March 19, 2024

Mr. Sandeep Mehta
Task Order Contracting Officer's Representative
U.S. Environmental Protection Agency, Region 7
11201 Renner Boulevard
Lenexa, Kansas 66219

Subject: Contract No. 68HERH19D0018; Task Order No. 68E0719F0190
Former Clinton Engines
605 and 607 East Maple Street, Maquoketa, Iowa 52060
Analysis of Brownfields Cleanup Alternatives

Dear Mr. Mehta:

Toeroek Associates, Inc. (Toeroek) and our teaming subcontractor, Tetra Tech, Inc. (Tetra Tech), (hereafter "Toeroek Team") are pleased to present the Analysis of Brownfields Cleanup Alternatives of the former Clinton Engines (the Site) in Maquoketa, Iowa, Jackson County, Iowa. This deliverable has been reviewed internally as part of Tetra Tech's quality assurance program, as well as Toeroek's quality assurance program, and is consistent with Toeroek's Quality Management Plan for the Resource Conservation and Recovery Act (RCRA) Enforcement and Permitting Assistance (REPA) contract. Documentation of this review is retained in the Toeroek Team's project files.

If you have any questions or comments, please contact Greg Hanna at 720-898-4102 or Kaitlyn Mitchell at 816-412-1742.

Sincerely,

Greg Hanna
Toeroek Team Program Manager

Kaitlyn Mitchell
Toeroek Team Project Manager

Enclosure: Analysis of Brownfields Cleanup Alternatives

cc: Amber Krueger, EPA Region 7
Lisa Dunning, EPA Region 7
Heather Wood, Tetra Tech
Toeroek Team Project Files

300 Union Boulevard., Suite 520
Lakewood, CO 80228
Telephone: 303-420-7735
Fax: 303-420-7658

ANALYSIS OF BROWNFIELDS CLEANUP ALTERNATIVES

FORMER CLINTON ENGINES
605 AND 607 EAST MAPLE STREET MAQUOKETA, JACKSON COUNTY, IOWA

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 7

Task Order	:	68E0719F0190
Subtask	:	009.03
EPA Region	:	7
Date Prepared	:	March 19, 2024
Contract No.	:	68HERH19D0018
Prepared by	:	Toeroek Associates, Inc.
Project Manager	:	Kaitlyn Mitchell
Telephone	:	816-412-1742
EPA TOCOR	:	Sandeep Mehta
Telephone	:	913-551-7763

CONTENTS

TABLES

APPENDICES

FIGURES (in Appendix A)

Figure

1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) tasked Toeroek Associates, Inc. (Toeroek) and its teaming subcontractor, Tetra Tech, Inc. (Tetra Tech), (hereafter "Toeroek Team") to provide technical support to the EPA Region 7 Brownfields Program under Contract 68HERH19D0018, Task Order (TO) 68E0719F0190. EPA Region 7 requested that the Toeroek Team conduct an Analysis of Brownfields Cleanup Alternatives (ABCA) of the former Clinton Engines (the Site) at 605 and 607 East Maple Street Maquoketa, Iowa (Appendix A, Figure 1).

The Site consists of three parcels (parcel ID numbers 145181938200900, 145181938200700, and 145181938200800) (Appendix A, Figure 2). The western parcel, hosting three buildings, is owned by the Jackson County Historical Society. The City owns the two vacant parcels on the eastern portion of the Site. Reuse plans for the Site will depend on results of this Phase II ESA investigation and levels of contamination detected (City of Maquoketa 2021).

The Toeroek Team performed this ABCA based on results of the Targeted Brownfields Assessment (TBA), which consisted of a Phase II Environmental Site Assessment (ESA) by the Toeroek Team (Toeroek Team 2023a) and subsequent quarterly groundwater sampling (Toeroek Team 2023b, c, d). This ABCA focuses on the results of the initial Phase II report, which included soil and soil-gas samples as well as groundwater samples. The initial Phase II ESA report concluded that remediation appeared warranted based on analytical results from soil, groundwater, and soil-gas samples. The subsequent quarter sampling confirmed the conclusions of the initial Phase II ESA report.

According to the Brownfields Assessment Application (EPA 2021), the current property owner of the eastern parcels, the City of Maquoketa, has shown interest in developing at the Site contingent on findings from the Phase II ESA. Future use of the Site is unknown; however, the application states that anticipated use will be recreation, commercial, or industrial land uses.

This ABCA also considers state and federal regulations regarding soil, groundwater, and soil gas. Iowa Department of Natural Resources (IDNR) Statewide Standards (SWSs) are the standard of contamination used by the Iowa Land Recycling Program (LRP) voluntary cleanup program. Soil sample results from this Phase II ESA were compared to Iowa Department of Natural Resources (IDNR) Statewide Standards (SWSs) and EPA Regional Screening Levels (RSLs) for residential and industrial land uses (IDNR 2023b, EPA 2023a). Analytical results from groundwater samples were compared to IDNR SWSs for Non-protected Groundwater, Federal Maximum Contaminant Levels (MCLs), and EPA RSLs for tap water if no MCL had been established (IDNR 2023b, EPA 2023a). RSLs for soil and groundwater assumed a target hazard quotient (THQ) of 0.1 and a carcinogenic risk (TR) of 10^{-6}. Concentrations of volatile organic compounds (VOCs) detected in exterior soil-gas samples were compared to EPA Vapor Intrusion Screening Levels (VISLs) assuming a THQ of 0.1 and a TR of 10^{-5} (EPA 2023a, b).

This ABCA provides three possible cleanup alternatives for the Site. Additional possible remedies not considered here include thermal desorption, bioremediation, and permeable reactive barriers. EPA's road map for brownfields cleanup alternatives provides additional remedies that may be used for chlorinated VOCs (CVOCs) such as those identified at the Clinton Engines site (EPA 2017). The options chosen for this ABCA are the cleanup alternatives that the Toeroek Team considered most likely to be used to reduce the mass of CVOCs within the Site boundaries.

In addition, the Clinton Engines site is a large, complex site that includes both on and offsite contamination. This ABCA focuses on source point reduction remediation options for the Site itself, not offsite contamination, and is intended only for a general comparison of effectiveness, implementation, and cost. Additional investigation would be required to better constrain the lateral and vertical extent of the source area within the Site boundaries. A better understanding of the source area would allow a more specific assessment of the ABCA factors, particularly cost. Further, this is not a remedial action plan and further cost estimating, and specifications will be required once an alternative is chosen. The future use of the site and any funding sources used for remediation could also impact the remediation alternative chosen and the cost of that alternative.

2.0 BACKGROUND AND DESCRIPTION

The Site consists of three parcels (parcel ID numbers 145181938200900, 145181938200700, and 145181938200800) (Appendix A, Figure 2) at 605 and 607 East Maple Street Maquoketa, Iowa. It is depicted on Section 19, Township 84 North, Range 3 East, as shown on the Maquoketa, Iowa, 7.5-minute topographic map (U.S. Geological Survey [USGS] 1980). Coordinates at the approximate center of the Site are 42.065375 degrees north latitude and 90.657173 degrees west longitude.

The western parcel, hosting three buildings, is owned by the Jackson County Historical Society. The City owns the two vacant parcels on the eastern portion of the Site. The Museum on the western parcel, the only building remaining from the original facility, is within a grassy area on the northwestern portion of the Site. The Museum is a 2-story brick building with entry stairs leading to the upper level at the north and a basement level partially below ground, with stairs providing access from the south. Clinton Engines formerly used it for offices and classrooms (Missman, Stanley & Associates, P.C. [MSA] 1999).

