Clay / Silt Source Zone ISCO Treatment Design Memorandum

Revised June 26, 2025

Clay / Silt Source Zone ISCO Treatment Design Proposal - Huster Substation Soil Treatment Activities: Operable Unit 4 (OU4), CERCLA No. 07-2012-0026.

INTRODUCTION

Ameren Missouri has scheduled an outage at the Huster Substation (Substation) for Spring 2026 to perform two critical tasks: (1) the replacement of transformer #2 which is reaching end of equipment life, and (2) modifications to support high-load electrical service to a large load customer data center that will be constructed approximately a half mile from the substation. Transformer 2 replacement provides a one-time opportunity for Ameren to have direct access to subsurface soils beneath and adjacent to the transformer (source zone) and treat chlorinated volatile organic compounds (CVOCs). The source zone is relatively small, approximately the size of a three-car garage. CVOCs in the source zone reside within the low-permeable cohesive soils (clay / silt) and are slowly released via diffusion into the groundwater with migration into the underlying sand aquifer. Treatment of these soils will minimize or eliminate CVOC migration to groundwater and accelerate the timetable for reduction of CVOC concentrations in groundwater under the Substation. The Substation (both a distribution and transmission substation) property is unique in that it must always remain operational since it is crucial to the energy supply needs of the community, contains high voltage equipment, and both overhead and below grade facilities.

SITE OVERVIEW

The following CVOCs have been identified within the Substation: tetrachloroethene (PCE), trichloroethene (TCE), cis 1,2-dichloroethene (cis-DCE), trans-1,2-dichloroethene (trans-DCE), 1,1-dichloroethene (1,1-DCE), and vinyl chloride (VC), as well as acetone and toluene. The suspected cause of CVOC impacts at the Substation is historical use of a cleaning agent in the vicinity of transformer #2. A safety data sheet (SDS) for the cleaning agent is provided as **Attachment A**. Concentrations of PCE and TCE have been historically identified in the vicinity of transformer #2 at the Substation with lower concentrations and other degradation products of PCE and TCE at varying depths and distances away from this transformer.

The geology of the Substation consists of a granular surface constructed of 2-3 feet of limestone rock, a copper earthing grid, and 1-2 feet of sand base. Beneath the base are natural clays and silts with a thickness of approximately 28-32 feet. These generally low permeability soils have intermixed, discontinuous narrow lenses (stringers) of trace to moderate sand, and the silt composition increases at depth. The lower 1-2 feet of the unit is primarily silt. Underlying the low permeability soils is a sand aquifer to an anticipated depth of 110 feet to bedrock contact. Beneath Substation transformer #2, a sump of the approximate transformer dimensions extends to a depth of 8-10 feet below ground surface (bgs). The sump is filled with 3–4-inch sized limestone rock. The confined / semi-confined shallow groundwater at the Substation is generally encountered at a depth of 16-20 feet bgs; however, shallower thin discontinuous perched zones may be infrequently encountered, especially near the sump.

EVALUATION OF TREATMENT METHODS

Ameren has evaluated several methods for treating cohesive soils in the source zone for implementation during the Spring 2026 planned outage and transformer replacement. The three-car garage sized area of CVOC-impacted soils (approximately 38 feet by 52 feet; ~2,000 square feet) near the center of the Substation, intermingled within tightly spaced equipment and high-voltage overhead lines/structures. The viability of four technologies for the treatment of CVOCS in cohesive soils are discussed below:

- Thermal Treatment (at the request of EPA)
- In Situ Chemical Oxidation (ISCO)
- In Situ Chemical Reduction (ISCR, aka ZVI-based PRBs) with or without soil fracturing/mixing
- Bioremediation (BIO) with or without soil fracturing/mixing

