Final

Former Lockbourne Air Force Base Landfill

Focused Feasibility Study Report

FUDS Site: G05 OH0007

Prepared for:

US Army Corps of Engineers

Contract No. W912QR-04-D-0020
Delivery Order No. 0029

Prepared by:

CH2MHILL®

April 2011

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Executive Summary

This focused feasibility study (FFS) report for the former Lockbourne Air Force Base (AFB) landfill near Lockbourne, Ohio, documents the development and evaluation of remedial action alternatives for closure of the landfill. The landfill has been divided into two areas of concern (AOCs): AOC 1 and AOC 2. In this FFS, the terms "landfill" and "site" are used interchangeably to describe the landfill project site, which consists of both AOC 1 and AOC 2. The FFS recommends appropriate remedial approaches to address risks posed by the site. The FFS report includes the following elements:

- Development of remedial action objectives (RAOs)
- Identification of a focused set of remedial alternatives according to effectiveness, implementability, and cost
- Detailed analysis of the alternatives according to the nine Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) feasibility evaluation criteria

Site Characteristics

The former Lockbourne AFB landfill site is approximately 145 acres. Historical landfill activities at the site date back to 1951. A waste disposal area was identified at the site in historical documentation.

AOC 1 was used for burning and burying wastes from the former Lockbourne AFB and the surface disposal of construction and demolition debris. AOC 1 occupies the western half of the site and is approximately 105 acres. At AOC 1, wastes were placed in trenches up to approximately 10 feet below ground surface (bgs), with some wastes placed in the saturated zone. Waste disposed at AOC 1 included municipal solid waste, water treatment (lime) sludge, black material that was similar in appearance to coal ash and construction and demolition debris.

AOC 2 is approximately 40 acres and is located on the eastern side of the site. Although there is scattered inert debris at the site, no buried waste was found at AOC 2 during test pitting activities. AOC 2 was separated from AOC 1 during the remedial investigation (RI) process with the intent of expediting reuse of this portion of the site where no buried waste was encountered.

The former Lockbourne AFB landfill is located within the Big Walnut Creek drainage basin. Surface drainage is controlled through an extensive network of storm drains, which include corrugated metal and concrete drainage pipes and open drainage ditches. Surface water drains from the site to a man-made perimeter ditch along the eastern and western boundaries of the site and ultimately drains to Big Walnut Creek. The ditch is to manage stormwater for the former Lockbourne AFB and it also served as a mitigation response in the case of a release on the base. The drainage ditch southeast of the site is referred to as the

East Ditch, and the ditch southwest of the site is referred to as the West Ditch. Sediment and surface water samples were collected from East Ditch and West Ditch to determine if they were impacted by the landfill activities. The East and West Ditches are considered to be part of AOC 1.

Hydrogeologic data collected to date indicate that there are three water bearing zones present in the area:

- The upper water-bearing zone (UWBZ) exists at depths ranging between 4 and 16 feet bgs in interbedded sand lenses of the upper silty clay unit. The upper silty clay unit is present from the ground surface to depths ranging from approximately 55 feet to more than 80 feet in the area of the former Lockbourne AFB landfill. There is a gray clay layer within the upper silty clay unit that is believed to be an effective aquitard (a zone within the earth that restricts the flow of groundwater from one aquifer to another) between the shallow water-bearing zone and the lower water-bearing zones (IT, 1996). Groundwater flow in the shallow unconsolidated deposits is toward the west and southwest.
- The intermediate depth aquifer (IDA) is present in the sand and gravel deposits at depths exceeding 50 feet bgs, where it is under confined conditions.
- The deep aquifer is separated from the IDA by a clay unit present at a depth of approximately 130 feet bgs. The deep aquifer contains sand and gravel deposits.

Investigation Results

Between 1995 and 2008, the U.S. Army Corps of Engineers (USACE) conducted several investigations, including several site investigations (SIs) and an RI. These investigations included multiple rounds of sampling of landfill gas, soil, sediment, surface water, and groundwater. Some of these investigations also included collection of geophysical measurements, test pit installation, methane sampling, and seep sampling.

The analytical results for inorganic constituents in the samples collected were compared to the background concentrations. The concentrations of the inorganics that were greater than background and the analytical results for the organic analytes then were compared to their respective human health U.S. Environmental Protection Agency (USEPA) residential risk-based regional screening levels (RSLs; USEPA 2008).

At AOC 1, polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), dioxins/furans, and inorganics were detected in surface and subsurface soil above the screening levels (which are the RSLs or background concentrations (for inorganics), whichever are higher.) Inorganics were detected above the screening levels in surface water and sediment from the East Ditch. Inorganics, an SVOC, PAHs, and dioxins/furans were detected above the screening levels in sediment and/or surface water samples from the West Ditch. Inorganics, an SVOC, PAHs, dioxins/furans were detected above the screening levels in UWBZ and IDA groundwater.

At AOC 2, PAHs, dioxins/furans, and inorganics were detected above their respective screening levels in surface soil. One inorganic and two volatile organic compounds were detected above screening levels in subsurface soil. PAHs, dioxins/furans, and inorganics

were detected above their respective screening levels in groundwater from the UWBZ. Dioxins/furans in groundwater from the IDA were detected above the screening levels.

A human health risk assessment (HHRA) was performed during the RI to evaluate potential current and future risks associated with detected constituents at the former Lockbourne AFB landfill site. Unacceptable risk was found in soil and groundwater in AOC 1, and in groundwater for AOC 2. Analytes that cause human health risk were identified as constituents of concern (COCs) for specific exposure areas.

An ecological risk assessment (ERA) was performed at AOC 1 and AOC 2 to evaluate potential current and future risks associated with detected constituents at these AOCs. The ERA also evaluated ditches located along the eastern and western portions of the site as separate exposure areas. Potential ecological risks were identified at the site. Specifically, risks were identified for terrestrial mammals and birds at AOC 1 and to lower-trophic receptors at AOC 1, the East Ditch, and the West Ditch. No unacceptable risk was identified for ecological receptors at AOC 2.

Remedial Action Objectives

Because of the identified risks at the site, remedial action is warranted, and the first step in developing remedial alternatives is identifying RAOs for the site. The following RAOs were selected for the site based upon consideration of applicable or relevant and appropriate requirements (ARARs), the baseline HHRA, and fate and transport of COCs:

- Eliminate unacceptable human and ecological risks due to potential exposure to COCs in soil
- Eliminate unacceptable risk from exposure to COCs in groundwater at the site
- Eliminate unacceptable transfer of contaminants to nearby surface water resources
- Beneficially reuse site material to complete landfill closure and provide for sustainability
- Allow for beneficial reuse of the site through creative site closure design, construction, and restoration

Once the RAOs were defined, potential ARARs were identified for remedy development.

Technology Screening and Development of Remedial Alternatives

AOC 1

For AOC 1, the presumptive remedy was used to screen technologies and develop remedial alternatives. A presumptive remedy is a cleanup technology that USEPA has identified, based upon its past experience and research, to be appropriate for cleanup of certain types of sites. USEPA determined the presumptive remedy for landfills, such as the former Lockbourne AFB landfill, is containment. Based on USEPA's presumptive remedy guidance, three alternatives were evaluated for AOC 1.

Alternative 1—No Action

The no action alternative is required to be considered in the FFS process. No action means that no remedial actions will be performed at AOC 1 to mitigate unacceptable risks identified; that is, no action would be taken to restrict potential exposures to surface or subsurface soil or to wastes. Natural attenuation processes, such as biodegradation, are expected to occur with the potential to reduce contaminant concentrations over time. However, the concentrations would not be monitored and the degree to which natural attenuation is occurring would not be documented. This alternative provides no institutional controls restricting future site use. Alternative 1 is retained as a baseline alternative, as required by the National Oil and Hazardous Substances Pollution Contingency Plan.

Alternative 2—Consolidation, Construction of a Compacted Clay Cap, Long-Term Management, and Institutional Controls

Alternative 2 would involve consolidating waste, and then constructing a compacted clay cap over the consolidated area. In addition, the area would be cleared and grubbed before construction, as it is currently covered with dense vegetation.

Long-term management also would be part of this alternative. The long-term management program would be documented in the landfill long-term management plan and is expected to include groundwater and landfill gas monitoring. Ideally, the groundwater monitoring network would be comprised of existing and new groundwater monitoring wells. Some existing wells may be abandoned during construction of the clay cap, but they would be replaced with new wells. For cost estimating purposes, it is assumed that groundwater monitoring would be conducted for 30 years. During the first 5 years, groundwater monitoring would occur quarterly for years 1 and 2, and semiannually for years 3, 4, and 5. For years 6 through 30, annual monitoring was assumed. The monitoring plan would be re-evaluated during the CERCLA 5-year review process.

Finally, environmental covenants would be implemented to restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cap.

Alternative 3—Consolidation, Construction of a Soil Cover, Long-Term Management, and Institutional Controls

Similar to Alternative 2, Alternative 3 also involves consolidating waste, and then constructing a soil cover over the consolidated area. The area would be cleared and grubbed before construction, as it is currently covered with dense vegetation.

Long-term management also is a part of this alternative. The long-term management program would be documented in the landfill long-term management plan and is expected to include groundwater monitoring. Tentatively, the groundwater monitoring network would be comprised of existing and new groundwater monitoring wells. Some existing wells may be abandoned during construction of the soil cover, but they would be replaced with new wells. For cost estimating purposes, it is assumed that groundwater monitoring would be conducted for 30 years. During the first 5 years, groundwater monitoring would occur quarterly for years 1 and 2, and semiannually for years 3, 4, and 5. For years 6 through

30, annual monitoring was assumed. The monitoring plan would be re-evaluated during the CERCLA 5-year review process.

Finally, environmental covenants would be implemented to restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cover.

AOC 2

Unacceptable risks at AOC 2 were identified only for exposure to groundwater, therefore, implementation of an environmental covenant is proposed for AOC 2 to restrict to the use of the groundwater beneath AOC 2. The two alternatives evaluated for AOC 2 are as follows.

Alternative 1—No Action

As described earlier, the no action alternative is required to be considered in the FFS process.

Alternative 2—Implementation of Environmental Covenants

Alternative 2 involves implementing an environmental covenant restricting the use of the groundwater beneath AOC 2.

Analysis of Remedial Alternatives

The remedial alternatives were evaluated against the nine CERCLA feasibility evaluation criteria. For AOC 1, the results of the detailed analysis indicate that Alternative 3 is protective of human health and the environment, complies with the ARARs, provides long-term effectiveness and permanence, reduces the mobility of material, has minimal short-term effects, is implementable, and is the least-cost alternative. For AOC 2, Alternative 2 is the only alternative that protects human health and the environment, complies with the ARARs, provides long-term effectiveness and permanence, has minimal short-term effects, and is implementable.

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Acronyms and Abbreviations

AFB	Air Force Base
ANG	Air National Guard
AOC	area of concern
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BLL	blood lead level
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	constituent (or chemical) of concern
COPC	constituent (or chemical) of potential concern
COPEC	constituent (or chemical) of potential ecological concern
CRAA	Columbus Regional Airport Authority
DDD	dichlorodiphenyl dichloroethane
DDE	dichlorodiphenyl ethylene
DDT	dichlorodiphenyl trichloroethane
E&E	Ecology and Environment, Inc.
EEG	Ellis Environmental Group, LC
ELCR	excess lifetime cancer risk
ERA	ecological risk assessment
FFS	focused feasibility study
ft/day	foot per day
FUDS	formerly used defense site
HHRA	human health risk assessment
HI	hazard index
HMW	high molecular weight
HQ	hazard quotient
IC	institutional control
IDA	intermediate depth aquifer
IRP	Installation Restoration Program
IT	IT Corporation
K	hydraulic conductivity
LAW	LAW Environmental Services, Inc.
LMW	low molecular weight
MCL	maximum contaminant level
MSW	municipal solid waste
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NR	negligible risk
NSV	no screening value
O&M	operations and maintenance
OAC	Ohio Administrative Code
Ohio EPA	Ohio Environmental Protection Agency
PAH	polynuclear aromatic hydrocarbon

PCB	polychlorinated biphenyl
PESI	Parsons Engineering Science, Inc.
PMC	Program Management Company
RAGS	Risk Assessment Guidance for Superfund
RANGB	Rickenbacker Air National Guard Base
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfC	reference concentration
RfD	reference dose
RI	remedial investigation
RSL	regional screening level
SI	site investigation
SVOC	semivolatile organic compound
TCDD	tetrachlorodibenzo-p-dioxin
TEF	toxic equivalency factor
TEQ	toxic equivalence
TMV	toxicity, mobility, or volume
USACE	U.S. Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UWBZ	upper water-bearing zone
VOC	volatile organic compound

SECTION 1

Introduction

The U.S. Army Corps of Engineers (USACE), Louisville District contracted CH2M HILL to conduct a focused feasibility study (FFS) to develop and evaluate remedial alternatives for the former Lockbourne Air Force Base (AFB) landfill near Columbus, Ohio (Figure 1-1), under Contract No. W912QR-04-D-0020, Delivery Order No. 0029. The landfill has been divided into two areas of concern (AOCs): AOC 1 and AOC 2. In this FFS, the terms "landfill" and "site" are used interchangeably to describe the landfill project site, which consists of both AOC 1 and AOC 2. The site is a formerly used defense site (FUDS) and is designated as G05 OH0007. Environmental response actions at FUDS conform to the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986, 42 United States Code 9601 et seq., the National Oil and Hazardous Substance Pollution Contingency Plan, commonly called the National Contingency Plan (NCP), and Engineer Regulation 200-3-1, as applicable. This FFS has been performed in general accordance with U.S. Environmental Protection Agency (USEPA) guidance titled *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988), and Ohio Environmental Protection Agency (Ohio EPA) guidance titled *Generic Statement of Work Remedial Investigation/Feasibility Study State Version* (Ohio EPA 1999).

The purpose of the FFS process is to develop, screen, and evaluate remedial alternatives that meet the NCP threshold criteria of overall protection of human health and the environment and are compliant with applicable or relevant and appropriate requirements (ARARs) established for the site.

The FFS report is organized as follows:

- **Section 1, Introduction**—The introduction includes a summary of the regulatory framework and the purpose and organization of the report.
- **Section 2, Background Information**—This section presents a summary of background information including, site description, site history, previous environmental investigations, site characteristics, nature and extent of contamination, and a synopsis of human health and ecological risk assessments.
- **Section 3, Remedial Action Objectives (RAOs)**—This section presents a discussion of the RAOs for the site.
- **Section 4, Technology Screening and Development of Remedial Alternatives**—This section discusses applicable remedial technologies and alternatives for the site. This section also presents the ARARs.
- **Section 5, Detailed Analysis of Alternatives**—This section presents the detailed analysis of the remedial alternatives identified in Section 4.
- **Section 6, Summary**—This section summarizes the conclusions and recommendations of the FFS.

- **Section 7, References**—This section presents a list of references consulted in developing the FFS report.

SECTION 2

Background Information

This section presents a synopsis of key background information including a site description, site history, previous environmental investigations, site characteristics (geology, hydrogeology, and soils), nature and extent of contamination, migration pathways, and a summary of the risk assessments. Detailed descriptions of the above topics have been presented in the *Remedial Investigation* (RI) *Report* (CH2M HILL 2010).

2.1 Site Description

The former Lockbourne AFB is located east of Interstate 71 in Franklin and Pickaway counties, just east of the village of Lockbourne, Ohio (Figure 1-1). The former AFB covered approximately 4,371 acres, some of which is now occupied by the Columbus Regional Airport Authority (CRAA), the 121st Air Refueling Wing of the Ohio Air National Guard (ANG), the Ohio Army National Guard, Lane Aviation, various retail and service businesses, and a Naval Reserve Center. The landfill is located within an undeveloped area west of the developed portion of the former Lockbourne AFB.

A site features map is provided as Figure 1-2. The site is bordered by Vause Road to the north, Tank Truck Road to the southeast, and railroad tracks to the southwest. A high-tension power line crosses the northwest side of the site. An inactive power line corridor runs from Tank Truck Road through the site, ending shortly after crossing the main site access road. Land use north of the site consists of residential and industrial development. Land use south/southwest of the site is primarily agricultural. Rickenbacker ANG Base (RANGB) and Rickenbacker International Airport are located east/southeast of the site; while the village of Lockbourne, Ohio is located west of the site. CRAA maintains control of entry to the site. Surface water drains to a man-made perimeter ditch along the eastern and western boundaries of the site and ultimately drains to Big Walnut Creek. Big Walnut Creek lies approximately 0.75 mile (at its closest point) west of the site. The portion of the drainage ditch southeast of the site is referred to as the East Ditch, and the portion southwest of the site is referred to as the West Ditch.

At AOC 1, wastes were placed in trenches up to approximately 10 feet below ground surface (bgs), with some wastes placed in the saturated zone. Waste disposed at AOC 1 included municipal solid waste, water treatment (lime) sludge, black material that was similar in appearance to coal ash, and construction and demolition debris. The East Ditch and West Ditch are considered to be a part of AOC 1.

AOC 2 is approximately 40 acres and is on the eastern side of the site. Although there is scattered inert debris at the site, no buried waste was found at AOC 2 during test pitting activities. AOC 2 was separated from AOC 1 during the RI process with the intent of expediting reuse of this portion of the site where no buried waste was encountered (Figure 1-2).

The former Lockbourne AFB landfill is considered to be unlined, based on observations made during review of historical records and during test pitting activities completed by CH2M HILL in 2008 (CH2M HILL 2009).

2.2 Site History

Relevant historical documents concerning the site indicate that between 1951 and 1979, approximately 51 acres were used for burning and burying wastes from the base. This area historically was referred to as the "heavily used area, "and lies within AOC 1. The remaining acreage, historically referred to as the "unused to moderately used area," was used for surface disposal of various wastes, primarily construction and demolition debris. The terms "heavily used" and "unused to moderately used" are historical terms that have been carried forward only for consistency.

The former Lockbourne AFB landfill received municipal solid waste (MSW), construction and demolition debris, and lime sludge from the former AFB water treatment plant. MSW is believed to have been generated from the base housing and other buildings on base. Construction and demolition debris is believed to have been generated during base renovations. Pavement debris is visible at the surface at some locations on the site. Information obtained during the Phase I site investigation (SI) records search (LAW Environmental Services, Inc. [LAW] 1995) suggests the former Lockbourne AFB landfill may have received pesticides and herbicides, ammunition, airplane parts, toxic and hazardous materials, household-type garbage, and construction debris. The wastes reportedly were disposed in trenches, up to approximately 10 feet bgs and on the ground surface (LAW 1995; CH2M HILL 2009). Aerial photographs, geophysical survey data, soil gas survey data, and surface and subsurface soil data (as summarized in the RI report [CH2M HILL 2010]) define the disposal extent and its characteristics.

2.3 Previous Environmental Investigations

A reverse chronological list of investigations conducted at or adjacent to the site is presented in Table 2-1. Information relevant to the site from these reports is summarized in Sections 2.4, 2.5, and 2.6.

2.4 Site Characteristics

Below is a summary of the site characteristics, including geology, hydrogeology, and soils. Further details can be found in the RI report (CH2M HILL 2010).

2.4.1 Geology

The site is characterized by approximately 200 feet of Pleistocene glacial drift, which fills a pre-glacial bedrock valley. Shales of the Ohio and Olentangy formations and limestones of the Columbus and Delaware formations underlie the area. The shale and limestone bedrock are Devonian Age. The surficial tills are mainly associated with ground moraine. Alluvial deposits are found in association with Walnut Creek and Big Walnut Creek. Soil near the site consists of medium textured glacial till and glacial outwash, mainly derived from limestone and dolomite.

TABLE 2-1
Summary of Site Investigations
Former Lockbourne AFB Landfill

Report Date	Entity Conducting the Investigations	Nature of Investigation	Activities Completed
2009	CH2M HILL	Additional SI	CH2M HILL conducted additional SI work, which included the following: – Installing test pits – Conducting geophysical survey work involving electromagnetic induction – Performing passive sampling for landfill gas
2007	EEG	RI	EEG conducted the RI field activities in 2003, which included the following: – Installing two UWBZ groundwater monitoring wells. – Collecting 17 groundwater samples, 24 surface soil samples, and 8 subsurface soil samples. – Collecting three surface water samples, four sediment samples, and one seep sample. – Collecting six geotechnical samples from outside the former Lockbourne AFB landfill. – Conducting a professional survey of the horizontal coordinates for soil, seep, surface water, and sediment sample locations. The survey also included the ground surface and top of casing elevations of groundwater monitoring wells.
2000	PMC	Phase II SI	Phase II investigation during 1997 included the following: – Installing and sampling three UWBZ and four IDA groundwater monitoring wells – Sampling three UWBZ and four IDA groundwater monitoring wells installed during the Phase I SI – Installing three piezometers – Conducting subsurface soil sampling at four Phase I SI surface soil locations – Collecting five co-located surface water and sediment samples – Collecting three additional seep samples Phase II investigation during 1998 included : – Collecting samples from six groundwater monitoring wells (three UWBZ and three IDA) – Collecting seven surface soil samples – Collecting three sediment samples
1998	IT	Phase II RI	Phase II RI Investigation at sites adjacent to the former Lockbourne AFB landfill during 1996 included: – Collecting surface soil, sediment, and groundwater samples at Site 19 (the North Coal Pile) – Collecting subsurface soil, groundwater, sediment samples at Site 20 (the South Coal Pile) – Collecting surface water and sediment samples from Site 25/27 (the Base Drainage Ditch)

TABLE 2-1
Summary of Site Investigations
Former Lockbourne AFB Landfill

Report Date	Entity Conducting the Investigations	Nature of Investigation	Activities Completed
1995	IT	Environmental Baseline Survey Investigation	IT conducted a clay layer investigation to determine if the gray clay/silt zone between the UWBZ and IDA at the RANGB is laterally continuous across the former AFB.
1995	PESI	Installation Restoration Program (IRP) SI	PESI investigated five Installation Restoration Program sites, adjacent to and upgradient of the former Lockbourne AFB landfill.
1995	LAW	Phase I SI	LAW conducted a two-stage Phase I SI Stage 1, conducted in October and November 1994, included the following: – Completing a geophysical survey – Completing a passive soil gas survey – Completing an unexploded ordnance survey Stage 2, conducted in May and June 1995, included the following: – Installing and sampling of three UWBZ groundwater monitoring wells and four IDA groundwater monitoring wells – Collecting hand-augured soil samples from the upper 3 feet of soil at 12 locations – Collecting three co-located surface water and sediment samples from the ditch along the western boundary of the former Lockbourne AFB landfill – Collecting two seep samples from the eastern bank of the west drainage ditch
1986	E&E	Site Screening Investigation	On behalf of USEPA, E&E, conducted a site screening investigation at the former Lockbourne AFB landfill, including: – Collecting soil and sediment samples along the southwestern and northern sides of the former Lockbourne AFB landfill – Collecting groundwater samples from the village of Lockbourne residential water supplies

AFB—Air Force Base; E&E—Ecology and Environment, Inc.; EEG—Ellis Environmental Group, LC; IDA—intermediate depth aquifer; IT—IT Corporation; LAW— LAW Environmental Services, Inc.; PESI—Parsons Engineering Science, Inc.; PMC—Program Management Company; RI – remedial investigation; SI—site investigation; UBWZ—upper water-bearing zone.

The uppermost unconsolidated unit at the site consists of about 80 feet of clayey, silty till with alternating sand and gravel deposits. This till is underlain by two sand and gravel deposits, which are approximately 50 to 100 feet deep and separated by a layer of clay and silt, which is up to 60 feet thick. Shale and limestone bedrock underlies the unconsolidated deposits.

Shallow wells screened in the uppermost, unconsolidated geologic unit reveal a shallow water table with flow directed west and southwest. Logs from private wells north of the site and an abandoned water supply well for the heating plant northeast of the site (Figure 1-2) indicate clay deposits at about 60 to 70 feet bgs. This is underlain by sand and gravel deposits to the

completion depths of the wells (ranging from 62 to 100 feet bgs). The geology at the site consists of clayey silty till alternating with relatively extensive sand and gravel deposits.

2.4.2 Hydrogeology

The hydrogeologic setting of the site is characterized by the presence of three water-bearing zones that are separated by relatively impermeable clay. The three water-bearing zones are the upper water-bearing zone (UWBZ), intermediate depth aquifer (IDA), and the deep sand aquifer. UWBZ groundwater exists at depths ranging between 4 and 16 feet bgs in interbedded sand lenses of the upper silty clay unit. The upper silty clay unit is present from the ground surface to depths ranging from approximately 55 feet to more than 80 feet in the area of the former site. Geotechnical analyses have characterized the grain size of the gray clay layer within this unit as silty lean clay. The gray clay layer appears to be laterally continuous throughout the site and RANGB where its thickness is more than 20 feet. The gray clay layer within the upper silty clay unit is believed to be an effective aquitard (a zone within the earth that restricts the flow of groundwater from one aquifer to another) between the shallow water-bearing zone and the lower water-bearing zones. The IDA is present in the sand and gravel deposits at depths exceeding 50 feet bgs, where it is under confined conditions. The deep sand aquifer is separated from the IDA by a silt and clay layer that inhibits interconnection between the aquifers.

