# FEASIBILITY STUDY REPORT

## HUSTER ROAD SUBSTATION
## Findett/Hayford Bridge Road Groundwater Site (OU4)
## 3800 HUSTER ROAD
## ST. CHARLES, MISSOURI

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________________________________
**Project Manager**

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## List of Abbreviations and Acronyms

| | |
|---|---|
| AOC | Administrative Order on Consent |
| bgs | Below ground surface |
| CERCLA | Comprehensive Environmental Response, Compensation and Liability Act |
| CFR | Code of Federal Regulations |
| cis-1,2-DCE | cis-1,2-Dichloroethene |
| COC | Contaminant of Concern |
| COPC | Contaminants of potential concern |
| DNAPL | dense, non-aqueous phase liquid |
| ft | Feet |
| GETS | Groundwater Extraction Treatment System |
| gpm | Gallons per minute |
| GW | groundwater |
| HHRA | Human Health Risk Assessment |
| HI | Hazard Index |
| ICs | Institutional Controls |
| ISB | In-Situ Bio-augmentation |
| ISCO | In-Situ Chemical Oxidation |
| MCL | Maximum Contaminant Level |
| ug/L | micrograms per liter |
| MDNR or The State | Missouri Department of Natural Resources |
| mg/kg | Milligram per kilogram |
| MNA | Monitored Natural Attenuation |
| MW | Monitoring Well |
| NCP | National Contingency Plan |
| Northern Plume | Downgradient of the Ameren Missouri Huster Road Substation |
| NPDES | National Pollutant Discharge Elimination System |
| O&M | Operation and maintenance |
| Off-site | Downgradient of the Ameren Missouri Huster Road Substation |
| OU | Operating Unit |
| ppb | Parts per billion |
| ppm | Parts per million |
| PCE | Perchloroethene or Tetrachloroethylene |
| PCB | Polychlorinated Biphenyl |
| PZ | Piezometers/monitoring wells |
| RA | Removal Action |
| RAGS | Risk Assessment Guidance for Superfund |
| RAO | Remedial Action Objective |
| RfC | Reference Concentration |
| RfD | Reference Dose |
| RI | Remedial Investigation |
| RME | Reasonable Maximum Exposure |
| RSLs | Regional Screening Levels |
| SAAOC | Settlement Agreement and Administrative Order on Consent |
| Site | Ameren Missouri Huster Road Substation |

| | |
|---|---|
| SOW | Statement of Work |
| TCE | Trichloroethylene |
| TMV | Toxicity, Mobility or Volume |
| UR | Unit Risk |
| USEPA or EPA | U.S. Environmental Protection Agency |
| USGS | United States Geological Survey |
| VC | Vinyl Chloride |
| VI | Vapor Intrusion |
| VISL | Vapor Intrusion Screening Level |
| VC | Vinyl Chloride |
| VOC | Volatile Organic Compound |
| WQS | Water Quality Standards (Missouri) |
| ZVI | Zero Valent Iron |

**LICENSED PROFESSIONAL ENGINEER'S AFFIRMATION**

"I attest that this document and all attachments were prepared under my direction or reviewed by me, and to the best of my knowledge and belief, the work described in the plan has been designed or completed in accordance with generally accepted engineering practices, including consideration of applicable industry standards, and the information presented is accurate and complete."

**Signature_________________________________________** **Date ___________**

**Licensed Professional Engineer – Missouri**

# I. INTRODUCTION

This Feasibility Study Report (FS) is prepared by Union Electric Company d/b/a Ameren Missouri (Ameren) with regard to the Huster Road Substation (the Site) a.k.a. Findett/Hayford Bridge Road Groundwater Site Operable Unit 4 (OU4). The report summarizes technology assessments conducted via pilot studies performed by Ameren and implementation of a groundwater extraction treatment system (GETS) installed and operated pursuant to the terms of a Settlement Agreement and Administrative Order on Consent (CERCLA-07-2012-0026) (2012 SAAOC). This FS report provides an analysis of potential remedial alternatives to address contaminants of concern (COC) in groundwater at the Site.

In September 2017, Ameren, the United States Environmental Protection Agency (USEPA), and the Missouri Department of Natural Resources (MDNR) entered into a second administrative order (CERCLA-07-2017-0129) (2017 SAAOC) to perform a Remedial Investigation (RI)/Feasibility Study (FS) for the Site. On May 9, 2019, USEPA approved the RI including a Human Health Risk Assessment (HHRA) performed as part of that analysis. As required by the 2017 SAAOC, the FS shall identify and evaluate alternatives to prevent, mitigate, or otherwise respond to or remediate any release or threatened release of hazardous substances, pollutants or contaminants at or from the Site.

As recognized by USEPA in the 2017 SAAOC, groundwater quality north of the Site complies with federal drinking water standards as a result of both on-site and off-site response actions performed by Ameren. In addition, while the Site is located within the City of St. Charles Elm Point Wellfield, none of the supply wells located adjacent (City Wells 4, 5) or north (City Wells 6, 7) of the Site, including the radial well (Well 9) exhibit detections of <u>any</u> amount of the following COCs: tetrachloroethylene (PCE), trichloroethylene (TCE), 1,2-cis-dichloroethylene (cis-DCE), or vinyl chloride (VC). Pursuant to the 2012 SAAOC, Ameren must address groundwater beneath the substation and within the GETS containment zone until groundwater complies with federal drinking water standards for six consecutive calendar quarters and soil sampling complies with Missouri Risk Based Corrective Action Standards which are identical to Federal RSLs. (*See* 2017 SAAOC, Paragraph 17). The remaining source area at the Site is localized to an area around electrical equipment labeled "Transformer 2". (*See* 2017 SAAOC, Paragraph 19).

**<u>For groundwater</u>**: Per the 2012 SAAOC, the site specific Applicable or Relevant and Appropriate Requirements (ARARs) (Federal and State of Missouri) for all COCs is the Maximum Contaminant Level (MCL) for each contaminant listed below:

| COC | MCL – ug/L |
|---|---|
| PCE | 5 |
| TCE | 5 |
| cis-DCE | 70 |
| VC | 2 |

**For soil**: The Site ARARs (Federal and State) are the Federal Regional Screening Levels (RSLs)(USEPA, 2018b) identified in Table 2 of the HHRA. Soil data from the 2018 soil sampling event (pre-injection of Pilot Study 4) are appended to this FS as Appendix E are below Industrial RSLs at all depths. Existing conditions satisfy the RSLs for industrial uses.

**Industrial**

| COC | RSL – mg/kg | RSL – ug/kg |
|---|---|---|
| PCE | 39 | 39,000 |
| TCE | 1.9 | 1,900 |
| cis-DCE | 230 | 230,000 |
| VC | 1.7 | 1,700 |

**Residential**

| COC | RSL – mg/kg | RSL – ug/kg |
|---|---|---|
| PCE | 8.1 | 8,100 |
| TCE | 0.41 | 410 |
| cis-DCE | 16 | 1,600 |
| VC | 0.059 | 59 |

Based upon the foregoing, this report (1) establishes a site-specific remedial action objective (RAO) that is protective of human health and the environment; and (2) proposes general response actions to satisfy that RAO and addresses the following:

- Documents current groundwater conditions and contaminants of concern (COC);
- Summarizes the effectiveness of interim response measures;
- Identifies and develops response measures;
- Evaluates alternative response measures; and,
- Proposes appropriate response measure alternatives.

## II. INTERIM REMEDIAL INVESTIGATION EFFORTS AND SUMMARY OF PILOT STUDIES

This section presents a description of the site location, a description of the interim measures implemented to address both on-site and off-site impacts and a summary of current conditions following the implementation of such measures. A brief description of the Site's geologic, hydrology and hydrogeologic settings is also included.

### A. SITE LOCATION AND GEOLOGY

The Site is comprised of eight (8) acres and is located at 3800 Huster Road in the City of St. Charles, Missouri. The Site is used for industrial purposes and contains active high-voltage transmission and distribution substation equipment. Such equipment is surrounded by a 12-foot berm and floodgate to protect the facility from potential floodwaters. In addition, a security fence encircles the substation and access is limited to trained utility workers. Given the presence of energized equipment, there is no public access to the Site. The Site Location Map (Figure 1) identifies the location of the Site on the St. Charles United States Geological Survey (USGS) topographic map. Figure 2 shows the approximate boundaries of the Site, and surrounding parkland. Huster Road is located to the west and Highway 370 is located north of the property.

***Figure 1 – Site Location Map***

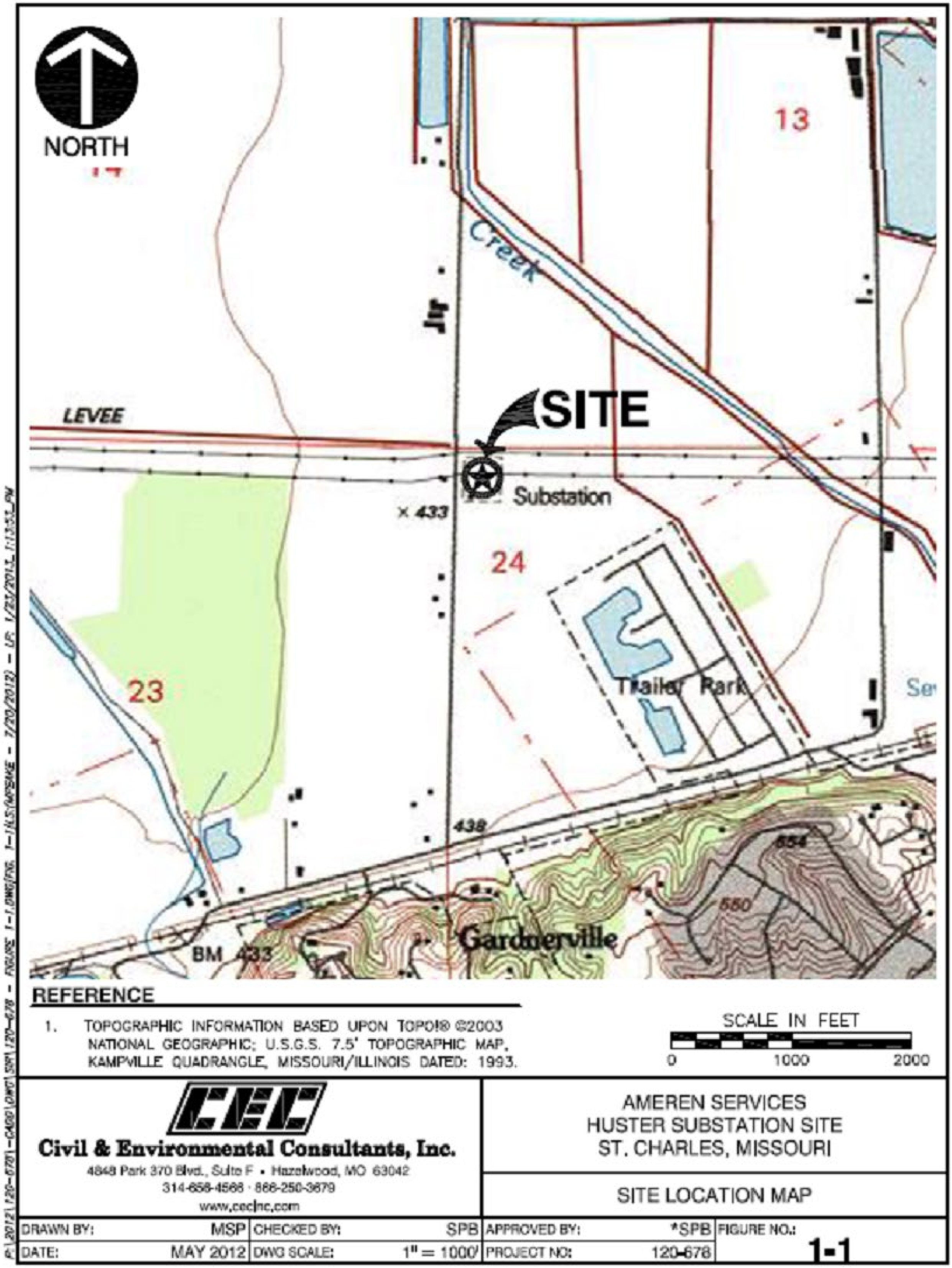


***Figure 2 – Site Plan***


### 1. SITE GEOLOGY

Site geology consists of approximately 107 feet of unconsolidated soils overlying consolidated limestone bedrock known as Mississippian-age St. Louis limestone. The St. Louis limestone is a massive gray fossiliferous limestone up to 100 feet thick. The unconsolidated materials above the limestone are a part of the flood plain of the Mississippi River, located approximately 2.8 miles north of the Site. The top 30-34 feet of the unconsolidated materials consist of clay with some silt, with silt content increasing in the last 10 feet above a sudden transition to silty fine-to-medium grained sand. The sand persists to the top of bedrock. Within the substation there are approximately 2-3 feet of gravel fill placed on top of the clay. Beneath the three main transformers are pits approximately 6 feet deep that have been backfilled with coarse (3-5 inch) rock.