The congestion at this active Substation severely limits viable cohesive soil treatment options. Both thermal and soil fractioning/mixing are not feasible options due to access limitations, temperature limitations, safety concerns, and/or operation and maintenance requirements. The subsurface within the Substation contains an extensive network of buried control cables and a copper ground grid necessary for safe and reliable substation operation. The control cables are associated with circuits that provide critical protection and control functions for the high-voltage electrical equipment, while the ground grid is required to conduct current (neutral imbalance and fault currents) and simultaneously maintain safe step and touch potentials for personnel working in and around the Substation. Per Ameren substation design standards, the maximum continuous operating temperature rating of the control cables is limited to 75 °C, with the primary design concern related to heating generated by the cable itself as a function of ampacity and conductor resistance – the temperature margin designed within the cable (75 °C operating temperature vs. 15 °C ambient temperature) is reserved for internal heating of the cable itself or sympathetic heating from adjacent cables in the case of the conduit and trench systems. Similarly, the copper ground grid has comparable thermal limitations, with the design of the conductor size being related to its ampacity and ability to conduct fault currents and simultaneously dissipate the resultant thermal energy. Therefore, disturbance or damage to buried equipment would result in a sustained substation power equipment outages impacting some or all 33,000 distribution customers supplied by the Substation. While thermal treatment and soil fractioning/mixing method may be feasible options at certain sites to address CVOCs, the use of such methods at the Substation creates an unacceptable operational risk to the Substation that are not presented by other EPA-approved technologies that have been used safely onsite. Ameren has concluded that soil fractioning/mixing methods and all thermal treatment technologies investigated are not viable as they create considerable operational risk and Ameren's ability to serve customers in a safe and reliable manner.

While ISCR and BIO have proven suitable for addressing CVOC concentrations in the sand aquifer, such applications are not suitable for treatment of cohesive soils and therefore were not considered further. Early interim measures attempting to place ISCR into the cohesive soils were abandoned due to application and daylighting concerns. Excessive pressures (greater than 250 psi) were reached during the pilot attempt which likely created localized fractures within the soils. This fracturing is undesirable as it creates preferential pathways that would bypass large areas of diffused CVOCs. And unlike chemical or thermal treatments, ISCR and BIO treatment cannot diffuse into cohesive soils to achieve the direct contact necessary for treatment to occur. Fracturing and soil mixing might be used at applicable sites to expand the surface area for contact to increase the potential success with ISCR and BIO treatment in cohesive soils, but these methods are not an option at the Substation due to below grade infrastructure. Biological amendments such as lactate have the potential to create significant biomass that could create operational concerns for soil treatment and would not be as effective on CVOCs diffused into the cohesive soils mass.

Due to the low permeability of the cohesive soils and limited access to such CVOC-containing soils hindered by infrastructure within the Substation, complete removal of all CVOCs in the soils is not attainable regardless of the treatment selected for the Substation. Treatments, including three separate permanganate-based ISCO treatments (one potassium permanganate application and two sodium permanganate applications) have been applied previously within the Substation. In combination with groundwater treatments, permanganate treatments have significantly reduced soil CVOCs which have resulted in enormous success in groundwater CVOC reduction near the source zone (**Table 1**):

TABLE 1 - CVOC reduction at two groundwater monitoring wells within the source zone

Sample Location	Analyte	Unit	Date		% Reduction
			2014	2025	
MW-08	cis-1,2-DCE	µg/L	8,210	3.6	99.96%
	Vinyl Chloride	µg/L	390	15.4	96.05%
MW-13	cis-1,2-DCE	µg/L	10,900	45.0	99.59%
	Vinyl Chloride	µg/L	377	73.9	80.40%

During the 2026 Spring Q2 outage Ameren proposes to treat subsurface soils in the source zone with a permanganate-based ISCO to reduce concentrations of residual CVOCs within the low permeability cohesive soils overlying the sand aquifer. Permanganate was chosen following successful results of various pilot tests performed in 2014-2018. Those pilot tests, including the treatment material, were approved by EPA and have proven to be effective. The permanganate-based oxidant treatment is successful because it acts similarly to the CVOCs in terms of density-driven flow along natural fractures and diffuses to destroy the CVOCs within the cohesive soils mass. The attached paper (**Attachment B**) demonstrates the capability for stable oxidants like permanganate to diffuse significant distances into low permeability materials and the associated significant reduction of contaminant diffusive mass flux out of the cohesive soils. Given the success of historical applications and the subsequent and ongoing reduction of CVOC concentrations at the Substation as shown above, further evaluation of other amendments is unnecessary.

As described herein, the continuous injection of permanganate-based oxidant at low flows and low pressures increases diffusion potential over a broader area and provides immediate treatment of CVOCs in cohesive soils upon contact. This injection method allows for the oxidant to distribution across a wide area, to effectively diffuse into the soils to achieve necessary contact at focused depths, and to achieve a greater CVOCs mass reduction potential when a permanganate concentration gradient is maintained. Biological amendments, such as lactate have the potential to create significant biomass that could create operational concerns for the treatment of the source zone and would not be as effective on the CVOCs diffused into the cohesive soils mass.