The Site is within a mixed-use area consisting of residential, agricultural, and commercial land. It is surrounded by single-family residences across South Clark Street to the west and commercial properties with some agricultural or undeveloped parcels to the north, east, and southeast. Agricultural land and several homes are south of the Site on the east side of South Clark Street (Toeroek Team 2023a).

Beginning in approximately 1945, the Site hosted industrial operations that included production of small engines. The Clinton Engines Company (Clinton Engines) acquired the property in 1950 from the Maquoketa Company and continued production of small engines. During the 1999 Phase I and II ESA, the machine shop, shipping and receiving, and one of the paint booths were in active use. The Phase I ESA report described other portions of the facility as dilapidated, with holes in the roof and walls, and standing water. Former operations included a foundry and die casting. Apparent underground storage tanks (UST), chemical storage rooms, and 55-gallon drums were noted in various areas (MSA 1999).

Clinton Engines officially closed in 1999, and the property was donated to the City of Maquoketa in 2000 (IDNR 2020). In 2004, the Jackson County Historical Society purchased the western parcel from City of Maquoketa (Beacon 2022). Review of aerial photographs indicated that most facility buildings had been razed by 2004, with only a former office/administration building left standing (Historic Aerials 2023). This building has been converted into the Museum. Other buildings associated with the facility were razed by about 2004. The Papke Heritage building southwest of the parking lot and the Train Depot building to the east were constructed in about 2014.

3.0 PREVIOUS INVESTIGATIONS

MSA conducted a Phase I and II ESA in 1999. These assessments confirmed presences (some former and some then current) at Clinton Engines facility of a foundry, machine shops, cast and painting operations, and at least seven USTs. Four USTs (two 1,000-gallon gasoline, one 2,000-gallon gasoline, and one 1,000-gallon hazardous waste) near the north side of the former machine shop had been removed in 1986 (MSA 1999). Most manufacturing buildings were south and southeast of the Museum. During the Phase II ESA, MSA reported elevated levels of VOCs; *cis*-1,2-dichloroethene (DCE); trichloroethene (TCE); and vinyl chloride (VC) in both groundwater and soil samples collected throughout the Site.

On May 23, 2005, IDNR notified the City of transfer of the Site to the Contaminated Sites Section within IDNR (IDNR 2005). Results from an Initial Site Screening (ISS), completed on June 2, 2005, indicated need for additional investigations at the Site (IDNR 2005). The Site was enrolled in the LRP in April 2008. According to the Voluntary LRP enrollment application, additional Site investigation activities occurred in 2006, including installation and sampling of eight groundwater monitoring wells (MW-10 through MW-17).

Reportedly, groundwater monitoring wells had been installed at the Site prior to enrollment in the Voluntary LRP program; however, Site files did not indicate who installed the wells or when they were installed (City of Maquoketa 2007). A 2006 Forest Road Consultants Work Plan and analytical data from groundwater samples from these wells accompanied the LRP application. Groundwater sampling by Forest Road Consultants indicated continued elevated concentrations of toluene, *cis*-DCE, TCE, and VC at a well southeast of the Museum. Soil sampling from borings advanced east of the Museum indicated similar elevated concentrations of the same contaminants. The enrollment application also included information pertaining to removal of three USTs (two 20,000-gallon diesel tanks and one 8,000-gallon tank of unidentified contents) from 2001 to 2002 (City of Maquoketa 2007).

Since 2006, further Site assessment activities have been sporadic, focusing primarily on delineation of extents of on-site and off-site groundwater contamination, and on-site vapor intrusion (VI). Off-site groundwater contamination by toluene; TCE; *cis*-DCE; *trans*-DCE; 1,1,2-trichloroethane (TCA); and VC was detected in off-site temporary wells as far as 900 feet north-northwest of the Site.

Additional Site investigation activities occurred in 2013, including sampling of "existing" groundwater monitoring wells, as well as groundwater at 13 boreholes, with mobile laboratory analysis by the direct-push technology (DPT) subcontractor, Below Ground Surface, Inc. (Impact7G, Inc. 2013).

Given the elevated chlorinated solvent concentrations in groundwater, IDNR required indoor VI sampling at the Museum (IDNR 2014). Sub-slab samples collected at the Museum in 2014 and 2015 contained TCE concentrations as high as 930 micrograms per cubic meter ($\mu g/m^3$). In response, cracks in the Museum basement were repaired, chemicals stored in the basement were relocated, and the sump pit area was passively vented. In December 2019, follow-up indoor air sampling at the Museum documented indoor air exceedances above LRP Residential Vapor Intrusion Risk Levels. As a result, two HE1X1NH energy recovery ventilators (ERVs) were installed at the Museum in September 2020 (IDNR 2020). These units have a typical air flow range of 925 cubic feet per minute (CFM) per unit, producing a total of 1.3 air exchanges per hour.

IDNR requested federal assistance in a letter dated February 17, 2020, regarding potential impacts of off-site groundwater contamination on nearby residential and commercial properties (IDNR 2020). IDNR also requested assistance related to VI sampling at surrounding properties near areas of known groundwater contamination to further determine potential impact (Tetra Tech 2021).

In June and July 2020, the Tetra Tech Superfund Technical Assessment and Response Team (START) collected indoor air samples at 28 locations—23 residential and five commercial properties. Ambient air samples were collected at two residential properties. During the second mobilization in July 2020, Tetra Tech START collected 12 DPT soil-gas samples from 8 feet below ground surface (bgs) and six DPT subsurface soil samples from about 5 feet bgs. Both soil-gas and soil samples were collected near a sanitary sewer line leading from the Site. START also collected drinking water samples from five domestic wells and three municipal wells. In June 2020, air samples were analyzed for TCE only. Air samples collected in July 2020 were analyzed for TCE; *cis*-1,2-DCE; *trans*-1,2-DCE; VC; and toluene. Soil samples and groundwater samples from drinking water wells were analyzed for VOCs (Tetra Tech 2021).

Results from the initial round of VI sampling in June 2020 indicated concentrations of less than 1.4 $\mu g/m^3$ of TCE in all but one sub-slab sample (3.1 $\mu g/m^3$). No indoor air samples yielded detections above EPA Removal Management Levels (RMLs).

Sub-slab vapor and indoor air samples collected at 15 other properties in July 2020 yielded similar low concentrations. TCE was identified in two sub-slab vapor samples and in four indoor air samples. No concentrations of *cis*-1,2-DCE; *trans*-1,2 DCE; or VC were detected in any sub-slab vapor sample; however, these compounds were reported at low concentrations in four indoor air samples. Toluene was detected in three sub-slab vapor samples. In indoor air samples, elevated toluene concentrations and frequent detections (in 15 of 16 samples) were reported, suggesting indoor sources rather than VI from subsurface soil or groundwater (Tetra Tech 2021).

In February 2021, to identify possible seasonal variations in TCE concentrations, resampling occurred at seven properties where TCE had been detected in either a sub-slab vapor or indoor air sample during the June or July 2020 sampling event. In February 2021, TCE was detected at 1.0 $\mu g/m^3$ in a sub-slab vapor sample from where the concentration had been 3.1 $\mu g/m^3$ in June 2020. Toluene was reported at 16 $\mu g/m^3$ in a sub-slab sample from where the concentration had been 7.0 $\mu g/m^3$ in July 2020. In a commercial building, *trans*-1,2-DCE was detected below the Commercial RML and Superfund Chemical Data Matrix (SCDM) Non-Cancer Risk Screening Concentration. Toluene was detected in six of seven indoor air samples at concentrations well below the residential RML and SCDM Non-Cancer Screening Level (Tetra Tech 2021).