The Phase II SI report (Program Management Company [PMC] 2000) compiled and interpreted hydrogeologic data. Salient features of the hydrogeologic conceptual site model are indicated below:

- The uppermost unconsolidated material consists of silty clay with sand lenses.
- Groundwater elevation data from the shallow monitoring wells indicate that a shallow water table exists within the silty clay ranging in depth from approximately 4 to 16 feet bgs, and is possibly under perched water conditions.
- Groundwater flow in the shallow saturated zone is generally toward the west-southwest with a horizontal gradient of approximately 0.0075 foot per foot. Figure 2-1 presents the potentiometric contour for the UWBZ with data collected in May 2004.
- The hydraulic conductivity (*K*) values derived from slug testing of the shallow wells range from approximately 1 to 28 feet per day (ft/day).
- The upper silty clay unit contains a gray clay layer that occurs at depths ranging from approximately 18 to 48 feet bgs; is laterally continuous, more than 20 feet thick, and dense; and has a low permeability. Thus, it is considered an effective aquitard separating the UWBZ from the lower aquifers.
- Below the silty clay is a sand and gravel unit, which comprises the IDA.
- Groundwater elevation data demonstrate the groundwater surface in the IDA wells is approximately 20 to 30 feet bgs, and the IDA exists under confined conditions.
- The groundwater flow in the IDA also is generally toward the west-southwest with a horizontal gradient of approximately 0.004 foot per foot. Figure 2-2 presents the potentiometric contour for the IDA with data collected in May 2004.

- The K values derived from slug testing of the IDA wells range from approximately 0.5 to 18 ft/day.
- The K values derived from vertical and horizontal permeability testing of the intermediate wells range from 0.0001 to 0.1 ft/day.
- A clay unit is present at a depth of approximately 130 feet bgs, which separates the IDA from a lower (deep) sand and gravel aquifer (Engineering Science 1992).
- Bedrock beneath the site occurs at approximately 200 feet bgs.

2.4.3 Soils

The U.S. Department of Agriculture Soil Conservation Service has described the soils near the site to be of two series: the Crosby series and the Kokomo series (National Cooperative Soil Survey 1980). The Crosby series consists of deep, somewhat poorly drained, slowly permeable soils formed in high-lime glacial till on uplands; slope ranges from 0 to 6 percent. The Kokomo series consists of deep, very poorly drained, moderately slowly permeable soils formed in high-lime Wisconsin Age glacial till on uplands; slope ranges from 0 to 2 percent.

2.5 Environmental Impact

This section summarizes the information obtained from previous investigations (Phase I SI completed in 1995 [LAW 1995], Phase II SI completed in 1997 and 1998 [PMC 2000], and an RI completed in 2003 [Ellis Environmental Group, LC {EEG} 2007]). The Phase I SI was completed to determine if contaminants are present in the area of the former landfill, their migration potential, and the necessity for additional investigation. Based on the findings of Phase I SI, a Phase II SI was completed to collect additional data. Subsequently, an RI was completed to define the nature and extent of waste disposal at the site, identify potential impacts to the drainage ditches located at the site, and characterize potential offsite transport of constituents of interest. Below is a summary of the environmental impacts detected at the site based on the investigations conducted. This summary compares the analytical results to screening criteria as a benchmark for the concentrations detected at the site. The screening criteria for each environmental media are presented in the RI Report (CH2M HILL 2010), which are the USEPA regional screening levels (RSLs; USEPA 2008) or background concentrations (for inorganics), whichever are higher. For groundwater, concentrations were also compared to USEPA drinking water maximum contaminant levels (MCLs), where available.

2.5.1 AOC 1

2.5.1.1 Surface Soil

Surface soil samples were collected from a depth of 0 to 1 foot bgs during the 2003, 1998, 1997, and 1995 sampling events. Sampling locations are shown on Figure 2-3. The following results were observed:

- Concentrations of volatile organic compounds (VOCs) detected in the surface soil samples were low and below their respective RSLs.

- The occurrence of semivolatile organic compounds (SVOCs) was more widespread. The most prevalent SVOCs were polynuclear aromatic hydrocarbons (PAHs), which are commonly associated with site activities (burning of wastes). Concentrations of 11 SVOCs (benz[a]anthracene; benzo[a]pyrene; benzo[b]fluoranthene; benzo[k]fluoranthene; chrysene; dibenz[a,h]anthracene; dibenzofuran; fluoranthene; indeno[1,2,3-cd]pyrene; naphthalene; and pyrene) were detected above their respective RSLs. These PAHs were detected throughout AOC 1.
- The most commonly occurring pesticides found at AOC 1 were p,p′-dichlorodiphenyl dichloroethane (p,p′-DDD); p,p′-dichlorodiphenyl ethylene (p,p′-DDE); and p,p′-dichlorodiphenyl trichloroethane (p,p′-DDT). These pesticides were detected during the RI and Phase I and II SIs. No pesticides were found to exceed their respective RSLs.
- Polychlorinated biphenyls (PCBs) were detected during the RI, but not during the Phase I and Phase II SIs. Three PCBs (PCB 1242, PCB 1248, and PCB 1260) exceeded their respective RSLs.
- Dioxin/furan congeners were detected in surface soil samples collected during the RI and Phase II SI. Four individual dioxin/furan congeners (heptachlorodibenzo-p-dioxins [total], hexachlorodibenzo-p-dioxins [total], octachlorodibenzo-p-dioxin, and 2,3,7,8-tetrachlorodibenzo-p-dioxin) exceeded their respective RSLs. The values of tetrachlorodibenzo-p-dioxin (TCDD) toxic equivalence (TEQ) exceeded the RSL in five samples. TCDD TEQ is a calculated number used for risk assessment. The World Health Organization dioxin toxic equivalency factors (TEFs) were used to calculate the 2,3,7,8-TCDD TEQ concentration for each sample where dioxins or furans were detected. The concentration of each dioxin congener was adjusted to a TEQ concentration of 2,3,7,8-TCDD using the TEF. The TEQ concentrations of the dioxin congeners then were added to determine the TCDD TEQ concentration, which was used in the risk assessment, along with the 2,3,7,8-TCDD toxicity values to calculate risks associated with exposure to the dioxins/furans. In the case of nondetects, one-half the reporting limit for the dioxin congener was multiplied by the TEF for that congener, and included in the calculation of the sample TCDD TEQ concentration. Figure 2-4 shows the locations where dioxins/furans were detected in surface soil.
- Three inorganics (lead, silver, and thallium) exceeded the screening criteria.

2.5.1.2 Subsurface Soil

Soil samples were collected and evaluated from depths of 1 to 10 foot bgs during the 2003, 1997, and 1995 sampling events. Sampling locations are shown on Figure 2-4 and 2-5. The following results were observed:

- VOCs were detected in the subsurface soil samples. However, no VOCs exceeded their respective RSLs.
- Similar to the surface soil samples, PAHs were the primary SVOCs detected. Six PAHs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, dibenz[ah]anthracene, and indeno[1,2,3-cd]pyrene) exceeded their respective RSLs.

- Pesticides were detected in subsurface soil samples, however, the frequency of occurrence was low, and no pesticides exceeded their respective RSLs.
- PCB 1254 was detected in one subsurface soil sample, and the concentration of the detected PCB 1254 exceeded its RSL.
- Dioxin/furan congeners were detected in subsurface soil samples collected. Among the different dioxins/furans that were detected, five dioxin/furan congeners exceeded their respective RSLs, including heptachlorodibenzofurans (total), heptachlorodibenzo-p-dioxins (total), hexachlorodibenzofurans (total), hexachlorodibenzo-p-dioxins (total), and pentachlorodibenzo-p-dioxins (total). The TCDD TEQ value exceeded the RSL at four locations. Figure 2-4 shows the locations where dioxins/furans were detected in subsurface soil.
- Three inorganics (aluminum, mercury, and thallium) exceeded the screening criteria.

2.5.1.3 Surface Water

Surface water samples were collected during the 2003, 1998, 1997, and 1995 sampling events. Sampling locations are shown on Figure 2-6. The following results were observed:

- VOCs were detected in samples collected during the Phase I and Phase II SIs; however, the detected concentrations were low. Methylene chloride was detected above its RSL in two samples collected from West Ditch during the Phase I SI, but these concentrations are associated with laboratory contamination.
- Although SVOCs were detected in samples collected, only one SVOC (bis[2-ethylhexyl]phthalate) was detected above the RSL. Bis(2-ethylhexyl)phthalate was detected above its RSL in only one sample collected in the West Ditch.
- Pesticides were analyzed for in surface water, but were not detected.
- PCBs were analyzed for in surface water, but were not detected.
- Elevated concentrations of dioxins/furan congeners were detected in samples collected during the Phase II SI from the West Ditch and from upgradient background locations. While no individual dioxin/furan congeners were detected above RSLs in the samples collected during the RI, the TCDD TEQ values exceeded the RSL in two samples collected from the West Ditch.
- Arsenic, lead, and thallium were detected above their respective RSLs in the West Ditch. Arsenic and thallium were detected above the RSL in the East Ditch.

2.5.1.4 Sediment Sampling

Sediment samples were collected during the 2003, 1998, 1997, and 1995 sampling events. Sampling locations are shown on Figure 2-6. The following results were observed:

- VOCs were detected in sediment samples collected from the East and West Ditches. No VOCs exceeded their respective RSLs.
- Visible oil sheen and hydrocarbon odors were observed at one of the locations (SD-02). Seventeen SVOCs were detected at this location. SVOCs were also detected in the

sediment samples collected from other locations. Two SVOCs (benzo[a]pyrene and benzo[b]fluoranthene) exceeded their RSLs in samples collected from the West Ditch. No SVOCs exceeded their respective RSLs in the sample collected from the East Ditch.

- Although pesticides were detected in samples collected from the West Ditch, none exceeded the RSLs. No pesticides were detected in the sample collected from the East Ditch.
- Only one PCB was detected in one sample collected from the West Ditch and it was detected below the RSL. No PCBs were detected in the sample collected from the East Ditch.
- Dioxins/furans were detected in upgradient background samples and those collected from the East and West Ditch. A review of available data suggests that upgradient sources may have contributed to surface water and sediment dioxin loading upgradient of the site. The TCDD TEQ values exceeded the RSL in the background samples only. Individual dioxin/furan congeners and the TCDD TEQ value were detected below the RSLs in samples collected from the West Ditch.
- Aluminum, arsenic, cobalt, iron, manganese, and thallium exceeded the screening criteria in the West Ditch. Manganese exceeded its screening criteria in the sediment sample collected from the East Ditch.

2.5.1.5 Groundwater

Four consecutive quarters of groundwater samples were collected in August 2003, November 2003, February 2004, and May 2004. Groundwater samples also were collected as part of the 1995, 1997, and 1998 sampling events. The following results were observed:

- Although VOCs were detected in groundwater samples collected during investigation activities, concentrations of VOCs detected were low. The only VOC detected above its RSL and MCL was methylene chloride. Methylene chloride is associated with laboratory contamination and does not appear to be related to former Lockbourne AFB landfill.
- Although no SVOCs were detected during the Phase II SI, five SVOCs were detected below the RSLs during the Phase I SI. Seven SVOCs (bis[2-ethylhexyl]phthalate, benz[a]anthracene, benz[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene, and naphthalene) were detected above their respective RSLs in groundwater in the UWBZ during the RI. Two of the SVOCs (benzo[a]pyrene and bis[2-ethylhexyl]phthalate) were detected above their respective MCLs in the UWBZ. Six SVOCs (bis[2-ethylhexyl]phthalate, benz[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene, and naphthalene) were detected above their respective RSLs in groundwater in the IDA during the RI. One of the SVOCs (bis[2-ethylhexyl]phthalate) was detected above the MCL.
- Groundwater in the UWBZ and IDA was analyzed for pesticides, which were not detected.
- Groundwater in the UWBZ and IDA was analyzed for PCBs, which were not detected.
- Seven individual dioxin/furan congeners (heptachlorodibenzo-p-dioxins [total], hexachlorodibenzo-p-dioxins [total], pentachlorodibenzo-p-dioxins [total], 2,3,7,8-tetrachlorodibenzo-p-dioxin, hexachlorodibenzofurans [total], 2,3,4,7,8-

pentachlorodibenzofuran, and 2,3,7,8-tetrachlorodibenzofuran) exceeded their respective RSLs in groundwater in the UWBZ. Two individual dioxin/furan congeners (hexachlorodibenzofurans [total] and 2,3,7,8-tetrachlorodibenzofuran) exceeded their respective RSLs in groundwater in the IDA. The TCDD-TEQ values exceeded the RSL and IDA.

- Inorganics that were detected above their respective RSLs and background concentrations in UWBZ wells were aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, thallium, and vanadium. Four inorganics (arsenic, cadmium, lead, and thallium) exceeded their respective MCLs in UWBZ wells. Inorganics that were detected above their respective RSLs in IDA wells were arsenic, aluminum, barium, chromium, cobalt, iron, lead, and manganese. The concentrations of arsenic and barium, however, were less than background concentrations. Two inorganics (arsenic and lead) exceeded their respective MCLs in IDA.

2.5.1.6 Seeps

Although seeps were located and sampled in previous sampling events, CH2M HILL made four attempts to locate previously identified seeps during the 2008-2009 SI (two September 2008 events, one October 2008 event, and one February 2009 event). No seeps were found. Representatives of CH2M HILL, Ohio EPA, and USACE agreed that seeps did not exist as persistent features, and therefore, they were excluded from the scope of the SI report. Since the seeps could not be located, and the data gathered from previous investigation could not be replicated, an assessment of risk was not conducted using the historical seep data. An explanation as to what happened to the seeps is speculation, but it may be attributed to changes in the migration of groundwater flow to the surface.

2.5.2 AOC 2

2.5.2.1 Surface Soil

Surface soil samples were collected from a depth of 0 to 1 foot bgs during the 2003 and 1995 sampling events. Sampling locations are shown on Figure 2-3. The following results were observed:

- Concentrations of VOCs detected in the surface soil samples were low and below their respective RSLs.
- Concentrations of five PAHs (benz[a]anthracene; benzo[a]pyrene; benzo[b]fluoranthene; dibenz[a,h]anthracene, and naphthalene) were detected above their respective RSLs. These PAHs were detected throughout AOC 2.
- Pesticides detected at AOC 2 were p,p′-DDD; p,p′-DDE; and p,p′-DDT; however, none exceeded their respective RSLs.
- PCBs were not detected in any of the surface soil samples collected.
- Dioxin/furan congeners were detected in surface soil samples collected. Among the different dioxins/furans that were detected, the most commonly occurring dioxins/furans were heptachlorodibenzo-p-dioxin, octachlorodibenzo-p-dioxin,

pentachlorodibenzofuran, tetrachlorodibenzofurans, and tetrachlorodibenzo-p-dioxins. The values of TCDD TEQ exceeded the RSL in one sample.

- Three inorganics (cobalt, manganese, and thallium) exceeded the screening criteria.

2.5.2.2 Subsurface Soil

Soil samples were collected from depths of 1 to 10 foot bgs during the 1995 sampling event. Sampling locations are shown on Figures 2-4 and 2-5. The following results were observed:

- A limited number of VOCs were detected in the subsurface soil samples and the concentrations of the detected VOCs were low. Two VOCs, methylene chloride and trans-1,3-dichloropropene exceeded their respective RSLs for indoor air. However, methylene chloride can be associated with laboratory contamination.
- Only di-n-butyl phthalate was detected in the subsurface soil samples collected. However, concentrations were below the RSL.
- No pesticides were detected in the subsurface soil samples.
- No PCBs were detected in the subsurface soil samples.
- Dioxin/furan congeners were detected in the two subsurface soil samples analyzed, but concentrations did not exceed the RSLs.
- One inorganic (arsenic) exceeded the screening criteria.

2.5.2.3 Surface Water

The East and West Ditches are considered to be part of AOC 1, so no surface water samples were collected for AOC 2.

2.5.2.4 Sediment Sampling

The East and West Ditches are considered to be part of AOC 1, so no sediment samples were collected for AOC 2.

2.5.2.5 Groundwater

Four consecutive quarters of groundwater samples were collected in August 2003, November 2003, February 2004, and May 2004. Groundwater samples also were collected as part of the 1995, 1997, and 1998 sampling events. The following results were observed:

- Although VOCs were detected, concentrations of VOCs detected were low. As seen with AOC 1, during the 1995 sampling event, methylene chloride was detected above its RSL, however, is associated with laboratory contamination.
- Five SVOCs (benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, and indeno[1,2,3-cd]pyrene) were detected above the RSLs in groundwater from the UWBZ. One SVOC (benzo[a]pyrene) was detected above the MCL in the UWBZ. SVOC detections in IDA were not above the RSLs or MCLs.
- Concentrations of pesticides in groundwater in the UWBZ and IDA were not detected.

- Concentrations of PCBs in groundwater in the UWBZ and IDA were not detected.
- The value of TCDD TEQ detected was above the RSL in groundwater from both UWBZ and IDA.
- Eight inorganics (aluminum, arsenic, chromium, cobalt, lead, manganese, nickel, and vanadium) were detected above their respective RSLs in the groundwater in the UWBZ; however, chromium was detected below the background level. Inorganic detections in IDA were not above the RSLs or MCLs.

2.6 Migration Pathways

The migration pathways for the contaminants at the site were identified in the RI based on a review of the nature and extent and the physical and chemical properties of the constituents of potential concern (COPCs). Analytes that exceeded background concentrations and risk-based screening levels were identified as COPCs for specific exposure areas.

Potential migration pathways for human exposures evaluated included:

- Surface soil to surface water and sediment as a result of surface runoff
- Surface soil to subsurface soil as a result of leaching
- Subsurface soil to groundwater and surface water as a result of leaching

A migration pathway is considered complete if a chemical present in a source is detected in other media some distance from the source at concentrations that illustrate a trend over background. An important component of migration pathway evaluation is the consideration of contaminant fate and transport mechanisms. A primary objective of the contaminant fate and transport assessment is to determine if COPCs have the potential to reach downgradient receptors.

The RI identified the following COPCs at the site:

AOC 1

- Surface Soil (0 to 1 foot bgs): PAHs, PCBs, inorganics, and dioxins/furans
- Total Soil (0 to 10 feet bgs): PAHs, one PCB, inorganics, and dioxins/furans
- East Ditch Surface water— Inorganics
- West Ditch, Surface Water — Inorganics and dioxins/furans
- East Ditch, Sediment — One inorganic
- West Ditch, Sediment —PAHs, one SVOC, and inorganics
- UWBZ Groundwater —PAHs, inorganics, dioxins/furans, and SVOCs
- IDA Groundwater —PAHs, inorganics, dioxins/furans, and one SVOC

AOC 2

- Surface Soil (0 to 1 foot bgs): PAHs, inorganics, and dioxins/furans
- Total Soil (0 to 10 feet bgs): One inorganics
- UWBZ Groundwater —PAHs, inorganics, and dioxins/furans

Significant factors affecting the fate and transport of COPCs include the chemical and physical properties of the COPCs and of the surrounding geology/environment. The noted COPCs, particularly the high molecular weight PAHs, PCBs, and dioxins/furans, generally

are insoluble in water and have a strong affinity to remain bound to soil. They therefore are not mobile in the dissolved phase and migrate primarily by colloidal transport or while sorbed to particulates. The surrounding geology/environment at the site also limits the potential for COPCs to migrate in groundwater. The permeabilities of the site soils and parent geologic materials in the shallow subsurface beneath the landfill are low, as identified in the RI presentation of site hydrogeology. Therefore, groundwater transport is likely a less significant mechanism for contaminant transport than surface runoff.

The qualitative fate and transport evaluation indicates the migration pathways most important to consider in developing remedial alternatives for the site are surface soil to sediment via surface water runoff, and surface soil to subsurface soil via infiltration/leaching. There is some evidence of migration of contaminants from surface soil to surface water via runoff, and from subsurface soil to groundwater via leaching. However, these migration routes are considered of less significance because the contaminants are not readily mobile in the dissolved phase and typically rely on transport via colloids or sorption to larger particulates, in groundwater or surface water.

2.7 Baseline Risk Assessment Summary

A synopsis of the risk levels, which were determined during the baseline risk assessment, is presented below. The baseline risk assessment is an analysis of the potential adverse health effects caused by exposure to hazardous substances released from a site in the absence of actions to control or mitigate these releases (that is, under an assumption of no action). The baseline risk assessment contributes to the characterization and subsequent development, evaluation, and selection of appropriate remedial alternatives.

2.7.1 Human Health Risk Assessment

A human health risk assessment (HHRA) was performed to evaluate potential current and future risks associated with detected constituents at the site. Surface soil, subsurface soil, sediment, surface water, and groundwater analytical data were evaluated in the HHRA. The HHRA has been prepared following USEPA guidance (including *Risk Assessment Guidance for Superfund* [RAGS] Part A, Part D, Part E, Part F; USEPA 1989, 2002, 2004, 2009), as well as Ohio EPA guidance (Ohio EPA 2004).

Analytes that exceeded background concentrations (for inorganics only) and exceeded risk-based screening levels were identified as COPCs for specific exposure areas. As discussed in Section 6.2.2 of the RI report (CH2M HILL 2010), TCDD TEQ concentrations were calculated using the dioxin/furan congener data. The TCDD TEQ was used to quantify risks in the HHRA evaluation. Table 6-5 of the RI report (CH2M HILL 2010) presents the constituents that were selected as COPCs for each of the media.

Potential risks were evaluated for the exposure pathways presented in Table 2-2.

Groundwater was divided into three potable use and vapor intrusion exposure units for the offsite resident evaluation: off-landfill IDA groundwater, AOC 1 UWBZ groundwater, and AOC 1 IDA groundwater. The off-landfill IDA groundwater exposure unit consists of groundwater data collected from monitoring well LCKMW-7. As shown on Figure 2-7, LCKMW-7 is at the eastern edge of the village of Lockbourne. As stated earlier,

groundwater flow in the shallow saturated zone (that is, UWBZ) and the IDA is generally toward the west and southwest. Groundwater data from LCKMW-7 were conservatively assumed to be representative of groundwater concentrations in offsite private wells. The AOC 1 UWBZ groundwater exposure unit consists of groundwater data collected from monitoring wells installed within the boundary of AOC 1 and screened in the UWBZ. The AOC 1 IDA groundwater exposure unit consists of groundwater data collected from monitoring wells installed within the boundary of AOC 1 and screened in the IDA.

TABLE 2-2
Evaluation of Potential Risks for Exposure Pathways
Former Lockbourne AFB Landfill

Exposure Area	Exposure Medium	Human Receptors
AOC 1	Surface soil	Current/Future Maintenance, Trespasser/Visitor, and Industrial Worker
AOC 1	Total soil*	Future Construction Worker
AOC 1	UWBZ groundwater	Future Construction Worker and Offsite Residents
AOC 1	IDA groundwater	Future Offsite Residents
AOC 1	Indoor air (vapor intrusion from groundwater - UWBZ) [1]	Future Offsite Residents
AOC 1	Indoor air (vapor intrusion from groundwater - IDA) [1]	Future Offsite Residents
AOC 2	Surface soil	Current/Future Maintenance, Trespasser/Visitor, and Industrial Worker, Future Onsite Facility Worker
AOC 2	Total soil*	Future Construction Worker
AOC 2	Indoor air (vapor intrusion from total soil*)	Future Onsite Facility Worker
AOC 2	UWBZ groundwater	Future Construction Worker
AOC 2	Indoor air (vapor intrusion from groundwater - UWBZ) [1]	Future Onsite Facility Worker
AOC 2	Indoor air (vapor intrusion from groundwater - IDA) [1]	Future Onsite Facility Worker
East Ditch	Sediment and surface water	Current/Future Trespasser/Visitor, Future Construction Worker
West Ditch	Sediment and surface water	Current/Future Trespasser/Visitor, Future Construction Worker
Off-Landfill	IDA groundwater	Future Offsite Residents
Off-Landfill	Indoor air (vapor intrusion from groundwater - IDA)[1]	Future Offsite Residents

* Total Soil – surface soil and subsurface soil combined (0 to 10 feet bgs).
[1] No COPCs were identified for indoor air (vapor intrusion from groundwater).

Potential human health risks are discussed independently for carcinogenic and noncarcinogenic constituents in the RI report (CH2M HILL 2010) because of the different toxicological endpoints, relevant exposure duration, and methods used to characterize risk. Some constituents may produce both noncarcinogenic and carcinogenic effects and were

evaluated in both groups. The methodology used to estimate noncarcinogenic hazards and carcinogenic risks are described below.

Noncarcinogenic health risks are estimated by comparing the calculated intake to a reference dose (RfD) or reference concentration (RfC). The calculated intake divided by the RfD or RfC is equal to the hazard quotient (HQ). An HQ that exceeds 1 (that is, the intake exceeds the RfD) indicates there is a potential for adverse health effects associated with exposure to that constituent. To assess the potential for noncarcinogenic health effects posed by exposure to multiple constituents, a hazard index (HI) approach is used (USEPA 1986). This approach assumes that noncarcinogenic hazards associated with exposure to more than one constituent are additive. The HI may exceed 1 even if all of the individual HQs are less than 1. HIs also are added across exposure routes and media to estimate the total noncarcinogenic health effects to a receptor posed by exposure through multiple routes and media. An HI greater than 1 indicates there is some potential for adverse noncarcinogenic health effects associated with exposure to the COPC. However, if the HI is greater than 1, separate HIs for the different target organs/effects are calculated, to determine if the HI for a specific target organ/effect is greater than 1. If the HI for each target organ/effect is not above 1, it can be assumed there is no unacceptable noncarcinogenic hazard to the receptor.

The potential for carcinogenic effects because of exposure to site-related constituents is evaluated by estimating the excess lifetime cancer risk (ELCR). ELCR is the excess incremental increase in the probability of developing cancer during one's lifetime as a result of the assumed exposures to the site constituents over an individual's risks without exposure to the site. The combined risk from exposure to multiple constituents was evaluated by adding the risks from individual constituents. Risks also were added across the exposure routes and media if an individual would be exposed through multiple routes and to multiple media. When a cumulative carcinogenic risk to an individual receptor under the assumed reasonable maximum exposure conditions at the site exceeds 100 in a million (that is, 10^{-4} excess carcinogenic risk), CERCLA generally requires remedial action to reduce risks at the site (USEPA 1991). If the cumulative risk is less than 10^{-4}, action generally is not required, but may be warranted if a risk-based chemical-specific standard (such as MCL) is exceeded. Ohio EPA's target risk level is 1×10^{-5} (Ohio EPA 2004).

