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November 20, 2019

Ms. Tanowa Troupe, Secretary
Public Utilities Commission of Ohio
180 East Broad Street, 11th Floor
Columbus, Ohio 43215

Re: Case Nos. 19-174-GA-RDR, *et al*. MGP Consolidated Cases

Duke Energy Ohio, Inc. requests that the Confidential Attachment filed under seal in Shawn Fiore's testimony in the 19-174-GA-RDR and 19-175-GA-ATA cases and labeled SSF-2 be released into the public record and the Motion for Confidential Treatment filed on March 29, 2019 be withdrawn. Enclosed for filing is a copy of the attachment SSF-2.

Should you have any questions please feel free to contact me.

Respectfully submitted,

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Focused Remedial Alternatives Analysis for the Phase 3 and Tower Areas

Prepared for

Duke Energy West End Property
Cincinnati, OH

November 2017

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US

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Acronyms and Abbreviations

BAP	benzo(a)pyrene
bgs	below ground surface
CH2M	CH2M HILL Engineers, Inc.
CNS	Covenant Not to Sue
COC	chemical of concern
GRA	general response action
ISS	in situ stabilization
MGP	Manufactured Gas Plant
NAPL	nonaqueous phase liquid
NFA	no further action
OAC	Ohio Administrative Code
OLM	oil-like materials
O&M	operation and maintenance
PAH	polycyclic aromatic hydrocarbon
RAA	Remedial Alternatives Analysis
RAO	remedial action objective
TLM	tar-like materials
UPUS	unrestricted potable use standards
VAP	Voluntary Action Program

Introduction

On behalf of Duke Energy Ohio, Inc. (Duke), CH2M HILL, Inc. (CH2M) completed this remedial alternatives analysis (RAA) for the Phase 3 Area and Tower Area (collectively referred to as the Subject Area) at Duke's West End Property (West End Property). The West End Property is located at 646 West Mehring Way in Cincinnati, Ohio. This remedial alternatives analysis has been prepared for Duke based on the results of a Phase II Property Assessment to address source areas, keep sources from migrating, and meet applicable standards under the Voluntary Action Program (VAP).

This report presents and analyzes remedial alternatives for the Subject Area, specifically, the Tower Area and the Phase 3 Area. The report is organized into the following sections:

- Section 1 – Introduction and Background information
- Section 2 – Remedial Strategy and Objectives
- Section 3 – Technology Screening
- Section 4 – Remedial Alternatives
- Section 5 – References

1.1 West End Property Setting

The West End Property is in Hamilton County, Ohio, approximately 0.5 mile southwest of downtown Cincinnati and directly west of the Brent Spence Bridge (Interstate 71/75). The West End Property is bisected by Mehring Way, with the northern part referred to as the "Front and Rose Parcel," and the southern part the "West End Parcel."

On the Front and Rose Parcel, the remedial action will focus on the southeast portion of the parcel, in what is referred to as the "Tower Area." A tower was erected (circa 1965), following the removal of historical structures. The tower has since been removed and the parcel contains no other structures and is used as an equipment storage and lay down area. The Tower Area is bounded by Mehring Way to the south and Rose Street to the east. Surface grades are generally flat with a slight slope towards the southwest.

On the West End Parcel, the remedial action will focus on the eastern portion of the parcel, identified as "Phase 3 Area." The Phase 3 Area is bounded by Mehring Way to the north, Rose Street to the east, and the Ohio River to the south. The surface is covered mostly with gravel, except for a few paved areas. It most recently housed the former eastern substation which was de-energized and removed following the construction of a new substation immediately adjacent to the west of the Phase 3 Area. Surface grades are generally flat, with a steep slope along the southern edge leading to the Ohio River.

1.2 West End Property History and Current Use

The West End Property was home to a manufactured gas plant (MGP), which began operations in the mid-1800s, and continued until the early-1900s, when it was transitioned to use as an electric-generating station. In the 1970s, all aboveground structures associated with the MGP operations were removed. Today, two large substations (Middle Station and West Station) operate in the central and western portions of West End Property, south of Mehring Way. The Front and Rose Parcel, to the north, is currently used as an equipment storage and lay down area by Duke.

1.3 Previous Investigations

VAP Phase I Environmental Assessment Report (Phase I) – The Phase I was completed in May 2010 by AECOM for the entirety of the West End Property. The Phase I identified no known previous environmental investigations at the site. It was found that a geotechnical investigation had been conducted in 1992 on the western end of the West End Property for the installation of a proposed transformer and circuit breaker pad (AECOM, 2010a).

The Phase I resulted in the recognition of two Identified Areas for the West End Property, consisting of the Front and Rose Parcel (Identified Area #1) and the West End Parcel (Identified Area #2). Under the VAP, an Identified Area is defined as a location where a release of a hazardous substance or petroleum has or may have occurred.

VAP Phase II Property Assessment Report (Phase II) – The Phase II was completed in December 2010 by AECOM on the West End Property, except for the Phase 3 and Tower Areas which were not accessible at that time. The Phase II assessment concluded that chemicals of interest associated with the former MGP processes were present above the Ohio EPA VAP standards in both surface and subsurface soil, including the presence of oil-like material (OLM) and tar-like material (TLM) at the site (AECOM, 2010b).

Remedial Action Completion Report – Based on the results of the Phase II, remedial activities were undertaken on the Phase 1, Phase 2 and Phase 2A Areas at the West End Property and a Remedial Action Completion Report was completed by Burns and McDonnell (2014) in July 2014. The Remedial Action Completion Report summarizes the remedial action that took place on the West End Property, immediately to the west of the Phase 3 Area and the Tower Area.

2017 VAP Phase II Property Assessment – A Phase II Property Assessment was completed by CH2M HILL Engineers, Inc. (CH2M) in 2017 on the Tower Area and the Phase 3 Area. Soil and TarGOST borings were advanced, and groundwater monitoring wells were installed and sampled to obtain additional information to allow for evaluation of conditions in these two areas and to evaluate remedial requirements applicable to the Subject Area.

1.4 Potential Source Areas

Historical MGP operations resulted in releases of the following MGP residuals to the environment: ash, slag, purifier materials, and coal tar. Both the West End and Front and Rose Parcels have undergone Ohio EPA VAP site assessments, and it was determined that chemicals of interest associated with these processes were present above the Ohio EPA VAP standards in both surface and subsurface soil. Several remediation projects have occurred on these parcels (Phase 1, 2, and 2A areas) to remove and/or stabilize contaminated materials and remove MGP structures known to contain residuals; however, it was likely that some residuals existed outside the footprint of these previously remediated areas based on historical operations and as confirmed in the 2017 Phase II Property Assessment.

The following gas production and storage features have been identified in previous investigations onsite and other MGP sites as potential sources of MGP residuals. Residuals may be present, even though some of these features have since been removed from the sites.

- Former Retort House: Retort buildings typically contained retorts (or ovens) that were used to generate coal gas by heating the coal under anoxic conditions to volatilize gaseous constituents of coal. The main byproducts of these procedures were coke, ash, cinders, and clinkers. Several retort buildings were historically present in the Phase 3 Area, but have since been demolished.
- Fuel and Oil Storage: Both a fuel oil house and an oil storage house were present on the southern edge of the Phase 3 Area. Only the fuel oil house currently remains. Presumably, fuel and oil

produced by or needed for the MGP processes was stored in these buildings. These areas may be a source of OLM, TLM, nonaqueous phase liquid (NAPL), and other MGP residuals.

- Tar Wells: Several former tar wells are in the Tower Area. In general, tar wells were below-grade structures used to store tar for later sale or use. Tar storage areas may be a source of OLM, TLM, NAPL, and other MGP residuals observed onsite.
- Coal/Coke and Ash Storage: Coal/coke and ash storage areas were onsite throughout the operational life of the MGP. Several coal piles, a coke bin, and an ash pit were present along the southern edge of the Phase 3 Area, and may be a source of MGP residuals. Additionally, a Coal House was present along the western edge of the Phase 3 Area and may be a source of MGP residuals.

1.5 Distribution of MGP Residuals

MGP residuals include ash, slag, and purifier materials resulting from previous MGP operations. Significant MGP residuals were identified in previous studies in the area to the west of both the Tower Area and Phase 3 Area. In the Phase 3 Area, MGP residuals were found to be present along the western edge. At most of the borings where probable MGP impacts were observed, the impacts were at or near the boring termination depth.

1.6 Distribution of Chemicals of Concern in Soils

Chemicals of concern associated with MGP sites typically consist of naphthalene; polycyclic aromatic hydrocarbons (PAHs), which include benzo(a)anthracene, benzo(a)pyrene (BAP), benzo(b)fluoranthene, benzo(g,h)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene; and heavy metals.

1.6.1 Tower Area

In general, elevated PAH concentrations were found to be present within the upper 20 feet in the Tower Area, with the main constituent being BAP. BAP does not generally partition to groundwater; however, analytical results indicated concentrations exceeding the Industrial/Commercial direct-contact standards for Construction/Excavation. Considering the analytical results from previous investigations for the site, it is likely that elevated BAP concentrations exist in the upper 20 feet across the entirety of the Tower Area. It should be noted that concentrations of benzene and naphthalene were found below action levels in the Tower Area.

1.6.2 Phase 3 Area

The main chemicals of concern found in the Phase 3 Area is BAP and is found at depths reaching up to 55 feet below ground surface (bgs). Likewise, the Phase 3 Area exhibited high concentrations of benzene as well. It should be noted that the locations exhibiting higher benzene concentrations generally also exhibited high naphthalene concentrations and exceedances of lead.

The surficial soil in the Phase 3 Area (0 to 15 feet bgs) exhibits high concentrations of chemicals of concern over most of the site. High concentrations of BAP are limited to the northwest portion of the site in the 16- to 30-foot depth interval. Below 30 feet, the contaminants are generally found along the western edge of the Phase 3 Area.

1.6.3 Oil-like Materials/Tar-like Materials

TarGOST testing performed during the Phase II Investigation was used to identify and delineate the extent of OLM and TLM at the Subject Area. The data obtained from the TarGOST investigation was evaluated to allow for a more accurate estimation of the extent of OLM and TLM impacts. The process used is described in the *VAP Phase II Property Assessment Report for the Phase 3 and Former Tower Areas* (CH2M, 2017). Confirmatory soil borings were used to confirm the findings of the TarGOST results. During that investigation, no direct evidence of TLM was identified; however, OLM was observed (NAPL or free-product) at several locations within the Phase 3 Area (primarily along the western boundary). No TLM or OLM was identified within the Tower Area. Figure 1 shows the two-dimensional depiction of the TarGOST results, Figure 2 shows the depth, thickness, and interpreted distribution of OLM/TLM, and cross sections are presented in Figures 3 and 4.

1.7 Distribution of Chemicals of Concern in Groundwater

Collectively, the data produced during investigations shows evidence of MGP-related impacts to groundwater, and concentrations do not meet VAP standards. Natural attenuation appears to be limiting the migration of dissolved organic constituents within the groundwater. It is likely that several biodegradation pathways are occurring at the site.

1.8 Chemicals of Concern Subsurface Transport

The occurrence, migration, and accumulation of MGP residual materials in the subsurface are typically controlled by several factors, including the following:

- The texture and porosity of the overburden materials
- The presence of capillary barriers and confining units that inhibit and influence vertical and horizontal migration
- The occurrence of groundwater within the overburden materials
- The physical nature and distribution of MGP-residual materials (density relative to water)

Generally, MGP residuals tend to migrate vertically (infiltrate) into surface and subsurface materials until they intersect a barrier. Barriers can consist of lower-permeability soil, such as clay, or bedrock or other impenetrable surfaces. Once MGP residuals encounter a barrier, they have the potential to travel laterally along the barrier if sufficient gradient exists. If the MGP residual source remains present, the lateral migration will continue along the barrier through zones of increased porosity, and vertical migration will continue through cracks or other vertical conduits. Only by removing the source of the MGP residuals can the migration of residuals be stopped.

1.9 Land Use Considerations

Current land use is for industrial purposes. The Subject Area being considered in this remedial alternatives analysis is owned and will be owned in the future by Duke, although construction of the new bridge is anticipated to cross over the Subject Area and would impede Duke’s ability to remediate or address the area in the future.

Remedial Strategy and Objectives

Given the Subject Area is anticipated to be the future location of a new bridge, the main remedial strategy is to manage exposures on the Subject Area relating to future construction and to manage long-term liability associated with the source areas and groundwater impacts. Additionally, the remedial action will be conducted in a manner to adhere to the VAP regulations. To accomplish this, remedial action objectives (RAOs) have been developed to serve as goals of the remediation.

2.1 Remedial Action Objectives

RAOs serve to ensure the overall protection of human health and the environment, including meeting all applicable VAP standards. This RAA will focus only on soil remedies, with groundwater remedies following completion under a separate RAA. Threshold criteria for achieving RAOs include the following Ohio EPA VAP applicable standards:

- Ohio Administrative Code (OAC) 3745-300-08 – Generic numerical standards
- OAC 3745-300-09 – Property-specific risk assessment procedures
- OAC 3745-300-10 – Groundwater classification and response requirements
- OAC 1301:7-9-13(G)(3)(a) – Petroleum UST corrective action

The RAOs for the Subject Area include the following:

- Overall protection of human health and the environment for future industrial/commercial land use.
- Mitigate exposure that exceeds applicable soil standards for site workers, trespassers, and construction workers.
- Mitigate the future potential for chemicals of concern (COCs) in soil to leach into groundwater.
- Mitigate the potential for migration of NAPL.

The above RAOs are further evaluated and screened using the criteria in Section 4.1 of this report.

Groundwater will continue to be monitored and evaluated for site groundwater impacts.

2.2 Voluntary Action Program Remedial Considerations

Remediation of the Subject Area is required to meet the standards set under the VAP. It should be noted that under the VAP, remediation can include a combination of active remediation (e.g., source removal or containment) and passive remediation (e.g., institutional or engineering controls) designed to meet all applicable standards and to mitigate risks to current and future site users. A summary of applicable VAP standards is presented in Table 1. Remedial activities that may be required to meet applicable VAP standards include the following:

- Surface soil in unpaved areas poses an unacceptable risk to current site workers and does not meet applicable VAP standards. To meet applicable commercial/industrial site worker standards under the VAP, remediation of unpaved surface soil is required.
- Construction workers could come into contact with OLM and/or TLM observed in certain areas of the Subject Area within the upper 20 feet. Where OLM or TLM are present, VAP applicable standards for construction workers are not met. Therefore, to meet applicable VAP construction

worker standards, remediation is required in areas with OLM or TLM present at depths of less than 20 feet.

- OLM and/or TLM are present within the soil column and have migrated from source areas and may continue to migrate, both horizontally and vertically. Further, OLM and TLM represent continuing sources of dissolved constituents in groundwater that exceed applicable standards. The VAP requires that current and future onsite and offsite receptors be protected and that future degradation of unimpacted groundwater does not occur. Remediation of OLM and TLM impacts is required to meet applicable VAP standards.
- The Ohio EPA defines “free product” as “a separate liquid hydrocarbon phase that has a measurable thickness of greater than one one-hundredth of a foot” [Ohio Administrative Code (OAC) 3745-300-01(A)(53)]. Measurable free product (NAPL) was not observed in monitoring wells; however, it was observed in soil borings onsite. VAP regulations state that properties with free product exceed applicable unrestricted potable use standards (UPUS) for groundwater [OAC 3745-300-08(B)(2)(c)]. Further, the VAP generally requires that free product be removed, or mitigated to the extent practicable, prior to issuance of a no further action (NFA) [OAC 3745-300-07(I)(4)]. As such, NAPL remediation is required to meet applicable VAP standards.

Technology Screening

3.1 General Response Actions

General response actions (GRAs) describe the broad range of actions that individually, or in combination, will satisfy the RAOs and applicable VAP standards. GRAs may include no action, institutional controls, engineering controls, containment, removal, treatment, disposal, monitoring, or a combination of these activities. Similar to RAOs, GRAs are typically medium-specific; however, specific GRAs as applied to a given site may address multiple impacted media. The GRAs presented below may be applied to multiple media and pathways.

To meet the RAOs for the West End Property, the following potential GRAs have been identified for consideration in remedial alternatives:

- **No Action.** Used for baseline comparison. No remedial measures are implemented in the No Action GRA. This would not satisfy the RAOs, nor the applicable VAP standards.
- **Institutional Controls.** Institutional controls may involve administrative actions that restrict access to, contact with, or use of contaminated areas. Examples of common institutional controls include environmental covenants regarding land or groundwater use and a soil management plan establishing protocols for disturbing impacted media, among others. The VAP allows implementation of such controls to meet some or all applicable standards, as appropriate.
- **Engineering Controls.** Engineering controls involve physical measures to restrict access to, contact with, or use of contaminated areas. Examples of common engineering controls include fencing, soil, or paving covers, capping, engineered barriers, and vapor intrusion barriers, among others. The VAP allows implementation of such controls to meet some or all applicable standards, as appropriate. VAP-compliant operation and maintenance (O&M) requirements, after receipt of the NFA or Covenant Not to Sue (CNS), may be necessary.
- **Containment.** Containment actions include control, isolation, and encapsulation technologies (such as vertical barrier walls combined with engineering controls) that involve little or no treatment but provide protection of human health and the environment by reducing mobility of contaminants and/or eliminating pathways of exposure. The VAP allows containment remedies to meet applicable standards, although VAP-compliant O&M, after receipt of NFA or CNS, may be necessary.
- **Removal**. These actions are taken to physically remove the contaminated media. These actions reduce the volume, and in some cases, the mobility of contaminants. The VAP encourages removal actions by not requiring subsequent actions beyond the receipt of the NFA or CNS.
- **Treatment.** These are *in situ* or *ex situ* actions taken to treat groundwater, soil, or NAPL using physical, chemical, thermal, and/or biological processes to reduce the toxicity, mobility, and/or volume of contamination and the availability of these contaminants for contact, consumption, and environmental transport and uptake. The VAP encourages treatment actions, through use of consolidated site permits and by not requiring subsequent actions beyond the receipt of the NFA or CNS.

3.2 Technology Screening Criteria

Each GRA (except for No Action) can be addressed by various remedial technologies. Remedial technologies are defined as the general categories of remedies under a GRA, such as a barrier wall, cap, in situ stabilization, etc. Many technology types and process options are available to implement the

GRAs described in Section 3.1. Table 2 provides an initial list of technologies and process options considered. The purpose of initially considering a wide range of technologies and process options is to ensure that potentially applicable options for the site media and COCs are not overlooked. Technologies were screened using the criteria of effectiveness, implementability, and relative cost, which are further defined as follows:

- **Effectiveness** – Considers (1) the ability of a process option to address the estimated areas or volumes of contaminated media and meet the RAOs and applicable VAP standards; (2) the potential impacts to human health and the environment during the construction and implementation phases; and, (3) the reliability and demonstrated success that the process has shown with respect to the types of contamination and site conditions that will be encountered.
- **Implementability** – Implementability includes both the technical and administrative feasibility of implementing a technology process option. The administrative feasibility considers the administrative or institutional aspects of using a process option such as potential restrictions of future land use, the availability of treatment, storage, and disposal services, and the availability of the equipment and workers to implement the technology.
- **Relative Cost** – Relative cost refers to the net-present cost to implement each technology.

3.3 Initial Evaluation of Technologies

Potential remedial technologies for addressing the impacted soils at the Subject Area are identified by drawing on a variety of sources including previous experience, EPA guidance documents, references specifically developed for application to the VAP and other contaminated sites, vendor-supplied data, and standard engineering texts. To help streamline the evaluation and screening of potential remedial technologies, and in consideration of the previous evaluations conducted, the initial identification of technologies in this RAA has been focused to include only those technologies with a reasonable potential for achieving the remedial action objectives.

3.3.1 Institutional Controls

Institutional action technologies reduce potential exposure to site contaminants by way of indirect methods rather than by containment or treatment of the contaminants or contaminated media. These technologies do not meet applicable standards by themselves, however, they may be combined with other technologies to meet standards.

3.3.1.1 Deed Restrictions

Description: Deed restrictions place legal limitations on future West End Property use. These restrictions would prohibit future uses of the property that could result in increased exposure to site contaminants (e.g., residential development, underground utility installation). The established boundaries and approved deed restriction language would be recorded on the property deed(s) and filed in accordance with applicable laws in the office of the recorder of deeds, and/or any other offices as required by applicable law where land ownership and transfer records are maintained for real property. Deed restrictions can be implemented with consent of the West End Property owner, but their effectiveness is dependent upon continued monitoring and enforcement.

Initial Screening: Deed restrictions can be effective in reducing the potential for disturbance of contaminated media. By restricting and/or controlling future site uses and activities, exposure risks can be controlled. Based on its effectiveness, this technology is **retained** for further consideration.

3.3.1.2 Soil Management Plan

Description: The purpose of a soil management plan (SMP) is to provide the requirements needed to ensure that soil disturbed during any construction activities does not adversely impact human health or the environment and that soils are handled, stored, and disposed of, or reused onsite, in accordance with applicable laws, and regulations. In addition, all requirements for soil specified in the SMP will also apply to the use of fill material as well, since some disturbance of in-place soils may occur during those activities.

Initial Screening: Soil Management Plans can be effective in managing the risks regarding the potential disturbance of contaminated media. By managing the site activities, exposure risks can be controlled. Based on its effectiveness, this technology is **retained** for further consideration.

3.3.1.3 Monitoring

Description: Environmental monitoring can be defined as the systematic sampling of air, water, soil, and biota in order to observe and study the environment conditions at a particular site. Monitoring can be conducted for a number of purposes, including to establish environmental baselines, trends, to test environmental modeling processes, to educate the public about environmental conditions, to ensure compliance with environmental regulations or to conduct an inventory of natural resources.

Initial Screening: Monitoring can be effective in assessing changed conditions, thus assessing the risks regarding the potential exposure of contaminated media. By monitoring the environmental media, exposure risks can be controlled. Based on its effectiveness, this technology is **retained** for further consideration

3.3.2 Engineering Controls

Engineering actions reduce the potential for direct exposure to site contaminants and the potential for migration of contaminants by removing hazardous conditions or by placing a barrier between the individual and the hazard. These technologies do not meet applicable standards by themselves, however, they may be combined with other technologies to meet standards.

3.3.2.1 Site Fencing

Description: A security fence provides an easily implemented, low cost method for restricting pedestrian traffic across areas of concern, thus decreasing the potential for exposure to contaminants or damage to on-site storage or containment structures. Periodic inspection and maintenance is required to maintain the integrity of a fence.

Initial Screening: Fencing is an effective method of restricting site access. Access to the West End Property is currently restricted by a chain-link fence, but repairs to this fence and some additional fencing may be required to adequately restrict site access. Thus, this technology is **retained** for further consideration.

3.3.2.2 Durable Covers

Description: Durable covers may include existing pavements and building, new paving, hardscapes or building foundations, soil/aggregate covers, or multi-layered engineered covers.

Initial Screening: Durable covers provide an effective method of restricting exposure to site contaminants. Low-permeability covers, such as pavement, reduce infiltration thus reducing potential for mobilization of contaminants in soils above the water table. Thus, this technology is **retained** for further consideration.

3.3.3 Containment

Containment technologies reduce the potential for direct exposure to site contaminants and the potential for migration of contaminants by physically isolating the contaminated media or wastes.

3.3.3.1 Vertical Barrier Wall

Description: A low-permeability wall is installed by excavating a trench supported by bentonite slurry and backfilling with a low-permeability material (or other suitable construction methods such as sheet pile walls) to prevent lateral NAPL migration and intercept and/or redirect groundwater flow for containment, collection, or controlled discharge.

Initial Screening: A vertical barrier wall would reduce the potential for migration of site contaminants through groundwater movement. However, the site is bounded by the Ohio River on the south side with several pipeline discharges along the waterfront that would penetrate the wall and would require significant excavation through a thick rubble fill layer that could potentially compromise the long-term integrity of the wall as large debris could penetrate softer low-permeable materials. Therefore, a vertical barrier wall is **eliminated** from further consideration.

3.3.3.2 NAPL Recovery Trench

Description: A NAPL recovery trench is installed by excavating trench supported by slurry consisting of a biodegradable guar and backfilling with a permeable material (such as pea gravel or other suitable materials) to prevent lateral NAPL migration and intercept NAPL flow for containment, collection, or controlled discharge.

Initial Screening: A NAPL recovery trench would reduce the potential for migration of site contaminants through NAPL movement. However, the site is bounded by the Ohio River on the south side with several pipeline discharges along the waterfront that would penetrate the trench, thus allowing potential bypass through the collection trench. There are collars and sealants available for use, however, long-term settlement of the pipelines would provide an avenue for NAPL breakthrough. Therefore, a NAPL recovery trench is **eliminated** from further consideration.

3.3.3.3 NAPL Recovery Wells

Description: A NAPL recovery well network is installed by drilling a series of vertical wells that are screened along the interface where NAPL is known to exist. The wells are slotted to an adequate size opening to allow for NAPL collection and filter pack materials are tailored to NAPL collection to avoid clogging to prevent lateral NAPL migration and capture NAPL flow for containment, collection, or controlled discharge.

Initial Screening: A NAPL recovery well system would reduce the potential for migration of site contaminants through NAPL movement. However, placement of the wells is critical to the performance of the system. Due to the heterogeneity of the NAPL occurrence at the site, there is a high potential that pockets of NAPL may not be completely captured and such systems are typically operated over an extended period of time. Despite this, a NAPL recovery well system is **retained** for further consideration.

3.3.4 Removal

Removal technologies focus on the physical removal of contaminated media. Removal technologies are commonly required to facilitate treatment and/or disposal actions.

3.3.4.1 Excavation - Shallow

Description: Shallow excavation of contaminated soils would be required for subsequent treatment and/or disposal actions. Contaminated soils could be excavated using standard practices and equipment, although a large volume of material to be removed may necessitate staged excavation or other special handling requirements. The disturbance of contaminated materials during excavation activities could result in fugitive dusts and increased inhalation and direct contact exposure risks, although engineering controls (e.g., keeping excavation faces damp) and personal protective equipment (e.g., dust masks) can mitigate the magnitude and impacts of such fugitive emissions.

Initial Screening: Although excavation alone is not a remedial technology, it may be required in conjunction with containment, treatment and/or disposal actions. Therefore, shallow excavation will be **retained** for further consideration.

3.3.4.2 Excavation - Deep

Description: Deep Excavation of contaminated soils would be required for subsequent treatment and/or disposal actions. Deep excavation of contaminated soils would require extraordinary means to achieve the goal of removing all impacted soils. In addition, significant dewatering would be necessary to manage soil excavations required. The disturbance of contaminated materials during excavation activities could result in fugitive dusts and increased inhalation and direct contact exposure risks, although engineering controls (e.g., keeping excavation faces damp) and personal protective equipment (e.g., dust masks) can mitigate the magnitude and impacts of such fugitive emissions.

Initial Screening: Deep excavations would require use of deep sheet pile systems or secant pile wall systems to provide lateral support for side wall soils adjacent to the excavation area. Likewise, groundwater within the excavation would need to be removed to allow excavation to continue to the necessary depths. Extraordinary safety precautions would be necessary for both equipment and workers in and near the excavation area. Therefore, deep excavation will be **eliminated** from further consideration

3.3.4.3 Off-Site Landfill

Description: This technology refers to the transportation and disposal of contaminated soils at an approved off-site landfill. An off-site landfill could provide for the secure containment of contaminated materials, thereby restricting the migration of constituents into the environment. The risk of exposure to chemicals of concern in the Subject Area would be eliminated by removing the affected soils from them. Excavation would be required prior to the off-site disposal of materials, and approvals would be required for the transportation and disposal of wastes at a permitted facility. Dewatering may be required prior to the off-site transportation and/or disposal of contaminated soils.

Initial Screening: Based on the current understanding of the previous operations conducted at the Subject Area, the contaminated soils would not be considered to be RCRA-listed hazardous waste. Under current regulations regarding manufactured gas plant waste [40 CFR 261.24(a)], hazardous waste characterization testing such as the toxicity characteristic leaching procedure (TCLP) is not considered applicable. As a result, it is likely that materials excavated from the Subject Area could be disposed of off-site as non-hazardous waste in a non-hazardous waste landfill. Because this technology provides an effective and proven means of containing contaminated soils that are removed from the Subject Area, it is **retained** for further consideration.

3.3.5 Treatment

Treatment technologies reduce the toxicity, mobility, or volume of contaminated media or wastes, thus reducing the potential for exposure to contaminants. Removal and disposal technologies are commonly used in conjunction with treatment alternatives.

3.3.5.1 Biological Treatment

Description: Biological treatment, sometimes referred to as bioremediation, generally refers to the breakdown of organic constituents by microorganisms. The most common processes are based on aerobic or anaerobic bacteria, such as those processes utilized in the treatment of municipal wastewaters. In-situ, pump and treat, solid-phase, slurry-phase, and soil heaping biological treatment techniques have been used to remediate contaminated soils at other sites, but this technology has not proven effective to address OLM and TLM. Soil flushing and soil washing/chemical extraction technologies (discussed below) may utilize biological degradation processes to enhance the remediation efficiency.

Initial Screening: The effectiveness of biological treatment can be influenced by a number of parameters including pH, temperature, availability of nutrients, and the presence of heavy metals. The potential effectiveness of biological treatment at the site is limited by unfavorable hydrogeologic conditions, specific contaminants that are resistant to biological degradation. Because this technology is not expected to be effective for the site conditions and contaminants, it is **eliminated** from further consideration.

3.3.5.2 In-Situ Soil Flushing

Description: Soil flushing involves the in-situ injection or percolation of a flushing solution into an area of waste or soil requiring remediation. This process could be applicable to the removal of contaminants from the soils and sludges in the vadose zone. The flushing solution is used to increase the mobility of constituents as it passes through the affected media, and the mobilized contaminants and flushing solution are subsequently collected. Water is a potential flushing solution, although aqueous surfactant solutions, organic solvents and biological processes (e.g., solutions of microorganisms, nutrients, and oxygen) have also been used. Well points, subsurface drains, or another type of collection system typically must be installed in the subsurface to collect the constituent-laden solution. In-situ soil flushing has not been proven effective at addressing OLM and TLM. The recovered solution would require treatment. This technology is typically not appropriate for soils with low permeabilities.

Initial Screening: By introducing a potentially toxic flushing solution into the ground, and increasing the mobility of contaminants, this technology could contribute to ground water contamination if the contaminant-laden solution is not completely recovered. Based on the relatively fine-grained nature of many of the site soils, the effectiveness of this technology would be limited by inadequate distribution of the flushing solution and incomplete contaminant removal. This technology would require long-term system operation. Due to the unfavorable site conditions, potential contribution to ground water contamination, long implementation time, and high costs associated with solution recovery, treatment and disposal, this technology is **eliminated** from further consideration.

3.3.5.3 In-Situ Stabilization/Solidification - Shallow

Description: Shallow in-situ stabilization/solidification can be employed to immobilize organic and inorganic compounds in wet or dry media, using reagents to produce a stable mass. The most common stabilization/solidification methods include cement-based methods, silicate-based (pozzolanic) methods, thermoplastic methods and organic polymer methods. Waste materials and/or affected soils can be mixed in-place with various soil mixing systems. Typically, this technology does not destroy constituents, but incorporates them into a dense, homogeneous, low-porosity structure that reduces their mobility. Because a reagent must be added to the soil, the volume of treated material may be greater than the original material volume by as much as 20 to 100 percent. This process is readily available and can sometimes be implemented for a relatively low cost.

Initial Screening: Shallow augering stabilization/solidification processes are potentially effective for inorganic and organic constituents identified at the site, have been shown to be effective in the Cincinnati area to depths of 60 ft and the number and type of constituents present can readily be optimized into a solidification mix. The heterogeneity of material types (e.g., sands, clays, etc.) and constituent types and concentrations across the site would require adequate mixing, but sites with similar conditions (e.g., East End) have been shown to be successful in treating in-place contaminants effectively. Because of its effectiveness and long-term benefits, this technology is **retained** for further consideration.

3.3.5.4 In-situ Stabilization/Solidification - Deep

Description: Deep in-situ stabilization/solidification can be employed to immobilize organic and inorganic compounds in wet or dry media, using reagents to produce a stable mass in deeper portions of the soil profile at the site. Similar to shallow in-situ stabilization/solidification, the most common stabilization/solidification methods include cement-based methods, silicate-based (pozzolanic) methods, thermoplastic methods and organic polymer methods. This process is readily available, however, deeper penetration at the site would require treatment through clean soil layers to the required depth of 110 ft below ground surface. Treatment of these cleaner portions of the soil strata cannot be avoided due to the mixing requirements of the equipment and process.

Initial Screening: The available stabilization/solidification processes are potentially effective for inorganic and organic constituents identified at the site and the number and type of constituents present can readily be optimized into a solidification mix, however, the feasibility of reaching the deeper contaminated pockets of OLM result in treatment of clean soil areas which result in significant additional costs with very limited environmental benefit. Because of its limited effectiveness and significantly higher costs, this technology is **eliminated** from further consideration.

3.3.5.5 Thermal Desorption

Description: In general, thermal desorption employs a process in which soils, sludges and solids with organic contamination are heated to temperatures of 300 to 1,200°F (depending on the unit and the constituents of concern), driving off water and organic contaminants. The vapors are conveyed to a gas handling system where they are scrubbed to remove particulate solids. With some units, the scrubbed off-gases are cooled to condense water and the organics, and then passed through a carbon adsorption system to remove the remaining organics. In other units, the exhaust gases are sent to a secondary burner where the residual organics are oxidized, followed by quenching and acid gas scrubbing, if required. Several full-scale, mobile thermal desorption (or thermal separation) units are commercially available. Treated soils may be returned to their original location if the levels achieved meet the clean-up criteria. Treatment residuals such as the recovered organics and the spent carbon from the gas treatment step require further treatment before disposal. Organic contaminants that can be effectively treated by this system range from relatively high-boiling point, semi-volatile compounds to low-boiling point, volatile compounds. This technology is not effective for the removal of heavy metals or OLM and TLM. Treatability studies are typically required to determine the effectiveness of this technology.

Initial Screening: Based on engineering experience and discussions with various vendors of this technology, thermal desorption is potentially effective for the treatment of the contaminated soils at the site. Vendors have preliminarily indicated that, given the material types, constituents and concentrations present at the site, thermal desorption would be challenging. Fine-grained soils, as well as soils with relatively high moisture contents, may require additional processing prior to treatment. Recovered organics will require additional treatment and/or disposal. Because of its potential low level of effectiveness and relative cost comparison to other equally appropriate treatment technologies, thermal desorption is **eliminated** from further consideration.

3.4 Technology Screening Results Summary

The technology screening is presented in Table 2. The technology screening resulted in the selection of the following effective and implementable technologies for use in developing remedial alternatives to be included in the detailed alternatives evaluation presented in Section 4. The No Action alternative is also retained for baseline comparison, although it is not effective at meeting RAOs or applicable VAP standards.

- No Action
- Institutional Controls – Access and use restrictions in the form of deed restrictions or environmental covenants (also referred to as institutional controls), a soil management/risk mitigation plan, and long-term groundwater monitoring. These remedial actions will be included in all the alternatives, except No Action.

- Engineering Controls – Durable covers and fencing/signs are retained for consideration in remedial alternatives. Durable cover types may include buildings, paving, hardscapes, soil covers, and multi-layered engineered covers.
- Containment – Installation of NAPL monitoring and recovery wells at the Phase 3 Area was retained to address containment of NAPL by interception and removal.
- Removal – Excavation of OLM/TLM-impacted soils above the water table with offsite landfill disposal was retained as a viable technology for remediation of MGP residual source areas and is consistent with remedies implemented on adjacent parcels of the West End Property and at other MGP sites.
- Treatment – In situ stabilization (ISS) to depths ranging up to 55 feet was retained as an effective in situ treatment technology for OLM/TLM-impacted soil and is consistent with remedies implemented on an adjacent parcel of the West End Property and at other MGP sites.

Remedial Alternatives

This section presents the remedial alternatives for the Subject Area that were developed to address the RAOs, applicable VAP standards, and future land use considerations. Since there are many possible combinations of technologies that can be used in each alternative, the alternatives presented represent a range of performance and cost options that feasibility, effectiveness, and implementability can be evaluated to determine the best alternative. Once an alternative is selected, the specific technologies implemented may be changed during the remedial design, assuming the change does not substantially alter the intent of the original alternative.

4.1 Evaluation Criteria

The remedial alternatives were subjected to a detailed evaluation against a series of criteria, which were divided into two categories: threshold criteria and balancing criteria. Threshold criteria define the minimum level of acceptable performance for an alternative that must be met for an alternative to be considered eligible for selection, and include the following:

- **Overall Protection of Human Health and the Environment –** This criterion must be met for an alternative to be eligible for selection and is used to assess whether and how the alternative achieves and maintains protection of human health and the environment, including the attainment of the RAOs and applicable VAP standards. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with applicable VAP standards. The evaluation of this criterion is also based on the evaluation of how risks are eliminated, reduced, or controlled through treatment, engineering, or administrative controls. Overall protection of human health and the environment considers reduction in baseline risks and protection of human health and the environment from effects caused by implementing the remedial alternative. This criterion is intended to ensure that the selected remedial action alternative would:
  - Protect human health and the environment.
  - Attain media cleanup goals.
  - Control sources of releases.
- **Compliance with RAOs and Applicable VAP Standards –** Evaluates the degree to which an alternative meets the RAOs and applicable VAP standards identified in Section 2.2.

The balancing criteria are used to weigh trade-offs among the alternatives that meet the threshold criteria and include the following:

- **Long-term Effectiveness –** This criterion is an evaluation of the long-term effectiveness of an alternative in maintaining protection of human health and the environment after RAOs and applicable VAP standards have been met. It assesses whether the alternative provides reliable protection over time. This criterion addresses the following:
  - Magnitude of residual risk remaining from untreated media or treatment residuals after remedial activities
  - Adequacy and reliability of controls such as containment systems and institutional controls necessary to manage the untreated media or treatment residuals that remain onsite

The residual risk from treatment residuals or untreated media can be measured by chemical concentrations or material volume remaining at the site after the remedial action is complete.

