away
Labor Hours	1,410 hours (well/SVE system install = 4 people 12 days, 10 hrs/day, pilot injections = 3 people 5 days, injections = 3 people for 22 days, 10 hrs/day; survey = 2 people for 1 day, 10 hrs/day; utility locate= 2 people for 2 days, 10 hrs/day, baseline sampling = 2 people 3 days,10 hr/day) - Construction Laborers
Other Known Onsite Activities	Water Use = 7,730 gallons for injections, 5,000 gallons for well install/decontamination
Additional EVO Injections/SVE operations	**4 additional injections, same quantity and scale as initial (assumptions below are for 1 injection event, all data entered 4x into SiteWise tool), SVE system (blower operating for 5 years)**
Material Production	
Treatment Chemicals and Materials	2,000 gallons soluble lactate substrate (specific gravity = 1.25, 10.4 lb/gal = 20,800 lbs total, 60 percent lactate by weight = 12,480 lbs, proxy EVO for lactate in SiteWise)
Transportation	
Personnel Transportation - Road	
Injection oversight	1 person, light duty truck, gas powered, 300 miles R/T, 1 trips
Utility Locate	Assume local travel approx. 25 miles R/T, 2 people, light duty truck, gas powered
Drilling/Injection Support Crew	3 person crew, heavy duty truck, diesel powered, 1,000 mi round trip (1 trip)
SVE system O&M	1 person, light duty truck, gas powered, 25 miles R/T, 60 trips
Equipment Transportation - Road	
Substrate	20,800 lbs (10.4 tons), transported 500 miles, empty return
Drill Rig Transport	Assume Geoprobe 6610DT or equivalent (5000 lb - 2.5 tons) 1 rigs transported using heavy duty diesel truck, tooling adds 1 ton. 500 miles one way, load is 3.5 tons
Injection Equipment Transport	Assume tanks, pumps, and associated injection equipment weigh a total of 5 tons (500 miles one way)
SVE Equipment Use	15 hp blower (Ohio electricity mix), operating for 5 years, 24 hrs per day (43,800 hours total)
Equipment Use	
Drilling/Injection	Assume 1 DPT rig, 134 injection points, 4 points at a time (~34 quads), 3 hours per quac
Residual Handling	
Residual Disposal/Recycling	assume waste is negligible for DPT injections (solid cores)
Labor Hours	1,920 hours (injections = 4 people for 10 days, 10 hrs/day x 4 events; 10 hrs/day; utility locate= 2 people for 2 days, 10 hrs/day, Routine O&M - 4 hrs per event, 12 times/year, 5 years) - Construction Laborers except O&M
Other Known Onsite Activities	Water Use = 7,730 gallons x 4
Long-term Monitoring	**6 years of quarterly performance monitoring and MNA**
Labor Hours	1,940 hours (approx. 60 hours per event for 24 groundwater events, 20 hours per event for 25 air sampling events) - Operating Engineers
Transportation	
Personnel Transportation - Road	Assume 1 vehicle, 2 people, light duty, gas powered truck (300 mile R/T, 49 trips, no shared groundwater and air monitoring trips)
Residual Handling	
Residual Disposal/Recycling	Assume low-flow sampling, 1 drum per event (approx. 500 lbs per drum, 0.25 tons), transported to landfill located 100 miles away (one way), 24 trips
Empty	100 miles away (one way), 24 trips

Note: The assumptions provided in this table are based on the FS conceptual design for this alternative. These assumptions are only provided to develop cost estimates and conduct the SiteWise environmental impact assessment, which are used to evaluate the alternatives. The actual design details would be developed during a future remedial design phase.

DPT = direct push technology	EVO = emulsified vegetable oil
R/T = round trip	hrs = hours
O&M = operations and maintenance	SVE = soil vapor extraction

TABLE 4

Relative Impact of Alternatives

Feasibility Study for AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Remedial Alternatives	GHG Emissions	Total energy Used	Water Used	NO_x Emissions	SO_x Emissions	PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Alternative 1—No Action	0	0	0	0	0	0	0	0
Alternative 2—Sealing and Monitoring	1	19	0	6.18E-04	1.94E-05	8.83E-05	4.95E-05	9.04E-03
Alternative 3—Active Depressurization	1,075	12,342	599,668	1.02E+00	5.25E+00	2.32E+00	1.36E-04	2.97E-02
Alternative 4—Enhanced Bioremediation and Soil Vapor Extraction	535.4	7174.2	2.94E+05	6.11E-01	2.31E+00	1.00E+00	9.66E-04	1.76E-01

Remedial Alternatives	GHG Emissions	Total energy Used	Water Used	NO_x Emissions	SO_x Emissions	PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
	metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Alternative 1—No Action	Low	Low	Low	Low	Low	Low	Low	Low
Alternative 2—Sealing and Monitoring	Low	Low	Low	Low	Low	Low	Low	Low
Alternative 3—Active Depressurization	High	High	High	High	High	High	Low	Low
Alternative 4—Enhanced Bioremediation and Soil Vapor Extraction	Medium	Medium	Medium	Medium	Medium	Medium	High	High

Notes:

The relative impact is a qualitative assessment of the relative footprint of each alternative, a rating of High for an alternative is assigned if it is at least 70 percent of the maximum footprint, a rating of Medium is assigned if it is between 30 and 70 percent of the maximum footprint, and a rating of Low is assigned if it is less than 30 percent of the maximum footprint.

Accident Risk is an estimate of how many accidents may occur. This risk is not the same as Cancer Risk, which is the probability (for a single person) of getting cancer. Accident risk is not comparable to Cancer Risk due to inherent fundamental differences.