Ameren installed seventeen monitoring wells at the Site with twelve finished to depths of 45 feet within the sands of the aquifer; two are screened at a 1-foot interface between the clay and sands of the aquifer at 31-32 feet; and three are installed into clays surrounding Transformer #2 and at varying depths between 15-30 feet. Quarterly sampling has occurred since 2014.

## B. GROUNDWATER EXTRACTION TREATMENT SYSTEM AND PILOT STUDIES

The following sections describe Ameren's installation of a groundwater extraction treatment system and the four pilot studies conducted on the Site.

## 1. GROUNDWATER EXTRACTION TREATMENT SYSTEM

To minimize the potential for off-site migration of groundwater impacted by COCs from the Site, Ameren installed in 2014 a groundwater extraction treatment system (GETS) at the north end of the substation property and inside the flood berm. The GETS is comprised of three (3) extraction wells with one inside and two outside the bermed area, and an air stripper housed in an aboveground structure. Groundwater from the extraction wells is pumped through the air stripper to remove volatile organic compounds prior to surface discharge via an NPDES permit (MO-0137642). The location of the extraction wells and the treatment system is depicted on Figure 3. Influent entering the GETS is sampled monthly (per NPDES) at manifold representing the three extraction wells (MW-5, MW-6 and MW-7).

***Figure 3 – Groundwater Extraction Treatment System & Extraction Wells***


The three extraction wells are screened at 35-45 feet below ground surface (bgs) and operated at a combined rate of approximately 62 gallons/minute. Per approval by USEPA in 2019, groundwater extraction is now limited to MW-5 at a rate of 16 gallons/minute. Groundwater flow moves through the shallow aquifer at a hydraulic conductivity rate of approximately thirty (30) feet per day ($10^{-2}$ cm/sec). As described more fully in this report, prior to reaching the GETS extraction well groundwater must first passes through subsurface areas that have received in-situ treatment applications (i.e. bio augmentation), which provides a primary layer of protection.

For the last three years, sampling data from MW-6 and MW-7 extraction wells located just outside the substation berm has been **below** the MCLs for all COCs, thereby indicating that the bio-area and GETS are successfully intercepting any impacted groundwater prior to leaving the Site. As reflected in ten quarters of sampling data, there has been no off-site rebounding of COCs. Appendix A contains a summary of sampling results from monitoring wells and piezometers located at and near the Site. With respect to on-site groundwater, concentrations of vinyl chloride at MW-5 are low, 3.8 ug/L, and only marginally exceed the MCL. In addition, following extended period of flood conditions (April – September) in 2019, it appears that a small amount of VC is now present in MW-7, as the December 2019 sampling detected concentrations of 3.3 ug/L, slightly above the MCL. Ameren does not believe such data constitutes a "rebounding effect" and instead more likely relates to the excessive movement of water during the extended flood conditions.

## 2. PILOT STUDIES

Between 2014 and 2018, Ameren conducted a series of pilot studies at the Site to evaluate the effectiveness of soil and groundwater treatment options. Such pilot studies and other remedial measures consisted of the following:

| Date | Pilot Tests & Interim Measures |
|---|---|
| **2014** | Installation and operation of on-site Groundwater Extraction Treatment System |
| **First Pilot (2014)** | On-Site: in-situ soil and groundwater treatment applications: EHC-enhanced ZVI and potassium permanganate injections (soils) – 3,951 gallons of potassium permanganate solution injected; Bio-augmentation (groundwater). |
| **Second Pilot (2015-16)** | Groundwater Treatment Application: off-site installation of two EHC-enhanced ZVI permeable barriers and injection of sodium persulfate near City Well no. 5 (completed in 2016) |
| | Soil Treatment: injection of sodium permanganate into cohesive soils surrounding Transformer #2 - 15,755 gallons of sodium permanganate solution injected. |
| **Third Pilot (2016)** | On-Site groundwater: Bio-augmentation over a wider area near Transformer #2 |
| **Fourth Pilot (2018)** | On-Site groundwater and soil: Bio-augmentation of groundwater around Transformer #2 and MW-14; Sodium Permanganate treatment of the soil in the same area – an additional 7,217 gallons of sodium permanganate solution was added in areas where the soil samples showed higher COCs levels. |

**ON-SITE PILOT STUDIES**

Within the substation property, Ameren assessed the potential effectiveness of the following in-situ treatment applications:

(a) *EHC® with zero valent iron* - EHC® is a product that combines ZVI, controlled-release carbon, and nutrients to promote strong reducing conditions when applied in subsurface environments where biodegradation is ongoing;

(b) *Permanganate (ISCO)* – In-Situ Chemical Oxidation (ISCO) using Permanganate (sodium and potassium) are strong oxidants that oxidizes and treats chlorinated compounds (e.g., PCE, TCE, cis-DCE, VC) found at the site. Ameren injected sodium and potassium permanganate into clay soils in areas of highest impact of COCs near Transformer #2 and into the perched groundwater via nearby wells (MW-39, MW-40 and MW-41). This treatment application results in an irreversible destruction of the constituent lineage as reflected in the chemical chain breakdown chemistry below:

PCE: $4KMnO_4 + 3C_2Cl_4 + 4H_2O \rightarrow 6CO_2 + 4MnO_{2(s)} + 4K^+ + 8H^+ + 12Cl^-$

TCE: $2KMnO_4 + C_2HCl_3 \rightarrow 2CO_2 + 2MnO_{2(s)} + 2K^+ + H^+ + 3Cl^-$

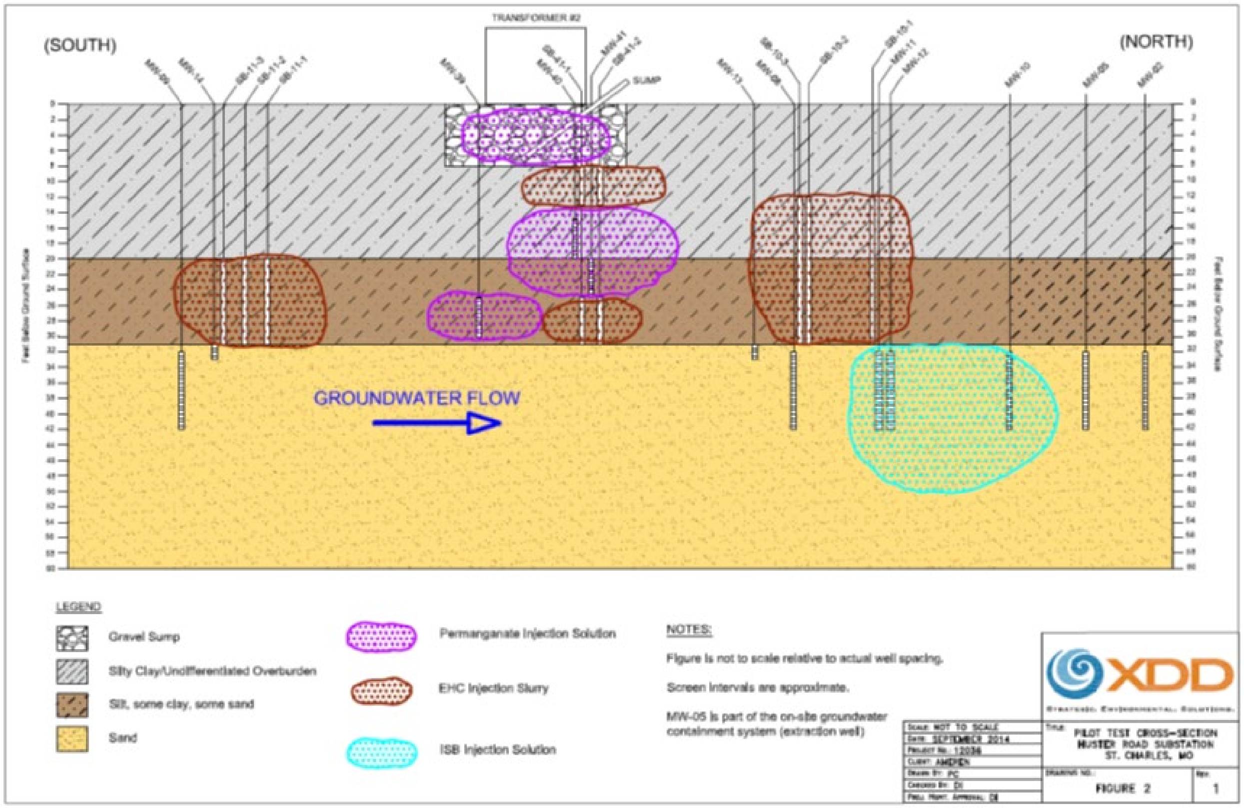
VC: $10KMnO_4 + 3C_2H_3Cl \rightarrow 6CO_2 + 10MnO_{2(s)} + 10K^+ + 3Cl^- + 7OH^- + H_2O$

(Reference: *Interstate Technology and Regulatory Council, Technical and Regulatory Guidance for In-Situ Chemical Oxidation of Contaminated Soil and Groundwater,* 2005.)

(c) *In-situ bio-augmentation (ISB)* - Bio-augmentation (dehalococcoides) creates a reactive zone approximately 15 feet in diameter around groundwater injection locations to provide sustained/long-term treatment and to augment reductive dechlorination of cis-DCE and VC into their decomposition compounds of ethene, ethane, and carbon dioxide (CO2). This treatment application results in a destruction of COC mass and is a non-reversible process.

The above treatment methods act in concert with each other and Site COCs are subject to multiple treatment applications as groundwater passes through the application areas. Soil and groundwater sampling data reflect that the treatment applications accelerate the breakdown of chlorinated solvents. Ameren installed temporary injection portals at various depths in the soil and groundwater. Overall, these pilot treatments drastically reduced or eliminated PCE and TCE in the soil and resulted in the significant reduction of cis-1,2-dichloroethene and vinyl chloride. Post 2016-remedial measures, soil concentrations are now below industrial RSLs and no further remediation is necessary to mitigate health risks associated with potential exposures to substation soil. (*See* Appendix B, HHRA p. 22) With respect to groundwater, following biomass applications (2016-18), COC concentrations decreased an average 50% with some achieving 99% reductions. Figure 4 below provides an illustration of various in-situ treatment applications used in the first pilot study. For clarity, a full-page version of Figure 4 is provided as Appendix C.

***Figure 4 – Subsurface Treatment - Huster Substation***




## OFF-SITE PILOT STUDIES

To evaluate and address impacted groundwater located north of the substation, Ameren injected a double EHC-enhanced ZVI permeable barrier north of City Well no. 5 and south of Highway 370. In addition, Ameren injected sodium persulfate as groundwater treatment near City Well no. 5, just north of the substation property.