The 12 soil-gas samples collected off site near the sewer line were analyzed for TCE; *cis*-1,2-DCE; *trans*-1,2-DCE; VC; and toluene via mobile laboratory by subcontractor, Below Ground Surface, Inc. None of these was detected in the samples (Tetra Tech 2021). These results suggested that vapor migration from the groundwater plume to shallow soils did not pose a significant threat off site (Tetra Tech 2021).

Soil sampling near the sewer line north and west of the Site yielded detections of TCE and *cis*-1,2-DCE at three locations north of the Site. Highest TCE concentration (3,000 µg/kg) was detected within 15 to 16 feet bgs in a boring near the northeast corner of the intersection of South Clark and East Maple Streets. TCE was detected at 610 µg/kg at 15-16 feet bgs, about 250 feet farther north. These contaminants were not detected in soil samples collected within 9 to 10 feet bgs from saturated clay at these two locations, suggesting contamination may be spreading through a saturated, sandy layer documented in the stratigraphy of the area (Tetra Tech 2021).

Groundwater samples collected from five downgradient domestic wells and three municipal wells did not contain VOCs other than the common laboratory contaminant acetone (Tetra Tech 2021). Total depths of the domestic drinking water wells registered with IDNR in the downgradient area generally range from about 140 to 200 feet bgs (IDNR 2023a). These domestic wells produce from the Silurian bedrock aquifer. City water derives from the Ordovician-Cambrian Aquifer at depths greater than 1,300 feet (below the Cambrian-aged St. Lawrence Formation), and most wells are upgradient or crossgradient of the Site.

4.0 PLANS FOR FUTURE USE

Future use of the Site is unknown; however, the Brownfields application states that anticipated use will be recreation, commercial, or industrial land uses. Iowa SWSs are based on an assumption of residential land use.

Based on analytical results from groundwater, soil, and soil-gas samples, further investigation and/or remediation appears warranted.

5.0 POTENTIAL CLEANUP ALTERNATIVES

The overall goal of any brownfields cleanup action is to address environmental conditions preventing or impeding the preferred type of Site redevelopment, and to do so in a manner protective of human health and the environment. This ABCA considers environmental media of soil and groundwater. Cleanup alternatives for soil are to conform to IDNR SWSs and EPA RSLs for residential and industrial land uses (IDNR 2023b, EPA 2023a). Analytical results from groundwater samples were to conform to IDNR SWSs for Non-protected Groundwater, Federal MCLs, and EPA RSLs for tap water if no MCL had been established (IDNR 2023b, EPA 2023a). RSLs for soil and groundwater assumed a THQ of 0.1 and a TR of 10^{-6}. VOC results from exterior soil-gas samples were to be compared to EPA Vapor Intrusion Screening Levels (VISLs) assuming a THQ of 0.1 and a TR of 10^{-5} (EPA 2023a, b). IDNR SWSs are the standard of contamination used by the Iowa LRP.

The Toeroek Team evaluated brownfields cleanup alternatives to address environmental effects identified during the Phase II ESA (Toeroek Team 2023a). The purpose of the ABCA was to present viable cleanup alternatives based on Site-specific conditions, technical feasibility, and preliminary cost evaluations.

The following sections describe brownfields cleanup alternatives for addressing contamination in soil, groundwater, and soil gas, including a "No Action" alternative. Following the description, each alternative is evaluated in terms of its effectiveness, implementability, and cost. The purpose of evaluating each alternative is to determine its advantages and disadvantages relative to the other alternatives in order to identify key tradeoffs that would affect selection of the preferred alternative.

Effectiveness of an alternative refers to its ability to meet objectives of the brownfields cleanup. Criteria applied to assess effectiveness of an alternative include all of the following:

- Overall protection of human health and the environment
- Long-term effectiveness
- Reduction of toxicity, mobility, or volume through treatment/removal
- Short-term effectiveness.

Criteria applied to assess implementability of an alternative are all of the following:

- Technical feasibility
- Administrative feasibility

- Availability of services and materials required during implementation of the alternative
- State acceptance
- Community acceptance.

Each alternative is evaluated to determine its estimated cost. The evaluations compare the alternatives' respective direct capital costs, which include equipment, services, and contingency allowances, as well as longer-term institutional controls (ICs), engineering controls (ECs), and operations and maintenance (O&M) costs. Again, the purpose of evaluating each alternative is to determine its advantages and disadvantages relative to the other alternatives in order to identify key tradeoffs that would affect selection of the preferred alternative.

5.1 EVALUATED CONTAMINATION

The following subsections convey evaluations of contamination in the relevant media:

5.1.1 Subsurface Soil

As part of the Toeroek Team Phase II ESA in 2023, 20 subsurface soil samples were collected at 18 groundwater monitoring well locations and analyzed for VOCs (Appendix A, Figure 3). Two samples were collected at MW-6B and MW-8B. Depth of sample collection from each core was within the zone inducing the highest reading of VOCs from a hand-held photoionization detector (PID). If field screening did not indicate evidence of VOCs, the sample was collected within the 2 feet of unconsolidated material closest to top of bedrock or terminus of the boring. Table 1 summarizes sampling depths.

TABLE 1

**SAMPLING DEPTHS OF SUBSURFACE SOIL SAMPLES
FORMER CLINTON ENGINES SITE, MAQUOKETA, IOWA**

Sample Location	Sample Depth (feet below ground surface [ft bgs])
MW-1B	19-21
MW-2B	55-57
MW-3B	36-38
MW-4B	24-26
MW-5B	21-23
MW-6B	18-20
	50-52
MW-8B	14-16
	55-57
MW-9	55-57
MW-10A	39-41
MW-10B	43-45
MW-11	44-46

TABLE 1

**SAMPLING DEPTHS OF SUBSURFACE SOIL SAMPLES
FORMER CLINTON ENGINES SITE, MAQUOKETA, IOWA**

Sample Location	Sample Depth (feet below ground surface [ft bgs])
MW-12	39-41
MW-13	22-24
MW-14	59-61
MW-101	114-116
MW-102	117-119
MW-103	19-21
MW-104	64-66

Comparisons of analytical data to IDNR SWS and EPA RSLs for residential and industrial land uses resulted in the following noteworthy findings:

- Concentrations of TCE were detected in 11 of the 20 subsurface soil samples, and exceeded both EPA residential and industrial RSLs for soil in five locations (MW-2, MW-4, MW-8B, MW-10A, and MW-10B). Some samples were collected within zones lower than the known contamination to evaluate chlorinated volatile organic compound (CVOC) concentrations in the underlying clay. Deeper samples collected within 55 to 57 feet bgs at MW-2B and MW-8B contained 2,400 µg/kg of TCE and 6,090 µg/kg of TCE, respectively—verifying migration of TCE to the deeper soils and no presence of a confining layer below the sandy layer screened in the older wells on the Site. None of the concentrations detected exceeded the IDNR SWS for soil.
- Concentrations of chloroform were detected in three of the 20 subsurface samples. Chloroform concentration in one sample (MW-1B) exceeded the EPA residential RSL, but not the industrial RSL or the IDNR SWS for soil.

Although no concentration of CVOC exceeded the Iowa SWS for soil, CVOCs detected in soil at the Site, TCE in particular, are detected in groundwater and soil gas on and downgradient from the Site, as described in Section 5.1.2 and Section 5.1.3.