Once the human health risks for carcinogenic and noncarcinogenic constituents were calculated, the exposure scenarios were evaluated to determine if they exceeded risk targets or not. The human health risk exposure scenarios at the site that do not exceed risk targets are identified in Table 2-3.

The exposure scenarios that exceed risk targets are identified in Table 2-4 along with the risk drivers, or constituents of concern (COCs). COCs are those constituents that, after the risk assessment, are responsible for the unacceptable risks at the site. The COCs typically drive the need for a remedial action at a site.

For soil exposure scenarios that exceed the risk target goals (that is, AOC 1 current/future maintenance and trespasser/visitor, and future construction worker), risks are driven primarily by PAHs and PCBs. Exposure to lead in AOC 1 soil by future construction workers would result in blood lead levels (BLLs) in children (fetuses of exposed construction workers) that exceed the acceptable criterion for BLLs for fetuses.

TABLE 2-3
Health Risk Exposure Scenarios—Acceptable Risk
Former Lockbourne AFB Landfill

Exposure Area	Exposure Medium	Human Receptors
AOC 1	Surface soil	Industrial Worker
AOC 2	Surface soil	Current/Future Maintenance, Trespasser/Visitor, and Industrial Worker; Future Onsite Facility Worker
AOC 2	Total soil	Future Construction Worker
AOC 2	Indoor air (vapor intrusion from total soil)	Future Onsite Facility Worker
East Ditch	Sediment and surface water	Current/Future Trespasser/Visitor Future Construction Worker
West Ditch	Sediment and surface water	Current/Future Trespasser/Visitor; Future Construction Worker

For groundwater exposure scenarios that exceed risk target goals (that is, future construction workers and offsite residents), risks are driven primarily by PAHs and dioxins/furans, and to a lesser extent by inorganics, VOCs, and phthalates. Lead concentrations in AOC 1 UWBZ groundwater would exceed the criterion for BLL in future children exposed to offsite groundwater. However, based on the chemistry, it is likely that a significant fraction of lead carried by water is expected to be in an undissolved form, which can consist of colloidal particles or larger undissolved particles of lead compounds. Also, the fate of lead is affected by the adsorption at mineral interfaces, the precipitation of sparingly soluble solid forms of the compound, and the formation of relatively stable organic-metal complexes or chelates with soil organic matter (CH2M HILL 2010). As a result, offsite migration of lead is not anticipated.

No residential exposure scenarios were calculated for AOC 2 because it is not a reasonably foreseeable use scenario. There are no plans for residential development; land use will remain industrial, and an environmental covenant will be used to limit land use to nonresidential activities.

2.7.2 Ecological Risk Assessment

This section presents the results from the ecological risk assessment (ERA), which was conducted to assess the potential risk to ecological receptors at AOCs 1 and 2 from exposure to site-related constituents. The ERA also identified the ditches located along the eastern and western portions of the site as separate exposure areas. Therefore, risks evaluated in the East Ditch and West Ditch are presented separately from AOCs 1 and 2. This ERA was conducted in accordance with EM 200-1-4, *Risk Assessment Handbook: Volume II – Environmental Evaluation* (USACE 1996) and *Ecological Risk Assessment Guidance Document* (Ohio EPA 2008).

This ERA was performed to evaluate the actual or potential ecological effects from exposures to the site. This multi-pathway analysis was based on reasonable, protective assumptions about the potential for ecological receptors lower-trophic receptors (such as plants and benthic invertebrates/soil invertebrates) and upper-trophic terrestrial and aquatic receptors (such as birds, mammals, and fish) to be exposed to and be adversely affected by exposure to COPCs.

TABLE 2-4
Exposure Scenarios that may Pose Unacceptable Risk
Former Lockbourne AFB Landfill

Exposure Area	Exposure Medium	Human Receptors	Quantitative Risk Results		Lead, BLL	Constituents of Concern
			Carcinogenic	Non-carcinogenic Hazard Index		
AOC 1	Surface soil	Current/future maintenance worker	1.9×10^{-4}	0.017		PAHs (benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene), PCB-1248
AOC 1	Surface soil	Current/future youth trespasser/visitor	1.1×10^{-4}	0.025		PAHs (benzo(a)pyrene, benz(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene), PCB-1248
AOC 1	Total soil	Future construction worker	1.0×10^{-4}	0.39	7.1-11.5 %	PAHs, (benzo(a)pyrene, dibenz(a,h)anthracene, benz(a)anthracene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene), PCB-1248, lead
AOC 1	UWBZ groundwater	Future construction worker	1.4×10^{-5}	2.5		PAHs (benzo(a)pyrene, dibenz(a,h)anthracene), dioxins/furans
AOC 2	UWBZ groundwater	Future construction worker	3.0×10^{-5}	3.1		PAHs (dibenz(a,h)anthracene, benz(a)pyrene, indeno(1,2,3-cd)pyrene), dioxins/furans
Off-landfill	IDA groundwater	Future offsite adult residents		5.7		Dioxins/furans
Off-Landfill	IDA groundwater	Future child residents		13		Dioxins/furans
AOC 1	UWBZ groundwater	Future offsite adult resident		28		Arsenic, iron, manganese, thallium, dioxins/furans
AOC 1	UWBZ groundwater	Future child resident		63	7.8%	Arsenic, cobalt, iron, lead, manganese, thallium, dioxins/ furans
AOC 1	IDA groundwater	Future offsite adult resident		7.7		Naphthalene, dioxins/furans
AOC 1	IDA groundwater	Future child resident		17		Iron, manganese, naphthalene, dioxins/furans

TABLE 2-4
Exposure Scenarios that may Pose Unacceptable Risk
Former Lockbourne AFB Landfill

Exposure Area	Exposure Medium	Human Receptors	Quantitative Risk Results		Lead, BLL	Constituents of Concern
			Carcinogenic	Non-carcinogenic Hazard Index		
Off Landfill	IDA groundwater	Future lifetime resident	7.6×10^{-3}			PAHs (benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, benzo(a)anthracene), dioxins/ furans
AOC 1	UWBZ groundwater	Future lifetime resident	9.2×10^{-3}			PAHs (benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene, benz(a)anthracene), naphthalene, bis(2-ethylhexyl) phthalate, dioxins/ furans, arsenic
AOC 1	IDA groundwater	Future lifetime resident	7.6×10^{-3}			PAHs (benzo(a)pyrene, benzo(b)fluoranthene, dibenz(a,h)anthracene, indeno(1,2,3-cd)pyrene), naphthalene, bis(2-ethylhexyl) phthalate, dioxins/ furans

AOC = area of concern
IDA = intermediate depth aquifer
PCB = polychlorinated biphenyl
UWBZ = upper water-bearing zone
BLL = blood lead level
PAH = polynuclear aromatic hydrocarbon
SVOC = semivolatile organic compound
VOC = volatile organic compound

The upper-trophic receptors were selected as surrogate species representing estimated exposure and subsequently risk to other species within comparable feeding guilds. Key wildlife receptors include the deer mouse, American robin, mourning dove, short-tailed shrew, red-tailed hawk, red fox, mallard, marsh wren, muskrat, belted kingfisher, and mink. For terrestrial mammals (deer mouse, short-tailed shrew, red fox, muskrat, and the mink), the ERA assumed they would be present at the site 100 percent of the time.

Table 2-5 summarizes the COPCs identified by medium and exposure scenario using maximum concentrations in Step 2 of the ERA process (that is, the initial screening ERA). These constituents were carried into Step 3 of the ERA process (that is, the first step of the baseline ecological risk assessment), in which the conservative assumptions employed in the SERA were refined and risk estimates were recalculated.

Based on the refined risk calculations represented in Section 7.3 of the RI report, COPCs were identified in media based on direct exposures. The following section presents a detailed discussion of the potential for the COPCs that pose unacceptable risk to receptor populations. Table 7-47 of the RI report summarizes the findings of ecological significance (CH2M HILL 2010).

2.7.2.1 Terrestrial Habitat

2.7.2.1.1 AOC 1. Based on a comparison of soil concentrations to benchmarks, lower-trophic receptors may be at risk because of exposure to aluminum, chromium, lead, mercury, selenium, thallium, zinc, DDT, PCBs, PAHs, and dioxins/furans.

Based on results of the food web modeling, invertivorous mammals may be at risk because of thallium, PCBs, benzo(a)anthracene, benzo(a)pyrene, pyrene, and dioxins/furans. Herbivorous mammals and carnivorous mammals may be at risk to PCBs. Insectivorous birds may be at risk because of exposure to PCBs and lead, while herbivorous birds may be at risk because of exposure to lead only.

2.7.2.1.2 AOC 2. Based on the assessment of the COPCs identified within AOC 2, it is unlikely that lower- or upper-trophic receptors are at risk. Furthermore, AOC 2 will be developed for commercial and/or industrial use and, as a result, it is likely that the current habitat present onsite will become limited or eliminated in some areas resulting in reduced exposure potential as receptors re-locate to areas where adequate habitat is present.

2.7.2.2 Aquatic Habitat

2.7.2.2.1 West Ditch. Based on a comparison of surface water to benchmarks, potential risk to lower-trophic aquatic receptors exists for direct exposure to dioxins/furans. Comparisons of sediment concentrations to benchmarks indicate potential risks for lower-trophic aquatic receptors from direct exposure to arsenic, DDD, DDE, DDT, PAHs (low molecular weight [LMW], high molecular weight [HMW], and total PAHs), and dioxins/furans. The results of the food web modeling indicated that no potential risk to upper-trophic aquatic receptors from exposure to site-related COPCs is present in the West Ditch.

TABLE 2-5
Chemicals of Potential Concern Summary (Step 2)
Former Lockbourne AFB Landfill

	Direct Exposure[1]						Food Web Exposures			
	Surface Soil		Sediment		Surface Water		Terrestrial Receptors3		Aquatic Receptors	
COPEC	**AOC 1**	**AOC 2**	**W. Ditch**	**E. Ditch**	**W. Ditch**	**E. Ditch**	**AOC 1**	**AOC 2**	**W. Ditch**	**E. Ditch**
Inorganics										
Aluminum	X						NSV[2]			
Antimony							X			
Arsenic		X	X					X	X	
Barium	X									
Cadmium							X			
Chromium, total	X									
Cobalt		X								
Copper	X						X			
Lead	X		X				X	X	X	
Manganese		X								
Mercury	X						X			
Selenium	X	X					X			
Silver							X			
Thallium	X	X					X	X		
Vanadium										
Zinc	X	X					X	X		
Pesticides/PCBs										
Chlordane, gamma-	X						X			
DDD, p,p'-			X							
DDE, p,p'-		X	X					X		

TABLE 2-5
Chemicals of Potential Concern Summary (Step 2)
Former Lockbourne AFB Landfill

	Direct Exposure[1]						Food Web Exposures			
	Surface Soil		Sediment		Surface Water		Terrestrial Receptors3		Aquatic Receptors	
COPEC	**AOC 1**	**AOC 2**	**W. Ditch**	**E. Ditch**	**W. Ditch**	**E. Ditch**	**AOC 1**	**AOC 2**	**W. Ditch**	**E. Ditch**
DDT, p,p'-	X	X	X				X	X		
PCB 1242							X			
PCB 1248	X						X			
PCB 1254	X						X			
PCB 1260							X			
Total PCBs	X		X				X		X	
SVOCs										
Acenaphthene	X		X							
Benzo(a)anthracene	X		X				X			
Benzo(a)pyrene	X		X				X			
Benzo(b)fluoranthene	X						X			
Benzoic Acid	NSV[2]	NSV[2]					NSV[2]	NSV[2]		
Benzo(k)fluoranthene	X						X			
Butylbenzyl phthalate	NSV[2]						NSV[2]			
Bis(2-ethylhexyl)phthalate	X		NSV[2]				X			
Carbazole	NSV[2]						NSV[2]			
Chrysene	X		X				X			
Dibenzo(a,h)anthracene	X						X			
Dibenzofuran	NSV[2]	NSV[2]					NSV[2]	NSV[2]		
Di-n-butyl phthalate	X						X			
Di-n-butyl phthalate	NSV[2]						NSV[2]			

TABLE 2-5
Chemicals of Potential Concern Summary (Step 2)
Former Lockbourne AFB Landfill

	Direct Exposure[1]						Food Web Exposures			
	Surface Soil		Sediment		Surface Water		Terrestrial Receptors3		Aquatic Receptors	
COPEC	**AOC 1**	**AOC 2**	**W. Ditch**	**E. Ditch**	**W. Ditch**	**E. Ditch**	**AOC 1**	**AOC 2**	**W. Ditch**	**E. Ditch**
Fluoranthene	X		X				X			
Fluorene	X									
Indeno(1,2,3-cd)pyrene	X						X			
Methylnaphthalene-2	X		X				X			
Methylphenol, 3- and/or 4-	NSV[2]						NSV[2]			
Naphthalene	X	X					X	X		
Phenanthrene	X		X				X			
Pyrene	X		X				X			
Total Low Molecular Weight PAHs	X		X	X			X			
Total High Molecular Weight PAHs	X		X	X			X	X		
Total PAHs			X	X						
VOCs										
Acetone	X	X	X				X	X		
Explosives										
Trinitrotoluene, 2,4,6-	NSV[2]						NSV[2]			
Dioxins/furans										
TCDD TEQ	X	X	X		X		X	X		

[1] Direct exposures based on maximum concentration for each media.
[2] No screening value available. Constituent was retained as COPEC and further evaluated in the risk characterization section.
[3] Food web exposures for terrestrial receptors were based on comparison of maximum constituent concentration to USEPA Region 5 ecological screening level (based on exposure to a masked shrew [*Sorex cinerus*]) and USEPA ecological soil screening levels for mammals and avian receptors.
COPEC—constituent (or chemical) of potential ecological concern; NSV – no screening value

2.7.2.2.2 East Ditch. Based on a comparison of surface water concentrations to benchmarks, significant ecological risks were not indicated for surface water. Comparison of sediment concentrations to benchmarks indicates potential risk to lower-trophic aquatic receptors from exposure to PAHs (LMW, HMW, and total PAHs). The results of the food web modeling indicated that no potential risk to upper-trophic aquatic receptors from exposure to site-related COPCs is present in the East Ditch.

2.7.2.3 Ecological Risk Conclusions

The results of the ERA are summarized in Table 2-6, including the exposure area, medium, and the ecological COCs.

TABLE 2-6
Ecological Risk Summary
Former Lockbourne AFB Landfill

Exposure Area	Exposure Medium	Receptors	Constituents of Concern
AOC 1	Surface soil (0 - 4 feet)	Terrestrial mammals	Thallium, PAHs, PCBs, dioxins/furans
		Terrestrial birds	Lead, PCBs
		Lower-trophic receptors	Aluminum, chromium, lead, mercury, selenium, thallium, zinc, DDT, PCBs, PAHs, dioxins/furans
AOC 2	Surface soil (0 - 4 feet)	Terrestrial mammals	NR
		Lower-trophic receptors	NR
East Ditch	Surface water	Lower-trophic receptors	NR
		Upper-trophic receptors	NR
	Sediment	Lower-trophic receptors	PAHs
		Upper-trophic receptors	NR
West Ditch	Surface water	Lower-trophic receptors	Dioxins/Furans
	Sediment	Lower-trophic receptors	Arsenic, DDD, DDE, DDT, PCBs, PAHs, dioxins/furans

NR = negligible risk as determined in the ERA

Based on the results of the ERA, potential ecological risks were identified. Specifically, potential risks were identified for terrestrial mammals and birds at AOC 1 and to lower-trophic receptors at AOC 1, the East Ditch, and the West Ditch. However, as presented in Section 7 of the RI, the East and West Ditches provide poor to marginal habitat quality for aquatic receptors (based on low habitat quality scores assessed using Ohio EPA's Qualitative Habitat Evaluation Index and USEPA's Rapid Bioassessment Protocol). Given the low habitat scores as well as the presence of a low diverse macroinvertebrate population void of high quality indicator species, it is unlikely that the East and West Ditches could support a viable fish population and it is unlikely they provide a significant source of food for upper-trophic populations.

No unacceptable risk was identified for ecological receptors at AOC 2.

SECTION 3

Remedial Action Objectives

The RAOs are developed in this FFS report to:

- Provide a basis for evaluating remedial alternatives
- Achieve the goal of protecting human health and environment from exposure to COCs at the site and surrounding areas

To ensure protection of human health and environment, remedial alternatives are selected to reduce the concentrations of residual contaminants, and/or to reduce the exposure of receptors to residual contaminants. Consequently, the RAOs are both contaminant-specific and exposure-specific, and consider the contaminants and media of interest, exposure pathways, and possible future receptors.

The following RAOs are selected based upon consideration of ARARs (Section 4.2), the baseline HHRA (Section 2.6), and fate and transport of COCs (Section 2.6):

- Eliminate unacceptable human and ecological risks due to potential exposure to COCs in soil
- Eliminate unacceptable risk from exposure to COCs in groundwater at the site
- Eliminate unacceptable transfer of contaminants to nearby surface water resources
- Beneficially reuse site material to complete landfill closure and provide for sustainability
- Allow for beneficial reuse of the site through creative site closure design, construction, and restoration

Detailed discussions of the RAOs are provided below.

3.1 Eliminate Unacceptable Human and Ecological Risks due to Potential Exposure to Constituents of Concern in Soil

This RAO was established to mitigate the risks posed to human and ecological receptors from the impacted surface and subsurface soil at the former site. Implementation of a compacted clay cap or soil cover over the impacted soil in AOC 1 would reduce this exposure. Environmental covenants would be implemented to restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cap/cover.

3.2 Eliminate Unacceptable Risk from Exposure to Constituents of Concern in Groundwater at the Site

This RAO was established to safeguard potential receptors of groundwater. An environmental covenant would be implemented for the site to restrict the use of groundwater for potable consumption and to limit unprotected construction worker exposures to groundwater at the site. Therefore, no onsite potable water use wells would be installed at the site. Implementation of a compacted clay cap or soil cover over the impacted media in AOC 1, after consolidation of wastes, would reduce infiltration of rain water and minimize downward migration of COCs to groundwater. Site groundwater also would be monitored via a network of wells, both onsite and downgradient, to confirm that COCs from the landfill at AOC 1 are not migrating downgradient.

3.3 Eliminate Unacceptable transfer of Contaminants to Nearby Surface Water Resources

This RAO was established to control erosion and surface water runoff at AOC 1, and to prevent the deposition of sediment into the East and West Ditches by capping or covering the former Lockbourne AFB landfill (AOC 1).

3.4 Beneficially Reuse Site Material to Complete Landfill Closure and Provide for Sustainability

Construction debris found at AOC 1 would be consolidated and would be used in grading. Additionally, cleared vegetation could be mulched and serve as raw material for landscaping, including construction of paths.

3.5 Allow for Beneficial Reuse of the Site through Creative Site Closure Design, Construction, and Restoration

This RAO was included to provide for appropriate future use of the land so that it may benefit the neighboring community and align with CRAA's goals for future redevelopment.

SECTION 4

Technology Screening and Development of Remedial Alternatives

This section presents the remedial technologies that were evaluated to meet the RAOs developed for the site. The remedial technologies identified are then used to develop the remedial alternatives considered in this FFS. Potential remedial technologies are identified through USEPA guidance documents, literature review, and experience at other sites. This section describes the identification and screening of remedial technologies and remedial alternatives based on the RAOs identified in Section 3.

4.1 Technology Screening

To select appropriate remedial alternatives that address the RAOs, potentially applicable remedial technologies were reviewed. The following USEPA guidance documents were used:

- *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA 1988)
- *Conducting Remedial Investigation/Feasibility Studies for CERCLA Municipal Landfill Sites* (USEPA 1991)
- *Presumptive Remedies: Policy and Procedures* (USEPA 1993a)
- *Presumptive Remedies for CERCLA Municipal Landfill Sites* (USEPA 1993b)
- *Application of CERCLA Municipal Landfill Presumptive Remedy to Military Landfills* (USEPA 1996)

4.1.1 Applicability of Presumptive Remedy for AOC 1

For landfills where municipal-type waste was disposed of, such as at AOC 1, technology identification and the screening process can be streamlined using presumptive remedies.

In general, presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and USEPA's scientific and engineering evaluation of performance data on technology implementation. USEPA evaluated technologies that have been consistently selected at past sites using the remedy selection criteria set out in the NCP; reviewed currently available performance data on the application of these technologies; and has determined that a particular remedy, or set of remedies, is presumptively the most appropriate for addressing specific types of sites (http://www.epa.gov/superfund/policy/remedy/presump/pol.htm). USEPA established containment as the presumptive remedy for municipal landfill sites (USEPA 1993b). Containment isolates the contamination to prevent direct contact by human or ecological receptors and reduces migration of contamination from soil to surface water, groundwater, and ambient air.

The *Application of the CERCLA Municipal Landfill Presumptive Remedy to Military Landfills* (USEPA 1996) discusses the decision criteria for the application of the presumptive remedy. This guidance indicates that it is applicable to landfills having the following characteristics:

- Risks are low-level, except for "hot spots"
- Treatment of wastes is usually impractical because of the volume and heterogeneity of waste
- Waste types include household, commercial, nonhazardous sludge, and industrial solid wastes
- Lesser quantities of hazardous wastes are present as compared to municipal wastes
- Land application units, surface impoundments, injection wells, and waste piles are not included

AOC 1 meets the above five requirements. Therefore, the presumptive remedy is the appropriate response action considered for AOC 1.

The risks identified for the site can be classified as low, except for certain areas of AOC 1 where wastes were detected. Based on preliminary estimation, the area that would be covered with waste after consolidation is approximately 40 acres. Based on previous investigations and/or historical records, it was determined that the types of wastes found at AOC 1 are typical of those associated with MSW, and there are no known areas of military specific wastes or hazardous wastes present.

4.1.2 Remedial Technologies

4.1.2.1 AOC 1

Remedial technologies are actions that can be undertaken to achieve the site-specific RAOs, either independently or in combination. The following technologies have been identified for AOC 1:

- No action
- Institutional controls
- Long-term management
- Passive landfill gas management
- Consolidation
- Installation of compacted clay cap with 6 inches of topsoil
- Installation of soil cover with 6 inches of topsoil

Each remedial technology action is discussed in the following sections.

4.1.2.1.1 No Action. No action means that nothing further would be done at AOC 1 to change the current conditions. This option is retained for this FFS report as this is required by the NCP to serve as a baseline for comparison to other remedial options. The no action alternative can be easily implemented because there is nothing to implement. No capital or operations and maintenance (O&M) costs are associated with this alternative. Institutional controls, containment, removal, treatment, or other mitigating actions are not provided to reduce the potential for exposure.

4.1.2.1.2 Institutional Controls. Institutional controls relate to legal or administrative tools taken to reduce the potential for exposure to site contaminants. Institutional controls include restrictions on land use or site groundwater, and/or site access and security measures. Institutional controls for AOC 1 would restrict access for future industrial workers and construction workers, current/future maintenance workers and trespassers, and would restrict exposure to groundwater. Institutional controls, however, do not reduce the identified risks to ecological receptors from contaminants in the surface soil Institutional controls do not prevent migration of COCs from soil to groundwater or migration of COCs to downgradient locations. Institutional controls, however, can reduce short-term environmental impacts caused by more aggressive construction options that result in vegetation clearing, generation of particulate air emissions, generation of wastes, and so on.

As indicated in the final RI report (CH2M HILL 2010), environmental covenants could be used in conjunction with other remedies to restrict land and groundwater use. With the cover/cap activities described below, the components of the environmental covenants that are suggested for AOC 1 include the following:

- Restrict future site uses
- Use of groundwater shall be restricted to limit exposure.
- Intrusive activities shall be prevented at the covered/capped area.

4.1.2.1.3 Long-Term Management. This remedial technology consists of periodic sampling of groundwater monitoring wells, located both onsite and downgradient, to assess potential migration of groundwater contamination. The appropriate frequency for groundwater monitoring depends on the rate with which contaminant concentrations change with natural attenuation processes, the location of possible receptors, and RAOs. Based, in part, on previous studies (such as Barcelona et al. 1989), groundwater would be monitored at an appropriate frequency to establish baseline conditions over a period of time sufficient to observe seasonal trends, responses to recharge, and to estimate attenuation rates for key contaminants.

Groundwater samples would be collected at a frequency to be determined in the long-term management plan prepared as part of the remedial design. For cost estimating purposes, the proposed schedule for monitoring used was:

- Year 1 and Year 2—Quarterly monitoring for VOCs, SVOCs, dioxins/furans, pesticides, and inorganics
- Years 3 through 5—Semiannual monitoring for VOCs, SVOCs, dioxins/furans, pesticides, and inorganics
- Years 6 through 30 – Annual monitoring for VOCs, SVOCs, dioxins/furans, pesticides, and inorganics

The final monitoring program would be documented in the long-term management plan.

4.1.2.1.4 Passive Landfill Gas Management. A soil gas survey conducted in 1994 (LAW 1995) detected benzene, toluene, ethylbenzene, xylenes, and total petroleum hydrocarbons. However, these results were attributed to a release of petroleum products near the northern border of the transmitter station and other sporadically distributed localized surface or

subsurface releases of common petroleum products and solvents. Most of the detected soil gas concentrations corresponded with geophysical anomalies.