The off-site treatments proved highly effective. Within twelve (12) months of the installation of the EHC permeable barriers, groundwater samples from PZ-10 (located north of the ZVI barriers) were **below** MCL levels for all COCs, indicating that such barrier was effective in protecting the City Well field located north of Highway 370. Currently, groundwater data from all PZs north of Highway 370 are below all MCLs, with the majority reflecting results below detection limits.

With respect to City Well no. 5, the sodium persulfate reduced all COC concentrations to below MCLs within eight months of injection. There has been **no rebound** in concentration levels, and sampling from all PZs continues to be below MCL with most results below detection limits.

## REDUCTIONS IN GROUNDWATER CONCENTRATIONS

The various treatment applications have resulted in significant reductions of groundwater contamination (see Figures 5, 6 & 7) and the ongoing degradation of COCs. Specifically, of the seventeen (17) monitoring wells on-site, one well (MW8) is slightly above MCL for TCE; three (3) wells (MW8, MW13, MW41) exceed MCL for cis-DCE; and at eight (8) MWs VC is above MCLs. Excursions above MCLs is largely limited to a small area immediately around Transformer #2. Such concentration reductions for TCE, cis-DCE and VC have been visually depicted via modelling[1] and are depicted below on Figures 5-7. (Areas that are above MCLs are discussed in the next section.)

[1] With respect to the plume maps above, it is important to note that depictions of radial impacts along the edges of the visualization area for 2019 are model errors derived from MW-13 that has higher concentrations and elevations than the surrounding wells. MW-3 and MW-1, while at very low concentrations, are the next highest concentrations thereby forcing the model to extrapolate in those directions and suggest higher levels than that observed in actual, monitored samples.

*Figure 5 – Treatment Progression - TCE Reduction*

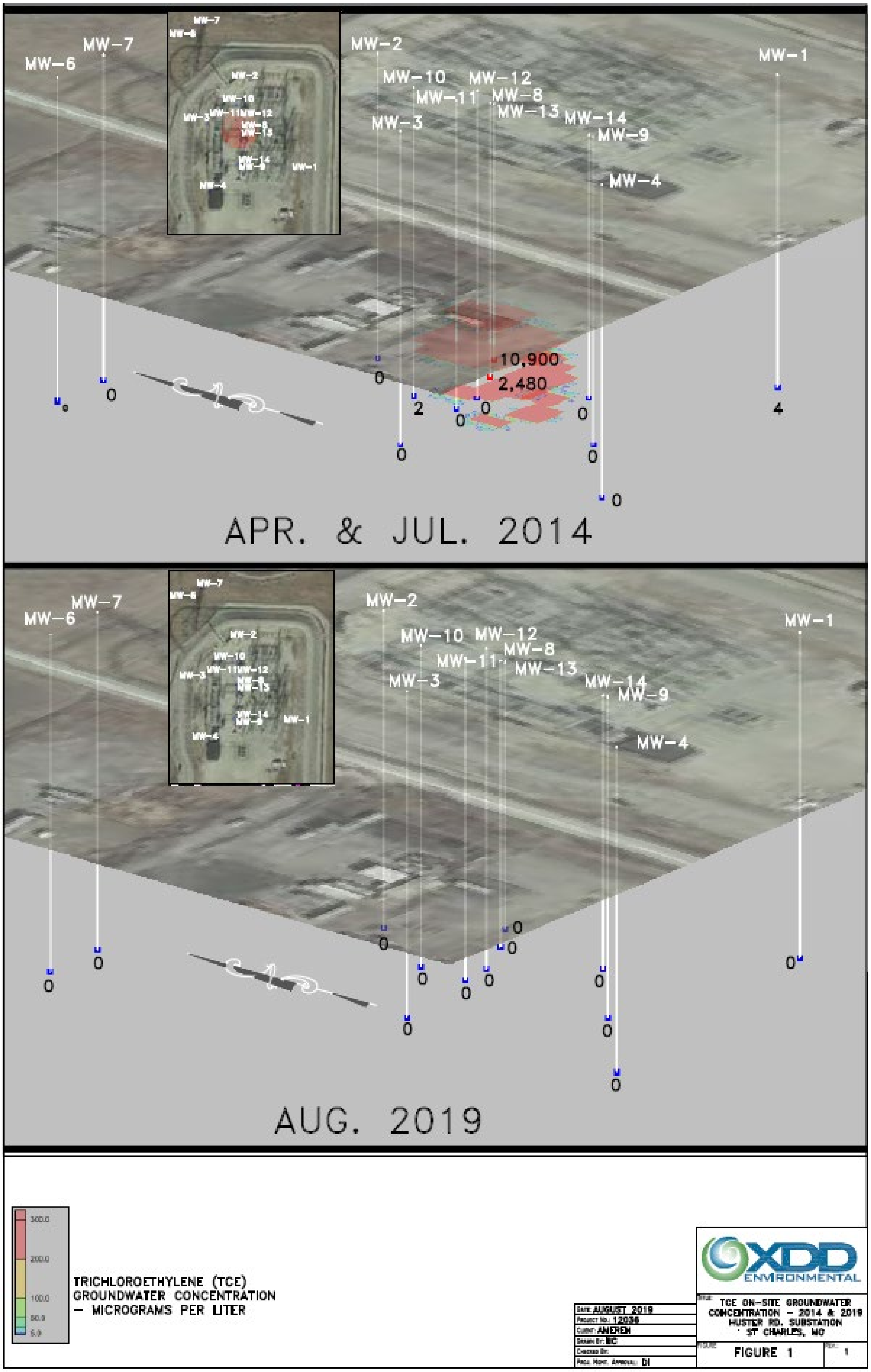


*Figure 6 – Treatment Progression - cis-1,2-DCE Reduction*

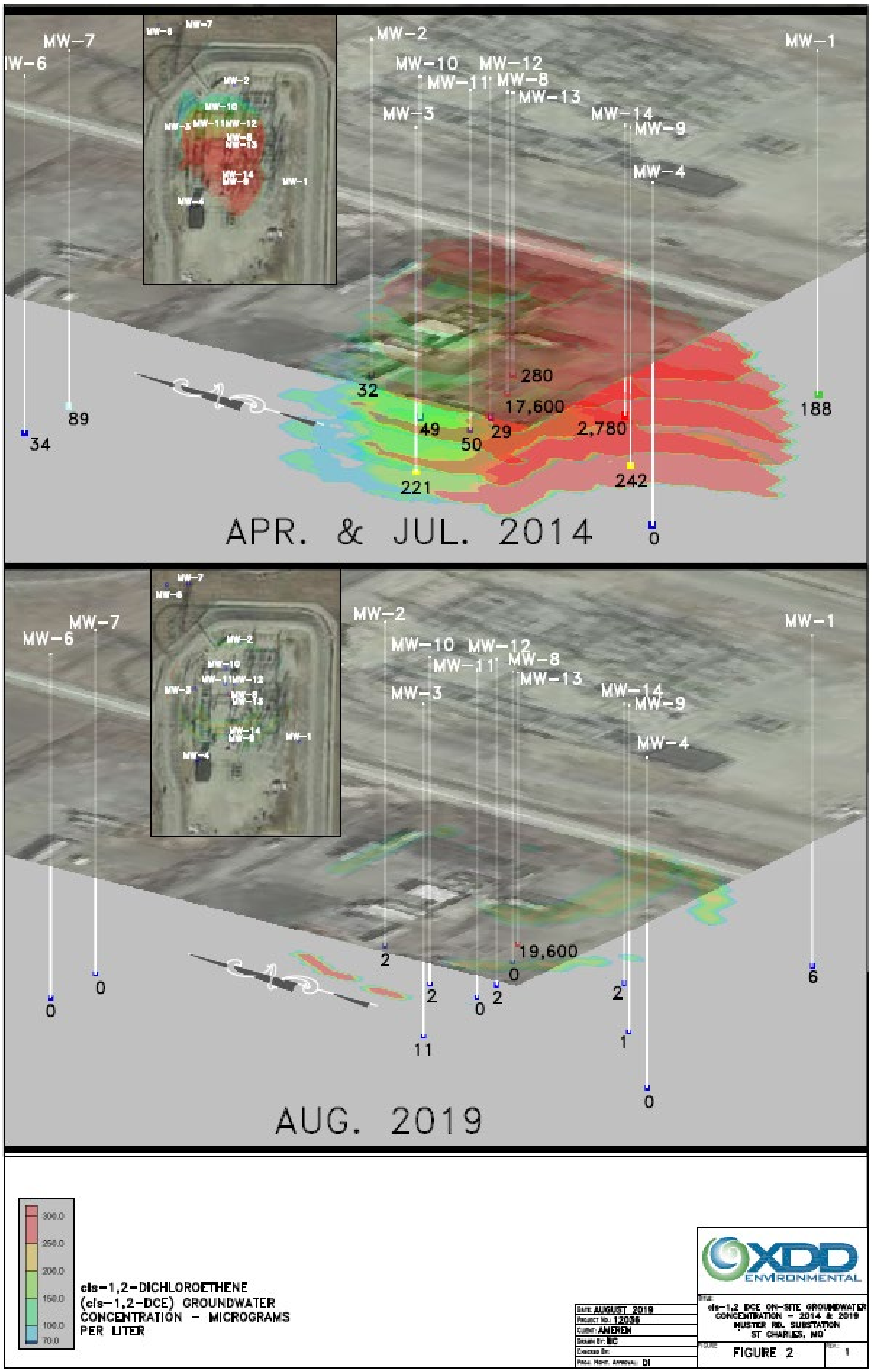
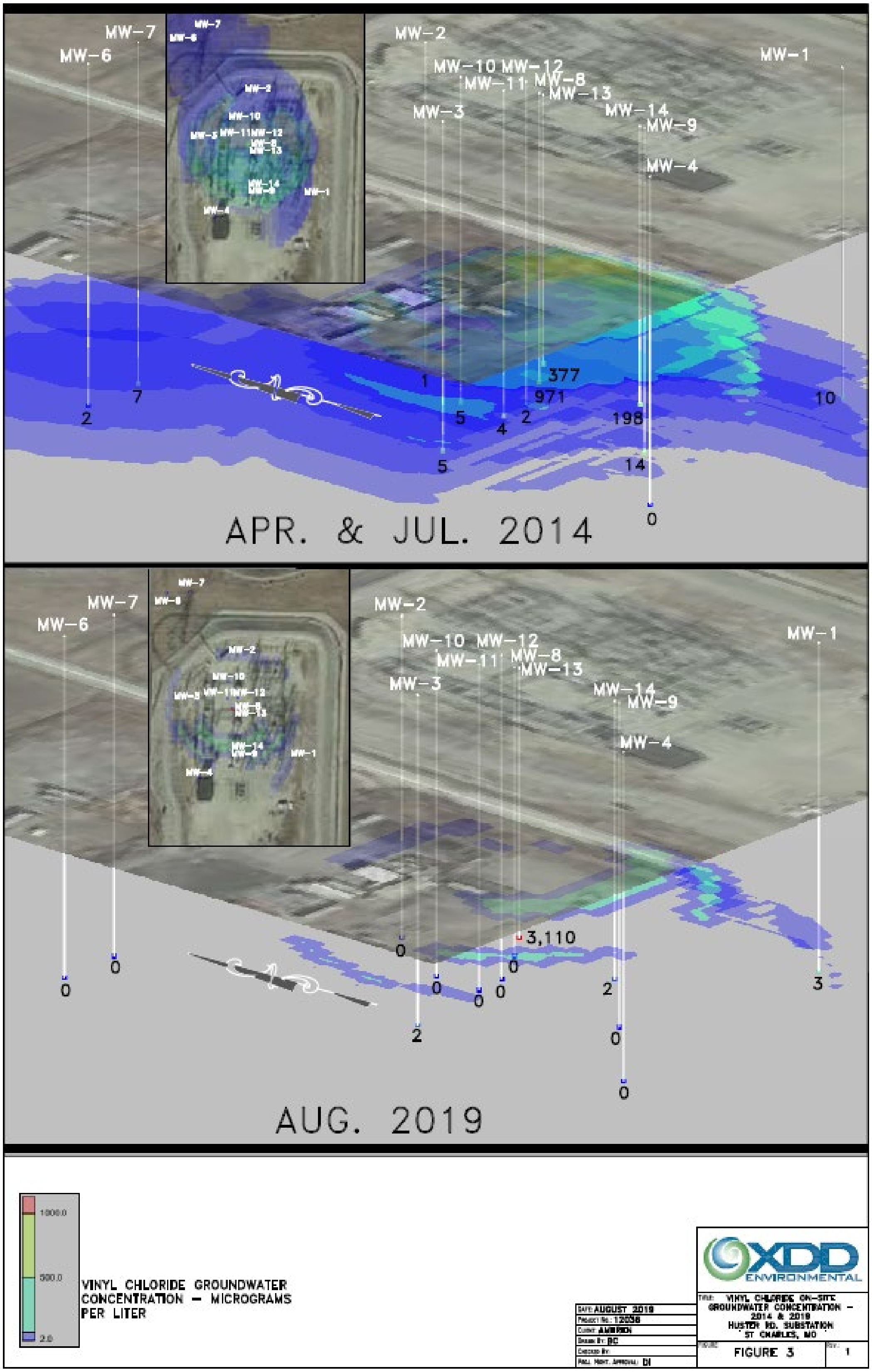