APPLICATION DESIGN

The key to successful mass reduction for any treatment is diffusion of the treatment into cohesive soils to maximize the potential of contact with CVOCs. The significant limitations and logistics in working at an active electrical substation limits viable options for treatment methodology and duration. Permanganate-based ISCO treatment is believed to be the best treatment approach at the Substation because CVOCs reduction occurs quickly (upon contact) and can effectively diffuse into the clay to destroy the CVOCs relative to other alternative treatments. The adjustable, low-flow cyclic injection process which will be monitored and controlled on a well-by-well basis, along with the dense well network of injection wells for treatment monitoring, will allow Ameren to meet challenging implementation requirements at the Substation. **Attachment C** provides a conceptual site model highlighting the areas projected for the permanganate-based ISCO treatment. The footprint for the treatment equipment will not interfere with the Substation operations, and construction and operation of the proposed low-flow injection system is simple. More importantly, implementation of this treatment during the prescheduled transformer replacement will allow full access to the source zone for treatment.

The proposed permanganate-based ISCO treatment will be initiated during the small window in the Spring of 2026 when an area of the Substation will be de-energized and taken out of service. During this outage there will be a 4-week window between removal and replacement of the transformer equipment where the sub-soils beneath transformer #2 will be accessible. Note that the existing transformer support foundation will remain in place within the excavation and will be utilized for placement of the new transformer. This critical window when the subsurface is exposed allows for direct access to and optimal monitoring of the ISCO treatment of these soils. Remediation contractors will be able to examine the open space and identify optimum/accessible locations to install vertical injection wells to the subsurface. Once the wells are installed then permanganate will be pumped very slowly at a low-flow and constant low pressure into the injection wells. This slow and consistent dosing of oxidant will allow optimal contact with the CVOC residuals as it permeates into natural cracks and crevices and diffuses within the cohesive soils.

Permanganate-based Treatment

Permanganate-based oxidants can be used safely over a wide range of pH values and do not require any additional amendments or catalysts for the destruction of the CVOCs. Use of a dense (relative to water) oxidant such as permanganate encourages oxidant migration along naturally existing cohesive soils pathways, thereby mimicking the probable transport path of any CVOCs that were released. Permanganate does not auto-decompose therefore dosage is designed based on projected oxidant demand required, permanganate monitoring, and presence of CVOCs. In addition, permanganate-based ISCO applications can remain in the subsurface for extended periods in low permeability soils relative to other oxidants. This increased longevity in the subsurface allows for a higher probability of migration through natural preferential soil pathways and for diffusion into the soils where it is expected that CVOCs have diffused into, resulting in increased contact with and destruction of the CVOCs. The increased longevity of permanganate and ability to diffuse into the cohesive soils also reduces or eliminates rebound of the CVOCs from the cohesive soils into groundwater (CLU-IN | Technologies > Remediation > About Remediation Technologies > In Situ Oxidation > Guidance).

Sodium permanganate will be used for this ISCO treatment. Sodium permanganate and potassium permanganate, non-specific chemical oxidants, are both particularly effective in the destruction of CVOCs to innocuous end products. Safety data sheets for sodium and potassium permanganate are provided in **Attachment D**. The only difference between sodium and potassium permanganate with respect to the ISCO application is the cation in the permanganate solution (i.e., sodium vs. potassium) and neither option impacts the oxidation potential / treatment of the CVOCs. The selection of one cation over another is based more on the application methods and the concentration of the permanganate needed for injection. Sodium permanganate as supplied in liquid form has a 40 percent solubility which can be easily diluted to the design injection permanganate concentration. Conversely, potassium permanganate, supplied in solid form with a solubility of only 5 percent, requires more equipment and labor to generate the liquid for injection.

Injection Wells

A closely spaced network of injection points (currently projected at approximately 4 feet spacing, on an aerial basis) will be installed beneath and around the transformer foundation in the accessible areas free of known infrastructure. The 1-inch PVC injection wells with 10-foot screens will be installed with a direct-push rig. The installation depth of the screens of the wells in the cohesive soils will be focused at 15-25 feet bgs. This interval will allow for placement of permanganate solution at the upper range of intended saturation and remain within the cohesive unit above the transition depth. Some diffusion of permanganate will occur into the cohesive soils both above and below the well screen interval expanding the area of treatment. Existing onsite monitoring wells (in the sand aquifer) will serve as observation points for the presence of the permanganate (via color changes in the groundwater). Additional monitoring points in the sand aquifer may be added to better assess vertical migration in some areas. These would be 5-foot screens placed in the upper most contact with the sand unit. Determination for the needs and locations of additional observation wells will be addressed in a formal work plan. Well maintenance is an expected requirement on any ISCO injection project. Prior permanganate injections at the Substation have not caused any major fouling or plugging concerns in or around the injection wells.