Based on the test pits completed by CH2M HILL during the SI and organic content, thickness of the wastes at AOC 1 are not significant (CH2M HILL 2009), and therefore, gas generation is anticipated to be low given the age of the waste. This is corroborated by the results obtained during the landfill gas screening (CH2M HILL 2009). During the methane sampling events conducted between February 13 and March 20, 2009, methane levels varied from 0 to 1.1 percent, carbon dioxide levels varied from 0 to 5.9 percent, and oxygen levels varied from 10.5 to 21.9 percent. Methane concentrations were below the action level of 1.25 percent methane (within structures) in air (as listed in 40 *Code of Federal Regulations* [CFR] 258). The low methane concentrations are consistent with expectations for a landfill with a depth of waste less than 10 feet and with no active disposal of waste for over 30 years.

- High rates of gas generation in landfills generally occur for a relatively short period (up to 10 years) after waste is placed and then decline with time. The site has been inactive for more than 30 years and observed low landfill gas monitoring results are consistent with this statement.
- No significant concentrations of VOCs were detected in the groundwater or soil samples.

Based on the above, landfill gas mitigation was not included in the remedial alternatives. Passive gas vents would be installed as part of the cap/cover design, and periodic monitoring at these vents would be conducted to ensure that the methane concentrations are low.

4.1.2.1.5 Consolidation. Figure 4-1 shows the approximate areas where wastes were detected in AOC 1 during investigation work. The area of waste disposal is approximately 50 acres. The presence of these wastes and soil contamination limits the proposed future activities in these areas. Consolidation of waste material would be undertaken to reduce landfill footprint and allow for the potential reuse of the cleared acreage. In accordance with Ohio Administrative Code (OAC) 3745-27-13(H)(6), wastes present at a landfill may be reconsolidated and can be placed within previously existing horizontal and vertical limits of waste placement. Waste cannot be used to backfill excavated areas outside the limits of waste placement, as per OAC 3745-27-13(H)(7). Consolidation also would mitigate impacts to the adjacent ditches, and to areas where wastes are present within the riparian areas. The East and West Ditches drain into Big Walnut Creek, a water body that has been identified by Ohio EPA as an Exceptional Warmwater Habitat (Ohio EPA 2000). Therefore, consolidating and capping/covering the wastes would effectively reduce potential risks posed by the landfill to Big Walnut Creek.

Excavation would require using standard construction equipment. If drums are encountered during the excavation, the hazards associated with drums would be determined before offsite disposal. Evaluation might be carried out by staging, opening, and sampling. Disposal of the drums would be based on the results of the evaluation. Ambient air would be monitored continuously during drum removal and sampling activities to protect the health of the workers.

4.1.2.1.6 Landfill Cap/Cover. Capping/covering is commonly applied to landfills because it is generally less expensive than other technologies and effectively will mitigate the

unacceptable risks to human health and the environment. Unacceptable risks for AOC 1 are summarized in Section 2.7. The landfill cap/cover would mitigate unacceptable risks by eliminating direct contact exposures with contaminated soil and waste and by eliminating the migration of contaminated surface soil to surrounding areas via surface water runoff. The landfill cap/cover would also reduce leaching to groundwater by minimizing surface water infiltration.

Two types of landfill caps/covers are being considered as follows, both of which meet the federal criteria for municipal solid waste landfills, 40 CFR 258.60, *Closure Criteria*.

- Compacted clay. This cap consists of a 24-inch-thick compacted clay layer with 6 inches of topsoil to support a vegetative cover. The clay cap would have a field permeability no greater than 1×10^{-7} centimeters per second. The method, field or laboratory testing, for determining the permeability of the cap will be determined during the landfill cap design. Slopes will range from a maximum of 4-foot horizontal: 1 foot-vertical to a minimum of 4 percent.
- Soil cover. This cover consists of a 24-inch-thick low permeability soil cover with 6 inches of topsoil to support a vegetative cover. The soil cover would have a field permeability no greater than 1×10^{-5} centimeters per second. The method, field or laboratory testing, for determining the permeability of the cover will be determined during the landfill cover design. The top 6 inches of topsoil would support a dense vegetative cover. Slopes will range from a maximum of 4 foot horizontal: 1 foot vertical to a minimum of 4 percent.

4.1.2.2 AOC 2

Remedial technologies are actions that can be undertaken to achieve the site-specific RAOs, either independently or in combination. The following technologies have been identified for AOC 2:

- No action
- Institutional controls

4.1.2.2.1 No Action. No action means that nothing further would be done at the site to change the current conditions. This option is retained for this FFS report as this is required by the NCP to serve as a baseline for comparison to other remedial options. The no action alternative can be easily implemented. No capital or O&M costs are associated with this alternative. Institutional controls, containment, removal, treatment, or other mitigating actions are not provided to reduce the potential for exposure.

4.1.2.2.2 Institutional Controls. Institutional controls relate to legal or administrative tools taken to reduce the potential for exposure to site contaminants. Institutional controls include restrictions on land or site groundwater use, and/or site access and security measures. Institutional controls do not prevent migration of COCs to downgradient locations. However, they can reduce short-term environmental impacts caused by more aggressive construction options that result in vegetation clearing, generation of particulate air emissions, generation of wastes, and so on. Institutional controls for AOC 2 would restrict human exposure to COCs in groundwater.

As indicated in the final RI report (CH2M HILL 2010), environmental covenants could be used to restrict groundwater use at AOC 2.

4.2 Identification of ARARs

Federal and state ARARs that affect the remedial action have been identified and evaluated. This evaluation is considered the first step in identifying regulations, requirements, and guidance that may be pertinent to actions to be taken at the site. This evaluation also includes an initial determination of whether potential ARARs actually qualify as applicable, or relevant and appropriate, based on known site conditions and a broad matrix of potential remedial technologies.

- *Applicable* requirements are cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal environmental, state environmental, or facility citing law that specifically address a hazardous substance, pollutant, contaminant, remedial alternative, location, or other circumstance at the site. For a requirement to be applicable, the remedial alternative or the circumstances at the site must satisfy the jurisdictional prerequisites of that requirement. "Applicability" implies that the remedial action or the circumstances at the site satisfy the jurisdictional prerequisites of a requirement. If a requirement is not applicable, one must consider whether it is both relevant and appropriate.
- *Relevant and appropriate* requirements are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility citing law that, while not legally applicable, address problems or situations sufficiently similar to the particular site conditions that their use may be well suited. For example, while Resource Conservation and Recovery Act (RCRA) regulations are not applicable to closing in place hazardous waste disposed of before 1980, RCRA regulations for closure with waste in place may be deemed relevant and appropriate. A requirement that is judged both relevant and appropriate must be complied with to the same degree as if it was applicable. In some circumstances, a requirement may be relevant to the particular site-specific situation, yet not be appropriate because of differences in the purpose of the requirement, the duration of the regulated activity, or the physical size or characteristic of the situation is intended to address. There is more discretion in the determination of relevant and appropriate requirements than in the determination of applicable requirements.

The three categories of ARARs are chemical-specific, location-specific, and action-specific. Chemical-specific ARARs are health- or risk-based concentration limits for specific hazardous substances in various environmental media set by federal and state regulations. Chemical-specific ARARs are numerical standards that establish the acceptable amount or concentration of a chemical that may be found in, or discharged to the environment. Chemical-specific ARARs may be derived from several standards including RCRA MCLs, Safe Drinking Water Act MCLs, and water quality criteria. No chemical-specific ARARs were identified.

Location-specific ARARs identify requirements that must be addressed during remedial activities because the activities occur in "special" locations. Location-specific ARARs include activities on and near wetlands and floodplains, archeological and natural resources,

historical landmarks, critical habitats of endangered or threatened species, and public drinking water systems. Location-specific ARARs may be derived from several standards including RCRA location requirements, National Historic Preservation Act of 1966, Endangered Species Act, Wilderness Act, Fish and Wildlife Coordination Act, Wild and Scenic Rivers Act, Coastal Zone Management Act, and the Clean Water Act. No location-specific ARARs were identified

Action-specific ARARs are technology-based or activity-based requirements or limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that were developed to accomplish a remedy. Table 4-1 presents the ARARs identified for the site and the proposed remedies for AOC 1 and AOC 2. No chemical- or location-specific ARARs were identified.

4.3 Screening Approach

This section assembles the feasible remedial technologies identified in Section 4.1 into remedial action alternatives for AOC 1 and AOC 2. The development process presented in this section consists of developing a list of alternatives based on the feasible technologies and process options, and screening of the potential alternatives based on effectiveness, implementability, and cost.

The following alternatives have been identified for AOC 1 for detailed evaluation:

- Alternative 1—No Action
- Alternative 2—Consolidation, Construction of a Compacted Clay Cap, Long-Term Management, and Institutional Controls
- Alternative 3—Consolidation, Construction of a Soil Cover, Long-Term Management, and Institutional Controls

The following alternatives have been identified for AOC 2 for detailed evaluation:

- Alternative 1—No Action
- Alternative 2—Implementation of Institutional Controls

Effectiveness is the degree to which an alternative meets RAOs and ARARs, safeguards human health and environment by reducing potential exposure to contaminated media, and protects the environment by preventing further transport of the contaminants. Alternatives that meet the criteria are considered effective; alternatives that are less effective or not effective are not considered further. Effectiveness focuses on the following:

- Potential effectiveness of the remedial alternatives in handling the estimated areas and volumes of the media of concern
- Ability of the remedial alternatives in meeting the RAOs
- Potential impacts to human health and the environment during the remedial action
- Reliability of the remedial alternatives with respect to the COCs and the site conditions

TABLE 4-1
Summary of ARARs
Former Lockbourne Air Force Base Landfill

	ARARs	Description of Regulation	Comments
1	OAC 3745-27-08 Construction Specifications for Sanitary Landfills	Specifies the minimum requirements for the soil/clay layers, granular drainage layer, geosynthetics, leachate management system, gas monitoring system, etc. Describes minimum standards for construction requirements for sanitary landfill facilities.	In coordination with Ohio EPA, USACE will be applying a waiver to this ARAR
2	OAC 3745-27-10 (effective August 15, 2003) Groundwater monitoring program for a sanitary landfill facility	Requires groundwater monitoring program for all sanitary landfill facilities. Requires that the system consist of a sufficient number of wells that are located so that samples indicate both upgradient (background) and downgradient water samples. Details minimum requirements that the system must be designed to meet. Details sampling and analysis procedures. Specifies procedures for assessment and correction of contamination.	In coordination with Ohio EPA, USACE will be applying a waiver to this ARAR
3	OAC 3745-27-13 (H) Sections 7 and 8 Disturbances Where Hazardous or Solid Waste Facility was Operated	Describes substantive limitations on any proposed filling, grading, excavating, building, drilling, or mining on land where a hazardous waste facility or solid waste facility was operated and how the activities will be accomplished.	
4	OAC 3745-27-11 (G) and (H) Final Closure of Sanitary Landfill Facilities	Requires closure of a landfill in a manner which minimizes the need for post-closure maintenance and minimizes post-closure formation and release of leachate and explosive gases to air, soil, groundwater, or surface water. Specifies acceptable cap design; barrier layer, granular drainage layer, soil and vegetative layer. Provides for use of comparable materials to those specified with approval of Director.	In coordination with Ohio EPA, USACE will be applying a waiver to this ARAR
5	OAC 3745-17-08B Restriction of emission of fugitive dust	Requires reasonably available control measures to prevent fugitive dust from becoming airborne.	

Implementability refers to the technical and administrative feasibility of implementing the alternative. Options that are technically or administratively difficult may be eliminated from further consideration. *Technical feasibility* refers to the ability of remedial alternatives to be constructed and reliably operated to meet technology-specific remediation regulations for process options until a remedial action is complete. The term also includes O&M, replacement, and monitoring (if needed) of technical components after remedial construction is complete.

Administrative feasibility refers to the ability to obtain approvals from federal and state agencies; availability of treatment, storage, and disposal services and capacity; and requirements for, and availability of, specific equipment and technical specialists.

Cost is evaluated relative to construction (capital) and long-term O&M required to operate and maintain the remedial alternatives. Cost plays a limited role in the screening of remedial alternatives at this stage.

4.3.1 Remedial Alternatives Screened for AOC 1

The following subsections describe the remedial alternatives screened for AOC 1 and the evaluation of their effectiveness, implementability, and cost.

4.3.1.1 Alternative 1—No Action

4.3.1.1.1 Description. The no action alternative is required to be considered in the FFS process. No action means that nothing would be done at AOC 1 to change the current contaminated soil conditions. Additionally, no action would be taken to restrict potential exposures to wastes. Natural attenuation processes, such as biodegradation, are expected to occur with the potential to reduce contaminant concentrations over time; however, the concentrations would not be monitored and the degree to which natural attenuation is occurring would not be documented. This alternative provides no institutional controls restricting future site use. Alternative 1 is retained as a baseline alternative, as required by the NCP.

4.3.1.1.2 Evaluation.
Effectiveness. The no action alternative relies entirely on unmonitored natural attenuation processes. Without monitoring or restrictions on future site use, impacted surface soil and site groundwater pose a risk to both human health and environment. Therefore, this alternative does not have the ability to meet the RAOs. This alternative does not minimize or mitigate potential impacts to nearby surface water or groundwater resources.

Implementability. There are no implementability considerations for the no action alternative.

Cost. This alternative has no associated costs.

4.3.1.2 Alternative 2—Consolidation, Construction of a Compacted Clay Cap, Long-Term Management, and Institutional Controls

4.3.1.2.1 Description. Alternative 2 involves consolidating waste and then constructing a compacted clay cap over the consolidated area. Figure 4-1 shows the different areas where wastes have been found. This figure also depicts the approximate area of AOC 1 to be capped. In addition, the area would be cleared and grubbed before construction, as it is currently covered with dense vegetation.

Long-term management also is part of this alternative. The final monitoring program would be documented in the landfill long-term management plan and is expected to include groundwater monitoring. Tentatively, the groundwater monitoring network would be comprised of existing and new groundwater monitoring wells. Some existing wells may be abandoned during construction of the clay cap, but they would be replaced with new wells. For cost estimating purposes, it is assumed that groundwater monitoring will be conducted for 30 years. During the first 5 years, groundwater monitoring would occur quarterly for years 1 and 2, and semiannually for years 3, 4, and 5. For years 6 through 30, annual

monitoring was assumed. The monitoring plan would be re-evaluated during the CERCLA 5-year review process.

Environmental covenants would restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cap.

The components of Alternative 2 are:

- Clearing and grubbing of existing vegetation
- Consolidating waste within the area to be capped
- Constructing a compacted clay cap consisting of at least 24-inch-thick impervious layer (clay), overlain with 6 inches of topsoil
- A passive venting system
- Implementing long-term O&M measures to ensure the protectiveness of the cap
- A drainage swale
- Defining a monitoring well network
- Implementing the environmental covenants

4.3.1.2.2 Evaluation.

Effectiveness. Installing a cap would reduce the vertical infiltration of precipitation into the contaminated soil/waste. The cap would be graded so that water would not pond and the overall drainage in the area would be improved. This, along with the cap itself, would reduce seep generation. In addition, the cap would prevent site personnel, wildlife, and the surrounding community from coming into direct contact with the contaminated soil. This alternative also would maximize the potential reuse of the site as long as reuse is consistent with the environmental covenants.

Monitoring groundwater would be effective in documenting that no offsite migration of the COCs is occurring. However, Alternative 2 would limit the future use of the site, as property restrictions would be implemented.

Implementability. Consolidating waste material and capping is easily implemented, and the resources required are anticipated to be available. Equipment and technical support is not anticipated to be difficult to locate as caps are commonly applied to landfills. Heavy equipment (such as bulldozers) and trained operators would be required for implementing this alternative.

Long-term management activities would be easily implemented with existing groundwater monitoring wells and installation of new wells downgradient can be easily accomplished. An environmental covenant for the site, in concept, has been discussed by CRAA and Ohio EPA.

Cost. Costs for this alternative would be greater than $15 million.

4.3.1.3 Alternative 3—Consolidation, Construction of a Soil Cover, Long-Term Management, and Institutional Controls

4.3.1.3.1 Description. Similar to Alternative 2, Alternative 3 also involves consolidating waste and then constructing a soil cover over the consolidated area. The area shown on Figure 4-1 also is applicable for Alternative 3. The area would be cleared and grubbed prior to construction, as it is currently covered with dense vegetation.

Long-term management also is part of this alternative. The final monitoring program would be documented in the landfill long-term management plan and is expected to include groundwater monitoring. Tentatively, the groundwater monitoring network would be comprised of existing and new groundwater monitoring wells. Some existing wells may be abandoned during construction of the soil cover, but they would be replaced with new wells. For cost estimating purposes, it is assumed that groundwater monitoring will be conducted for 30 years. During the first 5 years, groundwater monitoring would occur quarterly for years 1 and 2, and semiannually for years 3, 4, and 5. For years 6 through 30, annual monitoring is assumed. The monitoring plan would be re-evaluated during the CERCLA 5-year review process.

Environmental covenants also would restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cover.

The components of Alternative 3 are:

- Clearing and grubbing of existing vegetation
- Consolidating waste within the area to be covered
- Constructing a soil cover consisting of at least 24-inch-thick compacted soil, overlain with 6 inches of topsoil
- A passive venting system
- Implementing long-term O&M measures to ensure the protectiveness of the cover
- Installing a drainage swale
- Defining a monitoring well network
- Implementing the environmental covenants

4.3.1.3.2 Evaluation.

Effectiveness. The soil cover would prevent site personnel, wildlife, and the surrounding community from coming into direct contact with the contaminated soil. This alternative also would maximize the potential reuse of the site as long as reuse is consistent with the environmental covenants.

Monitoring groundwater would be effective in documenting that no offsite migration of the COCs is occurring. However, Alternative 3 would limit the future use of the site, as property restrictions would be implemented.

Implementability. Consolidating waste material and installing a soil cover is easily implemented, and the resources required are anticipated to be available. Equipment and

technical support is not anticipated to be difficult to locate as soil covers are commonly applied to landfills. Heavy equipment (such as bulldozers) and trained operators would be required for implementing this alternative.

Long-term management activities would be easily implemented with existing groundwater monitoring wells and installation of new wells downgradient can be easily accomplished. An environmental covenant for AOC 1, in concept, has been discussed by CRAA and Ohio EPA.

Cost. Costs for this alternative would be between $10 million and $15 million.

4.3.2 Remedial Alternatives Screened for AOC 2

The following subsections describe the remedial alternatives screened for AOC 2 and the evaluation of their effectiveness, implementability, and cost.

4.3.2.1 Alternative 1—No Action

4.3.2.1.1 Evaluation.

Effectiveness. This alternative does not meet the goals identified in the RAOs because it does not prevent exposure to groundwater at the site.

Implementability. There are no implementability considerations for the no action alternative.

Cost. This alternative has no associated costs.

4.3.2.2 Alternative 2—Implementation of Institutional Controls

4.3.2.2.1 Description. Alternative 2 involves implementation of an environmental covenant to restrict the use of the groundwater beneath AOC 2.

4.3.2.2.2 Evaluation.

Effectiveness. Implementation of environmental covenants would reduce exposure to groundwater. This alternative restricts the use of AOC 2 to industrial or commercial uses, therefore seemingly limiting the future use of the site. However, there are no plans for residential development of AOC 2, and residential use is not a reasonably foreseeable future use scenario.

Implementability. Implementation of environmental covenants would be easily implemented and, in concept, has been discussed with CRAA and Ohio EPA.

Cost. Costs for this alternative would be less than $10,000.

SECTION 5

Detailed Analysis of Alternatives

The information presented in this section is designed to aid decision makers in evaluating and selecting remedial alternatives to address contaminated soil and groundwater, associated with AOC 1 and groundwater at AOC 2. The detailed analysis follows the development and screening of alternatives presented in Section 4. The analysis provides the information necessary for selecting the preferred alternative, to be completed during the preparation of the Proposed Plan, and developing the Decision Document. The preferred alternative in the Proposed Plan will be provided for public comment prior to selection of a remedy, which will then be documented in a Decision Document.

5.1 Evaluation Criteria

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 March 8, 1990 *Federal Register* (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 support selection of a preferred alternative for implementation. The evaluation criteria are:

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

The criteria are divided into three groups: *threshold, balancing, and modifying* criteria. *Threshold criteria* must be met by a particular alternative for it to be eligible for selection as a remedial action. There is little flexibility in meeting the *threshold* criteria—either they are met by a particular alternative or the alternative is not considered acceptable. The two threshold criteria are:

- Overall protection of human health and the environment
- Compliance with ARARs

If ARARs cannot be met, a waiver may be obtained when one of the following exceptions listed in the NCP occurs (see 40 CFR 300.430 (f)(1)(ii)(C)(1 to 5):

1. The alternative is an interim measure and will become part of a total remedial action that will attain the ARARs.

2. Compliance with the requirement will result in greater risk to human health and the environment than other alternatives.
3. Compliance with the requirement is technically impracticable from an engineering perspective.
4. The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.
5. With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state.

Unlike the threshold criteria, the five *balancing criteria* weigh the tradeoffs between alternatives. A low rating on one *balancing* criterion can be compensated for by a high rating for another. The five balancing criteria include:

- Long-term effectiveness and permanence
- Reduction of TMV 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 preferred alternative. Community and state acceptance are not addressed in this FFS report, but will be included in the Decision Document. The criteria are discussed in further detail below.

5.1.1 Threshold Criteria

To be eligible for selection, an alternative must meet the two threshold criteria described below, or in the case of ARARs, must justify why a waiver is appropriate.

5.1.1.1 Overall Protection of Human Health and the Environment (Criterion 1)

Protectiveness is the primary requirement that remedial actions must meet under CERCLA. A remedy is protective if it adequately eliminates, reduces, or controls current and potential risk posed by the site through each exposure pathway. The assessment against this criterion describes how the alternative achieves and maintains protection of human health and the environment.

5.1.1.2 Compliance with ARARs (Criterion 2)

Compliance with ARARs is a statutory requirement of remedy selection. ARARs are federal and state cleanup standards, standards of control, and other substantive environmental statutes or regulations that are either “applicable” or “relevant and appropriate” to the cleanup action. The assessment against this criterion describes how the alternative complies with ARARs or presents the rationale for waiving an ARAR.

ARARs are discussed in terms of chemical-specific, location-specific, and action-specific. An alternative that does not comply with an ARAR may have grounds for invoking a waiver as described in the NCP under paragraph 40 CFR 300.430(f)(1)(ii)(C).

5.1.2 Balancing Criteria

The five balancing criteria for detailed evaluation of alternatives are indicated below.

5.1.2.1 Long-Term Effectiveness and Permanence (Criterion 3)

Long-term effectiveness and permanence are measured by how much risk remains after the remedy is completed. Alternatives providing the highest degree of long-term effectiveness and permanence are those that leave little or no waste, have little or no long-term maintenance and monitoring requirements, and minimize or eliminate the need for institutional controls. The evaluation for long-term effectiveness includes consideration of the following factors:

- Magnitude of the risk to human and environmental receptors posed by untreated waste or treatment residues after active remedial activities
- Type, degree, and adequacy of long-term management required for untreated waste or treatment residues after active remedial activities
- Long-term reliability of engineering to provide continued protection from untreated waste or treatment residues
- Potential need for replacement of the action and the continuing need for repairs to maintain the performance of the remedy

5.1.2.2 Reduction of TMV through Treatment (Criterion 4)

The statutory preference is a remedial action that employs treatment to reduce the TMV of hazardous substances. Criterion 4 addresses the anticipated performance of technologies to reduce TMV of hazardous substances. Alternatives that do not include treatment technologies are not considered to reduce TMV. This criterion considers the following:

- Treatment process(es)
- Amount of hazardous substances that will be treated or destroyed
- Degree of expected reduction in TMV through treatment, including how the treatment addresses the principal risk(s)
- Degree to which the treatment will be irreversible
- Type and quantity of residual wastes that will remain following treatment

5.1.2.3 Short-Term Effectiveness (Criterion 5)

This criterion evaluates the effectiveness of alternatives in maintaining protection of human health and the environment until the RAOs are met. Short-term effectiveness is measured by the following factors:

- Short-term risks that may be posed to the community during implementation of an alternative
- Potential adverse impacts on workers during implementation, and the effectiveness and reliability of protective measures
- Potential for adverse environmental impacts during implementation, and effectiveness and reliability of mitigation measures
- Estimated duration of implementation needed to achieve the remedial objectives

5.1.2.4 Implementability (Criterion 6)

Implementability deals with the difficulties of constructing and operating an alternative and the availability of materials and services required. The following facets are considered:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, reliability of the technology, ease of undertaking additional remedial actions, and ability to monitor the effectiveness of the remedy
- Administrative feasibility, including activities needed to coordinate with other offices and agencies, and the ability and time required to obtain necessary approvals and permits from other agencies (for offsite actions)
- Availability of services and materials necessary for implementing the alternative, including the availability of adequate offsite treatment, storage capacity, and disposal capacity and services; availability of necessary equipment and specialists, and provisions to provide necessary additional resources; and availability of prospective technologies

5.1.2.5 Cost (Criterion 7)

Under this criterion, an alternative is assessed in terms of its present worth capital and O&M costs. Preliminary cost estimates were developed for Alternatives 2 and 3 for AOC 1 and Alternative 2 for AOC 2, as no costs are associated with the no action alternative (Appendix A). These estimates are based on available information and are based on information provided by vendors, regulators, and personnel with experience on similar projects. The expected accuracy of these cost estimates is +50 percent to -30 percent (USEPA 1991). These cost estimates should not be considered the actual cost of designing and implementing a remedial action, but rather relative costs among the alternatives using consistent assumptions and estimating methods.