MMBTU - million British Thermal Unit

NOx - Nitrogen Oxides

SOx - Sulfur Oxides

PM10 - Particulate Matter

GHG - Greenhouse Gases

TABLE 5

Results: Alternative 2—Sealing and Monitoring

Feasibility Study for AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Component	Activities	GHG Emissions	Total Energy Used	Water Used	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Sealing and Monitoring	Consumables	0.00	0.00	NA	0.0E+00	0.0E+00	0.0E+00	NA	NA
	Transportation-Personnel	1.49	18.77	NA	6.2E-04	1.9E-05	8.8E-05	3.5E-05	2.8E-03
	Transportation-Equipment	0.00	0.00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0.00	0.00	0	0.0E+00	0.0E+00	0.0E+00	1.4E-05	6.2E-03
	Residual Handling	0.00	0.00	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	1.49	18.77	0.00	6.18E-04	1.94E-05	8.83E-05	4.95E-05	9.04E-03
Total		**1.5**	**19**	**0**	**6.18E-04**	**1.94E-05**	**8.83E-05**	**4.95E-05**	**9.04E-03**

Notes:

MMBTU - million British Thermal Unit

NOx - Nitrogen Oxides

SOx - Sulfur Oxides

PM10 - Particulate Matter

NA - Not Applicable

GHG - Greenhouse Gases

TABLE 6

Results: Alternative 3—Active Depressurization and Monitoring

Feasibility Study for AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Component	Activities	GHG Emissions	Total Energy Used	Water Used	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
System Installation	Consumables	0.08	3.08	NA	1.5E-04	2.1E-04	2.6E-05	NA	NA
	Transportation-Personnel	0.51	6.43	NA	2.1E-04	6.7E-06	3.0E-05	7.4E-06	6.0E-04
	Transportation-Equipment	0.70	9.17	NA	2.2E-04	3.9E-06	2.0E-05	6.2E-06	5.0E-04
	Equipment Use and Misc	0.72	8.69	0	7.3E-03	9.1E-04	6.8E-04	4.8E-05	1.2E-02
	Residual Handling	0.30	4.02	NA	1.7E-04	4.6E-05	2.4E-04	1.6E-06	1.3E-04
	Sub-Total	2.31	31.39	0	8.04E-03	1.17E-03	9.98E-04	6.37E-05	1.34E-02
Monitoring	Consumables	0	0	NA	0.0E+00	0.0E+00	0.0E+00	NA	NA
	Transportation-Personnel	2.31	29	NA	9.6E-04	3.0E-05	1.4E-04	4.2E-05	3.4E-03
	Transportation-Equipment	0	0	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	1,070	12,281	599,668	1.0E+00	5.2E+00	2.3E+00	3.0E-05	1.3E-02
	Residual Handling	0	0	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	1,072	12,311	599,668	1.01E+00	5.25E+00	2.32E+00	7.21E-05	1.63E-02
Total		**1,075**	**12,342**	**599,668**	**1.02E+00**	**5.25E+00**	**2.32E+00**	**1.36E-04**	**2.97E-02**

Notes:

MMBTU - million British Thermal Unit

NOx - Nitrogen Oxides

SOx - Sulfur Oxides

PM10 - Particulate Matter

NA - Not Applicable

GHG - Greenhouse Gases

TABLE 7

Results: Alternative 4—Enhanced Biodegradation and Soil Vapor Extraction

Feasibility Study for AOCs 17/18/19/103

Former Lockbourne Air Force Base, Ohio

Component	Activities	GHG Emissions	Total Energy Used	Water Used	NO_x Emissions	SO_x Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	metric ton	metric ton	metric ton		
Initial Injections/SVE System Installation	Consumables	13.95	968	NA	1.8E-02	3.0E-02	5.3E-03	NA	NA
	Transportation-Personnel	3.34	43	NA	1.1E-03	2.2E-05	1.1E-04	6.2E-05	5.0E-03
	Transportation-Equipment	5.06	66	NA	1.6E-03	2.8E-05	1.4E-04	2.0E-05	1.6E-03
	Equipment Use and Misc	8.05	97	12,730	8.1E-02	1.0E-02	7.6E-03	1.5E-04	3.7E-02
	Residual Handling	1	9	NA	1.4E-03	6.8E-04	3.6E-03	1.6E-06	1.3E-04
	Sub-Total	30.97	1,184	12,730	1.03E-01	4.14E-02	1.68E-02	2.29E-04	4.34E-02
Additional Injections/SVE Operations	Consumables	19.59	371	NA	3.9E-02	7.8E-02	1.6E-02	NA	NA
	Transportation-Personnel	7.17	93	NA	2.4E-03	5.1E-05	2.5E-04	1.2E-04	9.4E-03
	Transportation-Equipment	13.18	172	NA	4.1E-03	7.3E-05	3.7E-04	4.7E-05	3.8E-03
	Equipment Use and Misc	449.51	5,162	280,782	4.6E-01	2.2E+00	9.7E-01	2.0E-04	5.4E-02
	Residual Handling	0	0	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	489.45	5,798	280,782	5.02E-01	2.27E+00	9.85E-01	3.67E-04	6.67E-02
Monitoring	Consumables	0	0	NA	0.0E+00	0.0E+00	0.0E+00	NA	NA
	Transportation-Personnel	8.10	102	NA	3.4E-03	1.1E-04	4.8E-04	2.3E-04	1.8E-02
	Transportation-Equipment	0	0	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	0	0	0	0.0E+00	0.0E+00	0.0E+00	1.0E-04	4.5E-02
	Residual Handling	6.84	90	NA	2.6E-03	2.8E-04	1.5E-03	3.7E-05	3.0E-03
	Sub-Total	14.94	192	0	5.95E-03	3.88E-04	1.98E-03	3.71E-04	6.61E-02
Total		**535.4**	**7,174**	**293,512**	**6.11E-01**	**2.31E+00**	**1.00E+00**	**9.66E-04**	**1.76E-01**

Notes:

MMBTU - million British Thermal Unit

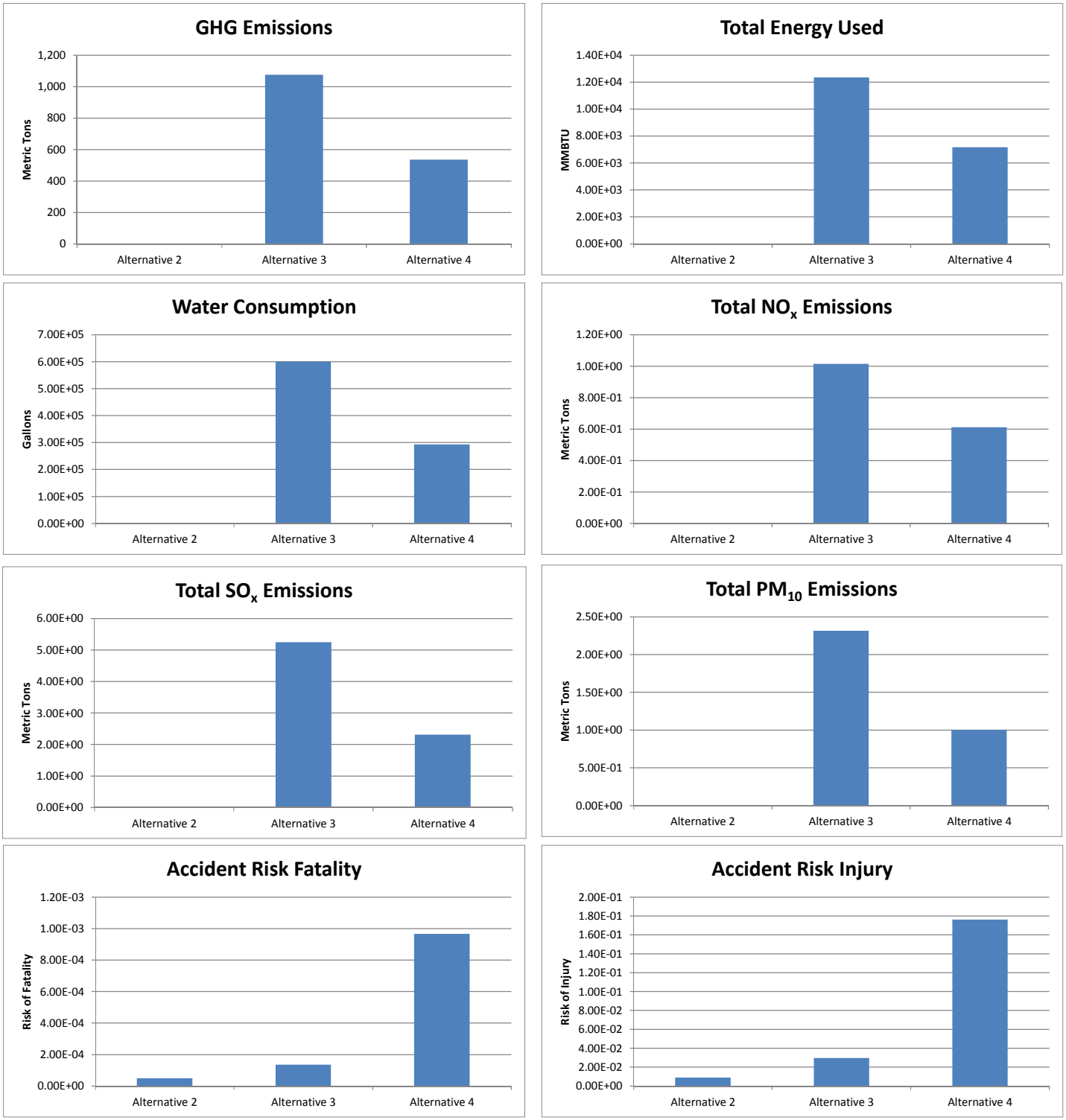
NOx - Nitrogen Oxides

SOx - Sulfur Oxides

PM10 - Particulate Matter

NA - Not Applicable

GHG - Greenhouse Gases



- Alternative 2 – Sealing and Monitoring
- Alternative 3 – Active Subslab Depressurization
- Alternative 4 – Enhanced Biodegradation and Soil Vapor Extraction

Figure 1
Summary of Results
Feasibility Study for AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

