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October 1, 2020

Ms. Kim Kuhn
Bureau of Land and Waste Management
SC Department of Health and Environmental Control
2600 Bull Street
Columbia, SC 29201

Regarding: Pilot Study Work Plan
Shakespeare Composite Structures Site
Newberry, South Carolina
SCDHEC VCC Number 14-6271-RP

Dear Ms. Kuhn:

On behalf of Signify North America Corporation, please find attached the Pilot Study (PS) Work Plan for the Shakespeare Composite Structures Site (the Site) located in Newberry, South Carolina. The PS Work Plan includes plans for multiple in-situ field tests at the Site. Attachments to this plan include an Underground Injection Control (UIC) Permit application and monitoring well permit applications. A copy of the UIC Permit application will be submitted to the South Carolina Department of Health and Environmental Control's (SCDHEC) Water Monitoring Assessment and Protection Division, under separate cover, within the next week for review.

Should you have any questions regarding the PS Work Plan please feel free to contact me at your convenience.

Sincerely,

AECOM Technical Services, Inc.

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Project Manager
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cc: Mr. Dean Weeks – Signify North America Corporation

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AECOM

Pilot Study Work Plan Shakespeare Composite Structures Site

RP-VCC-14-6271-RP
Signify North America

AECOM Project No.: 60635197
October 2020

Pilot Study Work Plan

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List of Acronyms

ABC®-Olé	Anaerobic Biochem ® Olé
ABC®+Olé	Anaerobic Biochem Plus® Olé
AECOM	AECOM Technical Services, Inc.
bgs	below ground surface
BSTS	bench-scale treatability study
cis-1,2-DCE	cis-1,2 – dichloroethene
CVOCs	chlorinated volatile organic compounds
DHB	*Dehalobacter spp.*
DHC	*Dehalococcoides*
DO	dissolved oxygen
DOT	Department of Transportation
ERD	enhanced reductive dechorination
EVO	emulsified vegetable oil
FS	feasibility study
ft	feet
ft/ft	feet per foot
ft/day	feet per day
ft/yr	feet per year
g/kg	grams per kilogram
IDW	investigation derived waste
ISB	in situ bioremediation
ISCR	in situ chemical reduction
ISCO	in situ chemical oxidation
ISB	in situ bioremediation
$KMnO_4$	potassium permanganate
MCLs	maximum contaminant levels
mg/L	milligrams per liter
MNA	monitored natural attenuation
msl	mean sea level
ORP	oxidation reduction potential
PSWP	Pilot Study Work Plan
psig	pounds per square inch gauge

List of Acronyms (cont'd.)

PVC	polyvinyl chloride
Redox Tech	Redox Tech, LLC
RemOx®S	RemOx®S ISCO reagent
RI	remedial investigation
ROI	radius of influence
RP-VCC	responsible party-voluntary cleanup contract
RP	responsible party
SCDHEC	South Carolina Department of Health and Environmental Control
Signify	Signify North America
SiREM	Laboratories
TCE	trichloroethene
TOD	total oxidant demand
UIC	underground injection control
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VCC	voluntary cleanup contract
VOCs	volatile organic compounds
ZVI	zero valent iron

Section 1. Introduction

The Shakespeare Composite Structures Site (the "Site"), located in Newberry, South Carolina is participating in a voluntary cleanup program with the South Carolina Department of Health and Environmental Control (SCDHEC). The Site is currently listed as responsible party – voluntary cleanup contract (RP-VCC) number RP-VCC-14-6271-RP. As part of the RP-VCC process the Site has undergone a Remedial Investigation (RI), which was completed in November 2018. The RI efforts delineated a plume of dissolved phase chlorinated volatile organic compounds (CVOCs) in Site groundwater. Based on the results of the RI, it is anticipated that an active groundwater treatment remedy will be required for at least a portion of Site groundwater. The RP for the Site [Signify North America – (Signify)] has previously conducted and will be conducting several activities that will be incorporated into a Feasibility Study (FS) for potential remedial altenatives to treat CVOC-impacted groundwater. Previously completed activities include a bench-scale treatability study (BSTS) that was conducted between September 2019 and January 2020. A BSTS Report was generated following the conclusion of the BSTS that summarized the results of the laboratory-based evaluation of multiple in situ remediation options and also recommended the performance of a field-scale pilot study.

This document serves as the Pilot Study Work Plan (PSWP) for proposed field-scale pilot study activities for Site-related CVOC-impacted groundwater. This PSWP has been developed to describe the implementation of the proposed pilot study activities and associated performance monitoring related to CVOC contamination located in shallow and intermediate zone groundwater where the highest concentrations of CVOCs have been detected during previous Site investigations CVOC impact in bedrock groundwater exists but at much lower concentrations and therefore is not addressed by this pilot study.

1.1 Facility and Site Setting

The Site is located on US Highway 76, approximately 1 mile northwest of Newberry, South Carolina **(Figure 1-1**). The Site is centered on the Valmont Composite Structures facility (the Facility, formerly known as Shakespeare Composite Structures), and includes several surrounding properties (**Figure 1-2**). The facility was originally opened to produce fiberglass products, and it has continued to be used for this manufacturing process. Operations at the facility include the design and manufacture of large fiberglass utility poles and cross arms and a variety of other fiberglass outdoor products such as posts, signs, sheet piling, and signposts. Manufacturing is conducted inside two separate buildings – the Main Building and the Pole Winder Building.

In addition to the Facility property, the Site includes several surrounding properties (**Figure 1-2**). General land use surrounding the facility consists of agricultural, residential, undeveloped, and commercial/light industrial properties (AECOM Technical Services, Inc. [AECOM], 2018).

Topography of the Site is generally flat on the Facility property. Land surface elevations generally decrease to the southwest, west, and north moving away from the Facility property. Surface elevations range from approximately 562 feet (ft) mean sea level (msl) on the east side of the Facility to less than 520 ft msl along an unnamed intermittent stream located to the north of the Facility.

A more detailed description of the facility's operation, surrounding property usage, and site topographic setting information is included in the RI Report (AECOM, 2018).

1.2 Previous Investigations

Several phases of investigative efforts have been performed at the Site. This includes multiple investigative efforts prior to execution of the VCC. The pre-VCC investigative efforts that were conducted include:

- Phase II Environmental Site Assessment – Collection of initial soil and groundwater samples from the Shakespeare facility (February through April 2014);
- Site Investigation – Collection of additional soil and groundwater samples from the Shakespeare facility along with several groundwater samples from surrounding private parcels (May 2014 through August 2014); and
- Expanded Investigation - Collection of additional shallow groundwater samples and evaluation of shallow bedrock for impacted groundwater on surrounding properties (August through September 2014).

An RP-VCC between the SCDHEC and Philips Electronics North America Corporation (PENAC) was executed in September 2014. Once this VCC was executed, additional investigative efforts were performed as part of the RI process.

The RI was implemented in two phases, beginning in 2014 after execution of the VCC. The RI was conducted to further evaluate the vertical and/or horizontal extent of previously identified CVOCs in soil and groundwater; assess additional potential areas of interest for secondary sources of VOCs that could be contributing to soil and/or groundwater impacts; evaluate potential vapor intrusion pathways; determine risk to potential human and ecological receptors; and provide additional data needed to develop a remedial strategy for the Site.

RI efforts determined that the source areas for CVOCs present in groundwater originated from historical operational practices that impacted groundwater beneath the western portions of the Main and Pole Winder Buildings located on the Facility property. CVOCs subsequently migrated both horizontally and vertically within groundwater away from the identified source areas and impacted multiple aquifer depth intervals (shallow, intermediate, and bedrock) beyond the Facility property.

In general, the water table at the Site is encountered in the fine sands and silts and clays of the residuum. Groundwater is encountered at depths ranging from approximately two ft below ground surface (bgs) near the northern end of the Site and on the Dickert property to as deep as approximately 18 ft bgs on the former Shakespeare Composite Structures facility. Groundwater beneath the Site is mainly encountered under unconfined conditions.

As a result, the direction of groundwater flow beneath this Site, particularly in the shallow (water table) zone follows topography, with flow components to the west and northwest. CVOCs have migrated within the water table and saprolite zones primarily through natural dispersion. Vertical migration downgradient of the source areas within the saprolite and into underlying granitic bedrock was influenced primarily by numerous privately-operated water supply wells located to the west and southwest of the Facility. Groundwater elevation and flow maps for the shallow and intermediate zones are provided as **Figures 1-3 and 1-4**, respectively.

Based on the groundwater elevations determined during the most recent measurement event (June 2018), the average horizontal hydraulic gradients for the shallow and intermediate zones were determined to be 0.016 feet per foot (ft/ft) to the west-northwest and 0.014 ft/ft to the west-northwest, respectively. A downward gradient between the shallow and intermediate zones was observed across the Site during the June 2018 event. During Phase II of the RI, hydraulic conductivity tests (slug tests) were conducted on select shallow and intermediate zone monitoring wells. The results of the slug tests indicated an average hydraulic conductivity of 0.80 feet per day (ft/day) and 0.72 ft/day for the shallow and intermediate zone, respectively. Based on an assumed effective porosity of 0.25, the calculated ground velocity for the shallow groundwater zone is approximately 0.05 ft/day or 18.25 feet per year (ft/yr). Using an assumed effective porosity of 0.3, the calculated ground velocity for the intermediate groundwater zone is approximately 0.03 ft/day or 10.95 ft/yr.

The RI defined the extent of CVOC-impacted groundwater at multiple aquifer depth intervals. Analytical results were screened against United States Environmental Protection Agency (USEPA) maximum contaminant levels (MCLs) to identify compounds of interest in groundwater beneath the Site. Concentrations of trichloroethene (TCE), cis-1,2 Dichloroethene (cis-1,2-DCE), and vinyl chloride (VC) exceeded their respective MCLs in several groundwater samples collected from the Site. Of these, TCE was the most frequently detected chemical in groundwater samples collected at the Site. The elevated concentrations of CVOCs are most widespread in shallow zone groundwater (upper portion of the water table aquifer). TCE and cis-1,2-DCE also exceeded their respective MCLs in one or more samples collected in the intermediate (saprolite) zone.

Because TCE was detected most frequently and at the highest concentrations in Site groundwater, the results for this compound have been used to represent the extent of impact in the shallow and intermediate groundwater zones. **Figures 1-5** through **1-6** depict the extent of TCE in shallow zone and intermediate zone groundwater beneath the Site based on data from the last site-wide monitoring event completed in June 2017.

A more detailed discussion of the results of the investigative efforts conducted at the Site to date is included in the RI Report (AECOM, 2018).

1.3 Feasibility Study Work Plan

The RI Report for the Site was submitted to the SCDHEC in November 2018 and subseqeuntly approved on February 4, 2019. Following approval of the RI Report, SCDHEC requested that Signify develop an FS Work Plan for the Site. The purpose of the FS Work Plan was to outline the proposed information that would be included in the Site FS. The cover letter for the FS Work Plan also proposed that a BSTS and subsequent pilot study should be completed prior to development of the FS. The FS Work Plan was submitted to SCDHEC on May 15, 2019 (AECOM, 2019). SCDHEC approved the FS Work Plan on June 4, 2019.

In their June 4, 2019 approval letter, SCDHEC requested that Signify submit a BSTS Work Plan by July 31, 2019. The BSTS Work Plan was approved by SCDHEC on August 23, 2019. The BSTS was subseqently implemented in September 2019.

1.4 Bench Scale Treatability Study

In order to develop a more definitive remediation plan for Site groundwater and prior to developing the FS for the Site, two potential in-situ remediation technologies for groundwater including in-situ chemical oxidation (ISCO) and enhanced reductive dechlorination (ERD) were evaluated in the BSTS as possible treatment options for the Site-related CVOCs (AECOM, 2020). ERD is an active groundwater remedial approach that can combine multiple in situ technologies to degrade CVOCs via reductive biological and/or abiotic chemical processes. In this case, ERD via in-situ bioremediation (ISB), via in situ chemical reduction (ISCR), and via a combination of both were evaluated by the BSTS.

On September 19, 2019, soil was collected from an area between monitoring wells MW-10 and MW-10I, and groundwater was collected from MW-10 and MW-10I. This area and the two monitoring wells are located just north of the Facility property on the Dickert property (**Figures 1-5 and 1-6**). Soil and groundwater samples were shipped to Redox-Tech, LLC (Redox Tech) in Cary, North Carolina for ISCO total oxidant demand (TOD) testing. Soil and groundwater samples were also submitted to SiREM Laboratories (SiREM) in Ontario, Canada for evaluation of the various ERD treatments.

The TOD evaluation was conducted to determine if native Site groundwater and saturated aquifer material would be amenable to ISCO treatment. Aquifer materials targeted for ISCO treatment that contain high natural organic carbon, high naturally reduced inorganic minerals such as iron, and elevated CVOC concentrations require higher concentrations of oxidant to effectively treat the targeted contaminants. TOD values determined in the four microcosms used for ISCO testing indicated a limited oxidant demand exerted by Site groundwater and saturated soil. TOD values for the microcosms ranged from less than 0.3 grams per kilogram (g/kg) to 2.8 g/kg, which falls within the typical range for saprolitic soils found in the Piedmont region of South Carolina. Based on these results and a subsequent discussion with Redox Tech, a TOD value of 1 to 2 g/kg was considered adequate for ISCO design purposes. Because the Site TOD value is low, these results indicated that ISCO may be a suitable remedial option to treat CVOC-impacted Site groundwater.

The BSTS for ERD evaluated the effectiveness of multiple treatment amendments for CVOC-impacted Site media including EDS-ER™ (an emulsified vegetable oil [EVO]), which promotes ISB via reductive dechlorination, MicroEVO™ (a sulfidated zero valent iron [ZVI]), which promotes abiotic ISCR, and KB- 1® Plus (a chlorinated solvent bioaugmentation microbial culture). One of the EDS-ER™ amended treatment microcosms and one of the MicroEVO™ ISCR amended treatment microcosms were also buffered using sodium bicarbonate to maintain the pH within the optimal range (i.e., 6 to 8 standard units) for reductive dechlorination to occur.

Based on the results of the BSTS, it was determined that the microcosm with buffered EVO that was amended approximately 40 days after initiation of testing with KB- 1® Plus was able to completely degrade the TCE in Site groundwater. The microcosms containing sulfidated ZVI saw an immediate decrease in TCE to approximately half of its initial concentration; however, bioaugmentation was required to promote further reduction in the concentration of TCE. VC remained in this sulfidated ZVI microcosm at the conclusion of the BSTS in January

2020. It was subsequently surmised that sulfidation of the ZVI likely interfered with the complete reduction of TCE to ethene and that non-sulfidated ZVI would likely be more effective.

Based on the results of the BSTS, both ISCO and ERD using a combination of ISB and ISCR were determined to be potentially applicable remediation technologies that could be used to address CVOC contamination in Site groundwater. A field-based pilot study was recommended as the next logical step in order to evaluate effectiveness, implementability, and cost associated with full-scale implementation of one or both technologies.

In their June 15, 2020 approval letter, SCDHEC reviewed and concurred with the BSTS results and recommendation for the completion of a pilot study at the Site. SCDHEC requested that Signify submit a PSWP by August 15, 2020. Signify subsequently requested an extension to complete the PSWP. A due date extension to October 2, 2020 was approved by SCDHEC on August 24, 2020.

Section 2. Pilot Study Location, Design, and Implementation

The following subsections describe the proposed pilot study location, design, and implementation procedures.

2.1 Pilot Study Location

Because both ISCO and ERD (using ISB and ISCR) are potentially applicable treatments for CVOCs in Site groundwater, the proposed pilot study will consist of separate pilot study areas. Based on the 2017 CVOC concentrations detected in shallow and intermediate zone groundwater, two areas were identified for the pilot study. One pilot study area is located within the eastern end of the Main Building near monitoring well TMW-31 and will be used to conduct the ISCO pilot study. The objective of the proposed ISCO pilot study is to decrease the TCE concentration in the shallow groundwater zone within this area using a strong chemical oxidant. **Section 2.2** describes the injection design and the amendment to be used to achieve the ISCO pilot study objective. The amendment will be injected through temporary points using direct-push technology (DPT) to treat the targeted shallow groundwater. Flow direction in shallow zone groundwater near TMW-31 is to the west-northwest (**Figure 1-3**). Site monitoring well construction details are provided in **Table 2-1**.

Figure 2-1 shows the ISCO pilot study area and the proposed DPT injection locations. It should be noted that a source area located in the western end of the Main Building was initially identified for the ISCO pilot study, however, this location is in the middle of a production area with high traffic and limited access. Another potential location near MW-8 located outside of the western end of the Main Building was also identified; however, without treatment of the source area within the vicinity of TMW-21 and TMW-22, ongoing impact from the upgradient source to downgradient groundwater at MW-8 would likely occur, and the effectiveness of the pilot study would be difficult to accurately evaluate. As a result, the area near TMW-31 was selected for the ISCO portion of the pilot study.

The ERD pilot study area is proposed to be conducted north of the Pole Winder Building across the railroad tracks on the Dickert Property. The objective of the proposed ERD pilot study is to decrease the concentration TCE in the shallow and intermediate groundwater zones within the vicinity of monitoring wells MW-10 and MW-10I. The ERD pilot study will include the concurrent injection of an organic carbon substrate and ZVI into the targeted shallow and intermediate zone groundwater to create strongly anaerobic and reducing conditions suitable for enhanced ISB and ISCR of the Site-related CVOCs in groundwater. Additional amendments including a pH buffer, additional nutrients, and a bioaugmentation culture will be used to enhance the ISB component of ERD. The ERD substrate and amendments will be delivered to the subsurface via DPT injection.

Figure 2-2 shows the ERD pilot study area and the proposed DPT injection locations for shallow zone groundwater treatment near MW-10. **Figure 2-3** shows the ERD pilot study area and the proposed DPT injection locations for intermediate zone groundwater treatment near MW-10I. Flow direction in shallow zone groundwater near MW-10 is to the west-northwest (**Figure 1-3**), and the flow direction in intermediate zone groundwater near MW-10I is to the west-northwest.

2.2 Pilot Study Design

The following subsections describe the injection design and amendments to be used to achieve the ISCO and ERD pilot study objectives.

2.2.1 ISCO Pilot Study

For the proposed ISCO injections via DPT, a radius of influence (ROI) of 8 ft was assumed in order to obtain adequate coverage for the successful treatment of shallow zone groundwater with elevated TCE in the vicinity of monitoring well TMW-31. For this area, a potassium permanganate ($KMnO_4$) solution (approximately 4% by weight) will be injected into three locations via DPT using a Geoprobe® series 6600 rig. The vertical injection interval targeted for the three injection locations is from approximately 11 ft bgs to 21 ft bgs. Note that the final DPT injection point locations, spacing, and injection depths are subject to change based on the field conditions encountered at the time of the injection event. Any changes to the proposed DPT injection locations, spacing, and/or injection depths will be documented in the Site field notes. The specific chemical oxidant product to be used is described in the following subsection.

2.2.1.1 RemOx®S ISCO Reagent

For the ISCO field pilot study, the Carus Corporation $KMnO_4$ product, RemOx®S ISCO reagent (RemOx®S) will used for the treatment of TCE in the shallow zone groundwater within the vicinity of TWM-31. RemOx®S is a strong chemical oxidant that has been used for the treatment of CVOCs in groundwater at numerous sites with varying lithologies including those similar to the Shakespeare Composite Structures Site. The use of RemOx®S will not require activation like other chemical oxidants such as persulfate or hydrogen peroxide. Its use is applicable over a wide range of pH, and it can easily be detected in monitoring wells several months following injection due to its natural deep purple color. RemOx®S is deep purple when it is chemically active and becomes brown once it is no longer active.

2.2.2 ERD (ISB and ISCR) Pilot Study

For the proposed ERD DPT injections, an ROI of 10 feet was assumed for both the shallow and intermediate zone groundwater in order to obtain adequate coverage for the successful treatment of groundwater with elevated TCE concentrations in the vicinity of MW-10 and MW-10I. For treatment of both zones, a barrier-type injection approach will be utilized. Five ERD DPT injections will be conducted upgradient of MW-10, and five ERD DPT injections will be conducted upgradient of MW-10I using a Geoprobe® series 7822 rig. The vertical injection interval targeted for shallow zone groundwater treatment is from approximately 20 ft bgs to 30 ft bgs. The vertical injection interval targeted for intermediate zone groundwater treatment is from approximately 31 ft bgs to 41 ft bgs. Note that the final DPT injection point locations, spacing, and/or injection depths are subject to change based on the field

conditions encountered at the time of the planned injection event. Any changes to the proposed DPT injection locations and spacing will be documented in the Site field notes.

The substrate to be used for the proposed ERD injections at the Site includes a combination of biological and chemical amendments that include Anaerobic Biochem Plus® Olé (ABC®+Olé), which is a combination of Anaerobic Biochem® Olé (ABC®-Olé) and ZVI, magnesium oxide, guar, RTB-1 (biological amendment consisting of *Dehalococcoides (DHC)*, and sodium sulfite. A description of each of these amendments is presented in the following subsections.

2.2.2.1 ABC®+Olé

A combination organic carbon source/ZVI substrate known as ABC®+Olé will be used for the ERD pilot study. ABC®+Olé is a combination bioremediation/chemical reductant product developed and patented by Redox Tech. The use of ABC®+Olé will result in the creation of strong reducing conditions within the targeted shallow and intermediate groundwater zones, which ultimately will enhance the reductive dechlorination of Site-related CVOCs via two mechanisms. First, ABC®+Olé contains a readily available carbon food source to indigenous microorganisms, which consists of a mixture of fast-release soluble lactic acids (glycerine) and slow-release fatty acids (oleic acid) along with a dipotassium phosphate buffer. This combination of products serves to promote the ISB of the targeted CVOCs. Second, ABC®+Olé contains added ZVI, which does not rely on microbial degradation to treat the targeted CVOCs but rather utilizes ISCR. ISCR by ZVI works via an abiotic degradation pathway (β-elimination) that occurs on the surface of the granular ZVI, with the ZVI primarily acting as an electron donor.

The addition of ZVI to the ABC®+Olé mixture provides a number of advantages over traditional ERD applications without ZVI. The ZVI provides an immediate reduction in existing groundwater conditions. ZVI also raises the pH in the targeted groundwater, and the corrosion of the ZVI produces small quantities of hydrogen gas, which is an energy source for a wide range of anaerobic bacteria. Finally, the β-elimination pathway accounts for the majority of the degradation that occurs when the targeted CVOCs come into contact with the ZVI. This pathway avoids the production of cis-1,2-DCE and VC and the potential “stall out” or accumulation of these constituents that may occur during microbially-induced reductive dechlorination.

For the proposed ERD injection event, the ABC®+Olé mixture will consist of 50% by weight ABC®-Olé and 50% by weight ZVI. In particular, the 50% by weight ABC®-Olé will consist of long chain fermentable carbon (C14 to C18 fatty acids), which is comprised of a mixture of fatty acid methyl ester, soybean oil, and an emulsifier, approximately 5% by weight glycerine, and 0.1% by weight dipotassium phosphate as a micronutrient and buffer.

2.2.2.2 Magnesium Oxide

At the Site, the native pH of the targeted shallow and intermediate groundwater zones is generally between 4.5 and 6.5 standard units. As a result, magnesium oxide, which is transformed into magnesium hydroxide upon contact with water, will be injected along with the ABC®+Olé to more aggressively raise and sustain the pH within the immediate vicinity of the DPT injection locations. The quantity of magnesium oxide to be injected will be approximately 1% by weight of the injected solution.

2.2.2.3 Guar

Guar is used as a stabilizing, thickening, and suspending agent for injection substrates. In this case, the added guar will be utilized to achieve the hydraulic emplacement of the ABC®+Olé mixture at each ERD DPT injection location.

2.2.2.4 RTB-1

Bioaugmentation, by means of RTB-1, will be used to increase the effectiveness of the planned ABC®+Olé injection. Bioaugmentation is defined as the addition of high-performance microbial cultures capable of degrading targeted CVOCs. Bioaugmentation for the treatment of chlorinated ethenes entails the addition of a naturally occurring, non-pathogenic, microbial culture that contains *DHC*, which are capable of completely dechlorinating TCE and its daughter products to harmless ethene. Bioaugmentation is often used when there is incomplete dechlorination of TCE following biostimulation with an organic carbon source.