Capital costs presented in this report include allowances for construction management (15 percent) and contingency (20 percent). O&M costs include a contingency of 20 percent. The present net worth is based on a 30-year project duration, and assumes a 2.7 percent discount rate (Office of Management and Budget 2009).

5.1.3 Modifying Criteria

State and community acceptance of a proposed remedial action are important elements in remedy selection. Concerns of state regulators and the local community must be addressed during the selection process and are generally termed “modifying criteria.”

5.1.3.1 State Acceptance (Criterion 8)

This evaluation criterion assesses the technical and administrative issues and concerns that the State of Ohio may have about each alternative. Preliminary input has been solicited from Ohio EPA, and will be incorporated into the evaluation of the alternatives in this document. Additional consideration will be provided for the state acceptance criterion after receiving comments on the Proposed Plan. This criterion will be fully addressed in the Decision Document.

5.1.3.2 Community Acceptance (Criterion 9)

This evaluation criterion evaluates the issues and concerns that the public may have regarding each of the alternatives. Community input regarding the alternatives will be solicited during the public comment period, during which time the Proposed Plan will be available for public review. A responsiveness summary will be prepared to address comments received during the public comment period. This criterion will be fully addressed in the Decision Document after public comments on the Proposed Plan are received.

5.2 Individual Analysis of Alternatives

Detailed analysis of each of the alternatives for AOC 1 and AOC 2 is presented below. Evaluation of each alternative against the seven threshold and balancing criteria is the first step in completing the detailed evaluation.

5.2.1 AOC 1

5.2.1.1 Alternative 1—No Action

This alternative is required to be evaluated by the NCP process as a baseline for other alternatives. The no action alternative does not include institutional controls, monitoring, or active remedial activities. This alternative does include natural attenuation processes, which ultimately reduce contaminant mass; however, the effectiveness of the ongoing natural attenuation is not assessed over time. Table 5-1 contains the detailed evaluation of Alternative 1.

TABLE 5-1
AOC 1 Individual Analysis of Alternative 1—No Action
Former Lockbourne AFB Landfill

Overall Protection Of Human Health and Environment	
Protection of human health	Human health is not protected as this alternative does not prevent direct exposure to surface soil, total soil, and UWBZ and IDA groundwater.
Environmental protection	Risks to ecological receptors are not addressed. Environmental protection is not achieved because infiltration of rainfall would not be reduced, nor would the potential migration of surface soil contamination via runoff.
Compliance With ARARs[1]	
Chemical-specific	No chemical-specific ARARs were identified.
Location-specific	No location-specific ARARs were identified.

TABLE 5-1
AOC 1 Individual Analysis of Alternative 1—No Action
Former Lockbourne AFB Landfill

Action-specific	Not applicable. Action-specific ARARs are not applicable because no action will be taken under this alternative.
Long-Term Effectiveness and Permanence	
Magnitude of residual risk	Residual risks would be high because the current risk of exposure to contaminated surface soil would not be reduced. Furthermore, additional waste materials could become exposed in the future because of erosion. The risk resulting from rainwater infiltration also would not be reduced.
Adequacy and reliability of controls	Some natural processes might reduce concentrations of COCs in groundwater over time, but this would not be documented.
5-year review	Not applicable.
Long-term management	Not applicable.
Reduction of Toxicity, Mobility, and Volume through Treatment	
Reduction of toxicity and volume	No active treatment. Some reduction may happen due to natural attenuation processes, such as biodegradation, dilution, dispersion, sorption, volatilization, and chemical and biochemical stabilization of contaminants.
Reduction in mobility	Unknown but expected through natural attenuation.
Short-Term Effectiveness	
Risk to community during remedial action	Not applicable.
Risk to workers during remedial action	Not applicable.
Time until remedial goals achieved	Unknown.
Environmental impacts	Present contaminant effects on local biology will continue.
Implementability	
Technical feasibility of operation and construction	Not applicable.
Reliability of technology	Not applicable
Availability of services and material	Not applicable.
Cost	
Present value cost	$0
Modifying Criteria	
State acceptance	No
Community acceptance	To be determined.

[1] ARARs are presented in Table 4-1.

5.2.1.2 Alternative 2—Consolidation, Construction of a Compacted Clay Cap, Long-Term Management, and Institutional Controls

Alternative 2 combines consolidation of surface debris and contaminated soil present at the site and construction of a compacted clay cap over the waste materials. Onsite materials would be used to the maximum extent possible to establish closure grades for AOC 1. Long-term management is a part of this alternative. Finally, environmental covenants would be implemented to restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cap. The area would be regraded to help prevent the ponding of water and improve overall drainage. This alternative is expected to inhibit vertical infiltration of precipitation into waste and reduce the potential for site personnel and the community from coming into direct contact with landfilled material.

For cost estimating purposes, the Alternative 2 components include:

- The section of the site where wastes have been disposed would be cleared and grubbed. At this stage, it has been estimated that approximately 50 acres of AOC 1 contains wastes. Keeping a conservative margin of 50 percent to account for workspace required during construction, and staging piles, the total area identified for clearing and grubbing is approximately 75 acres.
- Sustainable use options would be developed for the cleared vegetation.
- Waste would be consolidated within the area to be capped. The area of the proposed cap is approximately 40 acres. The area of the cap is an estimate, and the actual area would be determined during the landfill cover design. Based on current information, the area of the cap will not be extended into the approximately 5.5 acres that the former transmitter station occupied, which are not eligible for restoration by the FUDS program. Portions of the existing reinforced concrete structure located in the West Ditch will be removed and consolidated underneath the proposed cap. Removing portions of the structure will help to restore the ditch to a more natural condition and improve surface water drainage at the landfill while maintaining structural integrity of the landfill slope and future cap.
- The assumed average depth of excavation during consolidation of wastes would be approximately 6 feet. The assumed average depth is based on the observations made during the test pitting activities conducted by CH2M HILL in 2008. The depth of waste in the consolidation areas were between the ground surface and 4 feet. In some areas, the waste was greater than 8 feet. Additionally, only the area outside the proposed cap would be excavated, and the excavated material would be brought within the landfill cap area.
- In preparation for soil cap, construction and demolition debris will be roughly graded, as appropriate for surface drainage.
- A compacted soil cap consisting of at least a 24-inch-thick impervious layer (clay), overlain by 6 inches of topsoil would be constructed. Seeding, mulching (1 inch thick), and watering of cap area also would be done.
- Design of the soil cap would include installing vents to prevent the accumulation of landfill gases.

- Long-term O&M measures also would be implemented to ensure the protectiveness of the cap.
- Surface water drainage will be addressed through the construction of drainage swales along the perimeter of the landfill. As part of this effort, the East and West Ditches may be regraded. If needed, materials removed from the East and West Ditches during construction will be relocated underneath the proposed cap. Surface water design and regrading of the East and West Ditches will be coordinated with Ohio EPA to prevent downstream impacts to Big Walnut Creek.
- Five existing groundwater monitoring wells would be abandoned (MW-3, MW-5, MW-6, MW-12, and MW-13).
- New wells will be installed downgradient of the site as part of the long-term management program for the landfill.
- Monitoring would be conducted quarterly for 2 years and then semiannually for an additional 3 years. It is assumed that the groundwater would be monitored annually after that for the next 25 years. Samples would be tested for VOCs, SVOCs, dioxins/furans, pesticides, and inorganics.
- An environmental covenant would be implemented.

Table 5.2 contains the detailed evaluation of Alternative 2.

TABLE 5-2
AOC 1 Individual Analysis of Alternative 2—Consolidation, Construction of a Compacted Clay Cap, Long-Term Management, and Institutional Controls
Former Lockbourne AFB Landfill

Overall Protection of Human Health and Environment	
Protection of human health	Human health would be protected because this alternative would reduce risks associated with direct contact exposures to the contaminated surface soil, total soil, and groundwater.
Environmental protection	The cap also will reduce migration of COCs via runoff to adjacent ditches. The cap would reduce infiltration of precipitation, and thereby restrict migration of COCs from soil to groundwater. No remedial actions are proposed for residual chemicals in sediment. This alternative will alter the habitat in the area and will possibly disrupt environmental receptors for a period of time, though recovery is ultimately expected.
Compliance With ARARs[1]	
Chemical-specific	No chemical-specific ARARs were identified.
Location-specific	No location-specific ARARs were identified.
Action-specific	Yes. However, specific waivers are required, as presented in Table 5-4.
Long-Term Effectiveness and Permanence	
Reduction of residual risk	Installation of a cap will reduce much of the residual risks such as contact with contaminated surface soil and infiltration of groundwater through the contaminated waste material.
Adequacy and reliability of controls	Landfill caps are a reliable and proven technology. The effectiveness of the cap will depend on inspection and maintenance.

TABLE 5-2
AOC 1 Individual Analysis of Alternative 2—Consolidation, Construction of a Compacted Clay Cap, Long-Term Management, and Institutional Controls
Former Lockbourne AFB Landfill

5-year review	This would need a 5-year review.
Long-term management	Long-term management will include regular O&M along with groundwater monitoring of onsite and downgradient groundwater wells.
Reduction Of Toxicity, Mobility, and Volume through Treatment	
Reduction of toxicity and volume	No active treatment; consolidation and containment only.
Reduction in mobility	Yes, the cap would reduce the amount of infiltration of rainwater through the waste material that would reduce its ability to leach into the groundwater. Drainage controls and grading are expected to reduce the lateral migration of groundwater in contact with the waste.
Short-Term Effectiveness	
Risk to community during remedial action	Dust generation, increased noise levels, and increased truck traffic may have a small impact on the surrounding community. The risks would be minimal.
Risk to workers during remedial action	The risks to worker during construction consist of, but are not limited to, heavy equipment, excavation, and consolidation of contaminated soil. The risks are expected to be minimal.
Time until remedial goals achieved	RAOs will be achieved upon completion of the remedial action.
Environmental impacts	Construction will introduce some environmental impacts. These impacts are from the production and use of fuel for the heavy equipment, the disturbance of soil, and dust generation. Generally, these environmental impacts are negligible, and monitoring represents an environmentally sustainable remedial alternative provided the risks reduction rates are sufficient. In addition, the placement of a cap will improve the quality of the environment at the site when it is complete.
Implementability	
Technical feasibility of operation and construction	Capping is an easily implemented technology as it has been done at many other locations.
Reliability of technology	Capping has been proven to work.
Availability of services and material	Readily available.
Cost	
Present value cost	$15,482,000
Modifying Criteria	
State acceptance	Yes.
Community acceptance	To be determined.

[1] ARARs are presented in Table 4-1.

5.2.1.3 Alternative 3—Consolidation, Construction of a Soil Cover, Long-Term Management, and Institutional Controls

Alternative 3 combines consolidation of surface debris and contaminated soil present at the site and construction of a soil cover over the waste materials. Onsite materials would be used to the maximum extent possible to establish closure grades for AOC 1. Long-term management is a part of this alternative. Finally, environmental covenants would be implemented to restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cover. The area would be regraded to help prevent the ponding of water and improve overall drainage. This alternative is expected to inhibit vertical infiltration of precipitation into waste and reduce the potential for site personnel and the community from coming into direct contact with landfilled material.

For cost estimating purposes, the Alternative 3 components include:

- The section of the site where wastes have been disposed would be cleared and grubbed. At this stage, it has been estimated that approximately 50 acres of AOC 1 contains wastes. Keeping a conservative margin of 50 percent to account for workspace required during construction, and staging piles, the total area identified for clearing and grubbing is approximately 75 acres.
- Sustainable use options would be developed for the cleared vegetation.
- Waste would be consolidated within the area to be covered. The area of the proposed cover is approximately 40 acres. The area of the cover is an estimate, and actual area would be determined during the landfill cover design. Based on current information, the area of the cover will not be extended into the approximately 5.5 acres that the former transmitter station occupied, which are not eligible for restoration by the FUDS program. Portions of the existing reinforced concrete structure located in the West Ditch will be removed and consolidated underneath the proposed cover. Removing portions of the structure will help to restore the ditch to a more natural condition and improve surface water drainage at the landfill while maintaining structural integrity of the landfill slope and future cover.
- The assumed average depth of excavation during consolidation of wastes would be approximately 6 feet. The assumed average depth is based on the observations made during the test pitting activities conducted by CH2M HILL in 2008. The depth of waste in the consolidation areas were between the ground surface and 4 feet. In some areas, the waste was greater than 8 feet. Additionally, only the area outside the proposed cover would be excavated, and the excavated material would be brought within the landfill cover area.
- In preparation for soil cover, construction and demolition debris will be roughly graded, as appropriate for surface drainage.
- A soil cover would be constructed, consisting of at least a 24-inch-thick soil cover, overlain by 6 inches of topsoil. Seeding, mulching (1 inch thick), and watering of cover area also would be done.
- Design of the soil cover would include installing vents to prevent accumulation of landfill gases.

- Long-term O&M measures also would be implemented to ensure the protectiveness of the soil cover.
- Surface water drainage will be addressed through the construction of drainage swales along the perimeter of the landfill. As part of this effort, the East and West Ditches may be regraded. If needed, materials removed from the East and West Ditches during construction will be relocated underneath the proposed cover. Surface water design and regrading of the East and West Ditches will be coordinated with Ohio EPA to prevent downstream impacts to Big Walnut Creek.
- Five existing groundwater monitoring wells would be abandoned (MW-3, MW-5, MW-6, MW-12, and MW-13).
- New monitoring wells will be installed downgradient of the site as part of the long-term management program for the landfill.
- Monitoring would be conducted quarterly for 2 years and then semiannually for additional 3 years. It is assumed that the groundwater would be monitored annually after that for the next 25 years. Samples would be tested for VOCs, SVOCs, dioxins/furans, pesticides, and inorganics.
- An environmental covenant would be implemented.

Table 5-3 contains the detailed evaluation of Alternative 3. As noted in Table 5-4, Alternatives 2 and 3 will require waivers for three ARARs.

TABLE 5-3
AOC 1 Individual Analysis of Alternative 3—Consolidation, Construction of a Soil Cover, Long-Term Management, and Institutional Controls
Former Lockbourne AFB Landfill

Overall Protection Of Human Health and Environment	
Protection of human health	Human health would be protected because this alternative would reduce risks associated with direct contact exposures to the contaminated surface soil, total soil, and groundwater.
Environmental protection	The soil cover also will reduce migration of COCs via runoff to adjacent ditches. No remedial actions are proposed for residual chemicals in sediment. This alternative will alter the habitat in the area and will possibly disrupt environmental receptors for a period of time, though recovery is ultimately expected.
Compliance With ARARs[1]	
Chemical-specific	No chemical-specific ARARs were identified.
Location-specific	No location-specific ARARs were identified.
Action-specific	Yes. However, specific waivers are required, as presented in Table 5-4.
Long-Term Effectiveness and Permanence	
Reduction of residual risk	Installation of a soil cover will reduce much of the residual risks such as contact with contaminated surface soil.
Adequacy and reliability of controls	Landfill soil covers are a reliable and proven technology. The effectiveness of the soil cover will depend on inspection and maintenance.
5-year review	This would need a 5-year review.

TABLE 5-3
AOC 1 Individual Analysis of Alternative 3—Consolidation, Construction of a Soil Cover, Long-Term Management, and Institutional Controls
Former Lockbourne AFB Landfill

Long-term management	Long-term management will include regular O&M along with groundwater monitoring of onsite and downgradient groundwater wells.
Reduction of Toxicity, Mobility, and Volume Through Treatment	
Reduction of toxicity and volume	No active treatment, consolidation and containment only.
Reduction in mobility	Drainage controls and grading are expected to reduce the lateral migration of groundwater in contact with the waste.
Short-Term Effectiveness	
Risk to community during remedial action	Dust generation, increased noise levels, and increased truck traffic may have a small impact on the surrounding community. The risks would be minimal.
Risk to workers during remedial action	The risks to worker during construction consist of, but are not limited to, heavy equipment, excavation, and consolidation of contaminated soil. The risks are expected to be minimal.
Time until remedial goals achieved	RAOs will be achieved upon completion of the remedial action.
Environmental impacts	Construction will introduce some environmental impacts. These impacts are from the production and use of fuel for the heavy equipment, the disturbance of soil, and dust generation. Generally, these environmental impacts are negligible, and monitoring represents an environmentally sustainable remedial alternative provided the risks reduction rates are sufficient. In addition, the placement of a cover will improve the quality of the environment at the site when it is complete.
Implementability	
Technical feasibility of operation and construction	Soil cover is an easily implemented technology as it has been done at many other locations.
Reliability of technology	Soil cover has been proven to work.
Availability of services and material	Readily available.
Cost	
Present value cost	$12,916,000
Modifying Criteria	
State acceptance	Yes.
Community acceptance	To be determined.

[1] ARARs are presented in Table 4-1.

TABLE 5-4
AOC 1 ARAR Waivers
Former Lockbourne AFB Landfill

ARAR	Waiver	Waiver Justification
OAC 3745-27-08 Construction Specifications for Sanitary Landfills	This requirement is not applicable because waste disposal ended at the site in 1979, prior to the March 1, 1990 initial effective date of the regulation and because the regulation applies to active sanitary landfills operating under an approved permit. OAC 3745-27-08 is relevant and appropriate to Alternatives 2 and 3 because it addresses sites similar to the former Lockbourne AFB landfill and migration of contaminants that are similar to those that have been identified at the site. However, based on the nature and extent of impacts at the site, many of the specific requirements are not needed and the standard of performance can be achieved with alternate designs. This ARAR will be waived, per the National Contingency Plan 300.430(f)(1)(ii)(C)(4)) (see Note), because these alternatives will obtain a standard of performance that is equivalent to that required under OAC 3745-27-08.	Specifically, Alternatives 2 and 3 with a compacted clay cap and soil cover, respectively, will meet the same performance standard for the site as the composite cap specified in OAC 3745-27-08. OAC 3745-27-10, effective July 29, 1976, will be used to guide the proposed landfill cap design and construction. While OAC 2745-27-10 (effective July 29, 1976) is not an ARAR because it is not legally enforceable, the rule provides technical information on how to perform and evaluate the proposed response actions. The composite cap, as specified in OAC 3745-27-08, is designed to prevent human contact with the landfill waste and other contamination, eliminate runoff of contaminants from contaminated soils, and block leaching to groundwater and subsurface soils. Alternatives 2 and 3 caps will prevent direct contact with waste and contaminated soils, eliminate runoff of contaminants from contaminated soils, and reduce leaching to groundwater and subsurface soils. At this site additional leachate reduction is not needed because the COPCs at the site for groundwater are PAHs, PCBs, and dioxins, which are generally not mobile in the dissolved phase and migrate typically by colloidal transport or while sorbed to particulates. The additional redundancy provided by the composite cap for reducing leaching is not needed at this site because leaching to groundwater is not a significant migration pathway. The soil cover and clay cap would both adequately protect groundwater from further contamination. Furthermore, the composite cap includes additional elements that are not needed to protect human health and the environment at the site, such as an explosive gas control system. Because of the particular COPCs at this site, Alternatives 2 and 3 caps are as protective as the composite cap prescribed by OAC 3745-27-08. The composite cap required by OAC 3745-27-08 would cost an additional $125,000 - $220,000 per acre. Because both Alternatives 2 and 3 provide an equivalent level of performance specific to this site, there would be no benefit to incur the additional cost of implementing the composite cap as compared to the cost benefit of applying a waiver.

TABLE 5-4
AOC 1 ARAR Waivers
Former Lockbourne AFB Landfill

ARAR	Waiver	Waiver Justification
OAC 3745-27-10 (effective August 15, 2003) Groundwater Monitoring Program for a Sanitary Landfill Facility	This requirement is not applicable because waste disposal ended at the site in 1979, prior to the March 10, 1990 initial effective date of the regulation (the current rule has an effective date of August 15, 2003). OAC 3745-27-10 is relevant and appropriate to Alternatives 2 and 3 because it outlines the requirements for a groundwater monitoring system, which is needed at this site. However, the specific monitoring requirements of this regulation are unnecessary because the monitoring system that is planned will obtain a standard of performance that is equivalent to those requirements. This ARAR will be waived per the National Contingency Plan 300.430(f)(1)(ii)(C)(4)) (see Note), because these alternatives will obtain a standard of performance that is equivalent to that required under OAC 3745-27-10.	The proposed Alternatives 2 and 3 will include groundwater monitoring. However, OAC 3745-27-10 includes additional monitoring requirements that are not needed to protect human health and the environment at this site. For example, OAC 3745-27-10 requires analysis of over 200 parameters, many of which are not COCs at the site. Given the age of this landfill, the contaminants shown to drive risk in groundwater at this site are well known. The long term management proposed for the site would be more tailored to the risk drivers documented at the site and, therefore, be significantly less expensive than the monitoring program specified in OAC 3745-27-10. As a result, it will achieve a standard of performance that is equivalent to OAC 3745-27-10.
OAC 3745-27-11 (H) Final Closure of Sanitary Landfill Facilities	This regulation is not applicable because waste disposal ended at the site in 1979, prior to the March 1, 1990 initial effective date of the regulation and because the regulation applies to active sanitary landfills operating under an approved permit. Subparts of OAC 3745-27-11 (H) are relevant and appropriate because they address the final closure of a landfill unit. However, several of the specific final closure elements included in these subparts will be met through alternate methods that will obtain a standard of performance that is equivalent to those requirements. Therefore, an ARAR waiver will be used for Alternatives 2 and 3, per the National Contingency Plan 300.430(f)(1)(ii)(C)(4)) (see Note), because these alternatives will obtain a standard of performance that is equivalent to that required under OAC3745-27-11.	OAC 3745-27-11 (H) defines other closure requirements for closing sanitary landfills. The proposed surface water control design features and long-term management program, including groundwater monitoring for Alternatives 2 and 3 as well as the reuse of the site that will be included in the remedial design will achieve a standard of performance that is equivalent to the intent of these closure requirements identified in OAC 3745-27-11 (H).

Note: The NCP 300.430(f)(1)(ii)(C)(4)) states, “The alternative will obtain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.”

5.2.2 AOC 2

5.2.2.1 Alternative 1—No Action

As indicated earlier, this alternative is required to be evaluated by the NCP process as a baseline for other alternatives. The no action alternative does not include institutional controls, monitoring, or active remedial activities. The following table contains the detailed evaluation of Alternative 1.

TABLE 5-5
AOC 2 Individual Analysis of Alternative 1—No Action
Former Lockbourne AFB Landfill

Overall Protection of Human Health and Environment	
Protection of human health	Human health is not protected as this alternative does not prevent direct exposure to groundwater.
Environmental protection	Not applicable because there are no risks identified to ecological receptors at AOC 2.
Compliance With ARARs[1]	
Chemical-specific	No chemical-specific ARARs were identified.
Location-specific	No location-specific ARARs were identified.
Action-specific	Not applicable. Action-specific ARARs are not applicable because no action will be taken under this alternative.
Long-Term Effectiveness and Permanence	
Magnitude of residual risk	Residual risks would be high because the current risk of exposure to contaminated groundwater would not be reduced.
Adequacy and reliability of controls	Some natural processes might reduce concentrations of COCs in water over time, but this would not be documented.
5-year review	Not applicable.
Long-term management	Not applicable.
Reduction of Toxicity, Mobility, and Volume through Treatment	
Reduction of toxicity and volume	No active treatment. Some reduction may happen due to natural attenuation processes, such as biodegradation, dilution, dispersion, sorption, volatilization, and chemical and biochemical stabilization of contaminants.
Reduction in mobility	Unknown but expected through natural attenuation.
Short-Term Effectiveness	
Risk to community during remedial action	Not applicable.
Risk to workers during remedial action	Not applicable.
Time until remedial goals achieved	Unknown.
Environmental impacts	Not applicable.
Implementability	
Technical feasibility of operation and construction	Not applicable.
Reliability of technology	Not applicable.
Availability of services and material	Not applicable.

TABLE 5-5
AOC 2 Individual Analysis of Alternative 1—No Action
Former Lockbourne AFB Landfill

Cost	
Present value cost	$0
Modifying Criteria	
State acceptance	No.
Community acceptance	To be determined.

[1] ARARs are presented in Table 4-1.

5.2.2.2 Alternative 2—Implementation of Environmental Covenants

Alternative 2 involves implementation of an environmental covenant to restrict the use of the groundwater beneath AOC 2. Table 5.6 contains the detailed evaluation of Alternative 2.

5.2.3 Comparative Analysis of Alternatives

In the following analysis, the remedial alternatives are evaluated in relation to one another for each of the nine NCP criteria. The purpose of this analysis is to identify the relative advantages and disadvantages of each alternative. Comparative analyses of remedial alternatives are documented below. Table 5-7 summarizes this comparative analysis.

5.2.3.1 Protection of Human Health and the Environment

For AOC 1, Alternatives 2 and 3 are equally protective of human health and the environment. Even though Alternative 2 includes a less permeable cover than Alternative 3 and, therefore, would provide a greater reduction in surface water infiltration, the benefit is considered marginal because leaching to groundwater is not a significant migration pathway. Ecological receptors may be impacted from construction activities in the ditches; however, these activities will be temporary and the ecological habitats, although of low quality, are expected to recover. Alternative 1 does not protect human health and the environment because no action would be taken to mitigate unacceptable risks. For AOC 2, Alternative 2 is protective of human health and the environment, while Alternative 1 does not protect human health and the environment because no action would be taken to mitigate unacceptable risks.