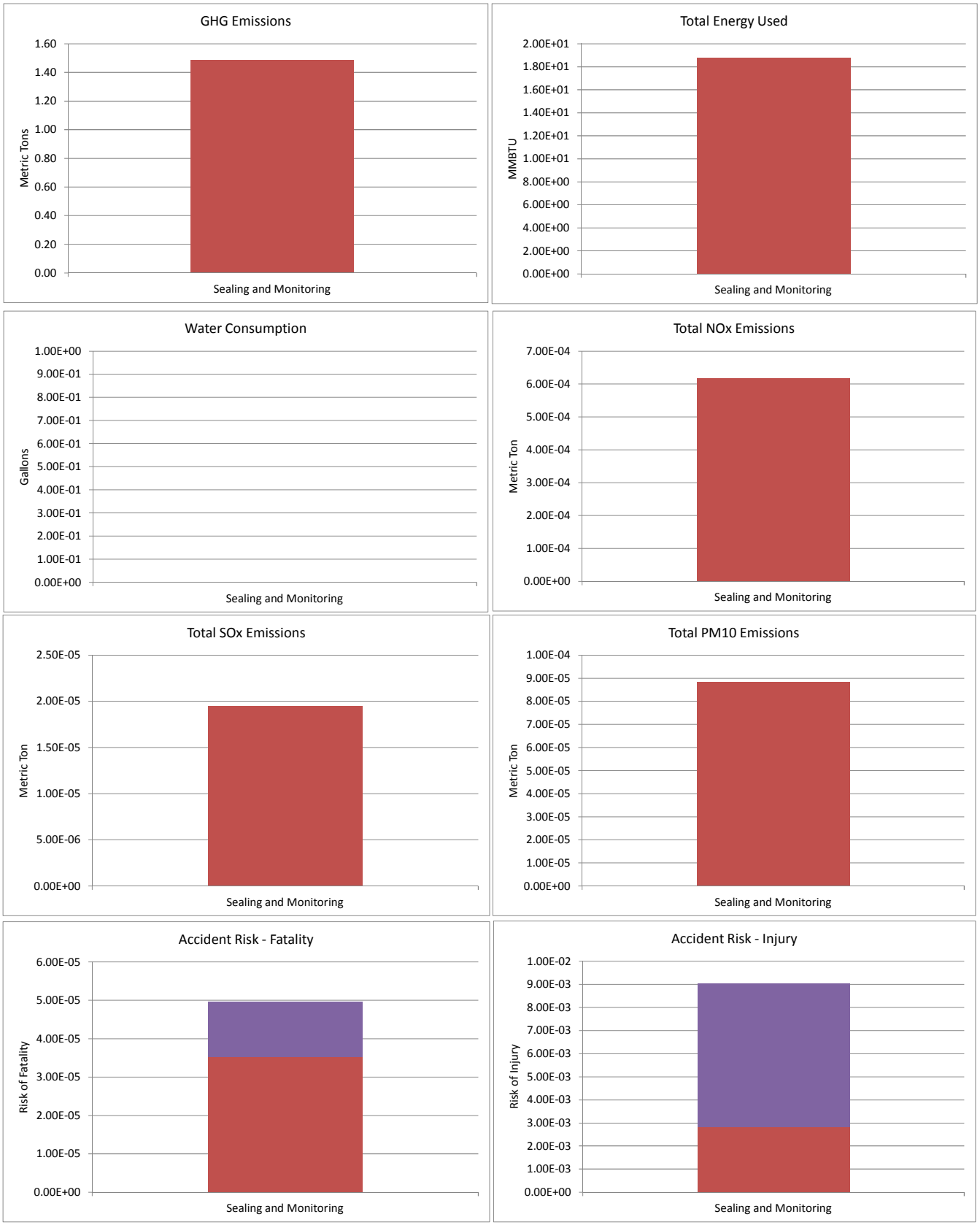


Figure 2
Alternative 2 Summary
Feasibility Study for AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Figure 3
Alternative 3 Summary
Feasibility Study for AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

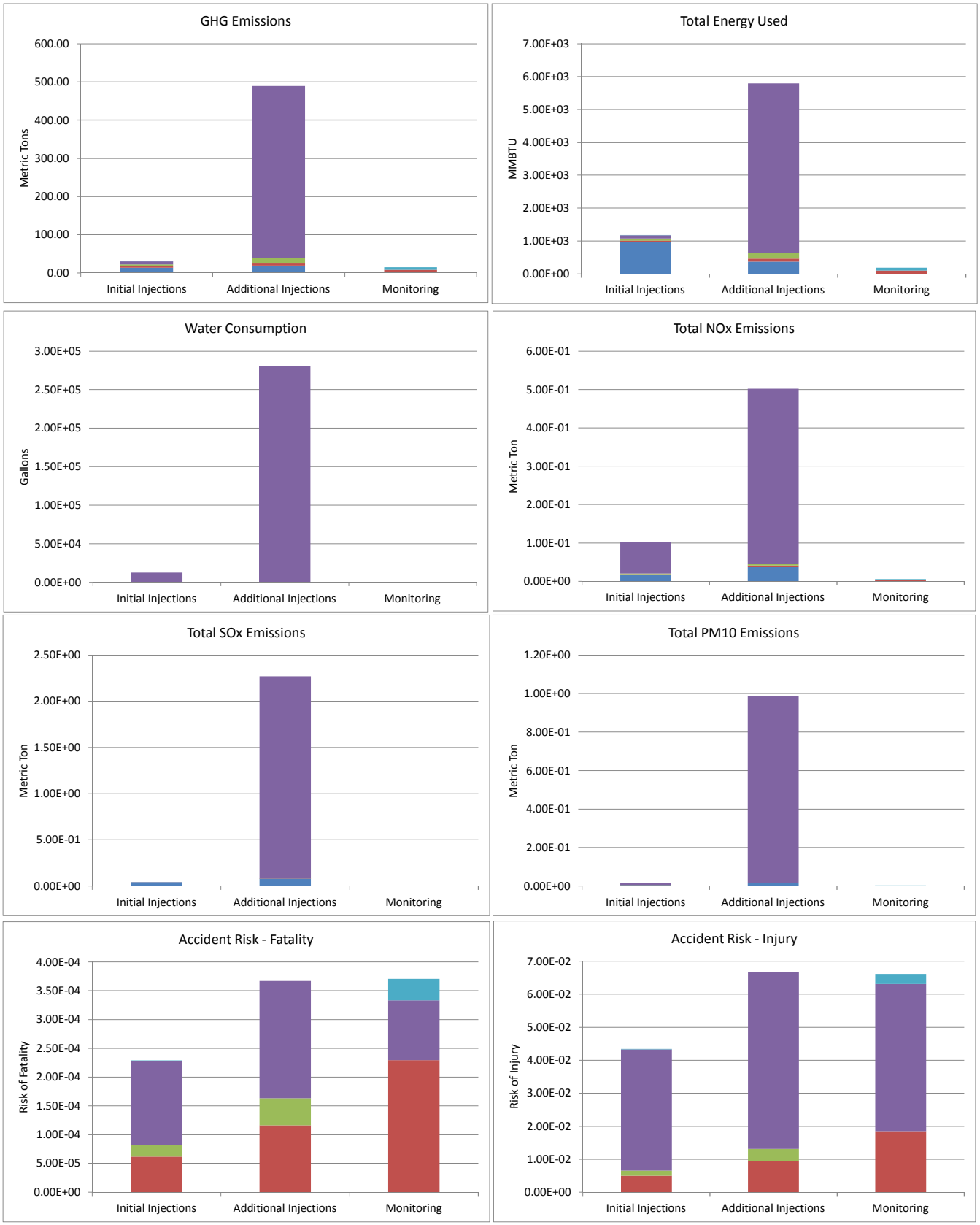


Figure 4
Alternative 4 Summary
Feasibility Study for AOCs 17/18/19/103
Former Lockbourne Air Force Base, Ohio

Appendix E
Remedial Alternatives Decision Analysis

Remedial Alternatives Decision Analysis

To facilitate an evaluation of alternatives, a decision analysis tool was used. CH2M HILL developed a multi-objective decision analysis approach to compare and evaluate alternatives against the five balancing criteria and corresponding subcriteria. The tool scores and weights the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) criteria, in addition to sustainability, for each of the alternatives (except No Action). In general, criteria that were considered to be the most important for identifying the differences between the alternatives were weighted high. A sensitivity analysis is also incorporated into the tool to assess which of the criteria has the greatest impact on the final score for the alternatives based on the initial (user-entered) input scores and weighting process. The tool provides a means to convey values made in the decision-making process. In the attachment, proposed plan, and decision document, sustainability results will provide an additional line of evidence to compare alternatives, taking into account the environmental impacts of implementing a particular remedy.