*Figure 7 – Treatment Progression - Vinyl Chloride Reduction*



## REDUCTIONS IN SOIL CONCENTRATIONS

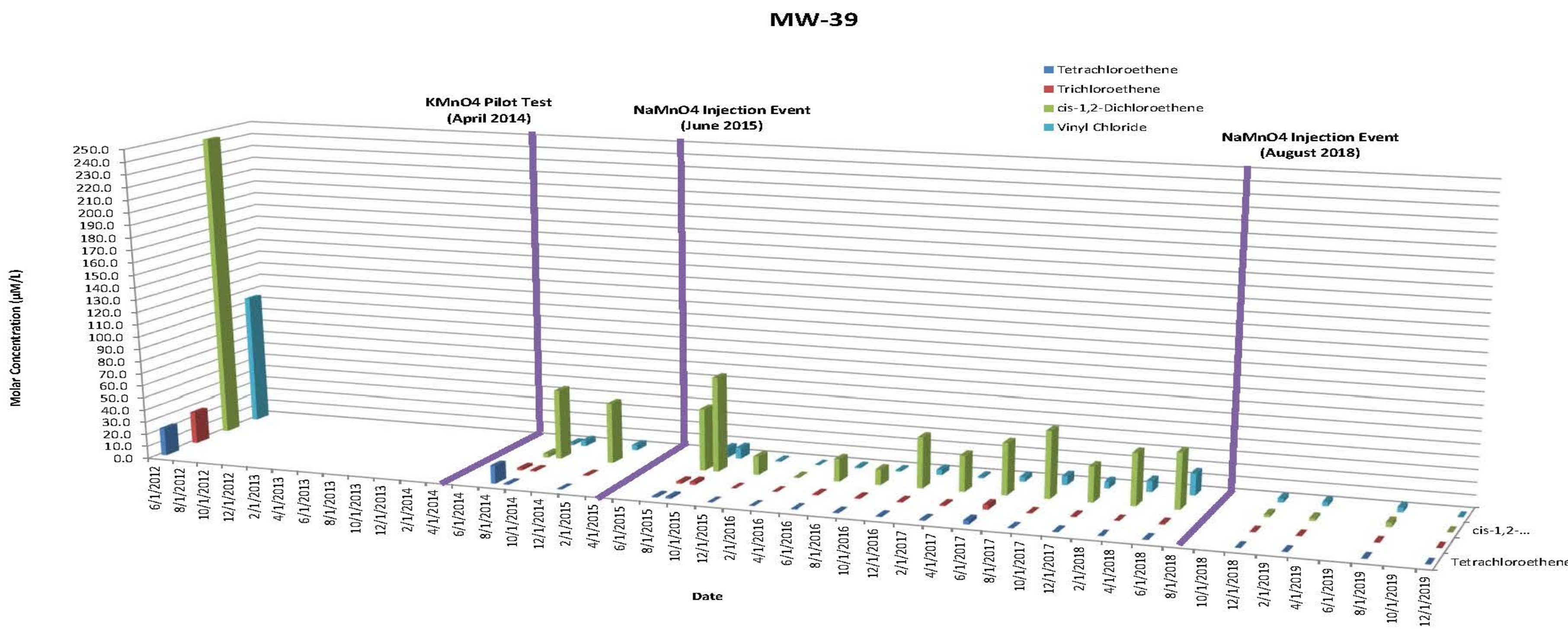
Permanganate treatment applications have resulted in significant reductions of soil contamination as demonstrated at MW-39, which is screened in the clay at 25-30 feet bgs (see Figure 8).

To understand the mass reduction that occurred at the Huster Substation, molar concentrations of each COC were calculated for each sampling event prior to and through the remedial activities. The molar concentration of a compound/substance is the molecular weight of that compound/substance per a unit volume of solution. It is often referred to as molarity, amount concentration or substance concentration. For chlorinated VOCs, the dechlorination process starts with the parent compound, PCE and is (typically) reduced in order to TCE, cis-1,2-DCE, vinyl chloride, and lastly methane, ethane, and ethene to complete the process. By calculating the total moles of a COC over time, the mass remaining can be observed and tracked for each compound. The molar concentration accounts for the different molecular weights of each COC allowing for a balanced mass comparison. The COC molecular weights are:

- PCE = 165.83 g/mol
- TCE = 131.4 g/mol
- cis-1,2-DCE = 96.95 g/mol
- VC = 62.498 g/mol

When added together, the degradation chain molar concentrations represent the total moles per unit of measure (liters). Figure 8 illustrates a visual tracking of the molar concentrations of each COC mass over time. To better represent the site condition changes as the remedial effort progressed, ISCO injection dates are also plotted. COC concentrations are typically reduced after an ISCO application, but can rebound to higher levels in later sampling events. This is due to COC mass that is sorbed to soils leaching back into the groundwater post-injection. The rebound concentration increases are due to the breakdown of the degradation chain to lower-tier compounds. Even though the concentration may be higher, the difference in molecular weight results in an overall mass reduction. The overall stepdown represented by the figure 8 illustrates a reduction in mass per sampling event over time. The figure also indicates that the level and possibility of a rebound decreases over time.

**Figure 8 - Molar Concentration Trends**
Ameren - Huster Substation
St. Charles, MO




Notes:
Data collected in June 2012 consists of soil data collected from intervals 23-24 feet below ground surface and 29-30 feet below ground surface.
Groundwater concentrations from June 2012 presented in this figure are estimated based on soil concentrations from the intervals described above.
uM = micromoles
1 uM = 1,000,000 moles (1 Mole = molecular weight of a compound, usually expressed in grams)

## III. REMEDIAL ACTION OBJECTIVES

As recognized in the 2012 SAAOC, the overall remedial goals (RAOs) for the site is for groundwater concentrations of COCs to be at or below MCLs and for soil concentrations at the substation property to achieve MRBCA or USEPA RSL standards.[2] The RAOs developed for the Site are discussed below.

**Groundwater:** The RAOs developed for the groundwater are discussed below.

For Human Health Protection:

- Prevent exposure to the COCs in groundwater above their MCLs.
- Prevent groundwater contamination from migrating off-Site.
- Restore groundwater to beneficial use (i.e., MCL).

**Soil:** The RAO developed for contaminated surface and subsurface soil is discussed below:

For Human Health Protection:

- Prevent ingestion/direct contact/inhalation containing COCs.
- Apply the current EPA/MDNR Regional Screening Levels for Industrial Users.
- Prevent migration of COCs from soil that would result in groundwater contamination in excess of the MCL.

As reflected in the chart below, actions performed either under the 2012 SAAOC or voluntarily by Ameren, have resulted in attaining the remedial objective for groundwater (MCL) **at all off-site locations** and significant process towards that goal has been recorded at the Site. The RAO for soil (USEPA RSL – Industrial Users) has been achieved as described in the previous section.

***Table 2 – Off-Site Site Locations – Groundwater Concentrations Comply With MCLs (RAO)***

| Location | Well # | Date all COCs < MCL |
|---|---|---|
| **North of 370** | PZ-1 | 9/2014 |
| | PZ-2 | 3/2018 |
| | PZ-3 | 11/2014 |
| | PZ-11<br>PZ-12 | 12/2014<br>12/2014 |
| **South of 370** | PZ-4 | 9/2015 |
| | PZ-5 | 8/2016 |
| | PZ-6 | 5/2014 |
| | PZ-7 | 10/2014 |
| | PZ-8 | 5/2015 |
| | PZ-9 | 4/2016 |
| | PZ-10 | 10/2016 |

[2] While the 2012 SAAOC referenced MRBCA standards, Ameren agreed to apply USEPA RSLs following discussions with USEPA and MDNR.

In addition, groundwater impacts from COCs within the Site have greatly improved following pilot test treatment applications. Residual impacts within the substation are generally limited to the central corridor area around Transformer #2.

***Table 3 – Substation Property Wells – Groundwater Concentrations Compared to MCLs (RAO)***

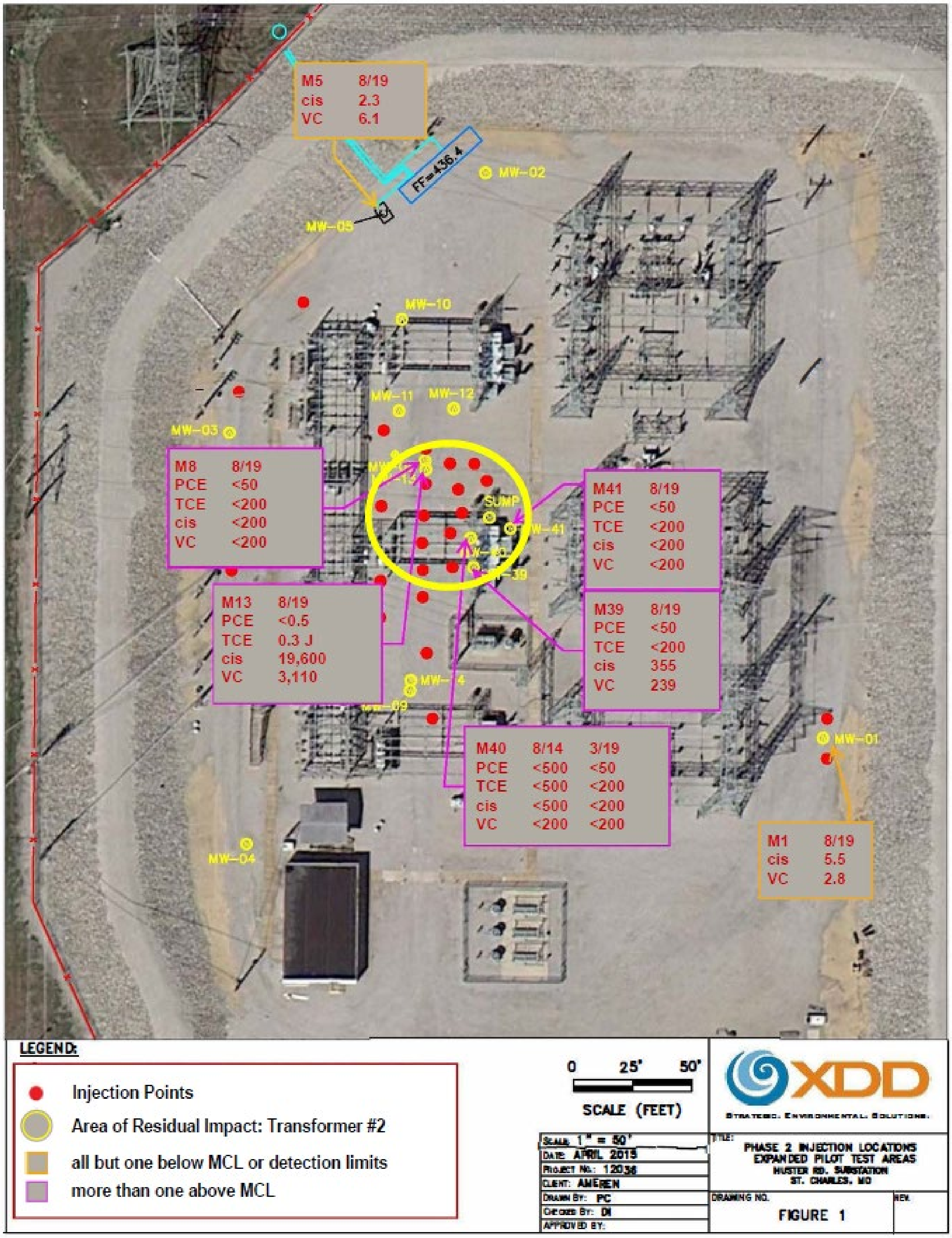
| **Location** | **Well Number** | **Date all COCs <MCL** |
|---|---|---|
| **Substation** | MW 2 | 4/2014 |
| | MW 3 | 6/2017 |
| | MW 4 | 12/2012 |
| | MW 6 | 9/2017 |
| | MW 9 | 10/2018 |
| | MW 10 | 8/2019 |
| | MW 11 | 6/2018 |
| | MW 12 | 6/2018 |
| | MW-39 | 12/2019 |

Of the seventeen onsite wells, groundwater data at ten (10) of the wells are at or below MCLs, the RAO for groundwater. The following seven (7) wells remain above the MCL: MW 1, MW 7, MW 8, MW 13, MW 14, MW 40, and MW 41.