5.1.2 Groundwater

As part of the Phase II ESA in 2023, groundwater samples were collected at 17 newly installed monitoring wells and analyzed for VOCs (Appendix A, Figure 3). Groundwater samples from the newly installed monitoring wells were collected about 2 weeks after well development via low-flow sampling technique.

Comparisons of analytical data to IDNR SWS and EPA RSLs for residential and industrial land uses resulted in the following noteworthy findings related to CVOCs also detected in soil at the Site:

- Concentrations of TCE were detected in 14 of the 15 groundwater samples. In 10 of those 14 samples, TCE concentrations exceeded the EPA MCL and IDNR SWS for protected groundwater (MW-1B, MW-2B, MW-3B, MW-6B, MW-8B, MW-9B, MW-10A, MW-10B, MW-12, and MW-14), and TCE exceedances of the IDNR SWS for non-protected groundwater were detected in seven samples (MW-2B, MW-3B, MW-8B, MW-9, MW-10A, MW-10B, and MW-12).
- Concentrations of 1,1-DCE were detected in seven of the 17 samples. In two of those seven (MW-8B and MW-12), 1,1-DCE concentrations exceeded the EPA MCL. In no sample did 1,1-DCE concentration exceed the IDNR SWS.
- Concentrations of cis-DCE were detected in 13 of the 17 samples. In eight of those 13 samples, cis-DCE concentrations exceeded the EPA MCL and IDNR SWS for protected groundwater (MW-1B, MW-2B, MW-3B, MW-8B, MW-10A, MW-10B, MW-12, and MW-14), while cis-DCE concentrations exceeded the IDNR SWS for non-protected groundwater in six samples (MW-2B, MW-3B, MW-8B, MW-10A, MW-10B, and MW-12).
- Concentrations of trans-DCE were detected in 12 of the 17 samples. In two of those 12 samples (MW-8 and MW-12), trans-DCE concentrations exceeded the EPA MCL and IDNR SWS for protected groundwater. In sample MW-8B, trans-DCE concentration exceeded the IDNR SWS for non-protected GW.
- Concentrations of VC were detected in nine of the 17 samples—all nine exceeded the EPA MCL and IDNR SWS for protected groundwater (MW-1B, MW-2B, MW-3B, MW-8B, MW-9, MW-10A, MW-10B, and MW-12). Of these, seven exceeded the IDNR SWS for non-protected groundwater (MW-1B, MW-2B, MW-3B, MW-8B, MW-10A, MW-10B, and MW-12).
- Concentration of carbon tetrachloride was detected in one of 17 groundwater samples (MW-3B), and exceeded the EPA residential RSL and IDNR SWS for protected groundwater, but not the IDNR SWS for non-protected groundwater.

5.1.3 Soil Gas

As part of the Phase II ESA in 2023, to investigate possible presence of contaminants in soil gas from historical activities at the Site, the Toeroek Team collected soil-gas samples from borings adjacent to monitoring wells. Soil-gas samples were submitted to Pace Analytical for analysis for VOCs via EPA Method Toxic Organics (TO)-15. Analytical data were compared to VISLs assuming a THQ of 0.1 and a TR of 10^{-5} (EPA 2023b).

VOCs were detected in all soil-gas samples. Detections of TCE concentrations in soil-gas samples adjacent to wells MW-2B, MW-3B, MW-8B, MW-9, MW-10A/B, and MW-11 exceeded the EPA residential VISL for TCE of 6.7 $\mu g/m^3$. Except in samples MW9-SG and MW10-SG, detected TCE concentrations also exceeded the commercial VISL of 20 $\mu g/m^3$.

5.2 EVALUATION OF CLEANUP ALTERNATIVES FOR SOIL AND GROUNDWATER

The Toeroek Team has developed three cleanup alternatives for all three affected media. These alternatives are considered to address source areas on the applicant's property and do not extend to considerations of off-Site contamination. Any remedies for off-Site contamination are outside the scope of the Brownfields Program.

Three options were evaluated for reuse: (1) no action, (2) soil excavation with off-site disposal and in-situ chemical oxidation, and (3) installation and operation of an in-situ air sparging and soil vapor extraction (SVE) system. These remedies were selected to address contamination in soil within the Site boundaries. CVOCs in soil contribute to contamination in groundwater and to contamination in soil gas, both directly and from contamination in groundwater. Alternatives 2 and 3 will also have knock-on effects reducing the mass of CVOCs in groundwater and soil gas on and off site, but this reduction is not a primary focus.

5.2.1 Alternative 1: No Action (Baseline)

The no action alternative is included as a baseline for comparison to the other proposed alternatives. This alternative would involve no containment, treatment, removal, or monitoring of contaminants. All contamination would be left in place, and no restrictions on future land use would be imposed.

Effectiveness

Because the no action alternative would not be protective of human health and the environment, it is not considered effective.

Implementation

Implementation of this alternative would require no effort because no containment, treatment, removal, or monitoring of contaminants would occur. Future redevelopment would have to consider the potential threat to human health and the environment.

Cost

This alternative would not involve any direct costs.

5.2.2 Alternative 2: Soil Excavation with Off-Site Disposal and In-Situ Chemical Oxidation

Alternative 2 would involve excavation of soil and in-situ application of permanganate in the areas where TCE has been detected at elevated concentrations. Disposal of excavated soil then would occur off site at a landfill facility.

Soil excavation would be focused on areas where concentrations of TCE in soil were highest. EPA residential RSLs were assumed as the cleanup level. For cost estimating purposes, the Toeroek Team assumed the following:

- Excavation: Soil excavation to a depth of 20 feet bgs or until encounter with groundwater—anticipated between 11 and 20 feet bgs. The approximate areas for excavation appear on Figure 4 in Appendix A.
    - Soil excavation of a 300- by 50-foot rectangle at the northwest corner of the Site running west to east with MW-10 at the eastern extent. Estimated volume of soil to be excavated to cleanup levels is approximately 11,110 cubic yards (CY), assuming an area of 15,000 square feet (SF) and depth of 20 feet bgs.
    - Soil excavation of a 50- by 50-foot square at MW-8. Estimated volume of soil to be excavated to cleanup levels is approximately 1,850 CY, assuming an area of 2,500 SF and depth of 20 feet bgs.
    - Soil excavation of a 50- by 50-foot square at MW-4. Estimated volume of soil to be excavated to cleanup levels is approximately 1,850 CY, assuming an area of 2,500 SF and depth of 20 feet bgs.
    - Soil excavation of a 50- by 50-foot square at MW-2. Estimated volume of soil to be excavated to cleanup levels is approximately 1,850 CY, assuming an area of 2,500 SF and depth of 20 feet bgs.
- Confirmation Sampling: One sample will be collected every 20 linear feet along the perimeter of the sidewalls. Floor samples should be collected at the same frequency as for sidewall samples. Confirmation soil sampling of deeper soils verifying contaminant concentrations below cleanup levels may not be achievable because of high concentrations of TCE at deep intervals, and verifications during the Phase II of migration of TCE to the deeper soils and no presence of a confining layer below the sandy layer screened in the older wells on the Site.
- In-situ chemical oxidation (ISCO): Following excavation to the discussed depths, an ISCO solution of permanganate will be applied at the base of each excavation pit to remediate the deeper soils and groundwater immediately below the base of the excavation.
- Backfill: Excavated areas would be backfilled with clean material from off the Site, graded, and seeded as needed for redevelopment after ISCO liquids would have had enough time to infiltrate into subsurface soils.
- Waste Disposal: All excavated soil would be accepted at a landfill facility as non-hazardous waste.