The approach does utilize several borings to better ensure diffusion across the area treatment and is comparable to the requirements for an ISCR approach or the significant disturbance of a mixing approach which cannot be used due to the presence of the grounding grid.

Low -Flow Cyclic Pumping

Injection of sodium permanganate will commence once the injection well network is installed. Several injection wells within the closely spaced network will be connected to a small volume pump which will periodically inject the sodium permanganate solution into the defined injection area. The injection sequence into the wells will be in a singular direction (yet to be determined based on construction setup) such as north to south, west to east, etc. Implementation of offset injection well spacing will allow for permanganate residual monitoring in the cohesive soils in the defined injection area via the injection wells that will not be injected at that moment. The injection equipment will allow for real-time adjustment of flows and pressures at the injection wells. Under low-flow and low-pressure conditions the permanganate will be absorbed into the cohesive soils and react with and destroy CVOCs in the soil. Given the size of the targeted treatment area, the total permanganate volume injected over the treatment window would be comparable to or less than previous permanganate-based ISCO treatments.

This application process uses the natural flow pathways of the CVOCs, allowing for sustained contact times for permanganate to travel through the natural pathways and diffuse into the cohesive soils in the same manner the CVOCs penetrated the soils. The process also allows the permanganate to saturate the cohesive soils to achieve optimal contact with the CVOCs. The cohesive unit within the injection range is saturated and below the static water level of the underlying confined unit as experienced by overnight recovery of perched water levels in well that has been purged. This continuous saturation, in combination with the proposed application approach using low pressures and low flow rates, limits additional fractures in the cohesive soils which would disrupt permanganate migration through naturally existing pathway and saturation into the cohesive soils. This configuration and injection method will provide the highest level of control for permanganate contact with the CVOCs.

Figure 1 shows the type of equipment typically used in this type of ISCO treatment. Benefits of the cyclic pumping approach for the Substation include:

- A closely spaced injection well configuration increases probability of CVOCs contact with permanganate
- The closely spaced injections wells can also provide a high density of monitoring locations to provide feedback on permanganate distribution and ISCO performance
- Direct injection into the transformer sump
- Use of bladder-style pumps with low but variable flow and injection pressure capabilities
    - Less likely to create unnatural preferential pathways compared to higher pressure pump injections
    - Creates an adjustable cyclic pressure/relief impulse that promotes migration through the existing effective pore space and natural pathways
- Each injection well has its own pump
    - Provides focused control at each well
    - Easier to adjust controls if adverse observations occur (e.g., daylighting of permanganate is observed outside the target treatment area)
- Electric power source already available at the Substation for control boxes (battery back-up options exist)
- Provides for smaller, individual batch/holding tanks for the permanganate, which is a safer option
- Less impact on Substation operations and less noise
- Provides greatest flexibility for system changes, long-term or secondary applications, as needed
- Provides ability to conduct application using low-flow injection over a long period (months) to reach the required injection volumes and radius of influence that best follows historical CVOCs natural migration pathways and for permanganate diffusion into the cohesive soils
- Can be easily constructed from readily available materials and equipment

Figure 1 - Typical Cyclic Pumping Equipment

SYSTEM MONITORING

The high density of injection well locations and depth/screened intervals using the cyclic pumping of permanganate-based ISCO treatment approach not only provides a high degree of injection control but also provides a dense monitoring network for process feedback and performance monitoring. During the treatment process select injection wells in the vicinity of an active injection point will be monitored for the visual presence of permanganate. Since perched groundwater is constantly present within the cohesive soils (as observed in monitoring wells MW-39, MW-40, and MW-41 at varying screening intervals of 15-20, 20-25, and 25-30 feet bgs near the base of the transformer), a ¾-inch bailer will be used to collect groundwater from the screened interval of the observation injection wells by lowering it within the well screen and returning it to surface with a perched groundwater sample which will be visually inspected for color. Permanganate imparts a pink (low concentration) to purple (higher concentration) color to the soils and groundwater when present. In addition, select injection points will be sampled for CVOCs in groundwater prior to, during, and post ISCO injection. This monitoring can identify oxidant distribution, provide evidence of oxidant demand (e.g., from CVOCs) and oxidant performance (e.g., permanganate initially not seen, but observed later in the injection period) and alert to any potential permanganate leaving the target treatment area. Should the presence of deep purple or purple be observed, injection(s) in the vicinity will be altered (reduced or stopped) based on Substation information and likelihood of a preferential pathway connection. The data collected from groundwater samples will help focus the injections into the sub-areas that would benefit from more permanganate mass and provide an overall evaluation of the total system performance relative to baseline conditions.