5.2.3.2 Compliance with ARARs

For AOC 1, Alternatives 2 and 3 would comply with ARARs, with the exception of OAC 3745-27-08 and OAC 3745-27-10 (effective 2003), for which waivers are required equally for both alternatives. Compliance with ARARs for Alternatives 2 and 3 will depend on continued implementation and enforcement of institutional controls and long-term landfill management, including groundwater monitoring. All of the identified ARARs are action-specific; therefore, they do not apply and would not be met by Alternative 1, the no action alternative. For AOC 2, the action-specific ARARs do not apply because Alternative 1 is a no action alternative and Alternative 2 involves only the administrative implementation of institutional controls.

TABLE 5-6
AOC 2 Individual Analysis of Alternative 2—Implementation of Environmental Covenants
Former Lockbourne AFB Landfill

Overall Protection of Human Health and Environment	
Protection of human health	Human health would be protected because this alternative would reduce risks associated with exposures to groundwater.
Environmental protection	This alternative is protective of the environment because no adverse impacts were identified to ecological receptors.
Compliance With ARARs[1]	
Chemical-specific	No chemical-specific ARARs were identified.
Location-specific	No location-specific ARARs were identified.
Action-specific	Not applicable because this alternative involves the administrative implementation of ICs only.
Long-Term Effectiveness and Permanence	
Reduction of residual risk	Implementation of environmental covenants will reduce the exposures to groundwater and therefore, reduce residual risks.
Adequacy and reliability of controls	Adequate.
5-year review	5-year reviews will be performed.
Long-term management	Long-term management will be required to help ensure compliance with the environmental covenants.
Reduction of Toxicity, Mobility, and Volume through Treatment	
Reduction of toxicity and volume	No active treatment.
Reduction in mobility	No active treatment.
Short-Term Effectiveness	
Risk to community during remedial action	No risk because environmental covenants are administratively implemented.
Risk to workers during remedial action	No risk because environmental covenants are administratively implemented.
Time until remedial goals achieved	Not applicable.
Environmental impacts	No risk because environmental covenants are administratively implemented.
Implementability	
Technical feasibility of operation and construction	Easily implementable.
Reliability of technology	Reliable.
Availability of services and material	Readily available.
Cost	
Present value cost	$6,000

TABLE 5-6
AOC 2 Individual Analysis of Alternative 2—Implementation of Environmental Covenants
Former Lockbourne AFB Landfill

Modifying Criteria	
State acceptance	Yes.
Community acceptance	To be determined.

[1] ARARs are presented in Table 4-1.
IC—institutional control.

5.2.3.3 Long-Term Effectiveness and Permanence

For AOC 1, Alternatives 2 and 3 will achieve long-term effectiveness and permanence as long as the institutional controls and the landfill cap/cover are enforced and maintained, respectively. Alternative 1 does not meet this criterion because no action would be taken. For AOC 2, Alternative 2 will achieve long-term effectiveness and permanence as long as the institutional controls remain in effect and are enforced. Alternative 1 does not meet this criterion because no action would be taken.

5.2.3.4 Reduction in Toxicity, Mobility, and Volume through Treatment

None of the alternatives for AOC 1 and AOC 2 and would reduce the toxicity, mobility, or volume of contaminants through treatment. For AOC 1, Alternatives 2 and 3 would afford the greatest extent of mobility reduction because the landfill cap/cover would reduce the migration of contaminants to surface water, sediment, and groundwater. However, treatment is not associated with any of the alternatives for either AOC 1 or AOC 2.

5.2.3.5 Short-Term Effectiveness

For AOC 1, Alternative 1 has no short-term risks to the remediation workers or to the community because no activities would be planned under this alternative. The short-term risks associated with the construction activities under both Alternatives 2 and 3 would be equally minimized by implementing appropriate health and safety procedures and other pollution prevention procedures. Short-term disruptions to the local community may be experienced from the heavy equipment operations, such as increased traffic of construction trucks in and out of the site, increased noise levels, and dust generation from the heavy equipment during regrading and cap/cover construction. However, these disruptions would be minimized through a proper planning for traffic routing and scheduling, soil erosion and sediment controls implementation, and periodic dust suppression. Under Alternatives 2 and 3, the RAOs would be achieved upon completion of the remedial action. Alternative 3 better achieves the sustainability and beneficial reuse RAOs over Alternative 2 because of the difficulty of establishing native grasses and deeper-rooted plants in six inches of topsoil over a 24-inch compacted clay cap. For AOC 2, Alternative 1 has no short-term risks to the remediation workers or to the community because no activities would be taken under this alternative. Alternative 2 has no short-term risks to the remediation workers or to the community because this alternative involves only administrative actions. RAOs would be achieved upon implementation of the institutional controls under Alternative 2.

5.2.3.6 Implementability

For AOC 1, this criterion does not apply to Alternative 1 because no action would be implemented. The technologies in both Alternatives 2 and 3 are equally readily implementable because they are well accepted and conventional, and they have been used successfully at numerous other landfill sites in Ohio and across the country. However, Alternative 3 is slightly easier to implement than Alternative 2 because of the relative ease of handling and compaction of the soil cover materials compared with imported clays. Additionally, both Alternatives 2 and 3 require the same level of coordination with state agencies. For AOC 2, this criterion does not apply to Alternative 1 because no action would be implemented. Alternative 2 involves only administrative actions which are easily implementable and frequently performed throughout the state.

5.2.3.7 Cost

As shown in Table 5-7, for AOC 1, with the exception of Alternative 1, Alternative 3 is the least cost alternative. For AOC 2, Alternative 1 is the most cost-efficient alternative.

TABLE 5-7
Comparative Analysis of Alternatives
Former Lockbourne AFB Landfill

	AOC 1			AOC 2	
Criteria	**Alternative 1—No Action**	**Alternative 2—Clay Cap, ICs, and Long-Term Management**	**Alternative 3—Soil Cover, ICs, and Long-Term Management**	**Alternative 1—No Action**	**Alternative 2—ICs**
Overall Protection of Human Health and the Environment	■	⦿	⦿	■	⦿
Compliance with Applicable or Relevant and Appropriate Requirements	NA	⦿[1]	⦿[1]	NA	NA
Long-Term Effectiveness and Permanence	○	⦿	⦿	○	⦿
Reduction of Toxicity, Mobility or Volume Through Treatment	○	**O**	**O**	○	○
Short-Term Effectiveness	○	**O**	**O**	○	⦿
Implementability	NA	⦿	⦿	NA	⦿
Cost[2]	$0[(2)]	$15,482,000[(2)]	$12,916,000[(2)]	$0[(2)]	$6,000[(2)]
State/Support Agency Acceptance	○	⦿	⦿	○	⦿
Community Acceptance[3]					

Ranking:

⦿ Well satisfies criterion **O** Moderately satisfies criterion ○ Poorly satisfies criterion ■ Does not meet criterion

[1]There are no chemical and location-specific ARARs, and specific waivers are requested for action-specific ARARs.

[2] Cost is the total present-worth value; cost accuracy ranges from -30% to +50%.

[3]To be determined

NA – The criterion does not apply to this alternative.

5.2.3.8 State Acceptance

For AOC 1, Alternatives 2 and 3 are equally acceptable to Ohio EPA. Alternative 1 is not acceptable because it does not meet the threshold criteria. For AOC 2, Alternative 2 is acceptable to Ohio EPA, while Alternative 1 is not acceptable because it does not meet the threshold criteria.

5.2.3.9 Community Acceptance

Assessment of community acceptance will be fully addressed in the Decision Document after receiving comments on the Proposed Plan.

SECTION 6

Summary

This FFS was prepared to address unacceptable risks in soil, sediment, surface water, and groundwater at AOC 1 and in groundwater for AOC 2. This necessitates implementation of a remedial action at the site.

Three remedial alternatives have been evaluated for AOC 1, including the no action option in accordance with NCP. Alternative 3 is the least cost remedy that is protective of human health and the environment. It has been proposed that onsite materials would be used to the maximum extent possible to establish the grades for landfill closure. Alternative 3 combines waste consolidation and construction of a soil cover over the waste materials. In addition to the cover, Alternative 3 includes institutional controls that will restrict the future use of AOC 1, restrict the use of the groundwater beneath AOC 1, and prevent intrusive activities on the landfill cap.

Two remedial alternatives have been evaluated for AOC 2, including the no action alternative in accordance with the NCP. Alternative 2 is the least cost alternative that is protective of human health. Alternative 2 includes an institutional control that would restrict the use of the groundwater at AOC 2.

Upon coordination of the RI report and the FFS report with Ohio EPA, a Proposed Plan will be prepared in accordance with CERCLA guidance documents. The Proposed Plan will include summaries of the previous and current RI activities and results, as well as the remedial alternatives evaluated for AOC 1 and AOC 2 in this FFS. 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 FFS, and describe the selected remedy.

SECTION 7

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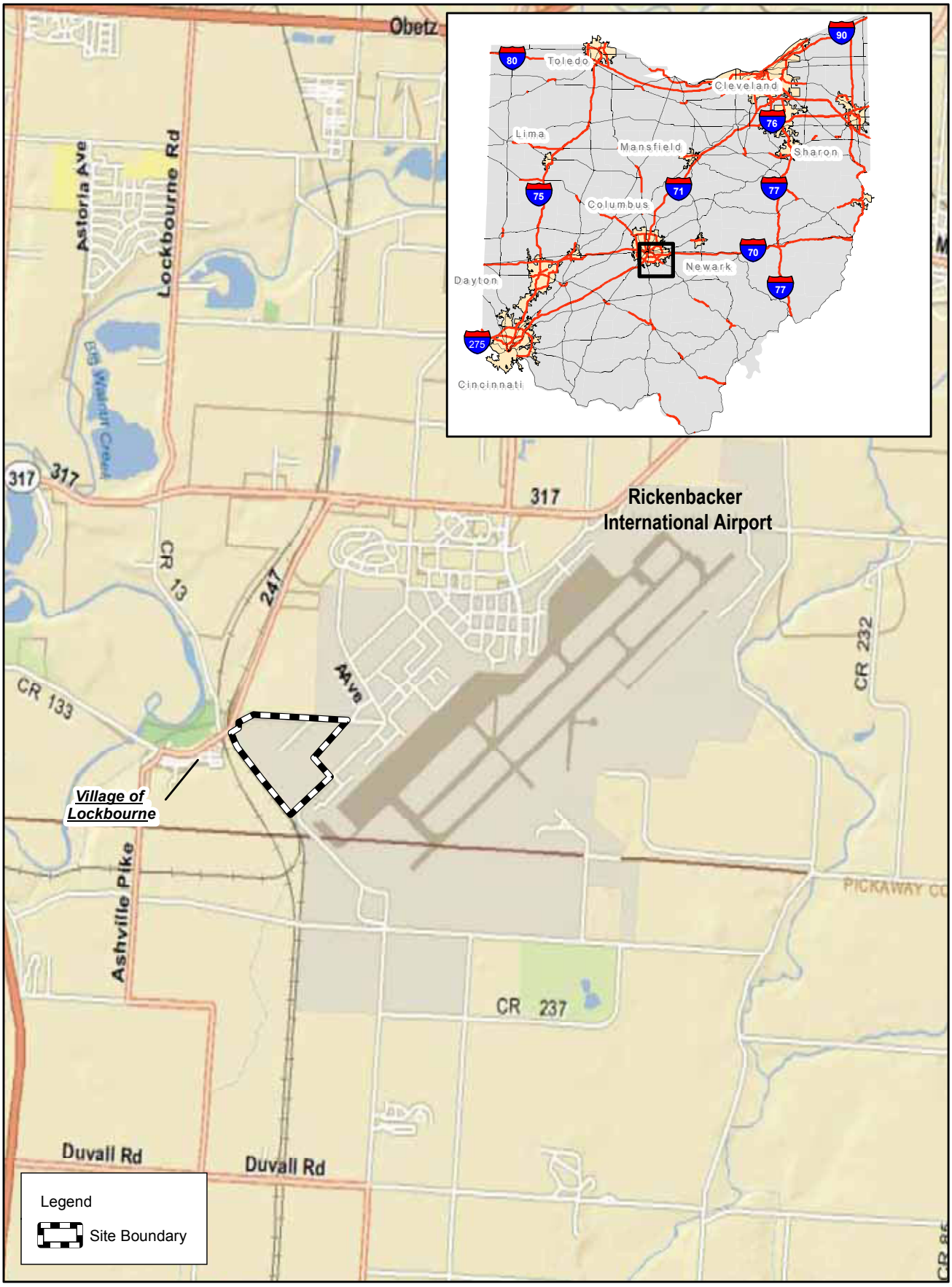

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Miles

Figure 1-1
Site Location Map
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

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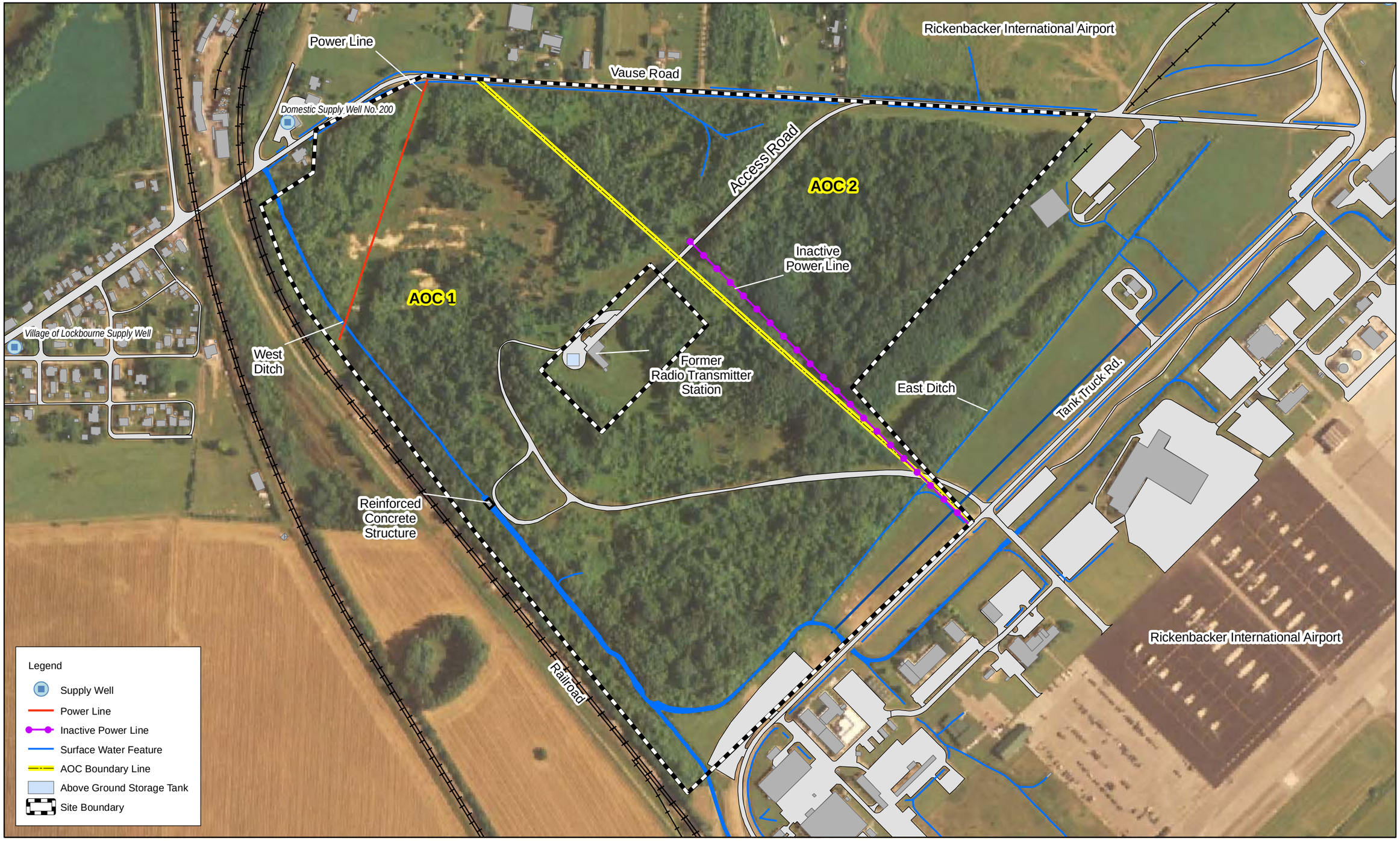

0 200 400 600 800
Feet
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Figure 1-2
Site Features Map
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

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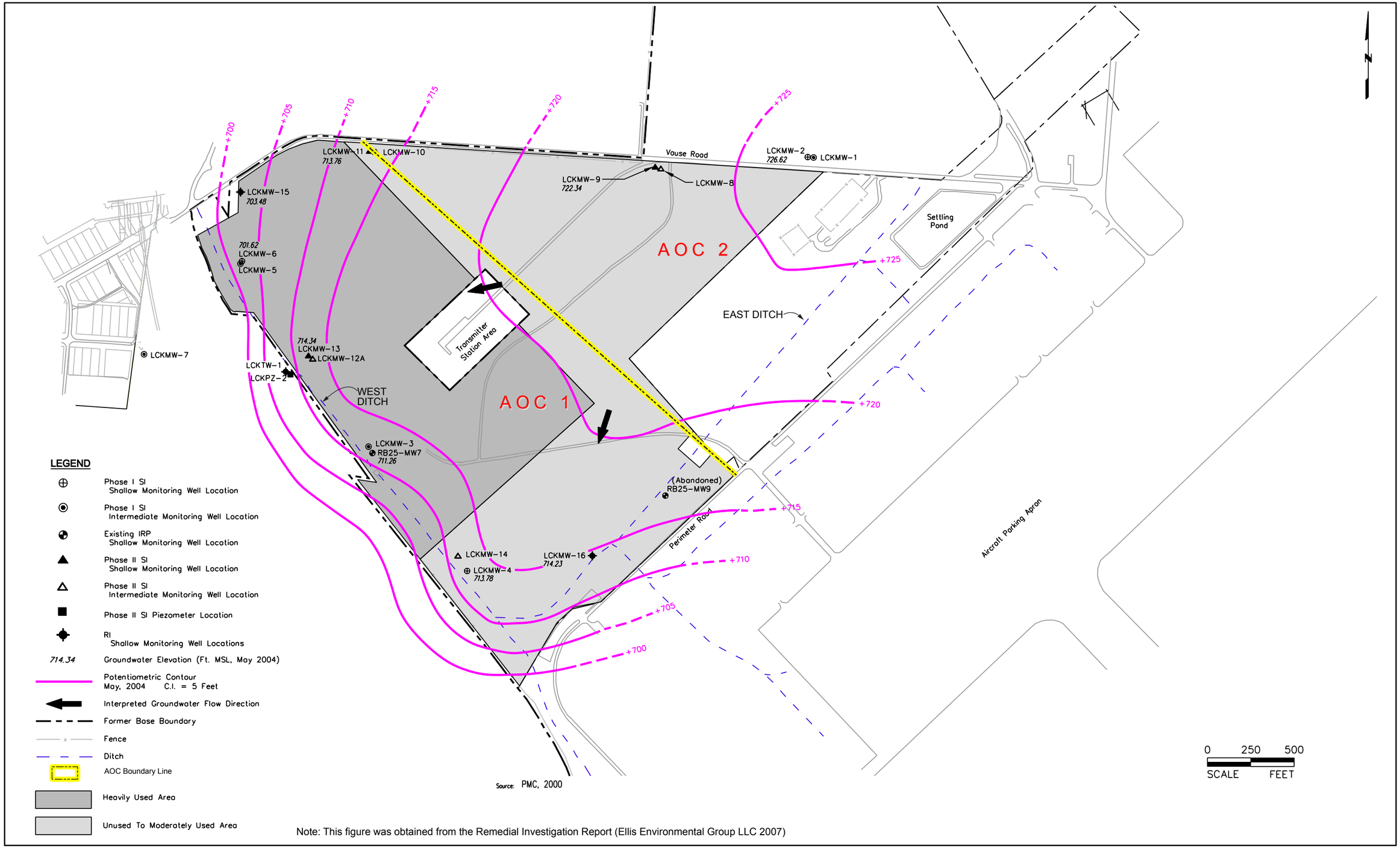
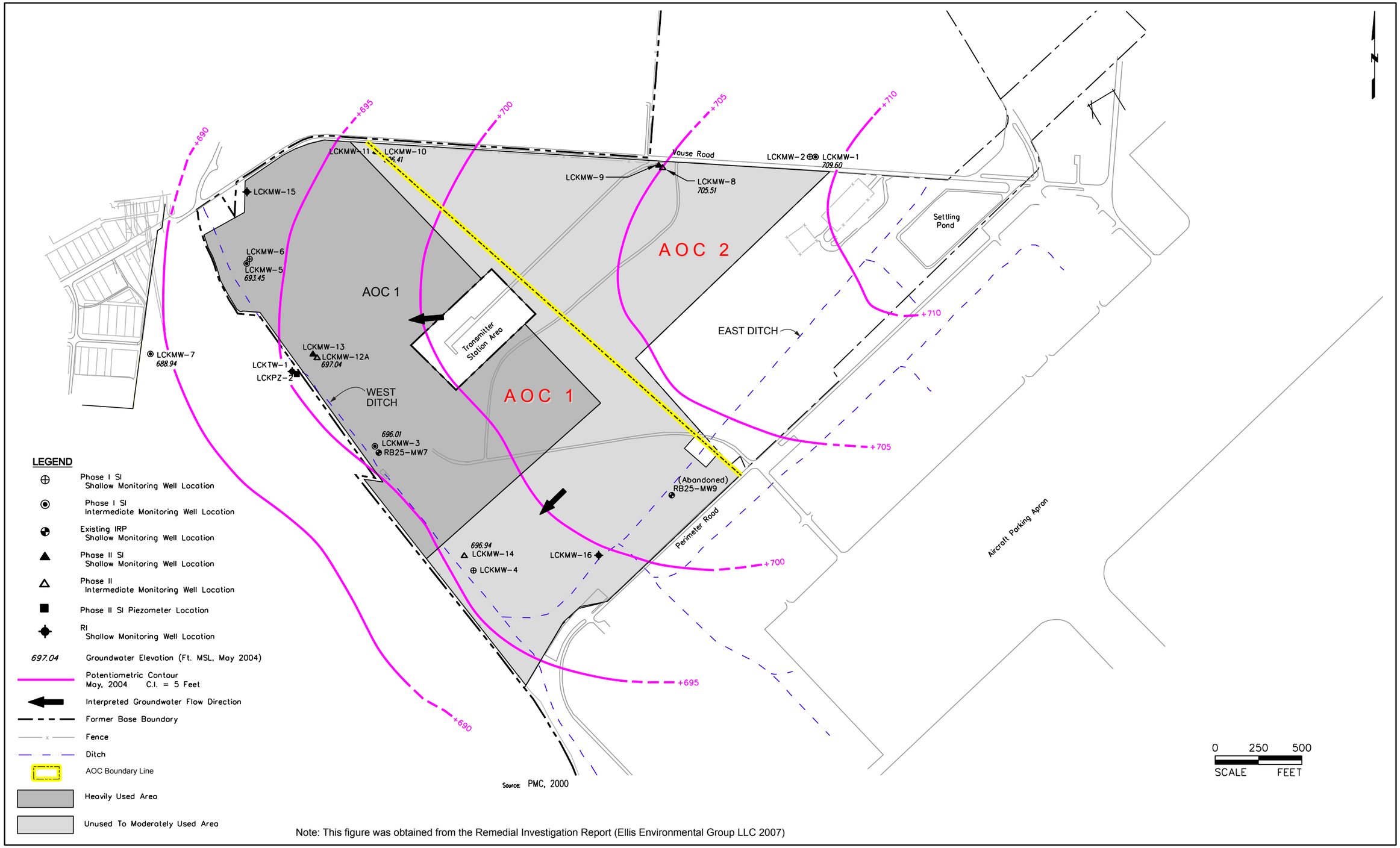
\\NORTHEND\PROJ\USACE\LOUISVILLEDISTRICT\366856LOCKBOURNE\MAPFILES\FS_FIGURES\FIGURE 1-2 - SITE FEATURES MAP.MXD BHATHAWA 4/14/2011 11:14:10



Note: This figure was obtained from the Remedial Investigation Report (Ellis Environmental Group LLC 2007)

Figure 2-1
Upper Water Bearing Zone Potentiometric Surface Map, May 2004
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio



Note: This figure was obtained from the Remedial Investigation Report (Ellis Environmental Group LLC 2007)

Figure 2-2
Intermediate Depth Aquifer Potentiometric Surface Map, May 2004
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