The results from the decision analysis tools is provided in Attachment 1. The multi-objective decision analysis charts indicate that Alternative 2 provides the best overall balance of the seven NCP criteria considered. Furthermore, Alternative 2 had the highest sustainability score. A higher score indicates better achievement of the criterion. The sensitivity analysis shows that the “Reduction in Toxicity, Mobility, and Volume” criterion score was the one most affected by the weighting process, followed by the “Protection of Human Health and the Environment” and “Compliance with ARARs” criteria. The other NCP criteria scores were not influenced by the weighting process.

Attachment 1
Analysis

TABLE E-1

User-Input Scores for Select Balancing Criteria

AOCs 17/18/19/103, Former Lockbourne AFB, Columbus, Ohio

Evaluation Criteria	Weight **(Do not input)**	Input Guidance	Alternative 1: No Action	Alternative 2: Monitoring	Alternative 3: Active Subslab Depressurization	Alternative 4: Enhanced Biodegradation and Soil Vapor Extraction
Protection of Human Health and the Environment	8	**PLEASE INPUT RELATIVE VALUES:**	1	4	4	4
Compliance with ARARs	8		1.00	4.00	4.00	4.00
Compliance with Chemical-Specific ARARs	5		0	4	4	4
Compliance with Action-Specific ARARs	5	**PLEASE INPUT RELATIVE VALUES:**	0	4	4	4
Compliance with Location-Specific ARARs	0	higher values for superior alternatives	0	0	0	0
Compliance with Other Criteria, Advisories, and Guidances	0	do not type in shaded cells--fixed calculations	0	0	0	0
Long-Term Effectiveness	10	**PLEASE INPUT RELATIVE VALUES:**	1.00	2.00	3.00	4.00
Magnitude of Residual Risk	5	higher values for superior alternatives	1	2	3	4
Adequacy and Reliability of Controls	5	do not type in shaded cells--fixed calculations	1	2	3	4
Reduction in Toxicity, Mobility, and Volume	6		1.00	1.00	2.00	4.00
Treatment Process Used and Materials Treated	5		1	1	2	4
Amount of Hazardous Materials Destroyed or Treated	5	**PLEASE INPUT RELATIVE VALUES:**	1	1	2	4
Degree of Expected Reductions in Toxicity, Mobility, and Volume	5	higher values for superior alternatives	1	1	2	4
Degree to Which Treatment is Irreversible	5	do not type in shaded cells--fixed calculations	1	1	2	4
Type and Quantity of Residual Remaining After Treatment	5		1	1	2	4
Short-Term Effectiveness	10		3.00	3.00	2.00	1.00
Protection of Community During Remedial Actions	5		3	3	2	1
Protection of Workers During Remedial Actions	5	**PLEASE INPUT RELATIVE VALUES:**	3	3	2	1
Environmental Impacts	5	higher values for superior alternatives	3	3	2	1
Time Until Remedial Action Objectives are Achieved	5	do not type in shaded cells--fixed calculations	3	3	2	1
Implementability	10		4.00	4.00	2.00	1.00
Ability to Construct and Operate the Technology	5		4	4	2	1
Reliability of the Technology	5		4	4	2	1
Ease of Undertaking Additional Remedial Actions, if Necessary	5		4	4	2	1
Ability to Monitor Effectiveness of Remedy	5	**PLEASE INPUT RELATIVE VALUES:**	4	4	2	1
Ability to Coordinate and Obtain Approvals From Other Agencies	5	higher values for superior alternatives	4	4	2	1
Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	5		4	4	2	1
Availability of Necessary Equipment and Specialists	5		4	4	2	1
Availability of Prospective Technologies	5		4	4	2	1
Cost	1		0.00	585000	2746000	5413000
Present Worth Cost	5	do not type in shaded cells--fixed calculations	0	$585,000	$2,746,000	$5,413,000
State Acceptance	0	**PLEASE INPUT RELATIVE VALUES:**	0	0	0	0
Community Acceptance	0	**PLEASE INPUT RELATIVE VALUES:**	0.00	0.00	0.00	0.00
Sustainability	6	**PLEASE INPUT RELATIVE VALUES:**	0.00	7.00	5.00	4.00

Note: Refer to Tables 3-6 for the scoring rationale. Subgroup score were assigned to match values in Table 3-7 of the FS.

TABLE E-2

Alternative Screening Criteria Scores

AOCs 17/18/19/103, Former Lockbourne AFB, Columbus, Ohio

	Alternative 1: No Action	Alternative 2: Monitoring	Alternative 3: Active Subslab Depressurization	Alternative 4: Enhanced Biodegradation and Soil Vapor Extraction
Protection of Human Health and the Environment	2.5	10.0	10.0	10.0
Compliance with ARARs	2.5	10.0	10.0	10.0
Compliance with Chemical-Specific ARARs	0.0	10.0	10.0	10.0
Compliance with Action-Specific ARARs	0.0	10.0	10.0	10.0
Compliance with Location-Specific ARARs	0.0	0.0	0.0	0.0
Compliance with Other Criteria, Advisories, and Guidances	0.0	0.0	0.0	0.0
Long-Term Effectiveness	2.5	5.0	7.5	10.0
Magnitude of Residual Risk	2.5	5.0	7.5	10.0
Adequacy and Reliability of Controls	2.5	5.0	7.5	10.0
Reduction in Toxicity, Mobility, and Volume	2.5	2.5	5.0	10.0
Treatment Process Used and Materials Treated	2.5	2.5	5.0	10.0
Amount of Hazardous Materials Destroyed or Treated	2.5	2.5	5.0	10.0
Degree of Expected Reductions in Toxicity, Mobility, and Volume	2.5	2.5	5.0	10.0
Degree to Which Treatment is Irreversible	2.5	2.5	5.0	10.0
Type and Quantity of Residual Remaining After Treatment	2.5	2.5	5.0	10.0
Short-Term Effectiveness	10.0	10.0	6.7	3.3
Protection of Community During Remedial Actions	10.0	10.0	6.7	3.3
Protection of Workers During Remedial Actions	10.0	10.0	6.7	3.3
Environmental Impacts	10.0	10.0	6.7	3.3
Time Until Remedial Action Objectives are Achieved	10.0	10.0	6.7	3.3
Implementability	10.0	10.0	5.0	2.5
Ability to Construct and Operate the Technology	10.0	10.0	5.0	2.5
Reliability of the Technology	10.0	10.0	5.0	2.5
Ease of Undertaking Additional Remedial Actions, if Necessary	10.0	10.0	5.0	2.5
Ability to Monitor Effectiveness of Remedy	10.0	10.0	5.0	2.5
Ability to Coordinate and Obtain Approvals From Other Agencies	10.0	10.0	5.0	2.5
Availability of Offsite Treatment, Storage, and Disposal Services and Capacit	10.0	10.0	5.0	2.5
Availability of Necessary Equipment and Specialists	10.0	10.0	5.0	2.5
Availability of Prospective Technologies	10.0	10.0	5.0	2.5
Cost	10.0	8.9	4.9	0.0
Present Worth Cost	10.0	8.9	4.9	0.0
State Acceptance	0.0	0.0	0.0	0.0
Community Acceptance	0.0	0.0	0.0	0.0
Sustainability	0.0	10.0	7.1	5.7
Overall Score	**187.5**	**237.8**	**187.8**	**174.9**