Not all *DHC*. in nature dechlorinate VC efficiently due to the lack of necessary enzymes. RTB-1 offers an enriched dechlorinating culture that includes lactate as a carbon source and uses TCE as an electron acceptor. As such, RTB-1 offers an enriched dechlorinating culture capable of efficiently degrading TCE, cis-1,2-DCE, and VC to innocuous ethene. The *DHC*. present in RTB-1 dechlorinate VC to ethene via halorespiration, and not via the less efficient cometabolic processes.

2.2.2.5 Sodium Sulfite

A small quantity of sodium sulfite will be used at each temporary ERD DPT injection location. The purpose of sodium sulfite addition is to precondition the targeted groundwater by deoxygenating it prior to the injection of the strictly anaerobic RTB-1 culture.

2.3 Pilot Study Implementation

Pilot study implementation activities are described in the following subsections.

2.3.1 Access Agreements

Appropriate access agreements will be executed as needed for properties affected by proposed pilot study activities prior to conducting any pilot study field work.

2.3.2 Injection Permitting

A Class V.A. SCDHEC underground injection control (UIC) permit to construct and operate, which will encompass the ISCO and ERD pilot study DPT injections to be conducted at the Site for aquifer remediation, will be obtained prior to conducting any on Site activities. A copy of the UIC permit application is included as **Attachment A**.

2.3.3 Utility Clearance

Underground utility clearance will be obtained prior to conducting any subsurface work associated with the pilot study (i.e., installation of temporary monitoring wells and installation of DPT injection points). Two utility surveys will be performed to identify all major above-grade and below-ground private and public utilities entering or crossing the Site; these surveys will be performed using the South Carolina One Call Service and a private utility locator. Subsurface utilities and other unknown anomalies within the ISCO and ERD pilot study areas will be located and marked with high visibility flagging and/or paint by the private utility locating service.

2.3.4 Temporary Observation Well Installation and Development

Three new temporary observation wells (ISCO-OBSW-1S, ERD-OBSW-1S, ERD-OBSW-1I) will be installed as part of pilot study activities. Based on the Site groundwater flow direction to the west-northwest for both the shallow and intermediate groundwater zones and a groundwater flow velocity of 18.25 ft/yr in the shallow zone and 10.95 ft/yr in the intermediate zone, ISCO-OBSW-1S will be installed approximately 15 to 20 feet northwest of TMW-31 and outside of the Main Building. ERD-OBSW-1S will be installed approximately 15 feet northwest of MW-10, and ERD-OBSW-1I will be installed approximately 10 feet northwest of MW-10I based on the slower groundwater flow velocity associated with intermediate zone groundwater. **Figures 2-1, 2-2, and 2-3** show the proposed locations of ISCO-OBSW-1S, ERD-OBSW-1S, and ERD-OBSW-1I, respectively.

All new temporary observation wells will be installed using rotosonic drilling techniques. ISCO-OBSW-1S will be installed to depth of approximately 21 ft bgs and will consist of 2-inch diameter Schedule 40 polyvinyl chloride (PVC) riser pipe attached to 10 ft of 0.010-inch circum-slotted Schedule 40 PVC well screen set from 11 to 21 ft bgs. ERD-OBSW-1S will be installed to depth of approximately 20 ft bgs and will consist of 2-inch diameter Schedule 40 PVC riser pipe attached to 10 ft of 0.010-inch circum-slotted Schedule 40 PVC well screen set from 10 to 20 ft bgs. ERD-OBSW-1I will be installed to depth of approximately 41 ft bgs and will consist of 2-inch diameter Schedule 40 PVC riser pipe attached to 10 ft of 0.010-inch circum-slotted Schedule 40 PVC well screen set from 31 to 41 ft bgs. Note that the final observation well locations and screen depths are subject to change based on the field conditions encountered at the time installation. Any changes will be documented in the Site field notes.

The screen for all new wells will be placed at the bottom of the boring, and a washed silica sand filter pack will be emplaced in the boring annulus around the outside of the screen from the bottom of the well to approximately 2 ft above the top of the well screen. The sand filter pack is used to stabilize the formation and to help yield a less turbid groundwater sample. A 2 ft thick (minimum) bentonite seal will be installed on top of the sand filter pack to seal the wells at the desired level. The well annulus will then be grouted to the existing ground surface with a cement/bentonite grout mixture. All wells will be flush mount and set in two-ft by two-ft by six-inch thick concrete pads. Soil cuttings generated during the well boring advancement and well construction will be contained in 55-gallon Department of Transportation (DOT)-approved drums as further described in **Section 2.3.10**. It is estimated that it will take two to three days to install the three new temporary observations wells. Typical monitoring well installation details for ISCO-OBSW-1S, ERD-OBSW-1S, and ERD-OBSW-1I are provided as **Figures 2-4, 2-5, and 2-6**, respectively.

In accordance with the requirements of Section H.1a (Monitoring Wells) of South Carolina Regulation R.61-71, the completed monitoring well permit applications for the three proposed temporary observation monitoring wells are provided in **Attachment B** of this PSWP.

Following installation, the temporary observation wells will be allowed to equilibrate and maintain a steady water level. The wells will subsequently be developed to remove gross sands and sediments generated during well installation activities and to allow the sand filter pack to settle and compact around the well screens. A submersible pump will be used to develop each of the newly installed wells. The submersible pump will be used to surge and purge the screened interval, removing gross sands and sediments that had accumulated in the well during installation. Development water from each well will be collected in 55 gallon DOT approved drums. Each drum will be transported to a staging area on the Valmont property, as determined by Valmont.

Water quality parameters including pH, specific conductance (SC), temperature, and turbidity will be monitored and recorded during the development process. Well development was considered complete when visible gross materials have been removed from the well and water quality parameters have stabilized to within 10%.

2.3.5 Baseline Groundwater Sampling Event

Upon completion of temporary observation well installation and development activities, a baseline groundwater sampling event will be conducted for both pilot study areas and prior to the planned DPT injection activities to provide current CVOC and biogeochemical data. This data will provide a baseline for subsequently monitoring the effectiveness of the pilot study injection events. Site monitoring well construction details are provided in **Table 2-1**.

Low-flow purging and sampling of eight monitoring wells (MW-2 as background well, TMW-29, TWM-31, ISCO-OBSW-1S, MW-10, ERD-OBSW-1S, MW-10I, ERD-OBSW-1I) will be conducted in accordance with applicable USEPA standard operating procedures using a peristaltic pump with Teflon®-lined polyethylene tubing. New tubing will be used at each monitoring well to eliminate the potential for cross-contamination between monitoring locations. Purge rates will range from 100 to 500 milliliters per minute to prevent excessive drawdown. Groundwater field indicator parameters will be measured and recorded during well sampling. The groundwater field indicator parameters include pH, specific conductivity, DO, ORP, temperature, and turbidity. The color of the collected groundwater sample will also be recorded. Active ISCO product RemOx®S is deep purple in color in groundwater. All water quality instrumentation will be calibrated prior to the baseline sampling event.

The baseline groundwater samples will be submitted to a State of South Carolina-certified analytical laboratory. Sample collection containers will be labeled with appropriate identifying information including sample location, sample identification, collection date and time, laboratory analyses to be performed, sampler's initials, and type of preservative. Samples will be placed on ice immediately after collection. Chain of custody forms and samples will be packed in coolers with ice. Custody seals will be affixed to the lid interface of each cooler to ensure that the samples have not been tampered with. Coolers will be shipped to the appropriate analytical laboratory.

The requested laboratory analysis for the ISCO pilot study and ERD pilot study are described in the following subsections.

2.3.5.1 ISCO Baseline Sampling Event Analytical Parameters

All ISCO pilot study baseline groundwater samples will be analyzed for VOCs utilizing USEPA Method SW-846 Method 8260B. Additionally, the groundwater samples will be analyzed for total dissolved solids via Method 2540C, and chloride by Method 9056A. **Table 2-2** provides the baseline ISCO groundwater monitoring program, and **Figure 2-1** shows the locations of the ISCO pilot study monitoring wells to be sampled.

2.3.5.2 ERD Baseline Sampling Event Analytical Parameters

All ERD pilot study baseline groundwater samples will be analyzed for VOCs utilizing USEPA Method SW-846 Method 8260B. Additionally, biogeochemical parameters will be collected for all ERD groundwater samples and include nitrate, nitrite, sulfate, and chloride by SW 9056A, dissolved (laboratory filtered) and total iron by SW 6020A, methane/ethane/ethene by RSK-175, alkalinity by SM 2320B, and total organic carbon by SW 9060A. The collected ERD groundwater samples will also be analyzed for *Dehalobacter spp (DHB)*, *DHC* and specific enzymes (functional genes) responsible for reductive dechlorination of CVOCs using Census® analysis. Census® analysis uses a molecular biological tool called quantitative polymerase chain reaction for enumeration of specific microorganisms and/or genes encoding specific biological functions. *DHB* can degrade TCE to cis-1,2-DCE, whereas *DHC* can perform complete degradation (i.e., TCE to ethene). **Table 2-2** summarizes the baseline ERD groundwater monitoring program, and **Figures 2-2 and 2-3** show the locations of the ERD pilot study monitoring wells to be sampled for shallow and intermediate zone groundwater, respectively.

2.3.6 Pilot Study Injection Event

The following subsections describe specific injection event details for the ISCO and ERD pilot study.

2.3.6.1 ISCO Injection Details

Redox Tech will be subcontracted to conduct the injection of RemOx®S via DPT with oversight provided by AECOM. As recommended by Redox Tech and verified by AECOM, a total of approximately 830 pounds of RemOx®S will be mixed with 2,250 gallons of water to create an approximate 4% by weight RemOx®S solution that will subsequently be injected into three temporary DPT points to treat shallow zone groundwater in the vicinity of TMW-31. The targeted treatment area encompasses approximately 550 square feet and assumes an 8-ft ROI for each DPT injection point. At each of the three temporary DPT injection locations, approximately 277 pounds of RemOx®S will be mixed with 750 gallons of water and subsequently injected using a chemical grout pump. Each DPT injection will be conducted over a 10-ft vertical interval from approximately 11 to 21 ft bgs. The RemOx®S solution will be injected in 2.5-ft intervals, which equates to 5 vertical intervals per DPT injection point location and 15 injection intervals overall.

The RemOx®S will be shipped to the site immediately prior to the ISCO injection event. To prepare the RemOx®S mixture, water will be obtained from the closest fire hydrant to the ISCO pilot study location after installation of a backflow preventer and water meter. The water will be contained in a mobile trailer-mounted holding tank or similar apparatus and subsequently transported from the fire hydrant location to the location of the proposed ISCO DPT injections.

The RemOx®S will be delivered to the site as a solid in 50-pound buckets. Prior to injection, the appropriate amount of RemOx®S will be added to the water holding tank. A stainless-steel paddle mixer will then be used to thoroughly mix the water and RemOx®S within the holding tank. Once the solution is fully mixed, a chemical grout pump will be used to inject the required quantity of ISCO solution through the DPT rods. Injection will be conducted in a bottom-to-top approach at each location.

A Geoprobe® series 6610 rig will be used to drive the DPT rods to the anticipated deepest injection interval (21 ft bgs). Injection will occur in two foot "lifts" starting at the bottom of the desired treatment interval. This process will continue until all five intervals at the particular ISCO DPT injection location (total of 750 gallons of RemOx®S solution per injection location) have been delivered into the subsurface. The targeted intervals for each DPT injection location are 21 feet bgs, 18.5 feet bgs, 16 feet bgs, 13.5 feet bgs, and 11 feet bgs.

The same mixing and injection process will be repeated for each of the three temporary DPT injection points. The average injection pressure for each interval will be approximately 100 pounds per square inch gauge (psig) with a maximum anticipated injection pressure of 125 psig. In the event of daylighting of the injected solution, injection will be stopped until the daylighting has been controlled. Any injection material that pools at the ground surface will be vacuumed, strained, and reinjected. All DPT injection points will be abandoned using a Portland cement or Portland cement/bentonite grout. The concrete will be patched to match the pre-existing surface as appropriate.

It is anticipated that it will take two working days to complete the ISCO injections. ISCO pilot study injection design details and total amendment quantities to be injected are summarized in **Table 2-3. Figure 2-1** shows the ISCO pilot study area and the associated DPT injection locations.

2.3.6.2 ERD Injection Details – Initial Event

Redox Tech will also be subcontracted to conduct the injection of ABC®+Olé for the ERD injection portion of the pilot study with oversight provided by AECOM. Five temporary shallow zone and five temporary intermediate zone groundwater DPT injection points will be used to inject the ABC®+Olé solution in a barrier-type formation upgradient of monitoring wells MW-10 and MW-10I. In total,10,000 pounds of ABC®+Olé in 5,000 gallons of water will be injected.

The ERD injectate chemicals will be shipped to the site immediately prior to the injection event. At each of the ten targeted DPT locations, an approximate 19% by weight solution of ABC®+Olé will be used. A 19% by weight solution equates to approximately 1,000 pounds of ABC®+Olé mixed with 500 gallons of water per DPT injection location. Each injection will be performed over a 10-ft vertical interval from approximately 20 ft bgs to 30 ft bgs for the targeted shallow zone groundwater and from approximately 31 ft bgs to 41 ft bgs for the targeted intermediate zone groundwater.

The 19% by weight solution is also equivalent to approximately 100 pounds of ABC®+Olé per vertical foot or 50 gallons of ABC®+Olé solution per vertical foot at each DPT injection location. In addition, approximately 50 pounds of magnesium oxide will be added per DPT injection location for pH buffering, and approximately 10 pounds of guar will be used to achieve hydraulic emplacement of the ABC®+Olé mixture at each injection point.

In preparation for injection, the stock ingredients for ABC®+Olé will need to be mixed together. Water will be obtained from the closest fire hydrant to the ERD pilot study location after installation of a backflow preventer and water meter. The water will be pumped into a mobile, trailer mounted 500-gallon polyethylene holding tank and then transported from the fire hydrant location to the site of the ERD DPT injections. ABC®-Olé, which will be delivered to the Site as a concentrated liquid in plastic totes, will be staged near the DPT injection locations and gravity drained into the holding tank containing the water. A stainless-steel paddle mixer will then be used to thoroughly mix the water and ABC®-Olé within the holding tank.

Following thorough mixing, 100 gallons of the ABC®-Olé stock mixture will be pumped using a double diaphragm pump from the 500-gallon polyethylene holding tank into two 75-gallon feed hoppers located on an open trailer that will also be staged next to the ERD injection locations. Each feed hopper will then contain 50-gallons of ABC®-Olé solution. ZVI, which comes in 50-pound buckets, will be staged next to the feed hopper trailer. One bucket of ZVI, five pounds of magnesium oxide, and one pound of guar will be added to each 75-gallon feed hopper. These materials will then be thoroughly mixed with the ABC®-Olé stock solution using shear mixing arms located in each of the 75-gallon feed hoppers, thereby creating the ABC®+Olé solution to be injected. Once the solution is fully mixed and suspended, a chemical grout pump will be used to inject all 100 gallons of the ABC®+Olé slurry through DPT rods set to the appropriate interval within the subsurface. Injection will be conducted in a bottom-to-top approach.

A Geoprobe® Model 7822 track rig or similar will be used to drive the DPT rods to the specified injection interval. Injection will occur in two foot “lifts” starting at the bottom of the desired treatment interval. The DPT rods will subsequently be pulled upwards to each successive interval until all five intervals at the ERD DPT injection location are completed (total of 500 gallons of ABC®+Olé solution per injection location). The intervals for each DPT injection location that targets shallow zone groundwater treatment in the vicinity of MW-10 are 20 feet bgs, 17.5 feet bgs, 15 feet bgs, 12.5 feet bgs, and 10 feet bgs. The intervals for each DPT injection location that targets intermediate zone groundwater in the vicinity of MW-10I are 41 feet bgs, 38.5 feet bgs, 36 feet bgs, 33.5 feet bgs, and 31 feet bgs.

The same mixing and injection process will be repeated for each of the ten temporary ERD DPT injection points. The average injection pressure for each interval will be approximately 50 psig with a maximum anticipated injection pressure of approximately 100 psig. In the event of daylighting of the injected material, injection will be stopped until the daylighting has been controlled. Any injection material that pools at the ground surface will be vacuumed, strained, and reinjected. All DPT injection points will be abandoned using a Portland cement or Portland cement/bentonite grout.

It will take an estimated four working days to complete the initial ERD injection event. Initial ERD pilot study injection design details and total amendment quantities to be injected are summarized in **Table 2-4. Figures 2-2 and 2-3** show the ERD pilot study area and the associated DPT injection locations for shallow zone and intermediate zone groundwater, respectively.

2.3.6.3 ERD Injection Details - Bioaugmentation Event

Based on the results of the BSTS described in **Section 1.4** of this PSWP, bioaugmentation will be conducted approximately 45 days after the initial ABC®+Olé injection event. This should allow enough time for the targeted

shallow and intermediate zone groundwater near MW-10 and MW-10I to become sufficiently conditioned (i.e., achieve low DO and ORP and neutral pH) for the injection of the RTB-1 microbial culture to promote ISB. To assist with the bioaugmentation process, additional carbon source in the form of ABC®-Olé and pH buffer in the form of magnesium oxide with be injected concurrently with the RTB-1.

For the bioaugmentation event, water again will be obtained from the closest fire hydrant to the ERD pilot study area. The water will be filled into a mobile, trailer mounted 500-gallon polyethylene holding tank and then transported from the fire hydrant location to the site of the previous ABC®+Olé DPT injections. ABC®-Olé, which will be delivered to the Site as a concentrated liquid in a plastic tote, will be staged near the bioaugmentation DPT injection locations and gravity drained into the holding tank containing the water. The ratio of the mixture will be 100 pounds of ABC®-Olé in 100 gallons of water. A stainless-steel paddle mixer will be used to thoroughly mix the water and ABC®-Olé within the holding tank. A total of 50 pounds of magnesium oxide will be added to the holding tank. Finally, 0.2 pounds of sodium sulfite will be added to the mixture to drive the ABC®-Olé solution anaerobic. Note that ZVI will not be added to the mixture for the bioaugmentation injection event.

Once the solution is fully mixed, a chemical grout pump will be used to inject a total of 20 gallons of the ABC®-Olé solution through DPT rods set to the appropriate interval within the subsurface. Halfway through injection at each interval, 0.4 liters of RTB-1 will be “slipstreamed” into the DPT rod to promote bioaugmentation. Subsequently, the remaining ABC®-Olé solution will be injected within the same interval.

A Geoprobe® Model 7822 track rig or similar will be used to drive the DPT rods to the specified injection interval. Injection will occur in two foot “lifts” starting at the bottom of the desired treatment interval. The DPT rods will subsequently be pulled upwards to each successive interval until all five intervals at the DPT injection location are completed (total of 100 gallons of bioaugmentation solution per DPT injection location). The intervals for each DPT injection location that target the shallow zone groundwater in the vicinity of MW-10 are 20 feet bgs, 17.5 feet bgs, 15 feet bgs, 12.5 feet bgs, and 10 feet bgs. The intervals for each DPT injection location that target the intermediate zone groundwater in the vicinity of MW-10I are 41 feet bgs, 38.5 feet bgs, 36 feet bgs, 33.5 feet bgs, and 31 feet bgs.

The same mixing and injection process will be repeated for each of the ten temporary bioaugmentation DPT injection points. In the event of daylighting of the injected material, injection will be stopped until the daylighting has been controlled. Any injection material that pools at ground surface will be vacuumed, strained, and reinjected. All DPT injection points will be abandoned using a Portland cement or Portland cement/bentonite grout.

It is anticipated that it will take two days to complete the ERD bioaugmentation event. **Table 2-5** provides a summary of the quantity of substrate materials to be injected during the bioaugmentation event.

2.3.7 Post-Injection Performance Monitoring Program

Post-injection performance monitoring will be conducted on a quarterly basis for one year to evaluate the effectiveness of the pilot study. The first performance monitoring event will be conducted approximately 30 days after completion of the ISCO and ERD injection event. The primary purpose of this event will be to verify that groundwater has been sufficiently conditioned (i.e., achieved low DO and ORP and neutral pH) in the ERD pilot study area prior to the planned injection of RTB-1. Subsequent performance monitoring events will used to track

changes in groundwater quality following injection, to assess the effectiveness of the ISCO and ERD injection events, and to evaluate progress towards reducing the TCE concentrations in groundwater within the pilot study areas. **Table 2-2** summarizes the post-injection performance monitoring program.

2.3.8 Health and Safety

Pilot study activities will be conducted in accordance with the current Site-specific Health and Safety Plan. At a minimum, all field personnel will be required to be 40-hour HAZWOPER-trained and wear the following protective equipment:

- Hard-hats (when working near the DPT rig);
- Steel-toed safety boots;
- Safety glasses;
- Latex gloves (as necessary); and
- Hearing protection (e.g., ear plugs when necessary).

Additional protective equipment including appropriate splash protection for those directly involved with the injection of RemOx®S and ABC®+Olé will be described in the injection subcontractor Health and Safety Plan.

2.3.9 Equipment Decontamination

All equipment used during field activities will arrive clean and decontaminated. Equipment decontamination activities will be conducted on field equipment that contacts site media to prevent cross-contamination. Pressure washing and/or steam cleaning activities will be conducted on non-sampling equipment (e.g., drill rods, DPT rods) using a portable pressure/steam washer. Non-sampling equipment will be placed within a temporary secondary containment and pressure/steam washed to remove residual soil from the equipment surfaces.

All groundwater sampling equipment that is used for more than one monitoring well will be cleaned between use at each well using the following procedure: Wash with non-phosphate laboratory soap solution; rinse with tap water; rinse with deionized or organic-free water; and use item immediately or wrap in plastic bag or aluminum foil for storage.

2.3.10 IDW Management

Investigation-Derived Waste (IDW) management will consist of soil cuttings, well development water, and decontamination water as well as purge water generated during monitoring well sampling events. IDW will be containerized in 55-gallon DOT-approved drums. The drums will be labeled to indicate the type of material contained, site location, investigation point of origin, and date on which materials were initially placed into the drum. Any drums used will be secured at the end of each day in an area identified by facility personnel. Grab samples will be collected from the drums and analyzed for waste characterization parameters. Soil and aqueous IDW will be analyzed for VOCs by USEPA SW-846, Method 8260B. The drums will be staged at the facility pending characterization, profiling, manifesting, and off-Site disposal. Other non-hazardous IDW (e.g., personal protective equipment, paper towels, trash, etc.) will be bagged and transported off-Site for disposal as municipal waste.

2.3.11 Pilot Study Summary Report

After the receipt of the last post-injection performance monitoring event analytical results, a Pilot Study Summary Report will be prepared and submitted to SCDHEC. This summary report will include a description of temporary observation well installation and development, pilot study injection event activities, baseline and post-injection

performance monitoring activities and associated analytical results, and a summary of conclusions and recommendations.