Although migration into the sand aquifer could only occur upon permanganate saturation or through a preferential pathway, the permanganate dosage is projected to quickly be expended upon contact with the CVOCs and other organic matter or reduced metals in the perched groundwater and cohesive soils near the point of injection; hence, the tight spacing of the injection points and low flow rates in the proposed injection approach. If non-depleted permanganate were to be observed in the sand aquifer groundwater in the source zone, it would be captured and treated by the GETS. Exhibit 1.9a of the CSM shows the effect of the capture zones of GETS extraction wells MW-05 and MW-15 for capturing impacted groundwater from the source zone. If non-depleted permanganate migrates from the treatment area and is not captured by the GETS it will continually be subject to rapid depletion in the soils and groundwater.

In the unlikely event non-depleted permanganate failed to expend from CVOCs and organic matter in surrounding soils and groundwater, bypassed the GETS capture zone, and then entered the aquifer, the permanganate concentration in the aquifer would be extremely diluted. As an example of soils capacity to deplete permanganate, the median permanganate demand in soils (**Attachment B**) is approximately 4 grams of permanganate per kilogram of soil; 100 gallons of permanganate at 100 grams per liter concentration. If released from the soils into the aquifer and if permanganate is assumed to mix over the aquifer depth and width of 5 feet, permanganate would be used up within 8 feet of migration from the release point. Therefore, even a 100-gallon release of permanganate into the underlying sands would not migrate for from the release point before being depleted.

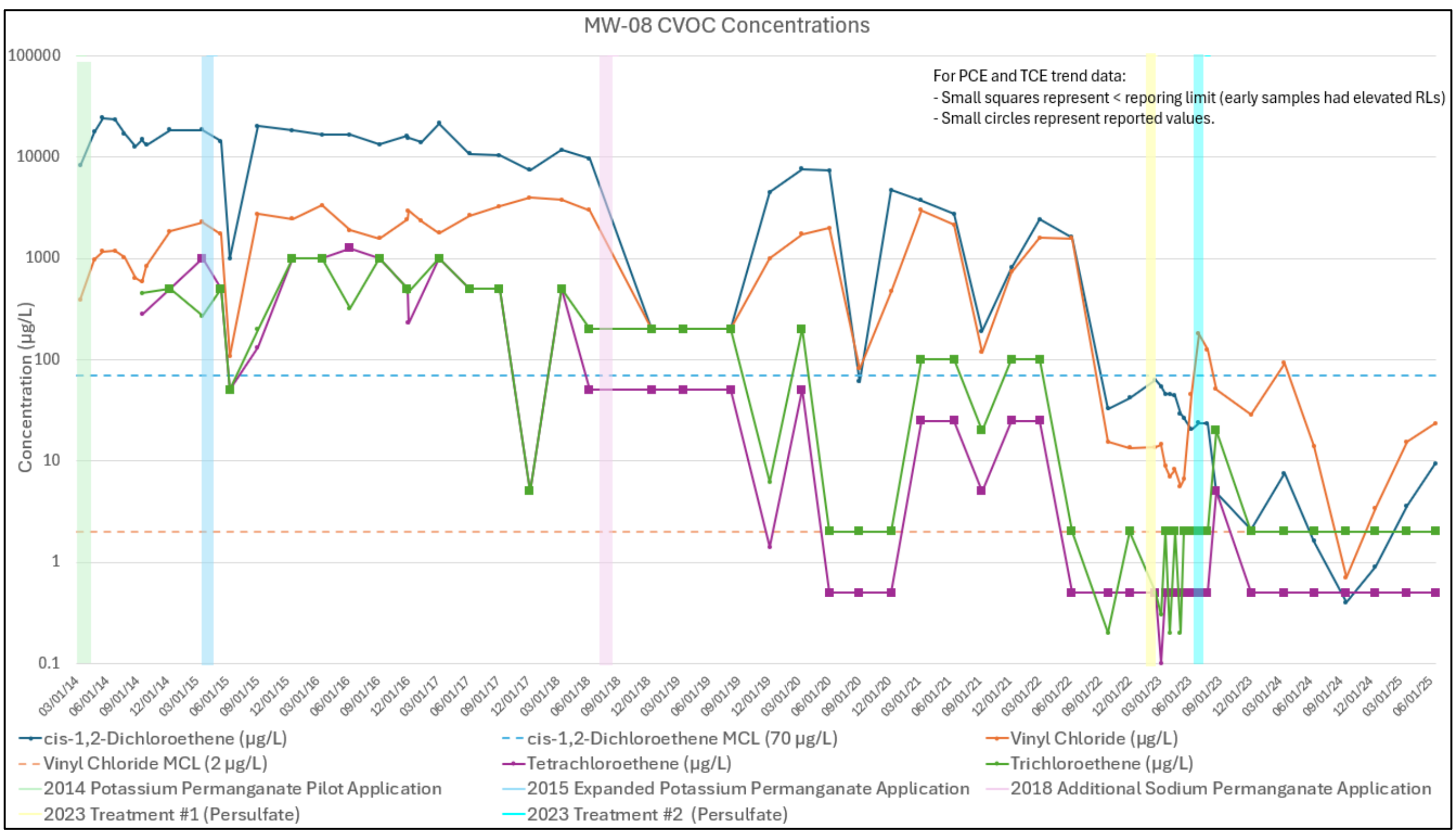
Further, this rapid depletion of oxidants was illustrated previously in the aquifer. Groundwater flow across the Substation, even with CW-04 and/or CW-05 operating, is slow, approximately 4 ft/day *(CSM, Appendix 6, ZVI-Based PRB Design Memorandum)*. Prior EPA-approved injections of persulfate directly into the sand aquifer have shown that while the injection point displayed persulfate for periods up to a few months, no monitoring well in the direction of groundwater flow towards the GETS showed active oxidant at any time, illustrating the rapid removal of any residual oxidant at any significant distance outside the injection wells. Based on Ameren's observations from previous applications, at no time was permanganate observed in the GETs influent or effluent, indicating that any migration in groundwater was limited. As described above, this application is a slow volume injection and is highly monitored so a release of 100 gallons into the aquifer would be detected rapidly and injection stopped at the location of concern.