Note: The scores entered on Table 1 were baselined to a ranking system between 1 to 10, with 1 being the lowest valued metric and 10 being the highest. The scores between 1 and 10 reflect the degree to which an alternative meets the attributes of the criterion; higher scores indicate better achievement of the criterion. A score of zero means that the alternative was not evaluated against that criterion.

TABLE E-3

Summary Scores for Threshold, Balancing, and Sustainability Criteria

AOCs 17/18/19/103, Former Lockbourne AFB, Columbus, Ohio

Factors		Alternative 1: No Action	Alternative 2: Monitoring	Alternative 3: Active Subslab Depressurization	Alternative 4: Enhanced Biodegradation and Soil Vapor Extraction
Threshold	Protection of Human Health and the Environment	0.8	3.2	3.2	3.2
	Compliance with ARARs	0.8	3.2	3.2	3.2
	Overall Threshold Score	**1.6**	**6.4**	**6.4**	**6.4**
Balancing	Long-Term Effectiveness	1.0	2.0	3.0	4.0
	Reduction in Toxicity, Mobility, and Volume	0.6	0.6	1.2	2.4
	Short-Term Effectiveness	3.0	3.0	2.0	1.0
	Implementability	4.0	4.0	2.0	1.0
	Cost	10.0	8.9	4.9	0.0
	Overall Balancing Score	**18.6**	**18.5**	**13.1**	**8.4**
Sustainability	Sustainability	0.0	4.2	3.0	2.4
	Overall Other Score	**0.0**	**4.2**	**3.0**	**2.4**

Alternative Scores based on Level 1 Criteria:	**20.2**	**29.1**	**22.5**	**17.2**
Balancing Criteria Scores	18.6	18.5	13.1	8.4
TPV (estimated)	$0	$585,000	$2,746,000	$5,413,000
TPV (low: -30%)	$0	$409,500	$1,922,200	$3,789,100
TPV (high: +50%)	$0	$877,500	$4,119,000	$8,119,500
Cost per Point (estimated) ($1,000)	N/A	$32	$209	$644
Cost per Point (low: -30%) ($1,000)	N/A	$22	$146	$451
Cost per Point (high: +50%) ($1,000)	N/A	$47	$314	$967

TABLE E-4
2nd Level Criteria Weighted Score
AOCs 17/18/19/103, Former Lockbourne AFB, Columbus, Ohio