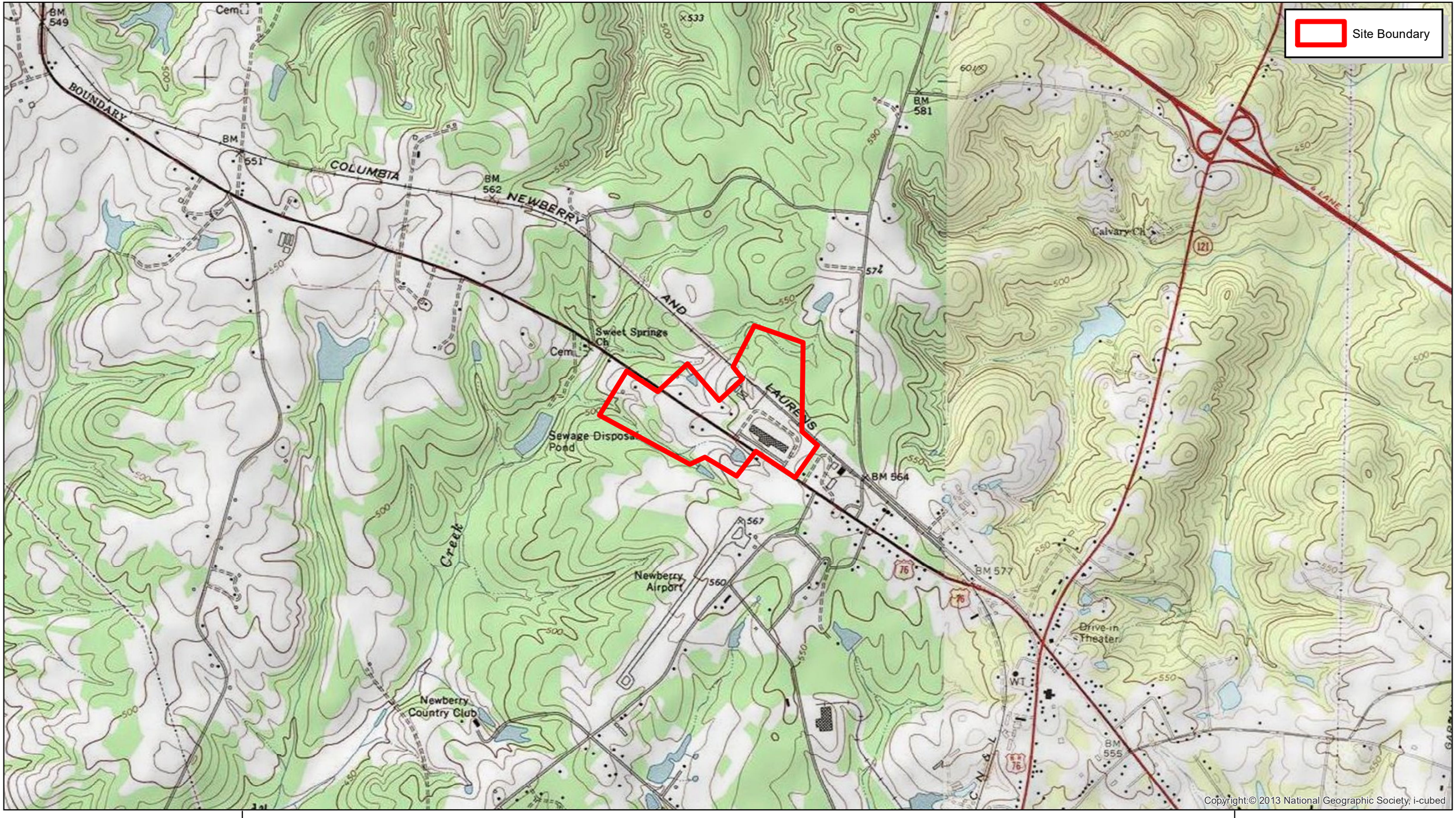
Section 3. References

AECOM, 2018. Remedial Investigation Report, Shakespeare Composite Structures, Newberry, South Carolina. November 2018.

AECOM, 2019. Feasibility Study Work Plan, Shakespeare Composite Structures, Newberry, South Carolina. May 2019

AECOM, 2020. Bench Scale Treatability Study Report, Shakespeare Composite Structures, Newberry, South Carolina. May 2020.

FIGURES



AECOM

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Figure 1-1: Site Location Map

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 9/10/20

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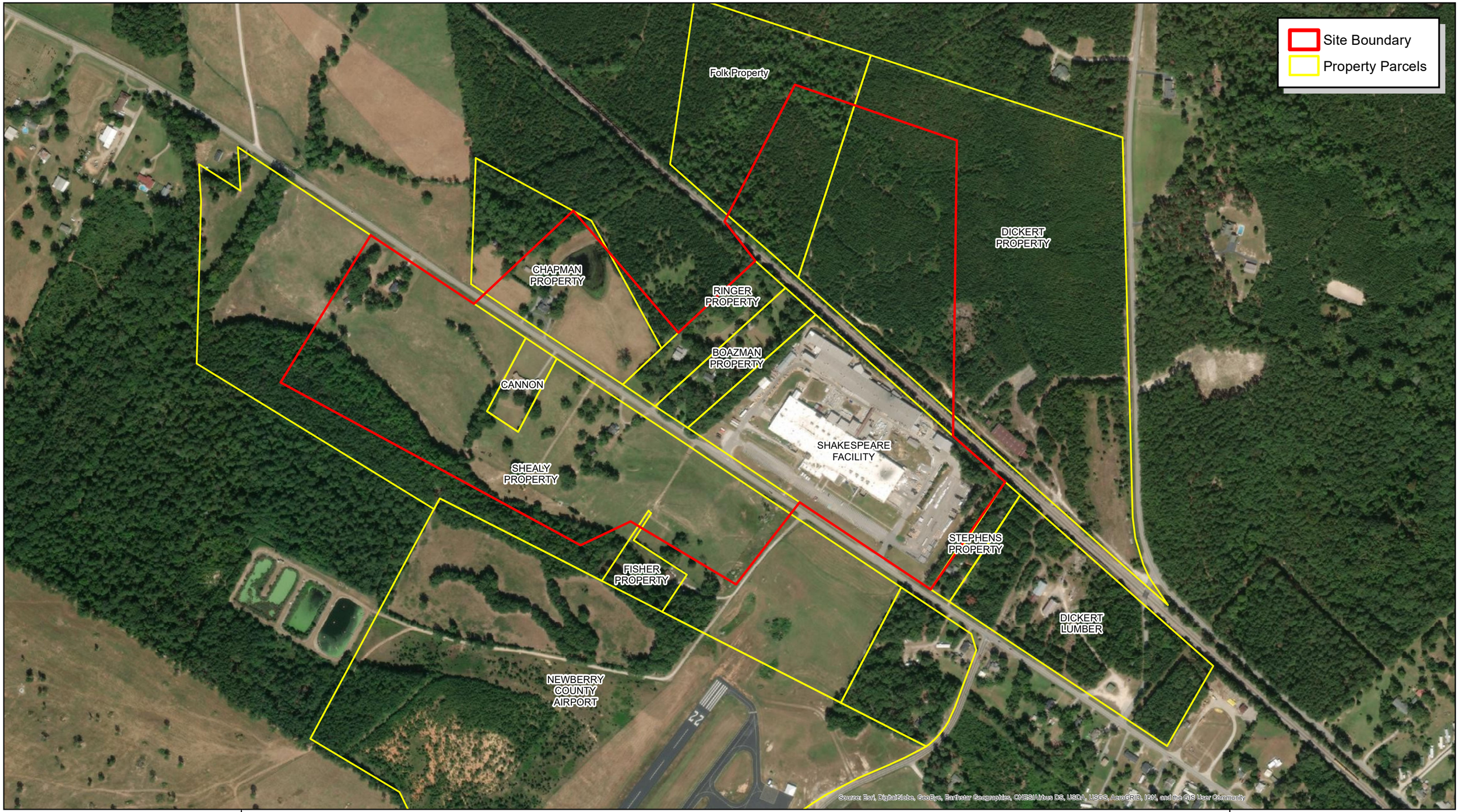

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Figure 1-2: Site Plan

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/10/20

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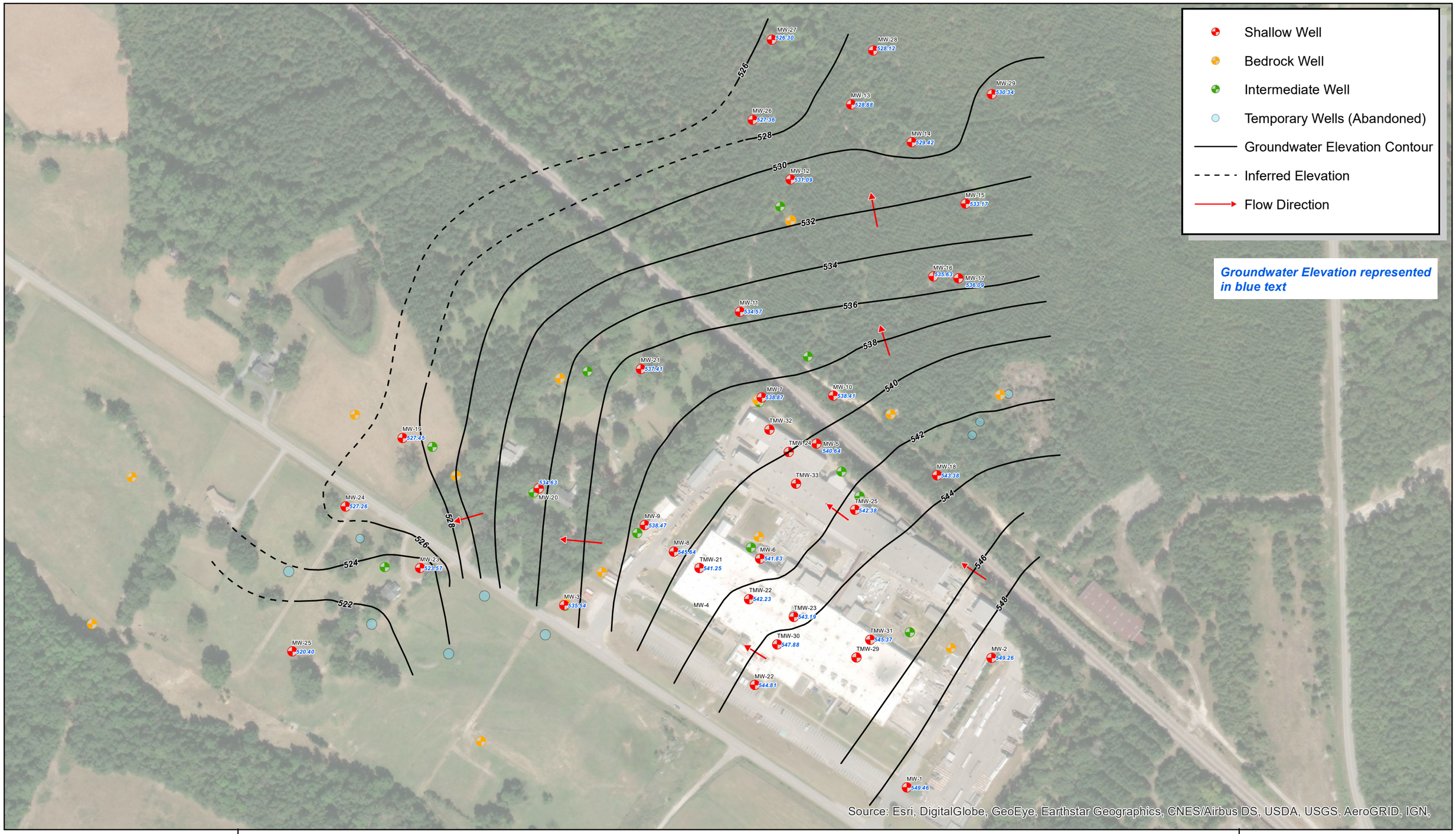

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Figure 1-3: Shallow Zone Groundwater Elevation Map - June 2018

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Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/10/20.

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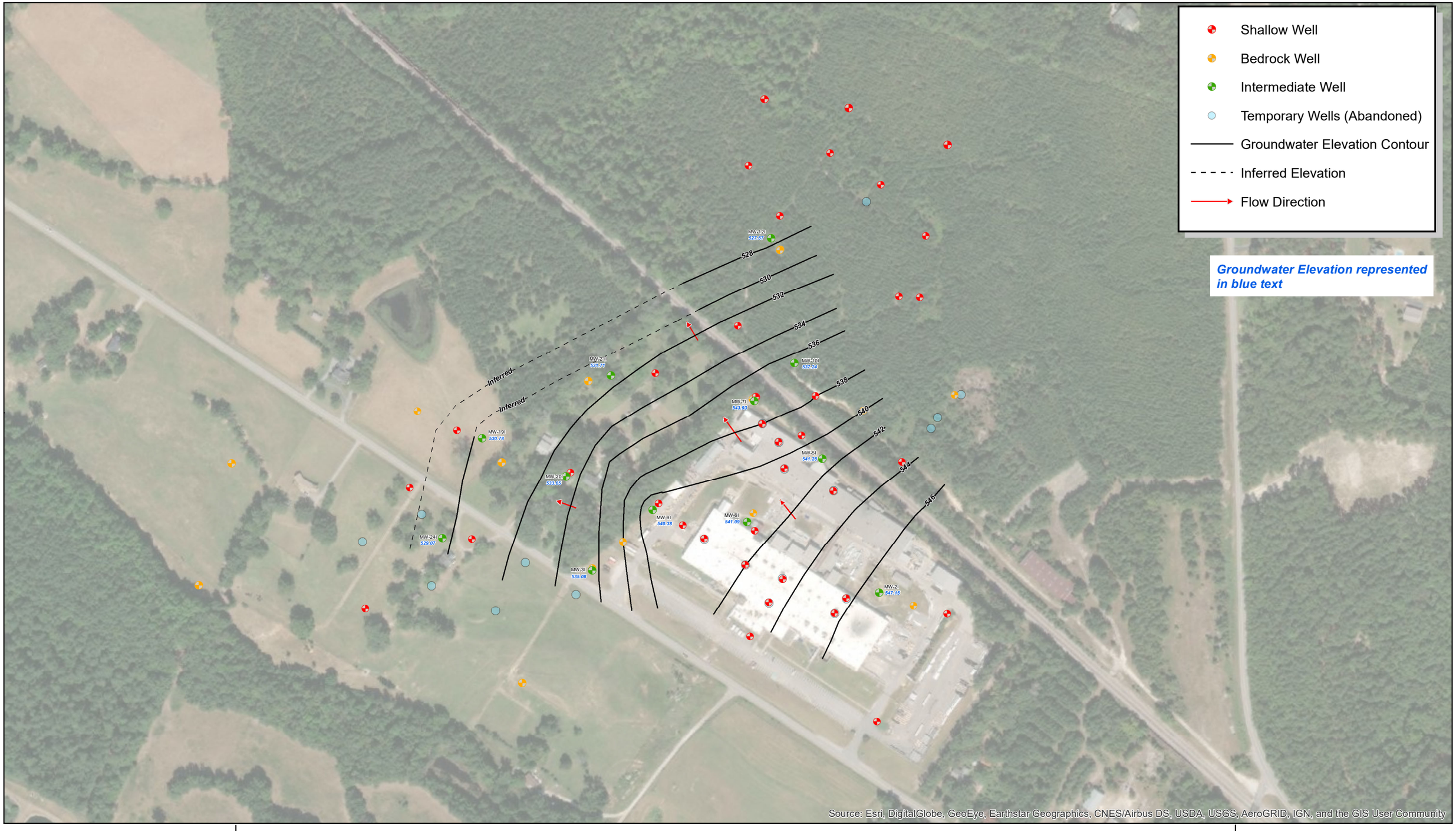

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Figure 1-4: Intermediate Zone Groundwater Elevation Map - June 2018

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Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/10/20

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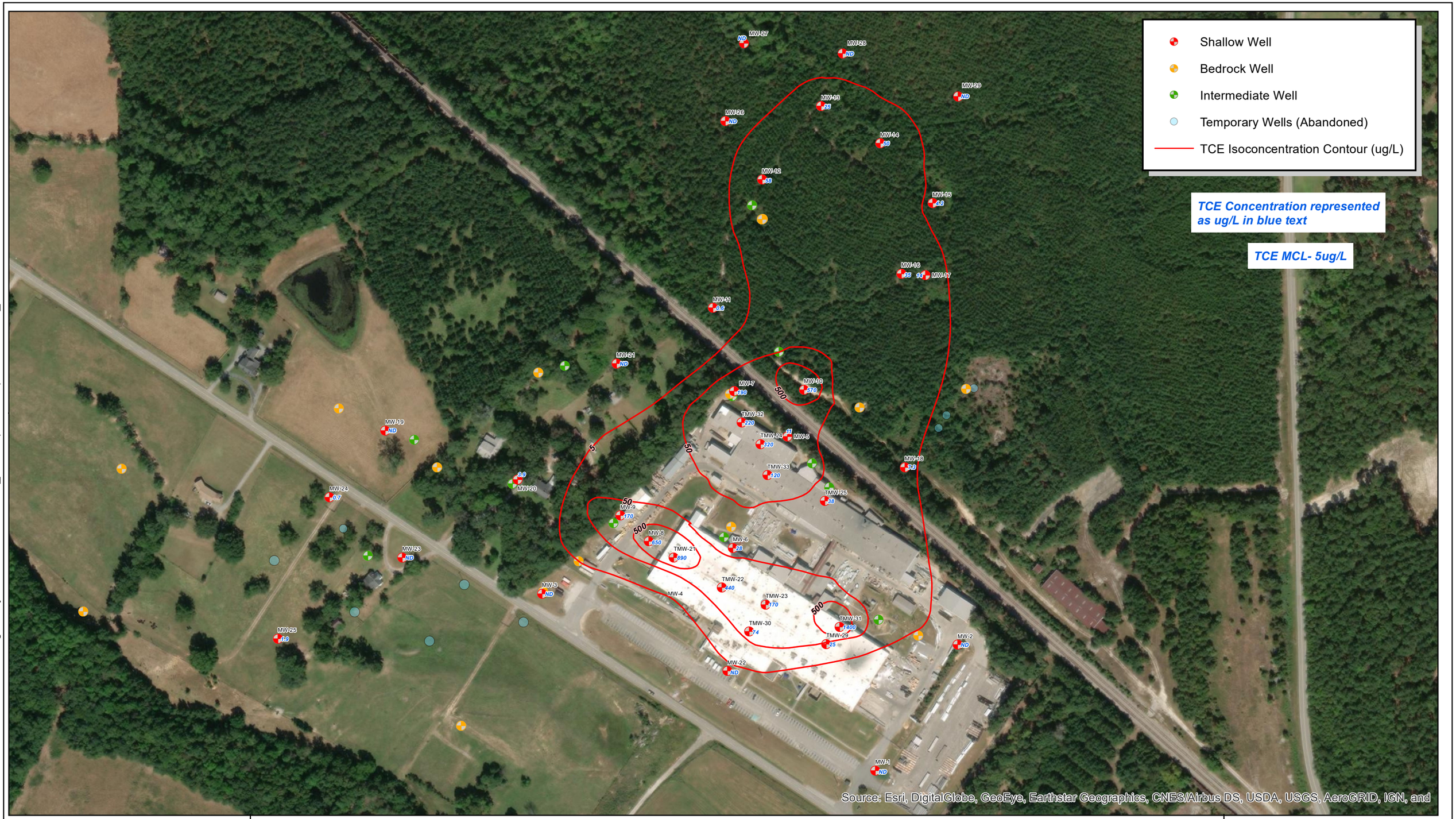

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Figure 1-5: TCE Concentration in Shallow Zone - June 2017

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/10/20

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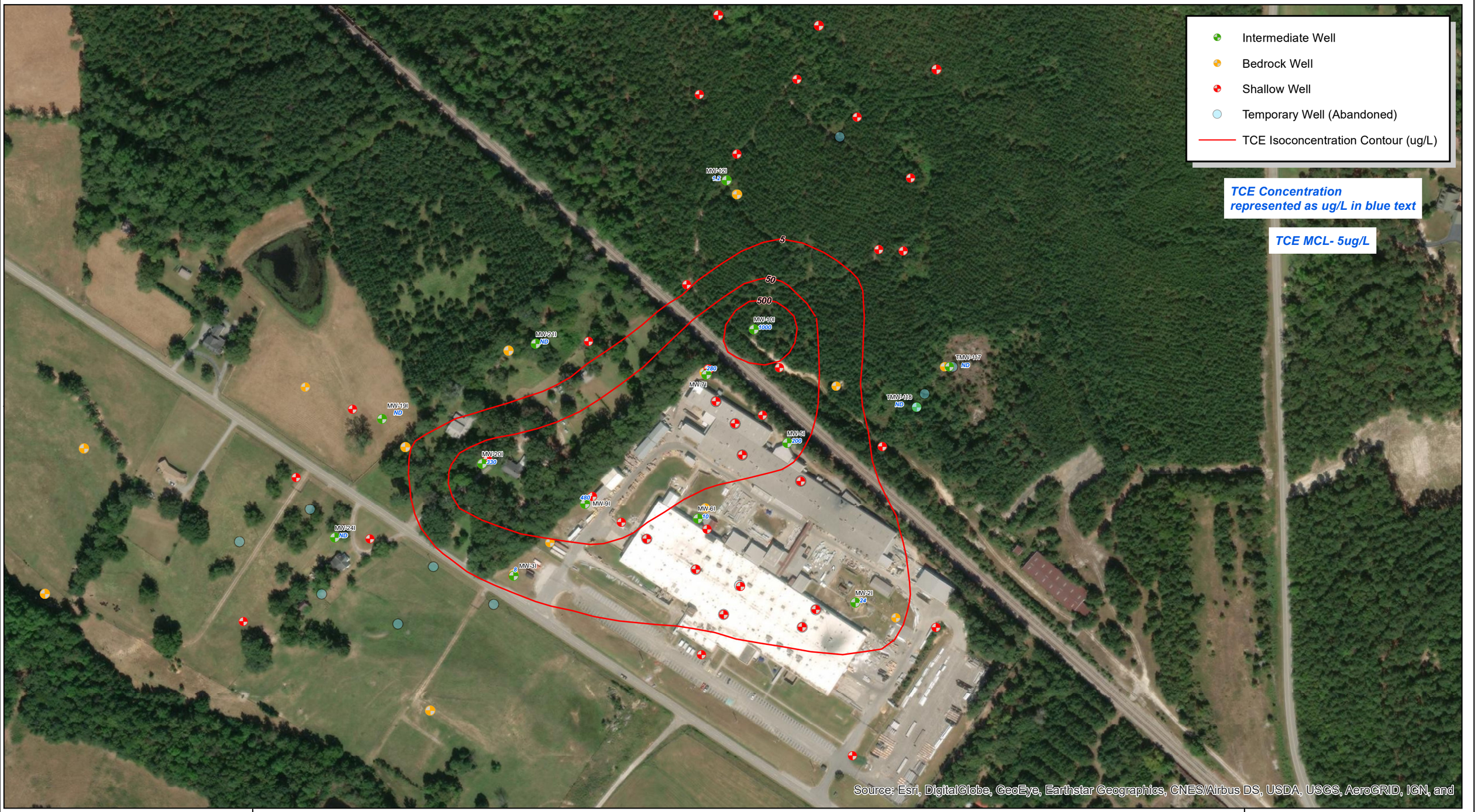

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Figure 1-6: TCE Concentration in Intermediate Zone - June 2017

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/11/20.

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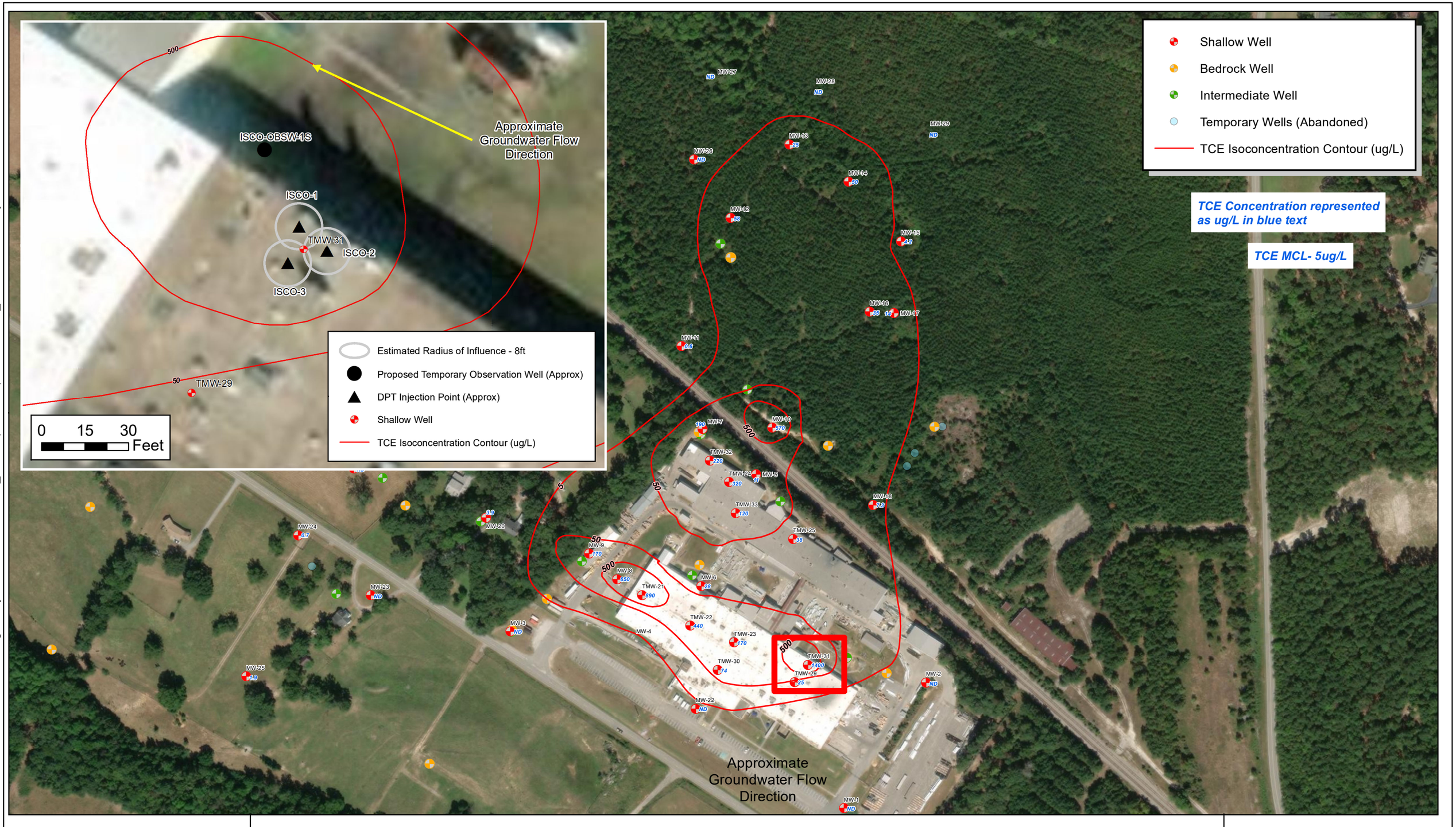

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Figure 2-1: ISCO Pilot Study Area - Shallow Zone

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/11/20.