If this cleanup alternative is selected, an additional soil sampling would be recommended to refine delineations of lateral and vertical extents of contamination and possibly reduce excavation volume. The company selected to apply the ISCO permanganate solution would be responsible to calculate how much of that solution would be required. Accurate design of ISCO application necessitates data on target level contaminants, as well as quantitative estimates of reduced minerals or oxidation-reduction potential and other subsurface chemistry (Haselow and others 2003).

Effectiveness

Soils with highest contaminant concentrations would be removed from the Site, thus reducing their ongoing contribution to contamination in groundwater and soil gas. Application of permanganate to the bottom of the excavation would promote additional treatment of CVOCs in soil and groundwater at the source area and enhance reduction of CVOC concentrations beyond the natural attenuation of these farther downgradient of the contaminant plume. However, some contaminants would remain on the Site, as this alternative is not intended to completely remove CVOCs from groundwater. Monitoring would be necessary to ensure ISCO is working to reduce contaminant levels and transform the contaminants into less harmful chemicals. This alternative would also require ongoing ICs to ensure that groundwater at the Site is not used as drinking water.

Implementation

Soil excavation by qualified equipment operators would accord with applicable state and federal regulations. Excavation of approximately 16,650 CY of soil is necessary to clean up the Site. All waste soil excavated during this process would be transported for disposal off site as either non-hazardous or hazardous waste, depending on results of toxicity characteristic leaching procedure (TCLP) analysis. In-situ chemicals would be selected and applied by a qualified specialist in in-situ applications. For cost estimating purposes, assumptions are that none of the excavated soil would be used as backfill, and all excavated soil would be handled as non-hazardous waste. In addition, planning this process would require careful consideration of precautions concerning worker health and safety.

Cost

Estimated total cost of Alternative 2 in 2024 dollars is **$850,000**. This cost does not include any ICs to prevent use of groundwater as drinking water, nor does it include the cost of ongoing downgradient groundwater monitoring. Table 2 lists total costs associated with this alternative. Costs were estimated by applying selected functions of Remedial Action Cost Engineering Requirements within the program RS Means. Details of costs are in Appendix B. This cost is based on the assumptions listed above and should be considered a very general estimate. Estimated costs for this alternative could be reduced if additional sampling occurs to further delineate lateral and vertical extents of contamination, thereby possibly reducing excavation volume.

TABLE 2

SOIL ALTERNATIVE 2 – TOTAL COSTS
FORMER CLINTON ENGINES SITE, MAQUOKETA, IOWA

Line Item	Cost
Soil Removal (Includes ISCO placement and backfilling)	$800,000
Mobilization/Demobilization	$1,300
Sampling/Oversight	$50,000
Total Alternative 2 Cost	**$851,300**
Total Alternative 2 Cost, rounded	**$850,000**

5.2.3 Alternative 3: In-Situ Air Sparging and Soil Vapor Extraction

Alternative 3 would involve in-situ air sparging (AS) and installation of an AS/SVE system within the Site boundary. SVE, as the name implies, extracts contaminant (such as TCE) vapor from the subsurface soil, above the water table by creating a partial vacuum to remove these contaminants. The vapor extracted from the soil-vapor extraction wells is treated to remove contaminants, if necessary. AS is a remedial technology which injects air into the subsurface below the water table to push contaminant vapor out of water to be collected by a SVE system. The combined technology (AS/SVE) can be effective at removing volatile organic chemicals (such as TCE) from subsurface soil and groundwater. This cleanup alternative would also be focused on areas where concentrations of TCE in soil were highest. EPA residential RSLs were again assumed as the cleanup level.

For cost estimating purposes, the Toeroek Team assumed the following:

- The SVE control building would be in an area of the Site where public access is minimal. SVE extraction wells would be placed every 100 feet along the perimeter of the Site along the north property line and east property line. An additional set of wells would be set every 100 feet; run north to south and placed just east of MW-10, MW-8, and MW-2; and end in the approximate middle of the property. Installations of 16 extraction wells are expected. Because TCE has been found deep within soil during the Phase II in 2022, the SVE system would be powered by a 5-horsepower motor. Extraction wells would be screened in the unsaturated (vadose) zone of soil. Approximate locations of wells appear on Figure 5 in Appendix A.
- An air injection well would be placed between every two SVE extraction wells, totaling eight air injection wells. Injection well depth would be at least 60 feet bgs to ensure injection into contaminated groundwater. Approximate locations of wells appear on Figure 5 in Appendix A.

- A pilot test would need to occur to optimize operations, including additional testing of subsurface conditions including, but not limited to, saturated thickness of soil above bedrock, permeability of soil and bedrock, sorption, and groundwater flux.
- Full-scale operation would continue for 30 years. For cost estimating purposes, the system would be assumed to operate for 30 years. Operations and maintenance for that 30 years would also include quarterly sampling.

Effectiveness

The AS/SVE system would likely reduce contaminant concentrations to below EPA residential RSLs which would achieve project cleanup goals for future use. Monitoring would be required to ensure effectiveness of the AS/SVE system. This alternative would also require ongoing control ICs to ensure that groundwater at the Site is not used as drinking water until residential RSLs goals are met.

Implementation

The AS/SVE system would necessitate a pilot study along with additional testing of subsurface conditions including, but not limited to, saturated thickness of soil above bedrock, permeability of soil and bedrock, sorption, and groundwater flux.

Cost

Estimated total cost of Alternative 3 in 2024 dollars is **$1,500,000**. This cost does not include any ICs to prevent use of groundwater as drinking water. The cost of ongoing downgradient groundwater monitoring is included with the O&M costs. Table 3 lists total costs associated with this alternative. Costs were estimated by applying selected functions of RS Means. Details of costs are in Appendix B. Estimated costs for this alternative could be reduced if additional sampling occurs to further delineate lateral and vertical extents of contamination, thereby possibly reducing the area to undergo treatment by the AS/SVE system.

TABLE 3

SOIL ALTERNATIVE 3 – TOTAL COSTS
FORMER CLINTON ENGINES SITE, MAQUOKETA, IOWA

Line Item	Cost
AS/SVE System Installation	$370,000
Operations and Maintenance (30 years)	$1,100,000
Total Alternative 3 Cost	**$1,470,000**
Total Alternative3 Cost, rounded	**$1,500,000**

5.3 RECOMMENDED CLEANUP ALTERNATIVE

This section recommends Alternative 3 (In-Situ Air Sparging and Soil Vapor Extraction) as the cleanup alternative for contaminated soil and groundwater at the Site. Although this alternative is not the lowest cost, it would allow the state, EPA, and other regulators to monitor the remedial activities and adjust the system as necessary. AS/SVE systems also cause little disruption to nearby properties and reach discrete subsurface soil locations within the groundwater bearing zone, in contrast to removal of contaminated shallow soils. This alternative would involve a direct approach and would allow unrestricted use of the Site if modeled or actual vapor intrusion levels were brought below residential VISLs. It would achieve regulatory compliance and would allow residential and/or commercial redevelopment of the Site. As stated above, costs for Site restoration, pilot studies, and subsurface characteristic studies have not been included in this ABCA.