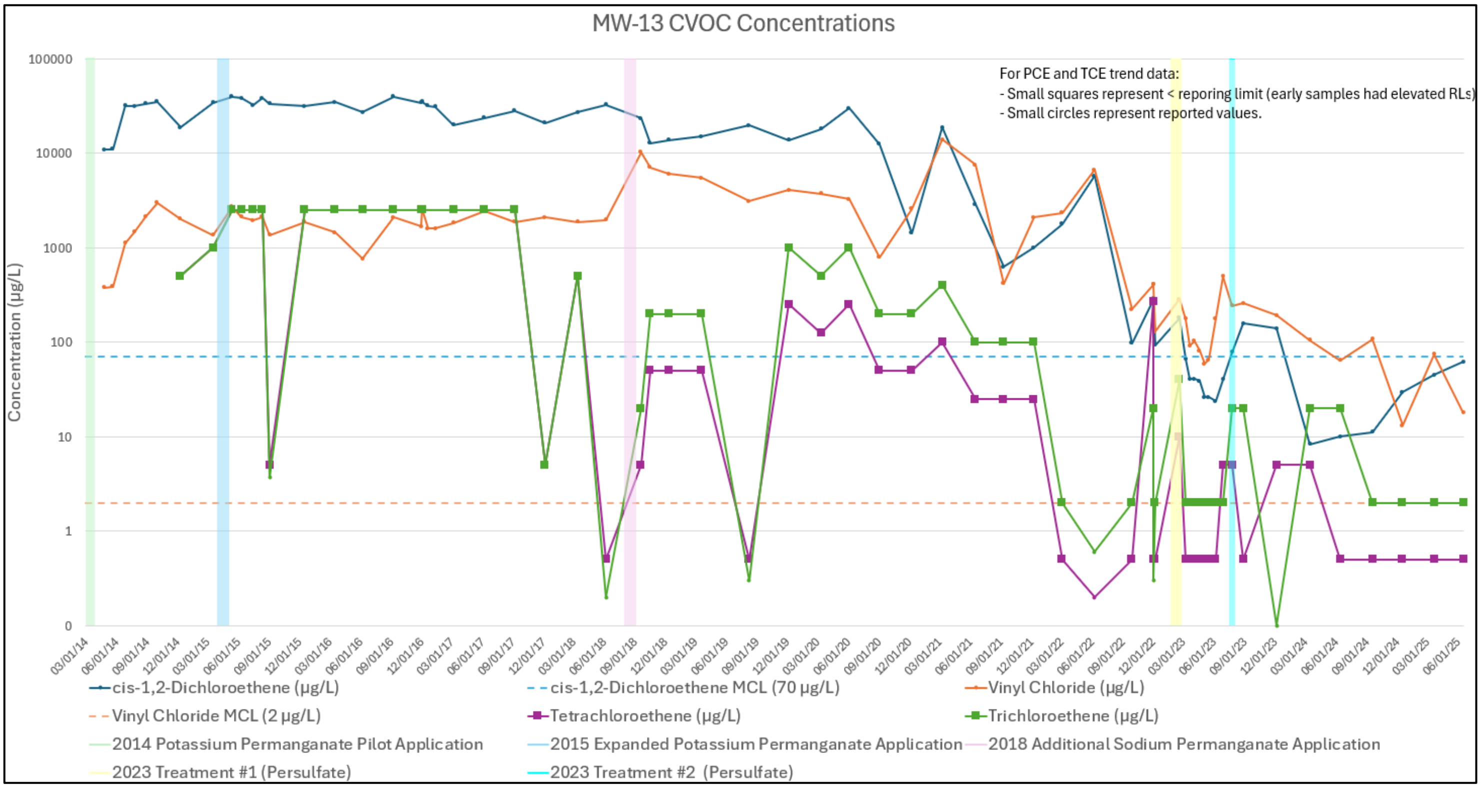
In the very unlikely event non-depleted permanganate moved through the aquifer and reach ZVI-based PRBs, the permanganate would react (oxidize and inactivate) only a negligible quantity of the 96,000 pounds of ZVI that exists inside and around the Substation. Based on the expected mass of permanganate that could reach the sand aquifer and ultimately the PRBs, the effect on the overall PRB longevity is expected to be extremely minor. Therefore, with the proposed injection approach, the associated field monitoring for permanganate and CVOCs, and continued operation of the GETS there is no real concern of permanganate reaching the PRBs or any of the City production wells.