Notes:
ISCO - In Situ Chemical Oxidation

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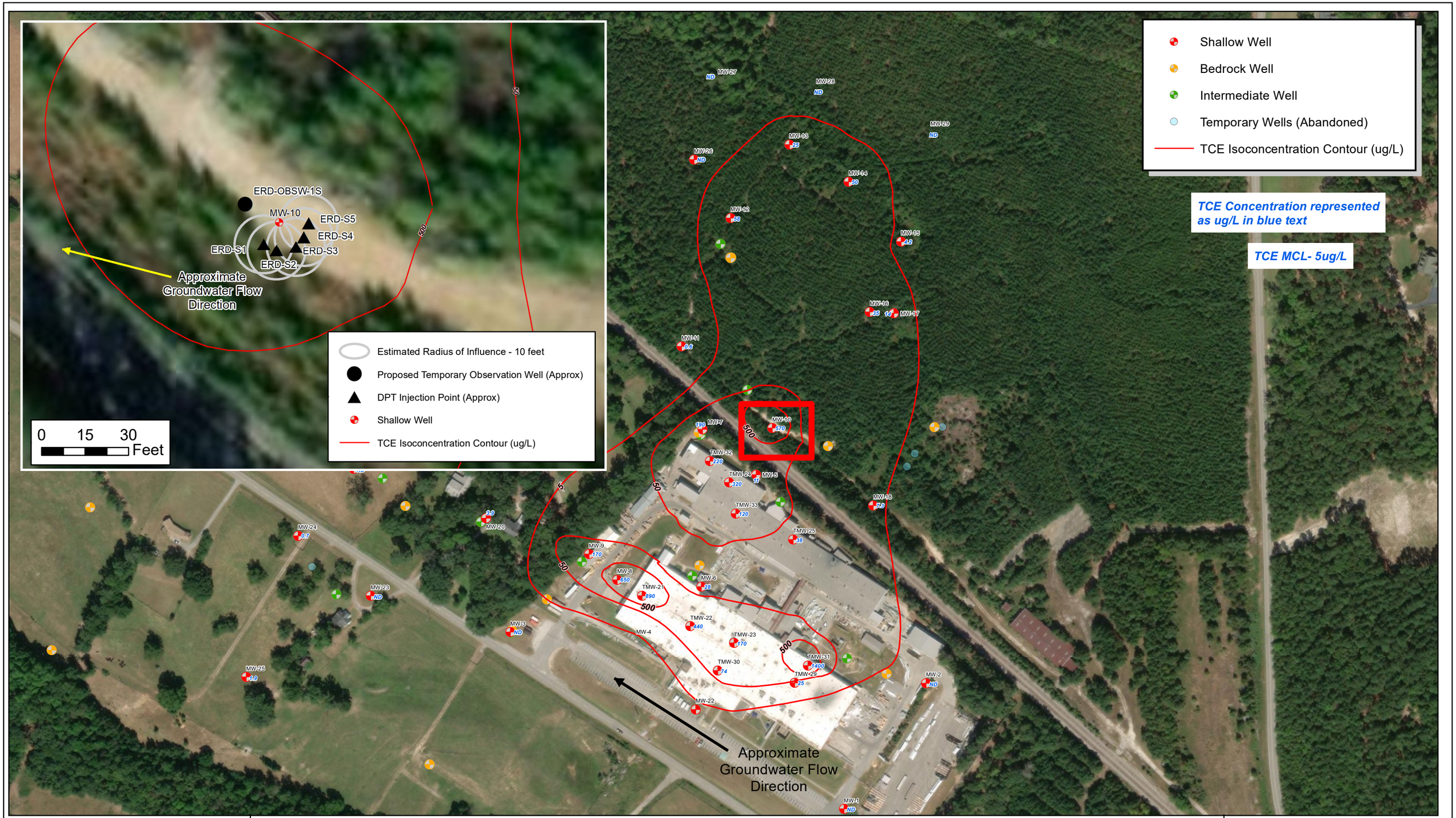

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Figure 2-2: Enhanced Reductive Dechlorination (ISB and ISCR) Pilot Study Area - Shallow Zone

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/11/20.

Note:
ISB - In Situ BioRemediation
ISCR - In Situ Chemical Remediation

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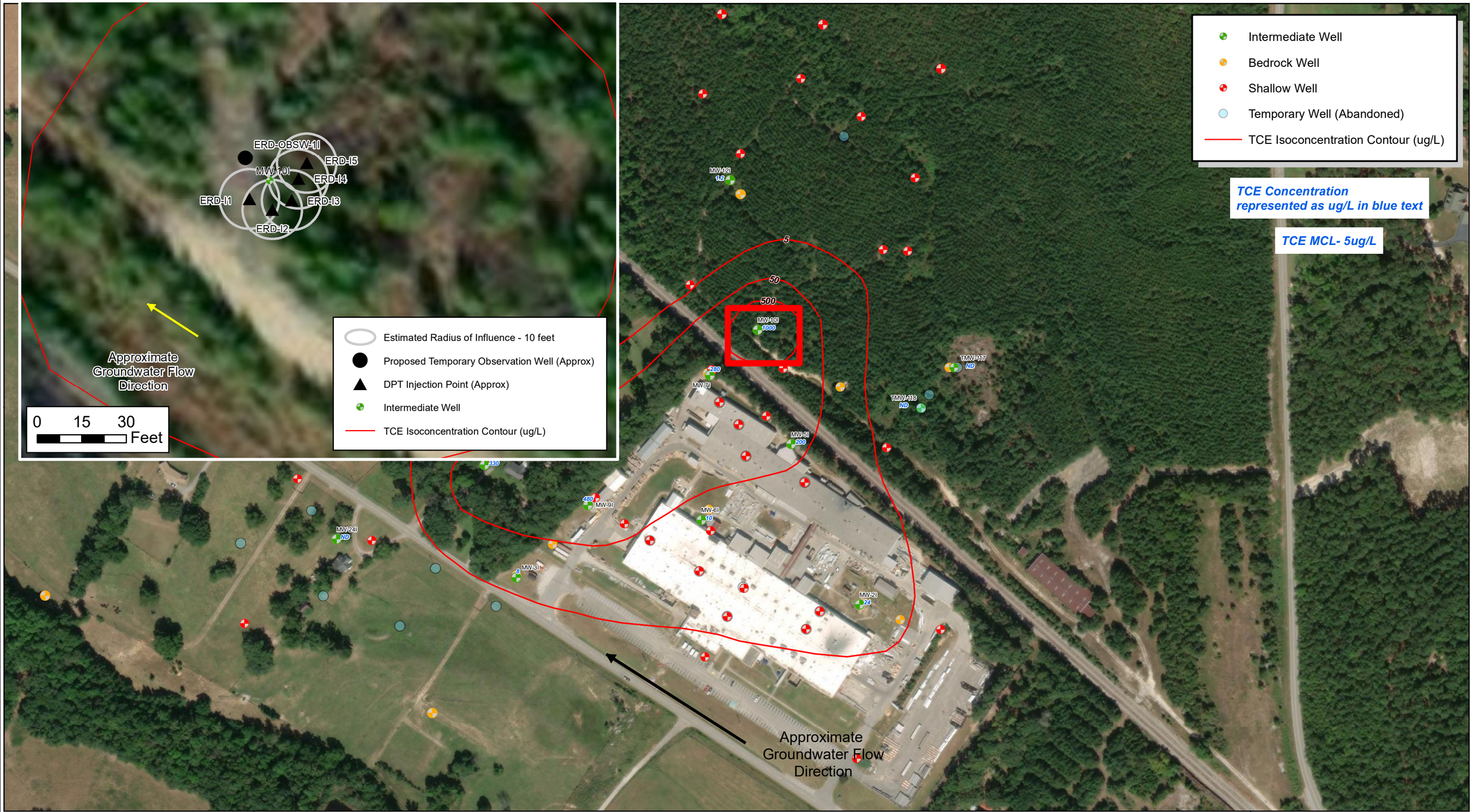

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Figure 2-3: Enhanced Reductive Dechlorination Pilot Study Area (ISB and ISCR) - Intermediate Zone

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/12/20.

Notes:
ISB - In Situ BioRemediation
ISCR - In Situ Chemical Reduction

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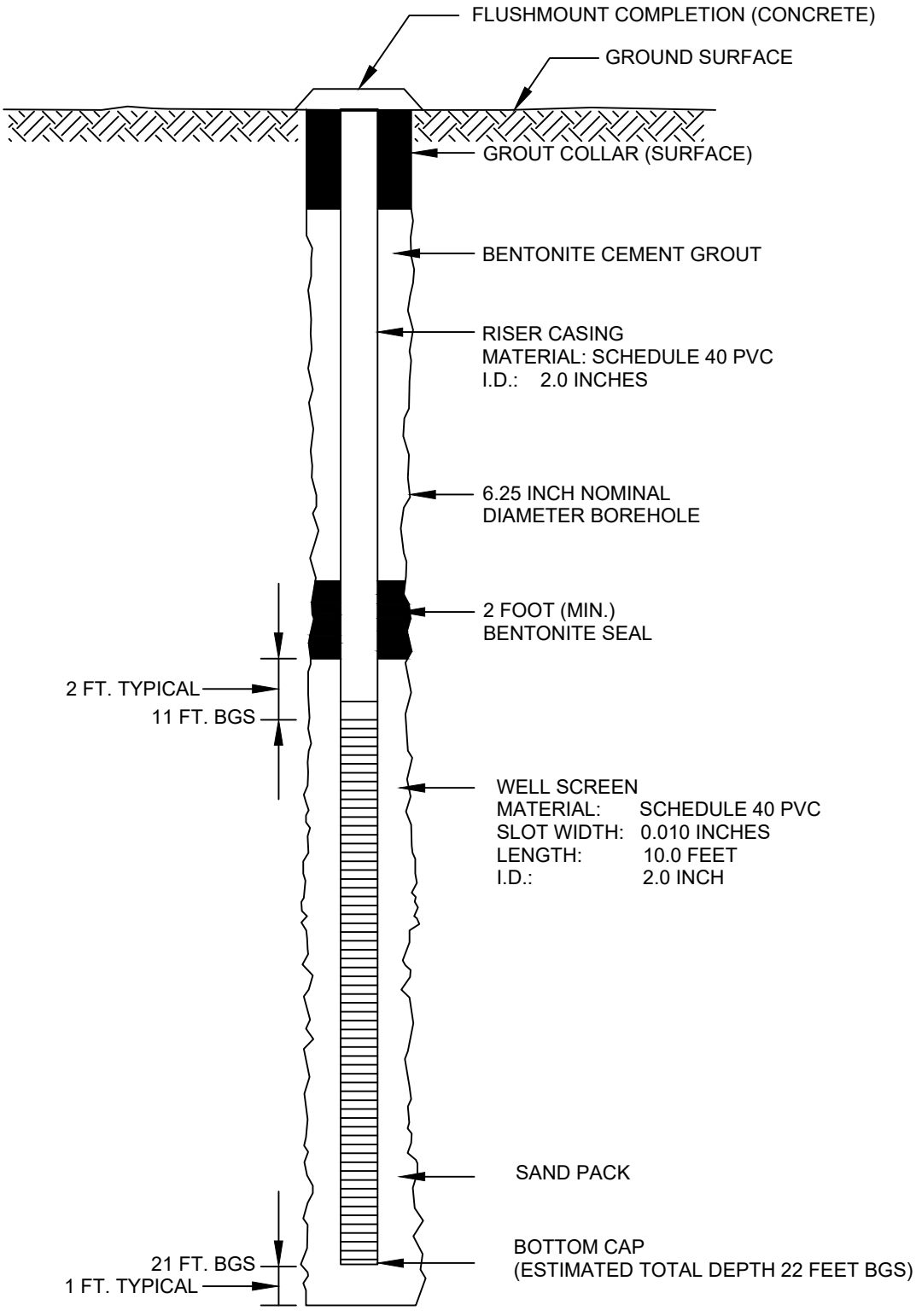

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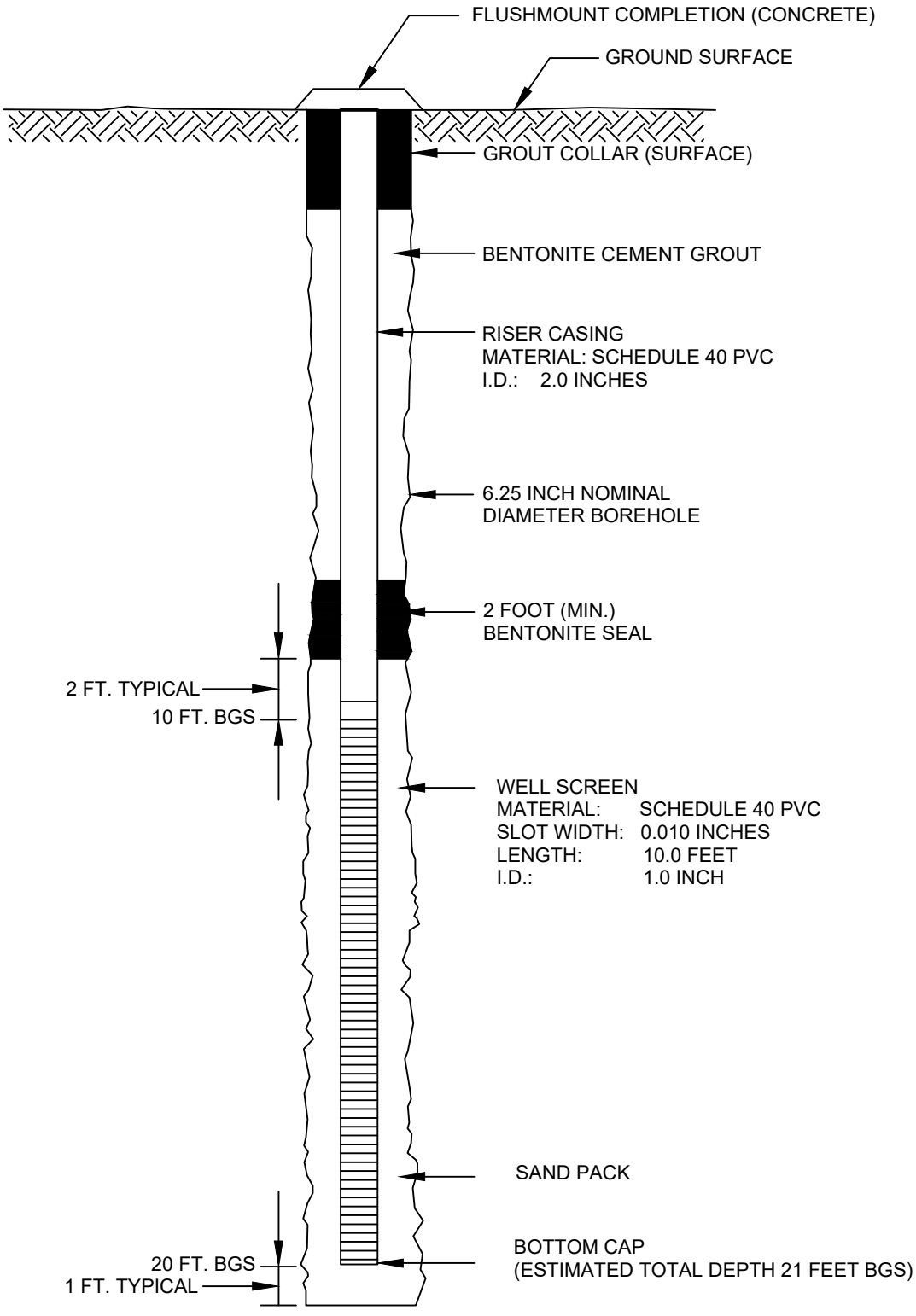
TYPICAL TEMPORARY OBSERVATION WELL CONSTRUCTION DETAIL
ISCO PILOT STUDY - SHALLOW ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
NEWBERRY, SOUTH CAROLINA

PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 2-4**



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TYPICAL TEMPORARY OBSERVATION WELL CONSTRUCTION DETAIL
ERD PILOT STUDY - SHALLOW ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
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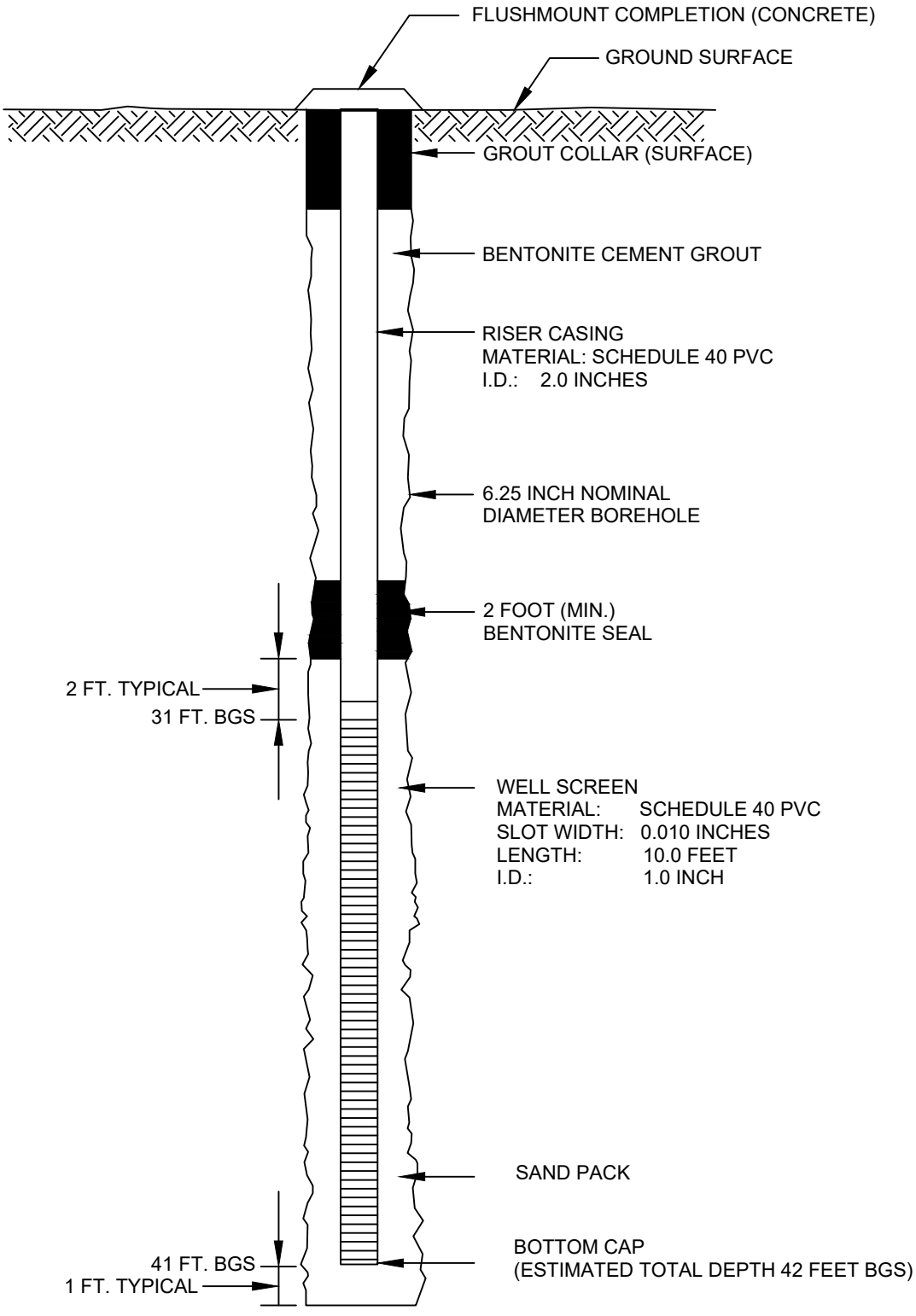
PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 2-5**



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TYPICAL TEMPORARY OBSERVATION WELL CONSTRUCTION DETAIL
ERD PILOT STUDY - INTERMEDIATE ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
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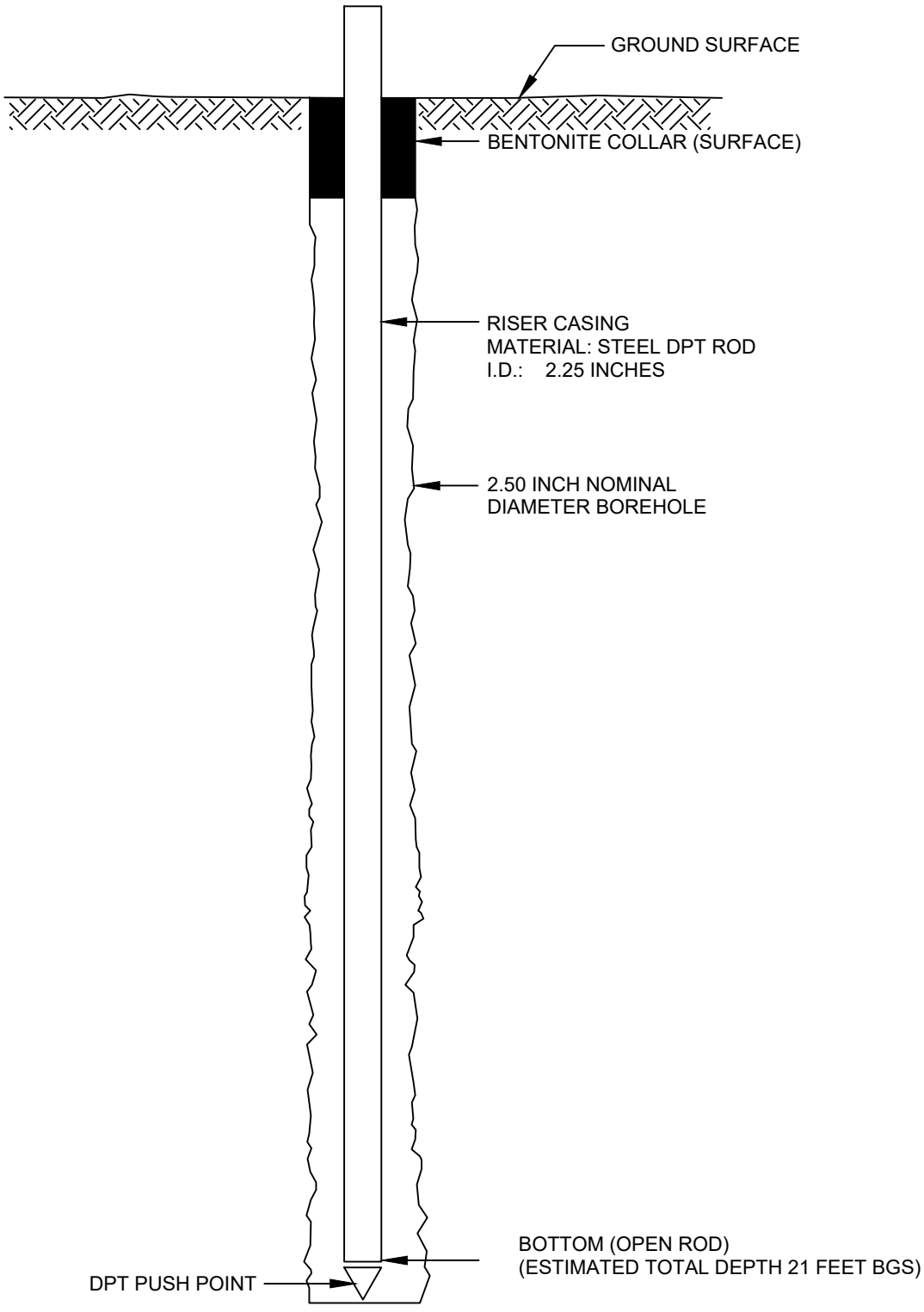
PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 2-6**