6.0 REFERENCES

Beacon. 2022. Jackson County, Iowa Assessor Parcel Interactive Map. https://beacon.schneidercorp.com/Application.aspx?AppID=80&LayerID=723&PageTypeID=1&PageID=938

City of Maquoketa. 2007. Land Recycling Program Enrollment Application. November 27.

City of Maquoketa. 2021. U.S. Environmental Protection Agency Region 7 Targeted Brownfields Assessment Application Form. August 21.

Haselow, J. S., R.L. Siegrist, M. Crimi, and T. Jarosch. 2003. "Estimating the total oxidant demand for *in situ* chemical oxidation design." *Remediation Journal*, *13*(4), 5-16. https://doi.org/10.1002/rem.10080

Historic Aerials. 2023. https://www.historicaerials.com/

Impact7G, Inc. 2013. Site Assessment Report Former Clinton Engines. June 21.

Iowa Department of Natural Resources (IDNR). 2005. Initial Site Screening Report. Site ID: 174. Site Name: Clinton Engines. June 2.

Iowa Department of Natural Resources (IDNR). 2014. Letter regarding Site Assessment Report pertaining to the Former Clinton Engines site in Maquoketa, Iowa. From Greg Fuhrmann, IDNR Land Recycling Program Coordinator. To Brian Wagner, City Manager, City of Maquoketa. December 16.

Iowa Department of Natural Resources (IDNR). 2020. Letter regarding Clinton Engines in Maquoketa, Iowa. From Amie Davidson, IDNR Land Quality Bureau Chief. To Ken Buchholz, U.S. Environmental Protection Agency (EPA) Assessment, Emergency Response & Removal Branch. February 17.

Iowa Department of Natural Resources (IDNR). 2023a. Private Well Tracking System. https://programs.iowadnr.gov/pwts/Default

Iowa Department of Natural Resources (IDNR). 2023b. Cumulative Risk Calculator – Statewide Standards. Accessed July 2023. https://programs.iowadnr.gov/riskcalc/Home/StatewideStandards

Missman, Stanley & Associates, P.C. (MSA). 1999. Phase I/ Phase II Environmental Assessment. Clinton Engines Property. 605 East Maple Street, Maquoketa Iowa. Prepared for the City of Maquoketa. October 15.

Tetra Tech, Inc. (Tetra Tech). 2021. Integrated Assessment: Preliminary Assessment/Site Inspection (PA/SI) and Removal Site Evaluation Report. TCE Clinton Engines Sites. Maquoketa, Iowa. April.

Toeroek Associates, Inc. and Tetra Tech Inc. (Toeroek Team). 2023a. Targeted Brownfields Assessment, Phase II Environmental Site Assessment, Former Clinton Engines, 605 and 607 East Maple Street, Jackson County, Maquoketa, Iowa. May 9.

Toeroek Associates, Inc. and Tetra Tech Inc. (Toeroek Team). 2023b. Targeted Brownfields Assessment, Phase II Environmental Site Assessment, Quarter 2, Former Clinton Engines, 605 and 607 East Maple Street, Jackson County, Maquoketa, Iowa. May 9.

Toeroek Associates, Inc. and Tetra Tech Inc. (Toeroek Team). 2023c. Targeted Brownfields Assessment, Phase II Environmental Site Assessment, Quarter 2, Former Clinton Engines, 605 and 607 East Maple Street, Jackson County, Maquoketa, Iowa. July 25.

Toeroek Associates, Inc. and Tetra Tech Inc. (Toeroek Team). 2023d. Targeted Brownfields Assessment, Phase II Environmental Site Assessment, Quarter 2, Former Clinton Engines, 605 and 607 East Maple Street, Jackson County, Maquoketa, Iowa. September 15.

U.S. Environmental Protection Agency (EPA). 2017. Brownfields Road Map to Understanding Options for Site Investigation and Cleanup, Sixth Edition. Office of Land and Emergency Management, EPA 542-R-17-003. https://www.epa.gov/sites/default/files/2017-11/documents/brownfieldsroadmapepa542-r-12-001.pdf

U.S. Environmental Protection Agency (EPA). 2021. Brownfields Assessment Application: Former Clinton Engines, 605 and 607 East Maple Street, Jackson County, Maquoketa, Iowa August 13.

U.S. Environmental Protection Agency (EPA). 2023a. Regional Screening Levels (RSLs) – Generic Tables. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

U.S. Environmental Protection Agency (EPA). 2023b. Vapor Intrusion Screening Level Calculator. https://www.epa.gov/vaporintrusion/vapor-intrusion-screening-level-calculator

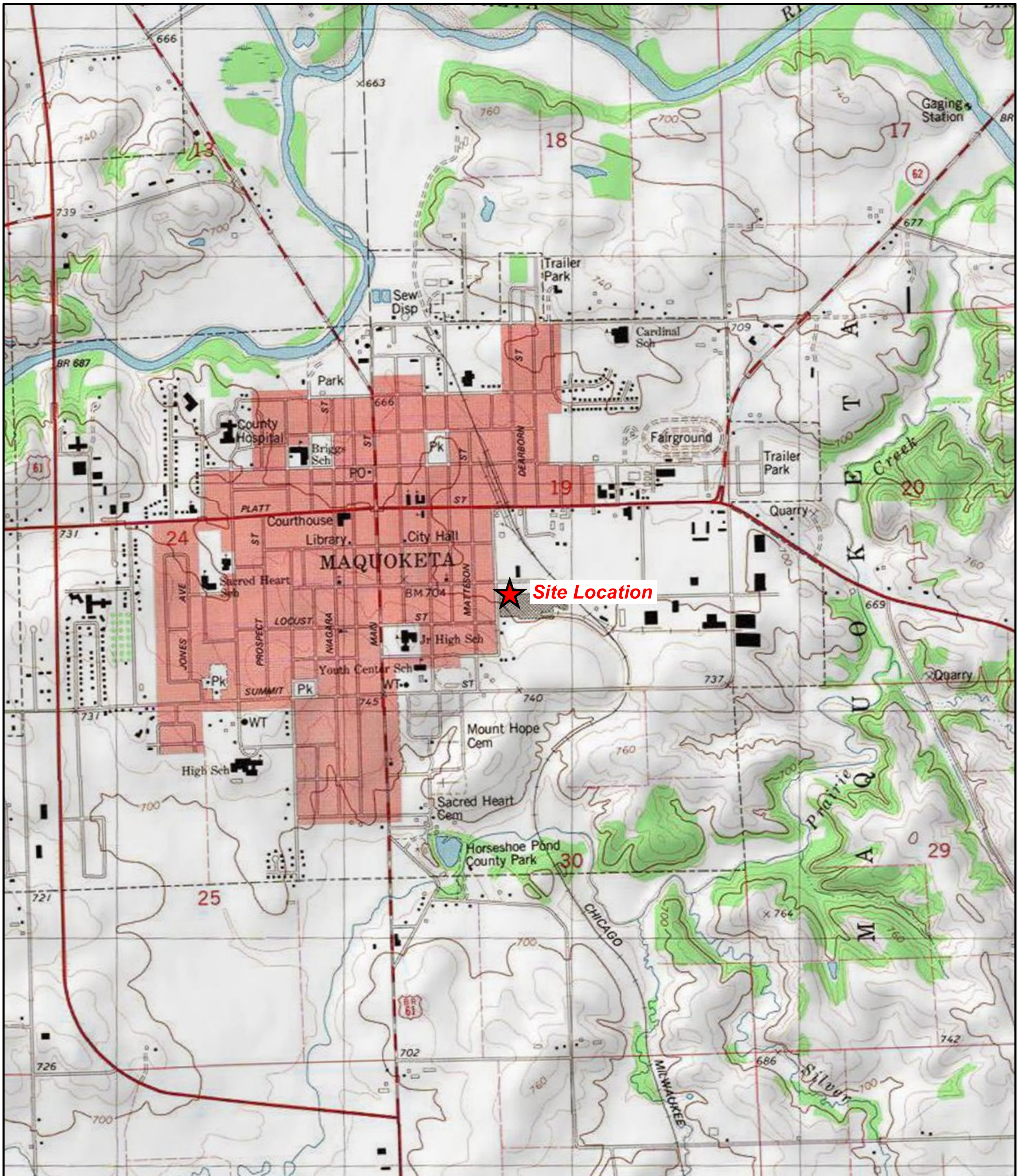
U.S. Geological Survey (USGS). 1980. Maquoketa, Iowa, Quadrangle Map. 7.5-Minute Topographic Series.