PRIOR PERMANGANATE FIELD APPLICATIONS AT SUBSTATION

Permanganate-based ISCO treatments were previously applied, via direct injection into existing wells (MW-39, MW-40, MW-41) and injection points located within the cohesive soils at the Substation in 2014, 2015 and 2018. **Attachment E** provides a cross section of the Substation showing historic treatments within the Substation, including historical permanganate injection locations/depths. The following sections provide details on each of the three permanganate injection events. Summaries of the injection treatment are provided in the SRIR (attachment D for 2015; attachment E for 2018). Table 1 above identified a significant reduction in groundwater CVOC concentrations of cis-DCE and VC within the source zone which are a direct result of the implementation of success BIO and ISCR treatments, but the long-term reduction in overall groundwater CVOC concentrations is an indirect result of the progressive permanganate-based ISCO treatments that have successfully reduced the overall mass of CVOCs in cohesive soils. ISCO reduced the PCE and TCE in the cohesive soils, while the BIO reduced the PCE and TCE in the groundwater. With limited PCE and TCE in the soils, the PCE and TCE were reduced quickly in the groundwater and not subjected to rebounding. The BIO could continue to degrade cis-1,2-DCE and VC in the groundwater. Additional permanganate treatment to the cohesive soils will further reduce cis-1,2-DCE and VC, thus reducing or eliminating leaching to groundwater. The long-term overall groundwater data reduction as shown below in the logarithmic graphs of monitoring wells MW-08 and MW-13 (located in the sand aquifer) is an indication that additional permanganate-based ISCO treatments in the cohesive soils are beneficial to expeditiously reach remediation goals.

FIGURE 2 (Logarithmic Graphs)–
Groundwater CVOC concentrations at Source Zone Monitoring Wells MW-08 and MW-13





2014 Pilot Application near Transformer #2:

In March 2014 approximately 3,950 gallons of potassium permanganate solution was injected into the low permeability soils during a pilot test in the vicinity of transformer #2 at the Substation. **Attachment F** provides a map of injection locations, injection cross section, and soil sample results for the 2014 treatment. Permanganate injection concentrations varied from 25 grams per liter (g/L) to 40 g/L over the pilot test duration. The injection volumes at each individual location as well as the injection intervals are summarized in Table 2 (dilute potassium permanganate was injected into MW-39, MW-40, MW-41 and the sump and sump backfill material beneath transformer #2 which is believed to be the primary source of CVOCs.)