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TYPICAL DPT INJECTION POINT DETAIL
ISCO PILOT STUDY - SHALLOW ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
NEWBERRY, SOUTH CAROLINA

PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 2-7**

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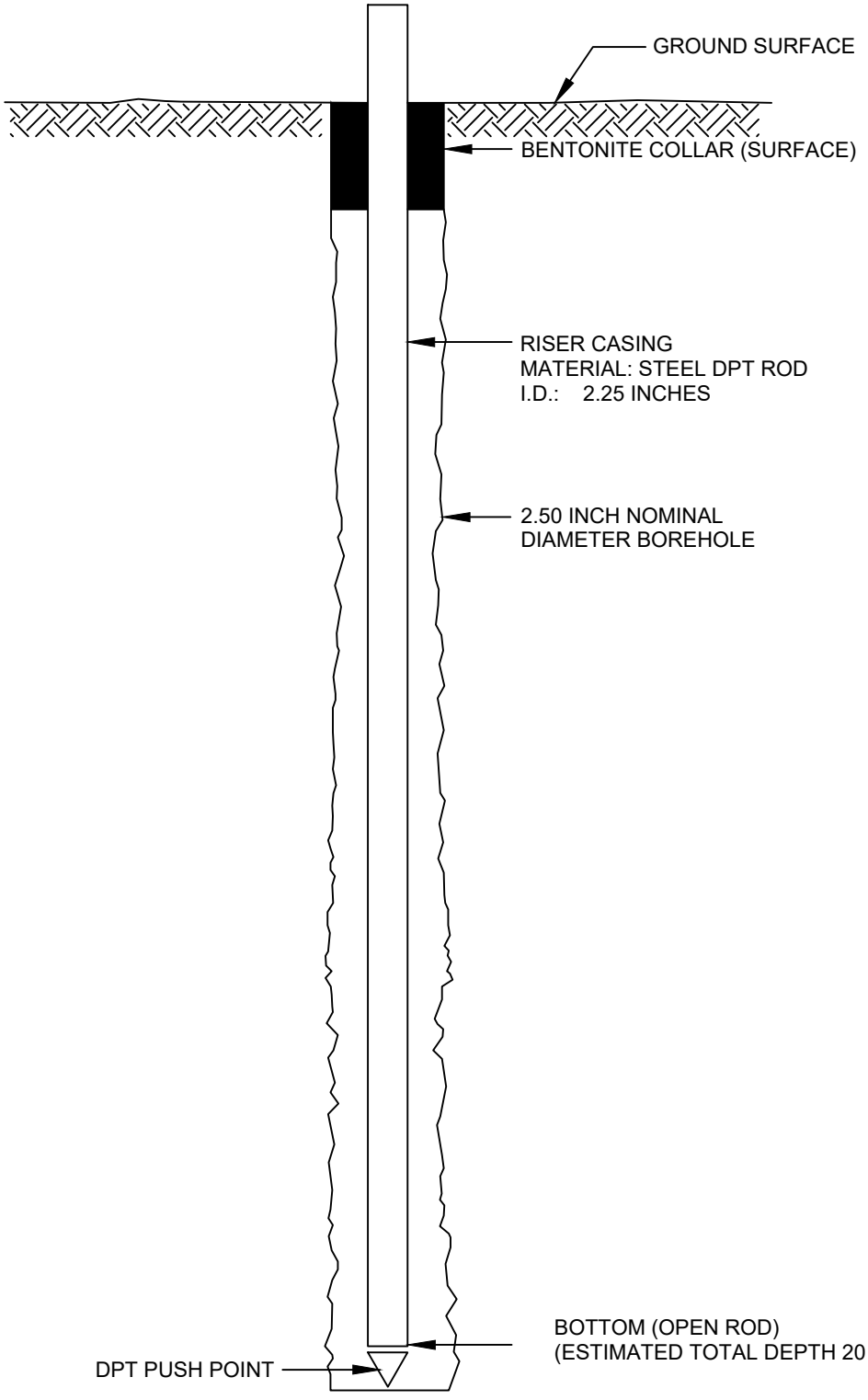

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TYPICAL DPT INJECTION POINT DETAIL
ERD PILOT STUDY - SHALLOW ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
NEWBERRY, SOUTH CAROLINA

PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 2-8**

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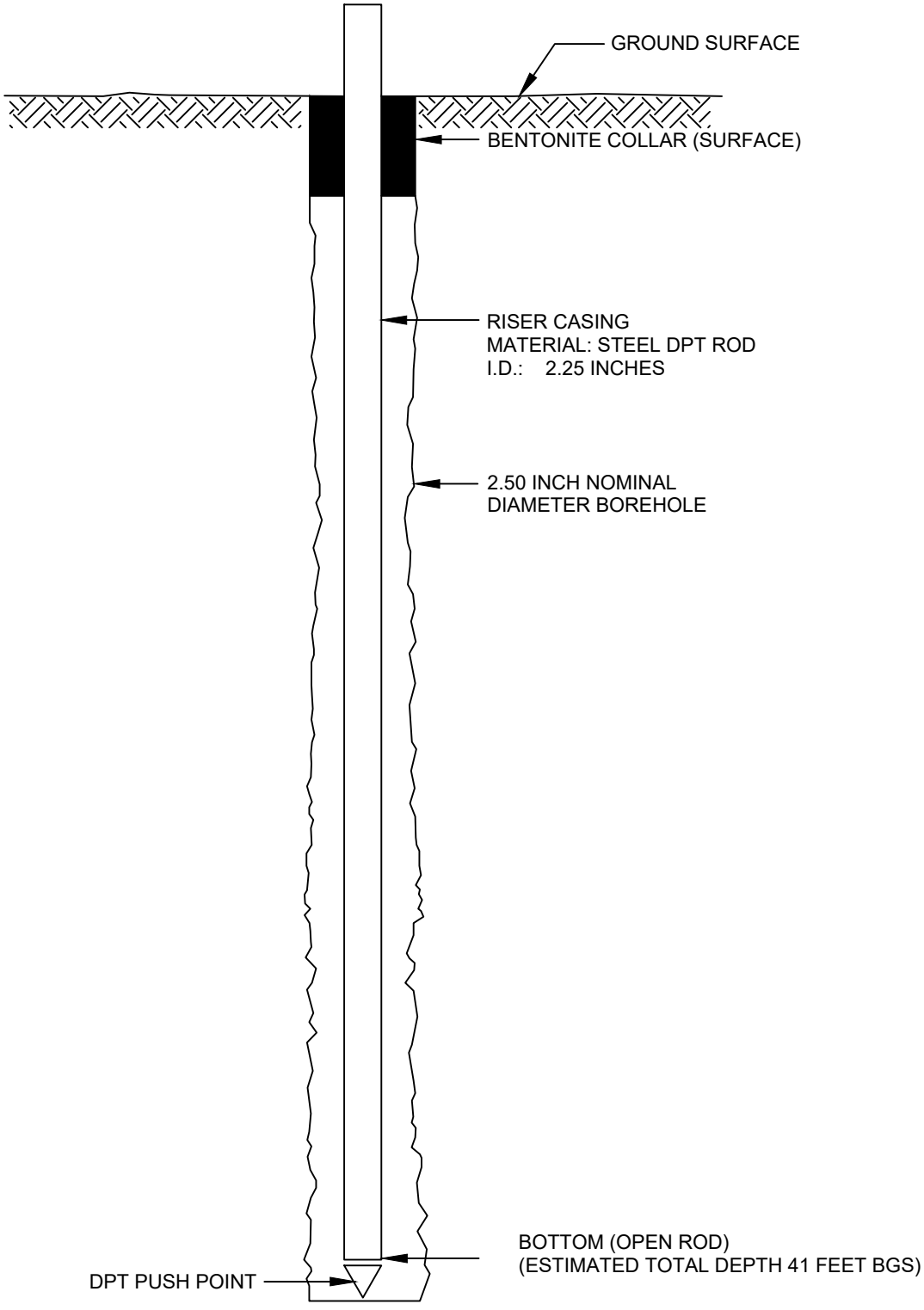

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TYPICAL DPT INJECTION POINT DETAIL
ERD PILOT STUDY - INTERMEDIATE ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
NEWBERRY, SOUTH CAROLINA

PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 2-9**

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TABLES

Table 2-1
Permanent Monitoring Well Construction Details
Shakespeare Composite Structures Site
Newberry, South Carolina

Well ID	Date of Installation	Location and Purpose	TD	Screen Interval (feet)	Diameter	Material	TOC Elevation (ft amsl)	Ground Elevation (ft amsl)	Depth to Bedrock (feet)	Top of Bedrock Elevation (ft amsl_	TD Elevation (ft amsl)
Shallow Wells											
MW-1	4/10/2014	Former Shakespeare property. Permanent well installed at former location of TMW-8	14.2	4.2 - 14.2	2 inch	Sch 40 PVC	561.85	561.85	15	546.85	547.65
MW-2	4/10/2014	Former Shakespeare property, Permanent well installed at former location of TMW-7	24.7	14.7-24.7	"	"	558.42	558.42	----	----	533.72
MW-3	4/10/2014	Former Shakespeare facility property - southwest corner of plant property	26	14.7-24.7	"	"	549.00	549.00	----	----	523.00
MW-4	4/11/2014	Former Shakespeare property. Permanent well installed at former location of TMW-3	26	15.2-25.2	"	"	560.13	560.13	----	-----	534.13
MW-5	4/14/2014	Former Shakespeare property. Permanent well installed at former location of TMW-11	26	15.8-25.8	"	"	557.74	557.74	----	-----	531.74
MW-6	4/14/2014	Former Shakespeare property. Permanent well installed at former location of TMW-5	26	15.7-25.7	"	"	561.32	561.32	----	----	535.32
MW-7	4/15/2014	Former Shakespeare property. Permament well installed at former location of TMW-16	26	14.8-24.8	"	"	554.72	554.72	----	----	528.72
MW-8	4/15/2014	Former Shakespeare property. Permament well installed at former location of TMW-13	26	15.5-25.5	"	"	558.27	558.27	----	-----	532.27
MW-9	4/16/2014	Former Shakespeare property. Permament well installed at former location of TMW-17	26	15.8-25.8	"	"	556.36	556.36	----	----	530.36
TMW-21	5/21/2014	Former Shakespeare property - west end of main building. Temporary well converted to permanent well.	23.5	13.5-23.5	1 inch	"	550.96	550.96	----	-----	527.46
TMW-22	5/21/2014	Former Shakespeare property - west end of main building. Temporary well converted to permanent well.	25	15-25	"	"	548.23	548.23	----	-----	523.23
TMW-23	5/27/2014	Former Shakespeare property - central portion of main building. Temporary wel onverted to permanent well.	25	15-25	"	"	537.03	537.03	----	-----	512.03
TMW-24	5/29/2014	Former Shakespeare property - west end of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	531.12	531.12	----	-----	506.12
TMW-25	5/29/2014	Former Shakespeare property - central portion of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	532.07	532.07	----	-----	507.07
TMW-29	6/3/2014	Former Shakespeare properrty - east central portion of main building. Temporary well converted to permanent well.	13	8-13	"	"	536.41	536.41	----	-----	523.41
TMW-30	6/3/2014	Fomrer Shakespeare property - Inside south central portion of main building. Temporary well converted to permanent well.	25	15-25	"	"	543.34	543.34	----	-----	518.34
TMW-31	6/3/2014	Former Shakespeare property - Inside north portion of main building. Temporary well converted to permanent well.	21	11-21	"	"	542.24	542.24	----	-----	521.24
TMW-32	6/4/2014	Former Shakespeare property - Inside northwest corner of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	551.59	551.59	----	-----	526.59
TMW-33	6/4/2014	Former Shakespeare property - Inside west central portion of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	531.58	531.58	----	-----	506.58
MW-10	8/4/2015	Dickert property - Former Location of TMW-42	30.32	20.3 - 30.3	2 inch	Sch 40 PVC	550.96	550.96	42	508.96	520.64
MW-11	"	Dickert property - Former Location of TMW-87	30.32	20.3 - 30.3	"	"	548.24	548.24	----	----	517.92
MW-12	"	Dickert property - Former Location of TMW-73	31.37	20.37 - 30.37	"	"	537.03	537.31	----	----	505.94
MW-13	"	Dickert property - Former Location of TMW-89	25.29	15.29 - 25.29	"	"	531.19	531.16	14	517.16	505.87
MW-14	8/5/2015	Dickert property - Former Location of TMW-95	20.22	10.22 - 20.22	"	"	532.07	531.97	----	----	511.75
MW-15	"	Dickert property - Former Location of TMW-98	11.63	1.63 - 11.63	"	"	536.41	536.32	----	----	524.69
MW-16	"	Dickert property - Fomer Location of TMW-99	20.29	10.29 - 20.29	"	"	543.35	543.23	----	----	522.94
MW-17	"	Dickert property - east of MW16	30.27	10.59 - 20.59	"	"	542.37	542.36	----	----	512.09
MW-18	8/3/2015	Dcikert property - Former Location of TMW 72	23.67	13.67 - 23.67	"	"	551.58	551.6	18	533.60	527.93
MW-19	8/6/2015	Chapman property - Former Location of TMW-105	14.77	4.77 - 14.77	"	"	531.58	531.59	11	520.59	516.82
MW-20	"	Boazman property - Former Location of TMW -38/102	35.3	25.3 - 35.3	"	"	541.92	541.86	----	----	506.56
MW-21	8/7/2015	Ringer property - South of TMW-39	24.17	14.17 - 24.17	"	"	548.24	548.28	----	----	524.11
MW-22	8/26/2015	Former Shakespeare property - South of entrance to main building	26.2	16.2 - 26.2	"	"	560.01	560.2	----	----	534
MW-23	12/15/2015	Shealy property - Former Location of TMW-107	25	10-20	"	"	543.48	543.75	----	----	518.75
MW-24	12/16/2015	Shealy property - Former Location of TMW-109	30	20 - 30	"	"	541.35	541.35	----	----	511.35
MW25	2/27/2016	Shealy property - Southwest of MW24I and MW23	30	20 - 30	"	"	535.60	535.5	30	505.50	505.5
MW-26	3/26/2018	Dickert property - north of MW-13	24.5	14.5 - 24.5	1 inch	Sch 40 PVC	533.67	533.88	---	---	509.38
MW-27	3/27/2018	Dickert property - north of MW-14	30	20 - 30	"	"	530.65	530.62	----	----	500.62
MW-28	3/27/2018	Folk property - west-northwest of MW-12	23.5	13.5 - 23.5	"	"	532.43	532.23	----	----	508.73
MW-29	3/27/2018	Folk property - northwest of MW-12	24	14 - 24	"	"	539.53	539.79	----	----	515.79
Intermediate Wells											
MW-2I	8/18/2015	Former Shakespeare property - west of MW-2	46.5	36.5 - 46.5	"	"	559.97	560.19	50	510.19	513.69
MW-3I	8/11/2015	Former Shakespeare property - adjacent to MW-3	54.73	44.7 - 54.7	"	"	548.84	548.96	----	----	494.23
MW-5I	8/19/2015	Fomer Shakespeare property - east of MW-5	57	47 - 57	"	"	559.70	559.6	56	503.60	502.6
MW-6I	8/21/2015	Former Shakespeare property - adjacent to MW-6	50	40 - 50	"	"	560.28	560.19	----	----	510.19
MW-7I	8/20/2015	Fomrer Shakespeare property - adjacent to MW-7	47.1	37.1 - 47.1	"	"	560.07	555.3	----	----	508.2
MW-9I	8/21/2015	Former Shakespeare property - adjacent to MW-9	47.6	37.6 - 47.6	"	"	556.07	556.08	----	----	508.48
MW-10I	8/24/2015	Dickert property - northwest of MW-10	41	31 - 41		"	548.4	548.5	----	----	507.5
MW-12I	6/12/2017	Dickert property - south of MW-12	47	36.8 - 46.8			536.6	536.44	----	----	489.44
MW-19I	5/6/2017	Chapman property - east of MW-19	23	17.6 - 22.6			536.4	536.51	----	----	513.51
MW-20I	8/11/2015	Boazman property - adjacent to MW-20, former Location of TMW-36	53.11	43.1 - 53.1	"	"	541.25	541.51	----	----	488.4
MW-21I	8/10/2015	Ringer property - adjacent to MW-2I	54.83	44.8 - 54.8	"	"	552.82	552.9	49	503.90	498.07
MW24I	2/18/2016	Shealy property - southwest of MW23	35	35 - 30	"	"	544.99	545.06	31	514.06	510.06

Notes:

Monitoring well targeted by ISCO pilot study.
Monitoring wells targeted by ERD pilot study.

ft amsl - feet above mean sea level
ERD - Enhanced Reductive Dechlorination
ISCO - In Situ Chemical Oxidation
PVC - polyvinyl chloride

Table 2-2
Pilot Study Performance Monitoring Program
Shakespeare Composite Structures Site
Newberry, South Carolina

Monitoring Well Details			Monitoring Event				
ID	**Location**	**Screen Depth (ft bgs)**	**Baseline**	**30 Days****	**4 Months****	**8 Months****	**12 Months****
Background Well							
MW-2	Upgradient well	14-27	1,2,3,4	1	1,2,3,4	1	1,2,3,4
ISCO Pilot Study Perfomance Monitoring Well Network - Shallow Groundwater Zone							
TMW-29	Sidegradient of injection area	8-13	1,2,3	1	1,2,3	1,2,3	1,2,3
TMW-31	Within injection area	11-21	1,2,3	1	1,2,3	1,2,3	1,2,3
ISCO-OBSW-1S	Downgradient from injection area	11-21*	1,2,3	1	1,2,3	1,2,3	1,2,3
ERD Pilot Study Perfomance Monitoring Well Network - Shallow Groundwater Zone							
MW-10	Within injection area	20.3-30.3	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5
ERD-OBSW-1S	Downgradient of injection area	20-30*	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5
ERD Pilot Study Perfomance Monitoring Well Network - Intermediate Groundwater Zone							
MW-10	Within injection area	31-41	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5
ERD-OBSW-1I	Downgradient of injection area	31-41*	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5

Field and Analytical Laboratory Parameter Monitoring Legend:

*Proposed well screen depth

**Post-injection monitoring events

1 = Field indicator parameters (color, turbidity, temperature, specific conductivity, pH, DO, ORP, and groundwater elevation).
2 = VOCs by SW 846, Method 8260B.
3 = Additional ISCO parameters (TDS by SW-846, Method 2540C and Chloride by SW 9056A).
4 = Biogeochemical parameters (Nitrate/Nitrite/Sulfate/Chloride by SW 9056A, Dissolved [lab filtered] and Total Iron by SW 6020A, Methane/Ethane/Ethene by RSK-175, Alkalinity by SM 2320B, and TOC by SW 9060A).
5 = *dehalococcoides, dehalobacter spp.* , vinyl chloride reductases via CENSUS® qPCR analysis.

Abbreviations:

DO - Dissolved Oxygen
ERD - Enhanced Re
ft bgs - Feet Below Ground Surface
ID - Monitoring Well Identification
ISCO - In Situ Chemical Oxidation
OBSW - observation well
ORP - Oxidation/Reduction Potential
qPCR - Quantitative Polymerase Chain Reaction
TDS - Total Dissolved Solids
TOC - Total Organic Carbon
VOC - Volatile Organic Compound

Table 2-3
ISCO Injection Design and Reagent Demand Summary
Shakespeare Composite Structures Site
Newberry, South Carolina

Shallow Groundwater Zone ISCO Injection - Near TMW-31		
Injection Design Parameter	**Units**	**Injection Zone Details**
Targeted Injection Interval	feet bgs	11 to 21
Interval	feet	10
Area	square feet	550
Total Treatment Volume	cubic feet	5,500
Total Volume	cubic yards	204
Total Volume	cubic meters	155.74
Estimated Effective Porosity		0.25
Pore Volume	cubic feet	1,375
Number of Injection Points	----	3
Estimated Injection Point ROI	feet	8.0
Targeted % of Pore Volume		0.22
Total Injection Volume	gallons	2,263
Total Injection Volume (Rounded)	**gallons**	**2,260**
Volume Per Injection Point	gallons	754
Volume Per Injection Point (Rounded)	**gallons**	**750**
Number of Injection Intevals	----	5
Volume Per Injection Interval	**gallons**	**150**
Estimated Soil Density	kilograms per cubic meter	1,600
Plume Soil Mass	kilograms	249,188
Estimated TOD	grams per kilogram	1.50
Total RemOx®S	grams	373,782
Total RemOx®S	pounds	824
Total RemOx®S (Rounded)	**pounds**	**830**
RemOx®S per Injection Location	**pounds**	**277**
Estimated Injection Duration	days	2

Notes:

bgs - below ground surface

DPT - direct push technology

ISCO - In-Situ Chemical Oxidation

RemOx®S - RemOx®S ISCO Reagent

ROI - Radius of Influence

TOD - total oxidant demand

Table 2-4
ERD Design Details - Initial Injection Event
Shakespeare Composite Structures Site
Newberry, South Carolina

	Shallow GW Zone (MW-10 Area)	Intermediate GW Zone (MW-10I Area)	Total
Targeted Treatment Areas and DPT Injection Point Details			
Area (square feet)	1,500	1,500	3,000
Shallow Groundwater Zone Depth (20 to 30 ft bgs)	10	-----	-----
Shallow Groundwater Zone Depth (31 to 41 ft bgs)	-----	10	
Aquifer Volume (cubic feet)	15,000	15,000	30,000
Estimated Radius of Influence	10	10	-----
Number of Injection Points	5	5	10
Average Horizontal Hydraulic Gradient (ft/ft)	0.016	0.014	-----
Average Hydraulic Conductivity (ft/day)	0.80	0.72	-----
Estimated Effective Porosity (unitless)	0.25	0.3	-----
Groundwater Seepage Velocity (ft/day)	0.05	0.03	-----
Estimated Injection Duration (days)	2	2	4
Total Quantities of ERD Injection Substrate Chemicals			
ABC®+Ole (50% by wt ZVI/50% by wt ABC®-Ole; pounds)	5,000	5,000	10,000
Water (gallons)	2,500	2,500	5,000
Micro-scale ZVI (pounds)	2,500	2,500	5,000
ABC®-Ole (lbs)	2,500	2,500	5,000
Long-Chain Fermentable Carbon (Oleic Acid; 60%)	1,500	1,500	3,000
Magnesium Oxide (pounds)	250	250	500
Guar (pounds)	50	50	100
Total Quantities per DPT Injection Point			
ABC®+Ole (50% by wt ZVI/50% by wt ABC®-Ole; pounds)	1000	1000	-----
Water (gallons)	500	500	-----
Micro-scale ZVI (pounds)	500	500	-----
ABC®-Ole (pounds)	500	500	-----
Long-Chain Fermentable Carbon (Oleic Acid; 60%)	300	300	-----
Magnesium Oxide (pounds)	50	50	-----
Guar (pounds)	10	10	-----
Total Quantities per DPT Point Injection Interval			
No. of Injection Intervals (20, 17.5, 15, 12.5, 10 ft bgs)	5	-----	-----
No. of Injection Intervals (41, 38.5, 36, 33.5, 31 ft bgs)	-----	5	-----
ABC®+Ole (50% by wt ZVI/50% by wt ABC®-Ole; pounds)	200	200	-----
Water (gallons)	100	100	-----
Micro-scale ZVI (pounds)	100	100	-----
ABC-Ole (pounds)	100	100	-----
Long-Chain Fermentable Carbon (Oleic Acid; 60%)	60	60	-----
Magnesium Oxide (pounds)	10	10	-----
Guar (pounds)	2	2	-----