### C. AREAS THAT MAY REQUIRE ADDITIONAL REMEDIATION

As reflected in the most recent round of sampling data, elevated concentrations of COCs are almost entirely limited to the encircled area reflected below for groundwater.

*Figure 9 – Substation Aerial View – Impacted Area*




Remedial objectives for off-site groundwater have been met and significant reductions in COC concentrations in substation groundwater has occurred with only a limited area in the vicinity of Transformer # 2 exceeding MCLs.

## IV. IDENTIFICATION, SCREENING, AND DEVELOPMENT OF CORRECTIVE MEASURE ALTERNATIVES

The identification and screening of response action alternatives was performed by first identifying groups of general response actions that can be used to achieve the RAOs outlined in Section III and listed below.

**Groundwater:** The RAOs developed for the groundwater are discussed below.

For Human Health Protection:

- Prevent exposure to the COCs in groundwater above their MCLs.
- Prevent groundwater contamination from migrating off-Site.
- Restore groundwater to beneficial use (i.e., MCL).

**Soil:** The RAO developed for contaminated surface and subsurface soil is discussed below:

For Human Health Protection:

- Prevent ingestion/direct contact/inhalation containing COCs.
- Apply the current EPA/MDNR Regional Screening Levels for Industrial Users.
- Prevent migration of COCs from soil that would result in groundwater contamination in excess of the MCL.

The next step was to expand the general response actions to develop specific remedial technologies based the specific mediums: soil and groundwater. These remedial technologies were screened to identify those technologies that could be used as potential response action alternatives for the specific medium in the *Remedial Action Objectives Technical Memorandum*. The retained response action alternatives are more thoroughly screened as a combined soil/water alternative as the final step in the development of the remedial alternatives below.

### A. REMEDIAL ACTION TECHNOLOGY SCREENING FOR GROUNDWATER AND SOILS

Potential remedial action technologies were identified and screened to identify those technologies that should be considered as remedial alternatives. As summarized more fully below, the above alternative technologies were screened for effectiveness and implementability. The narrative evaluations provide explanations of the conclusions regarding the effectiveness and implementability of the technology/alternative.

#### 1. EFFECTIVENESS SCREENING

The screening criteria used included:

- The reliability in meeting chemically-specific RSLs and MCLs. Technologies that do not allow the achievement of chemical-specific RSLs/MCLs or do not effectively contribute to the protection of human health or the environment at the site will not be considered further.

- The degree of permanent reduction in toxicity, mobility, or volume (TMV) achieved by the technology. Technology types and process options that permanently reduce TMV may be preferred over those that do not provide these benefits or the same degree of benefit.

- The potential long-term risks due to treatment residuals or containment systems. Technology types and process options that have significantly lower long-term risks may be preferred.

- The potential risks to the public, workers, or the environment during implementation. Technologies posing significantly lower adverse risks during implementation will be preferred.

### 2. IMPLEMENTABILITY SCREENING

The screening criteria used include:

- The site characteristics limiting the construction or effective functioning of the technology. Technologies that are limited by site conditions to a degree that their effective functioning is seriously impaired will be eliminated.

- Waste or media characteristics that limit the use or effective functioning of the technology. Technologies that are limited by waste or media characteristics to a degree that their effective functioning is seriously impaired will be eliminated.

- The availability of equipment needed to implement the alternative or the capacity of off-site treatment or disposal facilities needed to remediate the site. Technologies that are commercially developed and readily available will be given preference.

## B. GENERAL RESPONSE ACTIONS FOR GROUNDWATER

General response actions are categories of actions that may be implemented at sites to address risks to human health and the environment and to achieve remediation goals. The general response actions that were evaluated to assess their viability in achieving the remediation objectives are summarized in Table 4 and include:

1. No Action;

2. Monitored Enhanced Bio-augmentation Attenuation;

3. Pathway Elimination (Groundwater Elimination System - GETS);

4. Institutional Controls

A description of each of the general response actions evaluated follows.

### 1. NO ACTION

The "no action" alternative provides a baseline reference to evaluate other alternatives. A no further action approach maintains the Site in its current condition without additional measures to control exposures.

### 2. MONITORED ENHANCED BIO-AUGMENTATION ATTENUATION

Monitored Enhanced Bio-augmentation Attenuation is defined as the use of dehalococcoides to enhance existing natural attenuation processes. This alternative consists of a carefully controlled and monitored site cleanup approach that will reduce contaminant concentrations to levels that are protective of human health and the environment within a reasonable timeframe. Enhanced bio-augmentation attenuation includes the physical, chemical, and biological processes that reduce the mass, toxicity, mobility, volume, or concentration of contaminants. This requires extensive monitoring, data evaluation and risk assessment considerations.

## 3. PATHWAY ELIMINATION

Pathway elimination is a remediation technology known to be effective in controlling exposure routes by using a groundwater extraction system (GETS) that acts as a barrier to potential down gradient exposures to impacted groundwater. Though effective for controlling direct exposure and some hydrogeologic processes, the future use of the Site, or portions of the Site, may be limited and these systems may require periodic inspection and maintenance. Pathway elimination is protective of human health and the environment provided it remains in place and is properly maintained.

## 4. INSTITUTIONAL CONTROLS

Exposure pathways can be controlled through institutional control mechanisms such as site or area fencing to restrict access; land use limitations implemented through an environmental covenant; or other legal mechanisms such as ordinances or laws that restrict usage. An environmental covenant may be used when a property is to be remediated to a level determined by the potential environmental risks posed by a particular use, rather than to unrestricted use standards. The covenant is used to implement the risk-based cleanup by controlling the potential risks presented by residual impacted material. The covenant outlines the land use restrictions, environmental monitoring requirements, and a range of common engineering controls designed to control the potential environmental risk of residual impacted material. It will be referenced on the land records and effectively enforced over time. These actions may be used where physical conditions exist which reduce and/or prevent contact with impacted media and those physical conditions will remain for the foreseeable future.

### A. RESULTS OF REMEDIAL ALTERNATIVES SCREENING FOR GROUNDWATER

This section presents a justification for the selection or dismissal of remedial action alternatives utilizing the above methodology. A description of the screening evaluation is included in the following subsections.

### 1. ALTERNATIVE 1 – NO ACTION

**DESCRIPTION**

This alternative includes leaving the Site as-is, with no additional response actions performed. While a no action alternative is applicable to areas of the site where MCLs are not exceeded, it is the application of this alternative to the groundwater beneath a limited area of the Site that is evaluated here.

**EFFECTIVENESS**

The City of St. Charles relies upon groundwater for its water supply needs and the Site is located within the City's well field. Accordingly, this alternative is not effective in providing protection to human health and the environment and will not reduce TMV. This alternative would not meet the requirements of the 2012 SAAOC.

**IMPLEMENTABILITY**

This alternative is easily implemented.

**RESULT OF SCREENING**

This alternative is eliminated from further consideration for all areas of the Site which requires corrective action (i. e. where COC concentrations in groundwater exceed appropriate MCLs).

### 2. ALTERNATIVE 2 – MONITORED ENHANCED BIO-AUGMENTATION ATTENUATION

**DESCRIPTION**

Bio-augmentation techniques were evaluated in the first, third and fourth pilot studies which targeted the contaminants present in groundwater in the sand unit at the Site. A combined injection of an extended life organic substrate (to promote bacterial growth) combined with chlorinated solvent-degrading bacteria (dehalococcoides) was tested to stimulate biodegradation in the sand unit.

**EFFECTIVENESS**

The bio-augmentation performed well because the sand unit at the Site is conducive to a broader and more consistent spread of injectants**.** In fact, during multiple pilot studies, Ameren enhanced the naturally occurring processes by adding naturally occurring dehalococcoides in the areas of highest groundwater impact. Reductions in groundwater concentrations are being tracked using quarterly sampling of monitoring wells in and adjacent to the impacted groundwater area. The COC concentrations have been greatly reduced and the majority of MWs are now below MCLs for all COCs.

**IMPLEMENTABILITY**

The broader spread of reactants allows more flexibility in the selection of additional injection points, making implementation more effective compared to other applications.

**RESULT OF SCREENING**

Bio-augmentation has been proven effective and is retained for evaluation but designated as Monitored Enhanced Bio-augmentation Attenuation, since extensive treatment is already in place under the Site in the areas of highest remaining COCs.

### 3. ALTERNATIVE 3 – PATHWAY ELIMINATION - GROUNDWATER EXTRACTION TREATMENT SYSTEM (GETS)

**DESCRIPTION**

| Monitoring Well | PCE < MCL | TCE < MCL | cis-DCE <MCL | VC < MCL |
|---|---|---|---|---|
| MW-5 | Since 9/2014 | Since 9/14 | Since 12/15 | above (3.8 ug/L on 12/19) |
| MW-6 | Since 12/12 | Since 12/12 | Since 9/14 | Since 9/17 |
| MW-7 | Since 12/12 | Since 12/12 | Since 12/14 | above (3.3 ug/L on 12/19) |

The use of a groundwater extraction system to pump water thru an air stripper to remove VOCs from the groundwater prior to discharge per a NPDES permit.

**EFFECTIVENESS**

The extraction wells have been below or just above MCLs for several years. The table above lists when each well was below the MCL for specific COCs. Biomass particles have been observed on screen particles indicating the biomass colony has expanded from original injection locations.

**IMPLEMENTABILITY**

This alternative is already implemented.

**RESULT OF SCREENING**

This alternative is retained, but the GETS should be placed in in standby mode to prevent destruction of the biomass which has spread to MW-5. The biomass is capable of degrading any remaining COCs above the MCLs. The GETS could be restarted should the need arise.

### 4. ALTERNATIVE 4 – INSTITUTIONAL CONTROLS

**DESCRIPTION**

To ensure that public access to the site remains restricted, Ameren agrees to identify and document security measures at the site including fencing, locked gates, restricted access to approved personnel, digging restrictions and soil management and disposal practices. In the event Ameren ceases to use the Site for industrial purposes, Ameren will execute and file with the Recorder of Deeds Office, an environmental covenant prohibiting the instillation of potable water wells and soil excavations greater than 10 feet without prior notification. The environmental covenant will be in a form approvable by EPA and MDNR.

In addition, the installation of residential drinking water wells at the Site is prohibited by ordinance enacted by the City of St. Charles (See Appendix D).