TABLE 2 – 2014 Permanganate Injection Volumes

Well ID	Well Screen Interval (feet bgs)	Volume of Permanganate Solution Injected (gallons)
MW-39	(25-30)	801
MW-40	(20-25)	884
MW-41	(15-20)	892
SUMP	No screen, set @ 8 feet bgs	1,374
TOTAL		**3,951**

Laboratory analytical results from soil samples collected around injection well MW-41 four months after the pilot application indicated the CVOCs were significantly reduced within the soils where permanganate was applied. The screened interval for MW-41 is 15-20 feet bgs. SB-41-2, a soil boring with pre- and post- injection soils CVOCs data is located close to MW-41 and the transformer sump. A comparison with the post ISCO data from

SB-42-2 in 2014 (**Table 3)** shows that for soil sample representative of the potassium permanganate injection at MW-41, all the CVOCs were reduced by a range of 94 - 97 percent (%).

TABLE 3
Pre and Post Soil Analytical Data for MW-41-2 at the depth Potassium Permanganate was Injected

Soil Boring	Date	Depth (ft)	PCE (ug/kg)	TCE	cis-1,2-DCE	Vinyl Chloride
MW-41-2	12/1/12	15-16'	147,000	14,400	11,400	110 J
MW-41-2	7/23/14	16-20'	2.4 J	2.8 J	47.2	6.2

2015 Expanded Application:

Following the 2014 permanganate pilot study (90+% reduction of CVOCs), a more extensive application of permanganate was requested and approved by USEPA for the treatment of the CVOC impacted low permeability soils. **Attachment F** presents a map and summary of the 2015 permanganate injections volumes into the low permeability soils at the Substation. This expanded ISCO application area covered approximately 2,250 square feet (ft^2) and targeted a vertical interval of 20 feet. A total of twenty-two injection locations, using existing wells and temporary injection locations, via Geoprobe® direct push, were used to distribute the permanganate at varying depths and locations below ground surface. A total of 15,755 gallons of sodium permanganate solution was injected at an approximate concentration of 30 g/L permanganate into injections points (IPs) IP-1 and IP-2, and 60 g/L into the remaining IPs.

2018 Additional Application:

ISCO injections using sodium permanganate were also performed in 2018 to target additional specific areas/depths within the Substation that had not previously received treatment. Increases in the perched groundwater within MW-39 – MW-41 of cis-1,2-DCE and VC indicate that the previous injections of permanganate degraded PCE and TCE, but full degradation did not occur, therefore additional treatment was needed. Ten temporary injection wells were installed via Geoprobe® direct-push drilling techniques prior to injections. The injection locations and permanganate solution volumes are shown in **Attachment H,** and results of 2023 soil CVOC data is shown in **Attachment I**.

SUMMARY

During the planned outage and replacement of transformer #2 in the second quarter of 2026, treatment of cohesive soils under and in the vicinity of transformer #2 can be performed to reduce contaminant mass in this area of the Substation. This would minimize or eliminate CVOC migration to groundwater and accelerate the timetable for reduction of CVOC concentrations in groundwater under the Substation. Ameren has evaluated several potential technologies and application methods for the treatment of the cohesive soils in and around transformer #2 during the Spring 2026 planned outage. Permanganate-based ISCO is the proposed technology to treat CVOCs residuals within the low permeability / cohesive soils overlying the sand aquifer on the Substation in the vicinity of transformer #2. Permanganate, when applied, can remain in the subsurface for long periods, relative to other oxidants, allowing for a higher probability of more effective contact with and destruction of any CVOCs residuals on the cohesive soils. Due to its longevity in the soils, permanganate can also diffuse into cohesive soils over significant distances relative to other available oxidants. These advantages permit permanganate to both migrate through preferential natural pathways in the soils and to destroy CVOCs diffused into the soils. These capabilities optimize the ability to reduce or eliminate potential rebound of the CVOCs into the groundwater and the associated infiltration of the impacted groundwater into the underlying sand aquifer.

The recommended high control, low-flow and low-pressure cyclic pumping of permanganate into closely spaced injection wells is considered the most effective approach to overcome the challenging site-specific restrictions both from Substation logistics but also in achieving contact with the residual CVOCs in the low permeability soils. During application, observations on the flow of permanganate into the individual wells and the corresponding monitoring of other wells in proximity permits a high level of control of the injections, close monitoring of the distribution of the permanganate, and the ability to rapidly adjust the process to ensure the highest success in contacting and destroying any CVOCs residuals and minimizing loss of permanganate to the underlying sand aquifer. The injection point network will also be used for process performance monitoring relative to baseline conditions, and to focus on treatment efforts where needed over the duration of the process. The expected reduction in any CVOCs residuals contacted would further reduce the potential for leaching of CVOCs from the low permeability soils into the underlying sand aquifer and the associated environmental risk and exposure.