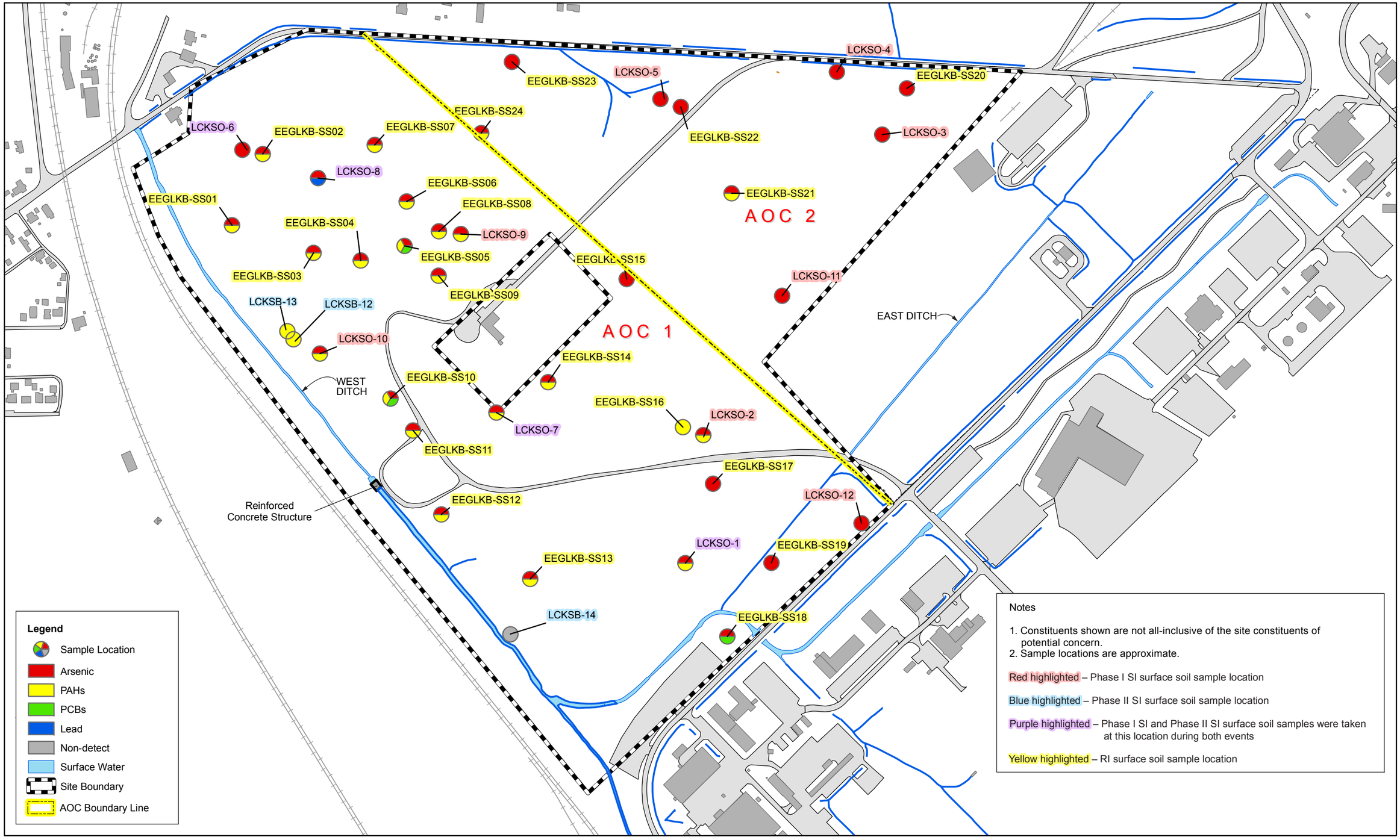


Figure 2-3
Surface Soil Results
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

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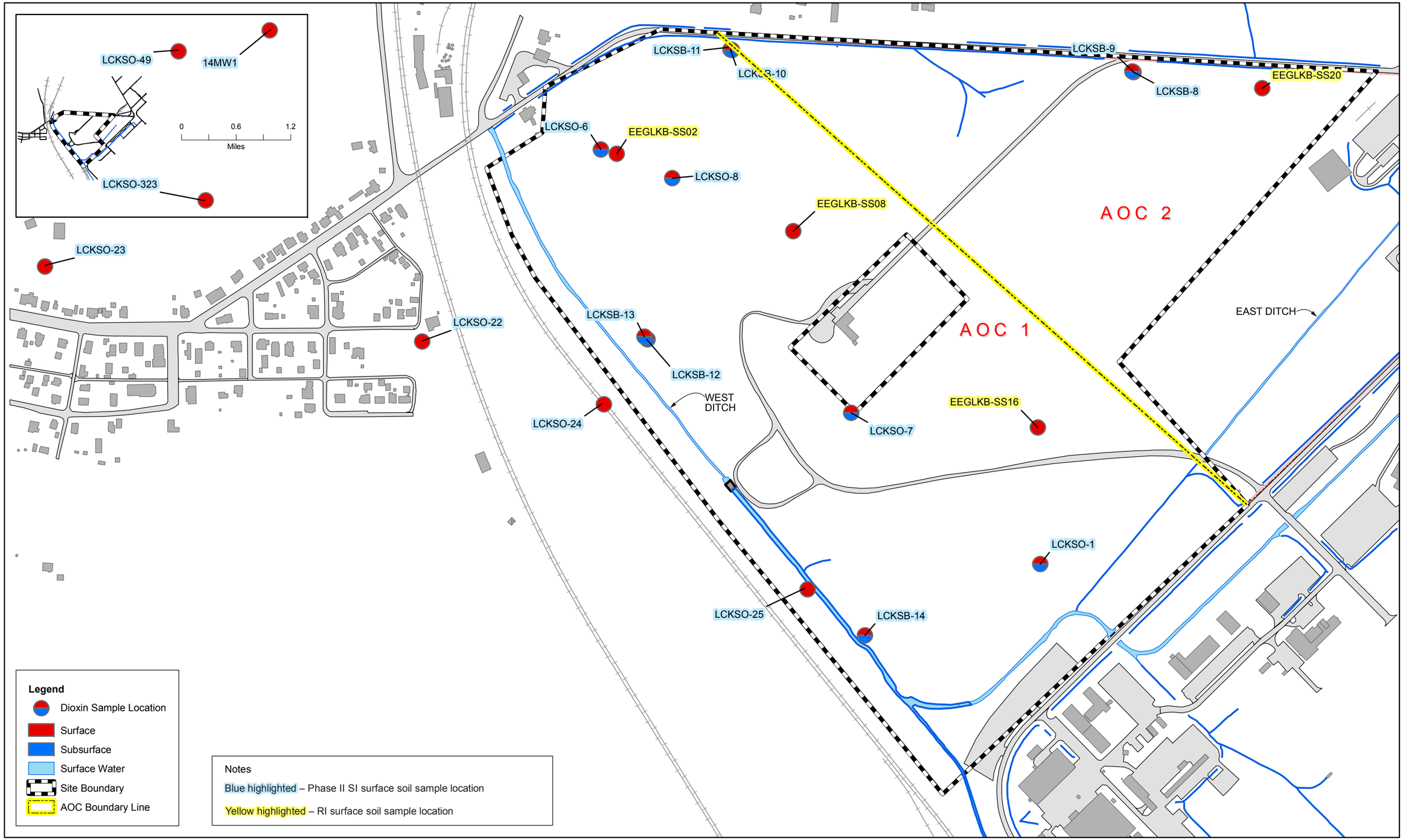

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0 350 700
Feet

Figure 2-4
Dioxins in Surface and Subsurface Soil
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

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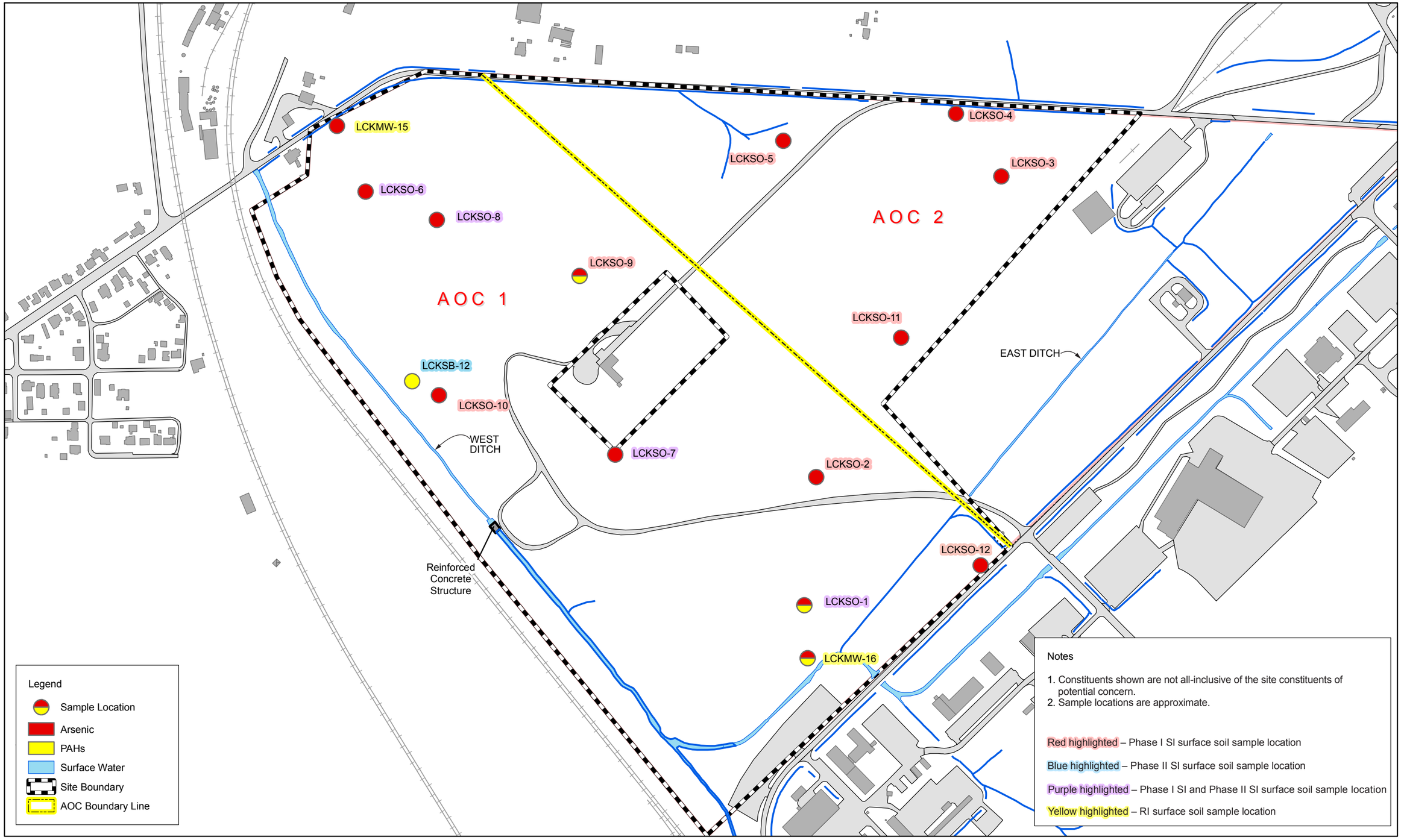

Figure 2-5
Subsurface Soil Results
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

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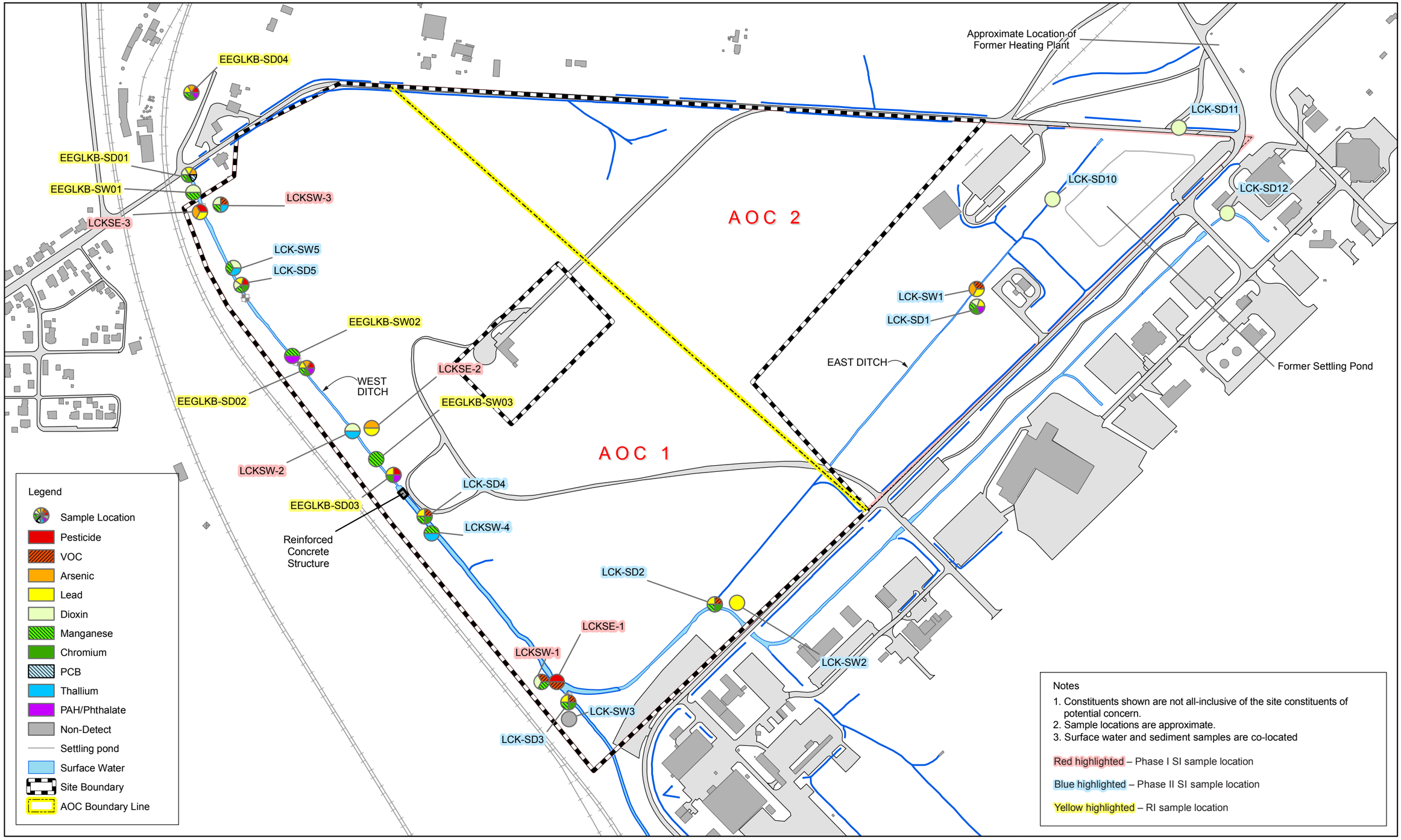

N

0 350 700
Feet

Figure 2-6
Surface Water and Sediment Results
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

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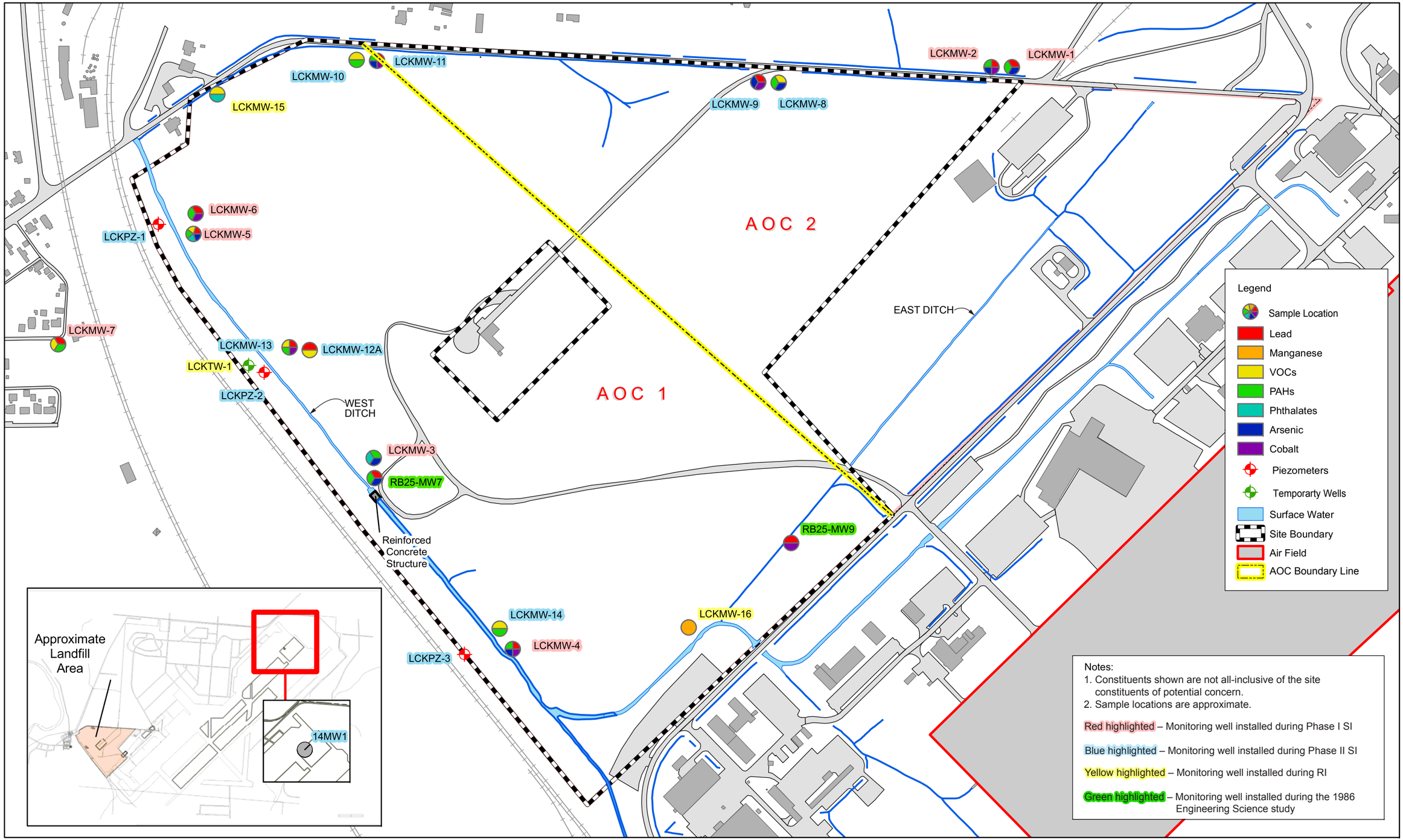

Figure 2-7
Groundwater Results
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Lockbourne, Ohio

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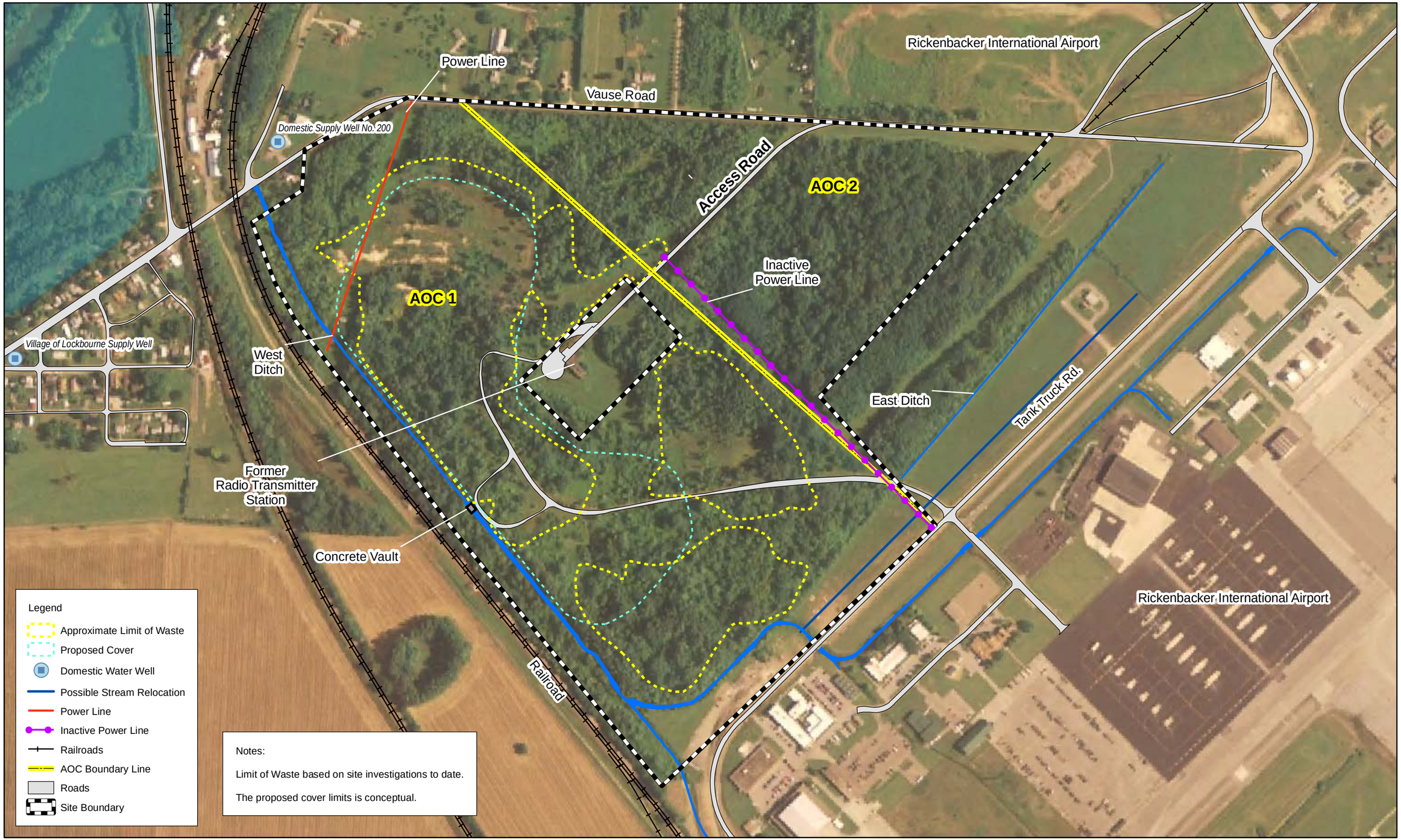

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0 550 1,100
Feet

Figure 4-1
Proposed Soil Cover Area
Focused Feasibility Study Report
Former Lockbourne Air Force Base Landfill, Ohio

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\\NORTHEND\PROJ\USACE\LOUISVILLEDISTRICT\366856LOCKBOURNE\MAPFILES\FS_FIGURES\FIGURE 4-1 - PROPOSED SOIL CAP AREA.MXD BHATHAWA 4/14/2011 11:14:42

COMPARISON OF TOTAL COST OF DIFFERENT OPTIONS

Site:	Former Lockbourne AFB Lanfill	**Base Year:**	2009	2010
Location:	Lockbourne, Ohio	**Date:**	9/25/2009	4/21/2010
Phase:	Remediation Cost Estimates			

Alternative:	**Alternative 1**	**Alternative 2+3 - partial**	**Alternative 2+3 - partial**	**Alternative 2 - partial**	**Alternative 2 - total**	**Alternative 3 - partial**	**Alternative 3 - total**
	No Action	**Institutional Controls**	**Long Term Monitoring**	**Consolidation and Installation of Compacted Clay Cap**		**Consolidation and Construction of a Soil Cover**	
Capital Cost	**$0**	$6,000	$83,800	$12,894,000	**$12,983,800**	$10,348,000	**$10,437,800**
Total Annual O&M Cost Year (1-2)	**$0**	$0	$225,200	$13,700	**$238,900**	$13,700	**$238,900**
Total Annual O&M Cost Year (3-5)	**$0**	$0	$122,300	$13,700		$13,700	
Total Annual O&M Cost Year (6-30)	**$0**	$0	$71,500	$13,700	**$85,200**	$13,700	**$85,200**
Total Periodic Cost every 5 years	**$0**	$0	$389,400	$126,000	**$515,400**	$95,000	**$484,400**
Total Present Value of Alternative (30 yrs)	**$ -**	$ 6,000	$ 2,222,200	$ 13,254,000	**$15,482,200**	$ 10,687,800	**$12,916,000**

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the alternatives. This is an order-of-magnitude cost estimate that is expected to be within -50 to +100 percent of the actual project costs.

Project Name: **Lockbourne, Ohio**
Scope: **Institutional Controls**

Site: Former Lockbourne Airforce Base Lanfill
Location: Lockbourne, Ohio
Phase: Remediation Cost Estimates

Description: This estimate is part of Alternatives 2 and 3. It includes filing of an environmental covanant, associated labor hours, and a contingency (20%). Discount rate is obtained from http://www.whitehouse.gov/omb/circulars_a094_a94_appx-c/. Need to consider the real discount rate for a 30-year period.