**EFFECTIVENESS**

The Huster Substation is considered Critical Energy Infrastructure Site and access to the property is strictly controlled. COC impacts on-site are localized to the area near Transformer No. 2 and at depth of 17 –27 feet bgs at the clay-aquifer interface. Existing institutional controls in the form of locked gates and fencing are effective to limit access to any subsurface soils that may be impacted by COCs. As described in Section VI, Ameren proposes to document in a site management plan the Site's safety features and public access restrictions. Such plan would include a draft environmental covenant that could be executed in the event Ameren Missouri terminates its current, industrial usage of the property and concentration levels are above remedial objectives.

**RESULT OF SCREENING**

This alternative is retained.

### B. ALTERNATIVES FOR DETAILED GROUNDWATER EVALUATION

#### 1. RETAINED RESPONSE ACTION ALTERNATIVES

The following remedial alternatives were retained for detailed evaluation:

Alternative 1 – No Action

Alternative 2 – Monitored Enhanced Bio-Augmentation Attenuation

Alternative 3 –Pathway Elimination - Groundwater Extraction System (GETS) in standby mode;

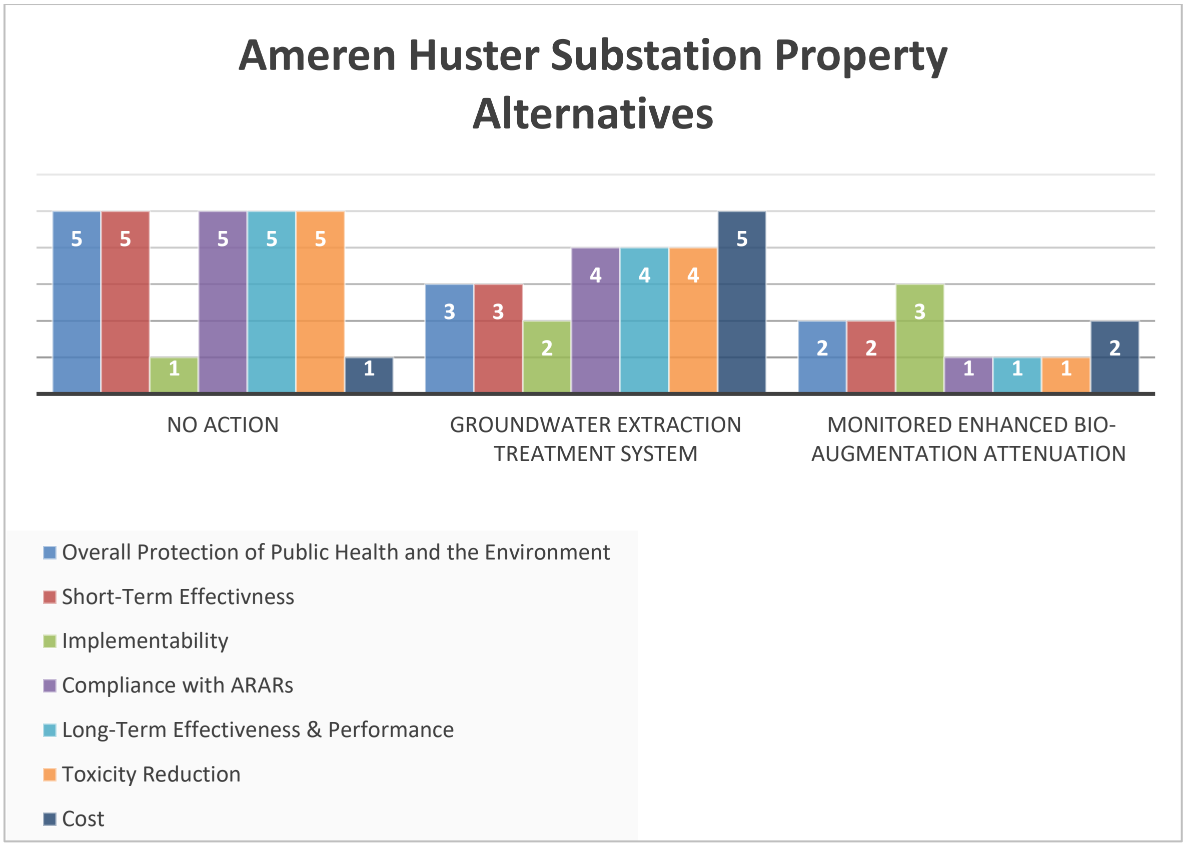
Alternative 4 – Institutional Controls

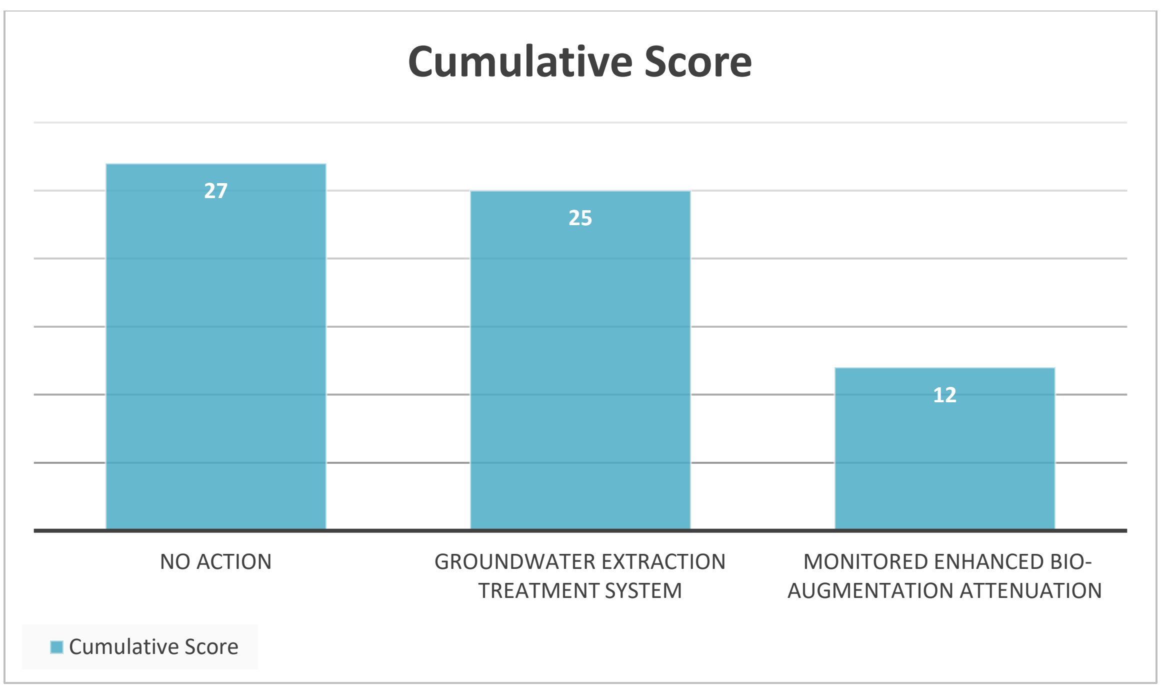
**COST ESTIMATES**

The estimated cost for Alternatives 1, 2, and 3 are contained in the table below along with estimated timeframe needed to achieve the groundwater Remedial Objective.

| ALTERNATIVE | ESTIMATED TIMEFRAME | COST |
|---|---|---|
| NO ACTION | 5-10 years | $0 |
| Pathway Elimination - GETS | 0 years – maintained onsite but placed in reserve mode | $903k incurred capital costs<br>$130k annual O&M |
| In-Situ Treatments:<br>• Monitored Enhanced Bio-Augmentation Attenuation | 2 years | $35,000 per treatment application |

***Table 4: Response Measure Technology Screening***
***Rating System: 1-5, with 1 as the Best and 5 the Least Desirable Alternative***



## E. RESULTS OF REMEDIAL ALTERNATIVES SCREENING FOR SOIL

This section presents a justification for the selection or dismissal of remedial action alternatives utilizing the above methodology. A description of the screening evaluation is included in the following subsections.

### 1. ALTERNATIVE 1 – NO ACTION

**DESCRIPTION**

This alternative includes leaving the Site as-is, with no additional response actions performed. It is the application of this alternative to the soil within the Site that is evaluated here.

**EFFECTIVENESS**

As confirmed by the HHRA, substation soils comply with both commercial/industrial and residential RSLs and no additional measures are necessary to mitigate health risks associated with potential exposures to substation soil. (See Appendix B, HHRA p. 22).

**IMPLEMENTABILITY**

This alternative would be easily implemented.

**RESULT OF SCREENING**

This alternative is retained.

### 2. ALTERNATIVE 2 – IN-SITU TREATMENT – CHEMCIAL OXIDATION

**DESCRIPTION**

This approach involves the injection of at least one oxidant to chemically break down the COCs to produce non-toxic end products.

**EFFECTIVENESS**

As part of the pilot test studies, Ameren considered a variety of products. Both potassium and sodium permanganate were evaluated.

Ameren conducted three pilot studies to assess the effectiveness of chemical oxidation. While such measures proved effective, the chemical reactions must be exercised to completion so as not to produce toxic end products such as vinyl chloride. In fact, according to the HHRA, the soil has reached both commercial/industrial and residential RSLs and no additional measures are necessary to mitigate health risks associated with potential exposures to substation soil.

**IMPLEMENTABILITY**

The pilot studies have shown that chemical oxidation using permanganates (sodium or potassium) has been successful in the reduction of the COCs in the clay soils at the Site.

**RESULT OF SCREENING**

Chemical oxidation has been proven effective and is retained for further analysis and use at the Site.

### 3. ALTERNATIVE 3 – INSTITUTIONAL CONTROLS

**DESCRIPTION**

To ensure that public access to the site remains restricted, Ameren agrees to identify and document security measures at the site including fencing, locked gates, restricted access to approved personnel, digging restrictions and soil management and disposal practices. In the event Ameren ceases to use the Site for industrial purposes, Ameren will execute and file with the Recorder of Deeds Office, an environmental covenant prohibiting the instillation of potable water wells and soil excavations greater than 10 feet without prior notification. The environmental covenant will be in a form approvable by EPA and MDNR.

**EFFECTIVENESS**

The Huster Substation is considered Critical Energy Infrastructure Site and access to the property is strictly controlled. COC impacts on-site are localized to the area near Transformer No. 2 and at depth of 17 –27 feet bgs at the clay-aquifer interface. Existing institutional controls in the form of locked gates and fencing are effective to limit access to any subsurface soils that may be impacted by COCs. As described in Section VI, Ameren proposes to document in a site management plan the Site's safety features and public access restrictions. Such plan would include a draft environmental covenant that could be executed in the event Ameren Missouri terminates its current, industrial usage of the property and concentration levels are above remedial objectives.

**RESULT OF SCREENING**

This alternative is retained.