- **Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment –** This criterion considers the degree to which alternatives employ removal or treatment technologies, as well as the anticipated performance of the removal or treatment technologies, by evaluating the amount of hazardous material removed or treated and the amount remaining onsite. The evaluation considers the magnitude of the reductions in toxicity, mobility, or chemical volume and the extent to which the treatment is irreversible as follows:
  - Amount of impacted media removed, destroyed, or treated
  - Degree of expected reduction in toxicity, mobility, and volume
  - Degree to which treatment is irreversible
  - Type and quantity of residual remaining after treatment
- **Short-term Effectiveness –** This criterion evaluates the effects of an alternative during the construction and implementation period of the remedial action before and until the time the RAOs are achieved and applicable VAP standards are addressed. This criterion addresses the following:
  - Time until RAOs are achieved and whether any short-term risks are promptly addressed
  - Protecting the community and site workers during remedial action by evaluating effects such as dust or other emissions, visual considerations, or transportation
  - Protecting workers during remedial action by evaluating reliability of health and safety protective measures during implementation
  - Protecting the environment during remedial action by evaluating potential effects on sensitive resources, including disturbance to cultural resources and wildlife.
- **Implementability –** This criterion evaluates the technical and administrative feasibility of alternatives and the availability of various services and materials required during its implementation. This criterion addresses the following:
  - Technical feasibility as the ability to construct, operate, and maintain the technology and the ability to monitor its effectiveness
  - Administrative feasibility as the ability to obtain approvals, rights-of-way, and permits
  - Availability of services and materials considering offsite treatment, storage capacity, disposal capacity, equipment, and specialists.
- **Community Acceptance –** This criterion evaluates the issues and concerns the public may have regarding each alternative. Impacts to or concerns of the community may include construction traffic and noise, odors and site emissions, hauling contaminated soils through the community to the disposal facility, and the degree to which human health or ecological risks are mitigated, among others.
- **Cost –** Cost encompasses all engineering, construction, and O&M costs incurred over the life of the project. The assessment, with respect to this criterion, is based on the qualitative cost for each alternative. These qualitative costs are reflected as “low, medium, or high”.

4.2 Description of Selected Alternatives

Remedial alternatives have been assembled to span the range of GRAs identified in Section 3, including no action, institutional and engineering controls, containment, removal, and treatment. A total of five alternatives for the Tower Area and six for the Phase 3 Area, including a No Action alternative, were developed.

The following alternatives were developed for the Tower Area and are described in the following subsections.

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls
- Alternative 3 – Engineering Controls
- Alternative 4 – Limited Soil Excavation, Institutional and Engineering Controls
- Alternative 5 – Soil Excavation, Institutional and Engineering Controls

The following alternatives were developed for the Phase 3 Area:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls
- Alternative 3 – Engineering Controls
- Alternative 4 – Limited OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls
- Alternative 5 – OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls
- Alternative 6 – OLM/TLM and Soil Excavation, ISS, Institutional and Engineering Controls

These remedial action alternatives are depicted in Figures 5 through 9 and are described in the following subsections.

4.2.1 Tower Area

Alternative 1 – No Action: The No Action alternative includes no remedial activities and will leave the site in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and will not provide any additional protection to human health and the environment over current conditions. Site conditions will not be monitored to document the natural attenuation or mobility of contamination. No action is required to implement the technology, and there is no associated cost. This alternative is retained as a baseline for comparison to other remedial alternatives, but would not meet applicable VAP standards or be protective of human health or the environment.

Alternative 2 – Institutional Controls: The Institutional Controls alternative includes implementing deed restrictions, a soil management/risk mitigation plan, and long-term groundwater monitoring plan. No remedial activities will occur and the site will remain in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and no additional protection to human health and the environment over current conditions will be provided. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

Alternative 3 – Engineering Controls: The Engineering Controls alternative includes implementing durable covers and fences to limit access to contaminants. No remedial activities will occur on site and contaminated media will remain in place with no treatment to prevent further contaminant migration. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

Alternative 4 – Limited Soil Excavation, Institutional and Engineering Controls: This alternative is intended to provide the minimum amount of remedial construction required to meet applicable VAP standards. Alternative 4 includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Limited excavation of contaminated soil in areas, as shown in Figure 5, to potential construction worker exposure depth of 20 feet, backfill with imported clean soil, and surface restoration with paving or gravel.

The components of this remedial alternative are illustrated in Figure 5.

Alternative 5 – Soil Excavation, Institutional and Engineering Controls: This alternative is similar to Alternative 4, but the difference is to completely remove contaminated material in order to meet applicable VAP standards. Alternative 5 includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of contaminated soil to potential construction worker exposure depth of 20 feet, backfill with imported clean soil, and surface restoration with paving or gravel.

The components of this remedial alternative are illustrated in Figure 6.

4.2.2 Phase 3 Area

Alternative 1 – No Action: The No Action alternative includes no remedial activities and will leave the site in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and will not provide any additional protection to human health and the environment over current conditions. Site conditions will not be monitored to document the natural attenuation or mobility of contamination. No action is required to implement the technology, and there is no associated cost. This alternative is retained as a baseline for comparison to other remedial alternatives, but would not meet applicable VAP standards or be protective of human health or the environment.

Alternative 2 – Institutional Controls: The Institutional Controls alternative includes implementing deed restrictions, a soil management/risk mitigation plan, and long-term groundwater monitoring plan. No remedial activities will occur and the site will remain in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and no additional protection to human health and the environment over current conditions will be provided. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

Alternative 3 – Engineering Controls: The Engineering Controls alternative includes implementing durable covers and fences to limit access to contaminants. No remedial activities will occur on site and contaminated media will remain in place with no treatment to prevent further contaminant migration. In and of itself, this alternative will not meet applicable VAP standards or be protective of human health or the environment.

Alternative 4 – Limited OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls: This alternative is intended to provide the minimum amount of remedial construction required to meet applicable VAP standards. Alternative 4 includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Limited excavation of OLM/TLM in soil in areas, shown in Figure 7, to potential construction worker exposure depth of 20 feet, backfill with imported clean soil, and surface restoration with paving or gravel.
- NAPL monitoring and recovery in up to 2 wells.

The components of Alternative 4 are illustrated in Figure 7.

Alternative 5– OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls: Alternative 5 is similar to Alternative 4, but is intended to remove more impacted soil and includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil to potential construction worker exposure depth of 20 feet, backfill with imported clean soil, and surface restoration with paving or gravel.
- NAPL monitoring and recovery in up to 2 wells.

The components of Alternative 5 are illustrated in Figure 8.

Alternative 6 – OLM/TLM and Soil Excavation, In Situ Stabilization, Institutional and Engineering Controls: This alternative includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil that is present in the upper 20 feet, followed by ISS of OLM in soil to a maximum depth of 55 feet. ISS swell placement will be limited to no shallower than 20 feet bgs. The upper 20 feet will be backfilled with imported clean soil and surface restoration with paving or gravel.

Alternative 6 considers the use of ISS to remediate NAPL impacts to a depth of 1 foot below the lowest depth at which OLM was identified in borings. Including ISS increases the maximum practical depth of remediation to 55 feet bgs at the deepest area. The alternative would be implemented with excavation to 20 feet bgs, then ISS ranging from 22 to 55 feet bgs, leaving room for ISS swell, and leaving the upper 20 feet (future construction worker zone) to be backfilled with clean soil.

The components of this Alternative 6 are illustrated in Figure 9.

4.3 Evaluation of Selected Alternatives

The results of the alternatives evaluation through comparison to the eight criteria is presented in Table 3 and discussed in the following subsections. A relative scoring is used in Table 3 to provide a relative ranking of the alternatives. The numeric scoring for the various criteria ranges from 0 through 4, with a score of 0 indicating the criteria is not met, and a score of 4 indicating the criteria is substantially achieved by the alternative. The scoring is not intended to identify the preferred alternative, rather, it provides a semi-quantitative means to illustrate and compare the relative benefits and short-comings of the various alternatives.

4.3.1 Tower Area

4.3.1.1 Alternative 1: No Action

The No Action alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative is the lowest cost to implement as there are no remedial actions implemented.

4.3.1.2 Alternative 2: Institutional Controls

The Institutional Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as there are no remedial actions implemented.

4.3.1.3 Alternative 3: Engineering Controls

The Engineering Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as the work only requires the use of durable covers and fencing/signs as remedial alternatives. Therefore, this alternative is not considered acceptable to meet all the VAP requirements.

4.3.1.4 Alternative 4: Limited Soil Excavation, Institutional and Engineering Controls

Excavation of the top 20 feet of contaminated soil in a limited area to mitigate the potential for construction workers to be exposed to impacted soils. RAOs and applicable VAP standards are met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

4.3.1.5 Alternative 5: Soil Excavation, Institutional and Engineering Controls

Excavation of the top 20 feet of contaminated soil across the Tower Area to mitigate the potential for construction workers to be exposed to impacted soils. RAOs and applicable VAP standards are met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

4.3.2 Phase 3 Area

4.3.2.1 Alternative 1: No Action

The No Action alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative is the lowest cost to implement as there are no remedial actions implemented.

4.3.2.2 Alternative 2: Institutional Controls

The Institutional Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as there are no remedial actions implemented.

4.3.2.3 Alternative 3: Engineering Controls

The Engineering Controls alternative does not satisfy any of the RAOs, nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative has a low cost to implement as the work only requires the use of durable covers and fencing/signs as remedial alternatives. Therefore, this alternative is not considered acceptable to meet all the VAP requirements.

4.3.2.4 Alternative 4: Limited OLM/TLM and Soil Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls

Excavation of the top 20 feet of a limited area of OLM/TLM-impacted soil mitigates the potential for construction workers to be exposed to impacted soils. However, a significant proportion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. NAPL monitoring and recovery wells will monitor NAPL migration offsite. RAOs and applicable VAP standards are partially met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

4.3.2.5 Alternative 5: OLM/TLM Excavation, NAPL Monitoring and Recovery, Institutional and Engineering Controls

Excavation of the top 20 feet of OLM/TLM-impacted soil across the Tower Area mitigates the potential for construction workers to be exposed to impacted soils. A significant proportion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater, but less than Alternative 4. NAPL monitoring and recovery wells will monitor NAPL migration offsite. RAOs and applicable VAP standards are partially met with this alternative. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

4.3.2.6 Alternative 6: OLM/TLM Excavation, In Situ Stabilization, NAPL Monitoring and Recovery, Institutional and Engineering Controls

Excavation of OLM/TLM-impacted soil in the upper 20 feet and stabilization of impacted soils to a maximum depth of 55 feet bgs will mitigate the potential for site and construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. Use of ISS to address OLM-impacted soils allows for a larger proportion of source material to be addressed as compared to excavation. OLM impacts will not remain. RAOs and applicable VAP standards are met with this alternative. This alternative is expected to result in a greater reduction in the potential for NAPL migration and COC leaching to groundwater. This alternative will have moderate impacts to site workers and the community during excavation and offsite hauling of impacted soils, and will require phased construction due to the excavation depth and active operations on and/or adjacent to the site.

References

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Tables

Table 1. VAP Applicable Standards and Remedial Considerations
Phase 3 and Tower Areas, West End Subject Areas
Cincinnati, Ohio

Applicable Standard[a]	Media	Pathway/Exposure Route	Receptor	Comment	Standard Currently Met?	Remediation Consideration[b]	Regulatory Reference
VAP GNS and GNS with MCA	Soil	Direct contact, ingestion, inhalation of particulates	Current and future land users	Must consider relevant standards related to current and reasonably anticipated future land use and potential receptors: Residential, Commercial, Industrial, and Construction Worker scenarios.	No	Remedy required for current and future users (active remediation and restrictions likely).	OAC 3745-300-08
POGWMPUS	Groundwater	Future groundwater users	Groundwater resources	This is an anti-degradation rule that protects currently unimpacted groundwater from future degradation.	No	Groundwater response requirements required as described in OAC 3745-300-10. Implementation of these actions may include removal of NAPL, active remediation, and institutional or engineering controls.	OAC 3745-300-10 (D)
Potable groundwater use standards	Groundwater	On-site potable and non-potable groundwater users	Current and future land users	Groundwater must meet VAP unrestricted potable use standards (UPUS).	No		OAC 3745-300-08
Non-potable groundwater use standards	Groundwater	On-site non-potable groundwater users	Current and future land users	Non-potable use of groundwater must pose no unacceptable risk to receptors.	No		OAC 3745-300-09
NAPL standard	Groundwater	Potable, non-potable groundwater users and ecological resources	Current and future land users and offsite users, Ohio River	VAP rules (3745-300-08(B)(2)) indicate that the presence of NAPL on groundwater is indicative of an UPUS exceedance.	No		OAC 3745-300-08
Groundwater response requirements	Groundwater	Contact with groundwater through applicable potable and non-potable groundwater uses	Current and future onsite and offsite groundwater receptors (e.g., Ohio River)	Response requirements are based on groundwater classification, source of the contaminants (onsite, offsite, or mixed) and presence of an urban setting designation. Additionally, groundwater exceeding UPUS that emanates into a surface water body adjoining the property triggers assessment of impacts to the surface water body.	No; to be determined.		OAC 3745-300-10
Surface water standards	Surface Water	Ecological resources	Current and future offsite users, Ohio River	Evaluated through sampling and analysis and (if needed) an ecological risk assessment, following VAP rules.	to be determined	These have not been evaluated.	OAC 3745-300-07
Pathways/exposure routes not considered by GNS or UPUS	Soil, Groundwater, and/or Soil Gas	All potentially complete pathways, if any, not considered in GNS or UPUS calculations	Current and future land users	Evaluated through sampling and analysis and (if needed) a human health risk assessment, following VAP rules, for current and reasonably anticipated future land uses.	No; to be determined.	These have not been evaluated.	OAC 3745-300-09

Notes:
GNS – VAP Single Chemical Generic Numerical Standard
MCA – Multiple Chemical Adjustment
POGWMPUS – Protection Of Groundwater Meeting Potable Uses Standards UPUS – Unrestricted Potable Use Standards
[a] Determination of applicable standards are discussed in OAC 3745-300-07 (F)(5).
[b] Remediation considerations are based on evaluation of the individual applicable standard noted for each consideration.

Table 2. Remedial Technology Screening
Phase 3 and Tower Areas, West End Subject Areas
Cincinnati, Ohio

General Response Action	Technology/Aproach	Description	Screening Criteria			Retained (Y/N)
			Effectiveness	Technical and Adminstrative Implementability	Relative Cost	
No Action	None	No remedial, investigative, or monitoring activity.	Not effective	No activity to implement.	No cost	Yes (for baseline comparison)
Institutional Controls	Deed Notice/Activity Use Limitations	Covenants, conditions, and restrictions, including groundwater use restrictions, excavation restrictions, and vapor intrusion mitigation evaluations for future structure construction or occupancy.	Effective to limit direct exposure to soil and groundwater through administrative mechanisms. May also use in combination with engineering controls for vapor intrusion risk in future structures. Supports addressing RAOs for reducing exposure risk to all media.	Readily implementable for soil and groundwater. However, requires added costs to future intrusive activities related to site operations due to need for additional environmental and health and safety controls related to soil management during construction.	Low	Yes
	Soil Management Plan	Implementation of a long-term risk management plan for future intrusive activities necessary to support ongoing facility operations, maintenance, and improvements.	Addresses RAO of mitigating potential future exposure to impacted soil in event of future site construction.	Soil management plans are common practice and considered highly implementable. However, requires added costs to future intrusive activities related to site operations due to need for additional environmental and health and safety controls related to soil management during construction.	Low	Yes
	Monitoring	Monitor wells over time to evaluate presence, concentrations, and migration of contaminants.	Not effective at reducing toxicity, mobility, or volume for any media; however, can monitor trends in concentrations and effectiveness of remedial actions. Does not directly contribute to meeting RAOs.	Readily implementable and necessarily a part of any alternative that does not consist of clean closure.	Low to Moderate	Yes
Engineering Controls	Site Fencing /Signs	Physical barrier placed around contaminated area to prevent access and alert to potential hazards.	Somewhat effective at mitigating direct exposures to soil if maintained and monitored. Supports addressing RAOs for reducing exposure risk to all media.	Implementable with local contractors and materials. Compatible with current facility use and security provisions already in place.	Low	Yes
	Durable Covers	Durable covers may include existing pavements and building, new paving, hardscapes or building foundations, soil/aggregate covers, or multi-layered engineered covers. Durable covers provide a horizontal barrier that prevents direct contact with the subsurface soils.	Effective means of addressing RAO of mitigating potential exposure to impacted site soils by industrial/commercial site workers and construction workers. Low-permeability covers, such as pavement, reduce infiltration thus reducing potential for mobilization of contaminants in soils above the water table.	Easily implementable - much of the study area is already paved. Must be used in combination with institutional controls for future development to effectively address soil exposure potential.	Low	Yes
Containment	Vertical Barrier Wall	Low-permeability wall installed by excavating trench supported by bentonite slurry and backfilling with a low-permeability material (or other suitable construction methods such as sheet pile walls) to prevent lateral NAPL migration and intercept and/or redirect groundwater flow for containment, collection, or controlled discharge.	Effective in mitigating future migration of NAPL and redirecting groundwater flow. Verification of wall continuity would be required during construction. The technical limitations to wall continuity would limit its effectiveness at this site.	Construction of a vertical barrier wall is implementable with local contractor and materials, and would have minimal impact on existing site structures and activities.The southern edge of the site adjacent to the riverbank contains fill and rubble, and there might be remnant MGP structures and piping that may pose challenges to constructing a continuous barrier wall.	High	No
	NAPL Recovery - Trench	Continuous permeable trench with NAPL collection piping and recovery risers to intercept DNAPL migration and allow for recovery by pumping.	Effective at intercepting NAPL in the outwash deposits; however, NAPL has also been observed in shallow fractured bedrock. The depth to bedrock would not be conducive to installing a trench into shallow bedrock. The technical limitations to trench continuity would limit its effectiveness at this site.	Construction of a recovery trench is implementable with local contractor and materials, and would have minimal impact on existing site structures and activities. The southern edge of the site adjacent to the riverbank contains fill and rubble, and there might be remnant MGP structures and piping that may pose challenges to constructing a NAPL recovery trench.	High	No
	NAPL Recovery - Wells (Passive or Active)	Extraction wells used to bail or pump separate phase DNAPL to the surface for collection and offsite disposal.	Effective at reducing volume of NAPL and intercepting potentially mobile NAPL in the vicinity of the well. Supports addressing NAPL migration RAO. Assessment of NAPL recoverability and zones of potential migration necessary for NAPL recovery wells to be effective and to determine whether active or passive recovery is appropriate.	Construction of the recovery wells is implementable with local contractor and materials, and would have minimal impact on existing site structures and activities. Recovery wells can be installed into bedrock in some areas of the site. The NAPL recovery program will likely require long term operation and maintenance.	Low to Moderate	Yes
Removal	Shallow Excavation	Excavation of soil and subsurface structures containing OLM and/or TLM above the water table. Excavated soils transported off-site for local permitted landfill disposal.	Effective at reducing toxicity, mobility, and volume of contaminated media. Supports addressing RAOs for all media.	Excavation is an easily implementable technology; however, the difficulty increases with increasing depth, excavation below the water table, and the presence of known and unknown subsurface obstructions that can hamper shoring system installation. Offsite disposal facilities are available to accept the excavated soil; however, daily facility acceptance capacity can reduce productivity. Excavation above the water table is known to be implementable at the site as a similar approach was previously used for remediation of a portion of the West Parcel; however, river flooding potential and gas plant operations restrictions can limit available construction periods.	Moderate to High	Yes
	Deep Excavation	Excavation of soil containing OLM below the water table. Excavated soils transported offsite for local permitted landfill disposal.	Effective at reducing toxicity, mobility, and volume of contaminated media. Supports addressing RAOs for all media.	Technically, deep excavations below the water table require significant shoring and dewatering operations that can result in adjacent ground movements and affects on nearby buildings and sensitive, critical infrastructure. River flooding potential and the depth of excavations represent a high safety hazard to site workers involved in the excavation and shoring operations.	High	No
	Off-Site Landfill	Transportation and disposal of contaminated soils at an approved off-site landfill.	Effective at reducing toxicity, mobility, and volume of contaminated media from the site. Provides secure containment of contaminated material preventing migration to the environment. Supports addressing RAOs for all media.	Permitting and approvals are need prior to implementation, and analytical testing will be required to determine an appropriate facility. Dewatering may be required prior to transport	Low to Moderate	Yes
Treatment	Biological Treatment	Utilize aerobic or anaerobic bacteria and/or other microorganisms to breakdown organic constituents.	Effectiveness is affected by pH, temperature, availability of nutrients, and the presence of heavy metals within	Easily implementable - utilizes existing and/or additional bacteria and microorganisms, and would have minimal impact on existing site structures and activities.Biological treatment will require long term operation and maintenance.	Low	No
	In-Situ Soil Flulshing	Injection or percolation of a flushing solution into the soil requiring remediation in order to increase the mobility of the contaminants. The mobilized contaminants and flushing solution are then collected.	Effectiveness is affected by the permeability of the soil and the type of flushing solution used.	Flushing is implementable with local contractor and materials, and would have minimal impact on existing site structures and activities. Recovery wells can be installed in surface soils. Recovery program will likely require long term operation and maintenance.	Moderate	No
	In-Situ Stabilization (ISS) via Auger Soil Mixing - Shallow	Mix OLM/TLM-impacted soil within the fill and clay layers to depths up to 60 feet in situ with solidifying reagents using large-diameter augers to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a solidified matrix with limited groundwater contact.	ISS has been effectively applied at another local MGP site in Cincinnati in similar fill and clay strata, and depths to 60 feet are generally achievable in similar soil types. ISS of OLM/TLM-impacted soils to the outwash layer is an effective means of eliminating the NAPL phase, mitigating the potential for OLM/TLM migration, and limiting leaching of contaminants to groundwater.	ISS is technically and administratively feasible and is a commonly used treatment technology on MGP sites. Qualified contractors and equipment are available regionally. Subsurface obstructions and structures could limit the suitability of this equipment in some areas or require prior removal of obstructions or structures.	Moderate	Yes
	ISS via Auger Soil Mixing - Deep	Mix OLM-impacted soil within the outwash layer to depths up to 110 feet in situ with solidifying reagents using large-diameter augers to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a solidified matrix with limited groundwater contact.	ISS is effective at treating sand and gravel soils containing OLM; however, it would be of limited effectiveness at this site due to technical limitations with implementation. The intermittent lenses of OLM in the outwash soils would require treatment of large zones of overlying clean soil to reach deep OLM lenses.	ISS of sand and gravel soils below 60 feet using soil mix augers is challenging and requires a site-specific drilling evaluation. Smaller-diameter augers and large amounts of drilling fluids (grout) are typically required to achieve these depths, resulting in greater than 50% spoils generation.	High	No
	In-Situ Thermal Treatment of OLM/TLM-Impacted Soil	An electrical current is passed between arrays of electrodes (electrical resistance heating) or heat is applied directly through wells and radiates outward (thermal conductive heating) for the purpose of heating the subsurface. The resultant heat reduces the viscosity of the DNAPL, reduces the residual saturation, and volatilizes contaminants. Groundwater and NAPL are recovered as treatment progresses.	For impacted soils above the water table, thermal treatment can destroy organic compounds as temperatures above the boiling point of water can be achieved. Below the water table, thermal treatment is limited to the boiling point of water and enhanced recovery of NAPL, but nonvolatile organic compound destruction is limited. Proximity to the river and high water table fluctuation potential may limit the effectiveness of this technology and may present increased risks for contaminant migration to the river during treatment.	Thermal treatment is not considered to be implementable at this site as heating of large volumes of varying fill and clay soils over extended periods presents potential settlement issues and associated risks to structures and active gas piping.	High	No

Table 3. Detailed Alternatives Analysis
Tower Area, West End Subject Area
Cincinnati, Ohio

Criteria		Alternative 1			Alternative 2			Alternative 3			Alternative 4			Alternative 5		
		No Action			Institutional Controls			Engineering Controls			Limited Soil Excavation, Institutional and Engineering Controls			Soil Excavation, Institutional and Engineering Controls		
THRESHOLD CRITERIA																
Overall Protection of Human Health and the Environment		●Does not mitigate potential risks to human health ●Does not mitigate potential risks to the environment		0	●Reduces risk to human health by indirectly controlling exposure to impacted media onsite ●Does not mitigate potential risks to the environment		1	●Reduces risk to human health by controlling exposure to impacted media onsite by means of a barrier ●Does not mitigate potential risks to the environment		1	● Reduces risk to human health by controlling exposure to impacted media onsite. Contaminated soil is eliminated from the construction worker zone		3	● Reduces risk to human health by controlling exposure to impacted media onsite. Contaminated soil is eliminated from the construction worker zone		4
Compliance with RAOs and Applicable VAP Standards	●Mitigate exposure that exceeds applicable standards for site workers, trespassers, and construction workers	●Does not mitigate potential exposure for for site workers, trespassers, or construction workers to soil exceeding VAP Commercial/Industrial and Construction/Excavation Worker GNSs	0	0	●Does not mitigate potential exposure for for site workers, trespassers, or construction workers to soil exceeding VAP Commercial/Industrial and Construction/Excavation Worker GNSs	0	0	●Does not mitigate potential exposure for for site workers, trespassers, or construction workers to soil exceeding VAP Commercial/Industrial GNS	0	0	●Risk of exposure is mitigated through the excavation of impacted soils within the potential construction worker zone (top 20')	4	4	●Risk of exposure is mitigated through the excavation of impacted soils within the potential construction worker zone (top 20')	4	4
	●Mitigate the potential for future vapor intrusion risks	●Does not include any measures to mitigate potential future vapor intrusion risks	0		●Does not include any measures to mitigate potential future vapor intrusion risks	0		●Does not include any measures to mitigate potential future vapor intrusion risks	0		●Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation of potential source material within the top 20'	4		●Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation of potential source material within the top 20'	4	
	●Mitigate potential for COCs in soil to leach into groundwater	●Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0		●Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0		●Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0		●Reduces potential for COCs to leach to groundwater through the excavation of source material in the top 20'. No identified contamination deeper than 20' on site.	4		●Reduces potential for COCs to leach to groundwater through the excavation of source material in the top 20'. No identified contamination deeper than 20' on site.	4	
	●Mitigate NAPL impacts to groundwater and the potential for migration of NAPL offsite	●Does not reduce, treat, or contain NAPL	0		●Does not reduce, treat, or contain NAPL	0		●Does not reduce, treat, or contain NAPL	0		●Reduces potential for NAPL migration by removing source material in the top 20'. No identified NAPL below 20' identified on site.	4		●Reduces potential for NAPL migration by removing source material in the top 20'. No identified NAPL below 20' identified on site.	4	
	●Mitigate potential future exposure to impacted groundwater for potable and non-potable uses	●Alternative does not include any measures to mitigate potential future exposure to groundwater	0		●Alternative does not include any measures to mitigate potential future exposure to groundwater	0		●Alternative does not include any measures to mitigate potential future exposure to groundwater	0		●Through the implementation of institutional controls, including deed restrictions, this alternative substantially mitigates potential future exposure to impacted groundwater	4		●Through the implementation of institutional controls, including deed restrictions, this alternative substantially mitigates potential future exposure to impacted groundwater	4	
THRESHOLD CRITERIA COMBINED SCORE				0			1			1			7			8
BALANCING CRITERIA																
Long-term Effectiveness		●This alternative is ineffective at reducing long-term risks to human health and the environment since no remedial actions are implemented		0	●This alternative is ineffective at reducing long-term risks to human health and the environment since no remedial actions are implemented		0	●This alternative is ineffective at reducing long-term risks to human health and the environment since no remedial actions are implemented		0	●Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls and source removal. Long-term source reduction and leaching to groundwater is mitigated with this alternative.		4	●Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls and source removal. Long-term source reduction and leaching to groundwater is mitigated with this alternative.		4
Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment		●No removal or treatment is accomplished in this alternative	0	0	●No removal or treatment is accomplished in this alternative	0	0	●No removal or treatment is accomplished in this alternative	0	0	●Limited removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative.	4	3.5	●Removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative.	4	4
		% of Impacted Soil Treated/Removed: 0%	0		% of Impacted Soil Treated/Removed: 0%	0		% of Impacted Soil Treated/Removed: 0%	0		% of Impacted Soil Treated/Removed: 100%	3		% of Impacted Soil Treated/Removed: 100%	4	
Short-term Effectiveness		● No impacts to community, workers, or environment associated with implementation of this alternative, however, current site risks are not addressed with this alternative as no remedial actions are implemented.		1	● No impacts to community, workers, or environment associated with implementation of this alternative, however, current site risks are not addressed with this alternative as no remedial actions are implemented.		1	● No impacts to community, workers, or environment associated with implementation of this alternative, however, current site risks are not addressed with this alternative as no remedial actions are implemented.		1	● Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers during excavation of impacted soils. This alternative requires offsite transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the site is addressed through groundwater use restrictions.		2	● Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers during excavation of impacted soils. This alternative requires offsite transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the site is addressed through groundwater use restrictions.		2
Implementability		● No action is highly implementable		4	● Institutional Controls are highly implementable		4	● Engineering Controls are highly implementable		4	● Placement of durable covers and establishment of institutional controls are highly implementable activities. Excavation to 20 feet is above the water table; however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative.		3	● Placement of durable covers and establishment of institutional controls are highly implementable activities. Excavation to 20 feet is above the water table; however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative.		3
Community Acceptance		●This alternative presents no construction impacts to the community, however long-term site risks are not addressed		0	●This alternative presents no construction impacts to the community, however long-term site risks are not addressed		1	●This alternative presents no construction impacts to the community, however long-term site risks are not addressed		1	●This alternative presents minor construction impacts to the community during contaminated soil excavation, however, long-term site risks are reduced by the extent of source removal accomplished.		3	●This alternative presents minor construction impacts to the community during contaminated soil excavation, however, long-term site risks are reduced by the extent of source removal accomplished.		3
Cost		Low		4	Low		3	Low		3	Medium		2	High		1
BALANCING CRITERIA COMBINED SCORE				9			9			9			17.5			17
TOTAL SCORE				9			10			10			24.5			25

Scoring Key:

4	Alternative substantially meets/addresses criterion
3	Alternative mostly meets/addresses criterion
2	Alternative partially meets/addresses criterion
1	Alternative slightly meets/addresses criterion
0	Alternative does not meet/address criterion

Note: See Section 4.1 for description of evaluation criteria.

Table 3. Detailed Alternatives Analysis
Phase 3, West End Gas Subject Area
Cincinnati, Ohio

Criteria		Alternative 1: No Action			Alternative 2: Institutional Controls		
THRESHOLD CRITERIA							
Overall Protection of Human Health and the Environment		●Does not mitigate potential risks to human health ●Does not mitigate potential risks to the environment		0	●Reduces risk to human health by indirectly controlling exposure to impacted media onsite ●Does not mitigate potential risks to the environment		1
Compliance with RAOs and Applicable VAP Standards	●Mitigate exposure that exceeds applicable standards for site workers, trespassers, and construction workers	●Does not mitigate potential exposure for for site workers, trespassers, or construction workers to soil exceeding VAP Commercial/Industrial and Construction/Excavation GNSs	0	0	●Does not mitigate potential exposure for for site workers, trespassers, or construction workers to soil exceeding VAP Commercial/Industrial and Construction Excavation GNSs	0	0
	●Mitigate the potential for future vapor intrusion risks	●Does not include any measures to mitigate potential future vapor intrusion risks	0		●Does not include any measures to mitigate potential future vapor intrusion risks	0	
	●Mitigate potential for COCs in soil to leach into groundwater	●Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0		●Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0	
	●Mitigate NAPL impacts to groundwater and the potential for migration of NAPL offsite	●Does not reduce, treat, or contain NAPL	0		●Does not reduce, treat, or contain NAPL	0	
	●Mitigate potential future exposure to impacted groundwater for potable and non-potable uses	●Alternative does not include any measures to mitigate potential future exposure to groundwater	0		●Alternative does not include any measures to mitigate potential future exposure to groundwater	0	
THRESHOLD CRITERIA COMBINED SCORE				0			1
BALANCING CRITERIA							
Long-term Effectiveness		●This alternative is ineffective at reducing long-term risks to human health and the environment since no remedial actions are implemented		0	●This alternative is ineffective at reducing long-term risks to human health and the environment since no remedial actions are implemented		0
Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment		●No removal or treatment is accomplished in this alternative	0	0	●No removal or treatment is accomplished in this alternative	0	0
		% of OLM/TLM Impacted Soil Treated/Removed: 0%	0		% of Impacted Soil Treated/Removed: 0%	0	
Short-term Effectiveness		● No impacts to community, workers, or environment associated with implementation of this alternative, however, current site risks are not addressed with this alternative as no remedial actions are implemented.		1	● No impacts to community, workers, or environment associated with implementation of this alternative, however, current site risks are not addressed with this alternative as no remedial actions are implemented.		1
Implementability		● No action is highly implementable		4	● Institutional Controls are highly implementable		4
Community Acceptance		●This alternative presents no construction impacts to the community, however long-term site risks are not addressed		0	●This alternative presents no construction impacts to the community, however long-term site risks are not addressed		1
Cost		Low		4	Low		3
BALANCING CRITERIA COMBINED SCORE				9			9
TOTAL SCORE				9			10

Criteria		Alternative 3: Engineering Controls			Alternative 4: Limited OLM/TLM Excavation, NAPL Monitoring and Recovery, and Institutional and Engineering Controls		
THRESHOLD CRITERIA							
Overall Protection of Human Health and the Environment		●Reduces risk to human health by controlling exposure to impacted media onsite by means of a barrier ●Does not mitigate potential risks to the environment		1	● Reduces risk to human health by controlling exposure to impacted media onsite. OLM/TLM is eliminated from the construction worker zone ●OLM/TLM impacted soil will remain below the construction worker zone, resulting in continued long-term leaching to groundwater. Migration of residual NAPL is mitigated through installation of NAPL recovery wells. This alternative partially addresses protection of the environment.		2
Compliance with RAOs and Applicable VAP Standards	●Mitigate exposure that exceeds applicable standards for site workers, trespassers, and construction workers	●Does not mitigate potential exposure for for site workers, trespassers, or construction workers to soil exceeding VAP Commercial/Industrial GNS	0	0	●Risk of exposure is mitigated through the excavation of impacted soils within the potential construction worker zone (top 20')	4	3.2
	●Mitigate the potential for future vapor intrusion risks	●Does not include any measures to mitigate potential future vapor intrusion risks	0		●Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation of potential source material within the top 20'	4	
	●Mitigate potential for COCs in soil to leach into groundwater	●Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0		●Slightly reduces potential for COCs to leach to groundwater through the excavation of source material in the top 20'; however, residual contamination deeper than 20' may continue to act as a source of potential groundwater contamination	2	
	●Mitigate NAPL impacts to groundwater and the potential for migration of NAPL offsite	●Does not reduce, treat, or contain NAPL	0		●Slightly reduces potential for NAPL migration by removing source material in the top 20', potentially mobile NAPL below 20' will remain	2	
	●Mitigate potential future exposure to impacted groundwater for potable and non-potable uses	●Alternative does not include any measures to mitigate potential future exposure to groundwater	0		●Through the implementation of institutional controls, including deed restrictions, this alternative substantially mitigates potential future exposure to impacted groundwater	4	
THRESHOLD CRITERIA COMBINED SCORE				1			5.2
BALANCING CRITERIA							
Long-term Effectiveness		●This alternative is ineffective at reducing long-term risks to human health and the environment since no remedial actions are implemented		0	●Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls and partial source removal. NAPL recovery is implemented to remove mobile NAPL where feasible. Long-term source reduction and leaching to groundwater is partially mitigated with this alternative.		2
Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment		●No removal or treatment is accomplished in this alternative	0	0	●Removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative. NAPL recovery is implemented to remove mobile NAPL where feasible. While this alternative removes OLM/TLM impacted soils within the top 20', OLM/TLM impacted soil will remain as a source of leaching to groundwater.	2	2
		% of Impacted Soil Treated/Removed: 0%	0		% of OLM/TLM Impacted Soil Removed: 31%	2	
Short-term Effectiveness		● No impacts to community, workers, or environment associated with implementation of this alternative, however, current site risks are not addressed with this alternative as no remedial actions are implemented.		1	● Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers during excavation of impacted soils. This alternative requires offsite transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the Site is addressed through groundwater use restrictions.		2
Implementability		● Engineering Controls are highly implementable		4	● Placement of durable covers and establishment of institutional controls are highly implementable activities. Active or passive NAPL recovery from wells is an established technology for MGP sites. Excavation to 20 feet is above the water table; however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative.		3
Community Acceptance		●This alternative presents no construction impacts to the community, however long-term site risks are not addressed		1	●This alternative presents minor construction impacts to the community during contaminated soil excavation, however, long-term site risks are only partially addressed.		2
Cost		Low		3	Medium		2
BALANCING CRITERIA COMBINED SCORE				9			13
TOTAL SCORE				10			18.2