CAPITAL COSTS

	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Deed Restriction						
	Env Cov Filing Fees	1	LS	$200.00	$200	Engr's estimate
	Env Cov Filing Labor hours	40	hr	$120.00	$4,800	Engr's estimate. It is assumed that bulk of the work needed for developing the environmental covenants will be completed by CRAA. The hours indicated here are primarily for review
	SUBTOTAL				$5,000	
	Contingency	20%			$1,000	
	SUBTOTAL				$6,000	
	TOTAL CAPITAL COST				**$6,000**	

OPERATIONS AND MAINTENANCE COST (Annual Cost)

DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
Annual O&M			hrs		$0	
TOTAL O&M COST					**$0**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Renewals & Replacements	5	1	LS	$0	$0	
Renewals & Replacements	10	1	LS	$0	$0	
Renewals & Replacements	15	1	LS	$0	$0	
Renewals & Replacements	20	1	LS	$0	$0	
Renewals & Replacements	25	1	LS	$0	$0	
Renewals & Replacements	30	1	LS	$0	$0	
				Total	$0	
TOTAL PERIODIC COST					**$0**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 2.7%

End Year	COST TYPE	Total Cost	Periodic Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$6,000		$6,000	1.000	$ 6,000
1	ANNUAL COST - O&M	$0		$0	0.974	$ -
2	ANNUAL COST - O&M	$0		$0	0.948	$ -
3	ANNUAL COST - O&M	$0		$0	0.923	$ -
4	ANNUAL COST - O&M	$0		$0	0.899	$ -
5	ANNUAL COST - O&M	$0	$0	$0	0.875	$ -
6	ANNUAL COST - O&M	$0		$0	0.852	$ -
7	ANNUAL COST - O&M	$0		$0	0.830	$ -
8	ANNUAL COST - O&M	$0		$0	0.808	$ -
9	ANNUAL COST - O&M	$0		$0	0.787	$ -
10	ANNUAL COST - O&M	$0	$0	$0	0.766	$ -
11	ANNUAL COST - O&M	$0		$0	0.746	$ -
12	ANNUAL COST - O&M	$0		$0	0.726	$ -
13	ANNUAL COST - O&M	$0		$0	0.707	$ -
14	ANNUAL COST - O&M	$0		$0	0.689	$ -
15	ANNUAL COST - O&M	$0	$0	$0	0.671	$ -
16	ANNUAL COST - O&M	$0		$0	0.653	$ -
17	ANNUAL COST - O&M	$0		$0	0.636	$ -
18	ANNUAL COST - O&M	$0		$0	0.619	$ -
19	ANNUAL COST - O&M	$0		$0	0.603	$ -
20	ANNUAL COST - O&M	$0	$0	$0	0.587	$ -
21	ANNUAL COST - O&M	$0		$0	0.572	$ -
22	ANNUAL COST - O&M	$0		$0	0.556	$ -
23	ANNUAL COST - O&M	$0		$0	0.542	$ -
24	ANNUAL COST - O&M	$0		$0	0.528	$ -
25	ANNUAL COST - O&M	$0	$0	$0	0.514	$ -
26	ANNUAL COST - O&M	$0		$0	0.500	$ -
27	ANNUAL COST - O&M	$0		$0	0.487	$ -
28	ANNUAL COST - O&M	$0		$0	0.474	$ -
29	ANNUAL COST - O&M	$0		$0	0.462	$ -
30	ANNUAL COST - O&M	$0	$0	$0	0.450	$ -
				TOTAL PRESENT VALUE OF ALTERNATIVE		**$ 6,000**

Inflation is considered to 2.1%

Project Name: **Lockbourne, Ohio**
Scope: **Groundwater Monitoring**

Site: Former Lockbourne Airforce Base Lanfill
Location: Lockbourne, Ohio
Phase: Remediation Cost Estimates

Description: This estimate is part of Alternatives 2 and 3. It includes installation of five new groundwater monitoring wells and abandonment and replacement of five existing monitoring wells. This estimate also includes costs associated with long term sampling and well maintenance.

Capital costs presented in this estimate include allowances for project management (15%), project planning ($10,000 lump), and contingency (20%). O&M costs include a contingency of 20%. Discount rate is obtained from http://www.whitehouse.gov/omb/circulars_a094_a94_appx-c/. Need to consider the real discount rate.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Well Abandonment (5 onsite wells will be abandoned)					
Mobilization and demobilization	1	LS	$1,000.00	$1,000	Engr's estimate
Construction of temporary decontamination station	1	LS	$300.00	$300	Engr's estimate
Well abandonment	5	per well	$800.00	$4,000	Engr's estimate
Miscellaneous related to IDW disposal	1	LS	$1,000.00	$1,000	Engr's estimate
SUBTOTAL WELL ABANDONMENT				$6,300	
Well Installation (5 new wells and 5 replacement wells - avg depth - 20 ft)					
Mobilization and demobilization	1	LS	$1,000.00	$1,000	From a previous quote
Construction of temporary decontamination station	1	LS	$1,000.00	$1,000	From a previous quote
Construct 2" PVC wells (10 wells, 20 feet each)	10	LS	$2,000.00	$20,000	From a previous quote
Install riser protective covers, pads	10	ea	$250.00	$2,500	From a previous quote
Well development (4 hrs per well)	40	hr	$110.00	$4,400	From a previous quote
Miscellaneous related to IDW disposal	1	LS	$2,000.00	$2,000	From a previous quote
Provide reconditioned drums	4	ea	$50.00	$200	From a previous quote
Per diem (2 drillers plus 1 consultant)	5	day	$2,160.00	$10,800	From a previous quote
SUBTOTAL WELL INSTALLATION				$41,900	
SUBTOTAL				$48,200	
Contingency	20%			$9,640	on construction
SUBTOTAL				$57,840	
Work Planning, Permitting, QA/QC plans and H&S Requirements		LS		$15,000	
SUBTOTAL				$72,840	
Project Management	15%			$10,926	on total cost, includes oversight labor
SUBTOTAL				$83,766	
TOTAL CAPITAL COST				**$83,800**	

OPERATIONS AND MAINTENANCE COST (Annual Cost)

DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
Years 1 and 2 (quarterly sampling)						
GW Sampling (Total 21 wells, 3 additional samples for QA/QC)						
Groundwater Sampling for VOCs (4 events/yr)		96	ea	$95	$9,120	
Groundwater Sampling for SVOCs (4 events/yr)		96	ea	$225	$21,600	
Groundwater Sampling for Dioxins (4 events/yr)		96	ea	$600	$57,600	
Groundwater Sampling for Pesticides (4 events/yr)		96	ea	$100	$9,600	
Groundwater Sampling for metals (4 events/yr)		96	ea	$125	$12,000	
Groundwater Sampling, Level D		4	LS	$300	$1,200	
Labor (prep & sampling)		240	hrs	$110	$26,400	60 hrs/event
Equipment - meters		4	LS	$300	$1,200	
Consumables		4	LS	$200	$800	
Data Validation		72	hrs	$120	$8,640	12 hrs/event + 24 hrs for initial event
Subtotal Annual O&M (Yr 1 to 2) - quarterly sampling					$148,160	
Years 3, 4, and 5 (semiannual sampling)						
GW Sampling (Total 21 wells, 3 additional samples for QA/QC)						
Groundwater Sampling for VOCs (2 events/yr)		48	ea	$95	$4,560	Analytical Costs
Groundwater Sampling for SVOCs (2 events/yr)		48	ea	$225	$10,800	Analytical Costs
Groundwater Sampling for Dioxins (2 events/yr)		48	ea	$600	$28,800	Analytical Costs
Groundwater Sampling for Pesticides (2 events/yr)		48	ea	$100	$4,800	Analytical Costs
Groundwater Sampling for metals (2 events/yr)		48	ea	$125	$6,000	Analytical Costs
Groundwater Sampling, Level D		2	LS	$300	$600	
Labor (prep & sampling)		120	hrs	$110	$13,200	60 hrs/event (two people for three ten hour days)
Equipment - meters		2	LS	$300	$600	
Consumables		2	LS	$200	$400	
Data Validation		32	hrs	$120	$3,840	12 hrs/event
Subtotal Annual O&M (Yr 3 to 5) - semi-annual sampling					$73,600	
Subtotal Annual O&M (Yr 6 to 30)					$36,800	(annually)
Reporting (1 annual report)		1	LS	$15,000	$15,000	
Contingency (Yr 1 to 2)		20%			$32,632	
Contingency (Yr 3 to 5)		20%			$17,720	
Contingency (Yr 6 to 30)		20%			$10,360	
Subtotal Annual O&M (Yr 1 to 2)					$195,792	
Subtotal Annual O&M (Yr 3 to 5)					$106,320	
Subtotal Annual O&M (Yr 6 to 30)					$62,160	
Project Management (Yr 1 to 2)		15%			$29,369	
Project Management (Yr 3 to 5)		15%			$15,948	
Project Management (Yr 6 to 30)		15%			$9,324	
TOTAL ANNUAL O&M COST Year 1 to 2					**$225,200**	
TOTAL ANNUAL O&M COST Year 3 to 5					**$122,300**	
TOTAL ANNUAL O&M COST Year 6 to 30					**$71,500**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Renewals & Replacements (includes 5-yr review report)	5	1	LS	$61,568	$61,568	Well replacement and/or maintenance
Renewals & Replacements (includes 5-yr review report)	10	1	LS	$62,861	$62,861	20% of capital cost
Renewals & Replacements (includes 5-yr review report)	15	1	LS	$64,181	$64,181	%-year review report = $40,000
Renewals & Replacements (includes 5-yr review report)	20	1	LS	$65,529	$65,529	
Renewals & Replacements (includes 5-yr review report)	25	1	LS	$66,905	$66,905	
Renewals & Replacements (includes 5-yr review report)	30	1	LS	$68,310	$68,310	
				Total	$389,354	
TOTAL PERIODIC COST					**$389,400**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 2.7%

End Year	COST TYPE	Total Cost	Periodic Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$83,800		$83,800	1.000	$ 83,800
1	ANNUAL COST - O&M	$225,200		$225,200	0.974	$ 219,279
2	ANNUAL COST - O&M	$225,200		$225,200	0.948	$ 213,515
3	ANNUAL COST - O&M	$122,300		$122,300	0.923	$ 112,906
4	ANNUAL COST - O&M	$122,300		$122,300	0.899	$ 109,937
5	ANNUAL COST - O&M	$122,300	$61,568	$183,868	0.875	$ 160,936
6	ANNUAL COST - O&M	$71,500		$71,500	0.852	$ 60,937
7	ANNUAL COST - O&M	$71,500		$71,500	0.830	$ 59,335
8	ANNUAL COST - O&M	$71,500		$71,500	0.808	$ 57,775
9	ANNUAL COST - O&M	$71,500		$71,500	0.787	$ 56,256
10	ANNUAL COST - O&M	$71,500	$62,861	$134,361	0.766	$ 102,936
11	ANNUAL COST - O&M	$71,500		$71,500	0.746	$ 53,337
12	ANNUAL COST - O&M	$71,500		$71,500	0.726	$ 51,935
13	ANNUAL COST - O&M	$71,500		$71,500	0.707	$ 50,570
14	ANNUAL COST - O&M	$71,500		$71,500	0.689	$ 49,240
15	ANNUAL COST - O&M	$71,500	$64,181	$135,681	0.671	$ 90,983
16	ANNUAL COST - O&M	$71,500		$71,500	0.653	$ 46,685
17	ANNUAL COST - O&M	$71,500		$71,500	0.636	$ 45,458
18	ANNUAL COST - O&M	$71,500		$71,500	0.619	$ 44,263
19	ANNUAL COST - O&M	$71,500		$71,500	0.603	$ 43,099
20	ANNUAL COST - O&M	$71,500	$65,529	$137,029	0.587	$ 80,427
21	ANNUAL COST - O&M	$71,500		$71,500	0.572	$ 40,863
22	ANNUAL COST - O&M	$71,500		$71,500	0.556	$ 39,788
23	ANNUAL COST - O&M	$71,500		$71,500	0.542	$ 38,742
24	ANNUAL COST - O&M	$71,500		$71,500	0.528	$ 37,724
25	ANNUAL COST - O&M	$71,500	$66,905	$138,405	0.514	$ 71,103
26	ANNUAL COST - O&M	$71,500		$71,500	0.500	$ 35,766
27	ANNUAL COST - O&M	$71,500		$71,500	0.487	$ 34,826
28	ANNUAL COST - O&M	$71,500		$71,500	0.474	$ 33,910
29	ANNUAL COST - O&M	$71,500		$71,500	0.462	$ 33,019
30	ANNUAL COST - O&M	$71,500	$68,310	$139,810	0.450	$ 62,867
			TOTAL PRESENT VALUE OF ALTERNATIVE			**$ 2,222,200**

Inflation is considered to 2.1% (Global Insight)

Alternative: 2
Name: Lockbourne, Ohio
Scope: Consolidation and Installation of Compacted Clay Cap

Site: Former Lockbourne Airforce Base Lanfill
Location: Lockbourne, Ohio
Phase: Remediation Cost Estimates

Description: This estimate is part of Alternative 2. It includes consolidation of various waste piles and installation of a compacted clay cap and passive venting system. This estimate also includes annual and periodic costs associated with monitoring and maintenance of the cap. This alternative assumes all waste material will be kept on site (no offiste transport) and that stormwater management will be covered under a separate action.

Capital costs presented in this estimate include allowances for construction management (15%), and contingency (20%). O&M costs include a contingency of 20%. Discount rate is obtained from http://www.whitehouse.gov/omb/circulars_a094_a94_appx-c/. Need to consider the real discount rate.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Waste Consolidation - Clearing AOC 1 and AOC 2					
Mobilization/demobilization	1	LS	$15,000.00	$15,000	Engr's Estimate
Fence cost (includes removal of existing fence and installation of new fence around the AOC 1	1	LS	$100,000.00	$100,000	Engr's Estimate
Vegetation removal - heavy brush, light trees, clear, chip, grub, and haul	75	acre	$6,500.00	$487,500	RS Means 2010
Excavation of waste materials to be consolidated	87,120	cu yd	$6.00	$522,720	RS Means 2010
Decontamination	1	ls	$4,000.00	$4,000	CCI 2010
Backfill - unclassfied fill from off site	87,120	cu yd	$20.00	$1,742,400	Common fill is $15/cy to import and then another $5/cy to place/grade.
SUBTOTAL WASTE CONSOLIDATION				$2,871,620.00	
Landfill Cap Installation					
Mobilization/demobilization	1	ea	$15,000.00	$15,000	Engr's Estimate
Monitoring with PID reader	4	month	$1,300.00	$5,200	
Grading	193,600	sy	$2.20	$425,920	CCI 2010
Clay placement on a 40 acrea area and compaction (6-inch lifts, 24-inch total depth)	129,712	cu yd	$40.00	$5,188,480	CCI 2010
Topsoil placement (6-inch lifts, 6-inch total depth)	32,428	cu yd	$30.00	$972,840	Topsoil is $25/cy to import and then another $5/cy to place/grade.
Hydroseeding/mulching and vegetative establishment	40	acre	$3,528.00	$141,120	CCI 2010
Topographic survey (2-foot contours)	1	LS	$40,000.00	$40,000	
Decontamination of heavy equipment	1	LS	$10,000.00	$10,000	
LANDFILL CAP INSTALLATION				$6,798,560	
Passive Vent Installation					
Total installed cost per vent	25	ea	$600.00	$15,000	CCI 2010
PASSIVE VENT INSTALLATION				$15,000	
SUBTOTAL				$9,685,180	
Contingency	20%			$1,937,036	
SUBTOTAL				$11,622,216	
Work Planning, Permitting, QA/QC plans and H&S Requirements	LS			$100,000	
SUBTOTAL				$11,722,216	
Construction Management	10%			$1,172,222	Includes oversight labor
SUBTOTAL				$12,894,438	
TOTAL CAPITAL COST				**$12,894,000**	

OPERATIONS AND MAINTENANCE COST (Annual Cost)

DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
Cap Maintenance						
Biannual inspection		16	hrs	$100	$1,600	
Biannual mowing (labor plus equipment) (40 acres plus surrounding)		96	acres	$50	$4,800	
Annual minor repairs		1	LS	$5,000	$5,000	
SUBTOTAL CAP MAINTENANCE					$11,400	
Subtotal Annual O&M					$11,400	
Reporting (included elsewhere)						
Contingency		20%			$2,280	
TOTAL ANNUAL O&M COST					**$13,700**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Renewals & Replacements	5	1	LS	$20,000	$20,000	
Renewals & Replacements	10	1	LS	$20,420	$20,420	
Renewals & Replacements	15	1	LS	$20,849	$20,849	
Renewals & Replacements	20	1	LS	$21,287	$21,287	
Renewals & Replacements	25	1	LS	$21,734	$21,734	
Renewals & Replacements	30	1	LS	$22,190	$22,190	
				Total	$126,479	
TOTAL PERIODIC COST					**$126,000**	

PRESENT VALUE ANALYSIS (30-year) Discount Rate = 2.7%

End Year	COST TYPE	Total Cost	Periodic Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$12,894,000		$12,894,000	1.000	$ 12,894,000
1	ANNUAL COST - O&M	$13,700		$13,700	0.974	$ 13,340
2	ANNUAL COST - O&M	$13,700		$13,700	0.948	$ 12,989
3	ANNUAL COST - O&M	$13,700		$13,700	0.923	$ 12,648
4	ANNUAL COST - O&M	$13,700		$13,700	0.899	$ 12,315
5	ANNUAL COST - O&M	$13,700	$20,000	$33,700	0.875	$ 29,497
6	ANNUAL COST - O&M	$13,700		$13,700	0.852	$ 11,676
7	ANNUAL COST - O&M	$13,700		$13,700	0.830	$ 11,369
8	ANNUAL COST - O&M	$13,700		$13,700	0.808	$ 11,070
9	ANNUAL COST - O&M	$13,700		$13,700	0.787	$ 10,779
10	ANNUAL COST - O&M	$13,700	$20,420	$34,120	0.766	$ 26,140
11	ANNUAL COST - O&M	$13,700		$13,700	0.746	$ 10,220
12	ANNUAL COST - O&M	$13,700		$13,700	0.726	$ 9,951
13	ANNUAL COST - O&M	$13,700		$13,700	0.707	$ 9,690
14	ANNUAL COST - O&M	$13,700		$13,700	0.689	$ 9,435
15	ANNUAL COST - O&M	$13,700	$20,849	$34,549	0.671	$ 23,167
16	ANNUAL COST - O&M	$13,700		$13,700	0.653	$ 8,945
17	ANNUAL COST - O&M	$13,700		$13,700	0.636	$ 8,710
18	ANNUAL COST - O&M	$13,700		$13,700	0.619	$ 8,481
19	ANNUAL COST - O&M	$13,700		$13,700	0.603	$ 8,258
20	ANNUAL COST - O&M	$13,700	$21,287	$34,987	0.587	$ 20,535
21	ANNUAL COST - O&M	$13,700		$13,700	0.572	$ 7,830
22	ANNUAL COST - O&M	$13,700		$13,700	0.556	$ 7,624
23	ANNUAL COST - O&M	$13,700		$13,700	0.542	$ 7,423
24	ANNUAL COST - O&M	$13,700		$13,700	0.528	$ 7,228
25	ANNUAL COST - O&M	$13,700	$21,734	$35,434	0.514	$ 18,204
26	ANNUAL COST - O&M	$13,700		$13,700	0.500	$ 6,853
27	ANNUAL COST - O&M	$13,700		$13,700	0.487	$ 6,673
28	ANNUAL COST - O&M	$13,700		$13,700	0.474	$ 6,498
29	ANNUAL COST - O&M	$13,700		$13,700	0.462	$ 6,327
30	ANNUAL COST - O&M	$13,700	$22,190	$35,890	0.450	$ 16,138
			TOTAL PRESENT VALUE OF ALTERNATIVE			**$ 13,254,000**

Inflation is considered to 2.1% (Global Insight)

Alternative:	**3**
Name:	**Lockbourne, Ohio**
Scope:	**Consolidation and Construction of a Soil Cover**
Site:	Former Lockbourne Airforce Base Lanfill
Location:	Lockbourne, Ohio
Phase:	Remediation Cost Estimates

Description: This estimate is part of Alternative 3. It includes consolidation of various waste piles and installation of a 24-inch thick soil landfill cover. This estimate also includes annual and periodic costs associated with monitoring and maintenance of the soil cover. This alternative assumes all waste material will be kept on site (no offiste transport) and that stormwater management will be covered under a separate action.

Capital costs presented in this estimate include allowances for construction management (15%) and contingency (20%). O&M costs include a contingency of 20%. Discount rate is obtained from http://www.whitehouse.gov/omb/circulars_a094_a94_appx-c/. Need to consider the real discount rate.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Waste Consolidation - Clearing AOC 1 and AOC 2					
Mobilization/demobilization	1	ls	$15,000.00	$15,000	Engr's Estimate
Fence cost (includes removal of existing fence and installation of new fence around the AOC 1	1	LS	$100,000.00	$100,000	Engr's Estimate
Vegetation removal - heavy brush, light trees, clear, chip, grub, and haul	75	acre	$6,500.00	$487,500	RS Means 2010
Excavation and relocation of waste materials to be consolidated	87,120	cu yd	$6.00	$522,720	RS Means 2010
Decontamination	1	ls	$4,000.00	$4,000	CCI 2010
Backfill - unclassfied fill from off site	87,120	cu yd	$20.00	$1,742,400	Common fill is $15/cy to import and then another $5/cy to place/grade.
SUBTOTAL WASTE CONSOLIDATION				$2,871,620.00	
Soil Cover Installation					
Mobilization/demobilization	1	ea	$15,000.00	$15,000	Engr's Estimate
Monitoring with PID reader	4	month	$1,300.00	$5,200	
Grading	193,600	sy	$2.20	$425,920	CCI 2010
Clay placement on a 40-acre area and compaction (6-inch lifts, 24-inch total depth)	129,712	cu yd	$22.50	$2,918,520	
Topsoil placement (6-inch lifts, 6-inch total depth)	32,428	cu yd	$30.00	$972,840	Topsoil is $25/cy to import and then another $5/cy to place/grade.
Hydroseeding/mulching and vegetative establishment	40	acre	$3,528.00	$141,120	
Topographic survey (2-foot contours)	1	ls	$40,000.00	$40,000	
Decontamination	1	ls	$10,000.00	$10,000	
SOIL COVER INSTALLATION				$4,528,600	
Passive Vent Installation					
Total installed cost per vent	25	ea	$600.00	$15,000	CCI 2010
PASSIVE VENT INSTALLATION				$15,000	
SUBTOTAL				$7,415,220	
Contingency	20%			$1,483,044	
SUBTOTAL				$8,898,264	
Work Planning, Permitting, QA/QC plans and H&S Requirements and landfill closure design	1	ls	$100,000.00	$100,000	
SUBTOTAL				$8,998,264	
Construction Management	15%			$1,349,740	Includes oversight labor
SUBTOTAL				$10,348,004	
TOTAL CAPITAL COST				**$10,348,000**	

OPERATIONS AND MAINTENANCE COST (Annual Cost)

DESCRIPTION	YEAR	QTY	UNIT	COST	TOTAL	NOTES
Cap Maintenance						
Biannual inspection		16	hrs	$100	$1,600	
Biannual mowing (labor plus equipment) (40 acres plus surrounding)		96	acres	$50	$4,800	
Annual minor repairs		1	ls	$5,000	$5,000	
SUBTOTAL CAP MAINTENANCE					$11,400	
Subtotal Annual O&M					$11,400	
Reporting (included elsewhere)						
Contingency		20%			$2,280	
TOTAL ANNUAL O&M COST					**$13,700**	

PERIODIC COSTS

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Renewals & Replacements	5	1	LS	$15,000	$15,000	
Renewals & Replacements	10	1	LS	$15,315	$15,315	
Renewals & Replacements	15	1	LS	$15,637	$15,637	
Renewals & Replacements	20	1	LS	$15,965	$15,965	
Renewals & Replacements	25	1	LS	$16,300	$16,300	
Renewals & Replacements	30	1	LS	$16,643	$16,643	
				Total	$94,859	
TOTAL PERIODIC COST					**$95,000**	

PRESENT VALUE ANALYSIS (30-year)

Discount Rate = 2.7%

End Year	COST TYPE	Total Cost	Periodic Cost	TOTAL COST/YEAR	DISCOUNT FACTOR	PRESENT VALUE
0	CAPITAL COST	$10,348,000		$10,348,000	1.000	$ 10,348,000
1	ANNUAL COST - O&M	$13,700		$13,700	0.974	$ 13,340
2	ANNUAL COST - O&M	$13,700		$13,700	0.948	$ 12,989
3	ANNUAL COST - O&M	$13,700		$13,700	0.923	$ 12,648
4	ANNUAL COST - O&M	$13,700		$13,700	0.899	$ 12,315
5	ANNUAL COST - O&M	$13,700	$15,000	$28,700	0.875	$ 25,121
6	ANNUAL COST - O&M	$13,700		$13,700	0.852	$ 11,676
7	ANNUAL COST - O&M	$13,700		$13,700	0.830	$ 11,369
8	ANNUAL COST - O&M	$13,700		$13,700	0.808	$ 11,070
9	ANNUAL COST - O&M	$13,700		$13,700	0.787	$ 10,779
10	ANNUAL COST - O&M	$13,700	$15,315	$29,015	0.766	$ 22,229
11	ANNUAL COST - O&M	$13,700		$13,700	0.746	$ 10,220
12	ANNUAL COST - O&M	$13,700		$13,700	0.726	$ 9,951
13	ANNUAL COST - O&M	$13,700		$13,700	0.707	$ 9,690
14	ANNUAL COST - O&M	$13,700		$13,700	0.689	$ 9,435
15	ANNUAL COST - O&M	$13,700	$15,637	$29,337	0.671	$ 19,672
16	ANNUAL COST - O&M	$13,700		$13,700	0.653	$ 8,945
17	ANNUAL COST - O&M	$13,700		$13,700	0.636	$ 8,710
18	ANNUAL COST - O&M	$13,700		$13,700	0.619	$ 8,481
19	ANNUAL COST - O&M	$13,700		$13,700	0.603	$ 8,258
20	ANNUAL COST - O&M	$13,700	$15,965	$29,665	0.587	$ 17,411
21	ANNUAL COST - O&M	$13,700		$13,700	0.572	$ 7,830
22	ANNUAL COST - O&M	$13,700		$13,700	0.556	$ 7,624
23	ANNUAL COST - O&M	$13,700		$13,700	0.542	$ 7,423
24	ANNUAL COST - O&M	$13,700		$13,700	0.528	$ 7,228
25	ANNUAL COST - O&M	$13,700	$16,300	$30,000	0.514	$ 15,412
26	ANNUAL COST - O&M	$13,700		$13,700	0.500	$ 6,853
27	ANNUAL COST - O&M	$13,700		$13,700	0.487	$ 6,673
28	ANNUAL COST - O&M	$13,700		$13,700	0.474	$ 6,498
29	ANNUAL COST - O&M	$13,700		$13,700	0.462	$ 6,327
30	ANNUAL COST - O&M	$13,700	$16,643	$30,343	0.450	$ 13,644
			TOTAL PRESENT VALUE OF ALTERNATIVE			**$ 10,687,800**

Inflation is considered to 2.1% (Global Insight)