## F. ALTERNATIVES FOR DETAILED SOIL EVALUATION RETAINED RESPONSE ACTION ALTERNATIVES

The following remedial alternatives were retained for detailed evaluation:

Alternative 1 – No Action

Alternative 2 – In-Situ Treatment – Chemical Oxidation; and

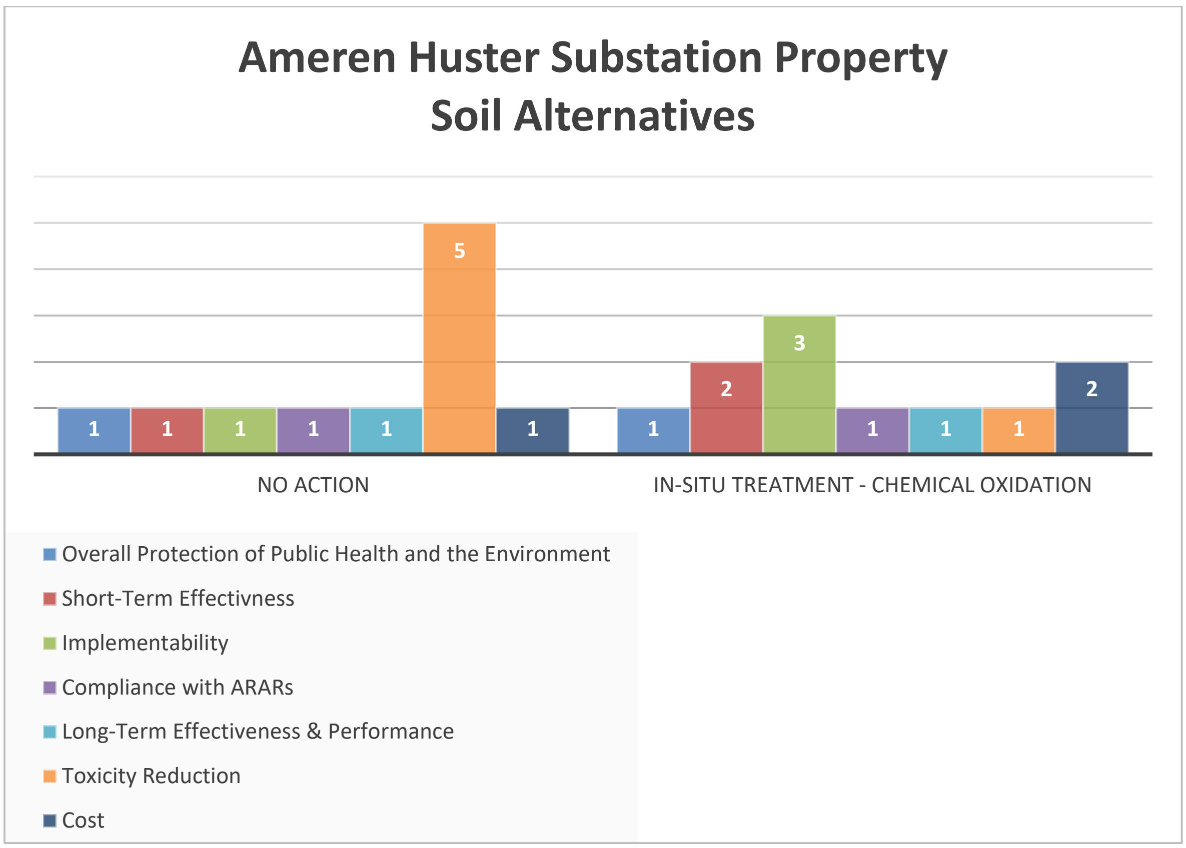
Alternative 3 – Institutional Controls

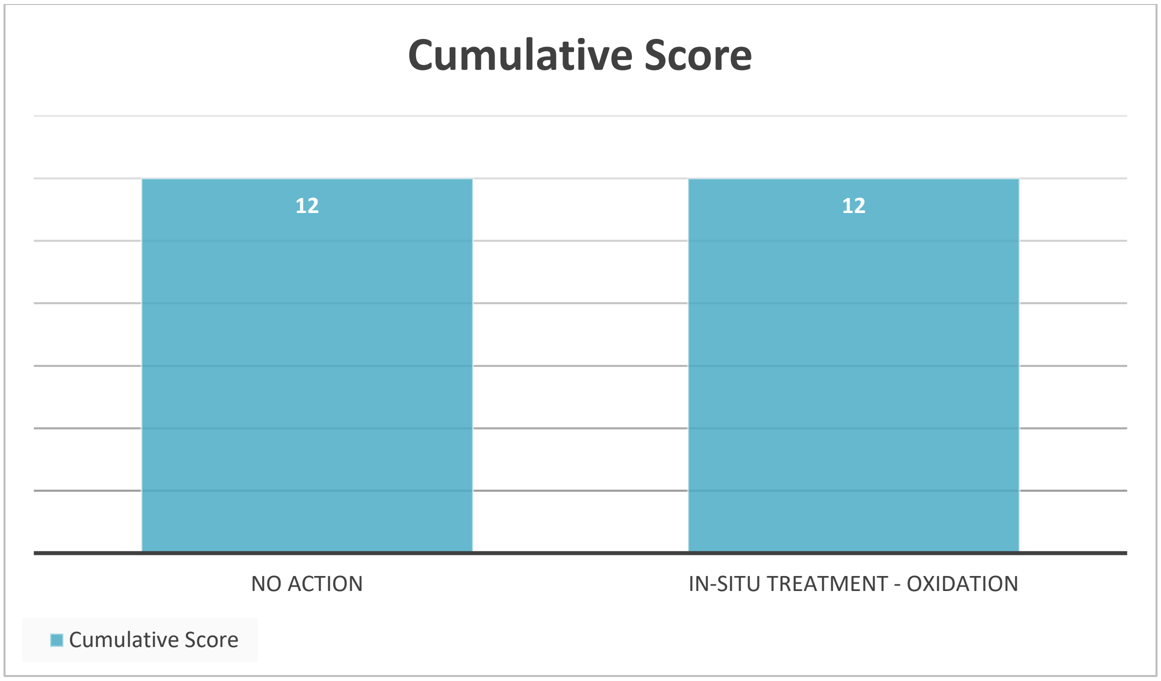
## COST ESTIMATES

The estimated cost for Alternatives 1, 2, and 3, are contained in the table below along with estimated timeframe needed to achieve the groundwater Remedial Objective.

| ALTERNATIVE | ESTIMATED TIMEFRAME | COST |
|---|---|---|
| NO ACTION | 0 years | $0 |
| In-Situ Treatment: Chemical Oxidation | 0 years | $150K for 2 treatments |
| Institutional Control | - | $0 |

***Table 4: Response Measure Technology Screening***
***Rating System: 1-5, with 1 as the Best and 5 the Least Desirable Alternative***






## V. COMBINED DETAILED ANALYSIS OF ALTERNATIVES

Described below are three combined remedial alternatives for addressing groundwater impacts in excess of COC MCLs and to reduce the risk of exposure to impacted soil even though concentrations are below industrial RSLs (Soil RAO). The three combined remedial alternatives consist of: **Alternative 1:** No Action; **Alternative 2:** Soil: In-Situ Chemical Oxidation; Groundwater: Monitored Enhanced Bio-augmentation Attenuation, GETS in standby mode and Institutional Controls, **Alternative 3:** Groundwater: Monitored Enhanced Bio-augmentation Attenuation, GETS in standby mode, Soil: No Action; and Institutional Controls (IC). Also included is a discussion of whether additional institutional controls are needed to address or mitigate Site impacts.

| Criteria | Alternative 1<br><br>**No Action** | Alternative 2<br><br>**Soil:** In-Situ Chemical Oxidation**;**<br><br>**Groundwater:** Monitored Enhanced Bio-augmentation Attenuation (ISB), GETS in standby mode,<br><br>**Institutional Controls** | Alternative 3<br><br>**Groundwater:** Monitored Enhanced Bio-Augmentation Attenuation, GETS in standby mode**;**<br><br>**Soil:** No Action;<br><br>**Institutional Controls** |
|---|---|---|---|
| **OVERALL PROTECTIVENESS** | | | |

| | | | |
|---|---|---|---|
| Human Health Protection | Soil is below industrial RSLs; groundwater COCs are above MCL but are subject to ongoing degradation via enhanced biomass. | Enhanced biomass monitored until COCs in groundwater achieve MCL. Additional applications as necessary. | Enhanced biomass monitored until COCs in groundwater achieve MCL. No additional measures for soil as concentrations are below Industrial RSLs. |
| - Direct Contact/Soil Ingestion | Per risk assessment, no risk of direct contact/soil ingestion exists as COCs in first 10 feet bgs are below EPA RSLs. | Per risk assessment, no risk of direct contact/soil ingestion exists as COCs in first 10 feet bgs are below EPA RSLs. | Per risk assessment, no risk of direct contact/soil ingestion exists as COCs in first 10 feet bgs are below EPA RSLs. |
| - Groundwater Ingestion for Existing Users | Groundwater Use prohibited per municipal ordinance; all offsite COCs below MCLs. | Groundwater Use prohibited per municipal ordinance; all offsite COCs below MCLs. | Groundwater Use prohibited per municipal ordinance; all offsite COCs below MCLs. |
| - Groundwater Ingestion for Future Users | Groundwater: COCs below MCLs at all but eight (8) locations, the enhanced biomass underlying this area continues to reduce the COCs.<br><br>Soil COCs < industrial RSLs, thereby reducing the potential of leaching to the groundwater. | In-situ soil oxidation reduced COCs in soil, thus reducing the potential for leaching to groundwater.<br><br>In-situ bio-augmentation in groundwater will continue to degrade remaining COCs. Additional application of biomass enhancement will be based on monitoring results and GETS reactivated if downgradient data reflect increase in COCs. | In-situ soil oxidation reduced COCs in soil, thus reducing the potential for leaching to groundwater.<br><br>In-situ bio-augmentation in groundwater will continue to degrade remaining COCs. Additional application of biomass enhancement will be based on monitoring results and GETS reactivated if downgradient data reflect increase in COCs. |

| | | | |
|---|---|---|---|
| - Environmental Protection | | Treatment applications result in irreversible soil oxidation; additional treatment as necessary; the bio-augmentation irreversibly reduces the groundwater COCs. GETS maintained in standby mode as necessary. | Soil meets Industrial RSLs. ***Groundwater***: the bio-augmentation irreversibly reduces the groundwater COCs and will continue to do so as long as a healthy biomass exists. GETS maintained in standby mode as necessary. |
| **COMPLIANCE WITH ARARs** | | | |
| Chemical Specific ARARs | COCs above MCL in groundwater near Transformer #2 | Would meet all MCLs at all monitoring wells both in the aquifer and clays within 3 years. | See Alternative 2 |
| Location Specific ARARs | Not relevant - there are no location specific ARARs | Not relevant - there are no location specific ARARs | Not relevant - there are no location specific ARARs |
| Action Specific ARARs | COCs remain above MCL. Soil already meets Industrial ARARs. | | |
| Other Criteria and Guidance | Municipal ordinance prohibits installation of private drinking water well in this area;<br><br>No COCs above the MCLs exist off-site; Site fencing and locked gates prevent public access. | See Alternative 1 | See Alternative 1 |
| **LONG-TERM EFFECTIVENESS AND PERMANENCE** | | | |
| **Magnitude of Residual Risk** | | | |
| - Direct Contact/Soil Ingestion | There is no risk as the soil residuals < EPA industrial RSL | See Alternative 1 | See Alternative 1 |
| - Groundwater Ingestion for Existing Users | Augmented biomass will continue to degrade COCs. | See Alternative 1 | See Alternative 1 |

| | | | |
|---|---|---|---|
| -Groundwater Ingestion for Future Users | Risk greater should the plume migrate off-site should enhanced attenuation be less effective than anticipated. | No risk with monitoring, keeping the existing biomass healthy with additional "feeding" applications as necessary; GETS in standby mode and restarted should COCs increase downgradient | No risk with monitoring, keeping the existing biomass healthy with additional "feeding" applications as necessary; GETS in standby mode and restarted should COCs increase downgradient |
| Adequacy and Reliability of Controls | No controls over remaining contamination, except the existing enhanced biomass near the highest levels of remaining COCs. No reliability. | Soil: Per pilot studies reduction potential of oxidation on the COCs have been reduced by 50 - 100%.<br><br>Groundwater: Per pilot studies bio-augmentation reflects 50-100% reduction of COCs and creates barrier layer between the higher COC concentration area and extraction well #5. COCs < MCL for all parameters except VC which is approaching MCLs. | Semi-annual monitoring to assess degradation process with additional treatment applications. GETS available if downgradient concentrations increase. |
| Need for 5-year Review | Review would be required to ensure adequate protection of human health and the environment is maintained. | Review may be needed. | Review may be needed. |
| **REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT** | | | |