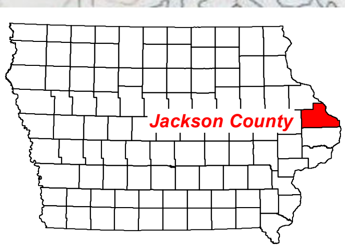
APPENDIX A

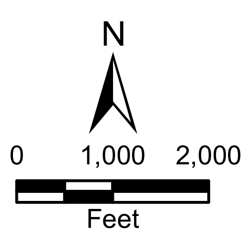
FIGURES

FIGURE 1

SITE LOCATION MAP







Source: Maquoketa, Iowa USGS 7.5 Minute Topo Quad, 1980

Former Clinton Engines
605 and 607 East Maple Street
Maquoketa, Jackson County, Iowa

Figure 1
Site Location Map

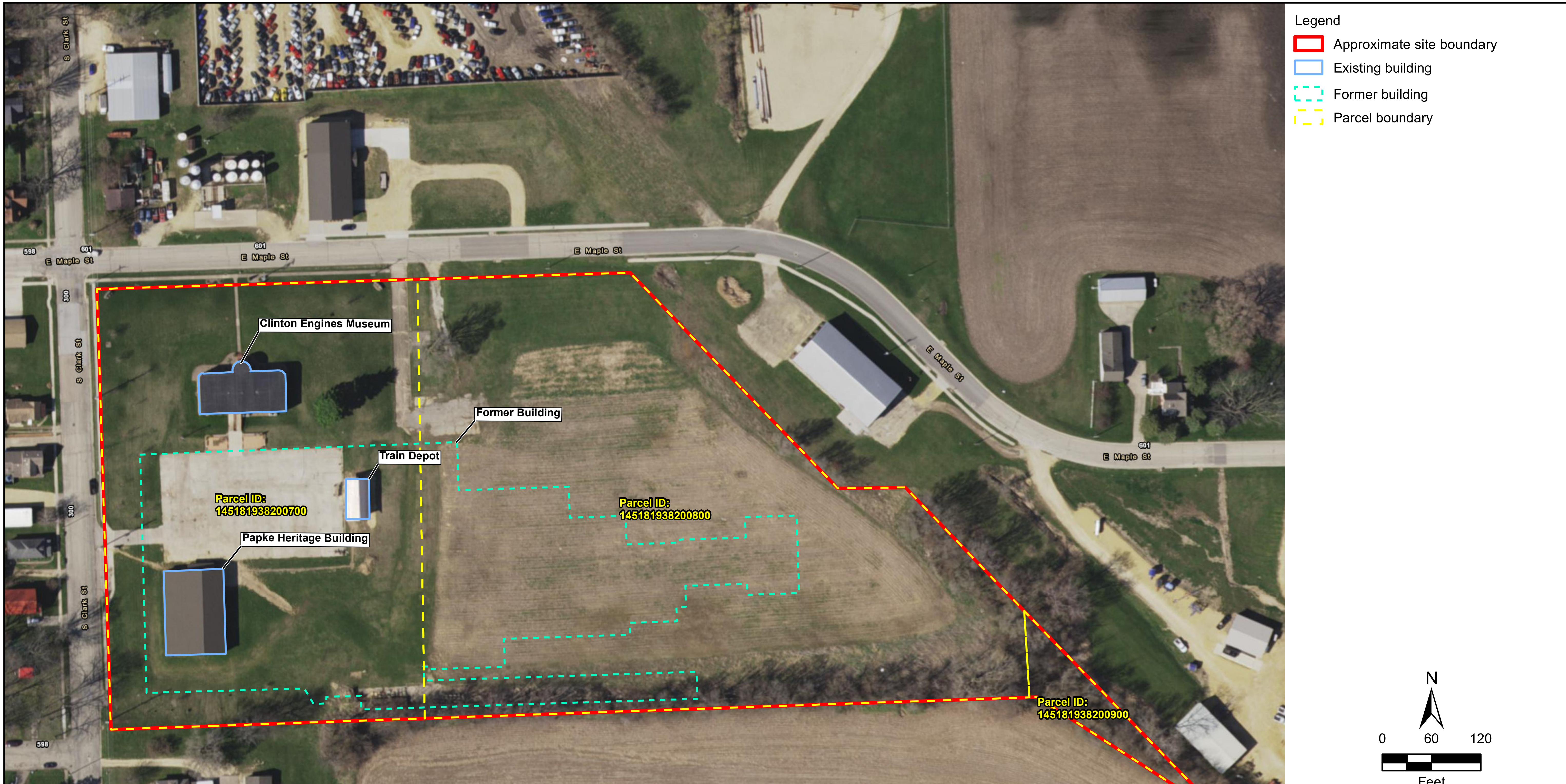
TETRA TECH
TOEROEK ASSOCIATES, INC.

Date: 1/12/2023 | Drawn By: Nick Wiederholt | Project No: 103G6521.0190.09.03

X:\P\6521\0190\09\Projects\mxd\PhaseII_ESA\Figure1.mxd

FIGURE 2

SITE LAYOUT MAP



Source: FCR Consulting, Inc., Former Clinton Engines - Site Map, 2010;
Iowa GIS Data.Org, Jackson Co., IA, Parcels, 2022;
Iowa State University GIS Support and Research Facility,
Iowa Geogrpahic Map Server, Aerial Imagery, 2016 - 2018

Former Clinton Engines
605 and 607 East Maple Street
Maquoketa, Jackson County, Iowa

Figure 2

Site Layout Map

TETRA TECH

TOEROEK ASSOCIATES, INC.

Date: 1/12/2023 Drawn By: Nick Wiederholt Project No: 103G6521.0190.09.03

FIGURE 3

2022 SAMPLE LOCATION MAP

Legend

- Monitoring well sample location
- Soil gas sample location
- Approximate site boundary

N

0 175 350

Feet

Source: Iowa State University GIS Support and Research Facility,
Iowa Geogrpahic Map Server, Aerial Imagery, 2016 - 2018

Former Clinton Engines
605 and 607 East Maple Street
Maquoketa, Jackson County, Iowa

Figure 3

2022 Sample Location Map

TETRA TECH

TOEROEK ASSOCIATES, INC.

Date: 1/12/2023 Drawn By: Nick Wiederholt Project No: 103G6521.0190.09.03

FIGURE 4

ALTERNATIVE 2: EXCAVATION AREAS

Source: Iowa State University GIS Support and Research Facility, Iowa Geogrpahic Map Server, Aerial Imagery, 2016 - 2018

Former Clinton Engines
605 and 607 East Maple Street
Maquoketa, Jackson County, Iowa

Figure 4
Alternative 2: Excavation Areas

TETRA TECH
TOEROEK ASSOCIATES, INC.