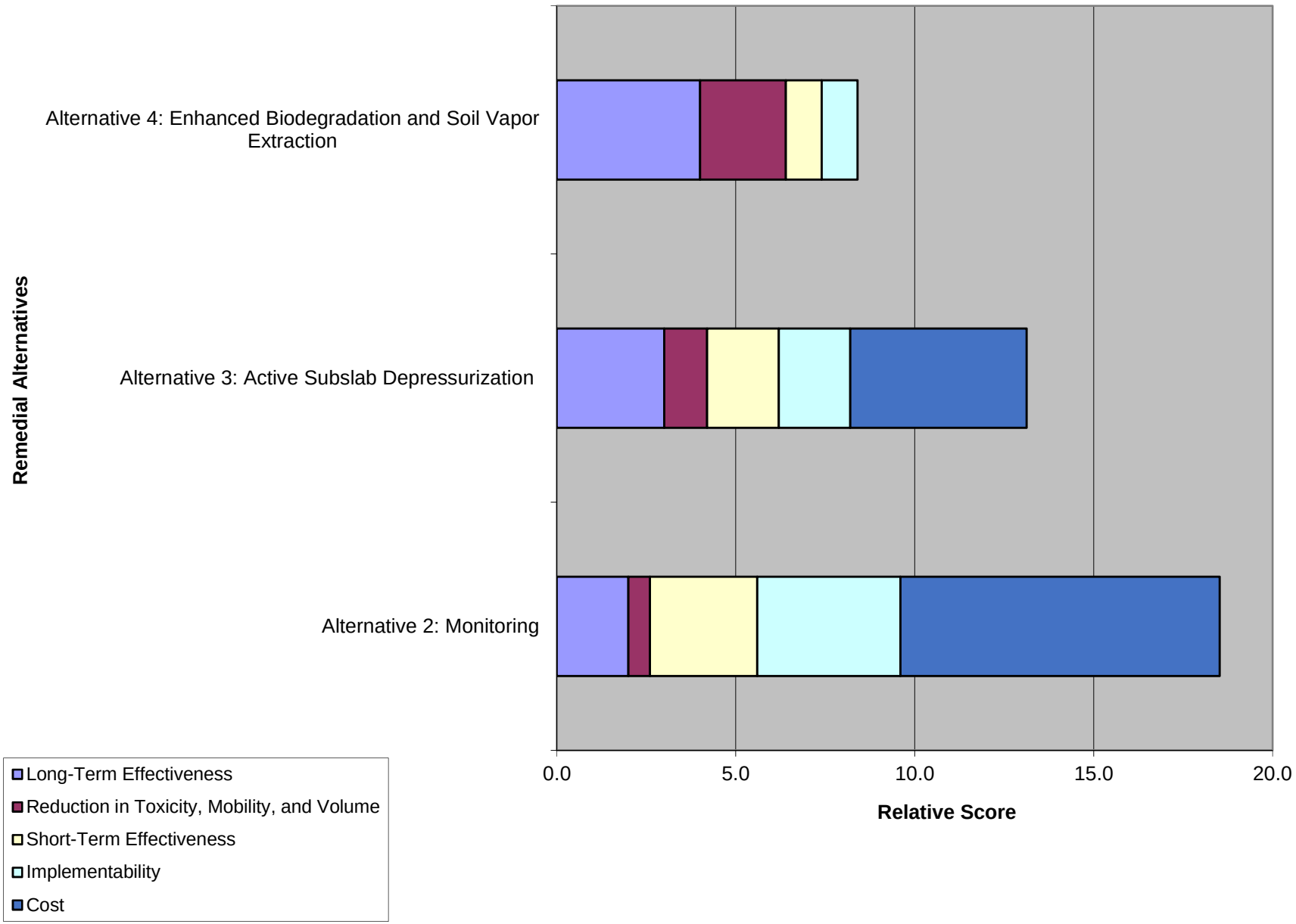
Threshold Factors	Alternative 1: No Action	Alternative 2: Monitoring	Alternative 3: Active Subslab Depressurization	Alternative 4: Enhanced Biodegradation and Soil Vapor Extraction
Protection of Human Health and the Environment			**1ST LEVEL CRITERIA**	
Compliance with ARARs			**1ST LEVEL CRITERIA**	
Compliance with Chemical-Specific ARARs	0.0	3.2	3.2	3.2
Compliance with Action-Specific ARARs	0.0	3.2	3.2	3.2
Compliance with Location-Specific ARARs	0.0	0.0	0.0	0.0
Compliance with Other Criteria, Advisories, and Guidances	0.0	0.0	0.0	0.0
Overall Compliance Score	**0.0**	**6.4**	**6.4**	**6.4**
Balancing Factors				
Long-Term Effectiveness			**1ST LEVEL CRITERIA**	
Magnitude of Residual Risk	1.0	2.0	3.0	4.0
Adequacy and Reliability of Controls	1.0	2.0	3.0	4.0
Overall Long-Term Effectiveness Score	**2.0**	**4.0**	**6.0**	**8.0**
Reduction in Toxicity, Mobility, and Volume			**1ST LEVEL CRITERIA**	
Treatment Process Used and Materials Treated	0.6	0.6	1.2	2.4
Amount of Hazardous Materials Destroyed or Treated	0.6	0.6	1.2	2.4
Degree of Expected Reductions in Toxicity, Mobility, and Volume	0.6	0.6	1.2	2.4
Degree to Which Treatment is Irreversible	0.6	0.6	1.2	2.4
Type and Quantity of Residual Remaining After Treatment	0.6	0.6	1.2	2.4
Overall Reduction Score	**3.0**	**3.0**	**6.0**	**12.0**
Short-Term Effectiveness			**1ST LEVEL CRITERIA**	
Protection of Community During Remedial Actions	3.0	3.0	2.0	1.0
Protection of Workers During Remedial Actions	3.0	3.0	2.0	1.0
Environmental Impacts	3.0	3.0	2.0	1.0
Time Until Remedial Action Objectives are Achieved	3.0	3.0	2.0	1.0
Overall Short-Term Effectiveness Score	**12.0**	**12.0**	**8.0**	**4.0**
Implementability			**1ST LEVEL CRITERIA**	
Ability to Construct and Operate the Technology	4.0	4.0	2.0	1.0
Reliability of the Technology	4.0	4.0	2.0	1.0
Ease of Undertaking Additional Remedial Actions, if Necessary	4.0	4.0	2.0	1.0
Ability to Monitor Effectiveness of Remedy	4.0	4.0	2.0	1.0
Ability to Coordinate and Obtain Approvals From Other Agencies	4.0	4.0	2.0	1.0
Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	4.0	4.0	2.0	1.0
Availability of Necessary Equipment and Specialists	4.0	4.0	2.0	1.0
Availability of Prospective Technologies	4.0	4.0	2.0	1.0
Overall Implementability Score	**32.0**	**32.0**	**16.0**	**8.0**
Cost			**1ST LEVEL CRITERIA**	
Total Present Value (Estimated)	0.0	58500.0	274600.0	541300.0
Total Present Value (Estimated) Inverse	10.0	8.9	4.9	0.0
Overall Cost Score	**0.0**	**58500.0**	**274600.0**	**541300.0**
Overall Cost Inverse Score	**10.0**	**8.9**	**4.9**	**0.0**