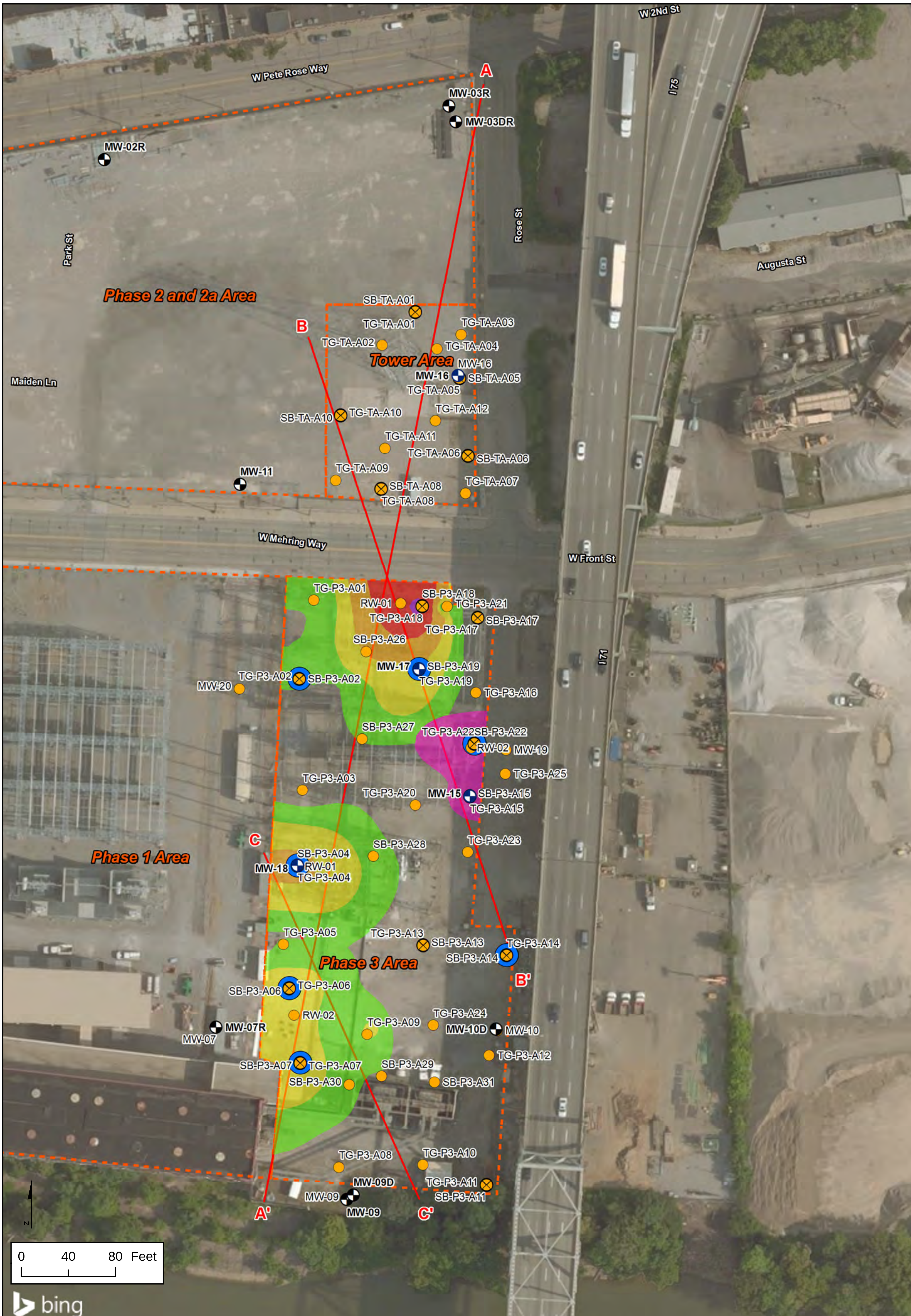
Criteria		Alternative 5: OLM/TLM Excavation, NAPL Monitoring and Recovery, and Institutional and Engineering Controls			Alternative 6: OLM/TLM Excavation, In-Situ Solidification, and Institutional and Engineering Controls		
THRESHOLD CRITERIA							
Overall Protection of Human Health and the Environment		● Reduces risk to human health by controlling exposure to impacted media onsite. OLM/TLM is eliminated from the construction worker zone ●OLM/TLM impacted soil will remain below the construction worker zone, resulting in continued long-term leaching to groundwater. Migration of residual NAPL is mitigated through installation of NAPL recovery wells. This alternative partially addresses protection of the environment.		3	● Reduces risk to human health by controlling exposure to impacted media onsite. OLM/TLM is eliminated from the construction worker zone, and is treated to a depth of 60'. ●NAPL impacts will be substantially mitigated through excavation and treatment; however, there is a potential for impacted soil to remain below the treatment zone, resulting in potential long-term leaching to groundwater. This alternative substantially addresses protection of the environment.		4
Compliance with RAOs and Applicable VAP Standards	●Mitigate exposure that exceeds applicable standards for site workers, trespassers, and construction workers	●Risk of exposure is mitigated through the excavation of impacted soils within the potential construction worker zone (top 20')	4	3.4	●Risk of exposure is mitigated through the excavation of impacted soils within the potential construction worker zone (top 20') and through stabilization of deeper soils.	4	3.8
	●Mitigate the potential for future vapor intrusion risks	●Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation of potential source material within the top 20'	4		●Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation and solidification of potential source material within the top 60'	4	
	●Mitigate potential for COCs in soil to leach into groundwater	●Slightly reduces potential for COCs to leach to groundwater through the excavation of source material in the top 20'; however, residual contamination deeper than 20' may continue to act as a source of potential groundwater contamination	3		●Reduces potential for COCs to leach to groundwater through the excavation and solidification of source material in the top 60'; however, residual contamination deeper than 60' may continue to act as a source of potential groundwater contamination	4	
	●Mitigate NAPL impacts to groundwater and the potential for migration of NAPL offsite	●Slightly reduces potential for NAPL migration by removing source material in the top 20', potentially mobile NAPL below 20' will remain	2		●Reduces potential for NAPL migration by removing source material in the top 20' and stabilizing source material to a depth of 60'. Potentially mobile NAPL below 60' will remain	3	
	●Mitigate potential future exposure to impacted groundwater for potable and non-potable uses	●Through the implementation of institutional controls, including deed restrictions, this alternative substantially mitigates potential future exposure to impacted groundwater	4		●Through the implementation of institutional controls, including deed restrictions, this alternative mitigates potential future exposure to impacted groundwater	4	
THRESHOLD CRITERIA COMBINED SCORE				6.4			7.8
BALANCING CRITERIA							
Long-term Effectiveness		●Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls and partial source removal. NAPL recovery is implemented to remove mobile NAPL where feasible. Long-term source reduction and leaching to groundwater is partially mitigated with this alternative.		2	●Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls, partial source removal, and ISS. Long-term source reduction and leaching to groundwater is substantially mitigated with this alternative.		4
Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment		●Removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative. NAPL recovery is implemented to remove mobile NAPL where feasible. While this alternative removes OLM/TLM impacted soils within the top 20', OLM/TLM impacted soil will remain as a source of leaching to groundwater.	2	2	●Removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative. A significant volume of OLM/TLM-impacted soil in the upper 20' is removed, and OLM/TLM-impacted soil is treated to a depth of 60' in this alternative.	4	4
		% of OLM/TLM Impacted Soil Removed: 32%	2		% of OLM/TLM Impacted Soil Treated/Removed: 100%	4	
Short-term Effectiveness		● Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers during excavation of impacted soils. This alternative requires offsite transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the site is addressed through groundwater use restrictions.		2	● Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers and construction workers during excavation and solidification of impacted soils. This alternative requires offsite transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the site is addressed through groundwater use restrictions.		2
Implementability		● Placement of durable covers and establishment of institutional controls are highly implementable activities. Active or passive NAPL recovery from wells is an established technology for MGP sites. Excavation to 20 feet is above the water table; however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative.		3	● Placement of durable covers and establishment of institutional controls are highly implementable activities. Excavation to 20 feet is above the water table, however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative. ISS of OLM/TLM in soil between 20-60 ft bgs is achievable with standard ISS equipment, however, river flooding potential between November and May may limit allowable construction timeframes for ISS within a 20-ft excavation.		2
Community Acceptance		●This alternative presents minor construction impacts to the community during contaminated soil excavation, however, long-term site risks are only partially addressed.		2	●This alternative presents moderate construction impacts to the community during contaminated soil excavation and hauling, however, long-term site risks are reduced by the extent of source removal accomplished.		2
Cost		High		1	High		1
BALANCING CRITERIA COMBINED SCORE				12			15
TOTAL SCORE				18.4			22.8

Scoring Key:

4	Alternative substantially meets/addresses criterion
3	Alternative mostly meets/addresses criterion
2	Alternative paritally meets/addresses criterion
1	Alternative slightly meets/addresses criterion
0	Alternative does not meet/address criterion

Note: See Section 4.1 for description of evaluation criteria.

Figures



LEGEND

Monitoring Well	Cross Section Transect Line
Confirmatory Boring with Monitoring Well installed in 2017	Project Boundary
TarGOST Sample Location	Observation of non-aqueous phase liquid (NAPL) in soil boring
Confirmatory Boring	

"Petro-Like" TarGOST Response Value (%RE)
- 20
- 50

"Tar-Like" TarGOST Response Value (%RE)
- 20
- 50
- 100
- 200
- 500

FIGURE 1
Planview Contours of TarGOST Response Data
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio

Notes:
1. %RE - percent of the reference emitter
2. Contours illustrate the maximum value at any depth for each grid node following 3D interpolation of TarGOST response data .

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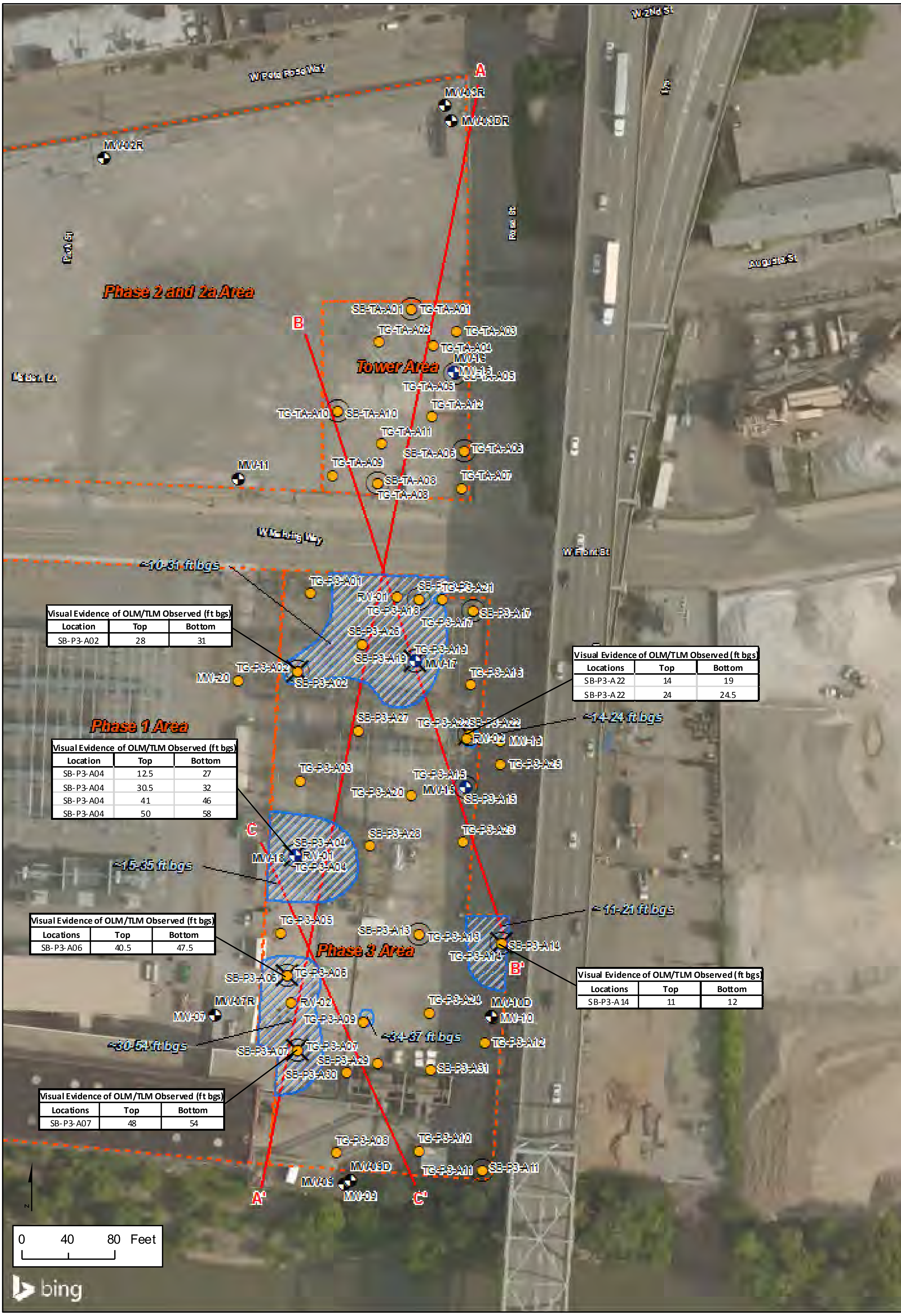

Visual Evidence of OLM/TLM Observed (ft bgs)		
Location	Top	Bottom
SB-P3-A02	28	31

Visual Evidence of OLM/TLM Observed (ft bgs)		
Locations	Top	Bottom
SB-P3-A22	14	19
SB-P3-A22	24	24.5

Visual Evidence of OLM/TLM Observed (ft bgs)		
Location	Top	Bottom
SB-P3-A04	12.5	27
SB-P3-A04	30.5	32
SB-P3-A04	41	46
SB-P3-A04	50	58

Visual Evidence of OLM/TLM Observed (ft bgs)		
Locations	Top	Bottom
SB-P3-A06	40.5	47.5

Visual Evidence of OLM/TLM Observed (ft bgs)		
Locations	Top	Bottom
SB-P3-A14	11	12

Visual Evidence of OLM/TLM Observed (ft bgs)		
Locations	Top	Bottom
SB-P3-A07	48	54

LEGEND
- Monitoring Well
- Confirmatory Boring with Monitoring Well installed in 2017
- TarGOST Sample Location
- Cross Section Transect Line
- Approximate Extents of OLM/TLM in Subsurface
- Project Boundary
- Confirmatory Boring
- Observation of non-aqueous phase liquid (NAPL) in soil boring

Note:
Approximate extents of oil-like material and tar-like material (OLM/TLM) based on multiple lines of evidence including the distribution of TarGOST laser-induced fluorescence responses, visual observations of non-aqueous phase liquid (NAPL) or free-product in soil, and laboratory analytical data

FIGURE 2
Depth, Thickness, and Interpreted Distribution of OLM/TLM
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio

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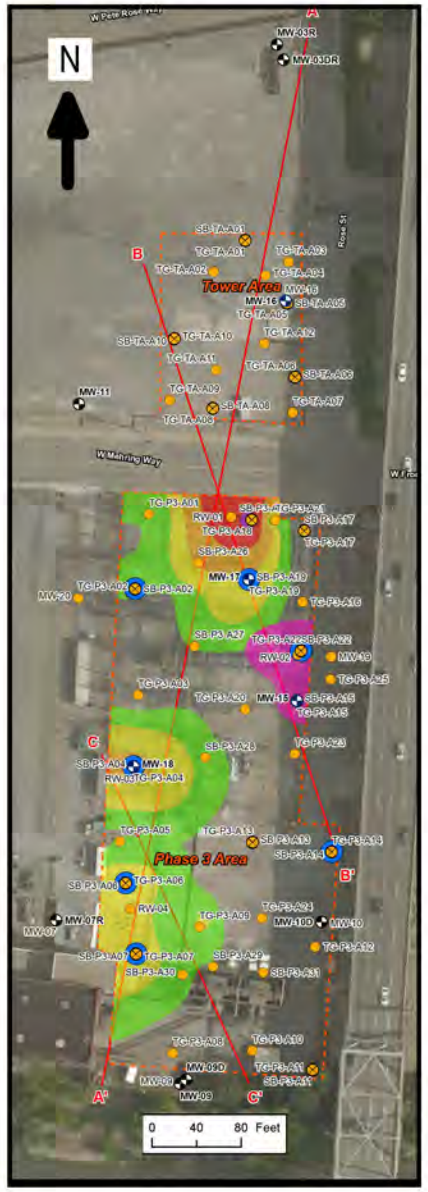
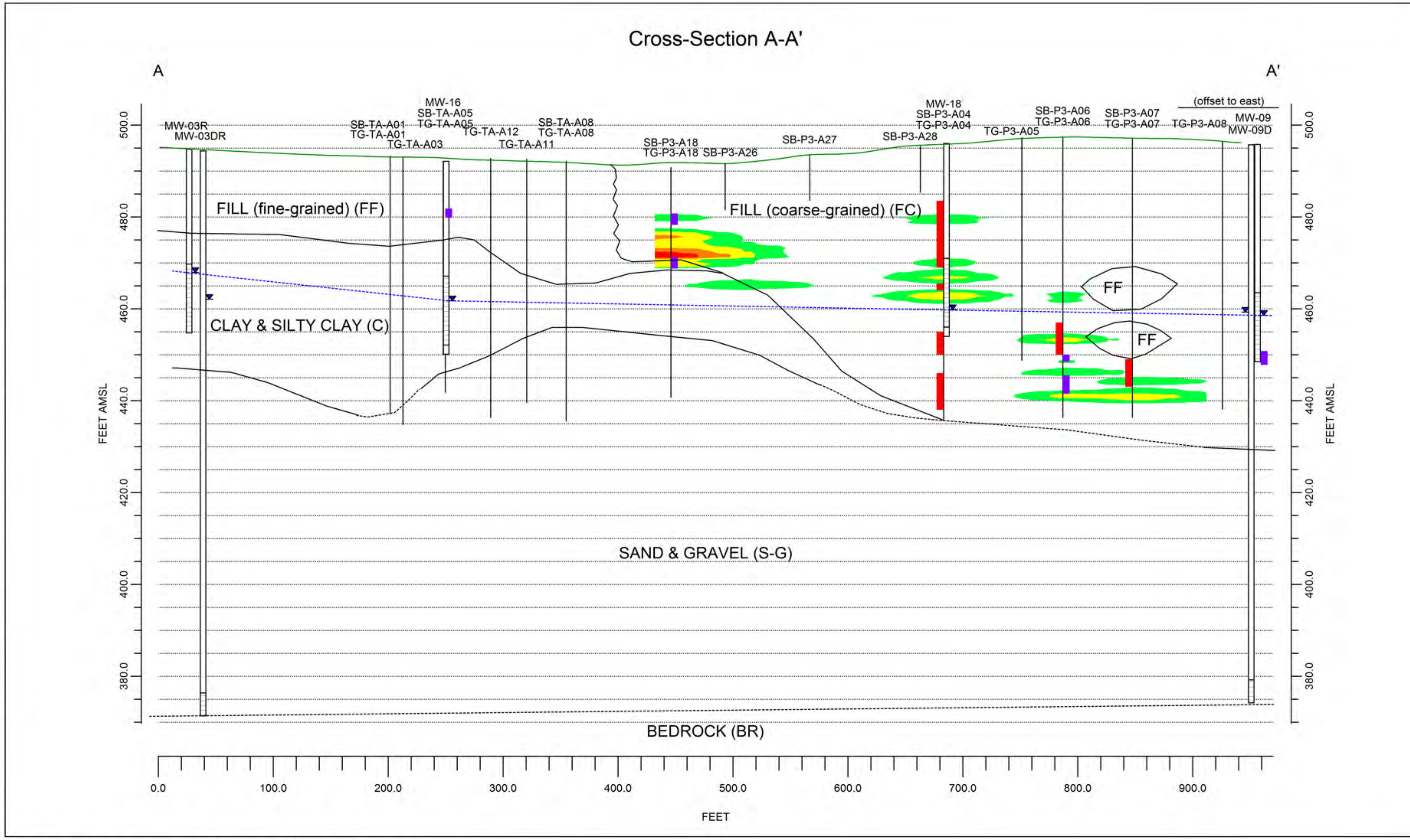




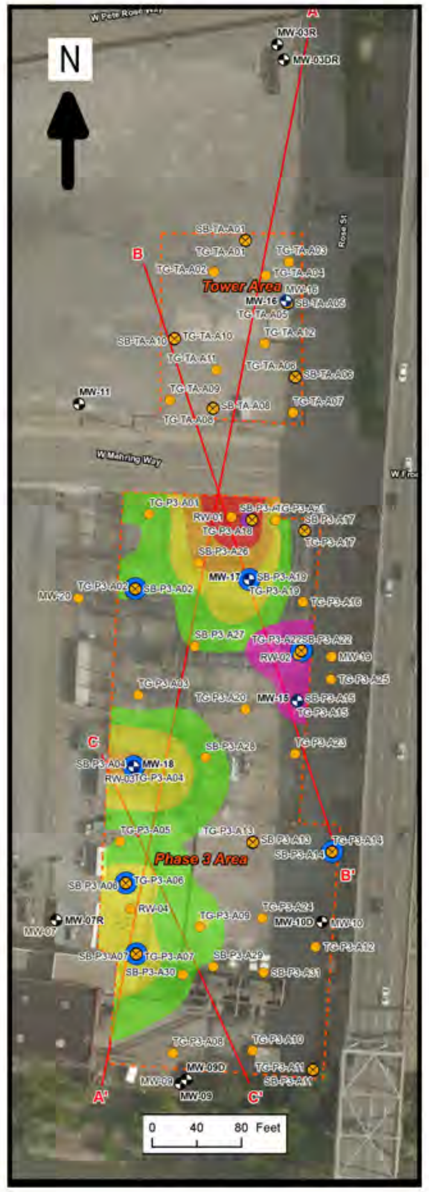
TarGOST ("Tar-Like") Response (%RE)	
(green)	20 - 50
(yellow)	50 - 100
(orange)	100 - 200
(red)	200 - 500

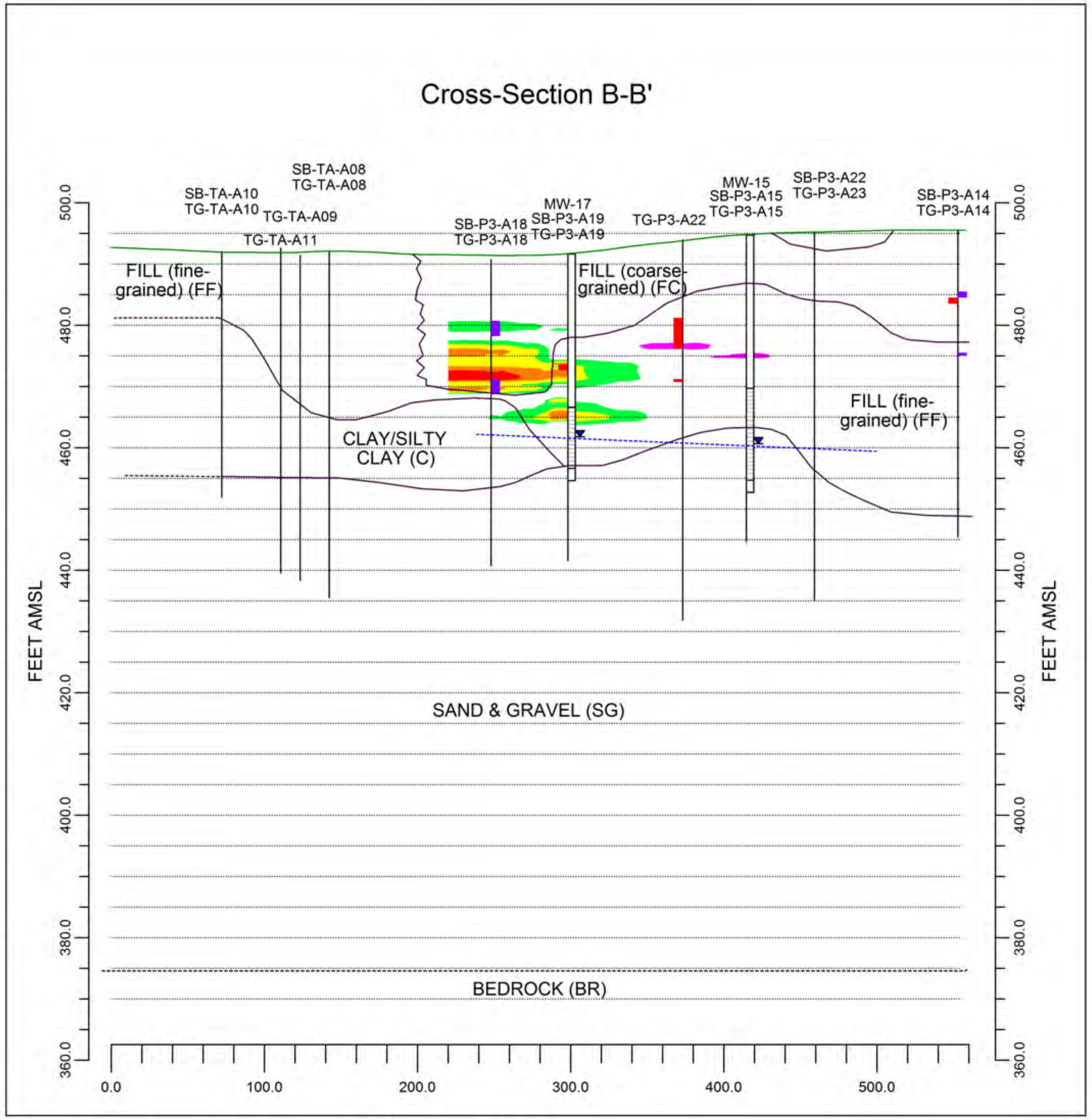
- Measured Groundwater Elevation (March 27, 2017)
- Approximate Water Table (based on March 27, 2017 measurements)
- Interval of Observed Sheen in Soil Boring
- Interval of Observed OLM in Soil Boring (sheen may also have been observed)

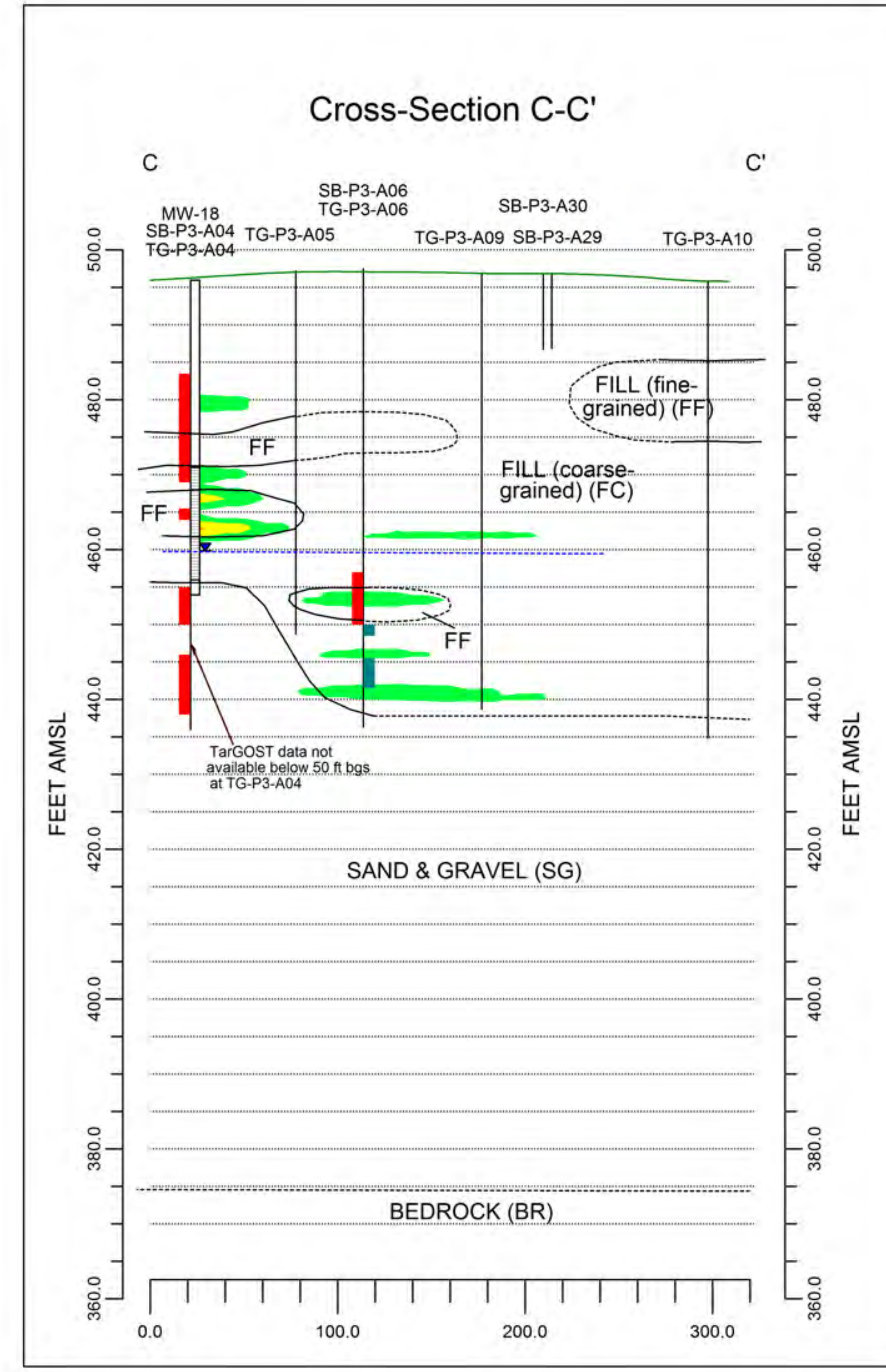
General Stratigraphy:
FF - fine-grained fill; consists primarily of clays, silts, sands, some gravel
FC - coarse-grained fill; consists primarily of concrete, brick, wood, slag, cinders, with sand, silt, gravel, some clay
C - clay/silty clay
SG - sand & gravel: varying intervals of sandy gravel and gravelly sand
BR - bedrock

FIGURE 3
Cross-Section A-A'
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio

ch2m







TarGOST ("Tar-Like") Response (%RE)

- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500

TarGOST ("Petro-Like") Response (%RE)

- 20 - 50
- 50 - 100

- Measured Groundwater Elevation (March 27, 2017)
- Approximate Water Table (based on March 27, 2017 measurements)
- Interval of Observed Sheen in Soil Boring
- Interval of Observed OLM in Soil Boring (sheen may have also been observed)

General Stratigraphy:
FF - fine-grained fill; consists primarily of clays, silts, sands, some gravel
FC - coarse-grained fill; consists primarily of concrete, brick, wood, slag, cinders, with sand, silt, gravel, some clay
C - clay/silty clay
SG - sand & gravel: varying intervals of sandy gravel and gravelly sand
BR - bedrock

FIGURE 4
Cross-Sections B-B' and C-C'
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio

ch2m.

LEGEND

Excavation (top 20')

Project Boundary

N

0 15 30 Feet

FIGURE 5

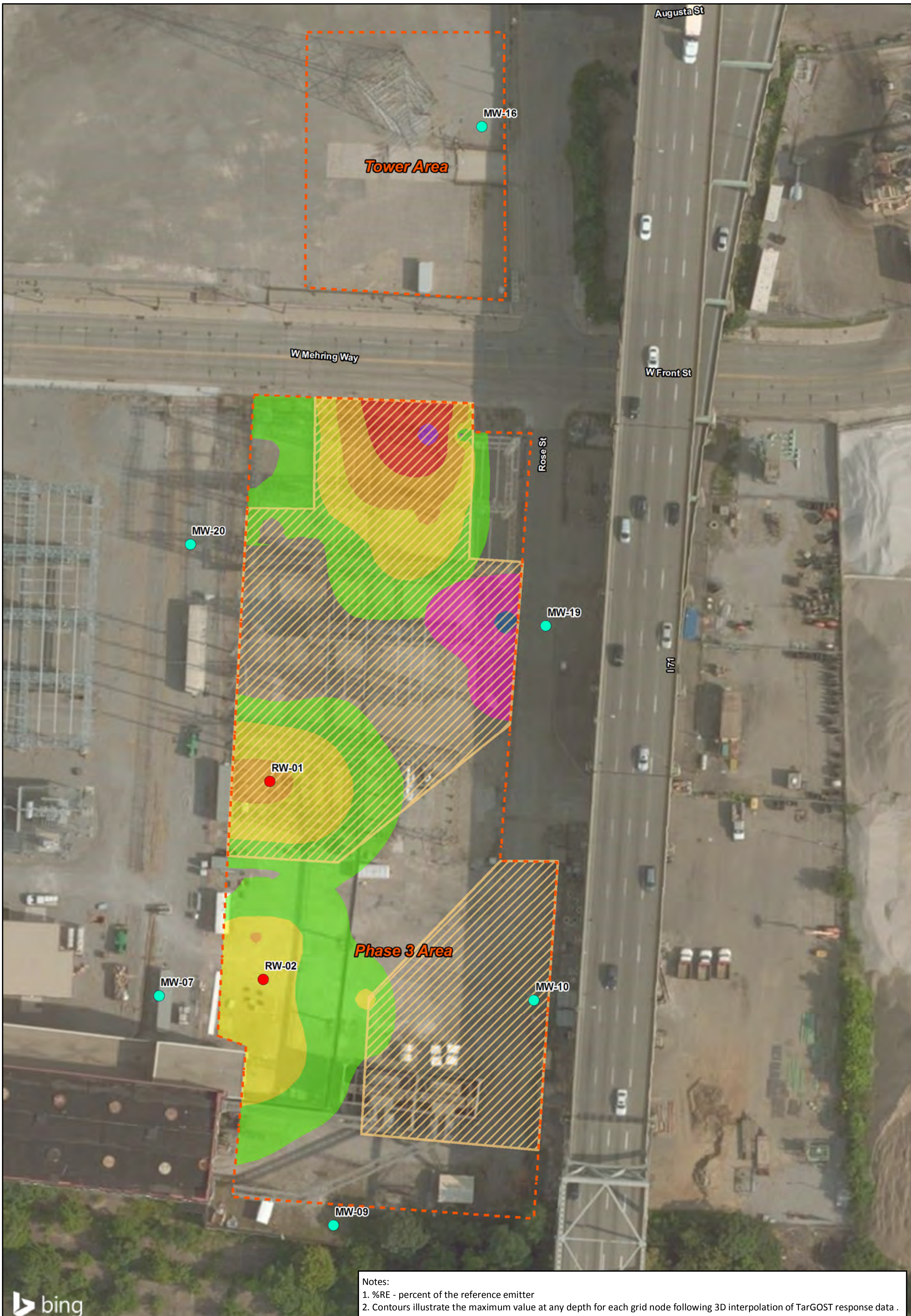
Alternative 4 - Tower Area

Remedial Alternatives Analysis Report

Duke West End Site - Phase 3 and Tower Areas

Cincinnati, Ohio

FIGURE 6
Alternative 5 - Tower Area
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio



Notes:
1. %RE - percent of the reference emitter
2. Contours illustrate the maximum value at any depth for each grid node following 3D interpolation of TarGOST response data .

LEGEND

- Groundwater Monitoring Well
- NAPR Recovery Well
- Excavation (top 20')
- Project Boundary

"Petro-Like" TarGOST Response Value (%RE)

- 20
- 50

"Tar-Like" TarGOST Response Value (%RE)

- 20
- 50
- 100
- 200
- 500

N

0 30 60 Feet

FIGURE 7
Alternative 4 - Phase 3 Area
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio

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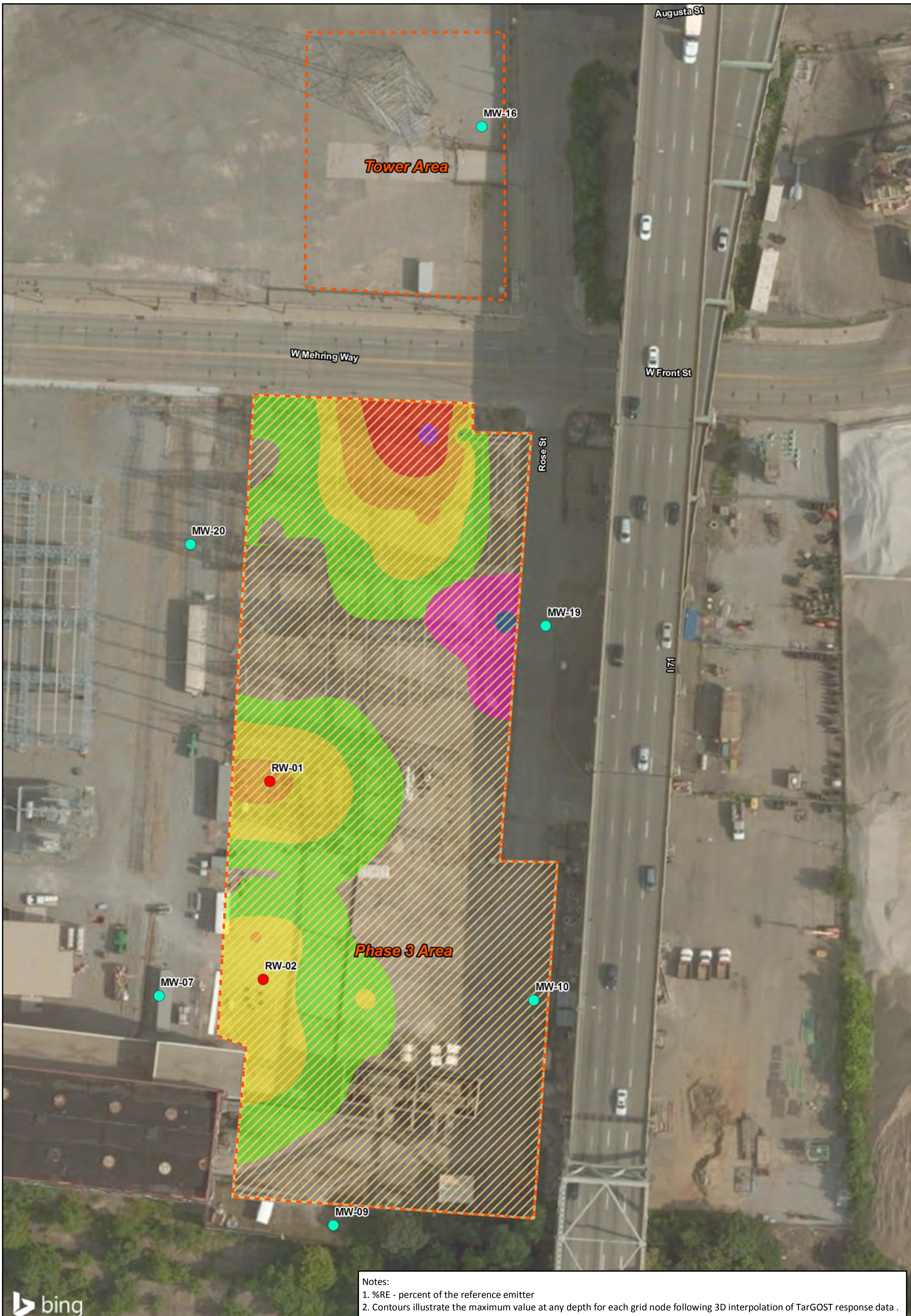

Notes:
1. %RE - percent of the reference emitter
2. Contours illustrate the maximum value at any depth for each grid node following 3D interpolation of TarGOST response data .

LEGEND

- Groundwater Monitoring Well
- NAPR Recovery Well
- Excavation (top 20')
- Project Boundary

"Petro-Like" TarGOST Response Value (%RE)

- 20
- 50

"Tar-Like" TarGOST Response Value (%RE)

- 20
- 50
- 100
- 200
- 500

N

0 30 60 Feet

FIGURE 8
Alternative 5 - Phase 3 Area
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio

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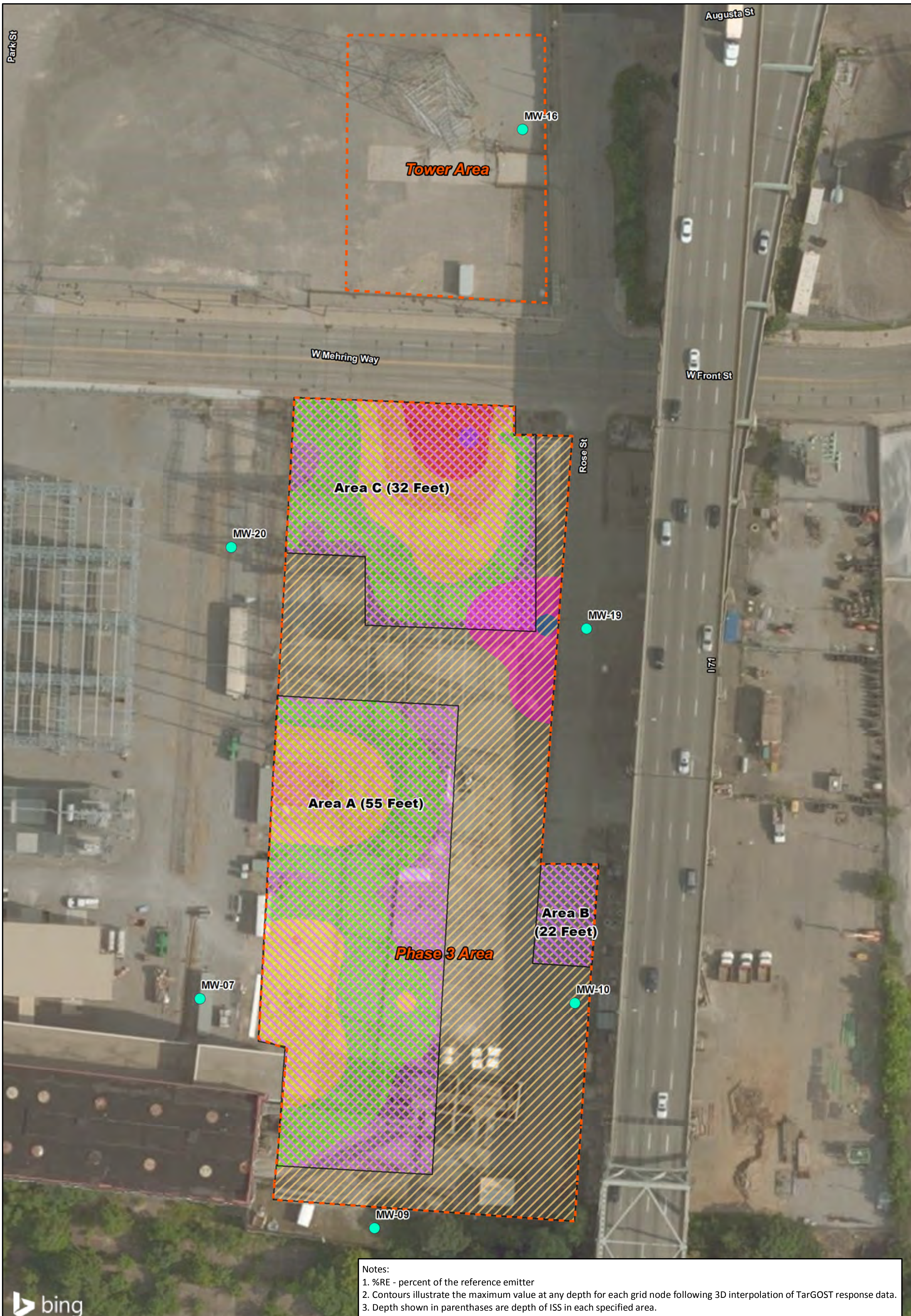

Notes:
1. %RE - percent of the reference emitter
2. Contours illustrate the maximum value at any depth for each grid node following 3D interpolation of TarGOST response data.
3. Depth shown in parenthases are depth of ISS in each specified area.