Date: 2/5/2024 Drawn By: Susmita Shrestha Project No: 103G6521.0190.09.03

FIGURE 5

ALTERNATIVE 3: IN-SITU AIR SPARGE AND SOIL-VAPOR EXTRACTION WELLS

Source: Iowa State University GIS Support and Research Facility, Iowa Geogrpahic Map Server, Aerial Imagery, 2016 - 2018

Former Clinton Engines
605 and 607 East Maple Street
Maquoketa, Jackson County, Iowa

Figure 5
Alternative 3: In-Situ Air Sparge and Soil-vapor Extraction Wells

TETRA TECH
TOEROEK ASSOCIATES, INC.

Date: 2/2/2024 Drawn By: Susmita Shrestha Project No: 103G6521.0190.09.03

X:\P\6521\0190\09\Projects\mxd\PhaseII_ESA\Figure5_1.25.2024.mxd

APPENDIX B

COST ESTIMATES

Alternative 2
Quantities:

Soil Removal Areas	Excavation (BCY)	Hauling (LCY)	Backfill (BCY)
MW-10	11110	16665	11110
MW-8	1850	2775	1850
MW-4	1850	2775	1850
MW-2	1850	2775	1850
Time Estimate (Days)	38.6		14.68

54.00

Soil Removal:

Line Item	MW-10				MW-8				MW-4				MW-2			
	Quantity	Unit	Unit Cost	Cost	Quantity	Unit	Unit Cost	Cost	Quantity	Unit	Unit Cost	Cost	Quantity	Unit	Unit Cost	Cost
Excavation	11110	BCY	$ 4.80	$ 53,328.00	1850	BCY	$ 4.80	$ 8,880.00	1850	BCY	$ 4.80	$ 8,880.00	1850	BCY	$ 4.80	$ 8,880.00
in-situ solution of permanganate at the base																
Loading Trucks	16665	LCY	$ 0.72	$ 11,998.80	2775	LCY	$ 0.72	$ 1,998.00	2775	LCY	$ 0.72	$ 1,998.00	2775	LCY	$ 0.72	$ 1,998.00
Hauling	16665	LCY	$ 8.58	$ 142,985.70	2775	LCY	$ 8.58	$ 23,809.50	2775	LCY	$ 8.58	$ 23,809.50	2775	LCY	$ 8.58	$ 23,809.50
Offsite Backfill	11110	LCY	$ 28.97	$ 321,856.70	1850	LCY	$ 28.97	$ 53,594.50	1850	LCY	$ 28.97	$ 53,594.50	1850	LCY	$ 28.97	$ 53,594.50
				$ 530,169.20				$ 88,282.00				$ 88,282.00				$ 88,282.00

Mobilization and Demobilization	Quantity	Unit	Unit Cost	Cost
	2	Ea	$ 651.70	$ 1,303.40

Soil Removal Total	**$ 796,318.60**

Confirmation Sampling/Oversight:

Line Item	Quantity	Unit	Unit Cost	Cost
Man Hours	432	HR	$ 100.00	$ 43,200.00
Lab Cost	101	Ea	$ 70.00	$ 7,070.00

*assume local lab
* assume oversight personnel is there every day of excavation and also performing sampling
*assume 8 hour days

Sampling/Oversight Total	**$ 50,270.00**

Project Total **$ 846,588.60**

Notes:

BCY	Bank cubic yards
Ea	Each
HR	Hours
LCY	Loose cubic yards

Excavation Assumptions	Unit Cost	Production
RS Means 312316131342		
Excavating, 20 feet (')-24' deep, 1.5-cubic-yard (CY) excavator	$ 4.80 BCY	432 CY per day
Crew B12B: Operator, Laborer, Excavator w/ 1.5 yard bucket		
*add 15% for loading on trucks		
Sheet Piling Systems	$ 43.76 SF	
RS Means 314116101500		960 square feet (SF) per day
Sheet Pile Systems 20' deep excavation, 27 pounds per square foot (psf), drive, extract and salvage		
Crew B40		
Hauling Assumptions		
RS Means 312323203025		132 loose cubic yards (LCY)/day
16.5 CY truck, 10 mile cycle, 15 minutes wait time		
Crew: B34C		
Backfill Assumption		
RS Means 312323130900		
Backfill compaction in 12' layers, roller compaction operator walking	$ 4.37 BCY	150 bank cubic yards (BCY)/day
Crew: B10A		
RS Means 312323154010		
Borrow loading and/or spreading 1.5 CY bucket	$ 24.60 BCY	1135 BCY/day
Crew: B12O		
Mobilization	$ 651.70 Each	
RS Means 015436501400		
Equipment 20-ton capacity		
In Situ Chemical Oxidation (ISCO)		
**Requires additional testings	Costs vary between contractor	

Alternative 3

Quantities:

	Quantity	Units
# of Extraction Wells	16	
Depth of Extraction Wells	8	ft
# of Air Injection Wells	8	
Depth of Air Injection Wells	60	ft
Total feet Drilled	608	ft

Time Estimate (Days)	6

	Quantity	Unit	Unit Cost	Cost	
Well Drilling	960	LF	$ 69.71	$ 66,921.60	
Well Casing	608	LF	$ 10.52	$ 6,396.16	
Well Screen Assembly	16	LF	$ 143.37	$ 2,293.92	*assuming 1 ft screen per well
5 HP Pump	3	Ea	$ 5,898.95	$ 17,696.85	
Piping from Wells to Barn	1330	LF	$ 10.00	$ 13,300.00	
SVE Control Barn	3	Ea	$ 85,000.00	$ 255,000.00	
Oversight	60	HR	$ 100.00	$ 6,000.00	*assuming oversight for entire drilling operation, 10 hr days, $100/hr

Operation and Maintenance for 30 years

Line Item	Quantity	Unit	Unit Cost	Cost	
Man Hours	9000	HR	$ 100.00	$ 900,000.00	*assuming 25 hours per month
*SVE System Materials		LS			
Lab Cost	3000	Ea	$ 70.00	$ 210,000.00	*assuming 25 samples quarterly

Project Total **$ 1,477,608.53**

Notes:

Ea	Each
ft	Feet
HP	Horsepower
HR	Hours
LF	Linear feet
LS	Lump Sum
SVE	Soil vapor extraction

Well Drilling Assumptions	**Unit Cost**		**Production**	
RS Means 331113100100	$ 24.28	linear feet (LF)	120	feet (ft) per day
Drilled, 4- to 6-inch (") diameter				
Crew: B23				
Pump				
RS Means 331113102000				
Pumps installed in wells to 100' deep 4" submersible, 5 HP	$ 5,898.95	Each		
Well Casing				
RS Means 331113108250	10.52	LF		
well casing polyvinyl chloride (pvc) 2" diameter				
Well Screen				
RS Means 331113108110	143.37	LF		
Well screen assembly 2 " diameter				
Portable building				
RS Means 015213201100	105.01	square feet (SF)		
**Pilot Study Required	Costs vary between Contractors			

*Cost Estimate Doesn't Include
Electrical power
Operational labor
Project management labor
Miscellaneous repair parts (belts, lubrication etc.)
Photoionization detector (PID) rental for operational control
Spent granulated active carbon (GAC)/replacement
Condensate water
Air emissions monitoring costs
Site monitoring costs