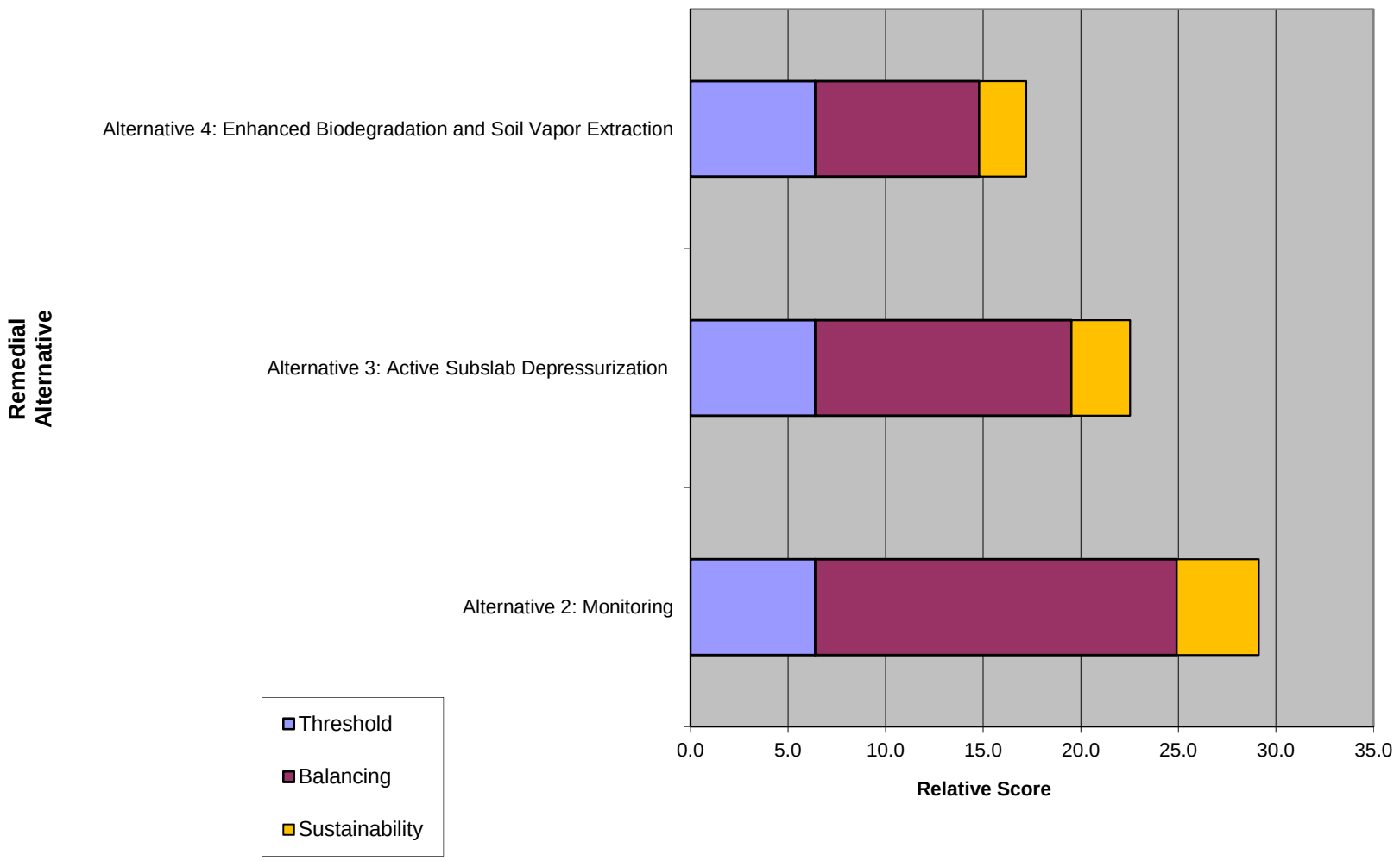
TABLE E-5

Sensitivity Analysis

AOCs 17/18/19/103, Former Lockbourne AFB, Columbus, Ohio

	Alternative 1: No Action	Alternative 2: Monitoring	Alternative 3: Active Subslab Depressurization	Alternative 4: Enhanced Biodegradation and Soil Vapor Extraction
Protection of Human Health and the Environment	1.3	1.3	1.3	1.3
Compliance with ARARs	1.3	1.3	1.3	1.3
Compliance with Chemical-Specific ARARs	NA	1.3	1.3	1.3
Compliance with Action-Specific ARARs	NA	1.3	1.3	1.3
Compliance with Location-Specific ARARs	NA	NA	NA	NA
Compliance with Other Criteria, Advisories, and Guidances	NA	NA	NA	NA
Long-Term Effectiveness	0.6	0.3	0.5	0.6
Magnitude of Residual Risk	1.0	1.0	1.0	1.0
Adequacy and Reliability of Controls	1.0	1.0	1.0	1.0
Reduction in Toxicity, Mobility, and Volume	1.7	1.7	1.7	1.7
Treatment Process Used and Materials Treated	1.7	1.7	1.7	1.7
Amount of Hazardous Materials Destroyed or Treated	1.7	1.7	1.7	1.7
Degree of Expected Reductions in Toxicity, Mobility, and Volume	1.7	1.7	1.7	1.7
Degree to Which Treatment is Irreversible	1.7	1.7	1.7	1.7
Type and Quantity of Residual Remaining After Treatment	1.7	1.7	1.7	1.7
Short-Term Effectiveness	1.0	1.0	1.0	1.0
Protection of Community During Remedial Actions	1.0	1.0	1.0	1.0
Protection of Workers During Remedial Actions	1.0	1.0	1.0	1.0
Environmental Impacts	1.0	1.0	1.0	1.0
Time Until Remedial Action Objectives are Achieved	1.0	1.0	1.0	1.0
Implementability	1.0	1.0	1.0	1.0
Ability to Construct and Operate the Technology	1.0	1.0	1.0	1.0
Reliability of the Technology	1.0	1.0	1.0	1.0
Ease of Undertaking Additional Remedial Actions, if Necessary	1.0	1.0	1.0	1.0
Ability to Monitor Effectiveness of Remedy	1.0	1.0	1.0	1.0
Ability to Coordinate and Obtain Approvals From Other Agencies	1.0	1.0	1.0	1.0
Availability of Offsite Treatment, Storage, and Disposal Services and Capacity	1.0	1.0	1.0	1.0
Availability of Necessary Equipment and Specialists	1.0	1.0	1.0	1.0
Availability of Prospective Technologies	1.0	1.0	1.0	1.0
State Acceptance	NA	NA	NA	NA
Community Acceptance	NA	NA	NA	NA
Sustainability	NA	1.7	1.7	1.7


Remedial Alternatives
Alternative 4: Enhanced Biodegradation and Soil Vapor Extraction
Alternative 3: Active Subslab Depressurization
Alternative 2: Monitoring
0.0
5.0
10.0
15.0
20.0
Relative Score
Long-Term Effectiveness
Reduction in Toxicity, Mobility, and Volume
Short-Term Effectiveness
Implementability
Cost


Remedial Alternative
Alternative 4: Enhanced Biodegradation and Soil Vapor Extraction
Alternative 3: Active Subslab Depressurization
Alternative 2: Monitoring
Threshold
Balancing
Sustainability
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
Relative Score