LEGEND

- Groundwater Monitoring Well
- ISS (Depth of Excavation)
- Excavation (top 20')
- Project Boundary

"Petro-Like" TarGOST Response Value (%RE)

- 20
- 50

"Tar-Like" TarGOST Response Value (%RE)

- 20
- 50
- 100
- 200
- 500

N

0 30 60 Feet

FIGURE 9
Alternative 6 - Phase 3 Area
Remedial Alternatives Analysis Report
Duke West End Site - Phase 3 and Tower Areas
Cincinnati, Ohio

ch2m

HALEY & ALDRICH

REPORT ON

FOCUSED REMEDIAL ALTERNATIVES ANALYSIS
EAST END GAS WORKS
CINCINNATI, OHIO

BY

Haley & Aldrich, Inc.
Portland, Maine

FOR

Duke Energy Ohio, Inc.

File No. 40674-005
7 August 2014

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1. INTRODUCTION

Haley &Aldrich, Inc. (Haley & Aldrich) has prepared this Focused Remedial Alternatives Analysis for the East End Gas Works site (EEGW, the Site) located in Cincinnati, Ohio. This alternatives analysis has been prepared for Duke Energy Ohio (Duke) to support decision-making on remedial actions to address impacted soil, oil-like material (OLM) and tar-like material (TLM) impacts in soil, and non-aqueous-phase liquid (NAPL), to the extent currently feasible, on upland portions of the Site.

The Site, which is owned by Duke, is comprised of three areas, referred to (for environmental cleanup purposes only) as the West Parcel, the Middle Parcel and the East Parcel, as shown on Figure 1. Also included in this alternatives analysis is a portion of the Riverside Drive property owned by Duke that is located east of the former Munson Street and west of the West Parcel. This area is shown on Figure 1 and is hereinafter referred to as "the area west of the West Parcel". This area has been impacted by the EEGW former MGP operations.

The West Parcel and the East Parcel have undergone prior remediation of OLM/TLM and other impacts in soils to a depth of 40 feet (ft) or shallower (i.e., above the water table and the normal water level in the adjacent Ohio River to the south). These completed remedial activities are documented in the West Parcel Remediation Construction Summary Report (Haley & Aldrich, 2012) and the East Parcel Remediation Construction Summary Report (Haley & Aldrich, 2013).

The following locations and impacted media are considered in this alternatives analysis:

- Soil and OLM and/or TLM impacts west of the West Parcel impacted by the former MGP operations, between the former Munson Street right of way and the West Parcel;
- Remaining deep OLM impacts, below previous remediation depths, that remain on the West Parcel;
- Soil and OLM and/or TLM impacts on the Middle Parcel;
- Remaining OLM and/or TLM impacts on the west portion of the East Parcel outside the limits of prior remediation on the East Parcel; and
- NAPL observed in monitoring wells on the West and Middle Parcels.

Groundwater impacts will only be addressed at this time through recovery and/or isolation of NAPL, and to the extent that the soil and/or OLM/TLM remedies aid in the remediation of, or isolation of impacted groundwater. Additional direct remediation of impacted groundwater will not be considered until source area remediation is completed and further analysis of on-site groundwater impacts and the potential for off-site downgradient impacts is investigated.

1.1 Previous Site Investigations

Site characterization activities for those areas considered in this remedial alternatives analysis have been documented in several prior reports as follows:

- 2007 Site Investigation Summary Report, East End Gas Works Site (AMEC, 2008);
- Letter Report, East End Gas Works Site Investigation (AMEC, 2008);
- Phase II Property Assessment Report, East End Gas Works, West Parcel (Burns & McDonnell, 2009);

- Phase II Property Assessment Report, East End Gas Works, East Parcel (Burns & McDonnell, 2009);
- West Parcel Remediation Construction Summary Report (Haley & Aldrich, 2012);
- East Parcel Remediation Construction Summary Report (Haley & Aldrich, 2013);
- Subsurface Investigation Results, Former DCI Property/Keck Street Property (Haley & Aldrich, 2011); and
- Phase II Property Assessment Report, East End Gas Works, Middle Parcel (Haley & Aldrich, 2014).

The following paragraphs present a brief summary of Site conditions pertinent to the evaluation of remedial alternatives. More in-depth information can be found in the reports referenced above.

1.2 Site History and Current Site Use

The Site is generally located at 2801 Riverside Drive (f/k/a Eastern Ave) in Cincinnati, Ohio. The Site appears to have been first developed as a residential and/or agricultural property before 1875. In 1875, Cincinnati Gas Light and Coke Company purchased the property. Construction of the gas works began before 1882 and was completed after 1884. The facility operated as a manufactured gas plant (MGP) until 1909, when the arrival of natural gas halted MGP production. MGP production began again around 1925 and continued until the 1960s. Gas was manufactured using the coal carbonization, water gasification, carbureted water gas and oil gas processes. Other historical operations at the Site have been associated with the Cincinnati Consolidated Street Railway Company, B.P. Clapp Ammonia Company, Pendleton Car House and Generation Station, and John Frederick Manufacturer of Yellow Prussiate of Potash.

Currently, the Middle Parcel is used as a synthetic natural gas peaking plant in which propane, air, and natural gas are mixed to make synthetic natural gas. This facility is also a city gate station, which is a point where gas coming into the state of Ohio is measured and regulated (custody transfer point from Kentucky to Ohio). Also, the Site is used as a district headquarters for field operations (Construction & Maintenance [C&M]) – pipeline repair, installation, maintenance, etc. Propane is stored at the Site in a cavern. The East Parcel is currently used for gas pipelines. The West Parcel contains a vaporizer facility that was constructed in 2012.

The area west of the West Parcel appears to have been first developed as residential properties before 1891 and continued with this use until 2006, while the remaining portions of the Riverside Drive property was utilized for commercial purposes (see Phase I report for the Riverside Drive property). A portion of the area west of the West Parcel appears to have been part of the former MGP. In April 2006 and April 2007, two building permits were issued by the Cincinnati Building Department for excavation and filling activities by the then owner, DCI Properties, on the Riverside Drive property (including the area west of the West Parcel). The filling activity included the placement of 80,000 cubic yards of fill across the property. Duke acquired this property from DCI Properties in 2011. This property is not currently being used for any active gas operations, but has been utilized since its purchase by Duke for staging equipment for gas pipeline projects.

1.3 Site Setting

Topographically, the Site is fairly level except for a steep slope along the southern portion of the Site, leading to the Ohio River. Site elevations range from approximately 508 ft above mean sea level (MSL) near Riverside Drive to approximately 456 ft MSL, near the river (Newark Kentucky-Ohio Topographic Quadrangle), which corresponds to the normal Ohio River pool elevation in this area.

The main portion of the Site is located approximately 35 to 50 ft above the river's normal pool elevation. Based on investigative activities, bedrock beneath the Site slopes toward the south. Along Riverside Drive, gray limestone bedrock is encountered at depths of between 20 and 25 ft below ground surface (bgs), while nearer to the river, in the southern portion of the Site, bedrock is encountered at depths from 65 ft to more than 100 ft bgs.

Unconsolidated material beneath the Site consists of fill material ranging from 10 to 15 ft thick near Riverside Drive to more than 30 ft thick near the center/southern portions of the Site. The fill material generally consists of sand and gravel, with varying amounts of ash, slag, cobbles, boulders, and demolition debris from former MGP facilities and crushed limestone spoils from construction of the propane cavern. A confining clay layer is encountered below the fill material and ranges in thickness from 20 to 40 ft. Along the northern portion of the Site, this clay layer is deposited directly on bedrock, whereas in the southern portion of the Site, this clay layer overlies an outwash layer. Alternating layers of sand and gravel outwash deposits underlie the clay layer and range in thickness of 30 to greater than 70 ft along the southern portion of the Site.

Based on surface topography, surface water flow at the Site is to the south, toward the Ohio River. Also based on topography, river flow direction, and groundwater monitoring events conducted at the Site, shallow groundwater flow is expected to be to the south-southwest. The water table generally occurs within the lower portion of the clay or the upper portion of the outwash sand and gravel, with water levels influenced by the Ohio River stage.

The Middle Parcel contains numerous active and abandoned buried utilities, including gas lines, water lines, brick storm sewer lines, concrete storm sewer lines, sanitary sewer lines, drain lines, electrical lines, and critical infrastructure for storage and transfer of gas and water.

1.4 Potential Source Areas

Historical MGP operations performed on the West, Middle, and East Parcels resulted in releases of MGP-related residuals including ash, slag, purifier materials, and coal tar. The coal tar impacts include sheens and staining of soils, the presence of OLM and/or TLM in soils, and the presence of a dense NAPL (DNAPL) in some monitoring wells. The known MGP structures containing MGP residuals on the East and West Parcels were removed during prior remedial actions on these parcels, however, some impacts remain outside of or beneath previously remediated areas.

Potential remaining sources of environmental impacts identified in soil and groundwater at the Site are located on the Middle Parcel and include the eastern and western gas holders, eastern and western tar wells, former tar separators, tar settling tanks, a former retort building, and former coal storage areas, as well as the former purifiers in the eastern, northern, and western buildings. Based on the results of Middle Parcel investigation activities completed, potential sources of MGP residuals include the following gas production and storage features:

- Former Retort House: Retort buildings typically contained retorts (or ovens) that were used to generate coal gas by heating the coal under anoxic conditions to volatilize gaseous constituents of coal. The main byproducts of these procedures were coke, ash, cinders, and clinkers.

- Tar Separators and Tar Settling Tanks: Tar separators and settling tanks (presumably below grade) were located adjacent to the retort building. Presumably, tar produced by the MGP processes was separated in this area. Tar treatment areas may be a source of OLM, TLM and NAPL, and other MGP residuals, observed on Site.

- Tar Wells: Tar wells, two currently identified, were located east of the eastern holder and west of the western holder. In general, tar wells were below-grade structures, used to store tar for later sale or use. Tar storage areas may be a source of OLM, TLM and NAPL, and other MGP residuals, observed on Site.

- Eastern and Western Gas Holders: Two historical gas holders have been identified at the Middle Parcel. These structures were used to store gas, after manufacture, at fairly low pressures prior to distribution. Such structures may be a source of NAPL and other MGP residuals.

- Coke/Coal Storage: Coal and coke storage areas were on Site throughout the operational life of the MGP. Coal and coke fragments were observed in various borings and test pits installed during investigation activities. Such structures may be a source of MGP residuals observed at the Site.

- Purifiers: After manufacture, the gas was purified (noxious materials were removed) utilizing purification media, which resulted in a purifier waste, often a source of cyanide contamination. Based on experience with other MGP sites, this waste was often disposed in pits or on the ground at some distance from purifier buildings, due to its noxious odor. While no obvious purifier waste disposal areas have been identified at the Site, this material, intermixed with Site fill and demolition debris may be a source of COCs in soil.

1.5 Distribution of MGP Residuals

MGP residuals such as ash, slag, and purifier materials are present primarily in the fill resulting from previous MGP operations. Releases of OLM and/or TLM have impacted primarily the fill and underlying clay (through fractures and interbedded sandy seams). OLM has also migrated into the outwash sand and gravel unit to the top of bedrock, and has been observed in bedrock fractures in some locations where bedrock coring was performed. The lateral distribution of OLM and/or TLM in the fill and clay, in the outwash, and atop bedrock is shown on Figures 2, 3, and 4, respectively. OLM and/or TLM in the fill and clay is present over a large portion of the Middle Parcel, eastward to the limits of in-situ solidification on the East Parcel, westward to the excavation limits on the West Parcel, and in the southeast corner of the area west of the West Parcel (see Figure 2). OLM has been observed in the outwash sand and gravel in the southern half of the Site, from the southeast corner of the area west of the West Parcel to the western edge of the Pittsburgh Street driveway. The OLM in this soil unit generally occurs in lenses from a few inches to more than 15 ft in thickness (see Figure 3). The OLM atop the bedrock surface generally occurs in the southern portion of the Site, from the southeast corner of the area west of the West Parcel eastward to Pittsburgh Street and the southwest corner of the East Parcel (see Figure 4). The OLM and/or TLM limits in fill, clay, outwash, and atop bedrock has not been fully delineated to the south as investigation activities to date have been limited to the upland portions of the Site.

Numerous groundwater monitoring wells have been installed at the Site. Based on monitoring performed to date, DNAPL has been observed to accumulate in the following deep wells screened in the outwash: MW-3D (West Parcel - abandoned), MW-3DR (West Parcel), MW-10D (West Parcel - abandoned), MW-22D (Middle Parcel), and MW-23D (Middle Parcel). These well locations are shown on Figure 2. Three shallow wells previously located on the West Parcel, MW-13S, MW-14S, and MW-15S, also contained DNAPL, however, these wells were screened within zones excavated during 2010-2011 remediation of the West Parcel.

Several cross-sections have been prepared illustrating the geology and distribution of OLM, TLM and NAPL, as shown in Figures 5 through 8. Soil containing OLM and/or TLM does not meet applicable VAP standards.

1.6 Distribution of Contaminants of Concern in Soils

1.6.1 Area West of the West Parcel

Soil sampling was performed in the area west of the West Parcel in 2011. Sample intervals were selected to characterize the 0 to 2-ft zone for commercial/industrial worker exposure, the 0 to15-ft zone for construction worker exposure and deeper zones for OLM and/or TLM impacts. In general, samples containing OLM and/or TLM were not analyzed due to the presence of visible impacts and it was assumed that soils containing OLM and/or TLM would likely exceed VAP Commercial/Industrial GNS. Additionally, soil containing OLM and/or TLM does not meet applicable VAP standards. The soil analytical data for the area west of the West Parcel is summarized in Appendix A. Risks to a commercial worker associated with potential exposures to soil from 0 to 2 ft bgs, and to a construction worker associated with potential exposures to soil from 0 to 15 ft bgs were evaluated by comparing the Ohio VAP Generic Standards (GNS) for commercial workers and construction workers (published in Table 3 of VAP Rule 8) to the constituent concentrations reported in each sample using a multiple chemical adjustment (MCA) approach. The MCA was completed by establishing a ratio of the reported result for each constituent to the generic standard. Separate ratios were calculated for cancer and non-cancer health effects, based on the specific effect that each VAP generic standard is based on. Ratios were calculated for each chemical detected in each sample within the 0 to 2 ft bgs and 0 to 15 ft bgs data sets, and then summed among all constituents to derive total cancer and non-cancer risk ratios for each sample. Using this approach, total cancer risk ratios greater than 1 indicate that cancer risks exceed the Ohio Environmental Protection Agency (Ohio EPA) cancer risk limit of $1x10^{-5}$; non-cancer risk ratios greater than 1 indicate that the hazard index exceeds the Ohio EPA non-cancer risk limit of a hazard index of 1. Conversely, total risk ratios of 1 or less indicate that Ohio EPA risk limits are not exceeded.

Appendix A provides documentation of this evaluation for the area west of the West Parcel. Total risk ratios for soil 0 to 2 ft bgs, for potential exposures by a commercial worker, are below 1 for each sample, indicating that soil within this area would not pose a health risk to workers if left unpaved. Similarly, total risk ratios for soil 0 to 15 ft bgs, for potential exposures by a construction worker, are below 1 for each sample, indicating that soil within this area would not pose a health risk to workers who may excavate into it. No OLM was observed in borings within the 0 to 15-ft zone. No remediation of this shallow soil is necessary to allow for commercial use or excavation. However, the presence of OLM in the soils below 15 ft bgs poses a risk to construction workers that may excavate and come into contact with these materials, if encountered. Soil containing OLM and/or TLM does not meet applicable VAP standards.

1.6.2 West Parcel

For the West Parcel to the top of the riverbank, soil impacts up to 40 ft bgs, as detailed in the West Parcel Remediation Construction Summary Report, have been mitigated through a combination of excavation and a 2-ft thick soil cover. OLM is present at depths greater than 40 ft. Soil containing OLM does not meet applicable VAP standards. Potential soil impacts beyond the top of the riverbank outside the current fence line have not been investigated and, therefore, are not addressed in this alternatives analysis.

1.6.3 East Parcel

For the East Parcel to the top of the riverbank, soil impacts up to 22 ft bgs, as detailed in the East Parcel Remediation Construction Summary Report, have been mitigated through a combination of excavation, in-situ solidification, and a 2-ft thick soil cover. A small area in the western portion of the East Parcel adjacent to Pittsburgh Street contains OLM and/or TLM and was not included in the East Parcel remedial construction due to facility operational considerations. Soil containing OLM and/or TLM does not meet applicable VAP standards. This area will be addressed in conjunction with the Middle Parcel remediation and has been considered in the development of alternatives evaluated in this report. Potential soil impacts beyond the top of the riverbank outside the current fence line have not been investigated and, therefore, are not addressed in this alternatives analysis.

1.6.4 Middle Parcel

For the Middle Parcel, remedial investigations conducted during 2012 and 2013 included soil sampling to characterize the 0 to 2-ft zone for commercial/industrial worker exposure, the 0 to 15 ft-zone for construction worker exposure and deeper zones beneath OLM/TLM impacts. In general, samples containing OLM/TLM were not analyzed due to the presence of visible impacts and it was assumed that soils containing OLM and/or TLM would likely exceed VAP Commercial/Industrial GNS. Additionally, soil containing OLM and/or TLM does not meet applicable VAP standards. The soil analytical data for the Middle Parcel is summarized in the Middle Parcel Phase II Property Assessment Report (Phase II PA). Exceedance of VAP Commercial/Industrial GNS occurred for benzo(a) pyrene in several samples and naphthalene in one sample. Exceedances of VAP Construction Worker GNS were detected for naphthalene, 1,2,4-trimethylbenzene, and lead.

As documented in the Phase II PA, total risk ratios for unpaved soil 0 to 2 ft bgs, for potential exposures by a long-term full time commercial/industrial worker, exceed 1, indicating that soil within the unpaved areas would pose an unacceptable risk to full time commercial/industrial workers. Risks are primarily contributed by benzo(a)pyrene, which are substantially influenced by the concentrations reported in sample HA-SB-E34 adjacent to the Pittsburgh Street driveway. If this sample was excluded from the calculated exposure point concentration (EPC), then the risk ratios would not exceed 1. That is, precluding direct contact with soil in this area would reduce risks to commercial/industrial workers to within acceptable levels for this pathway.

For the soils that are presently paved, the MCA evaluated contact with soil assuming that the pavement is removed. As documented in the Phase II PA, total risk ratios for unpaved soil 0 to 2 ft bgs, for potential exposures by a long-term full time commercial/industrial worker, are less than 1, indicating that soil within this area would not pose an unacceptable risk to full time commercial/industrial workers if the pavement was not maintained. Total risk ratios for soil 0 to 15 ft bgs, for potential exposures by a construction worker, do not exceed 1, indicating that soil within this area would not pose an unacceptable risk to construction workers who may excavate into it. However, the presence of OLM and TLM in the Site soils within the 0 to 15 ft bgs interval and below poses a risk to construction workers that may excavate and come into contact with these materials, if encountered. Soil containing OLM and/or TLM does not meet applicable VAP standards.

Visitors or trespassers may enter the Middle Parcel. Complete exposure pathways for on-site visitors may include: incidental ingestion and dermal contact with soil; inhalation of fugitive dust in ambient air generated due to wind erosion of non-vegetated portions of the Site; and inhalation of VOCs emanating from soil into ambient air. Based on evaluation of Site sampling data and associated MCA activities presented in the Middle Parcel Phase II PA, it is assumed that visitors and trespassers would remain on paved areas/on-site areas for much less time than Site workers. Therefore, impacts in soils present at the Site do not exceed VAP standards for visitors/trespassers.

1.6.5 OLM/TLM

To facilitate calculation of the approximate percentage of OLM and/or TLM removed or treated as part of the remedial alternatives evaluated in Section 4, percentages of soil volume containing OLM and/or TLM were determined for various depth intervals. Depth intervals were selected based on excavation/treatment depths of the various remedial technologies evaluated in the detailed alternatives analysis. Percentages were determined based on a review of the geologic cross-sections depicted in Figures 5 through 8; and are listed below:

- 0 to 15 ft bgs: approximately 15% of the soil volume contains OLM and/or TLM
- 15 to 40 ft bgs: approximately 20% of the soil volume contains OLM
- 40 to 60 ft bgs: approximately 5% of the soil volume contains OLM
- 60 ft bgs - Bedrock: approximately 5% of the soil volume contains OLM

1.7 Distribution of Contaminants of Concern in Groundwater

MGP-related COCs have been detected in groundwater samples collected from shallow and deeper monitoring wells installed at the Middle and West Parcels at concentrations exceeding unrestricted potable use standards (UPUS). The most recent groundwater monitoring was performed as part of the Middle Parcel Phase II investigations in November 2012 and February and May 2014. Review of the groundwater analytical results indicates that groundwater samples collected from shallow wells are impacted with MGP-related COCs (typically benzene and other VOCs, various PAHs, and certain metals) at concentrations in excess of UPUS. Groundwater impacts in excess of UPUS were typically encountered in monitoring wells MW-20S, MW-21S, MW-22S, MW-24S, and MW-26S. Groundwater samples collected from the deeper groundwater were impacted with MGP-related COCs (typically benzene, ethylbenzene, toluene, and 1,2,4-trimethlybenzene, and naphthalene, and other compounds) at concentrations in excess of UPUS. Samples were not collected from monitoring wells MW-22D or MW-23D because NAPL was present in these wells during gauging. A groundwater sample was collected from MW-3DR in November 2012, as no NAPL was observed at that time; however, NAPL was encounter in MW-3DR during the February and May 2014 gauging events. Under the VAP rules, NAPL presence in a well is considered an UPUS exceedence. The presence of the NAPL in the deep wells also documents the apparent mobile nature of the OLM in the subsurface of the Site.

These results indicate that groundwater has been impacted by former MGP operations and that risks to current and future Site users may exist if groundwater is used or contacted. In addition, several wells are located on the southern boundary of the Site, closest to the Ohio River. Therefore, remediation is needed to meet VAP applicable standards. The east-west lateral extent of impacted groundwater appears to be bracketed by well MW-K09S/D in the area west of the West Parcel, and MW-7S/D on the East Parcel. Quarterly groundwater monitoring is being performed at the Site in 2014 and will be reported separately.

1.8 Contaminant Transport

The occurrence, migration and accumulation of MGP residual materials in the subsurface are typically controlled by several factors, including:

- The texture and porosity of the overburden materials;
- The presence of capillary barriers and confining units which inhibit vertical migration and influence horizontal migration;
- The occurrence of groundwater within the overburden materials; and,
- The physical nature and distribution of MGP-residual materials (density relative to water).

In general, MGP-residual materials introduced to the surface or subsurface materials migrate vertically downward under the force of gravity through the overburden material until the material intersects a zone of lower permeability, such as the clay layer underlying Site fill. Once encountering a lower permeability zone, DNAPL has the potential to migrate laterally along the top of a lower permeability zone if sufficient diving head and a gradient exist. Based on review of site data, it appears that the MGP residuals have migrated beyond the extent of the former MGP footprint (horizontally) and below the native clay layer (vertically), indicating that vertical conduits (which could include fractured clays or desiccation cracks in unsaturated clay as well as former MGP structures, such as gas holder foundations, tar well foundations, etc.) may exist. It should be noted that desiccation cracks or clay fractures were observed in the unsaturated clay on the West Parcel in the tar lagoon area, both during the investigation and excavation activities.

If a continual source of residual material is present, the horizontal migration of the residual materials in the subsurface is expected to continue along the zones of increased porosity and/or permeability, and downward through vertical conduits. Removal or containment of the source(s) enables both vertical and lateral migration to reach equilibrium, as determined by the surface tension, density and viscosity of the material, porosity and permeability of the subsurface soils, and presence/absence of a continual source of the material.

1.9 Land Use Considerations

Current land use is for industrial purposes. All the property being considered in this remedial alternatives analysis is owned by Duke. The area surrounding the Site to the west, north, and east is a mix of commercial and residential properties. The Ohio River abuts the Site to the south. The Middle Parcel contains numerous active and abandoned utilities including drains, natural gas, propane, water, sewer, and critical gas and water infrastructure. Remediation of the Site, and in particular the Middle

Parcel, will need to be sequenced to accommodate relocation or protection of affected utilities as needed to ensure no disruption of operations or service.

2. REMEDIAL STRATEGY AND OBJECTIVES

2.1 VAP Remedial Considerations

Based on the soil and groundwater impacts summarized in the previous Section, remediation will be required to meet all applicable standards under the VAP. It should be noted that under the VAP, remediation can include a combination of active remediation (e.g. source removal or containment) and passive remediation (institutional or engineering controls) designed to meet all applicable standards and to mitigate risks to current and future site users. A summary of applicable VAP standards is presented in Table I. Remedial activities that may be required to meet applicable VAP standards include:

- Surface soil in unpaved areas poses an unacceptable risk to current Site workers and does not meet applicable VAP standards. To meet applicable commercial/industrial Site worker standards under the VAP, remediation of unpaved surface soil is required, especially focused on the vicinity of HA-SB-E34 which drives the EPC risk exceedance.

- Construction workers could come into contact with OLM and/or TLM observed in certain areas of the Site within the upper 15 ft. Where OLM or TLM are present, VAP applicable standards for construction workers are not met. Therefore, to meet applicable VAP construction worker standards, remediation is required in areas with OLM or TLM present at depths of less than 15 ft.

- OLM and/or TLM are present within the soil column and have migrated from source areas and may continue to migrate, both horizontally and vertically. Further, OLM and TLM represent continuing sources of dissolved constituents in groundwater that exceed applicable standards. The VAP requires that current and future on-site and off-site receptors be protected. Remediation of OLM and TLM impacts is required in order to meet applicable VAP standards.

- The Ohio EPA defines "free product" as "a separate liquid hydrocarbon phase that has a measurable thickness of greater than one one-hundredth of a foot." Measurable free product (NAPL) was observed in deep monitoring wells MW-3DR, MW-22D and MW-23D. VAP rules state that properties with free product exceed applicable unrestricted potable use standards (UPUS) for ground water (O.A.C. 3745-300-08(B)(2)(c)). Further, the VAP generally requires that free product be removed, or mitigated to the extent practicable, prior to issuance of an NFA (OAC 1301:7-9-13(G)(3)(a)). As such, NAPL remediation is required to meet applicable VAP standards.

- Site shallow groundwater is classified as a Class B under the VAP; however, the deeper groundwater is classified as a Critical Resource under the VAP. Because Site groundwater is impacted above UPUS, response requirements (including but not limited to institutional or engineering controls) are required to prevent on-site human exposure to groundwater exceeding UPUS, in accordance with VAP rules (OAC 3745-300-10 (E)(2)(a)). In addition, the extent of groundwater impacts, particularly to the south, has not been determined. Therefore, further response requirements related to on-site and off-site groundwater cannot currently be determined until the extent of groundwater impacts have been defined and after evaluating the effect of the source remediation activities.

2.2 Remedial Action Objectives

Remedial Action Objectives (RAOs) are overall protection of human health and the environment, including meeting all applicable VAP standards. For the areas of the Site considered in this Remedial Alternatives Analysis, the threshold criteria for achieving RAOs include the following (VAP applicable standards included in parentheses):

- Overall protection of human health and the environment;
- Mitigate exposure that exceeds applicable standards for Site workers, trespassers, and construction workers (OAC 3745-300-08 and OAC 3745-300-09);
- Mitigate the potential for future vapor intrusion risks if Site uses change (OAC 3745-300-07(I)(1)(a)(iii));
- Mitigate the potential for COCs in soil to leach into groundwater (OAC 3745-300-08, OAC 3745-300-09, and OAC 3745-300-10);
- Mitigate NAPL impacts to groundwater and the potential for migration of NAPL off-site (OAC 3745-300-08 and OAC 1301:7-9-13(G)(3)(a));
- Mitigate potential future exposure to impacted groundwater for potable and non-potable uses (OAC 3745-300-08, OAC 3745-300-09, and OAC 3745-300-10), and
- Evaluate the potential for Site groundwater to impact downgradient receptors (this investigation/evaluation will be performed in the future and, therefore, is not included in remedial alternatives identified in this report) (OAC 3745-300-08 (A)(1) and (H), and OAC 3745-300-09 (E)).

The above RAOs are then further evaluated and screened using the criteria in Section 4.1 of this report.

3. TECHNOLOGY SCREENING

3.1 General Response Actions

General response actions (GRAs) describe the broad range of actions that individually, or in combination, will satisfy the RAOs and applicable VAP standards. GRAs may include no action, institutional controls, engineering controls, containment, removal, treatment, disposal, monitoring or a combination of these. Similar to RAOs, GRAs are typically medium-specific; however, specific GRAs as applied to a given site may address multiple impacted media. The GRAs presented below may be applied to multiple media and pathways.

To meet the RAOs for the Site, the following potential GRAs have been identified for consideration in remedial alternatives:

- **No Action.** Used for baseline comparison. No remedial measures are implemented in the No Action GRA. This would not satisfy the RAOs, nor the applicable VAP standards.

- **Institutional Controls.** Institutional controls may involve administrative actions that restrict access to, contact with or use of contaminated areas. Examples of common institutional controls include environmental covenants regarding land or groundwater use, a soil management plan establishing protocols for disturbing impacted media, among others. The VAP allows implementation of such controls to meet some or all applicable standards, as appropriate.

- **Engineering Controls.** Engineering controls involve physical measures to restrict access to, contact with or use of contaminated areas. Examples of common engineering controls include fencing, soil or paving covers, capping, engineered barriers, and vapor intrusion barriers, among others. The VAP allows implementation of such controls to meet some or all applicable standards, as appropriate. VAP compliant operation and maintenance (O&M) requirements, after receipt of the No Further Action (NFA) or Covenant Not To Sue (CNS), may be necessary.

- **Containment.** Containment actions include control, isolation and encapsulation technologies (such as vertical barrier walls combined with engineering controls) that involve little or no treatment but provide protection of human health and the environment by reducing mobility of contaminants and/or eliminating pathways of exposure. The VAP allows containment remedies to meet applicable standards, although VAP compliant O&M, after receipt of NFA or CNS, may be necessary.

- **Removal.** These actions are taken to physically remove the contaminated media. These actions reduce the volume, and in some cases, the mobility of contaminants. The VAP encourages removal actions by not requiring subsequent actions beyond the receipt of the NFA or CNS.

- **Treatment.** These are *in-situ* or *ex-situ* actions taken to treat groundwater, soil or NAPL using physical, chemical, thermal and/or biological processes to reduce the toxicity, mobility and/or volume of contamination and the availability of these contaminants for contact, consumption and environmental transport and uptake. The VAP encourages treatment actions, through use of consolidated site permits and by not requiring subsequent actions beyond the receipt of the NFA or CNS.

3.2 Technology Screening Criteria

Each GRA (except for No Action) can be addressed by various remedial technologies. Remedial technologies are defined as the general categories of remedies under a GRA, such as a barrier wall, cap, in-situ solidification etc. Many technology types and process options are available to implement the GRAs described in Section 3.1. Table II provides an initial list of technologies and process options considered. The purpose of initially considering a wide range of technologies and process options is to ensure that potentially applicable options for the site media and COCs are not overlooked. Technologies were screened using the criteria of effectiveness, implementability and relative cost; which are further defined as follows:

- **Effectiveness** – Considers 1) the ability of a process option to address the estimated areas or volumes of contaminated media and meet the RAOs and applicable VAP standards; 2) the potential impacts to human health and the environment during the construction and implementation phases; and, 3) the reliability and demonstrated success the process has shown with respect to the types of contamination and site conditions that will be encountered.

- **Implementability** – Implementability includes both the technical and administrative feasibility of implementing a technology process option. The administrative feasibility considers the administrative or institutional aspects of using a process option such as potential restrictions of future land use, the availability and capacity of treatment, storage and disposal services and the availability of the equipment and workers to implement the technology.

- **Relative Cost** – Cost plays a role in the screening of process options, but not to the same level as the other criteria. Relative capital and operation and maintenance (O&M) costs are used rather than detailed estimates. The costs for each process option are evaluated on the basis of engineering judgment as high, medium or low relative to the other process options in the same technology type.

3.3 Technology Screening Results Summary

The technology screening is presented in Table II. The technology screening resulted in the selection of the following effective and implementable technologies for use in developing remedial alternatives to be included in the detailed alternatives evaluation presented in Section 4. No Action is also retained for baseline comparison, although it is not effective at meeting RAOs or applicable VAP standards.

- **No Action**

- **Institutional Controls** – Access and use restrictions in the form of deed restrictions or environmental covenants (also referred to as institutional controls), a soil management/risk mitigation plan and long-term groundwater monitoring. These remedial actions will be included in all the alternatives, except No Action;

- **Engineering Controls** – Durable covers, fencing/signs and potential future building vapor intrusion barriers are retained for consideration in remedial alternatives. Durable cover types may include buildings, paving, hardscapes, soil covers and multi-layered engineered covers;

- **Containment** - Installation of NAPL monitoring and recovery wells at the southern edge of the Middle and West Parcels and in the area west of the West Parcel was retained to address containment of potentially mobile NAPL by interception and removal;
- **Removal** – Excavation of OLM/TLM-impacted soils above the water table with off-site landfill disposal was retained as a viable technology for remediation of MGP residual source areas and is consistent with remedies implemented on adjacent parcels of the Site and at other MGP sites;
- **Treatment** – In-situ solidification (ISS) to depths up to 60 ft was retained as an effective in-situ treatment technology for OLM/TLM-impacted soil and is consistent with remedies implemented on and adjacent parcel of the Site and at other MGP sites.

4. REMEDIAL ALTERNATIVES

In this section, remedial alternatives are assembled to address the RAOs and comply with applicable VAP standards. There are many possible combinations of technologies and process options that could be used to formulate the alternatives. It is not practical to assemble every possible combination, nor is it necessary for the purposes of the alternative development and evaluation because many of the possible combinations are similar in performance and cost. The intent of the alternative assembly process is to create a set of alternatives that represents a range of performance and cost options so that the feasible, effective and implementable alternatives can be comparatively evaluated against each other to determine a preferred alternative while meeting the RAOs and addressing applicable VAP standards. Once a preferred alternative is selected, changes to the specific process options within a given technology type can be made during remedial design and subsequently implemented without compromising the remedy selection process in the remedial alternatives analysis. Likewise, the remedy selection process would be the same if areas identified in this analysis were remediated with multiple mobilizations.

Remedial alternatives have been assembled to span the range of GRAs identified in Section 3 including no action, institutional and engineering controls, containment, treatment and removal. A total of five alternatives, including a No Action Alternative, were developed.

The following alternatives were developed and are described in the following sections.

- Alternative 1 – No Action.
- Alternative 2 –Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring.
- Alternative 3 – OLM/TLM Excavation in Construction Worker Zone, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring.
- Alternative 4 – OLM/TLM Excavation to Water Table, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring.
- Alternative 5 – In-Situ Solidification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring.

These remedial action alternatives are depicted in Figures 9 through 12 and are described below.

Alternative 1 - No Action: The No Action Alternative includes no remedial activities and will leave the Site in its present condition. Contaminated media will remain in place with no treatment to prevent further contaminant migration and will not provide any additional protection to human health and the environment over current conditions. Site conditions will not be monitored to document the natural attenuation or mobility of contamination. No action is required to implement the technology and there is no associated cost. This alternative is retained as a baseline for comparison to other remedial alternatives, but would not meet applicable VAP standards or be protective of human health or the environment.

Alternative 2 - Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring: This alternative is intended to provide the minimum actions necessary to address risks to site workers associated with soils impacted by MGP residuals. Similar to the No Action alternative, this alternative does not meet all RAOs or address all applicable VAP standards and is retained for comparison. Alternative 2 includes the following remedial technologies:

- Engineering controls (fencing and signs, durable covers) and institutional controls (land use restriction for commercial/industrial use only, groundwater use restriction for potable or non-potable uses, and a soil management/risk mitigation plan for future intrusive activities).
- The surface soils (0 to 2 ft bgs) in paved areas of the Middle Parcel and on the area west of the West Parcel do not pose a risk to visitors or Site workers, and the existing surface soils in these areas constitute a current durable cover. For unpaved portions of the Middle Parcel, risks to Site workers from exposure to surface soils are primarily driven by the benzo(a)pyrene concentration at boring location HA-SB-E34 (see Section 1.6). Therefore, removal of the top 2 ft of soil in the area between the east edge of Pittsburgh Street and the East Parcel fenceline between the northern property line at Riverside Drive and the sewer manhole west of boring HA-SB-E10 is included;
- A 2-ft soil cover in the area of soil excavation east of Pittsburgh Street.
- Groundwater monitoring will be performed for up to 30 years using the existing monitoring well network at the Site, which includes the following 21 wells:
  - West Parcel: MW-19S, MW-3DR, MW-4DR;
  - Area west of the West Parcel (east of Munson Street): MW-K09S, MW-K09D;
  - East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - Middle Parcel: MW-20S, MW-20D, MW-21S, MW-21D, MW-22S, MW-22D, MW-23D, MW-24S, MW-24D, MW-25D, and MW-26S.