Notes:
DPT - direct push technology
ERD - enhanced reductive dechlorination
ft bgs - feet below ground surface
ft/day - feet per day
ft/ft - feet per foot
GW - groundwater
lbs - pounds
wt - weight
ZVI - zero valent iron

Table 2-5
ERD Design Details - Bioaugmentation Event
Shakespeare Composite Structures Site
Newberry, South Carolina

	Shallow Zone GW (MW-10 Area)	Intermediate Zone GW (MW-10I Area)	Total
Targeted Treatment Areas and DPT Injection Point Details			
Area (square feet)	1,500	1,500	3,000
Shallow Groundwater Zone Depth (20 to 30 ft bgs)	10	-----	-----
Shallow Groundwater Zone Depth (31 to 41 ft bgs)	-----	10	
Aquifer Volume (cubic feet)	15,000	15,000	30,000
Estimated Radius of Influence	10	10	-----
Number of Injection Points	5	5	10
Average Horizontal Hydraulic Gradient (ft/ft)	0.016	0.014	-----
Average Hydraulic Conductivity (ft/day)	0.80	0.72	-----
Estimated Effective Porosity (unitless)	0.25	0.3	-----
Groundwater Seepage Velocity (ft/day)	0.05	0.03	-----
Estimated Injection Duration (days)	0.5	0.5	1
Total Quantities of ERD Injection Substrate Chemicals			
ABC®-Ole (pounds)	500	500	1,000
Water (gallons)	500	500	1,000
Magnesium Oxide (pounds)	250	250	500
RTB-1 (liters)	10	10	20
Sodium Sulfite (pounds)	1	1	2
Total Quantities per DPT Injection Point			
ABC®-Ole (pounds)	100	100	-----
Water (gallons)	100	100	-----
Magnesium Oxide (pounds)	50	50	-----
RTB-1 (liters)	2	2	-----
Sodium Sulfite (pounds)	0.20	0.20	-----
Total Quantities per DPT Point Injection Interval			
No. of Injection Intervals (20, 17.5, 15, 12.5, 10 ft bgs)	5	-----	-----
No. of Injection Intervals (41, 38.5, 36, 33.5, 31 ft bgs)	-----	5	-----
ABC®-Ole (pounds)	20	20	-----
Water (gallons)	20	20	-----
Magnesium Oxide (pounds)	10	10	-----
RTB-1 (liters)	0.4	0.4	-----
Sodium Sulfite (pounds)	0.04	0.04	-----

Notes:
DPT - direct push technology
ERD - enhanced reductive dechlorination
ft bgs - feet below ground surface
ft/day - feet per day
ft/ft - feet per foot
GW - groundwater
lbs - pounds
wt - weight
ZVI - zero valent iron

Attachment A

UIC Permit Application

Underground Injection Control Permit Application

Shakespeare Composite Structures Site
19845 US-76
Newberry, South Carolina 29108
Voluntary Cleanup Contract 14-6271-RP

Prepared for:

Signify North America Corporation
200 Franklin Square Drive
Somerset, NJ 08873

Submitted to:

South Carolina Department of Health and Environmental Control
2600 Bull Street
Columbia, South Carolina 29201

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101 Research Drive
Columbia, South Carolina 29203-9389

October 2020

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LIST OF ACRONYMS

%	percent
µg/L	micrograms per liter
ABC®-Olé	Anaerobic Biochem ® Olé
ABC®+Olé	Anaerobic Biochem Plus® Olé
AECOM	AECOM Technical Services, Inc.
bgs	below ground surface
BSTS	bench scale treatability study
cis-1,2-DCE	cis-1,2-dichloroethene
CVOCs	chlorinated volatile organic compounds
DHB	*Dehalobacter spp*
DHC	*Dehalococcoides*
DO	dissolved oxygen
DPT	Direct Push Technology
ERD	enhanced reductive dechlorination
ft	feet; foot
ft/ft	feet per foot
ft/day	feet per day
ft/yr	feet per year
ISB	in situ bioremediation
ISCO	in situ chemical oxidation
ISCR	in situ chemical reduction
IDW	industrial derived waste
MCLs	maximum contaminant levels
ORP	oxidation reduction potential
psig	pounds per square inch gauge
Redox Tech	Redox Tech, LLC
RemOx®S	RemOx®S ISCO reagent
RI	Remedial Investigation
ROI	radius on influence
SCDHEC	South Carolina Department of Health and Environmental Control
TCE	trichloroethene
UIC	underground injection control
USEPA	United State Environmental Protection Agency
VC	vinyl chloride
VCC	Voluntary Cleanup Contract
VOC	volatile organic compound

Form I UIC	DHEC Underground Injection Control Permit Application Ground-Water Protection Division (Collected under the Authority of Title 48 Chapter I of the 1976 South Carolina Code of Laws)	I. EPA ID NUMBER	T/A	C
		U		

Read attached instructions before starting.

For OfficialUse Only

Application Approved month day year	Date Received month day year	Permit Well Number

Comments

II. Facility Name and Address	III. Owner/Operator and Address
Facility Name: Shakespeare Composite Structures Site	Owner/OperatorName: Signify North American Corporation
Street Address: 19845 US-76	Street Address: 200 Franklin Square Drive
City: Newberry; State: South Carolina; Zip Code: 29646	City: Somerset; State: New Jersey; Zip Code: 08873

IV. Ownership Status (Select One)

☐ A. Federal ☐ B. State ☒ C. Private ☐ D. Public ☐ E. Other (Explain)

V. SIC Codes

2221 | 2262 | 2295

VI. Well Status (Select A, B or C)

☐ A. Operating | Date Started *(MM/DD/YYYY)* To be determined | ☐ B. Modification/Conversion ☒ C. Proposed

VII. Type of Permit Requested - Class and Type of Well (see reverse)

A. Class(es) enter code(s)	B. Type(s) enter code(s)	C. If class is "other" or type is code 'Y', explain	D. Number of Wells per type
V.A.	i		23 DPT Temporary Points

VIII. Location of Wells or Approximate Center of field or Project

C	A. Latitude				B. Longitude			
I		Deg	Min	Sec		Deg	Min	Sec
		34	31	07.26		81	63	45.47

IX. Attachments

Complete the following questions on a separate sheet(s) and number accordingly; see instructions for Classes 11, 111, and V, complete and submit on a separate sheet(s) attachments A-U as appropriate. Attach maps where required. List attachments by letter which are applicable and include with your application.

X. Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment.

A. Name (Type or Print)	Title	B. Phone No.
Mr, Dean Weeks	Sr. Project Manager	(908) 705-4743

C. Signature: [signature]

D. Date Signed (MM/DD/YYYY): 9/29/2020

DHEC2502(08/1997)

ATTACHMENT A: ACTIVITY FOR REVIEW

PILOT STUDY LOCATION

Because in situ chemical oxidation (ISCO) and enhanced reductive dechlorination (ERD) using a combination of in situ bioremediation (ISB) and in situ chemical reduction (ISCR) were both determined to be potentially applicable treatments for chlorinated volatile organic compounds (CVOCs) in Site groundwater during a previously conducted bench scale treatability study (BSTS), the proposed pilot study will consist of multiple study areas. Based on the 2017 CVOC concentrations detected in shallow and intermediate zone groundwater, two areas were identified for the pilot study. One pilot study area is located within the eastern end of the Main Building near monitoring well TMW-31 and will be used to conduct the ISCO pilot study. The objective of the proposed ISCO pilot study is to decrease the concentration of trichloroethene (TCE) in the shallow groundwater zone within this area using a strong chemical oxidant. **Figure 1** shows the ISCO pilot study area and the proposed ISCO direct push technology (DPT) injection locations. Site monitoring well construction details are provided in **Table 1**.

The ERD pilot study area is proposed to be conducted on a private parcel of property (Dickert Property) located north of the existing production facility. The objective of the proposed ERD pilot study is to decrease the concentration of TCE in the shallow and intermediate groundwater zones within the vicinity of monitoring wells MW-10 and MW-10I. The ERD pilot study will include the concurrent injection of an organic carbon substrate and zero valent iron (ZVI) into the targeted shallow and intermediate zone groundwater to create strongly anaerobic and reducing conditions suitable for enhanced ISB and ISCR of the Site-related CVOCs in groundwater. Additional amendments including a pH buffer, additional nutrients, and a bioaugmentation culture will be used to enhance the ISB component of ERD. The ERD substrate and amendments will be delivered to the subsurface via DPT injection. **Figure 2** shows the ERD pilot study area and the proposed DPT injection locations for shallow zone groundwater treatment near MW-10. **Figure 3** shows the ERD pilot study area and the proposed DPT injection locations for intermediate zone groundwater treatment near MW-10I.

PILOT STUDY DESIGN

The following subsections describe the injection design and amendments to be used to achieve the ISCO and ERD pilot study objectives.

ISCO Pilot Study

For the ISCO field pilot study area, a potassium permanganate ($KMnO_4$) solution (approximately 4 percent (%) by weight) will be injected into three locations via DPT using a Geoprobe® series 6600 rig. The KMnO4 solution will be injected through the temporary DPT points to treat the TCE in shallow groundwater zone groundwater in the vicinity of monitoring well TMW-31. Flow direction in shallow zone groundwater near TMW-31 is to the west-northwest. A radius of influence (ROI) of 8 feet (ft) for each of the ISCO DPT injection points was assumed in order to obtain adequate coverage for the successful treatment of shallow zone groundwater contamination. The vertical injection interval targeted for the

three ISCO DPT injection locations is from approximately 11 ft below ground surface (bgs) to 21 ft bgs. Note that the final DPT injection point locations, spacing, and injection depths are subject to change based on the field conditions encountered at the time of the injection event. Any changes to the proposed DPT injection locations, spacing, and/or injection depths will be documented in the Site field notes. The specific chemical oxidant product to be used is described in the following subsection.

RemOx®S ISCO Reagent

For the ISCO pilot study, the Carus Corporation $KMnO_4$ product, RemOx®S ISCO reagent (RemOx®S) will used for the treatment of TCE in the shallow zone groundwater in the vicinity of TWM-31. RemOx®S is a strong chemical oxidant that has been used for the treatment of CVOCs in groundwater at numerous sites with varying lithologies including those similar to the Shakespeare Composite Structures Site. The use of RemOx®S will not require activation like other chemical oxidants such as persulfate or hydrogen peroxide. Its use is applicable over a wide range of pH, and it can easily be detected in monitoring wells several months following injection due to its natural deep purple color. RemOx®S is deep purple when it is chemically active and becomes brown once it is no longer active. A Safety Data Sheet for RemOx®S is included in **Appendix A**.

ERD (ISB and ISCR) Pilot Study

For the ERD field pilot study area, an organic carbon substrate ZVI solution (approximately 19% by weight) with additional amendments including a bioaugmentation culture will be injected into ten DPT locations. The ERD solution will be injected through the temporary DPT points to treat shallow zone and intermediate zone groundwater in the vicinity of MW-10 and MW10I, respectively. Flow direction in shallow zone groundwater near MW-10 is to the west-northwest, and the flow direction in intermediate zone groundwater near MW-10I is to the west-northwest. An ROI of 10 ft was assumed for both the shallow and intermediate zone groundwater in order to obtain adequate coverage for the successful treatment of shallow zone and intermediate zone groundwater. Using a barrier-type formation, five ERD DPT injections will be conducted upgradient of MW-10, and five ERD DPT injections will be conducted upgradient of MW-10I using a Geoprobe® series 7822 rig. The vertical injection interval targeted for shallow zone groundwater treatment is from approximately 20 ft bgs to 30 ft bgs. The vertical injection interval targeted for intermediate zone groundwater treatment is from approximately 31 ft bgs to 41 ft bgs. Note that the final DPT injection point locations, spacing, and/or injection depths are subject to change based on the field conditions encountered at the time of the planned injection event. Any changes to the proposed DPT injection locations and spacing will be documented in the Site field notes.

The substrate to be used for the proposed ERD injections at the Site is a combination of biological and chemical amendments that include Anaerobic Biochem Plus® Olé (ABC®+Olé), which is a combination of Anaerobic Biochem® Olé (ABC®-Olé) and ZVI, magnesium oxide, guar, RTB-1 (biological amendment consisting of *Dehalococcoides (DHC)*, and sodium sulfite. Safety Data Sheets for these compounds are included in **Appendix A**. A description of each of these amendments is presented in the following subsections.

ABC®+Olé

A combination organic carbon source/ZVI substrate known as ABC®+Olé will be used for the ERD pilot study. ABC®+Olé is a combination bioremediation/chemical reductant product developed and patented by Redox Tech, LLC (Redox Tech). The use of ABC®+Olé will result in the creation of strong reducing conditions within the targeted shallow and intermediate groundwater zones, which ultimately will enhance the reductive dechlorination of Site-related CVOCs via two mechanisms. First, ABC®+Olé contains a readily available carbon food source to indigenous microorganisms, which consists of a mixture of fast-release soluble lactic acids (glycerine) and slow-release fatty acids (oleic acid) along with a dipotassium phosphate buffer. This combination of products serves to promote the ISB of the targeted CVOCs. Second, ABC®+Olé contains added ZVI, which does not rely on microbial degradation to treat the targeted CVOCs but rather utilizes ISCR. ISCR by ZVI works via an abiotic degradation pathway (β-elimination) that occurs on the surface of the granular ZVI, with the ZVI primarily acting as an electron donor.

The addition of ZVI to the ABC®+Olé mixture provides a number of advantages over traditional ERD applications without ZVI. The ZVI provides an immediate reduction in existing groundwater conditions. ZVI also raises the pH in the targeted groundwater, and the corrosion of the ZVI produces small quantities of hydrogen gas, which is an energy source for a wide range of anaerobic bacteria. Finally, the β-elimination pathway accounts for the majority of the degradation that occurs when the targeted CVOCs come into contact with the ZVI. This pathway avoids the production of cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride VC and the potential "stall out" or accumulation of these constituents that may occur during microbially-induced reductive dechlorination.

For the proposed ERD injection event, the ABC®+Olé mixture will consist of 50% by weight ABC®-Olé and 50% by weight ZVI. In particular, the 50% by weight ABC®-Olé will consist of long chain fermentable carbon (C14 to C18 fatty acids), which is comprised of a mixture of fatty acid methyl ester, soybean oil, and an emulisifier, approximately 5% by weight glycerine, and 0.1% by weight dipotassium phosphate as a micronutrient and buffer.

Magnesium Oxide

At the Site, the native pH of the targeted shallow and intermediate groundwater zones is generally between 4.5 and 6.5 standard units. As a result, magnesium oxide, which is transformed into magnesium hydroxide upon contact with water, will be injected along with the ABC®+Olé to more aggressively raise and sustain the pH within the immediate vicinity of the DPT injection locations. The quantity of magnesium oxide to be injected will be approximately 1% by weight of the injected solution.

Guar

Guar is used as a stabilizing, thickening, and suspending agent for injection substrates. In this case, the added guar will be utilized to achieve the hydraulic emplacement of the ABC®+Olé mixture at each ERD DPT injection location.

RTB-1

Bioaugmentation, by means of RTB-1, will be used to increase the effectiveness of the planned ABC®+Olé injection. Bioaugmentation is defined as the addition of high-performance microbial cultures capable of degrading targeted CVOCs. Bioaugmentation for the treatment of chlorinated ethenes entails the addition of a naturally occurring, non-pathogenic, microbial culture that contains *DHC*, which are capable of completely dechlorinating TCE and its daughter products to harmless ethene. Bioaugmentation is often used when there is incomplete dechlorination of TCE following biostimulation with an organic carbon source.

Not all *DHC*. in nature dechlorinate VC efficiently due to the lack of necessary enzymes. RTB-1 offers an enriched dechlorinating culture that includes lactate as a carbon source and uses TCE as an electron acceptor. As such, RTB-1 offers an enriched dechlorinating culture capable of efficiently degrading TCE, cis-1,2-DCE, and VC to innocuous ethene. The *DHC*. present in RTB-1 dechlorinate VC to ethene via halorespiration, and not via the less efficient cometabolic processes.

Sodium Sulfite

A small quantity of sodium sulfite will be used at each temporary ERD DPT injection location. The purpose of sodium sulfite addition is to precondition the targeted groundwater by deoxygenating it prior to the injection of the strictly anaerobic RTB-1 culture.

INJECTION EVENT DETAILS

ISCO Injection Details

Redox Tech will be subcontracted to conduct the injection of RemOx®S via DPT with oversight provided by AECOM. As recommended by Redox Tech and verified by AECOM, a total of approximately 830 pounds of RemOx®S will be mixed with 2,250 gallons of water to create an approximate 4% by weight RemOx®S solution that will subsequently be injected into three temporary DPT points to treat shallow zone groundwater in the vicinity of TMW-31. The targeted treatment area encompasses approximately 550 square feet and assumes an 8-ft ROI for each DPT injection point. At each of the three temporary DPT injection locations, approximately 277 pounds of RemOx®S will be mixed with 750 gallons of water and subsequently injected using a chemical grout pump. Each DPT injection will be conducted over a 10-ft vertical interval from approximately 11 to 21 ft bgs. The RemOx®S solution will be injected in 2.5-ft intervals, which equates to 5 vertical intervals per DPT injection point location and 15 injection intervals overall.

The RemOx®S will be shipped to the site immediately prior to the ISCO injection event. To prepare the RemOx®S mixture, water will be obtained from the closest fire hydrant to the ISCO pilot study location after installation of a backflow preventer and water meter. The water will be contained in a mobile trailer-mounted holding tank or similar apparatus and subsequently transported from the fire hydrant location to the location of the proposed ISCO DPT injections.

The RemOx®S will be delivered to the site as a solid in 50-pound buckets. Prior to injection, the appropriate amount of RemOx®S will be added to the water holding tank. A stainless-steel paddle mixer will then be used to thoroughly mix the water and RemOx®S within the holding tank. Once the solution is fully mixed, a chemical grout pump will be used to inject the required quantity of ISCO solution through the DPT rods. Injection will be conducted in a bottom-to-top approach at each location.

A Geoprobe® series 6610 rig will be used to drive the DPT rods to the anticipated deepest injection interval (21 ft bgs). Following delivery of the solution, the DPT rods will be pulled up 2.5 feet, and the next quantity of solution will be injected. This process will continue until all five intervals at the particular ISCO DPT injection location (total of 750 gallons of RemOx®S solution per injection location) have been delivered into the subsurface. The targeted intervals for each DPT injection location are 21 feet bgs, 18.5 feet bgs, 16 feet bgs, 13.5 feet bgs, and 11 feet bgs.

The same mixing and injection process will be repeated for each of the three temporary DPT injection points. In the event of daylighting of the injected solution, injection will be stopped until the daylighting has been controlled. Any injection material that pools at the ground surface will be vacuumed, strained, and reinjected. All DPT injection points will be abandoned using a Portland cement or Portland cement/bentonite grout. The concrete will be patched to match the pre-existing surface as appropriate.

ISCO pilot study injection design details and total amendment quantities to be injected are summarized in **Table 2**. **Figure 1** shows the ISCO pilot study area and the associated DPT injection locations.

ERD Injection Details – Initial Event

Redox Tech will also be subcontracted to conduct the injection of ABC®+Olé for the ERD injection portion of the pilot study with oversight provided by AECOM. Five temporary shallow zone and five temporary intermediate zone groundwater DPT injection points will be used to inject the ABC®+Olé solution in a barrier-type formation upgradient of monitoring wells MW-10 and MW-10I. In total,10,000 pounds of ABC®+Olé in 5,000 gallons of water will be injected.

The ERD injectate chemicals will be shipped to the site immediately prior to the injection event. At each of the ten targeted DPT locations, an approximate 19% by weight solution of ABC®+Olé will be used. A 19% by weight solution equates to approximately 1,000 pounds of ABC®+Olé mixed with 500 gallons of water per DPT injection location. Each injection will be performed over a 10-ft vertical interval from approximately 20 ft bgs to 30 ft bgs for the targeted shallow zone groundwater and from approximately 31 to 41 ft bgs for the targeted intermediate zone groundwater.

The 19% by weight solution is also equivalent to approximately 100 pounds of ABC®+Olé per vertical foot or 50 gallons of ABC®+Olé solution per vertical foot at each DPT injection location. In addition, approximately 50 pounds of magnesium oxide will be added per DPT injection location for pH buffering, and approximately 10 pounds of guar will be required to achieve hydraulic emplacement of the ABC®+Olé mixture at each injection point.

In preparation for injection, the stock ingredients for ABC®+Olé will need to be mixed together. Water will be obtained from the closest fire hydrant to the ERD pilot study location after installation of a backflow preventer and water meter. The water will be filled into a mobile, trailer mounted 500-gallon polyethylene holding tank and then transported from the fire hydrant location to the site of the ERD DPT injections. ABC®-Olé, which will be delivered to the Site as a concentrated liquid in plastic totes, will be staged near the DPT injection locations and gravity drained into the holding tank containing the water. A stainless-steel paddle mixer will then be used to thoroughly mix the water and ABC®-Olé within the holding tank.

Following thorough mixing, 100 gallons of the ABC®-Olé stock mixture will be pumped using a double diaphragm pump from the 500-gallon polyethylene holding tank into two 75-gallon feed hoppers located on an open trailer that will also be staged next to the ERD injection locations. Each feed hopper will then contain 50-gallons of ABC®-Olé solution. ZVI, which comes in 50-pound buckets, will be staged next to the feed hopper trailer. One bucket of ZVI, five pounds of magnesium oxide, and one pound of guar will be added to each 75-gallon feed hopper. These materials will then be thoroughly mixed with the ABC®-Olé stock mixture using shear mixing arms located in each of the 75-gallon feed hoppers, thereby creating the ABC®+Olé solution to be injected. Once the solution is fully mixed and suspended, a chemical grout pump will be used to inject all 100 gallons of the ABC®+Olé solution through DPT rods set to the appropriate interval within the subsurface. Injection will be conducted in a bottom-to-top approach.

A Geoprobe® Model 7822 track rig or similar will be used to drive the DPT rods to the specified injection interval. The DPT rods will subsequently be pulled upwards to each successive interval until all five intervals at the ERD DPT injection location are completed (total of 500 gallons of ABC®+Olé solution per injection location). The intervals for each DPT injection location that targets shallow zone groundwater treatment in the vicinity of MW-10 are 20 feet bgs, 17.5 feet bgs, 15 feet bgs, 12.5 feet bgs, and 10 feet bgs. The intervals for each DPT injection location that targets intermediate zone groundwater in the vicinity of MW-10I are 41 feet bgs, 38.5 feet bgs, 36 feet bgs, 33.5 feet bgs, and 31 feet bgs.

The same mixing and injection process will be repeated for each of the ten temporary ERD DPT injection points. In the event of daylighting of the injected material, injection will be stopped until the daylighting has been controlled. Any injection material that pools at the ground surface will be vacuumed, strained, and reinjected. All DPT injection points will be abandoned using a Portland cement or Portland cement/bentonite grout.

Initial ERD pilot study injection design details and total amendment quantities to be injected are summarized in **Table 3**. **Figures 2 and 3** show the ERD pilot study area and the associated DPT injection locations for shallow zone and intermediate zone groundwater, respectively.

ERD Injection Details – Bioaugmentation Event

Based on the results of the previously conducted BSTS, bioaugmentation will be conducted approximately 45 days after the initial ABC®+Olé injection event. This should allow enough time for the targeted shallow and intermediate zone groundwater near MW-10 and MW-10I to become sufficiently conditioned (i.e., achieve low dissolved oxygen [DO] and oxidation reduction potential [ORP] and neutral

pH) for the injection of the RTB-1 microbial culture to promote ISB. To assist with the bioaugmentation process, additional carbon source in the form of ABC®-Olé and pH buffer in the form of magnesium oxide with be injected concurrently with the RTB-1.