| | | | |
|---|---|---|---|
| Treatment Process Used | None | **Soil**: Injection of Sodium Permanganate, if needed;<br>**Groundwater**: ISB injection, **GETS** - Air Stripping - currently in standby mode can be restarted, if necessary | **Groundwater**: "Feeding" consists of WilClear$^{R}$, a sodium lactate product and EOS$^{R}$, an emulsified oil. EOS$^{R}$ is a slow release compound that adsorbs to soils and provides food for an extended period of time. **GETS** (air stripper) in standby can be restarted, if necessary. |
| Amount Destroyed or Treated | None | **Soil**: has reached industrial RSLs at all depths due to pilot studies performed onsite. No further treatment of soil is needed at this time according to the HHRA.<br>**Groundwater:** The majority of the monitoring wells are below MCL, with just a couple monitoring wells above MCL for 1 or 2 COCs, these areas are within the already enhanced biomass and are being effectively degraded and no COCs are showing up in down-gradient wells. | **Groundwater**: The majority of the monitoring wells are below MCL, with just a couple monitoring wells above MCL for 1 or 2 COCs, these areas are within the already enhanced biomass and are being effectively degraded and no COCs are showing up in down-gradient wells. |

| | | | |
|---|---|---|---|
| Reduction of Toxicity, Mobility or Volume | None | **Soil:** to below industrial RSLs. No further treatment of soil is needed at this time according to the HHRA.<br><br>**Mass Reduction in Soi**l: In 2012 - 17,000 cy of soil (estimated dimensions 90 x 150 x 34 feet deep). Estimated impacted area in 2020 reduced to approximately 2,500 cy (estimated dimensions 36 x 56 x 34 feet) with detectable levels of COCs. | |
| Irreversible Treatment | None | ***Soil***: The oxidation of the COCs is an irreversible treatment.<br><br>***Groundwater***: Bio-augmentation process is the systematic degradation of the COCs and is irreversible.<br><br>***GETS***: placed in stand-by mode and can be restarted if downgradient COCs increase to ensure no COCs leave the Site thru another irreversible process - air stripping. | ***Groundwater***: Per pilot studies enhanced biomass injected beneath highest soil COC area and in the highest groundwater COCs result in irreversible destruction of COCs by 50-100%.<br><br>***GETS***: placed in stand-by mode and can be restarted if downgradient COCs increase to ensure no COCs leave the Site thru another irreversible process - air stripping. |
| Type and Quantity of Residuals Remaining After Treatment | Potential for some COCs to remain above MCLs. | All residuals will be completely degraded to MCLs and the industrial RSLs for all COCs. | All residuals will be completely degraded to MCLs and the industrial RSLs for all COCs. |
| Statutory Preference For Treatment | Does not satisfy | Satisfies | Satisfies |

| | | | |
|---|---|---|---|
| **SHORT-TERM EFFECTIVENESS** | | | |
| Community Protection | Risk to community not increased by remedy implementation. | Risk to the community is eliminated by minimizing leaching to groundwater thru irreversible destruction of the COCs in the soil. The biomass under the area where the highest soil COCs existed provides another layer of irreversible destruction before reaching the GETS extraction well. Leaving the GETS on-site (but not operating unless determined to be needed) ensures no COCs above the MCLs leave the Site as it can be restarted quickly. | Risk to the community is eliminated. The biomass under the area where the highest soil COCs existed provides a layer of irreversible destruction before reaching the GETS extraction well. Leaving the GETS on-site ensures no COCs above the MCLs leave the Site as it can be restarted if necessary. |
| Worker Protection | No significant risks to workers. | See Alternative 1 | See Alternative 1 |
| Environmental Impacts | Continued impact from existing conditions | No environmental impacts | No environmental impacts |
| Time Until Action is Completed | Not applicable | Two years | Two years |
| **IMPLEMENTABILITY** | | | |
| Ability to Construct and Operate | No construction or operation | GETS is already installed. Additional in-situ treatments can be performed with months if necessary. | GETS is already installed. Additional feeding of biomass can be performed with months if necessary. |
| Ease of Doing More Action if Needed | No Actions are being performed. | Injection wells for in-situ chemical oxidation are in place. Injection wells for feeding in-situ biomass are in place. GETS is already in place and will be kept in condition for restarting if necessary. | Injection wells for feeding in-situ biomass are in place. GETS is already in place and will be kept in condition for restarting if necessary. |

| | | | |
|---|---|---|---|
| Ability to Monitor Effectiveness | Not Effective | Groundwater monitoring installed and monitored quarterly | Groundwater monitoring wells installed and monitored quarterly |
| Ability to Obtain Approvals and Coordinate with Other Agencies | Unlikely | NPDES permit issued for the GETS; both USEPA and MDNR have approved chemical oxidation and bio-augmentation in-situ treatment applications. | NPDES permit issued for the GETS; USEPA and MDNR have approved bio-augmentation in-situ treatment applications. |
| Community Acceptance | Unlikely | Acceptance by the community is likely as this alternative actively reduces any remaining COCs in both soil and groundwater. | Acceptance by the community is likely as the soil has already achieved Industrial and Residential RSLs per the HHRA. The groundwater is being actively degraded by an existing biomass and will be monitored for changes. |
| Availability of Services and Capacities | No services or capacities required. | Current contractor is available and has the ability to supply materials and personnel for in-situ treatments and the O&M of the GETS. | Current contractor is available and has the ability to supply materials and personnel for in-situ treatments and the O&M of the GETS. |
| Availability of Equipment, Specialists and Materials | None required | The current contractor has the equipment, staff, materials and capability to perform this alternative. | See Alternative 2 |

| | | | |
|---|---|---|---|
| Availability of Technologies | None required | Chemical oxidation by injection of permanganates into the soil have already be found effective in the pilot studies and well as the injection of biomass into the aquifer sands. The GETS is already operational, but is currently pumping mainly clean water - only VC exceeds MCL by a few ppb and biomass is showing up in the first set of filters. | ISB has already been injected under the substation and an enhanced biomass has been established. The GETS is already operational, but is currently pumping mainly clean water - only VC exceeds MCL by a few ppb and biomass is showing up in the first set of filters. |
| **COST** | | | |
| Capital Cost | $0 | GETS - $903 K | GETS - $903 K |
| Five Year Annual O&M Cost | $0 | Bio-augmentation - $35,000/application Chemical oxidation - $75,000/application, Monitoring/Sampling: $100,000.00; Restart of GETS, if necessary - $10,000 plus $120,000/year | Bio-Augmentation Feeding - $35,000/application; Monitoring/Sampling: $100,000.00: Restart of GETS , if necessary $10,000 plus $120,000/year |

**Conclusion and Recommendation:**

Ameren recommends that Alternative 3 be selected to achieve the RAO for the Site. Based upon results obtained thus far from various pilot studies and confirmed by the most recent December 2019 sampling event, COCs at the site have responded to treatment applications and continue to degrade. Compliance with federal drinking water standards (MCLs) for the COCs is achievable. Additional chemical oxidation applications have the potential to kill microbes thereby undermine the effectiveness of bio-augmentation.

As summarized in Tables 2 and 3, all off-site monitoring wells (PZ 1-12) and approximately half of 17 substation monitoring wells already satisfy the RAO criteria. (*See* Appendix A to review analytical data).

- As reflected in monthly NPDES sampling, influent concentrations into the GETS (MW 5) of cis-1,2-DCE are well below MCL and vinyl chloride is at 3.8 ug/L.

- Biomass has been injected downgradient from Transformer #2, creating an attenuation zone that reduces COCs as groundwater passes through the zone.

- The GETS should be placed in standby mode as the biomass has spread and is being collected on filter screens within the GETS. Continued water extraction could dissipate the biomass thereby undermining ongoing groundwater treatment. The GETS would remain at the site but be placed in standby mode.

- Ongoing monitoring can be focused on biomass application areas to confirm ongoing degradation and evaluate potential for re-applications if necessary. Wells demonstrating compliance with the MCLs for an extended period and no longer needed for monitoring would be closed in accordance with state requirements. The specific wells designated for this purpose would be identified in a groundwater monitoring plan.

- To ensure that public access to the site remains restricted, Ameren agrees to identify and document security measures at the site including fencing, locked gates, restricted access to approved personnel, digging restrictions and soil management and disposal practices. In the event Ameren ceases to use the Site for industrial purposes, Ameren will execute and file with the Recorder of Deeds Office, an environmental covenant prohibiting the instillation of potable water wells and soil excavations greater than 10 feet without prior notification. The environmental covenant will be in a form approvable by EPA and MDNR.

**APPENDIX E**

**The table below summaries the soil sampling performed in July 2018 prior to the 4th pilot study to inject additional sodium permanganate. The last column details the additional sodium permanganate added at the depths indicated based upon the analytical results. The additional sodium permanganate would further degrade the listed COC concentrations.**

| Boring # and Depth | PCE | TCE | cis-DCE | VC | Gallons of NaMnO4 (92g/L) Injected after sampling in 2018 |
|---|---|---|---|---|---|
| **RAO - Industrial User RSL – ug/kg** | **39,000** | **1,900** | **230,000** | **1,700** | |
| **Residential RSLs – ug/kg** | 8,100 | 410 | 1,600 | 59 | |
| **IP-27-25** | <3 | <3 | 127 | 126 | |
| **IP-27-26** | 0.8 J | 0.4 J | 1,530 | 1,170 | 190 |
| **IP-28-15** | 36.8 | 1.9 | 759 | 26 | 96 |
| **IP-28-6** | 3 J | 0.6 J | <3.6 | <3.6 | |
| **IP-29-10.5** | 0.7 J | 0.9 J | 1.7 J | 1.1 J | |
| **IP-29-24.5** | <2.5 | <2.5 | 147 | 46.7 | 74 |
| **IP-30-24.5** | 0.4 J | <2.1 | 218 | 67.3 | 92 |
| **IP-30-27** | <2.4 | 0.9 J | 1,390 | 614 | |
| **IP-31-24.5** | <2.2 | <2.2 | 21.2 | 0.6 J | 56 |
| **IP-31-5.0** | <2.4 | <2.4 | <2.4 | <2.4 | |
| **IP-32-6.5** | <46.1 | <46.1 | <46.1 | <46.1 | 53 |
| **IP-33-10** | <2.6 | <2.6 | <2.6 | <2.6 | 676 |
| **IP-33-5.0** | <78.6 | <78.6 | <78.6 | <78.6 | |
| **IP-34-24.5** | <2.2 | <2.2 | 3.5 | 5 | 525 |
| **IP-34-26.5** | <2.4 | <2.4 | 2.8 | 13.2 | |
| **IP-35-24.5** | <2.7 | <2.7 | 598 | 677 | 1468 |
| **IP-36-20.5** | <2.2 | <2.2 | 3,860 | 295 | 1046 |
| **IP-36-25** | <2.9 | 0.5 J | 2,430 | 946 | |
| **IP-37-25** | 17.3 | 9.8 | 1,790 | 286 | 1648 |
| **IP-37-28** | 94 J | 28 J | 2,600 | 208 | |

| | | | | | |
|---|---|---|---|---|---|
| **IP-38-14** | 1.4 J | <4.4 | 2.4 J | <4.4 | 131 |
| **IP-38-17** | <2.3 | <2.3 | 13.8 | 13.6 | |
| **IP-39-25** | <2.5 | <2.5 | 25.1 | 50.7 | 636 |
| **IP-40-24.5** | <2.2 | <2.2 | 311 | 188 | 1.450 |
| **IP-41-27** | <2.1 | <2.1 | 110 | 265 | 2,917 |
| **IP-42-31** | <57.5 | <57.5 | 1,220 | 28 J | |
| **IP-44-27.5** | <2.3 | <2.3 | 16.7 | 3 | 54 |
| **IP-45-29.5** | <51 | <51 | 804 | 14 J | |
| **IP-46-29.5** | <54.5 | <54.5 | 2,550 | 71.4 | |
| **IP-46-32** | 1.1 J | <1.9 | 127 | 1.4 J | |

**All results are below the Industrial RSLs.**
**Light Green denotes meeting both Industrial and Residential RSLs.**