The components of this remedial alternative are illustrated on Figure 9.

Alternative 3 – OLM/TLM Excavation in Construction Worker Zone, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring: This alternative is intended to provide the minimum amount of remedial construction required to meet applicable VAP standards. Alternative 3 includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil to potential construction worker exposure depth of 15 ft, backfill with imported clean soil, and surface restoration with paving, gravel, or vegetated cover, varying based on current Site use.
- Installation of a 2-ft clean soil cover between the east edge of the Pittsburgh Street paving and the East Parcel fenceline from the northern limit of OLM/TLM excavation to the northern property limit at Riverside Drive;
- NAPL monitoring and recovery in up to 8 wells (Middle Parcel, West Parcel, west of the West Parcel); and
- Groundwater monitoring will be performed for up to 30 years in up to 13 wells, including:
  - West Parcel: MW-19S, MW-3DR, MW-4DR;
  - Area west of the West Parcel (east of Munson Street): MW-K09S, MW-K09D;
  - East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - Middle Parcel: Up to 3 new groundwater monitoring wells installed post-remediation.

The components of this remedial alternative are illustrated on Figure 10.

Alternative 4 – OLM/TLM Excavation to Water Table, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring: This alternative includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil that is present above the water table, to a maximum depth of approximately 40 ft, backfill with imported clean soil, and surface restoration with paving, gravel, or vegetated cover, varying based on current Site use.
- Installation of a 2-ft clean soil cover between the east edge of the Pittsburgh Street paving and the East Parcel fenceline from the northern limit of OLM/TLM excavation to the northern property limit at Riverside Drive;
- NAPL monitoring and recovery in up to 8 wells (Middle Parcel, West Parcel, west of the West Parcel); and
- Groundwater monitoring will be performed annually for up to 30 years in up to 13 wells, including:
  - West Parcel: MW-19S, MW-3DR, MW-4DR;
  - Area west of the West Parcel: MW-K09S, MW-K09D;
  - East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - Middle Parcel: Up to 3 new groundwater monitoring wells installed post-remediation.

The components of this remedial alternative are illustrated on Figure 11.

Alternative 5 - In-Situ Solidification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring: This alternative includes the following remedial technologies:

- Engineering controls (fencing and signs) and institutional controls (land use restriction for commercial/industrial use only and groundwater use restriction for potable or non-potable uses and a soil management/risk mitigation plan for future intrusive activities).
- Excavation of OLM/TLM in soil that is present in the upper 20 ft, followed by ISS of OLM in soil to a maximum depth of 60 ft which generally includes OLM impacts to the bottom of the clay layer or the upper portion of the outwash layer). ISS swell placement will be limited to no shallower than 15 ft bgs. The upper 15 ft will be backfilled with imported clean soil and surface restoration with paving, gravel, or vegetated cover, varying based on current Site use.
- Installation of a 2-ft clean soil cover between the east edge of the Pittsburgh Street paving and the East Parcel fenceline from the northern limit of OLM/TLM excavation to the northern property limit at Riverside Drive;
- NAPL monitoring and recovery in up to 8 wells (Middle Parcel, West Parcel, west of the West Parcel); and
- Groundwater monitoring will be performed annually for up to 30 years in up to 13 wells, including:
  - West Parcel: MW-19S, MW-3DR, MW-4DR;
  - Area west of the West Parcel: MW-K09S, MW-K09D;
  - East Parcel: MW-6, MW-7S, MW-7D, MW-8S, MW-8D; and
  - Middle Parcel: Up to 3 new groundwater monitoring wells installed post-remediation.

This alternative considers the use of ISS to remediate NAPL impacts. Including ISS increases the maximum practical depth of remediation to the bottom of the clay layers, or approximately 60 ft bgs (i.e., 20 ft below the water table). The alternative would be implemented with excavation to approximately 15 to 20 ft bgs, then ISS to the bottom of clay or approximately 60 ft bgs where NAPL extends to this deep (not on Pittsburgh Street), leaving room for ISS swell, and leaving the upper 15 ft (future construction worker zone) to be backfilled with clean soil. This approach would apply to both the Middle Parcel and NAPL area west of the West Parcel.

The components of this remedial alternative are illustrated on Figure 12.

4.1 Evaluation Criteria

The remedial alternatives were subjected to a detailed evaluation against a series of criteria, which were divided into two categories; threshold criteria and balancing criteria. Threshold criteria define the minimum level of acceptable performance for an alternative that must be met for an alternative to be considered eligible for selection, and include:

Overall Protection of Human Health and the Environment – This criterion must be met for an alternative to be eligible for selection and is used to assess whether and how the alternative, as a whole, achieves and maintains protection of human health and the environment, including the attainment of the RAOs and applicable VAP standards. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness and compliance with applicable VAP standards. The evaluation of this criterion is also based on the evaluation of how risks are eliminated, reduced or controlled through treatment, engineering or administrative controls. Overall protection of human health and the environment considers reduction in baseline risks and protection of human health and the environment from effects caused by implementing the remedial alternative. This criterion is intended to ensure that the selected remedial action alternative would:

- Protect human health and the environment;
- Attain media cleanup goals; and
- Control sources of releases.

Compliance with RAOs and Applicable VAP Standards – Evaluates the degree to which an alternative meets the RAOs and applicable VAP standards identified in Section 2.2.

The balancing criteria are used to weigh trade-offs among the alternatives that meet the threshold criteria and include:

Long-term Effectiveness - This criterion is an evaluation of the long-term effectiveness of an alternative in maintaining protection of human health and the environment after RAOs and applicable VAP standards have been met. It assesses whether the alternative provides reliable protection over time. This criterion addresses:

- Magnitude of residual risk remaining from untreated media or treatment residuals at the conclusion of remedial activities; and,
- Adequacy and reliability of controls such as containment systems and institutional controls necessary to manage the untreated media or treatment residuals which remain on-site.

The residual risk from treatment residuals or untreated media can be measured by chemical concentrations or material volume remaining at the Site after remedial action is complete.

Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment – This criterion considers the degree to which alternatives employ removal or treatment technologies, as well as the anticipated performance of the removal or treatment technologies, by evaluating the amount of hazardous material removed or treated and the amount remaining on-site. The evaluation considers the magnitude of the reductions in toxicity, mobility or chemical volume and the extent to which the treatment is irreversible as follows:

- Amount of impacted media removed, destroyed or treated;
- Degree of expected reduction in toxicity, mobility and volume;
- Degree to which treatment is irreversible; and,
- Type and quantity of residual remaining after treatment.

Short-term Effectiveness – This criterion evaluates the effects of an alternative during the construction and implementation period of the remedial action before and until the time the RAOs are achieved and applicable VAP standards are addressed. This criterion addresses:

- Time until RAOs are achieved and whether any short-term risks are promptly addressed;
- Protecting the community and Site workers during remedial action by evaluating effects such as dust or other emissions, visual considerations or transportation;
- Protecting workers during remedial action by evaluating reliability of health and safety protective measures during implementation; and,
- Protecting the environment during remedial action by evaluating potential effects on sensitive resources, including disturbance to cultural resources and wildlife.

Implementability – This criterion evaluates the technical and administrative feasibility of alternatives and the availability of various services and materials required during its implementation. This criterion addresses:

- Technical feasibility as the ability to construct, operate and maintain the technology and the ability to monitor its effectiveness;
- Administrative feasibility as the ability to obtain approvals, rights-of-way and permits; and,
- Availability of services and materials considering off-site treatment, storage capacity, disposal capacity, equipment and specialists.

Community Acceptance - This criterion evaluates the issues and concerns the public may have regarding each alternative. Impacts to or concerns of the community may include construction traffic and noise, odors and site emissions, hauling contaminated soils through the community to the disposal facility, degree to which human health or ecological risks are mitigated, among others.

Cost – This criterion evaluates the direct and indirect capital costs required to implement the alternative as well as the projected operation, maintenance and monitoring costs. This criterion addresses:

- Direct costs, including expenditures for the equipment, labor and materials necessary to install/perform remedial actions;
- Indirect costs, including expenditures for engineering, administrative and other services required to complete the implementation of remedial alternatives; and,
- Periodic operation, maintenance and long-term monitoring costs.

The costs of the remedial action include the direct and indirect costs. The operation, maintenance and monitoring costs have not been discounted for present worth, but are presented in total present day amounts for a 30-year period. The estimated costs provided for the remedial alternatives have an accuracy of -30% to +50%, which is typical for an alternatives analysis stage. Costing detail is provided in Appendix B.

4.2 Evaluation of Alternatives

The results of the alternatives evaluation through comparison to the eight criteria is presented in Table III and discussed below. A relative scoring is used on Table III to provide a relative ranking of the alternatives. The numeric scoring for the various criteria ranges from 0 through 4, with a score of 0 indicating the criteria is not met and a score of 4 indicating the criteria is substantially achieved by the alternative. The scoring is not intended to identify the preferred alternative, rather, it provides a semi-quantitative means to illustrate and compare the relative benefits and short-comings of the various alternatives. This evaluation assumes that the property use remains industrial.

4.2.1 Alternative 1: No Action

The No Action alternative does not satisfy any of the RAOs nor does it meet applicable VAP standards and is not protective of human health or the environment. This alternative is the lowest cost to implement as there are no remedial actions implemented.

4.2.2 Alternative 2: Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring

Implementation of engineering and institutional controls mitigates potential risks associated with direct contact with impacted media thru installation of durable covers, implementation of a soil management/risk mitigation plan, groundwater use restrictions, and land use restrictions. However, this alternative does not remove or treat any OLM/TLM impacted soils and does not address the potential migration of NAPL or the potential leaching of COCs from soil to groundwater. As such, Alternative 2 is not considered to be protective of the environment and only marginally meets some of the RAOs and VAP applicable standards. Additionally, despite the implementation of engineering and institutional controls, the presence of OLM/TLM in shallow Site soils within the construction zone will continue to pose a potential risk to construction workers, even with the implementation of a soil management/risk management plan. The cost of this alternative is estimated at $1.3 million.

4.2.3 Alternative 3: OLM/TLM Excavation in Construction Worker Zone, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring

Excavation of the top 15 ft of OLM/TLM-impacted soil mitigates the potential for construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. This alternative will remove approximately 30% of the identified OLM/TLM-impacted soils at the Site, and will remove former MGP structures containing MGP residuals including the tar wells, tar settling tank, tar separator, and the upper portion of the gas holders in the Middle Parcel. However, a significant proportion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. Inclusion of NAPL monitoring and recovery wells may address potential NAPL migration off-site. RAOs and applicable VAP standards are partially met with this alternative and to a greater extent than Alternative 2. This alternative will have moderate impacts to Site workers and the community during excavation and off-site hauling of impacted soils and will required phased construction to accommodate active facility operations and infrastructure. The cost of this alternative is estimated at $18.3 million.

4.2.4 Alternative 4: OLM/TLM Excavation to Water Table, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring

Excavation of OLM/TLM-impacted soil above the water table (up to approximately 40 ft bgs) will mitigate the potential for Site and construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. This alternative will remove approximately 85% of the identified OLM/TLM impacted soils at the Site, and will remove former MGP structures containing MGP residuals including the tar wells, tar settling tank, tar separator, and the gas holders in the Middle Parcel. A portion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. Inclusion of NAPL monitoring and recovery wells may address potential NAPL migration off-site. RAOs and applicable VAP standards are partially met with this alternative and to a greater extent than Alternatives 2 and 3. The proportion of OLM -impacted soil that will remain in this alternative is significantly less than in Alternative 3; as such, this alternative is expected to result in a greater reduction in the potential for NAPL migration and COC leaching to groundwater. This alternative will have the greatest impacts to Site workers and the community during excavation and off-site hauling of impacted soils and will required phased construction to accommodate active facility operations and infrastructure. This alternative is also the most prone to delays or extended construction schedules due to river flooding potential between November and May. This alternative has the highest cost of all the alternatives estimated at $44.6 million.

4.2.5 Alternative 5: In-Situ Solidification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring

Excavation of OLM/TLM-impacted soil in the upper 20 ft and solidification of impacted soils to a maximum depth of 60 ft bgs will mitigate the potential for Site and construction workers to be exposed to impacted soils during maintenance or future infrastructure improvements. Use of ISS to address OLM-impacted soils allows for a larger proportion of source material to be addressed as compared to excavation. This alternative will remove or treat approximately 90% of the OLM/TLM impacted soils at the Site, and will remove former MGP structures containing MGP residuals including the tar wells, tar settling tank, tar separator, and the gas holders. A portion of OLM impacts will remain, which are mobile and are a source of COCs to groundwater. Inclusion of NAPL monitoring and recovery wells may address potential NAPL migration off-site. RAOs and applicable VAP standards are partially met with this alternative and to a greater extent than Alternatives 2, 3 and 4. The proportion of OLM -impacted soil that will remain in this alternative is significantly less than in Alternative 3 and Alternative 4; as such, this alternative is expected to result in a greater reduction in the potential for NAPL migration and COC leaching to groundwater. This alternative will have moderate impacts to Site workers and the community during excavation and off-site hauling of impacted soils, although less than Alternative 4, and will required phased construction to accommodate active facility operations and infrastructure. This alternative is somewhat prone to delays or extended construction schedules due to river flooding potential between November and May. The cost of this alternative is estimated at $44.5 million.

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TABLE I
VAP APPLICABLE STANDARDS AND REMEDIAL CONSIDERATIONS
EAST END GAS WORKS SITE
CINCINNATI, OHIO

Applicable Standard (1)	Media	Pathway / Exposure Route	Receptor	Comment	Standard Currently Met?	Remediation Consideration (2)	Regulatory Reference
VAP GNS and GNS with MCA	Soil	Direct contact, ingestion, inhalation of particulates	Current and future land users	Must consider relevant standards related to current and reasonably anticipated future land use and potential receptors: Residential, Commercial, Industrial and Construction Worker scenarios.	No	Remedy Required for current and future users (active remediation and restrictions likely)	Ohio Administrative Code (OAC) 3745-300-08
Vapor intrusion to indoor air	Indoor Air	Inhalation	Future residential land users	Indoor air sampling data indicates no current risk to current land users, but potential future VI risks may remain associated with possible future residential land uses, and related to near-surface MGP residuals (OLM, TLM, NAPL). Ohio EPA May 2010 Guidance "Sample Collection and Evaluation of Vapor Intrusion to Indoor Air"	No	Land use restrictions required for future users	OAC 3745-300-07 (I)(1)(a)(iii)
POGWMPUS	Groundwater	Future groundwater users	Groundwater resources	This is an anti-degradation rule that protects currently unimpacted groundwater from future degradation.	No	Groundwater response requirements required as described in OAC 3745-300-10. Implementation of these actions may include removal of NAPL, active remediation, and institutional or engineering controls.	OAC 3745-300-10 (D)
Potable groundwater use standards	Groundwater	On-site potable and non-potable groundwater users	Current and future land users	Groundwater must meet VAP unrestricted potable use standards (UPUS).	No		OAC 3745-300-08
Non-potable groundwater use standards	Groundwater	On-site non-potable groundwater users	Current and future land users	Non-potable use of groundwater must pose no unacceptable risk to receptors.	No		OAC 3745-300-09
NAPL standard	Groundwater	Potable, non-potable groundwater users and ecological resources	Current and future land users and off-site users, Ohio River	VAP rules (3745-300-08(B)(2)) indicates that the presence of NAPL on groundwater is indicative of an UPUS exceedence. Further, BUSTR rules, incorporated into the VAP standards, require the removal of free product to the maximum extent practicable.	No		OAC 3745-300-08 and OAC 1301:7-9-13(G)(3)(a)
Groundwater response requirements	Groundwater	Contact with groundwater through applicable potable and non-potable groundwater uses	Current and future on-site and off-site groundwater receptors (e.g., Ohio River)	Response requirements are based on groundwater classification, source of the contaminants (on site, off-site, or mixed) and presence of an urban setting designation. Additionally, groundwater exceeding UPUS that emanates into a surface water body adjoining the property triggers assessment of impacts to the surface water body.	No, to be determined.		OAC 3745-300-10
Pathways / exposure routes not considered by GNS or UPUS	Soil, Groundwater, and /or Soil Gas	All potentially complete pathways, if any, not considered in GNS or UPUS calculations	Current and future land users	Evaluated through sampling and analysis and (if needed) a human health risk assessment (HHRA), following VAP rules, for current and reasonably anticipated future land uses.	No, to be determined	These have not been evaluated.	OAC 3745-300-09

TABLE I
VAP APPLICABLE STANDARDS AND REMEDIAL CONSIDERATIONS
EAST END GAS WORKS SITE
CINCINNATI, OHIO

Applicable Standard (1)	Media	Pathway / Exposure Route	Receptor	Comment	Standard Currently Met?	Remediation Consideration (2)	Regulatory Reference
Risk to ecological resources	Sediment / Surface Water	Ecological and human health exposure pathways	Ecological resources and potential current or future users	Also reference Ohio EPAs "Guidance of Conducting Ecological Risk Assessments," US EPA Region 5 ecological screening levels, and other standards listed in the referenced rules.	Unknown – impacts beyond the upland top of bank have not been investigated	The potential for impacts to ecological receptors is undetermined because insufficient data have been collected between the site top of bank and the river	OAC 3745-300-08 (A)(1) and (H), and 09 (E)

Notes:

GNS – VAP Single Chemical Generic Numerical Standard
MCA – Multiple Chemical Adjustment
POGWMPUS – Protection Of Groundwater Meeting Potable Uses Standards
UPUS – Unrestricted Potable Use Standards
(1) Determination of applicable standards are discussed in OAC 3745-300-07 (F)(4).
(2) Remediation considerations are based on evaluation of the individual applicable standard noted for each consideration.

TABLE II
REMEDIAL TECHNOLOGY SCREENING
EAST END GAS WORKS SITE
CINCINNATI, OHIO

General Response Action	Technology/Approach	Description	Screening Criteria: Effectiveness	Screening Criteria: Technical and Administrative Implementability	Screening Criteria: Relative Cost	Retained (Y/N)
No Action	None	No remedial, investigative, or monitoring activity.	Not effective	No activity to implement	No cost	Y (for baseline comparison)
Institutional Controls	Deed Notice/Activity Use Limitations	Covenants, conditions, and restrictions including groundwater use restrictions, excavation restrictions, and vapor intrusion mitigation evaluations for future structure construction or occupancy.	Effective to limit direct exposure to soil and groundwater through administrative mechanisms. May also use in combination with engineering controls for vapor intrusion risk in future structures. Supports addressing RAOs for reducing exposure risk to all media.	Readily implementable for soil and groundwater. However, requires added costs to future intrusive activities related to site operations due to need for additional environmental and health and safety controls related to soil management during construction.	Low	Y
	Soil Management Plan	Implementation of a long-term risk management plan for future intrusive activities necessary to support on-going facility operations, maintenance and improvements.	Addresses RAO of mitigating potential future exposure to impacted soil in event of future site construction.	Soil management plans are common practice and considered highly implementable. However, requires added costs to future intrusive activities related to site operations due to need for additional environmental and health and safety controls related to soil management during construction.	Low	Y
	Monitoring	Monitor wells over time to evaluate presence, concentrations and migration of contaminants.	Not effective at reducing toxicity, mobility or volume for any media, however, can monitor trends in concentrations and effectiveness of remedial actions. Does not directly contribute to meeting RAOs.	Readily implementable and necessarily a part of any alternative that does not consist of clean closure.	Low to Moderate	Y
Engineering controls	Site Fencing /Signs	Physical barrier placed around contaminated area to prevent access and alert to potential hazards.	Somewhat effective at mitigating direct exposures to soil if maintained and monitored. Supports addressing RAOs for reducing exposure risk to all media.	Implementable with local contractors and materials. Compatible with current facility use and security provisions already in place.	Low	Y
	Durable Covers	Durable covers may include existing pavements and building, new paving, hardscapes or building foundations, soil/aggregate covers, or multi-layered engineered covers. Durable covers provide a horizontal barrier that prevents direct contact with the subsurface soils.	Effective means of addressing RAO of mitigating potential exposure to impacted site soils by industrial/commercial site workers and construction workers. Low permeability covers, such as pavement, reduce infiltration thus reducing potential for mobilization of contaminants in soils above the water table.	Easily implementable - much of the study area is already paved. Must be used in combination with institutional controls for future development to effectively address soil exposure potential.	Low	Y
	Vapor Intrusion Barriers	Multi-layered systems including sprayed sealers and impermeable liners installed during new construction to mitigate risk of vapor intrusion. A vapor intrusion assessment would be needed for future building construction to determine if mitigation is necessary.	If installed correctly during construction, foundation membranes have been proven to reduce vapor intrusion risk. Supports addressing RAO for future vapor intrusion risk.	Readily implementable for new construction and applicable for soil gas contaminant concentrations that exceed risk criteria for indoor workers.	Low	Y (for future structures where VI risk exists)

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REMEDIAL TECHNOLOGY SCREENING
EAST END GAS WORKS SITE
CINCINNATI, OHIO

General Response Action	Technology/Approach	Description	Screening Criteria: Effectiveness	Screening Criteria: Technical and Administrative Implementability	Screening Criteria: Relative Cost	Retained (Y/N)
Containment	Vertical Barrier Wall	Low permeability wall installed by excavating trench supported by bentonite slurry and backfilling with a low permeability material (or other suitable construction methods such as sheet pile walls) to prevent lateral NAPL migration and intercept and/or redirect groundwater flow for containment, collection, or controlled discharge.	Effective in mitigating future migration of NAPL and redirecting groundwater flow. Verification of wall continuity would be required during construction. The technical limitations to wall continuity would limit its effectiveness at this site.	Administratively, this would not be implementable due to the sensitive, critical infrastructure at the southern edge of the site that is very vibration sensitive. This would limit the areas where a vertical barrier wall could be installed. The depth of the wall (up to 110 feet) and the need to key in to the bedrock surface along which the NAPL has migrated poses significant technical challenges. The southern edge of the site adjacent to the riverbank contains fill and rubble, and there will likely be remnant MGP structures and piping that will pose challenges to constructing a continuous barrier wall.	High	N
	NAPL Recovery - Trench	Continuous permeable trench with NAPL collection piping and recovery risers to intercept DNAPL migration and allow for recovery by pumping.	Effective at intercepting NAPL in the outwash deposits, however, NAPL has also been observed in shallow fractured bedrock. The depth to bedrock would not be conducive to installing a trench into shallow bedrock. The technical limitations to trench continuity would limit its effectiveness at this site.	Administratively, this would not be implementable due to the sensitive, critical infrastructure at the southern edge of the site that is very vibration sensitive. This would limit the areas where a recovery trench could be installed. The depth of the trench (up to 110 feet) and the need to key in to the bedrock surface along which the NAPL has migrated poses significant technical challenges. The southern edge of the site adjacent to the riverbank contains fill and rubble, and there will likely be remnant MGP structures and piping that will pose challenges to constructing a NAPL recovery trench.	High	N

TABLE II
REMEDIAL TECHNOLOGY SCREENING
EAST END GAS WORKS SITE
CINCINNATI, OHIO

General Response Action	Technology/Approach	Description	Screening Criteria: Effectiveness	Screening Criteria: Technical and Administrative Implementability	Screening Criteria: Relative Cost	Retained (Y/N)
Containment	NAPL Recovery - Wells (Passive or Active)	Extraction wells used to bail or pump separate phase DNAPL to the surface for collection and offsite disposal.	Effective at reducing volume of NAPL and intercepting potentially mobile NAPL in the vicinity of the well. Supports addressing NAPL migration RAO. Assessment of NAPL recoverability and zones of potential migration necessary for NAPL recovery wells to be effective and to determine whether active or passive recovery is appropriate. NAPL recovery well effectiveness will be limited in the southern portion of the site where existing sensitive, critical infrastructure limits the locations where well could be installed.	Construction of the recovery wells is implementable with local contractor and materials, and would have minimal impact on existing site structures and activities. Recovery wells can be installed into bedrock in some areas of the site. Ability to recover NAPL may be limited in the area of sensitive, critical infrastructure due to vibration concerns. The NAPL recovery program will likely require long term operation and maintenance.	Low to Moderate	Y
Removal	Shallow Excavation	Excavation of soil and subsurface structures containing OLM and/or TLM above the water table. Excavated soils transported off-site for local permitted landfill disposal.	Effective at reducing toxicity, mobility, and volume of contaminated media. Supports addressing RAOs for all media.	Excavation is an easily implementable technology, however, the difficulty increases with increasing depth, excavation below the water table, and the presence of known and unknown subsurface obstructions which can hamper shoring system installation. Off-site disposal facilities are available to accept the excavated soil, however, daily facility acceptance capacity can reduce productivity. Excavation above the water table is known to be implementable at the site as a similar approach was previously used for remediation of a portion of the West Parcel, however, river flooding potential and gas plant operations restrictions can limit available construction periods. Due to active facility operations and active subsurface infrastructure on the Middle Parcel, excavation activities would need to be phased to accommodate infrastructure protection and/or relocation and continued facility operations.	Moderate to High	Y

TABLE II
REMEDIAL TECHNOLOGY SCREENING
EAST END GAS WORKS SITE
CINCINNATI, OHIO

General Response Action	Technology/Approach	Description	Screening Criteria: Effectiveness	Screening Criteria: Technical and Administrative Implementability	Screening Criteria: Relative Cost	Retained (Y/N)
	Deep Excavation	Excavation of soil containing OLM below the water table. Excavated soils transported off-site for local permitted landfill disposal.	Effective at reducing toxicity, mobility, and volume of contaminated media. Supports addressing RAOs for all media.	Excavation of OLM-impacted soils below the water table to bedrock (40-110 ft bgs) is not administratively practical due to the presence of sensitve, critical infrastructure at the site. Technically, deep excavations below the water table require significant shoring and dewatering operations which can result in adjacent ground movements and affects on nearby buildings and sensitive, critical infrastructure. River flooding potential and the depth of excavations represent a high safety hazard to site workers involved in the excavation and shoring operations. Due to active facility operations and active subsurface infrastructure on the Middle Parcel, excavation activities would need to be phased to accommodate infrastructure protection and/or relocation and continued facility operations.	High	N
Treatment	In-Situ Solidification (ISS) via Auger Soil Mixing - Shallow	Mix OLM/TLM-impacted soil within the fill and clay layers to depths up to 60 feet in-situ with solidifying reagents using large diameter augers to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a solidified matrix with limited groundwater contact.	ISS has been effectively applied at another local MGP site in Cincinnati in similar fill and clay strata, and depths to 60 feet are generally achievable in similar soil types. ISS of OLM/TLM impacted soils to the outwash layer is an effective means of eliminating the NAPL phase, mitigating the potential for OLM/TLM migration and limiting leaching of contaminants to groundwater.	ISS is technically and administratively feasible and is a commonly used treatment technology on MGP sites. Qualified contractors and equipment are available regionally. Subsurface obstructions and structures could limit the suitability of this equipment in some areas or require prior removal of obstructions or structures. Due to active facility operations and active subsurface infrastructure on the Middle Parcel, excavation activities would need to be phased to accommodate infrastructure protection and/or relocation and continued facility operations.	Moderate	Y

TABLE II
REMEDIAL TECHNOLOGY SCREENING
EAST END GAS WORKS SITE
CINCINNATI, OHIO

General Response Action	Technology/Approach	Description	Screening Criteria: Effectiveness	Screening Criteria: Technical and Administrative Implementability	Screening Criteria: Relative Cost	Retained (Y/N)
	ISS via Auger Soil Mixing - Deep	Mix OLM-impacted soil within the outwash layer to depths up to 110 feet in-situ with solidifying reagents using large diameter augers to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a solidified matrix with limited groundwater contact.	ISS is effective at treating sand and gravel soils containing OLM, however, would be of limited effectiveness at this site due to technical limitations with implementation. The intermittent lenses of OLM in the outwash soils would require treatment of large zones of overlying clean soil to reach deep OLM lenses.	ISS of sand and gravel soils below 60 feet using soil mix augers is challenging and requires a site-specific drilling evaluation. Smaller diameter augers and large amounts of drilling fluids (grout) are typically required to achieve these depths, resulting in greater than 50% spoils generation.	High	N
Treatment	ISS via Jet Grouting - Deep	Mix OLM/TLM-impacted soil within the within the outwash layer to depths up to 110 feet in-situ with solidifying reagents using jet grouting to reduce permeability and reduce water contact with contaminated soils, thereby containing the impacted soils in a solidified matrix with limited groundwater contact.	ISS via jet-grout is not an effective means of mitigating deep product impacts due to the infeasibility of locating and targeting the thin disconnected lenses of product in the outwash at the site.	Jet grouting of deep impacts is considered to be administratively feasible but technically infeasible. Jet grouting results in large spoils volumes and can be difficult to achieve complete horizontal and vertical treatment of deep zones with varying soil gradations.	High	N
	In-Situ Thermal Treatment of OLM/TLM-Impacted Soil	An electrical current is passed between arrays of electrodes (electrical resistance heating) or heat is applied directly through wells and radiates outward (thermal conductive heating) for the purpose of heating the subsurface. The resultant heat reduces the viscosity of the DNAPL, reduces the residual saturation, and volatilizes contaminants. Groundwater and NAPL are recovered as treatment progresses.	For impacted soils above the water table, thermal treatment can destroy organic compounds as temperatures above the boiling point of water can be achieved. Below the water table, thermal treatment is limited to the boiling point of water and enhanced recovery of NAPL, but non-volatile organic compound destruction is limited. Proximity to the river and high water table fluctuation potential may limit the effectiveness of this technology and may present increased risks for contaminant migration to the river during treatment.	Thermal treatment is not considered to be implementable at this site due to the active gas infrastructure present over large portions of the Middle Parcel. Additionally, heating of large volumes of varying fill and clay soils over extended periods presents potential settlement issues and associated risks to structures and active gas piping.	High	N

TABLE III
DETAILED ALTERNATIVES ANALYSIS
EAST END GAS WORKS SITE
CINCINNATI, OHIO

Criteria		Alternative 1: No Action			Alternative 2: Durable Covers, Institutional and Engineering Controls and Groundwater Monitoring			Alternative 3: OLM/TLM Excavation in Construction Worker Zone, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring			Alternative 4: OLM/TLM Excavation to Water Table, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring			Alternative 5: In-Situ Solidification, NAPL Monitoring and Recovery, Institutional and Engineering Controls and Groundwater Monitoring		
THRESHOLD CRITERIA																
Overall Protection of Human Health and the Environment		• Does not mitigate potential risks to human health • Does not mitigate potential risks to the environment		0	• Reduces risk to human health by controlling exposure to impacted media on-site. • Presence of NAPL is not mitigated, and impacts to groundwater by site contaminants are not mitigated, therefore, this alternative is not protective of the environment.		1	• Reduces risk to human health by controlling exposure to impacted media on-site. OLM/TLM is eliminated from the construction worker zone • Approximately 70% of OLM/TLM impacted soil will remain below the construction worker zone, resulting in continued long-term leaching to groundwater. Migration of residual NAPL is mitigated through installation of NAPL recovery wells. This alternative partially addresses protection of the environment.		2	• Reduces risk to human health by controlling exposure to impacted media on-site. OLM/TLM is eliminated from the construction worker zone • NAPL impacts will be mostly mitigated through excavation; however, approximately 15% of OLM/TLM impacted soil will remain below the construction worker zone, resulting in continued long-term leaching to groundwater. Migration of residual NAPL is mitigated through installation of NAPL recovery wells. This alternative mostly addresses protection of the environment.		3	• Reduces risk to human health by controlling exposure to impacted media on-site. OLM/TLM is eliminated from the construction worker zone, and is treated in the vadose zone and up to 20 feet into the saturated zone. • NAPL impacts will be substantially mitigated through excavation and treatment; however, approximately 10% of OLM/TLM impacted soil will remain below the treatment zone, resulting in potential long-term leaching to groundwater. Migration of residual NAPL is mitigated through installation of NAPL recovery wells. This alternative substantially addresses protection of the environment.		4
Compliance with RAOs and Applicable VAP Standards	• Mitigate exposure that exceeds applicable standards for site workers, trespassers, and construction workers	• Does not mitigate potential exposure for for site workers, trespassers, or construction workers to soil exceeding VAP Commercial/Industrial GNS	0	0	• Alternative partially mitigates potential risk of exposure through the implementation of an engineered cover • Potential risk of exposure to construction workers conducting intrusive work remains	1	1.4	• Risk of exposure is mitigated through the excavation of impacted soils within the potential construction worker zone (top 10')	4	2.8	• Risk of exposure is mitigated through the excavation of all impacted soils within the potential construction worker zone	4	3.2	• Risk of exposure is mitigated through the excavation and of all impacted soils, and any potential solidified soils, within the potential construction worker zone	4	3.6
	• Mitigate the potential for future vapor intrusion risks	• Does not include any measures to mitigate potential future vapor intrusion risks	0		• Reduces potential future vapor intrusion risks through the implementation of institutional controls, but future structures may require vapor mitigation controls due to residual contamination	2		• Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation of potential source material within the top 10'	4		• Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation of potential source material within the top 40'	4		• Reduces potential future vapor intrusion risks through the implementation of institutional controls and excavation and solidification of potential source material within the top 60'	4	
	• Mitigate potential for COCs in soil to leach to groundwater	• Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0		• Does not reduce, treat, or contain source material that has the potential to leach COCs to groundwater	0		• Slightly reduces potential for COCs to leach to groundwater through the excavation of source material in the top 10'; however, residual contamination deeper than 10' may continue to act as a source of potential groundwater contamination	1		• Reduces potential for COCs to leach to groundwater through the excavation of source material in the top 40'; however, residual contamination deeper than 40' may continue to act as a source of potential groundwater contamination	2		• Reduces potential for COCs to leach to groundwater through the excavation and solidification of source material in the top 60'; however, residual contamination deeper than 60' may continue to act as a source of potential groundwater contamination	3	
	• Mitigate NAPL impacts to groundwater and the potential for migration of NAPL off-site	• Does not reduce, treat, or contain NAPL	0		• Does not reduce, treat, or contain NAPL	0		• Slightly reduces potential for NAPL migration by removing source material in the top 10', potentially mobile NAPL below 10' will remain	1		• Reduces potential for NAPL migration by removing source material in the top 40', potentially mobile NAPL below 40' will remain	2		• Reduces potential for NAPL migration by removing source material in the top 40', potentially mobile NAPL below 60' will remain	3	
	• Mitigate potential future exposure to impacted groundwater for potable and non-potable uses	• Alternative does not include any measures to mitigate potential future exposure to groundwater	0		• Through the implementation of institutional controls, including deed restrictions, this alternative substantially mitigates potential future exposure to impacted groundwater	4		• Through the implementation of institutional controls, including deed restrictions, this alternative substantially mitigates potential future exposure to impacted groundwater	4		• Through the implementation of institutional controls, including deed restrictions, this alternative mitigates potential future exposure to impacted groundwater	4		• Through the implementation of institutional controls, including deed restrictions, this alternative mitigates potential future exposure to impacted groundwater	4	
THRESHOLD CRITERIA COMBINED SCORE				0			2.4			4.8			6.2			7.6
BALANCING CRITERIA																
Long-term Effectiveness		• This alternative is ineffective at reducing long-term risks to human health and the environment since no remedial actions are implemented		0	• Exposure to impacted soil and groundwater by site workers is effectively controlled by institutional controls. A Risk Management Plan is used to manage construction worker exposure to OLM/TLM-impacted soils. Long-term source reduction and leaching to groundwater is not accomplished with this alternative.		1	• Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls and partial source removal. NAPL recovery is implemented to remove mobile NAPL, where feasible. Long-term source reduction and leaching to groundwater is partially mitigated with this alternative.		2	• Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls and partial source removal. NAPL recovery is implemented to remove mobile NAPL, where feasible. Long-term source reduction and leaching to groundwater is mostly mitigated with this alternative.		3	• Exposure to impacted soil and groundwater by site workers and construction workers is effectively controlled by institutional controls and partial source removal. NAPL recovery is implemented to remove mobile NAPL, where feasible. Long-term source reduction and leaching to groundwater is substantially mitigated with this alternative.		4
Reduction of Toxicity, Mobility, or Volume Through Removal or Treatment		• No removal or treatment is accomplished in this alternative	0	0	• Removal of impacted surface soils driving the current site worker risk is accomplished in this alternative. No NAPL recovery is implemented to remove mobile NAPL, so potential NAPL migration off-site is not addressed. No removal or treatment of OLM/TLM-impacted soil is accomplished in this alternative.	1	0.5	• Removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative. NAPL recovery is implemented to remove mobile NAPL, where feasible. While this alternative removes OLM/TLM impacted soils within the top 10', approximately 70% of OLM/TLM impacted soil will remain as a source of leaching to groundwater.	1	1	• Removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative. NAPL recovery is implemented to remove mobile NAPL, where feasible. While a significant volume of OLM/TLM-impacted soil in the vadose zone is removed in this alternative, approximately 15% of OLM/TLM impacted soil will remain as a source of leaching to groundwater.	3	3	• Removal of impacted soils driving the current site worker and construction worker risks is accomplished in this alternative. NAPL recovery is implemented to remove mobile NAPL, where feasible. A significant volume of OLM/TLM-impacted soil in the vadose zone and up to 20 feet into the saturated zone is removed or treated in this alternative, approximately 10% of OLM/TLM impacted soil will remain as a source to groundwater.	4	4
		% of OLM/TLM Impacted Soil Treated/Removed: 0%	0		% of OLM/TLM Impacted Soil Treated/Removed: 0%	0		% of OLM/TLM Impacted Soil Treated/Removed: 30%	1		% of OLM/TLM Impacted Soil Treated/Removed: 85%	3		% of OLM/TLM Impacted Soil Treated/Removed: 90%	4	
Short-term Effectiveness		• No impacts to community, workers, or environment associated with implementation of this alternative, however, current site risks are not addressed with this alternative as no remedial actions are implemented.		1	• Minimal impacts to community, workers, and environment associated with construction of durable covers adjacent to Pittsburgh Street. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the Site is addressed through groundwater use restrictions. However, OLM/TLM in soil, NAPL, and impacts to groundwater are not addressed in this alternative.		2	• Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers during excavation of impacted soils. This alternative requires off-site transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the Site is addressed through groundwater use restrictions.		2	• Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers and construction workers during excavation of impacted soils. This alternative requires off-site transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the Site is addressed through groundwater use restrictions.		1	• Implementation of this alternative will require close coordination with facility operations both for construction logistics and sequencing and for health and safety protection of site workers and construction workers during excavation and solidification of impacted soils. This alternative requires off-site transport of contaminated soils. Current risks to site workers are immediately addressed by implementation of this alternative. Potential exposure to impacted groundwater at the Site is addressed through groundwater use restrictions.		2
Implementability		• No action is highly implementable		4	• Placement of durable covers and establishment of institutional controls are highly implementable activities.		4	• Placement of durable covers and establishment of institutional controls are highly implementable activities. Active or passive NAPL recovery from wells is an established technology for MGP sites. Excavation to 15 feet is above the water table; however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative.		3	• Placement of durable covers and establishment of institutional controls are highly implementable activities. Active or passive NAPL recovery from wells is an established technology for MGP sites. Excavation to 40 feet is above the water table, however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative. River flooding potential between November and May will likely limit allowable construction timeframes for deep excavations.		1	• Placement of durable covers and establishment of institutional controls are highly implementable activities. Active or passive NAPL recovery from wells is an established technology for MGP sites. Excavation to 20 feet is above the water table, however, given the active site operations, gas infrastructure, and buildings, phased excavation and backfill and excavation shoring systems will be necessary to implement this alternative. ISS of OLM/TLM in soil between 20-60 ft bgs is achievable with standard ISS equipment, however, river flooding potential between November and May may limit allowable construction timeframes for ISS within a 20-ft excavation.		2
Community Acceptance		• This alternative presents no construction impacts to the community, however long-term site risks are not addressed		0	• This alternative presents minimal construction impacts to the community, however, long-term site risks are only partially addressed		1	• This alternative presents minor construction impacts to the community during contaminated soil excavation, however, long-term site risks are only partially addressed.		2	• This alternative presents moderate construction impacts to the community during contaminated soil excavation and hauling, however, long-term site risks are reduced by the extent of source removal accomplished.		1	• This alternative presents moderate construction impacts to the community during contaminated soil excavation and hauling (but less than Alternative 4), however, long-term site risks are reduced by the extent of source removal accomplished.		2
Cost		$ 0.0 M		4	$ 1.3 M		3	$ 10.3 M		2	$44.6M		1	$ 44.5M		1
BALANCING CRITERIA COMBINED SCORE				9			11.5			12			10			15.0