For the bioaugmentation event, water again be obtained from the closest fire hydrant to the ERD pilot study area. The water will be filled into a mobile, trailer mounted 500-gallon polyethylene holding tank and then transported from the fire hydrant location to the site of the previous ABC®+Olé DPT injections. ABC®-Olé, which will be delivered to the Site as a concentrated liquid in a plastic tote, will be staged near the bioaugmentation DPT injection locations and gravity drained into the holding tank containing the water. The ratio of the mixture will be 100 pounds of ABC®-Olé in 100 gallons of water. A stainless-steel paddle mixer will be used to thoroughly mix the water and ABC®-Olé within the holding tank. A total of 50 pounds of magnesium oxide will be added to the holding tank. Finally, 0.2 pounds of sodium sulfite will be added to the mixture to drive the ABC®-Olé solution anaerobic. Note that ZVI will not be added to the mixture for the bioaugmentation injection event.

Once the solution is fully mixed, a chemical grout pump will be used to inject a total of 20 gallons of the ABC®-Olé solution through DPT rods set to the appropriate interval within the subsurface. Halfway through injection at each interval, 0.4 liters of RTB-1 will be "slipstreamed" into the DPT rod to promote bioaugmentation. Subsequently, the remaining ABC®-Olé solution will be injected within the same interval.

A Geoprobe® series 7720 rig will be used to drive the DPT rods to the specified injection interval. The DPT rods will subsequently be pulled upwards to each successive interval until all five intervals at the DPT injection location are completed (total of 100 gallons of bioaugmentation solution per DPT injection location). The intervals for each DPT injection location that target the shallow zone groundwater in the vicinity of MW-10 are 20 feet bgs, 17.5 feet bgs, 15 feet bgs, 12.5 feet bgs, and 10 feet bgs. The intervals for each DPT injection location that target the intermediate zone groundwater in the vicinity of MW-10I are 41 feet bgs, 38.5 feet bgs, 36 feet bgs, 33.5 feet bgs, and 31 feet bgs.

The same mixing and injection process will be repeated for each of the ten temporary bioaugmentation DPT injection points. In the event of daylighting of the injected material, injection will be stopped until the daylighting has been controlled. Any injection material that pools at ground surface will be vacuumed, strained, and reinjected. All DPT injection points will be abandoned using a Portland cement or Portland cement/bentonite grout.

Table 4 provides a summary of the quantity of substrate materials to be injected during the bioaugmentation event.

INVESTIGATION DERIVED WASTE MANAGEMENT

Investigation derived waste (IDW) management will consist of non-hazardous decontamination water generated during the cleaning of the DPT rods between injection locations and non-hazardous purge

water generated during pilot study performance monitoring activities (refer to **Attachment D**). All IDW will be containerized in 55-gallon Department of Transportation-approved drums. The drums will be labeled to indicate the type of material contained, site location, investigation point of origin, date on which materials were initially placed in the container, and they will be secured at the end of each day. Grab and/or composite samples of the decontamination water and purge water will be collected and analyzed for waste characterization. Aqueous IDW will be analyzed for VOCs by United States Environmental Protection Agency (USEPA) Analytical Procedures Manual SW-846, Method 8260B. The drums will be staged in a secure location at the Site pending characterization, profiling, manifesting, and off-site disposal. Other non-hazardous IDW (e.g., personal protective equipment, paper towels, trash, etc.) will be bagged and transported off-site for disposal as a municipal waste at a trash collection point near the Site.

ATTACHMENT B: WELL CONSTRUCTION DETAILS

Since DPT drill rods will be utilized for solution injection, no permanent injection wells will be installed at the Site. A typical temporary ISCO DPT injection point detail is provided as **Figure 4**. Typical ERD DPT injection point details for treatment of shallow zone and intermediate zone groundwater are provided as **Figures 5 and 6**, respectively. The proposed temporary ISCO and ERD DPT injection locations were previously shown on **Figures 1 through 3**.

ATTACHMENT C: OPERATING DATA

Operating Data for the ISCO portion of the pilot study is presented first. Operating Data for the ERD portion of the pilot study is subsequently presented.

The fluid to be injected: RemOx®S/Water Mixture

Number of injection wells: Three temporary ISCO DPT injection points.

1) Average and maximum daily rate and volume of RemOx®S/Water Mixture to be injected:

A 4.2% by weight RemOx®S solution will be used to treat CVOCs in shallow zone groundwater within the vicinity of TMW-31. Approximately 277 pounds of RemOx®S will be mixed with 750 gallons of water per DPT injection location, which equates to 55.4 pounds of RemOx®S mixed with 150 gallons of water per injection interval for a total of 5 injection intervals per DPT injection location.

2) Average and maximum daily rate and volume of air/groundwater to be withdrawn from each recovery well:

No air or groundwater will be withdrawn from the proposed ISCO DPT injection locations.

3) Average and maximum injection pressure:

The average injection pressure for each interval will be approximately 100 pounds per square inch gauge (psig).

Average injection pressure will equal approximately 100 psig with a maximum injection pressure of approximately 125 psig.

4) Pumping schedule:

For the ISCO portion of the pilot study, the DPT rods will be driven to the bottom of each temporary injection point. A total of 150 gallons of RemOx®S solution will be injected into the first of five injection intervals. Following completion of injection into the bottom interval, the DPT rods will be pulled upwards to each successive interval until all five intervals at the ISCO DPT injection location are completed (total of 750 gallons of RemOx®S solution per injection location). The five targeted intervals for each ISCO DPT injection location are 21 ft bgs, 18.5 ft bgs, 16 ft bgs, 13.5 ft bgs, and 11 ft bgs.

5) Proposed ranges in the concentration of all contaminant constituents within the injection fluid:

None.

6) Length of time the project is expected to require injection remediation:

The ISCO injection event is anticipated to be conducted in the winter or spring of 2021. It is anticipated that it will take two working days to complete the ISCO injections. The proposed time frame to conduct the injection event is approximate and contingent upon approval of this permit application and subsequent issuance of the underground injection control (UIC) Permit to Construct and Operate. The requested expiration date for the UIC Permit to Operate should be for 1 year from the date of issuance. The reason for the requested timeframe is to account for unforeseen delays to the start of the injection event (e.g., access agreement issues, unforeseen weather events, etc.).

The fluid to be injected: Anaerobic Biochem® Plus Olé (ABC®+Olé)

Number of injection wells: 20 temporary ERD DPT injection points (10 per injection event)

1) Average and maximum daily rate and volume of ABC®+Olé /Water Mixture to be injected:

For the initial ERD injection event, an approximate 19.3% by weight solution of ABC®+Olé will be used at each of the ten targeted DPT locations. A 19.3% by weight solution equates to approximately 1,000 pounds of ABC®+Olé mixed with 500 gallons of water per DPT injection location or 200 pounds of ABC®+Olé mixed with 100 gallons of water per injection interval for a total of 5 injection intervals per ERD DPT injection location. In addition, approximately 50 pounds of magnesium oxide will be added per DPT injection location for pH buffering, and approximately 10 pounds of guar will be used to achieve hydraulic emplacement of the ABC®+Olé solution at each ERD injection point.

For the bioaugmentation injection event (to be conducted approximately 45 days after the initial ERD injection event), an approximate 11% by weight solution of ABC®Olé will be used at each of the ten targeted DPT locations. An 11% by weight solution equates to

approximately 100 pounds of ABC®Olé (no ZVI added) mixed with 100 gallons of water per bioaugmentation DPT injection location or 20 pounds of ABC®Olé mixed with 20 gallons of water per injection interval for a total of 5 injection intervals per DPT injection location. In addition, approximately 50 pounds of magnesium oxide will be added for pH buffering, 2 liters of RTB-1 will be added for bioaugmentation, and 0.2 pounds of sodium sulfite will be added to drive the solution anaerobic per bioaugmentation DPT injection location.

2) Average and maximum daily rate and volume of air/groundwater to be withdrawn from each recovery well:

No air or groundwater will be withdrawn from the proposed ERD DPT injection locations.

3) Average and maximum injection pressure:

For both injection events, the average injection pressure for each interval will be approximately 50 psig with a maximum injection pressure of approximately 100 psig.

4) Pumping schedule:

For the initial ERD portion of the pilot study, the DPT rods will be driven to the bottom of each temporary injection point. A total of 100 gallons of ABC®+Olé solution will be injected into the first of five injection intervals. Following completion of injection into the bottom interval, the DPT rods will be pulled upwards to each successive interval until all five intervals at the DPT injection location are completed (total of 500 gallons of ABC®+Olé solution per injection location). The five targeted intervals for each shallow zone ERD DPT injection location are 20 ft bgs, 17.5 ft bgs, 15 ft bgs, 12.5 ft bgs, and 10 ft bgs. The five targeted intervals for each intermediate zone ERD DPT injection location are 41 ft bgs, 38.5 ft bgs, 36 ft bgs, 33.5 ft bgs, and 31 ft bgs.

For the bioaugmentation portion of the pilot study, the DPT rods will be driven to the bottom of each temporary injection point. A total of 20 gallons of ABC®Olé solution and 0.4 liters of RTB-1 will be injected into the first of five injection intervals. Following completion of injection into the bottom interval, the DPT rods will be pulled upwards to each successive interval until all five intervals at the bioaugmentation DPT injection location are completed (total of 100 gallons of ABC®Olé solution and 2 liters of RTB-1 per injection location). The five targeted intervals for each shallow zone bioaugmentation DPT injection location are 20 ft bgs, 17.5 ft bgs, 15 ft bgs, 12.5 ft bgs, and 10 ft bgs. The five targeted intervals for each intermediate zone bioaugmentation DPT injection location are 41 ft bgs, 38.5 ft bgs, 36 ft bgs, 33.5 ft bgs, and 31 ft bgs.

5) Proposed ranges in the concentration of all contaminant constituents within the injection fluid:

None.

6) Length of time the project is expected to require injection remediation:

The ERD and bioaugmentation injection events are anticipated to be conducted in the winter or spring of 2021. It is anticipated that it will take four working days to complete the initial ERD injections and additional one working day to complete the ERD bioaugmentation injections. The proposed time frame to conduct the injection event is approximate and contingent upon approval of this permit application and subsequent issuance of the UIC Permit to Construct and Operate. The requested expiration date for the UIC Permit to Operate should be for 1 year from the date of issuance. The reason for the requested timeframe is to account for unforeseen delays to the start of the injection event (e.g., access agreement issues, unforeseen weather events, etc.).

ATTACHMENT D: PERFORMANCE MONITORING PROGRAM

An initial performance monitoring event will be conducted at the Site using select monitoring wells that will serve as baseline CVOC concentration data for monitoring the effectiveness of the proposed ISCO and ERD injection events. Following the completion of the bioaugmentation injection event, a pilot study summary report will be prepared to summarize injection event activities, baseline and post-injection performance monitoring activities and associated analytical results, and a summary of conclusions and recommendations. The injection of RemOx®S and ABC®+Olé will be followed by four post-injection groundwater performance monitoring events. At the end of the post-injection performance monitoring period, AECOM will evaluate the analytical data collected throughout the year-long monitoring program and determine the effectiveness RemOx®S and ABC®+Olé with bioaugmentation as remedial alternatives for Site groundwater.

For the baseline and post-ISCO injection performance monitoring events, groundwater samples will be collected from one upgradient well (MW-2), injection area monitoring well (TMW-31), from one sidegradient monitoring well (TMW-29), and from one downgradient observation well (ISCO-OBSW-1S) to be installed as part of the pilot study.

For the baseline and post-ERD injection performance monitoring events for targeted shallow zone groundwater, samples will be collected from one injection area monitoring well (MW-10) and from one downgradient observation well (ERD-OBSW-1S) to be installed as part of the pilot study. For the baseline and post-ERD injection performance monitoring events for targeted intermediate zone groundwater, samples will be collected from one targeted injection area monitoring well (MW-10I) and from one downgradient observation well (ERD-OBSW-1I) to be installed as part of the pilot study. MW-2 will also serve as the background sampling point for the ERD related monitoring program as well.

Groundwater samples will be collected using either a peristaltic or Grundfos pump. Dedicated Teflon®-lined tubing will be used to eliminate the potential for cross-contamination. New tubing will be used at each monitoring well to eliminate the potential for cross-contamination between monitoring locations. Purge rates will range from 100 to 500 milliliters per minute to prevent excessive drawdown. Groundwater field indicator parameters will be measured and recorded during well sampling. The

groundwater indicator parameters include pH, specific conductance, DO, ORP, temperature, and turbidity. The color of the water sample will also be recorded. Active RemOx®S is deep purple in groundwater. All water quality instrumentation will be calibrated prior to the monitoring event. Field sampling equipment is listed in **Table 5**.

Sample collection containers will be labeled with appropriate identifying information including sample location, sample identification, collection date and time, laboratory analyses to be performed, sampler's initials, and type of preservative. Samples will be placed on ice immediately after collection. Chain of custody forms and samples will be packed in coolers with ice. Custody seals will be affixed to the lid interface of each cooler to ensure that the samples have not been tampered with. Coolers will be shipped to the appropriate analytical laboratory. The baseline groundwater collected will be submitted to a State of South Carolina-certified analytical laboratory.

As shown in **Table 6**, groundwater samples collected during the baseline and quarterly post-injection performance monitoring events are intended to evaluate the effectiveness of ISCO and ERD with bioaugmentation at treating TCE and its degradation products.

All ISCO pilot study baseline groundwater samples will be analyzed for VOCs utilizing USEPA Method SW-846 Method 8260B. Additionally, the ISCO pilot study groundwater samples will be analyzed for total dissolved solids via Method 2540C, and chloride by Method 9056A.

All ERD pilot study baseline and quarterly post-injection groundwater samples will be analyzed for VOCs utilizing USEPA Method SW-846 Method 8260B. Additionally, biogeochemical parameters will be collected for all ERD groundwater samples and include nitrate, nitrite, sulfate, and chloride by SW 9056A, dissolved (laboratory filtered) and total iron by SW 6020A, methane/ethane/ethene by RSK-175, alkalinity by SM 2320B, and total organic carbon by SW 9060A. The collected ERD groundwater samples will also be analyzed for *Dehalobacter spp (DHB)*, *DHC* and specific enzymes (functional genes) responsible for reductive dechlorination of CVOCs using Census® analysis. Census® analysis uses a molecular biological tool called quantitative polymerase chain reaction for enumeration of specific microorganisms and/or genes encoding specific biological functions. *DHB* can degrade TCE to cis-1,2-DCE, whereas *DHC* can perform complete degradation (i.e., TCE to ethene).

Groundwater sampling protocol, including the sample containers, sample volume, sample preservation, and sample holding times for each analytical method is presented in **Table 7**.

ATTACHMENT E: EXSISTING OR PENDING STATE/FEDERAL PERMITS

The work at the Site will be conducted under Voluntary Cleanup Contract (VCC) number 14-6271-RP, effective in September 2014. The South Carolina Department of Health and Environmental Control (SCDHEC) is the primary regulatory contact. Prior to injection activities and as standard practice, SCDHEC will issue a UIC Permit to Construct and then issue a UIC Permit to Operate. However, because injection using DPT tools and equipment is a single-motion of advancing the drill string to depth followed by injection of ISCO or ERD solution as the DPT drill rods are pulled upward and removed from

the ground, the construction and operation are completed in a single phase and not as two separate phases separated by several days. As a result, AECOM is requesting that the UIC Permit to Construct and Permit to Operate be issued on the same date or consecutively so as not to inadvertently cause delays in completing the planned ISCO and ERD injection activities.

ATTACHMENT F: DESCRIPTION OF BUSINESS

The Site is located on US Highway 76, approximately 1-mile northwest of Newberry, South Carolina (**Figure 7**). The Site is centered on the Valmont Composite Structures facility (the Facility, formerly known as Shakespeare Composite Structures), and includes several surrounding properties (**Figure 8**). The facility was originally opened to produce fiberglass products and has continued to be used for this process. As previously described, operations at the facility include the design and manufacture of large fiberglass utility poles and cross arms, and a variety of other fiberglass outdoor products such as posts, signs, sheet piling, and signposts. Manufacturing is conducted inside two separate buildings – the Main Building and the Pole Winder Building. A more detailed description of the facility's operation is included in the Remedial Investigation (RI) Report (AECOM, 2018).

Several phases of investigative efforts have been conducted at the Site. This includes multiple efforts prior to execution of the VCC. The pre-VCC investigative efforts that were performed include:

- Phase II Environmental Site Assessment – Collection of initial soil and groundwater samples from the Shakespeare facility (February through April 2014);
- Site Investigation – Collection of additional soil and groundwater samples from the Shakespeare facility along with several groundwater samples from surrounding private parcels (May 2014 through August 2014); and
- Expanded Investigation - Collection of additional shallow groundwater samples and evaluation of shallow bedrock for impacted groundwater on surrounding properties (August through September 2014).

An RP-VCC between the SCDHEC and Philips Electronics North America Corporation was executed in September 2014. Once this VCC was executed, investigative efforts were performed as part of the RI process.

The RI was implemented in two phases, beginning in 2014 after execution of the VCC. The RI was conducted to further evaluate the horizontal and vertical extent of previously identified CVOCs in soil and groundwater; assess additional potential areas of interest for either secondary sources of VOCs that could be contributing to soil and/or groundwater impacts; evaluate potential vapor intrusion pathways; determine risk to potential human and ecological receptors; and provide additional data needed to develop a remedial strategy for the Site.

RI efforts determined that the source areas for CVOCs present in groundwater originated from historical operational practices that impacted groundwater beneath the western portions of the Main and Pole Winder Buildings located on the facility property. CVOCs subsequently migrated both horizontally and vertically within groundwater away from the identified source areas and impacted multiple aquifer depth intervals beyond the facility property.

The RI defined the extent of CVOC-impacted groundwater at multiple aquifer depth intervals. Analytical results were screened against USEPA maximum contaminant levels (MCLs) to identify compounds of interest in groundwater beneath the Site. Concentrations of TCE, cis-1,2 dichloroethene (cis-1,2-DCE), and vinyl chloride exceeded their respective MCLs in several groundwater samples collected from the Site. Of these, TCE was the most frequently detected chemical in groundwater samples collected at the Site. The elevated concentrations of CVOCs are most widespread in shallow zone groundwater (upper portion of the water table aquifer). TCE and cis-1,2-DCE also exceeded their respective MCLs in one or more samples collected in the intermediate (saprolite) zone.

ATTACHMENT G: AREA OF REVIEW

The proposed ISCO and ERD injection Area of Review includes a fixed radius of ¼ mile that is centered between both pilot study areas. This Area of Review is shown on **Figure 9**.

ATTACHMENT H: MAPS OF WELLS AND AREA OF REVIEW

1) A topographic map extending one mile beyond the property boundaries is attached as **Figure 10**.

2) All monitoring wells within the Area of Review are shown on **Figure 9**. The well construction details for the monitoring wells at Site are provided in **Table 1**. A short-term, hazardous waste storage area, which is primarily used for spent acetone and used in the fiberglass product manufacturing process at the Site is also shown on **Figure 9**.

3) The proposed ISCO injection event will only target shallow zone groundwater while the ERD and bioaugmentation injection events will target both shallow zone and intermediate zone groundwater. Potentiometric maps of shallow zone and intermediate zone groundwater at the Site based on June 2018 groundwater level measurements are provided as **Figures 11 and 12**, respectively.

ATTACHMENT I: CROSS SECTIONS/DIAGRAMS/DISCUSSION

The geology of the Site and immediate vicinity consists in descending order from the ground surface of fill, residuum, saprolitic soils, weathered granitic bedrock, and granitic bedrock. A site map illustrating orientation of cross sections and four associated cross sections are provided in **Appendix B**. These cross-sections illustrate the general occurrence of the lithologic units beneath the Site and the relative locations of Site monitoring wells and their screened intervals.

Shallow soils (from land surface to approximately 6 ft bgs) encountered beneath the Shakespeare facility appear to be fill material placed during construction of the original buildings. Shallow residuum-related sediments encountered beneath the fill material on the facility and other areas generally consist of pale brown and reddish-brown fine-grained sands and silt to silts and silty clay with sand. The thickness of the residuum sediments vary across the Site ranging from as little as three feet to up to ten feet. These soils

have been severely weathered and contain little to no rock fabric texture and consist of varying percentages of sand, silt, and clay.

The residuum grades downward to a less weathered saprolitic zone with varying percentages of sands, silts, and clay. Saprolitic soils are differentiated from the residuum in this area by color and visually evident relict rock fabric or structure. The residuum soils are more consistent in color, while the saprolitic soils contain sediments of varying color related to degradation of the granitic parent rock minerals (white to pale red – feldspar, gray – quartz, dark gray to black – biotite and hornblende). The saprolitic soils range from one foot to more than ten feet in thickness across the Site.

The saprolitic soils are underlain by bedrock consisting of granite and/or granitic gneiss. The majority of the Site is underlain primarily by an aphanitic (fine grained) granite. The bedrock content appears to change to more of a granitic gneiss beneath the west-southwest portion of the Site (AECOM, 2018).

ATTACHEMENT J: NAMES AND DEPTH OF UNDERGROUND SOURCES OF DRINKING WATER

No underground sources of drinking water will be affected by the planned ISCO and ERD injection events. RemOx®S will only be injected into shallow zone groundwater underneath the facility between 11 ft bgs and 21 ft bgs to treat an area approximately 550 square feet in size. Drinking water for the facility is provided through the local municipal water supply (i.e., Newberry County Water and Sewer Authority).

ABC®+Olé and the additional ERD amendments will be injected into the shallow zone aquifer between 10 ft bgs and 20 ft bgs to treat an area approximately 1,500 square feet in size. These same compounds will be injected into the intermediate zone aquifer between 31 ft bgs and 41 ft bgs to treat an area 1,500 square feet in size. Groundwater is not used as a drinking water source on the Dickert property where the ERD pilot study will be conducted.

ATTACHMENT K: HYDRAULIC CONTROL

The proposed ISCO injection event will target the shallow groundwater zone in the vicinity of TMW-31 while the ERD and bioaugmentation injection events will target shallow and intermediate groundwater zone in the vicinity of MW-10 and MW-10I, respectively. Groundwater elevation and flow maps for shallow and intermediate zone groundwater are provided as **Figures 11 and 12**, respectively.

In general, the water table at the Site is encountered in the fine sands and silts and clays of the residuum. Groundwater is encountered at depths ranging from approximately two ft bgs near the northern end of the Site and on the Dickert property to as deep as approximately 18 ft bgs on the former Shakespeare facility. Groundwater beneath the Site is mainly encountered under unconfined conditions.

As a result, the direction of groundwater flow beneath this site, particularly in the shallow (water table) zone follows topography, with flow components to the west and northwest. CVOCs have migrated within the water table and saprolite zones primarily through natural dispersion. Vertical migration of CVOCs

downgradient of the source areas within the saprolite and into underlying granitic bedrock was influenced primarily by numerous privately-operated water supply wells located to the west and southwest of the Facility.

Based on the groundwater elevations determined during the June 2018 measurement event, the average horizontal hydraulic gradients for the shallow and intermediate zones were determined to be 0.016 feet per foot (ft/ft) to the west-northwest and 0.014 ft/ft to the west-northwest, respectively. A downward gradient between the shallow and intermediate zones was observed across the Site during the June 2018 event. During Phase II of the RI, hydraulic conductivity tests (slug tests) were conducted on select shallow and intermediate zone monitoring wells. The results of the slug tests indicated an average hydraulic conductivity of 0.80 feet per day (ft/day) and 0.72 ft/day for the shallow and intermediate zone, respectively. Based on an assumed effective porosity of 0.25, the calculated groundwater velocity for the shallow zone groundwater is approximately 0.05 ft/day or 18.25 feet per year (ft/yr). Using an assumed effective porosity of 0.3, the calculated groundwater velocity for the intermediate zone groundwater is approximately 0.03 ft/day or 10.95 ft/yr.

Existing monitoring wells TMW-29 and TMW-31 and temporary observation well ISCO-OBSW-1S for the ISCO pilot study and existing monitoring wells MW-10 and MW-10I and temporary observation wells ERD-OBSW-1S and ERD-OBSW-1I will be sampled as part of the Site post-injection performance monitoring program to demonstrate lateral hydraulic control as previously described in **Attachment D**.