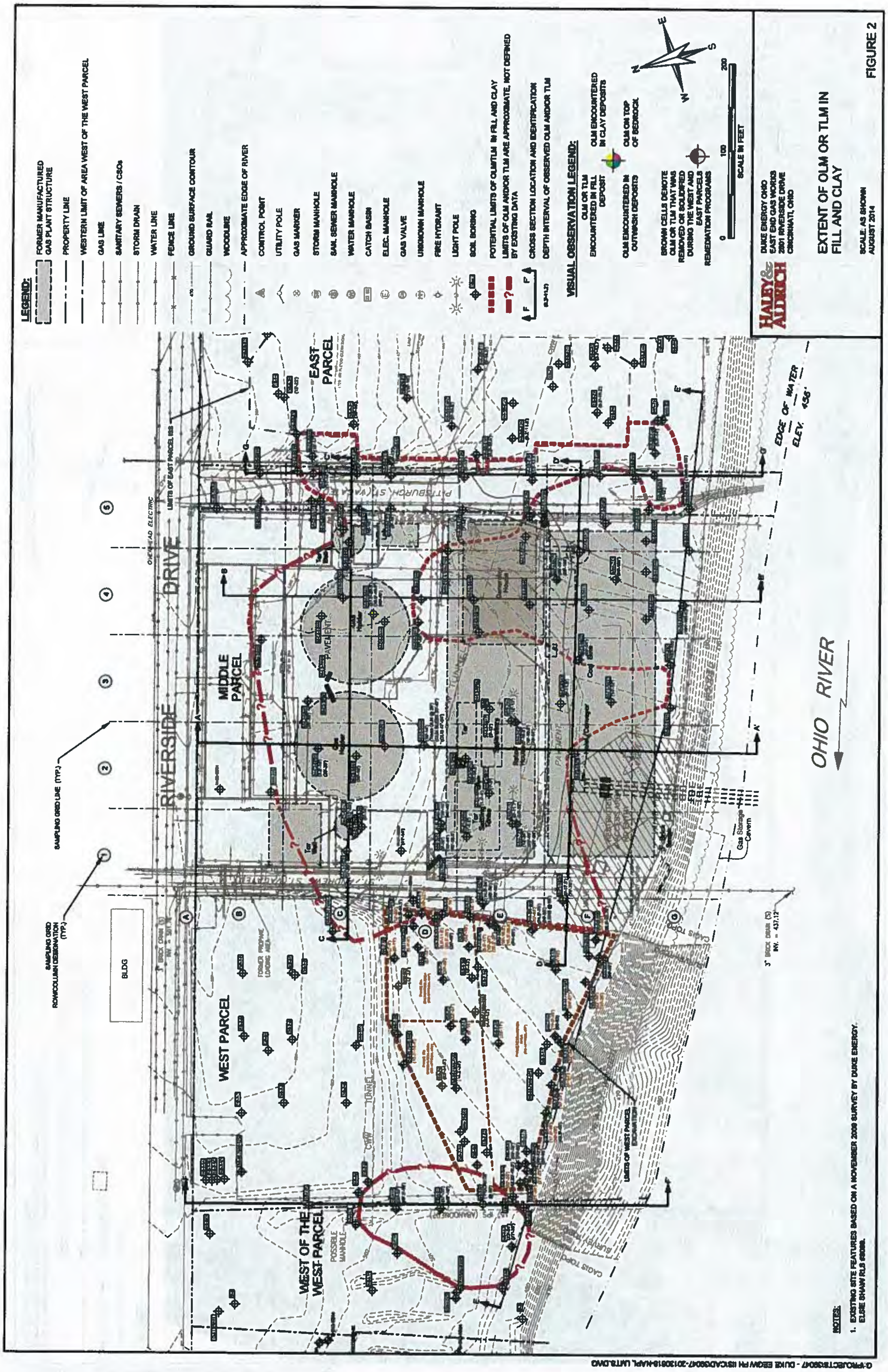
Scoring Key:

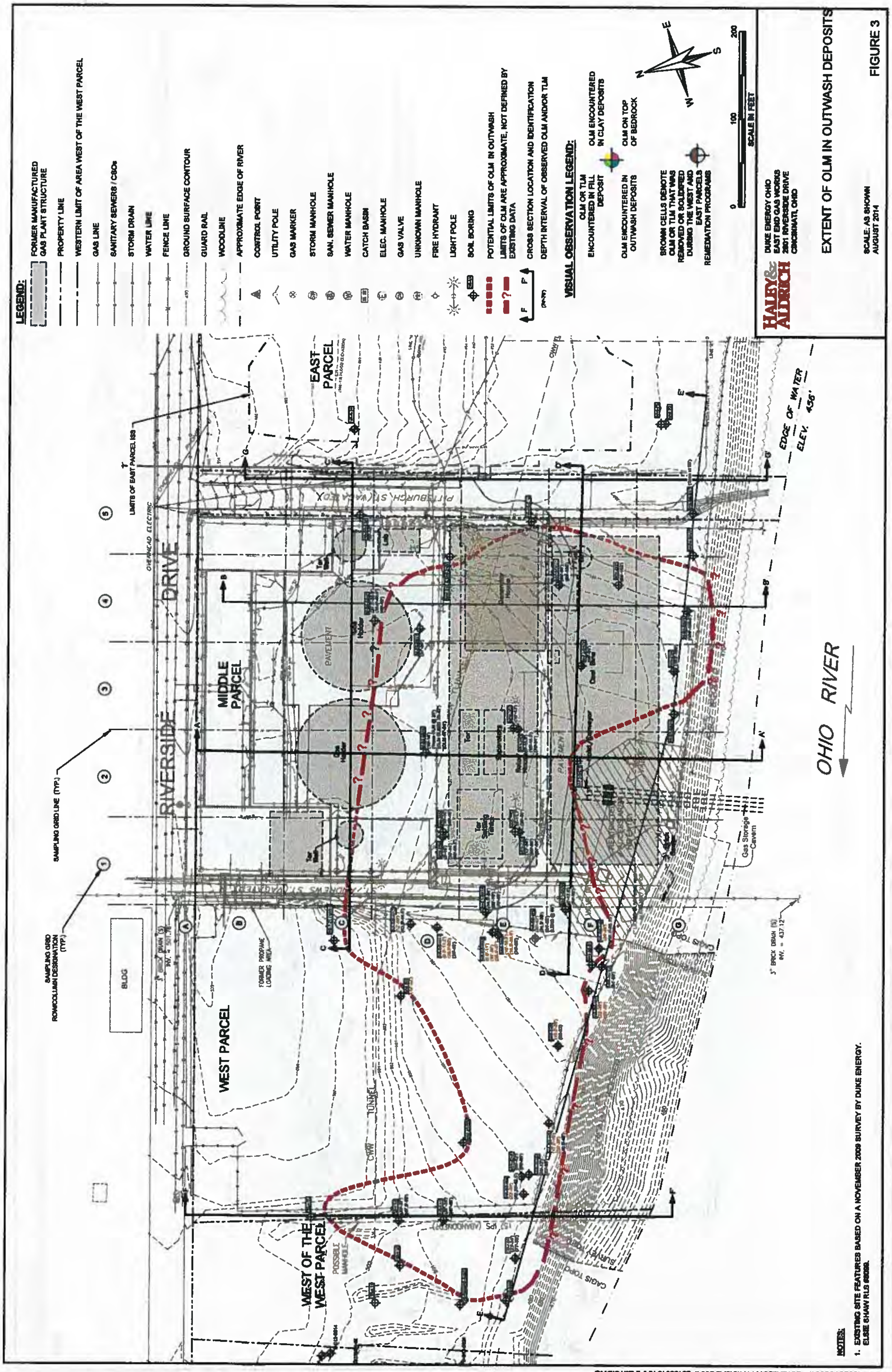
4	Alternative substantially meets/addresses criterion
3	Alternative mostly meets/addresses criterion
2	Alternative partially meets/addresses criterion
1	Alternative slightly meets/addresses criterion
0	Alternative does not meet/address criterion

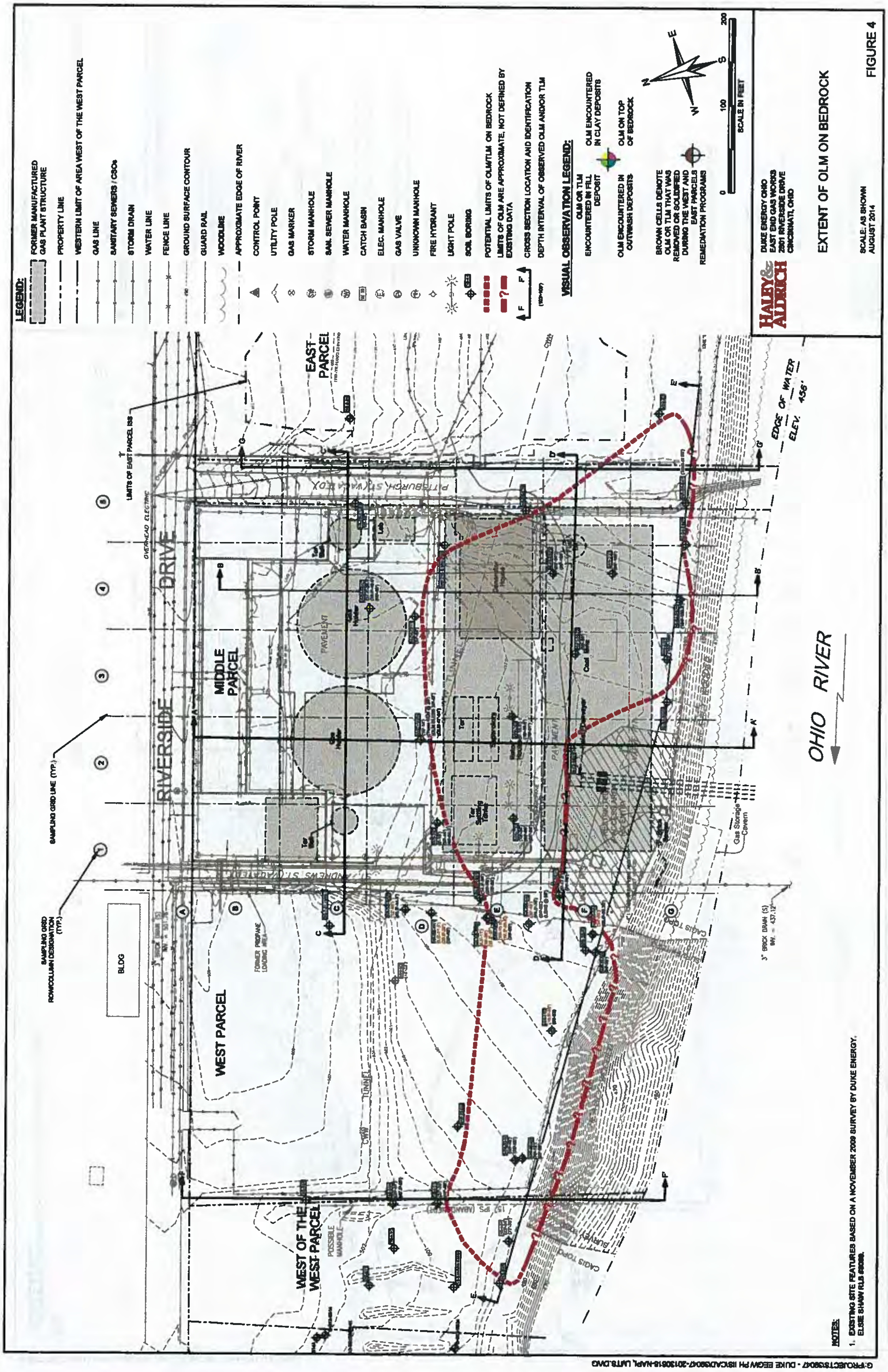
Note: See Section 4.1 for description of evaluation criteria.

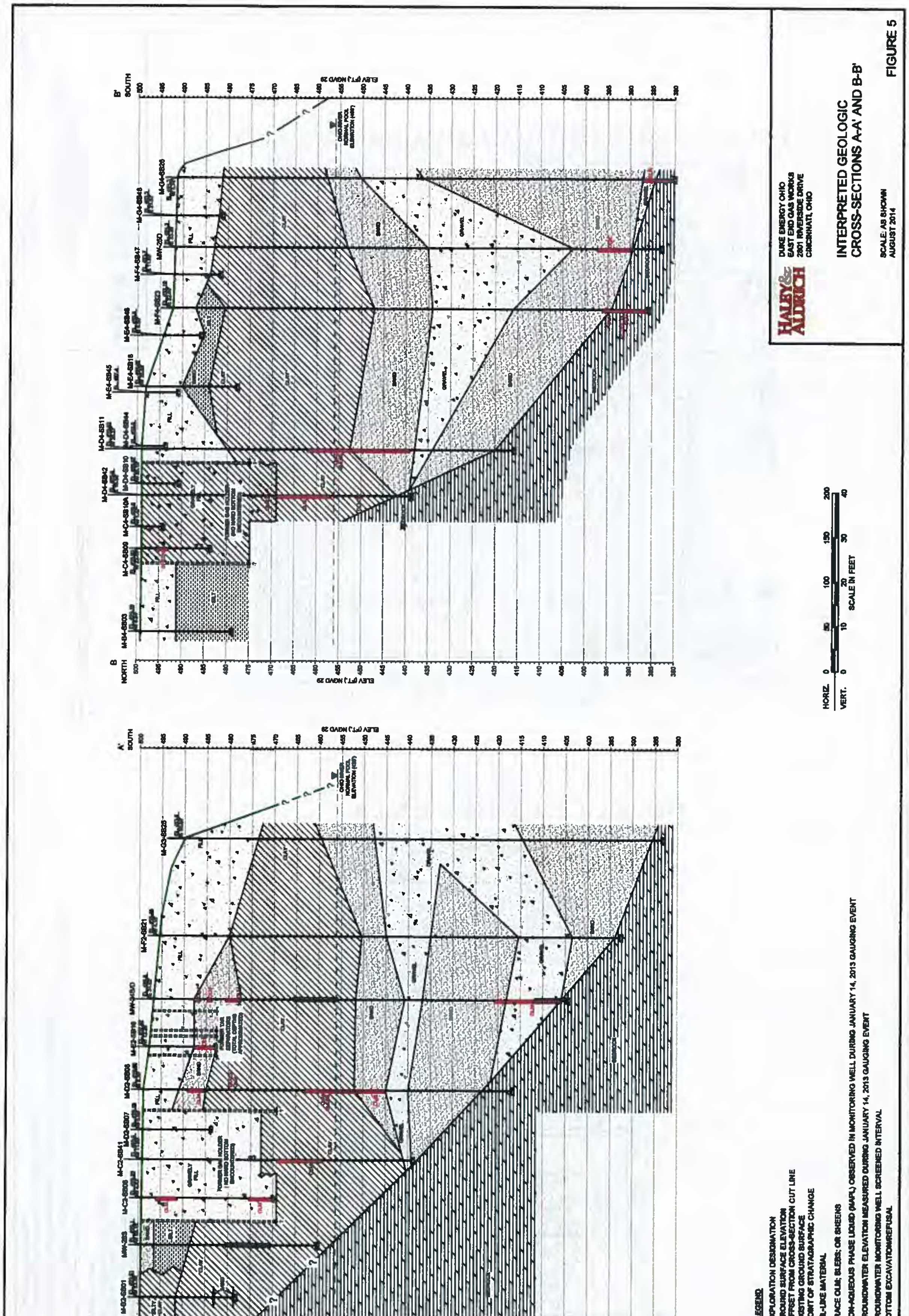
Haley Aldrich
G:\PROJECTS\[illegible] - Duke EEGW PH III\Remedial Alt Analysis\Tables\Table III Alternatives Analysis.xlsx

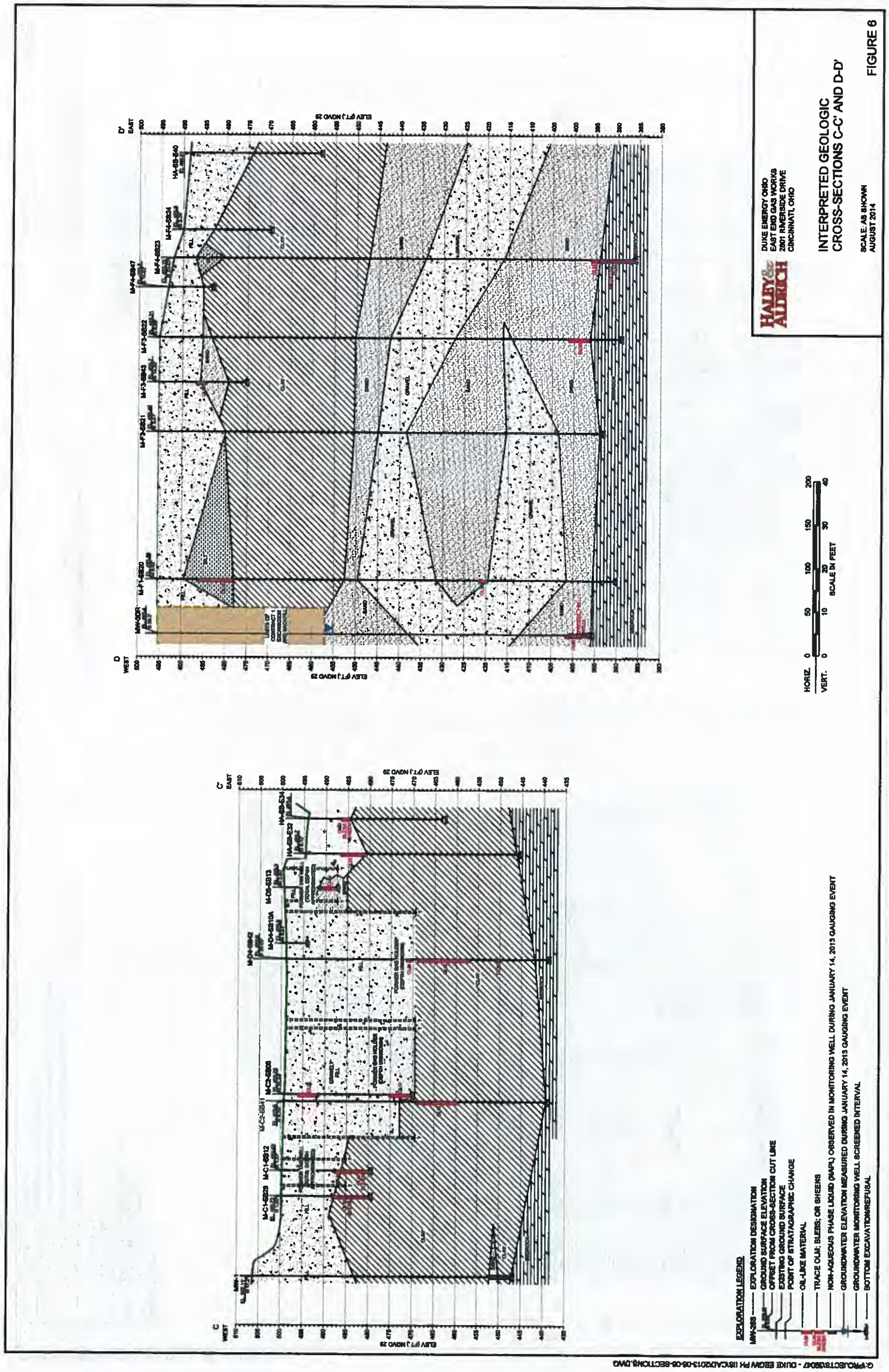

EAST PARCEL
MIDDLE PARCEL
WEST PARCEL
WEST OF THE WEST PARCEL
RIVERSIDE DRIVE
PITTSBURGH STREET (VACATED)
ST ANDREWS (VACATED)
MUNSON ST
OHIO RIVER
Fence
LEGEND:
FENCE
DUKE PROPERTY LIMIT
LIMITS OF FORMER RIVERSIDE DRIVE PROPERTY STREETS
WESTERN LIMIT OF AREA WEST OF THE WEST PARCEL
SCALE IN FEET
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2801 RIVERSIDE DRIVE
CINCINNATI, OHIO
SITE PLAN
SCALE: AS SHOWN
JUNE 2014
FIGURE 1

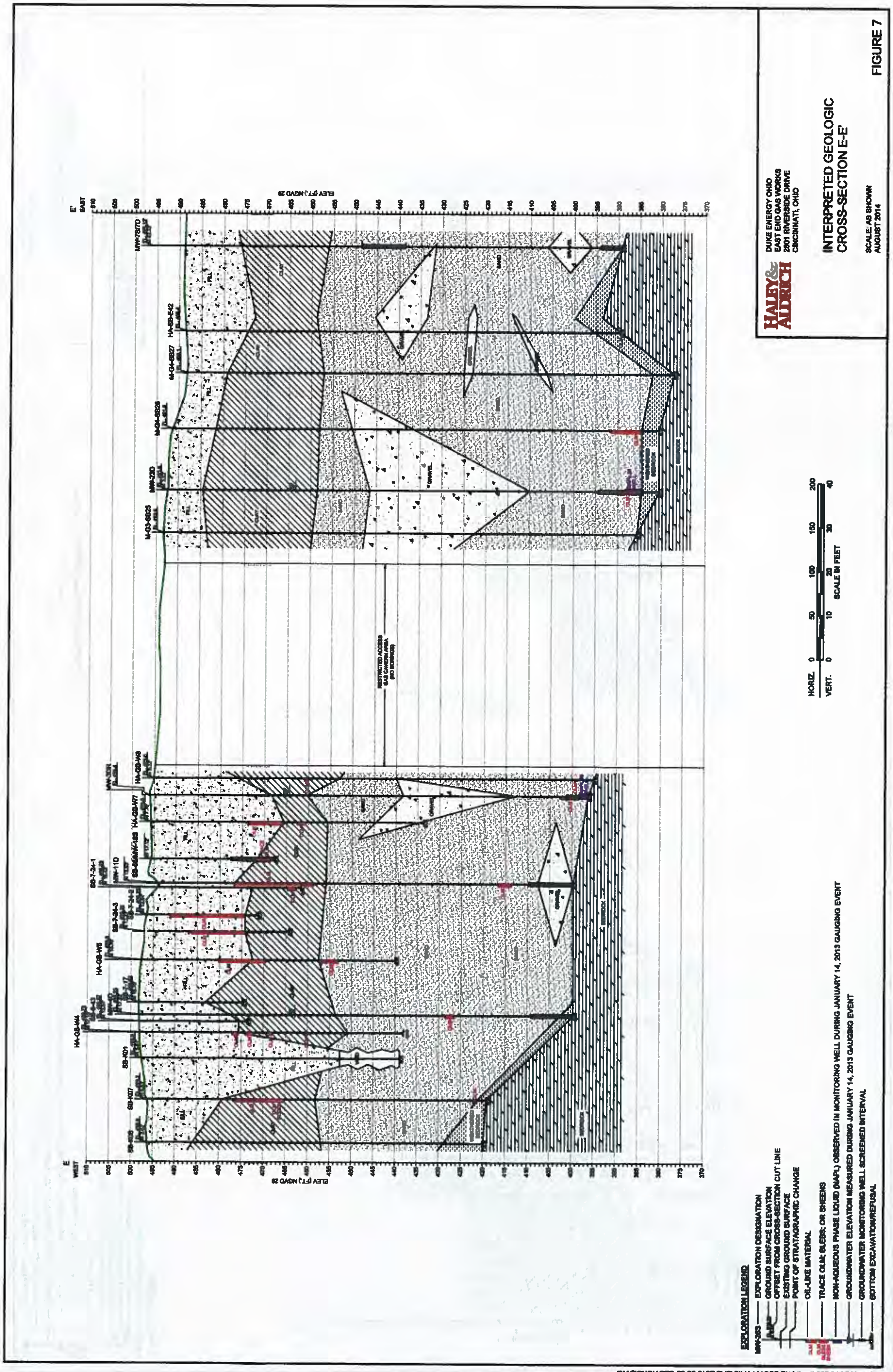

LEGEND:
FORMER MANUFACTURED GAS PLANT STRUCTURE
PROPERTY LINE
WESTERN LIMIT OF AREA WEST OF THE WEST PARCEL
GAS LINE
SANITARY SEWERS / CSOs
STORM DRAIN
WATER LINE
FENCE LINE
GROUND SURFACE CONTOUR
GUARD RAIL
WOODLINE
APPROXIMATE EDGE OF RIVER
CONTROL POINT
UTILITY POLE
GAS MARKER
STORM MANHOLE
SAN. SEWER MANHOLE
WATER MANHOLE
CATCH BASIN
ELEC. MANHOLE
GAS VALVE
UNKNOWN MANHOLE
FIRE HYDRANT
LIGHT POLE
SOIL BORING
POTENTIAL LIMITS OF OLM/TLM IN FILL AND CLAY
LIMITS OF OLM AND/OR TLM ARE APPROXIMATE, NOT DEFINED BY EXISTING DATA
CROSS SECTION LOCATION AND IDENTIFICATION
DEPTH INTERVAL OF OBSERVED OLM AND/OR TLM
VISUAL OBSERVATION LEGEND:
OLM OR TLM ENCOUNTERED IN FILL DEPOSIT
OLM ENCOUNTERED IN CLAY DEPOSITS
OLM ENCOUNTERED IN OUTWASH DEPOSITS
OLM ON TOP OF BEDROCK
BROWN CELLS DENOTE OLM OR TLM THAT WAS REMOVED OR SOLIDIFIED DURING THE WEST AND EAST PARCELS REMEDIATION PROGRAMS
SCALE IN FEET
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2801 RIVERSIDE DRIVE
CINCINNATI, OHIO
EXTENT OF OLM OR TLM IN FILL AND CLAY
SCALE: AS SHOWN
AUGUST 2014
FIGURE 2
RIVERSIDE DRIVE
WEST PARCEL
MIDDLE PARCEL
EAST PARCEL
WEST OF THE WEST PARCEL
BLDG
PAVEMENT
OHIO RIVER
EDGE OF WATER ELEV. 456'
Gas Storage Cavern
NOTES:
1. EXISTING SITE FEATURES BASED ON A NOVEMBER 2009 SURVEY BY DUKE ENERGY.

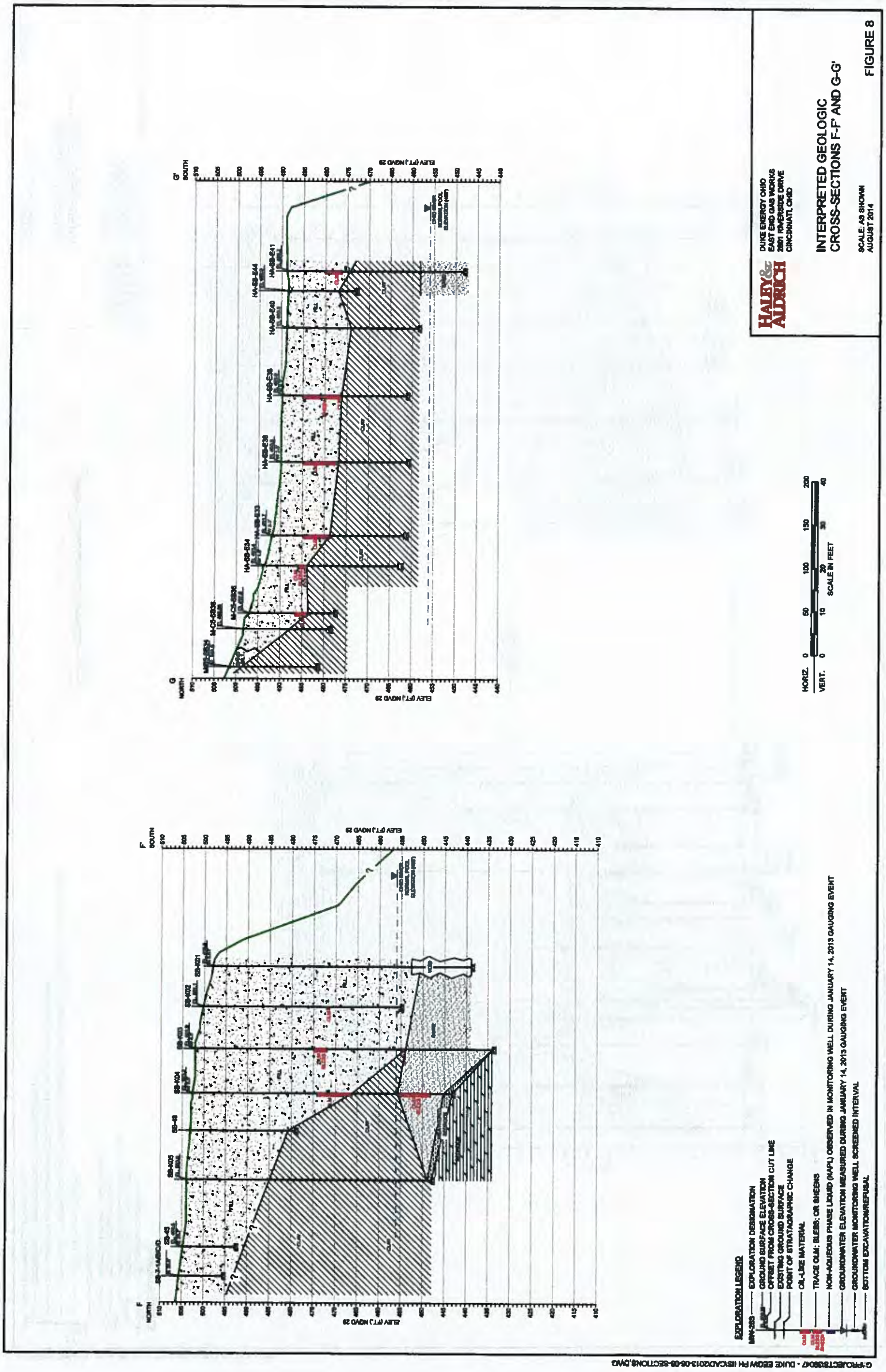

LEGEND:
FORMER MANUFACTURED GAS PLANT STRUCTURE
PROPERTY LINE
WESTERN LIMIT OF AREA WEST OF THE WEST PARCEL
GAS LINE
SANITARY SEWERS / CSOs
STORM DRAIN
WATER LINE
FENCE LINE
GROUND SURFACE CONTOUR
GUARD RAIL
WOODLINE
APPROXIMATE EDGE OF RIVER
CONTROL POINT
UTILITY POLE
GAS MARKER
STORM MANHOLE
SAN. SEWER MANHOLE
WATER MANHOLE
CATCH BASIN
ELEC. MANHOLE
GAS VALVE
UNKNOWN MANHOLE
FIRE HYDRANT
LIGHT POLE
SOIL BORING
POTENTIAL LIMITS OF OLM IN OUTWASH
LIMITS OF OLM ARE APPROXIMATE, NOT DEFINED BY EXISTING DATA
CROSS SECTION LOCATION AND IDENTIFICATION
DEPTH INTERVAL OF OBSERVED OLM AND/OR TLM
VISUAL OBSERVATION LEGEND:
OLM OR TLM ENCOUNTERED IN FILL DEPOSIT
OLM ENCOUNTERED IN CLAY DEPOSITS
OLM ENCOUNTERED IN OUTWASH DEPOSITS
OLM ON TOP OF BEDROCK
BROWN CELLS DENOTE OLM OR TLM THAT WAS REMOVED OR SOLIDIFIED DURING THE WEST AND EAST PARCELS REMEDIATION PROGRAMS
SCALE IN FEET
0
100
200
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
CINCINNATI, OHIO
EXTENT OF OLM IN OUTWASH DEPOSITS
SCALE: AS SHOWN
AUGUST 2014
FIGURE 3
RIVERSIDE DRIVE
WEST PARCEL
MIDDLE PARCEL
EAST PARCEL
WEST OF THE WEST PARCEL
OHIO RIVER
EDGE OF WATER ELEV. 456'
SAMPLING GRID LINE (TYP.)
SAMPLING GRID ROW/COLUMN DESIGNATION (TYP.)
LIMITS OF EAST PARCEL
OVERHEAD ELECTRIC
BLDG
FORMER PROPANE LOADING AREA
POSSIBLE MANHOLE
TUNNEL
PAVEMENT
Gas Holder
Gas Storage Cavern
NOTES:
1. EXISTING SITE FEATURES BASED ON A NOVEMBER 2009 SURVEY BY DUKE ENERGY.

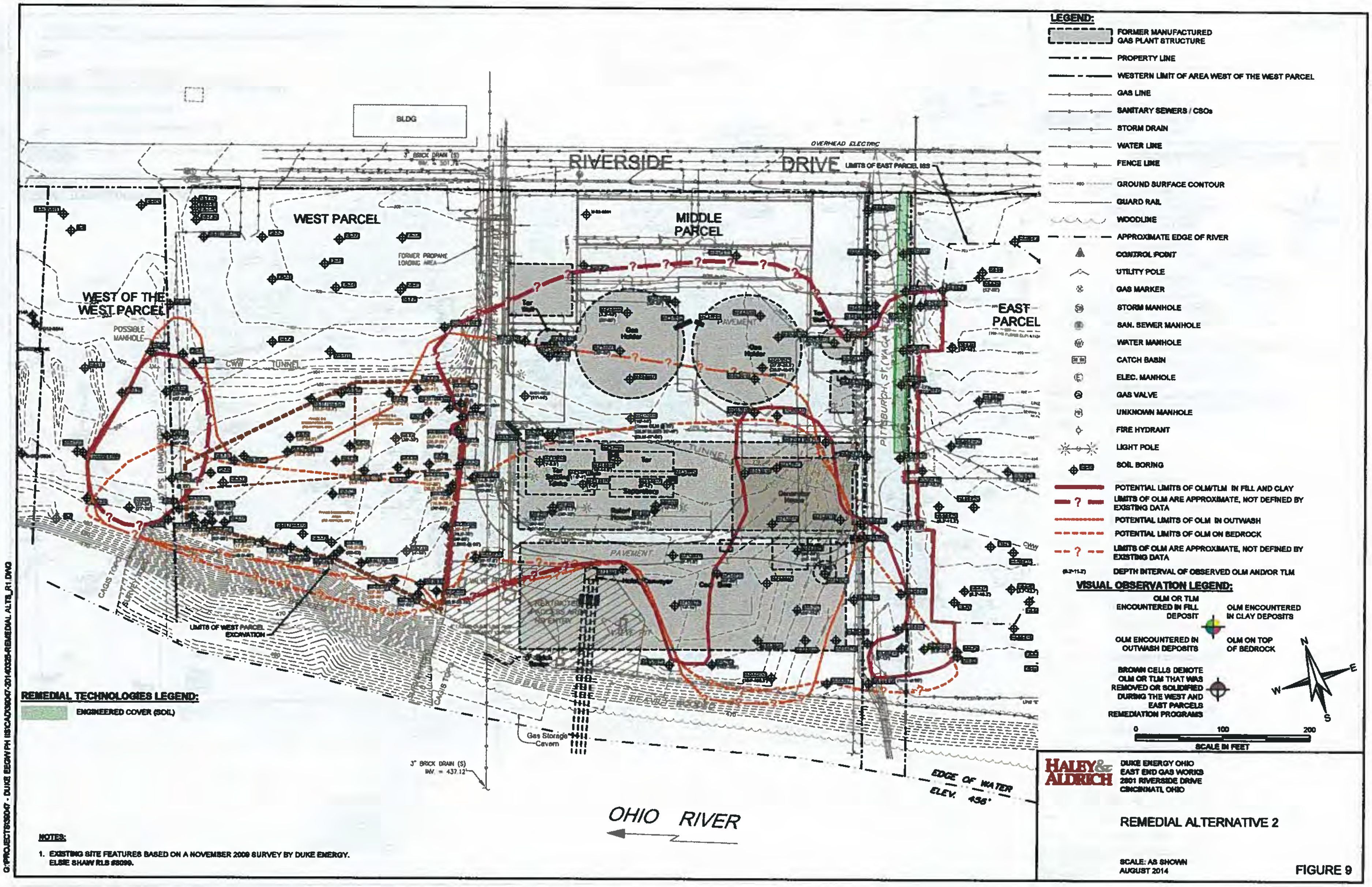

LEGEND:
FORMER MANUFACTURED GAS PLANT STRUCTURE
PROPERTY LINE
WESTERN LIMIT OF AREA WEST OF THE WEST PARCEL
GAS LINE
SANITARY SEWERS / CSOs
STORM DRAIN
WATER LINE
FENCE LINE
GROUND SURFACE CONTOUR
GUARD RAIL
WOODLINE
APPROXIMATE EDGE OF RIVER
CONTROL POINT
UTILITY POLE
GAS MARKER
STORM MANHOLE
SAN. SEWER MANHOLE
WATER MANHOLE
CATCH BASIN
ELEC. MANHOLE
GAS VALVE
UNKNOWN MANHOLE
FIRE HYDRANT
LIGHT POLE
SOIL BORING
POTENTIAL LIMITS OF OLM/TLM ON BEDROCK
LIMITS OF OLM ARE APPROXIMATE, NOT DEFINED BY EXISTING DATA
CROSS SECTION LOCATION AND IDENTIFICATION
DEPTH INTERVAL OF OBSERVED OLM AND/OR TLM
VISUAL OBSERVATION LEGEND:
OLM OR TLM ENCOUNTERED IN FILL DEPOSIT
OLM ENCOUNTERED IN CLAY DEPOSITS
OLM ENCOUNTERED IN OUTWASH DEPOSITS
OLM ON TOP OF BEDROCK
BROWN CELLS DENOTE OLM OR TLM THAT WAS REMOVED OR SOLIDIFIED DURING THE WEST AND EAST PARCELS REMEDIATION PROGRAMS
SCALE IN FEET
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2201 RIVERSIDE DRIVE
CINCINNATI, OHIO
EXTENT OF OLM ON BEDROCK
SCALE: AS SHOWN
AUGUST 2014
FIGURE 4
RIVERSIDE DRIVE
WEST PARCEL
MIDDLE PARCEL
EAST PARCEL
WEST OF THE WEST PARCEL
OHIO RIVER
EDGE OF WATER ELEV. 456'
SAMPLING GRID LINE (TYP.)
SAMPLING GRID ROW/COLUMN DESIGNATION (TYP.)
LIMITS OF EAST PARCEL ISS
BLDG
Gas Storage Cavern
NOTES:
1. EXISTING SITE FEATURES BASED ON A NOVEMBER 2009 SURVEY BY DUKE ENERGY.

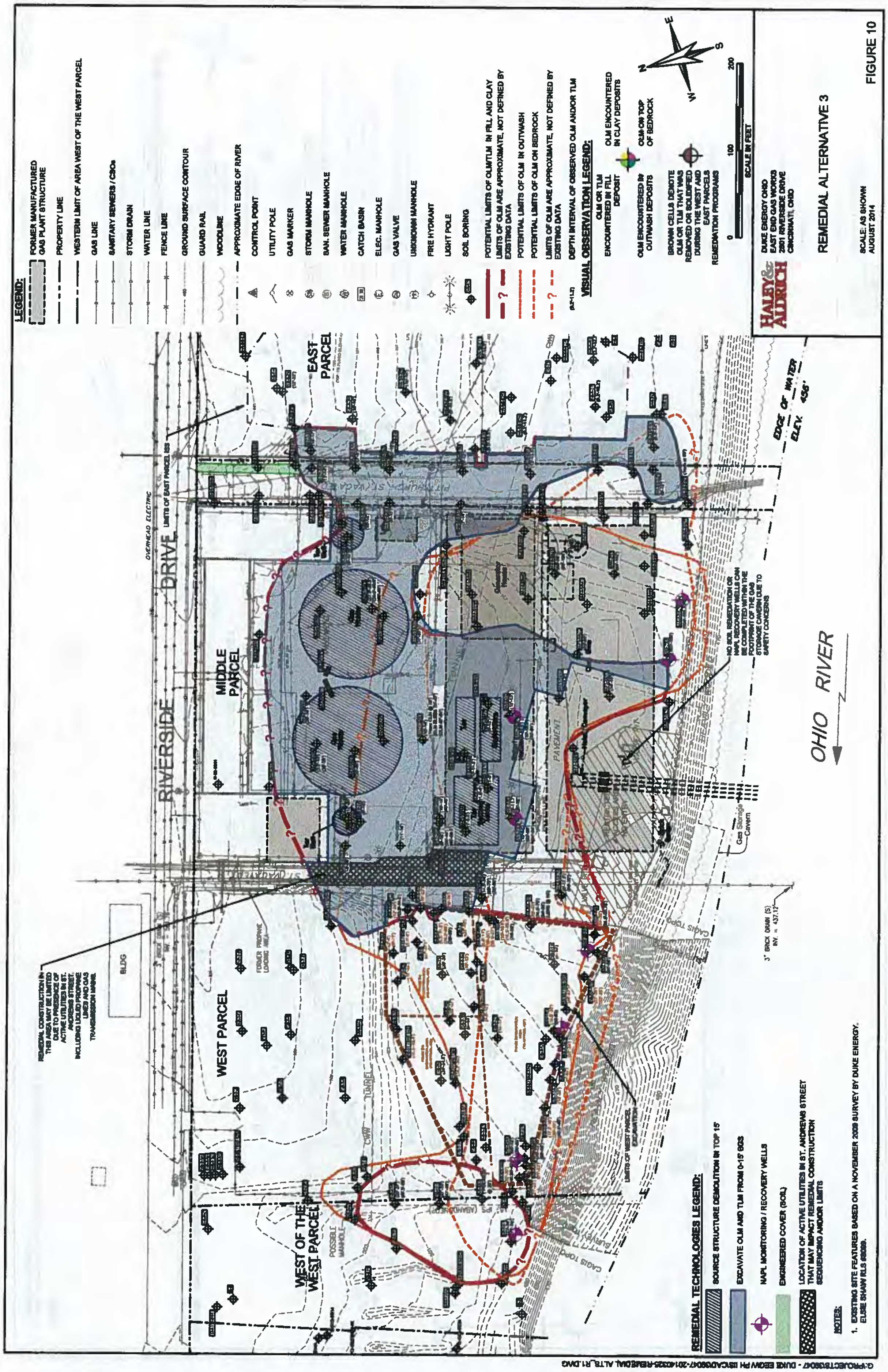

EXPLORATION LEGEND
EXPLORATION DESIGNATION
GROUND SURFACE ELEVATION
OFFSET FROM CROSS-SECTION CUT LINE
EXISTING GROUND SURFACE
POINT OF STRATIGRAPHIC CHANGE
OIL-LIKE MATERIAL
TRACE OLM; BLEBS; OR SHEENS
NON-AQUEOUS PHASE LIQUID (NAPL) OBSERVED IN MONITORING WELL DURING JANUARY 14, 2013 GAUGING EVENT
GROUNDWATER ELEVATION MEASURED DURING JANUARY 14, 2013 GAUGING EVENT
GROUNDWATER MONITORING WELL SCREENED INTERVAL
BOTTOM EXCAVATION/REFUSAL
SCALE IN FEET
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2501 RIVERSIDE DRIVE
CINCINNATI, OHIO
INTERPRETED GEOLOGIC CROSS-SECTIONS A-A' AND B-B'
SCALE: AS SHOWN
AUGUST 2014
FIGURE 5

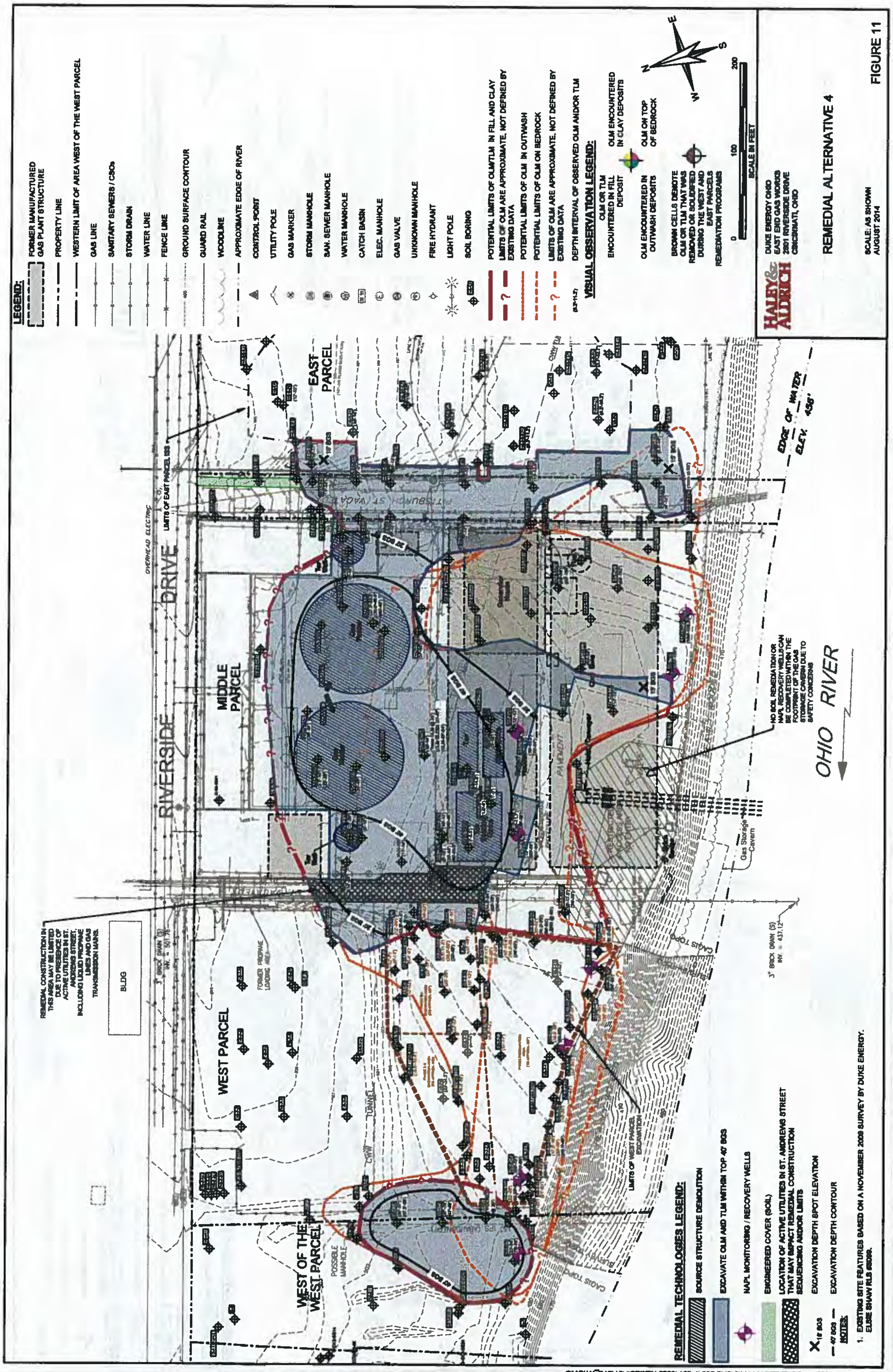

EXPLORATION LEGEND
EXPLORATION DESIGNATION
GROUND SURFACE ELEVATION
OFFSET FROM CROSS-SECTION CUT LINE
EXISTING GROUND SURFACE
POINT OF STRATAGRAPHIC CHANGE
OIL-LIKE MATERIAL
TRACE OLM; BLEBS; OR SHEENS
NON-AQUEOUS PHASE LIQUID (NAPL) OBSERVED IN MONITORING WELL DURING JANUARY 14, 2013 GAUGING EVENT
GROUNDWATER ELEVATION MEASURED DURING JANUARY 14, 2013 GAUGING EVENT
GROUNDWATER MONITORING WELL SCREENED INTERVAL
BOTTOM EXCAVATION/REFUSAL
HORIZ.
VERT.
SCALE IN FEET
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2801 RIVERSIDE DRIVE
CINCINNATI, OHIO
INTERPRETED GEOLOGIC
CROSS-SECTIONS C-C' AND D-D'
SCALE: AS SHOWN
AUGUST 2014
FIGURE 6

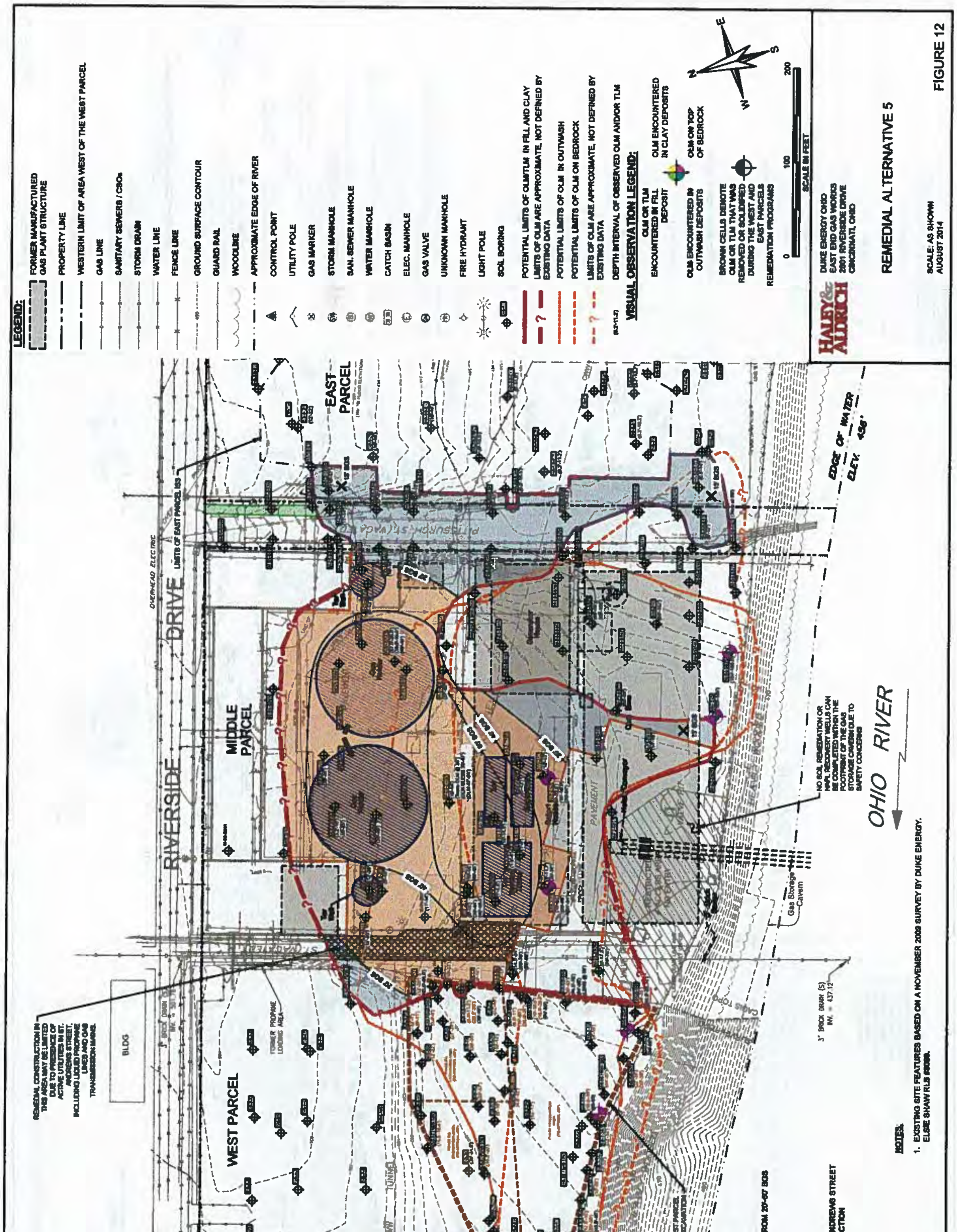

DUKE ENERGY OHIO
EAST END GAS WORKS
2001 RIVERSIDE DRIVE
CINCINNATI, OHIO
INTERPRETED GEOLOGIC
CROSS-SECTION E-E'
SCALE: AS SHOWN
AUGUST 2014
FIGURE 7
EXPLORATION LEGEND
EXPLORATION DESIGNATION
GROUND SURFACE ELEVATION
OFFSET FROM CROSS-SECTION CUT LINE
EXISTING GROUND SURFACE
POINT OF STRATIGRAPHIC CHANGE
OIL-LIKE MATERIAL
TRACE OIL; BLEBS; OR SHEENS
NON-AQUEOUS PHASE LIQUID (NAPL) OBSERVED IN MONITORING WELL DURING JANUARY 14, 2013 GAUGING EVENT
GROUNDWATER ELEVATION MEASURED DURING JANUARY 14, 2013 GAUGING EVENT
GROUNDWATER MONITORING WELL SCREENED INTERVAL
BOTTOM EXCAVATION/REFUSAL
HORIZ.
VERT.
SCALE IN FEET
ELEV (FT.) NGVD 29
WEST
EAST
E
E'


HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2801 RIVERSIDE DRIVE
CINCINNATI, OHIO
INTERPRETED GEOLOGIC CROSS-SECTIONS F-F' AND G-G'
SCALE: AS SHOWN
AUGUST 2014
FIGURE 8
EXPLORATION LEGEND
SCALE IN FEET


LEGEND:
FORMER MANUFACTURED GAS PLANT STRUCTURE
PROPERTY LINE
WESTERN LIMIT OF AREA WEST OF THE WEST PARCEL
GAS LINE
SANITARY SEWERS / CSOs
STORM DRAIN
WATER LINE
FENCE LINE
GROUND SURFACE CONTOUR
GUARD RAIL
WOODLINE
APPROXIMATE EDGE OF RIVER
CONTROL POINT
UTILITY POLE
GAS MARKER
STORM MANHOLE
SAN. SEWER MANHOLE
WATER MANHOLE
CATCH BASIN
ELEC. MANHOLE
GAS VALVE
UNKNOWN MANHOLE
FIRE HYDRANT
LIGHT POLE
SOIL BORING
POTENTIAL LIMITS OF OLM/TLM IN FILL AND CLAY
LIMITS OF OLM ARE APPROXIMATE, NOT DEFINED BY EXISTING DATA
POTENTIAL LIMITS OF OLM IN OUTWASH
POTENTIAL LIMITS OF OLM ON BEDROCK
LIMITS OF OLM ARE APPROXIMATE, NOT DEFINED BY EXISTING DATA
DEPTH INTERVAL OF OBSERVED OLM AND/OR TLM
VISUAL OBSERVATION LEGEND:
OLM OR TLM ENCOUNTERED IN FILL DEPOSIT
OLM ENCOUNTERED IN CLAY DEPOSITS
OLM ENCOUNTERED IN OUTWASH DEPOSITS
OLM ON TOP OF BEDROCK
BROWN CELLS DENOTE OLM OR TLM THAT WAS REMOVED OR SOLIDIFIED DURING THE WEST AND EAST PARCELS REMEDIATION PROGRAMS
N
E
S
W
0
100
200
SCALE IN FEET
RIVERSIDE DRIVE
OVERHEAD ELECTRIC
LIMITS OF EAST PARCEL
BLDG
WEST PARCEL
MIDDLE PARCEL
EAST PARCEL
WEST OF THE WEST PARCEL
POSSIBLE MANHOLE
FORMER PROPANE LOADING AREA
CWW
TUNNEL
Gas Holder
PAVEMENT
PITTSBURGH ST (VACATED)
LIMITS OF WEST PARCEL EXCAVATION
Gas Storage Cavern
3" BRICK DRAIN (S) INV. = 437.12
EDGE OF WATER ELEV. 436'
OHIO RIVER
REMEDIAL TECHNOLOGIES LEGEND:
ENGINEERED COVER (SOIL)
NOTES:
1. EXISTING SITE FEATURES BASED ON A NOVEMBER 2009 SURVEY BY DUKE ENERGY. ELSIE SHAW RLS #8099.
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2801 RIVERSIDE DRIVE
CINCINNATI, OHIO
REMEDIAL ALTERNATIVE 2
SCALE: AS SHOWN
AUGUST 2014
FIGURE 9


LEGEND:
FORMER MANUFACTURED GAS PLANT STRUCTURE
PROPERTY LINE
GAS LINE
STORM DRAIN
WATER LINE
FENCE LINE
GROUND SURFACE CONTOUR
GUARD RAIL
WOODLINE
APPROXIMATE EDGE OF RIVER
CONTROL POINT
UTILITY POLE
GAS MARKER
STORM MANHOLE
SAN. SEWER MANHOLE
WATER MANHOLE
CATCH BASIN
ELEC. MANHOLE
GAS VALVE
UNKNOWN MANHOLE
FIRE HYDRANT
LIGHT POLE
SOIL BORING
VISUAL OBSERVATION LEGEND:
SCALE IN FEET
DUKE ENERGY OHIO
EAST END GAS WORKS
2301 RIVERSIDE DRIVE
CINCINNATI, OHIO
REMEDIAL ALTERNATIVE 3
SCALE: AS SHOWN
AUGUST 2014
FIGURE 10
HALEY & ALDRICH
RIVERSIDE DRIVE
OVERHEAD ELECTRIC
EAST PARCEL
MIDDLE PARCEL
WEST PARCEL
WEST OF THE WEST PARCEL
BLDG
PAVEMENT
OHIO RIVER
EDGE OF WATER ELEV. 456'
Gas Storage Cavern
REMEDIAL TECHNOLOGIES LEGEND:
SOURCE STRUCTURE DEMOLITION IN TOP 15'
NAPL MONITORING / RECOVERY WELLS
ENGINEERED COVER (SOIL)
NOTES:
1. EXISTING SITE FEATURES BASED ON A NOVEMBER 2009 SURVEY BY DUKE ENERGY.


LEGEND:
REMEDIAL TECHNOLOGIES LEGEND:
VISUAL OBSERVATION LEGEND:
NOTES:
RIVERSIDE DRIVE
WEST PARCEL
MIDDLE PARCEL
EAST PARCEL
WEST OF THE WEST PARCEL
OHIO RIVER
EDGE OF WATER ELEV. 436'
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2001 RIVERSIDE DRIVE
CINCINNATI, OHIO
REMEDIAL ALTERNATIVE 4
SCALE: AS SHOWN
AUGUST 2014
FIGURE 11


LEGEND:
FORMER MANUFACTURED GAS PLANT STRUCTURE
PROPERTY LINE
WESTERN LIMIT OF AREA WEST OF THE WEST PARCEL
GAS LINE
SANITARY SEWERS / CSOs
STORM DRAIN
WATER LINE
FENCE LINE
GROUND SURFACE CONTOUR
GUARD RAIL
WOODLINE
APPROXIMATE EDGE OF RIVER
CONTROL POINT
UTILITY POLE
GAS MARKER
STORM MANHOLE
SAN. SEWER MANHOLE
WATER MANHOLE
CATCH BASIN
ELEC. MANHOLE
GAS VALVE
UNKNOWN MANHOLE
FIRE HYDRANT
LIGHT POLE
SOIL BORING
POTENTIAL LIMITS OF OLM/TLM IN FILL AND CLAY
LIMITS OF OLM ARE APPROXIMATE, NOT DEFINED BY EXISTING DATA
POTENTIAL LIMITS OF OLM IN OUTWASH
POTENTIAL LIMITS OF OLM ON BEDROCK
LIMITS OF OLM ARE APPROXIMATE, NOT DEFINED BY EXISTING DATA
DEPTH INTERVAL OF OBSERVED OLM AND/OR TLM
VISUAL OBSERVATION LEGEND:
OLM OR TLM ENCOUNTERED IN FILL DEPOSIT
OLM ENCOUNTERED IN CLAY DEPOSITS
OLM ENCOUNTERED IN OUTWASH DEPOSITS
OLM ON TOP OF BEDROCK
BROWN CELLS DENOTE OLM OR TLM THAT WAS REMOVED OR SOLIDIFIED DURING THE WEST AND EAST PARCELS REMEDIATION PROGRAMS
0 100 200
SCALE IN FEET
HALEY & ALDRICH
DUKE ENERGY OHIO
EAST END GAS WORKS
2801 RIVERSIDE DRIVE
CINCINNATI, OHIO
REMEDIAL ALTERNATIVE 5
SCALE: AS SHOWN
AUGUST 2014
FIGURE 12
REMEDIAL TECHNOLOGIES LEGEND:
SOURCE STRUCTURE DEMOLITION
EXCAVATION FROM 0-20' BGS AND ISS FROM 20'-60' BGS
EXCAVATION FROM 0-20' BGS
ENGINEERED COVER (SOIL)
LOCATION OF ACTIVE UTILITIES IN ST. ANDREWS STREET THAT MAY IMPACT REMEDIAL CONSTRUCTION SEQUENCING AND/OR LIMITS
NAPL MONITORING / RECOVERY WELLS
ISS DEPTH CONTOUR
EXCAVATION DEPTH SPOT ELEVATION
NOTES:
1. EXISTING SITE FEATURES BASED ON A NOVEMBER 2009 SURVEY BY DUKE ENERGY. ELSIE SHAW RLS #8089.
REMEDIAL CONSTRUCTION IN THIS AREA MAY BE LIMITED DUE TO PRESENCE OF ACTIVE UTILITIES IN ST. ANDREWS STREET, INCLUDING LIQUID PROPANE LINES AND GAS TRANSMISSION MAINS.
BLDG
RIVERSIDE DRIVE
OVERHEAD ELECTRIC
LIMITS OF EAST PARCEL ISS
WEST PARCEL
MIDDLE PARCEL
EAST PARCEL
WEST OF THE WEST PARCEL
POSSIBLE MANHOLE
FORMER PROPANE LOADING AREA
CWW TUNNEL
PAVEMENT
LIMITS OF WEST PARCEL EXCAVATION
Gas Storage Cavern
3" BRICK DRAIN (S) INV. = 437.12
NO SOIL REMEDIATION OR NAPL RECOVERY WELLS CAN BE COMPLETED WITHIN THE FOOTPRINT OF THE GAS STORAGE CAVERN DUE TO SAFETY CONCERNS
OHIO RIVER
EDGE OF WATER ELEV. 456'
N E S W

APPENDIX A

Risk Calculations – West of the West Parcel

TABLE A-1
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Commercial	Standard Basis Cancer or Non-Cancer (C or NC)	SB-K02 7/29/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer	SB-K04 8/1/2011 N 0 - 2 (ft)	Risk Ratio (SB-K04) Cancer	Risk Ratio (SB-K04) Non-Cancer	SB-K07 8/2/2011 N 0 - 2 (ft)	Risk Ratio (SB-K07) Cancer	Risk Ratio (SB-K07) Non-Cancer
Inorganic Compounds (mg/kg)											
Aluminum, Total	-	-	12600	-	-	16400	-	-	18200	-	-
Arsenic, Total	82	C	4.76	0.058	-	7.34	0.090	-	5.35	0.065	-
Barium, Total	370000	NC	48.4	-	0.00013	72.6	-	0.00020	56.6	-	0.00015
Beryllium, Total	5100	NC	0.684	-	0.00013	1.06	-	0.00021	0.895	-	0.00018
Calcium, Total	-	-	73700	-	-	43300	-	-	43400	-	-
Chromium, Total	7900	C	16.1	0.0020	-	18.9	0.0024	-	20.5	0.0026	-
Cobalt, Total	23000	NC	14.8	-	0.00064	15.1	-	0.00066	16.2	-	0.00070
Copper, Total	-	-	18.7	-	-	25.8	-	-	23.4	-	-
Iron, Total	-	-	30600	-	-	31200	-	-	35300	-	-
Lead, Total	1800	-	94.4	-	0.052	163	-	0.091	49.5	-	0.028
Magnesium, Total	-	-	14700	-	-	9410	-	-	9110	-	-
Manganese, Total	-	-	620	-	-	527	-	-	529	-	-
Mercury, Total	290	NC	0.06	-	0.00021	0.12	-	0.00041	0.079	-	0.00027
Nickel, Total	44000	NC	27	-	0.00061	29.7	-	0.00068	28.4	-	0.00065
Potassium, Total	-	-	1860	-	-	3320	-	-	3600	-	-
Selenium, Total	15000	NC	2.24	-	0.00015	0.681	-	0.000045	ND (2.18)	-	-
Sodium, Total	-	-	198	-	-	146	-	-	233	-	-
Thallium, Total	230	-	ND (2.36)	-	-	ND (2.2)	-	-	ND (2.18)	-	-
Vanadium, Total	26000	NC	20.9	-	0.00080	28.9	-	0.0011	36.7	-	0.0014
Zinc, Total	880000	NC	88.1	-	0.00010	100	-	0.00011	98.3	-	0.00011
Semi-Volatile Organic Compounds (SIM) (mg/kg)											
1-Methylnaphthalene	360	NC	0.0241	-	0.000067	0.0115	-	0.000032	0.00847	-	0.000024
2-Methylnaphthalene	360	NC	0.00653	-	0.000018	0.0136	-	0.000038	0.0106	-	0.000029
Acenaphthene	56000	NC	0.0367	-	0.00000066	0.0243	-	0.00000043	0.0348	-	0.00000062
Acenaphthylene	28000	NC	0.107	-	0.0000038	0.00859	-	0.00000031	0.0173	-	0.00000062
Anthracene	280000	NC	0.0682	-	0.00000024	0.0923	-	0.00000033	0.101	-	0.00000036
Benzo(a)anthracene	76	C	0.0906	0.0012	-	0.268	0.0035	-	0.342	0.0045	-
Benzo(a)pyrene	7.7	C	0.0841	0.011	-	0.209	0.027	-	0.313	0.041	-
Benzo(b)fluoranthene	77	C	0.0739	0.0010	-	0.225	0.0029	-	0.307	0.0040	-
Benzo(g,h,i)perylene	28000	NC	0.0739	-	0.0000026	0.177	-	0.0000063	0.305	-	0.000011
Benzo(k)fluoranthene	770	C	0.062	0.000081	-	0.178	0.00023	-	0.253	0.00033	-
Chrysene	7600	C	0.0808	0.000011	-	0.26	0.000034	-	0.325	0.000043	-
Dibenz(a,h)anthracene	7.7	C	0.0176	0.0023	-	0.0465	0.0060	-	0.0717	0.0093	-
Fluoranthene	37000	NC	0.213	-	0.0000058	0.486	-	0.000013	0.718	-	0.000019
Fluorene	37000	NC	0.0441	-	0.0000012	0.025	-	0.0000007	0.0272	-	0.00000074
Indeno(1,2,3-cd)pyrene	77	C	0.0478	0.00062	-	0.121	0.0016	-	0.193	0.0025	-
Naphthalene	150	C	0.022	0.00015	-	0.0115	7.7E-05	-	0.0152	0.00010	-
Phenanthrene	28000	NC	0.198	-	0.0000071	0.327	-	0.000012	0.349	-	0.000012
Pyrene	28000	NC	0.179	-	0.0000064	0.541	-	0.000019	0.657	-	0.000023

TABLE A-1
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name Sample Date Sample Type Sample Depth (bgs)	VAP Commercial	Standard Basis Cancer or Non-Cancer (C or NC)	SB-K02 7/29/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer	SB-K04 8/1/2011 N 0 - 2 (ft)	Risk Ratio (SB-K04) Cancer	Risk Ratio (SB-K04) Non-Cancer	SB-K07 8/2/2011 N 0 - 2 (ft)	Risk Ratio (SB-K07) Cancer	Risk Ratio (SB-K07) Non-Cancer
Volatile Organic Compounds (mg/kg)											
1,2,4-Trimethylbenzene	120	NC	ND (0.00257)	-	-	ND (0.0021)	-	-	ND (0.00196)	-	-
1,3,5-Trimethylbenzene	95	NC	ND (0.00257)	-	-	**0.00107**	-	0.000011	ND (0.00196)	-	-
2-Butanone (Methyl Ethyl Ketone)	100000	NC	ND (0.0642)	-	-	ND (0.0524)	-	-	**0.00701**	-	0.000000070
Acetone	100000	NC	**0.0589**	-	0.00000059	**0.0477**	-	0.00000048	**0.0445**	-	0.00000045
Benzene	140	C	**0.00442**	3.2E-05	-	**0.00354**	2.5E-05	-	**0.00405**	2.9E-05	-
Carbon disulfide	1400	NC	**0.00697**	-	0.0000050	**0.00506**	-	0.0000036	**0.00878**	-	0.0000063
Cymene (p-Isopropyltoluene)	-	-	ND (0.00257)	-	-	ND (0.0021)	-	-	**0.00303**	-	-
Ethylbenzene	230	NC	**0.00155**	-	0.0000067	**0.00128**	-	0.0000056	**0.0017**	-	0.0000074
Tetrachloroethene	53	C	**0.0014**	2.6E-05	-	ND (0.0021)	-	-	ND (0.00196)	-	-
Toluene	520	NC	**0.00565**	-	1.1E-05	**0.00442**	-	0.0000085	**0.00519**	-	0.000010
Xylene (total)	370	NC	**0.00297**	-	8.0E-06	**0.00223**	-	0.0000060	**0.00223**	-	0.0000060
		Total Risk	SB-K02	0.076	0.055	SB-K04	0.13	0.094	SB-K07	0.13	0.031

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and CIDARS data base (downloaded June 6, 2013) for constituents not published in Rule 08.
Value for pyrene used as a surrogate for acenaphthylene, phenanthrene, and benzo(g,h,i)perylene.
Value for 1-methylnaphthalene used for 2-methylnaphthalene
Value for hexavalent chromium used for total chromium
C - Standard is based on a cancer risk of 1E-05
NC - Standard is based on a non-cancer hazard index of 1
2. Risk ratio calculated as EPC / VAP standard
3. Results in bold are detected above the laboratory reporting limit.
4. "-": Indicates information not available or analysis not performed.

TABLE A-1
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Commercial	Standard Basis Cancer or Non-Cancer (C or NC)	SB-K08 8/3/2011 N 0 - 2 (ft)	Risk Ratio (SB-K08 N)		SB-K08 8/3/2011 FD 0 - 2 (ft)	Risk Ratio (SB-K08 FD)	
				Cancer	Non-Cancer		Cancer	Non-Cancer
Inorganic Compounds (mg/kg)								
Aluminum, Total	-	-	16700	-	-	14200	-	-
Arsenic, Total	82	C	8.55	0.10	-	7.19	0.088	-
Barium, Total	370000	NC	80.2	-	0.00022	87.8	-	0.00024
Beryllium, Total	5100	NC	0.905	-	0.00018	0.748	-	0.00015
Calcium, Total	-	-	39400	-	-	45500	-	-
Chromium, Total	7900	C	18.9	0.0024	-	16.6	0.0021	-
Cobalt, Total	23000	NC	15.2	-	0.00066	12.5	-	0.00054
Copper, Total	-	-	22.1	-	-	20.6	-	-
Iron, Total	-	-	35000	-	-	28700	-	-
Lead, Total	1800	-	49.1	-	0.027	65.2	-	0.036
Magnesium, Total	-	-	7730	-	-	11300	-	-
Manganese, Total	-	-	565	-	-	512	-	-
Mercury, Total	290	NC	0.14	-	0.00048	0.099	-	0.00034
Nickel, Total	44000	NC	25.8	-	0.00059	21.2	-	0.00048
Potassium, Total	-	-	2570	-	-	2350	-	-
Selenium, Total	15000	NC	ND (2.21)	-	-	ND (2.19)	-	-
Sodium, Total	-	-	156	-	-	150	-	-
Thallium, Total	230		ND (2.21)	-	-	ND (2.19)	-	-
Vanadium, Total	26000	NC	29.5	-	0.0011	27.9	-	0.0011
Zinc, Total	880000	NC	108	-	0.00012	112	-	0.00013
Semi-Volatile Organic Compounds (SIM) (mg/kg)								
1-Methylnaphthalene	360	NC	0.0239	-	0.0000664	0.0184	-	0.000051
2-Methylnaphthalene	360	NC	0.0307	-	0.0000853	0.0221	-	0.000061
Acenaphthene	56000	NC	0.0931		0.0000017	0.185		0.0000033
Acenaphthylene	28000	NC	0.0333	-	0.0000012	0.0685	-	0.0000024
Anthracene	280000	NC	0.322	-	0.0000012	1.35	-	0.0000048
Benzo(a)anthracene	76	C	1.08	0.014	-	3.66	0.048	-
Benzo(a)pyrene	7.7	C	0.897	0.12	-	2.68	0.35	-
Benzo(b)fluoranthene	77	C	0.916	0.012	-	2.65	0.034	-
Benzo(g,h,i)perylene	28000	NC	0.677	-	0.000024	1.69	-	0.000060
Benzo(k)fluoranthene	770	C	0.699	0.00091	-	2.03	0.0026	-
Chrysene	7600	C	0.886	0.00012	-	2.61	0.00034	-
Dibenz(a,h)anthracene	7.7	C	0.142	0.018	-	0.511	0.066	-
Fluoranthene	37000	NC	2.21	-	0.0000597	6.26	-	0.00017
Fluorene	37000	NC	0.114	-	0.0000031	0.238	-	0.0000064
Indeno(1,2,3-cd)pyrene	77	C	0.486	0.0063	-	1.39	0.018	-
Naphthalene	150	C	0.0613	0.00041	-	0.0302	0.00020	-
Phenanthrene	28000	NC	1.39	-	0.000050	3.26	-	0.00012
Pyrene	28000	NC	1.97	-	0.000070	5.2	-	0.00019

TABLE A-1
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 2 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Commercial	Standard Basis Cancer or Non-Cancer (C or NC)	SB-K08 8/3/2011 N 0 - 2 (ft)	Risk Ratio (SB-K08 N) Cancer	Risk Ratio (SB-K08 N) Non-Cancer	SB-K08 8/3/2011 FD 0 - 2 (ft)	Risk Ratio (SB-K08 FD) Cancer	Risk Ratio (SB-K08 FD) Non-Cancer
Volatile Organic Compounds (mg/kg)								
1,2,4-Trimethylbenzene	120	NC	**0.00152**	-	0.000013	**0.00162**	-	0.000014
1,3,5-Trimethylbenzene	95	NC	ND (0.00207)	-	-	ND (0.00242)	-	-
2-Butanone (Methyl Ethyl Ketone)	100000	NC	**0.0179**	-	0.00000018	ND (0.0605)	-	-
Acetone	100000	NC	**0.0784**	-	0.00000078	**0.0524**	-	0.0000005
Benzene	140	C	**0.00622**	4.4E-05	-	**0.00685**	4.9E-05	-
Carbon disulfide	1400	NC	0.0131	-		**0.0222**	-	0.000016
Cymene (p-Isopropyltoluene)	-	-	ND (0.00207)	-	-	ND (0.00242)	-	-
Ethylbenzene	230	NC	**0.00226**	-	0.0000098	**0.00206**	-	0.000009
Tetrachloroethene	53	C	ND (0.00207)	-	-	ND (0.00242)	-	-
Toluene	520	NC	**0.00763**	-	0.000015	**0.00726**	-	0.000014
Xylene (total)	370	NC	**0.00393**	-	0.000011	**0.00418**	-	0.000011
		Total Risk	SB-K08	0.28	0.031	SB-K08	0.61	0.040

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and CIDARS data base (d
   Value for pyrene used as a surrogate for acenaphthylene, phenanthrene, and benzo(g,h,i)perylei
   Value for 1-methylnaphthalene used for 2-methylnaphthalene
   Value for hexavalent chromium used for total chromium
   C - Standard is based on a cancer risk of 1E-05
   NC - Standard is based on a non-cancer hazard index of 1
2. Risk ratio calculated as EPC / VAP standard
3. Results in bold are detected above the laboratory reporting limit.
4. "-": Indicates information not available or analysis not performed.

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Construction	Standard Basis Cancer or Non-Cancer (C or NC)	SB-K01 7/28/2011 N 13 - 15 (ft)	Risk Ratio (SB-K01) Cancer	Risk Ratio (SB-K01) Non-Cancer	SB-K02 7/29/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer
Inorganic Compounds (mg/kg)								
Aluminum, Total	-	-	15500	-	-	12600	-	-
Arsenic, Total	420	NC	5.22	-	0.012	4.76	-	0.011
Barium, Total	120000	NC	102	-	0.00085	48.4	-	0.00040
Beryllium, Total	3100	NC	0.933	-	0.00030	0.684	-	0.00022
Calcium, Total	-	-	25700	-	-	73700	-	-
Chromium, Total	13000	C	20.8	0.0016	-	16.1	0.0012	-
Cobalt, Total	4000	NC	19	-	0.0048	14.8	-	0.0037
Copper, Total	-	-	34.4	-	-	18.7	-	-
Iron, Total	-	-	39100	-	-	30600	-	-
Lead, Total	750	NC	447	-	0.60	94.4	-	0.13
Magnesium, Total	-	-	8530	-	-	14700	-	-
Manganese, Total	-	-	547	-	-	620	-	-
Mercury, Total	190	NC	0.56	-	0.0029	0.06	-	0.00032
Nickel, Total	21000	NC	37.1	-	0.0018	27	-	0.0013
Potassium, Total	-	-	2370	-	-	1860	-	-
Selenium, Total	9700	NC	0.933	-	0.00010	2.24	-	0.00023
Sodium, Total	-	-	197	-	-	198	-	-
Vanadium, Total	17000	NC	26.8	-	0.0016	20.9	-	0.0012
Zinc, Total	580000	NC	387	-	0.00067	88.1	-	0.00015
Semi-Volatile Organic Compounds (SIM) (mg/kg)								
1-Methylnaphthalene	360	NC	0.00293	-	0.0000081	0.0241	-	0.000067
2-Methylnaphthalene	360	NC	0.00335	-	0.0000093	0.00653	-	0.0000181
Acenaphthene	440000	NC	0.00251	-	0.0000000057	0.0367	-	0.000000083
Acenaphthylene	220000	NC	0.00209	-	0.000000010	0.107	-	0.00000049
Anthracene	1000000	NC	0.00628	-	0.0000000063	0.0682	-	0.000000068
Benzo(a)anthracene	680	C	0.0243	0.000036	-	0.0906	0.00013	-
Benzo(a)pyrene	69	C	0.0243	0.00035	-	0.0841	0.0012	-
Benzo(b)fluoranthene	690	C	0.0239	0.000035	-	0.0739	0.00011	-
Benzo(g,h,i)perylene	220000	NC	0.0264	-	0.00000012	0.0739	-	0.00000034
Benzo(k)fluoranthene	6900	C	0.0201	0.0000029	-	0.062	0.0000090	-
Chrysene	69000	C	0.0268	0.00000039	-	0.0808	0.0000012	-
Dibenz(a,h)anthracene	69	C	0.00586	0.000085	-	0.0176	0.00026	-
Fluoranthene	290000	NC	0.0557	-	0.00000019	0.213	-	0.00000073
Fluorene	290000	NC	0.00251	-	0.0000000087	0.0441	-	0.00000015
Indeno(1,2,3-cd)pyrene	690	C	0.0155	0.000022	-	0.0478	0.000069	-
Naphthalene	84	NC	0.00335	-	0.000040	0.022	-	0.00026
Phenanthrene	220000	NC	0.0331	-	0.00000015	0.198	-	0.00000090
Pyrene	220000	NC	0.049	-	0.00000022	0.179	-	0.00000081

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Construction	Standard Basis Cancer or Non-Cancer (C or NC)	SB-K01 7/28/2011 N 13 - 15 (ft)	Risk Ratio (SB-K01) Cancer	Risk Ratio (SB-K01) Non-Cancer	SB-K02 7/29/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer
Volatile Organic Compounds (mg/kg)								
1,2,4-Trimethylbenzene	35	NC	ND (0.00214)	-	-	ND (0.00257)	-	-
1,3,5-Trimethylbenzene	200	NC	ND (0.00214)	-	-	ND (0.00257)	-	-
2-Butanone (Methyl Ethyl Ketone)	15000	NC	**0.013**	-	0.00000087	ND (0.0642)	-	-
Acetone	100000	NC	**0.0822**	-	0.00000082	**0.0589**	-	0.00000059
Benzene	150	NC	**0.00171**	-	0.000011	**0.00442**	-	0.000029
Bromobenzene	-	-	ND (0.00214)	-	-	ND (0.00257)	-	-
Carbon disulfide	190	NC	**0.0011**	-	0.0000058	**0.00697**	-	0.000037
Cymene (p-Isopropyltoluene)	-	-	ND (0.00214)	-	-	ND (0.00257)	-	-
Ethylbenzene	230	NC	ND (0.00214)	-	-	**0.00155**	-	0.0000067
Hexane	190	NC	**0.00975**	-	0.000051	-	-	-
Isopropylbenzene	260	NC	ND (0.00214)	-	-	ND (0.00257)	-	-
Naphthalene	84	NC	ND (0.00536)	-	-	ND (0.00642)	-	-
Tetrachloroethene	220	C	ND (0.00214)	-	-	**0.0014**	0.0000064	-
Toluene	520	NC	**0.0014**	-	0.0000027	**0.00585**	-	0.000011
Xylene (total)	370	NC	ND (0.00536)	-	-	**0.00297**	-	0.0000080
		Total Risk	SB-K01	0.0021	0.62	SB-K02	0.0030	0.15

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and CIDARS data base (downloaded June 6, 2013) for constituents not published in Rule 08.
Value for pyrene used as a surrogate for acenaphthylene, phenanthrene, and benzo(g,h,i)perylene.
Value for 1-methylnaphthalene used for 2-methylnaphthalene
Value for hexavalent chromium used for total chromium
C - Standard is based on a cancer risk of 1E-05
NC - Standard is based on a non-cancer hazard index of 1
2. Risk ratio calculated as EPC / VAP standard
3. ND (#): Result is not detected above the indicated reporting limit.
4. Results in bold are detected above the laboratory reporting limit.
5. "-": Indicates information not available or analysis not performed.

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Construction	SB-K02 7/29/2011 N 5 - 7 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer	SB-K03 7/29/2011 N 13 - 15 (ft)	Risk Ratio (SB-K03) Cancer	Risk Ratio (SB-K03) Non-Cancer	SB-K04 8/1/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer	SB-K04 8/1/2011 N 6 - 8 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer
Inorganic Compounds (mg/kg)													
Aluminum, Total	-	9810	-	-	15800	-	-	16400	-	-	10400	-	-
Arsenic, Total	420	5.57	-	0.013	3.94	-	0.0094	7.34	-	0.017	7.17	-	0.017
Barium, Total	120000	55.1	-	0.00046	50.1	-	0.00042	72.6	-	0.00061	71.3	-	0.00059
Beryllium, Total	3100	0.542	-	0.00017	0.867	-	0.00028	1.06	-	0.00034	0.528	-	0.00017
Calcium, Total	-	79200	-	-	26500	-	-	43300	-	-	89100	-	-
Chromium, Total	13000	12.1	0.00093	-	20	0.0015	-	18.9	0.0015	-	11.8	0.00091	-
Cobalt, Total	4000	10.5	-	0.0026	17.9	-	0.0045	15.1	-	0.0038	8.8	-	0.0022
Copper, Total	-	25.6	-	-	23.7	-	-	25.8	-	-	25.9	-	-
Iron, Total	-	23900	-	-	35800	-	-	31200	-	-	22000	-	-
Lead, Total	750	28.5	-	0.038	112	-	0.15	163	-	0.22	87.9	-	0.12
Magnesium, Total	-	21200	-	-	8150	-	-	9410	-	-	19200	-	-
Manganese, Total	-	610	-	-	534	-	-	527	-	-	554	-	-
Mercury, Total	190	0.028	-	0.00015	0.52	-	0.0027	0.12	-	0.00063	0.15	-	0.00079
Nickel, Total	21000	17.9	-	0.00085	36.5	-	0.0017	29.7	-	0.0014	13.9	-	0.00066
Potassium, Total	-	1790	-	-	2670	-	-	3320	-	-	1190	-	-
Selenium, Total	9700	1.35	-	0.00014	1.71	-	0.00018	0.681	-	0.000070	ND (2.2)	-	-
Sodium, Total	-	208	-	-	199	-	-	146	-	-	135	-	-
Vanadium, Total	17000	23.8	-	0.0014	25.7	-	0.0015	28.9	-	0.0017	23.6	-	0.0014
Zinc, Total	580000	65.2	-	0.00011	105	-	0.00018	100	-	0.00017	71.4	-	0.00012
Semi-Volatile Organic Compounds (SIM) (mg/kg)													
1-Methylnaphthalene	360	0.0105	-	0.000029	0.00572	-	0.000016	0.0115	-	0.000032	0.0465	-	0.00013
2-Methylnaphthalene	360	0.0113	-	0.0000314	0.00245	-	0.0000068	0.0136	-	0.000038	0.0645	-	0.00018
Acenaphthene	440000	0.0723	-	0.00000016	0.00939	-	0.000000021	0.0243	-	0.00000006	0.226	-	0.00000051
Acenaphthylene	220000	0.1	-	0.00000045	0.0139	-	0.000000063	0.00859	-	0.000000039	0.179	-	0.00000081
Anthracene	1000000	0.328	-	0.00000033	0.0196	-	0.000000020	0.0923	-	0.00000009	0.974	-	0.0000010
Benzo(a)anthracene	680	1.78	0.0026	-	0.0327	0.000048	-	0.268	0.00039	-	3	0.0044	-
Benzo(a)pyrene	69	1.89	0.027	-	0.0294	0.00043	-	0.209	0.0030	-	2.78	0.040	-
Benzo(b)fluoranthene	690	1.73	0.0025	-	0.0274	0.000040	-	0.225	0.00033	-	2.44	0.0035	-
Benzo(g,h,i)perylene	220000	1.75	-	0.0000080	0.0274	-	0.00000012	0.177	-	0.00000080	2.55	-	0.000012
Benzo(k)fluoranthene	6900	1.35	0.00020	-	0.0237	0.0000034	-	0.178	2.6E-05	-	2.27	0.00033	-
Chrysene	69000	1.6	0.000023	-	0.0314	0.00000046	-	0.26	3.8E-06	-	2.67	0.000039	-
Dibenz(a,h)anthracene	69	0.404	0.0059	-	ND (0.00408)	-	-	0.0465	6.7E-04	-	0.602	0.0087	-
Fluoranthene	290000	3.42	-	0.000012	0.0715	-	0.00000025	0.486	-	0.0000017	5.88	-	0.000020
Fluorene	290000	0.064	-	0.00000022	0.0131	-	0.000000045	0.025	-	0.000000086	0.283	-	0.0000010
Indeno(1,2,3-cd)pyrene	690	1.14	0.0017	-	0.0172	0.000025	-	0.121	0.00018	-	1.67	0.0024	-
Naphthalene	84	0.0226	-	0.00027	0.00653	-	0.000078	0.0115	-	0.00014	0.15	-	0.00179
Phenanthrene	220000	0.896	-	0.0000041	0.0649	-	0.0000030	0.327	-	0.0000015	2.75	-	0.000013
Pyrene	220000	3.52	-	0.000016	0.0625	-	0.0000028	0.541	-	0.0000025	5.16	-	0.000023

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name Sample Date Sample Type Sample Depth (bgs)	VAP Construction	SB-K02 7/29/2011 N 5 - 7 (ft)	Risk Ratio (SB-K02) Cancer	 Non-Cancer	SB-K03 7/29/2011 N 13 - 15 (ft)	Risk Ratio (SB-K03) Cancer	 Non-Cancer	SB-K04 8/1/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	 Non-Cancer	SB-K04 8/1/2011 N 6 - 8 (ft)	Risk Ratio (SB-K02) Cancer	 Non-Cancer
Volatile Organic Compounds (mg/kg)													
1,2,4-Trimethylbenzene	35	ND (0.00164)	-	-	ND (0.00202)	-	-	ND (0.0021)	-	-	ND (0.00219)	-	-
1,3,5-Trimethylbenzene	200	ND (0.00164)	-	-	ND (0.00202)	-	-	**0.00107**	-	0.0000054	ND (0.00219)	-	-
2-Butanone (Methyl Ethyl Ketone)	15000	ND (0.0411)	-	-	ND (0.0505)	-	-	ND (0.0524)	-	-	ND (0.0549)	-	-
Acetone	100000	**0.0318**	-	0.00000032	ND (0.0505)	-	-	**0.0477**	-	0.0000005	**0.0377**	-	0.00000038
Benzene	150	**0.00348**	-	0.000023	**0.00352**	-	0.000023	**0.00354**	-	0.000024	**0.00541**	-	0.000036
Bromobenzene	-	ND (0.00164)	-	-	ND (0.00202)	-	-	ND (0.0021)	-	-	ND (0.00219)	-	-
Carbon disulfide	190	**0.00126**	-	0.0000066	ND (0.00505)	-	-	**0.00506**	-	0.000027	**0.00737**	-	0.000039
Cymene (p-Isopropyltoluene)	-	ND (0.00164)	-	-	ND (0.00202)	-	-	ND (0.0021)	-	-	ND (0.00219)	-	-
Ethylbenzene	230	**0.00121**	-	0.0000053	**0.00113**	-	0.0000049	**0.00128**	-	0.0000056	**0.0015**	-	0.0000065
Hexane	190	**0.0157**	-	0.000083	**0.0133**	-	0.000070	-	-	-	-	-	-
Isopropylbenzene	260	ND (0.00164)	-	-	ND (0.00202)	-	-	ND (0.0021)	-	-	ND (0.00219)	-	-
Naphthalene	84	**0.00175**	-	0.000021	ND (0.00505)	-	-	ND (0.00524)	-	-	ND (0.00549)	-	-
Tetrachloroethene	220	**0.000658**	0.0000030	-	ND (0.00202)	-	-	ND (0.0021)	-	-	ND (0.00219)	-	-
Toluene	520	**0.00417**	-	0.0000080	**0.00382**	-	0.0000073	**0.00442**	-	0.0000085	**0.00542**	-	0.000010
Xylene (total)	370	**0.00211**	-	0.0000057	ND (0.00505)	-	-	**0.00223**	-	0.0000060	**0.00244**	-	0.0000066
		SB-K02	0.041	0.058	SB-K03	0.0021	0.17	SB-K04	0.0061	0.24	SB-K04	0.061	0.14

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and C
   Value for pyrene used as a surrogate for acenaphthylene, phenanthrene, an
   Value for 1-methylnaphthalene used for 2-methylnaphthalene
   Value for hexavalent chromium used for total chromium
   C - Standard is based on a cancer risk of 1E-05
   NC - Standard is based on a non-cancer hazard index of 1
2. Risk ratio calculated as EPC / VAP standard
3. ND (#): Result is not detected above the indicated reporting limit.
4. Results in bold are detected above the laboratory reporting limit.
5. "-": Indicates information not available or analysis not performed.

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name		SB-K07	Risk Ratio (SB-K02)		SB-K07	Risk Ratio (SB-K02)		SB-K08	Risk Ratio (SB-K02)		SB-K08	Risk Ratio (SB-K02)	
Sample Date		8/2/2011			8/2/2011			8/3/2011			8/3/2011		
Sample Type	VAP	N			N			N			FD		
Sample Depth (bgs)	Construction	0 - 2 (ft)	Cancer	Non-Cancer	9 - 10 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer	0 - 2 (ft)	Cancer	Non-Cancer
Inorganic Compounds (mg/kg)													
Aluminum, Total	-	18200	-	-	11400	-	-	16700	-	-	14200	-	-
Arsenic, Total	420	5.35	-	0.013	15.8	-	0.038	8.55	-	0.020	7.19	-	0.017
Barium, Total	120000	56.8	-	0.00047	140	-	0.0012	80.2	-	0.00067	87.8	-	0.00073
Beryllium, Total	3100	0.895	-	0.00029	0.879	-	0.00028	0.905	-	0.00029	0.746	-	0.00024
Calcium, Total	-	43400	-	-	18000	-	-	39400	-	-	45500	-	-
Chromium, Total	13000	20.5	0.0016	-	14.6	0.0011	-	18.9	0.0015	-	16.6	0.0013	-
Cobalt, Total	4000	16.2	-	0.0041	12.3	-	0.0031	15.2	-	0.0038	12.5	-	0.0031
Copper, Total	-	23.4	-	-	55	-	-	22.1	-	-	20.6	-	-
Iron, Total	-	35300	-	-	30200	-	-	35000	-	-	28700	-	-
Lead, Total	750	49.5	-	0.066	150	-	0.20	49.1	-	0.065	65.2	-	0.087
Magnesium, Total	-	9110	-	-	3500	-	-	7730	-	-	11300	-	-
Manganese, Total	-	529	-	-	680	-	-	565	-	-	512	-	-
Mercury, Total	190	0.079	-	0.00042	0.57	-	0.0030	0.14	-	0.00074	0.099	-	0.0005
Nickel, Total	21000	28.4	-	0.0014	21.5	-	0.0010	25.8	-	0.0012	21.2	-	0.0010
Potassium, Total	-	3600	-	-	1770	-	-	2570	-	-	2350	-	-
Selenium, Total	9700	ND (2.18)	-	-	ND (2.31)	-	-	ND (2.21)	-	-	ND (2.19)	-	-
Sodium, Total	-	233	-	-	149	-	-	166	-	-	150	-	-
Vanadium, Total	17000	36.7	-	0.0022	29.6	-	0.0017	29.5	-	0.0017	27.9	-	0.0016
Zinc, Total	580000	98.3	-	0.00017	134	-	0.00023	108	-	0.00019	112	-	0.00019
Semi-Volatile Organic Compounds (SIM) (mg/kg)													
1-Methylnaphthalene	360	0.00847	-	0.000024	0.0187	-	0.000044	0.0239	-	0.000066	0.0184	-	0.000051
2-Methylnaphthalene	360	0.0106	-	0.000029	0.0201	-	0.0000558	0.0307	-	0.000085	0.0221	-	0.0000614
Acenaphthene	440000	0.0346	-	0.000000079	0.102	-	0.00000023	0.0931	-	0.00000021	0.185	-	0.00000042
Acenaphthylene	220000	0.0173	-	0.000000079	0.00725	-	0.000000033	0.0333	-	0.00000015	0.0685	-	0.00000031
Anthracene	1000000	0.101	-	0.00000010	0.381	-	0.00000038	0.322	-	0.00000032	1.35	-	0.0000014
Benzo(a)anthracene	680	0.342	0.00050	-	0.882	0.0013	-	1.08	0.0016	-	3.66	0.0054	-
Benzo(a)pyrene	69	0.313	0.0045	-	0.685	0.0099	-	0.897	0.013	-	2.68	0.039	-
Benzo(b)fluoranthene	690	0.307	0.00044	-	0.616	0.00089	-	0.916	0.0013	-	2.65	0.0038	-
Benzo(g,h,i)perylene	220000	0.305	-	0.0000014	0.519	-	0.0000024	0.677	-	0.000003	1.69	-	0.0000077
Benzo(k)fluoranthene	6900	0.253	3.7E-05	-	0.568	0.000082	-	0.699	0.00010	-	2.03	0.00029	-
Chrysene	69000	0.325	4.7E-06	-	0.793	0.000011	-	0.886	0.000013	-	2.61	0.000038	-
Dibenz(a,h)anthracene	69	0.0717	1.0E-03	-	0.141	0.0020	-	0.142	0.0021	-	0.511	0.0074	-
Fluoranthene	290000	0.718	-	0.0000025	2.18	-	0.0000075	2.21	-	0.0000076	6.26	-	0.000022
Fluorene	290000	0.0272	-	0.000000094	0.0829	-	0.00000029	0.114	-	0.00000039	0.238	-	0.00000082
Indeno(1,2,3-cd)pyrene	690	0.193	0.00028	-	0.395	0.00057	-	0.486	0.00070	-	1.39	0.0020	0.0020
Naphthalene	84	0.0152	-	0.00018	0.0173	-	0.00021	0.0613	-	0.00073	0.0302	-	0.00036
Phenanthrene	220000	0.349	-	0.0000016	1.21	-	0.0000055	1.39	-	0.0000063	3.26	-	0.000015
Pyrene	220000	0.657	-	0.0000030	1.99	-	0.0000090	1.97	-	0.0000090	5.2	-	0.000024

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Construction	SB-K07 8/2/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer	SB-K07 8/2/2011 N 9 - 10 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer	SB-K08 8/3/2011 N 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer	SB-K08 8/3/2011 FD 0 - 2 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer
Volatile Organic Compounds (mg/kg)													
1,2,4-Trimethylbenzene	35	ND (0.00196)	-	-	ND (0.00202)	-	-	**0.00152**	-	0.000043	**0.00162**	-	0.000046
1,3,5-Trimethylbenzene	200	ND (0.00196)	-	-	ND (0.00202)	-	-	ND (0.00207)	-	-	ND (0.00242)	-	-
2-Butanone (Methyl Ethyl Ketone)	15000	**0.00701**	-	0.00000047	**0.00798**	-	0.00000053	**0.0179**	-	0.0000012	ND (0.0605)	-	-
Acetone	100000	**0.0445**	-	0.00000045	**0.0802**	-	0.00000080	**0.0784**	-	0.00000078	**0.0524**	-	0.00000052
Benzene	150	**0.00405**	-	0.000027	**0.00483**	-	0.000032	**0.00622**	-	0.000041	**0.00685**	-	0.000046
Bromobenzene	-	ND (0.00196)	-	-	ND (0.00202)	-	-	ND (0.00207)	-	-	ND (0.00242)	-	-
Carbon disulfide	190	**0.00878**	-	0.000046	**0.00259**	-	0.000014	**0.0131**	-	0.000069	**0.0222**	-	0.00012
Cymene (p-Isopropyltoluene)	-	**0.00303**	-	-	ND (0.00202)	-	-	ND (0.00207)	-	-	ND (0.00242)	-	-
Ethylbenzene	230	**0.0017**	-	0.0000074	ND (0.00202)	-	-	**0.00226**	-	0.0000098	**0.00206**	-	0.0000090
Hexane	190	-	-	-	-	-	-	-	-	-	-	-	-
Isopropylbenzene	260	ND (0.00196)	-	-	ND (0.00202)	-	-	ND (0.00207)	-	-	ND (0.00242)	-	-
Naphthalene	84	ND (0.0049)	-	-	ND (0.00506)	-	-	ND (0.00517)	-	-	ND (0.00605)	-	-
Tetrachloroethene	220	ND (0.00196)	-	-	ND (0.00202)	-	-	ND (0.00207)	-	-	ND (0.00242)	-	-
Toluene	520	**0.00519**	-	1.0E-05	**0.00129**	-	0.0000025	**0.00763**	-	0.000015	**0.00726**	-	0.000014
Xylene (total)	370	**0.00223**	-	6.0E-06	ND (0.00506)	-	-	**0.00393**	-	0.000011	**0.00418**	-	0.000011
		SB-K07	0.0084	0.088	SB-K07	0.016	0.25	SB-K08	0.020	0.10	SB-K08	0.06	0.11

Notes and Abbreviations:
1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and C
Value for pyrene used as a surrogate for acenaphthylene, phenanthrene, an
Value for 1-methylnaphthalene used for 2-methylnaphthalene
Value for hexavalent chromium used for total chromium
C - Standard is based on a cancer risk of 1E-05
NC - Standard is based on a non-cancer hazard index of 1
2. Risk ratio calculated as EPC / VAP standard
3. ND (#): Result is not detected above the indicated reporting limit.
4. Results in bold are detected above the laboratory reporting limit.
5. "-": Indicates information not available or analysis not performed.

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name Sample Date Sample Type Sample Depth (bgs)	VAP Construction	SB-K09 6/4/2011 N 4.5 - 6.5 (ft)	Risk Ratio (SB-K02) Cancer	Risk Ratio (SB-K02) Non-Cancer
Inorganic Compounds (mg/kg)				
Aluminum, Total	-	12100	-	-
Arsenic, Total	420	6.46	-	0.015
Barium, Total	120000	40.5	-	0.00034
Beryllium, Total	3100	0.698	-	0.00023
Calcium, Total	-	75000	-	-
Chromium, Total	13000	14.3	0.0011	-
Cobalt, Total	4000	11.6	-	0.0029
Copper, Total	-	21.1	-	-
Iron, Total	-	25800	-	-
Lead, Total	750	61.3	-	0.082
Magnesium, Total	-	8430	-	-
Manganese, Total	-	534	-	-
Mercury, Total	190	0.15	-	0.00079
Nickel, Total	21000	18	-	0.00086
Potassium, Total	-	2370	-	-
Selenium, Total	9700	ND (2.33)	-	-
Sodium, Total	-	194	-	-
Vanadium, Total	17000	24.3	-	0.0014
Zinc, Total	580000	86.3	-	0.00015
Semi-Volatile Organic Compounds (SIM) (mg/kg)				
1-Methylnaphthalene	360	7.09	-	0.020
2-Methylnaphthalene	360	12.7	-	0.035
Acenaphthene	440000	5.29	-	0.000012
Acenaphthylene	220000	2.27	-	0.000010
Anthracene	1000000	18.4	-	0.000018
Benzo(a)anthracene	680	19.5	0.029	-
Benzo(a)pyrene	69	9.69	0.14	-
Benzo(b)fluoranthene	690	7.66	0.011	-
Benzo(g,h,i)perylene	220000	4.21	-	0.000019
Benzo(k)fluoranthene	6900	7.39	0.0011	-
Chrysene	69000	11.6	0.00017	-
Dibenz(a,h)anthracene	69	2.16	0.031	-
Fluoranthene	290000	26.7	-	0.000092
Fluorene	290000	7.96	-	0.000027
Indeno(1,2,3-cd)pyrene	690	4.03	0.0058	
Naphthalene	84	12	-	0.14
Phenanthrene	220000	32.3	-	0.00015
Pyrene	220000	24.2	-	0.00011

TABLE A-2
MCA AND SUMMARY OF SOIL ANALYTICAL RESULTS - 0 TO 15 FEET
AREA WEST OF THE WEST PARCEL
DUKE ENERGY
CINCINNATI, OHIO

Location Name / Sample Date / Sample Type / Sample Depth (bgs)	VAP Construction	SB-K09 / 8/4/2011 / N / 4.5 - 6.5 (ft)	Risk Ratio (SB-K02) Cancer	Non-Cancer
Volatile Organic Compounds (mg/kg)				
1,2,4-Trimethylbenzene	35	**0.0423**	-	0.0012
1,3,5-Trimethylbenzene	200	**0.0185**	-	0.000093
2-Butanone (Methyl Ethyl Ketone)	15000	**0.0188**	-	0.0000013
Acetone	100000	**0.137**	-	0.0000014
Benzene	150	**0.00452**	-	0.000030
Bromobenzene	-	**0.00131**	-	-
Carbon disulfide	190	ND (0.00456)	-	-
Cymene (p-Isopropyltoluene)	-	**0.00316**	-	-
Ethylbenzene	230	**0.00333**	-	0.000014
Hexane	190	-	-	-
Isopropylbenzene	260	**0.00159**	-	0.0000061
Naphthalene	84	**2.19**	-	0.026
Tetrachloroethene	220	**0.000857**	0.0000039	-
Toluene	520	**0.0115**	-	0.000022
Xylene (total)	370	**0.0431**	-	0.00012
		SB-K09	0.22	0.33

Notes and Abbreviations:

1. Values from OAC 3745-300-08(C)(3) (Current rules: April 18, 2013) and C
   Value for pyrene used as a surrogate for acenaphthylene, phenanthrene, an
   Value for 1-methylnaphthalene used for 2-methylnaphthalene
   Value for hexavalent chromium used for total chromium
   C - Standard is based on a cancer risk of 1E-05
   NC - Standard is based on a non-cancer hazard index of 1
2. Risk ratio calculated as EPC / VAP standard
3. ND (#): Result is not detected above the indicated reporting limit.
4. Results in bold are detected above the laboratory reporting limit.
5. "-": Indicates information not available or analysis not performed.

APPENDIX B

Remedial Alternatives Cost Estimation Backup

Client	Duke Energy Ohio, Inc.
Site	East End Gas Works
Location	Cincinnati, OH
Remedial Cost Evaluation	

Alternative 2 - Engineered Covers and Deed Restrictions

Items	Quantity	Unit	Unit Cost	Total Cost	Notes
Mobilization/Demobilization	1	LS	$ 5,000.00	$ 5,000.00	Engineering judgment, prior project experience
Soil Excavation (top 2-feet) [1]	250	cy	$ 10.00	$ 2,500.00	Engineering judgment, prior project experience
Soil Treatment and Disposal	425	ton	$ 35.00	$ 14,875.00	Preliminary engineering estimate based on similar remediation projects
Backfill (0.5-2' BGS) [2]	188	cy	$ 23.00	$ 4,312.50	Engineering judgment, prior project experience
Topsoil Placement and Grading (top 6")	360	sy	$ 7.30	$ 2,628.00	Engineering judgment, prior project experience
Seeding	360	sy	$ 1.11	$ 399.60	Engineering judgment, prior project experience
Paving [3]	0	sf	$ 5.50	$ -	Engineering judgment, prior project experience
Environmental Controls (dust, erosion, odor, vapor, stormwater) [4]	1	weeks	$ 2,500.00	$ 2,500.00	Preliminary engineering estimate based on similar remediation projects
Air Monitoring	1	weeks	$ 5,000.00	$ 5,000.00	Preliminary engineering estimate based on similar remediation projects
Groundwater Monitoring [5]	30	year	$ 30,000.00	$ 900,000.00	
Subtotal				$ 937,215.10	
Design and Permitting	12%			$ 112,465.81	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design
Contingency	15%			$ 140,582.27	15% contingency assumed due to limited complexity of this alternative
PM/CM	14%			$ 131,210.11	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8
Total - Alternative 2				$ 1,322,000	

1. 0-2' BGS excavation area includes grass strip between Pittsburgh St. and the East Parcel.
2. Sand/gravel backfill includes all cap areas.
3. Alternative does not require paving.
4. Project duration assumes excavation rate of 500 cy/day, 1,500 cy/day for backfill and topsoil placement.
5. Groundwater monitoring assumes existing 21 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.

Client	Duke Energy Ohio, Inc.
Site	East End Gas Works
Location	Cincinnati, OH
Remedial Cost Evaluation	

Alternative 3 - Excavation of NAPL Impacted Soils in Top 15'

Items	Quantity	Unit	Unit Cost	Total Cost	Notes
Mobilization/Demobilization	1	LS	$ 75,000.00	$ 75,000.00	Engineering judgment, prior project experience
Soil Excavation (0-15 feet) (1)	71,400	cy	$ 10.00	$ 714,000.00	Engineering judgment, prior project experience
Support of Excavation	42,000	sf	$ 75.00	$ 3,150,000.00	Engineering judgment, prior project experience
Soil Treatment and Disposal	121,380	ton	$ 35.00	$ 4,248,300.00	Preliminary engineering estimate based on similar remediation projects
Backfill	71,400	cy	$ 23.00	$ 1,642,200.00	Engineering judgment, prior project experience
Topsoil Placement and Grading	2,000	sy	$ 7.30	$ 14,600.00	Engineering judgment, prior project experience
Seeding	2,000	sy	$ 1.11	$ 2,220.00	Engineering judgment, prior project experience
MGP Structures Foundation Demolition and Loading	3,500	ton	$ 60.00	$ 210,000.00	Engineering judgment, prior project experience
Demo Debris Transportation and Disposal	3,500	ton	$ 30.00	$ 105,000.00	Engineering judgment, prior project experience
NAPL Monitoring and Recovery Wells	8	each	$ 3,000.00	$ 24,000.00	Engineering judgment, prior project experience
Paving (2)	98,300	sf	$ 5.50	$ 540,650.00	Engineering judgment, prior project experience
Environmental Controls (dust, erosion, odor, vapor, stormwater) (3)	45	weeks	$ 5,000.00	$ 225,000.00	Preliminary engineering estimate based on similar remediation projects
Air Monitoring	45	weeks	$ 15,000.00	$ 675,000.00	Preliminary engineering estimate based on similar remediation projects
Groundwater Monitoring (4)	30	year	$ 23,000.00	$ 690,000.00	
NAPL Monitoring and Recovery	30	year	$ 12,000.00	$ 360,000.00	
Subtotal				$ 12,675,970.00	
Design and Permitting	8%			$ 1,014,077.60	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design
Contingency	25%			$ 3,168,992.50	25% contingency assumed due to potential variability in excavation volume and disposal costs.
PM/CM	11%			$ 1,394,356.70	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8
Total - Alternative 3				$ 18,254,000	

1. 0-15' BGS excavation area includes NAPL areas on the Middle parcel.
2. Pavement area is assumed to include the existing operations area of the Middle Parcel.
3. Project duration assumes excavation rate of 500 cy/day, 1,500 cy/day for backfill, and 2 weeks for paving.
4. Groundwater monitoring assumes 13 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.

Client	Duke Energy Ohio, Inc.
Site	East End Gas Works
Location	Cincinnati, OH
Remedial Cost Evaluation	

Alternative 4 - Excavation of NAPL Impacted Soils Above the Water Table

Items		Quantity	Unit	Unit Cost	Total Cost	Notes
Mobilization/Demobilization		1	LS	$ 100,000.00	$ 100,000.00	Engineering judgment, prior project experience
Soil Excavation [1]		178,700	cy	$ 30.00	$ 5,361,000.00	Engineering judgment, prior project experience
Support of Excavation		83,700	sf	$ 85.00	$ 7,114,500.00	Engineering judgment, prior project experience
Soil Treatment and Disposal		303,790	ton	$ 35.00	$ 10,632,650.00	Preliminary engineering estimate based on similar remediation projects
Topsoil Placement and Grading (top 6") [2]		4,000	sy	$ 7.30	$ 29,200.00	Engineering judgment, prior project experience
Seeding		4,000	sy	$ 1.11	$ 4,440.00	Engineering judgment, prior project experience
Backfill		178,700	cy	$ 23.00	$ 4,110,100.00	Engineering judgment, prior project experience
MGP Structures Foundation Demolition and Loading		4,800	ton	$ 60.00	$ 288,000.00	Engineering judgment, prior project experience
Demo Debris Transportation and Disposal		4,800	ton	$ 30.00	$ 144,000.00	Engineering judgment, prior project experience
NAPL Monitoring and Recovery Wells		8	each	$ 3,000.00	$ 24,000.00	Engineering judgment, prior project experience
Paving [3]		98,300	sf	$ 5.50	$ 540,650.00	Engineering judgment, prior project experience
Environmental Controls (dust, erosion, odor, vapor, stormwater) [4]		100	weeks	$ 5,000.00	$ 500,000.00	Preliminary engineering estimate based on similar remediation projects
Air Monitoring		100	weeks	$ 15,000.00	$ 1,500,000.00	Preliminary engineering estimate based on similar remediation projects
Groundwater Monitoring [5]		30	year	$ 23,000.00	$ 690,000.00	
NAPL Monitoring and Recovery		30	year	$ 12,000.00	$ 360,000.00	
Subtotal					$ 31,398,540.00	
Design and Permitting	6%				$ 1,883,912.40	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design
Contingency	25%				$ 7,849,635.00	25% contingency assumed due to potential variability in excavation volume and disposal costs.
PM/CM	11%				$ 3,453,839.40	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8
Total - Alternative 4					$ 44,586,000	

1. Excavation volume includes all NAPL impacted soils above the water table on the Middle Parcel and the area west of the West Parcel. Increase in unit cost compared to other Alternatives is due to complexity associated with a 40' deep excavation.
2. Loam and seed is limited to portion of DCI East included in excavation program, grassed area east of Pittsburgh Street, and portion of West Parcel included in excavation program.
3. Pavement area is assumed to include the existing operations area of the Middle Parcel.
4. Project duration assumes excavation rate of 500 cy/day, 1,500 cy/day for backfill, and 2 weeks for paving.
5. Groundwater monitoring assumes 13 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.

Client Duke Energy Ohio, Inc.
Site East End Gas Works
Location Cincinnati, OH
Remedial Cost Evaluation

Alternative 5 - ISS of NAPL Impacted Soils Above the Outwash

Items	Quantity	Unit	Unit Cost	Total Cost	Notes
Mobilization/Demobilization	1	LS	$ 150,000.00	$ 150,000.00	Engineering judgment, prior project experience
Pre-ISS Soil Excavation [1]	80,500	cy	$ 10.00	$ 805,000.00	Engineering judgment, prior project experience
Pre-ISS Excavation Support	66,600	sf	$ 75.00	$ 4,995,000.00	Engineering judgment, prior project experience
Pittsburgh Street Soil Excavation [2]	20,900	cy	$ 11.00	$ 229,900.00	Engineering judgment, prior project experience
Soil Treatment and Disposal [3]	191,080	ton	$ 35.00	$ 6,687,800.00	Preliminary engineering estimate based on similar remediation projects
Topsoil Placement and Grading (top 6") [4]	19,100	sy	$ 7.30	$ 139,430.00	Engineering judgment, prior project experience
Seeding	19,100	sy	$ 1.11	$ 21,201.00	Engineering judgment, prior project experience
ISS of NAPL Impacts	117,500	cy	$ 100.00	$ 11,750,000.00	Engineering judgment, prior project experience
Post ISS Swell Removal [5]	11,000	cy	$ 10.00	$ 110,000.00	Engineering judgment, prior project experience
Backfill	68,000	cy	$ 23.00	$ 1,564,000.00	Engineering judgment, prior project experience
MGP Structures Foundation Demolition and Loading	4,800	ton	$ 60.00	$ 288,000.00	Engineering judgment, prior project experience
Demo Debris Transportation and Disposal	4,800	ton	$ 30.00	$ 144,000.00	Engineering judgment, prior project experience
NAPL Monitoring and Recovery Wells	8	each	$ 3,000.00	$ 24,000.00	Engineering judgment, prior project experience
Paving [6]	98,300	sf	$ 5.50	$ 540,650.00	Engineering judgment, prior project experience
Environmental Controls (dust, erosion, odor, vapor, stormwater) [7]	142	weeks	$ 5,000.00	$ 710,000.00	Preliminary engineering estimate based on similar remediation projects
Air Monitoring	142	weeks	$ 15,000.00	$ 2,130,000.00	Preliminary engineering estimate based on similar remediation projects
Groundwater Monitoring [8]	30	year	$ 23,000.00	$ 690,000.00	
NAPL Monitoring and Recovery	30	year	$ 12,000.00	$ 360,000.00	
Subtotal				$ 31,338,981.00	
Design and Permitting	6%			$ 1,880,338.86	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8, Remedial Design
Contingency	25%			$ 7,834,745.25	25% contingency assumed due to potential variability in deep soil mixing costs.
PM/CM	11%			$ 3,447,287.91	EPA/ACOE FS Cost Guide July 2000, EPA 540-R-00-002, Exhibit 5-8
Total - Alternative 5				$ 44,502,000	

1. Excavation volume includes all ISS areas excavated to 15' BGS.
2. Excavation volume includes the Pittsburgh Street area excavted to 18' BGS
3. Soil treatment and disposal includes Pre-ISS, Pittsburgh St., and Post-ISS swell excavation volumes.
4. Loam and seed is limited to the area west of the West Parcel included in ISS program and grassed area east of Pittsburgh Street.
5. Assumes that approximatly 2' of swell will need to be removed over the ISS area.
6. Pavement area is assumed to include the existing operations area of the Middle Parcel.
7. Project duration assumes excavation and ISS rate of 500 cy/day, 1,500 cy/day for backfill, and 2 weeks for paving.
8. Groundwater monitoring assumes 13 wells sampled semi-annually and is based sampling and reporting costs from current monitoring program.