REFERENCES

AECOM, 2018. Remedial Investigation Report, Shakespeare Composite Structures, Newberry, South Carolina. November 2018.

FIGURES

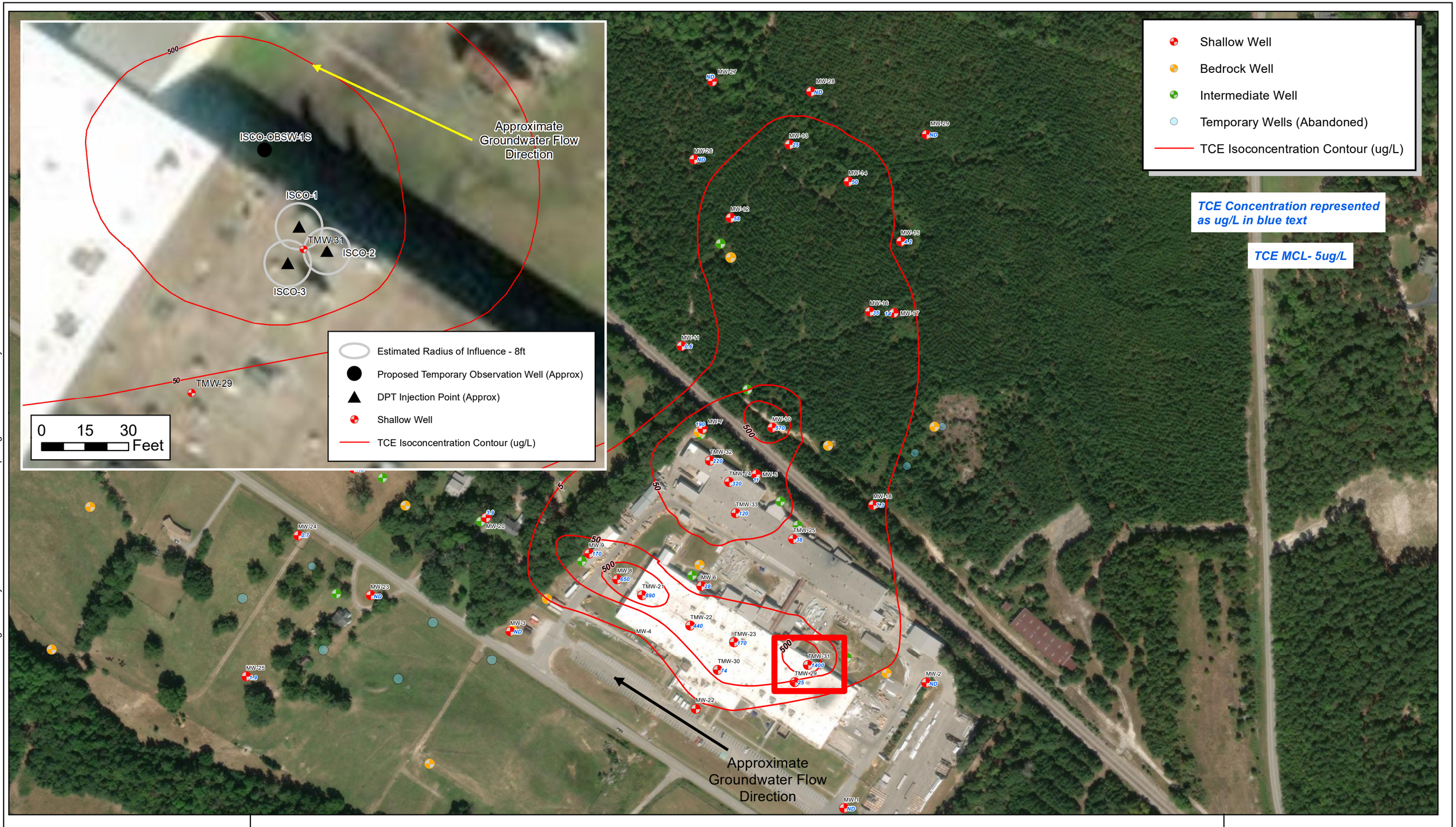

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Figure 1: ISCO Pilot Study Area - Shallow Zone

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/21/20.

Notes:
ISCO - In Situ Chemical Oxidation

N W E S

0 125 250 500 Feet

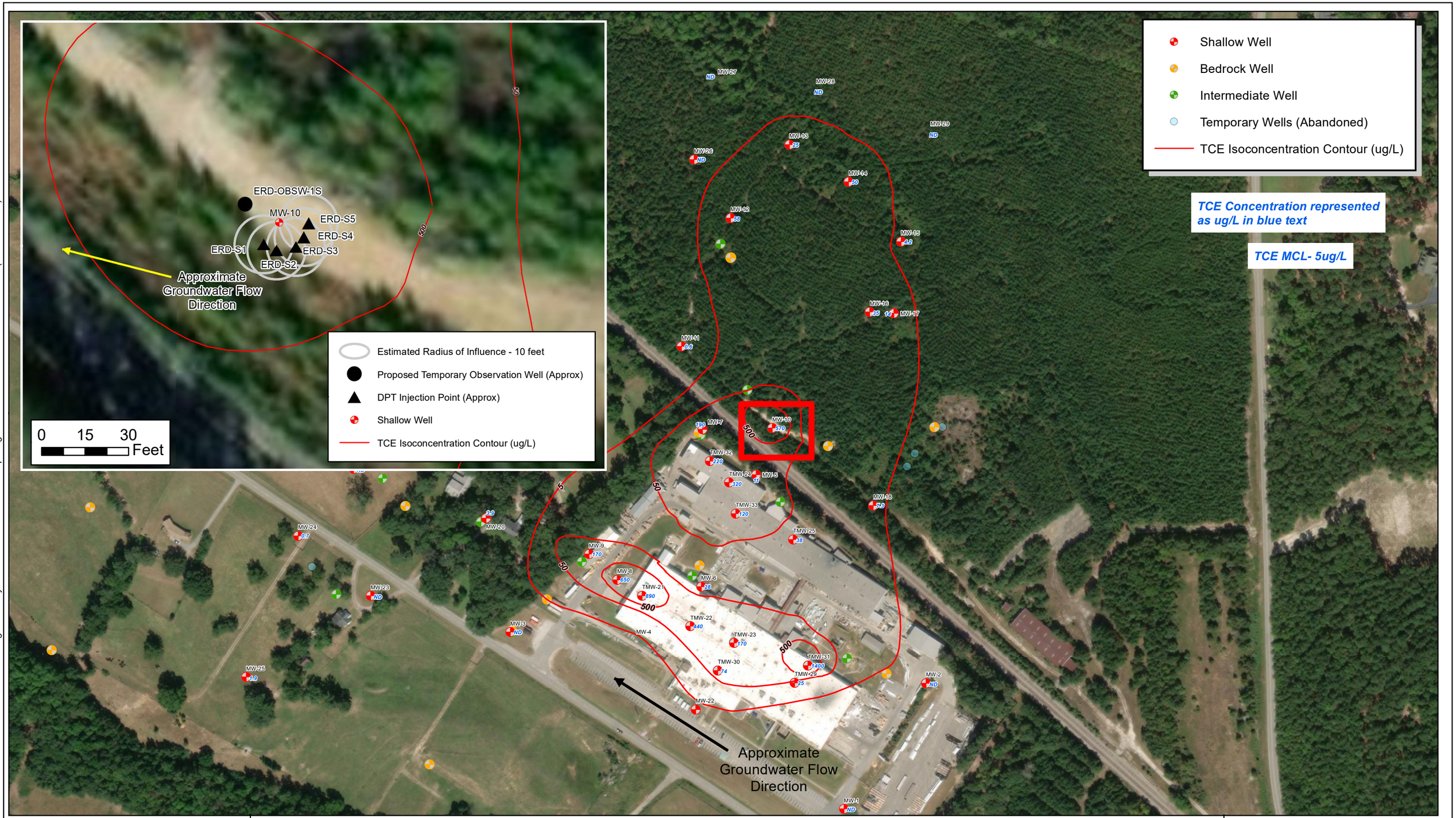

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Figure 2: Enhanced Reductive Dechlorination (ISB and ISCR) Pilot Study Area - Shallow Zone

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/11/20.

Note:
ISB - In Situ BioRemediation
ISCR - In Situ Chemical Remediation

N W E S

0 125 250 500 Feet

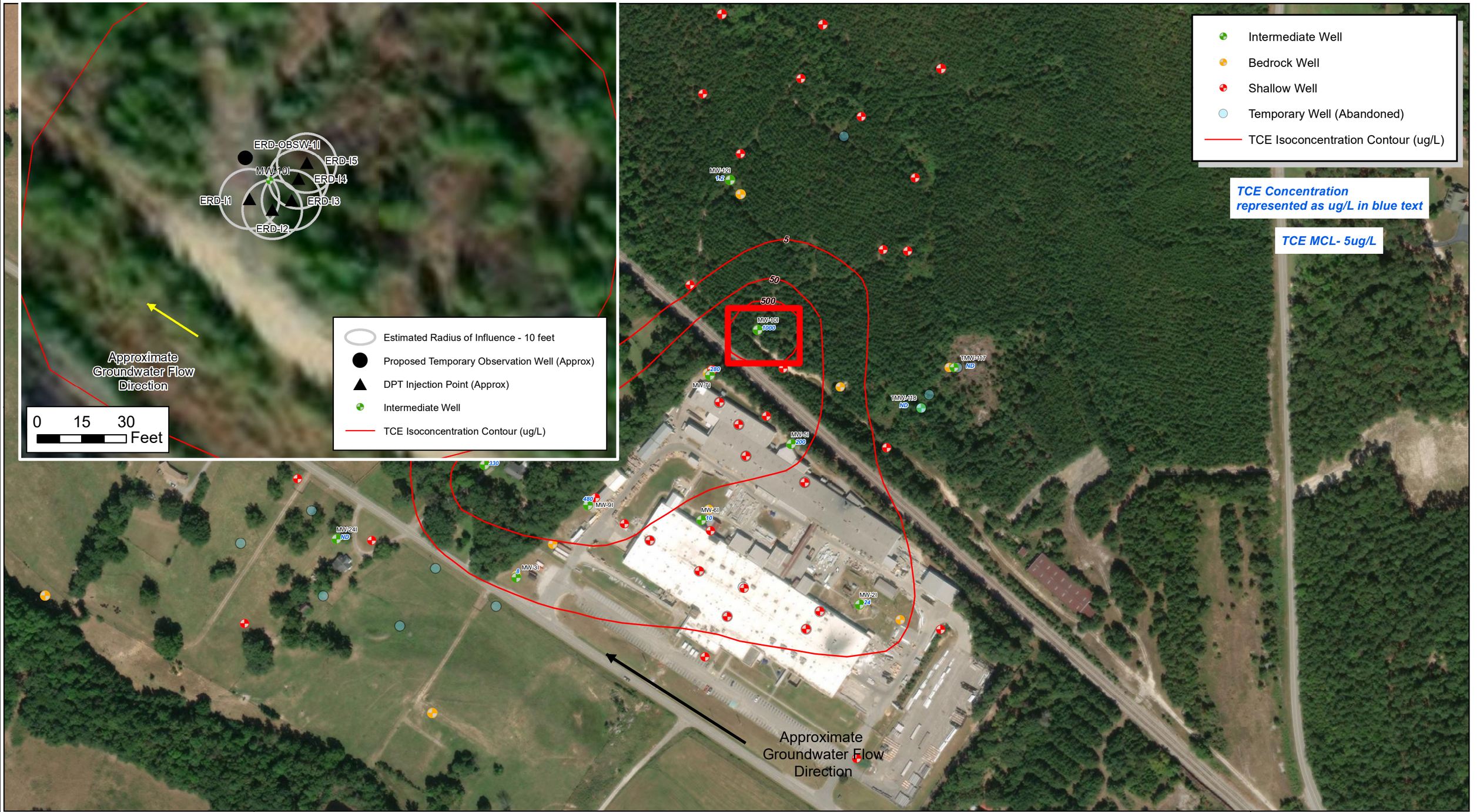

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Figure 3: Enhanced Reductive Dechlorination Pilot Study Area (ISB and ISCR) - Intermediate Zone

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/21/20.

Notes:
ISB - In Situ BioRemediation
ISCR - In Situ Chemical Reduction

N
W E
S

0 250 500 Feet

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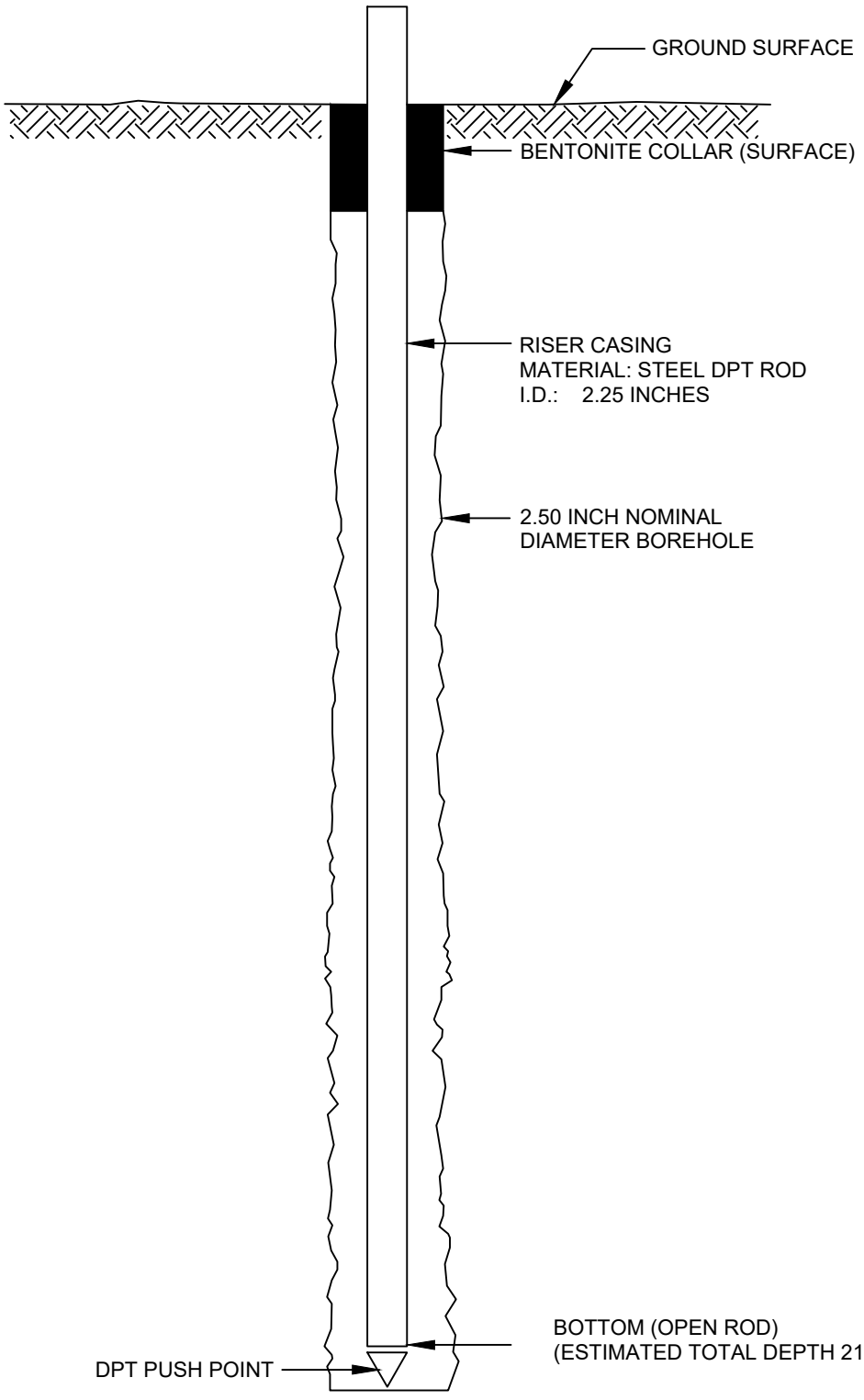

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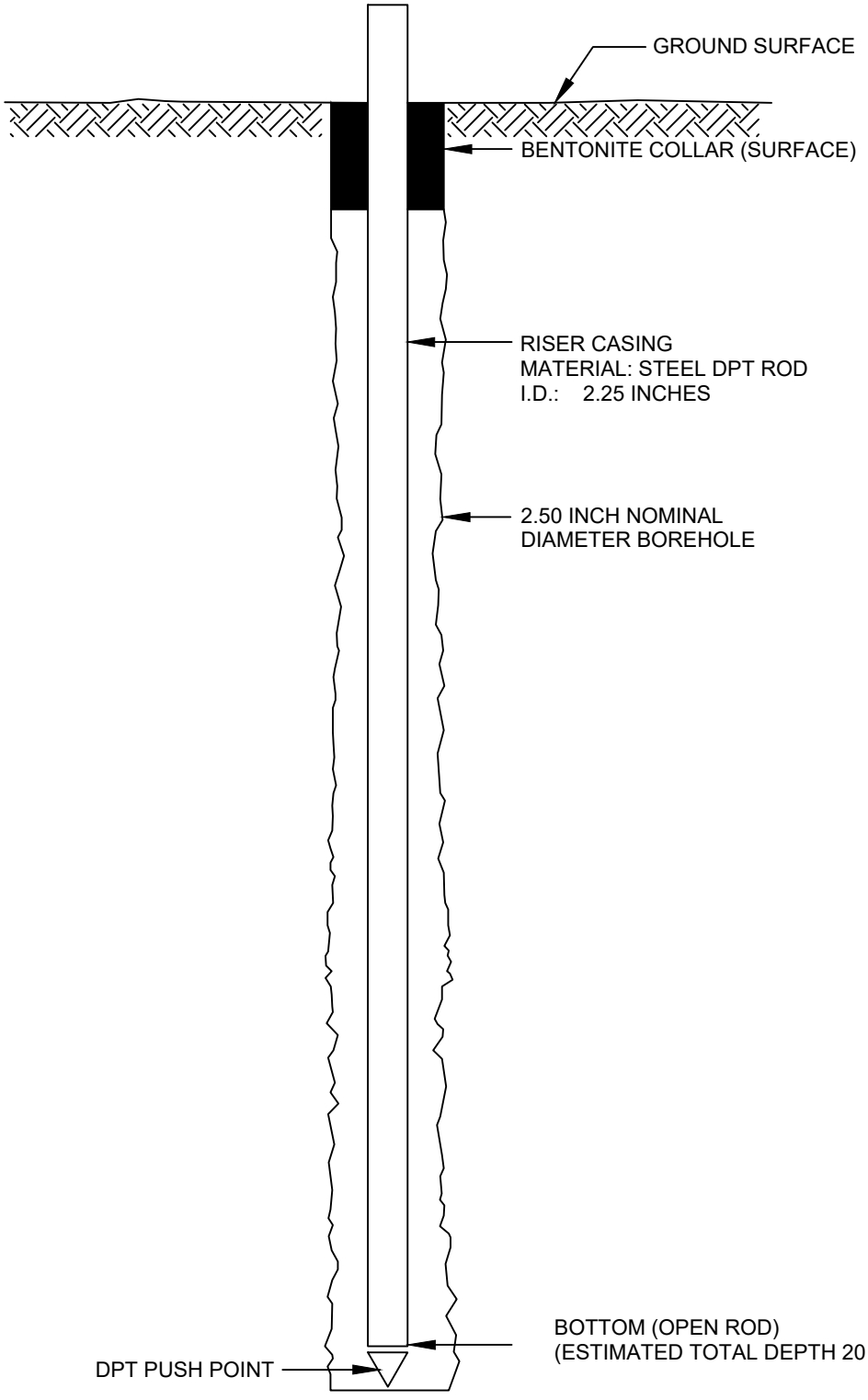
TYPICAL DPT INJECTION POINT DETAIL
ISCO PILOT STUDY - SHALLOW ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
NEWBERRY, SOUTH CAROLINA

PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 4**



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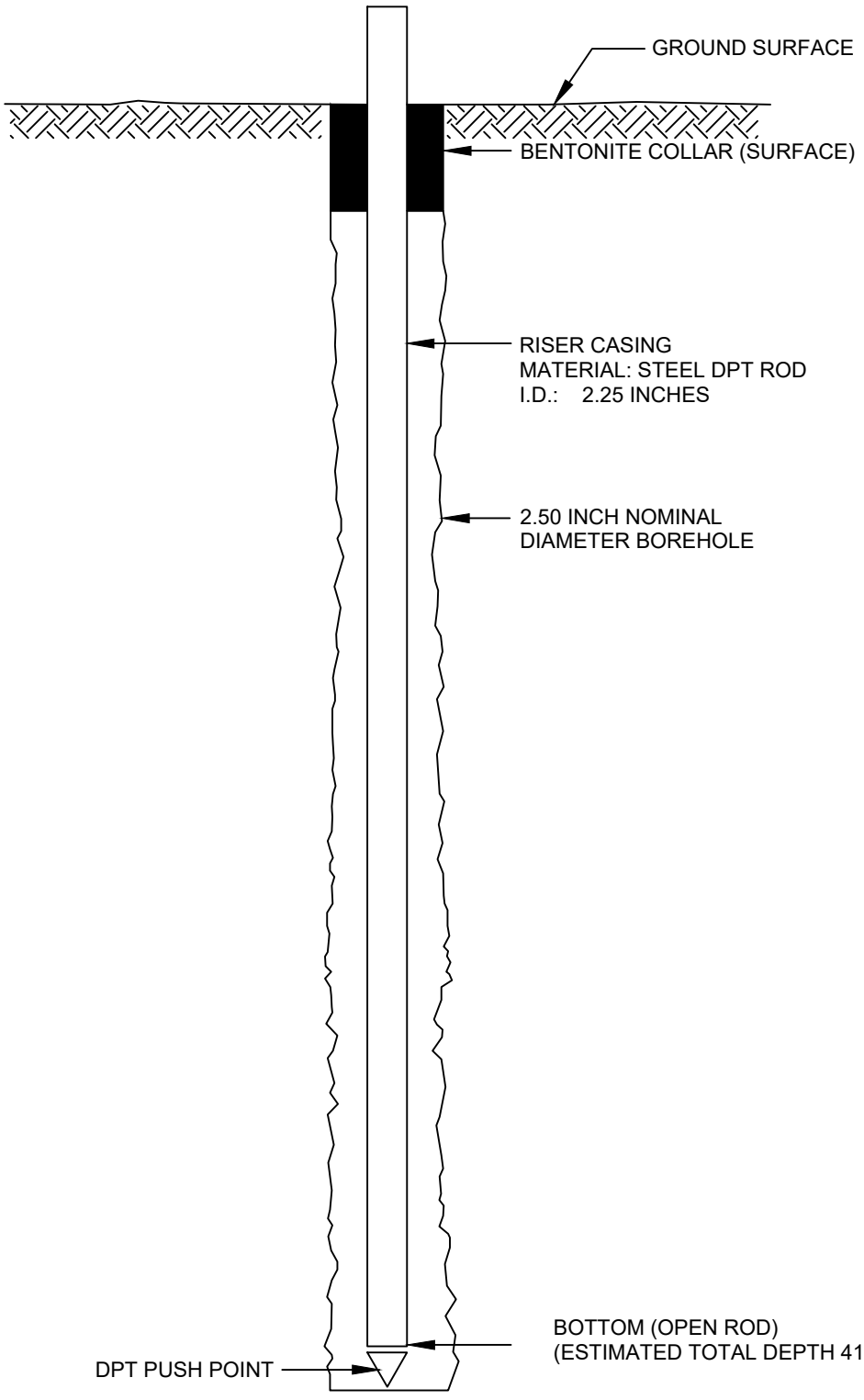
TYPICAL DPT INJECTION POINT DETAIL
ERD PILOT STUDY - SHALLOW ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
NEWBERRY, SOUTH CAROLINA

PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 5**



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TYPICAL DPT INJECTION POINT DETAIL
ERD PILOT STUDY - INTERMEDIATE ZONE

SHAKESPEARE COMPOSITE STRUCTURES SITE
NEWBERRY, SOUTH CAROLINA

PROJECT NO.	DRAWN BY:	DATE:	
60635197	RJS	09/11/2019	**FIGURE 6**

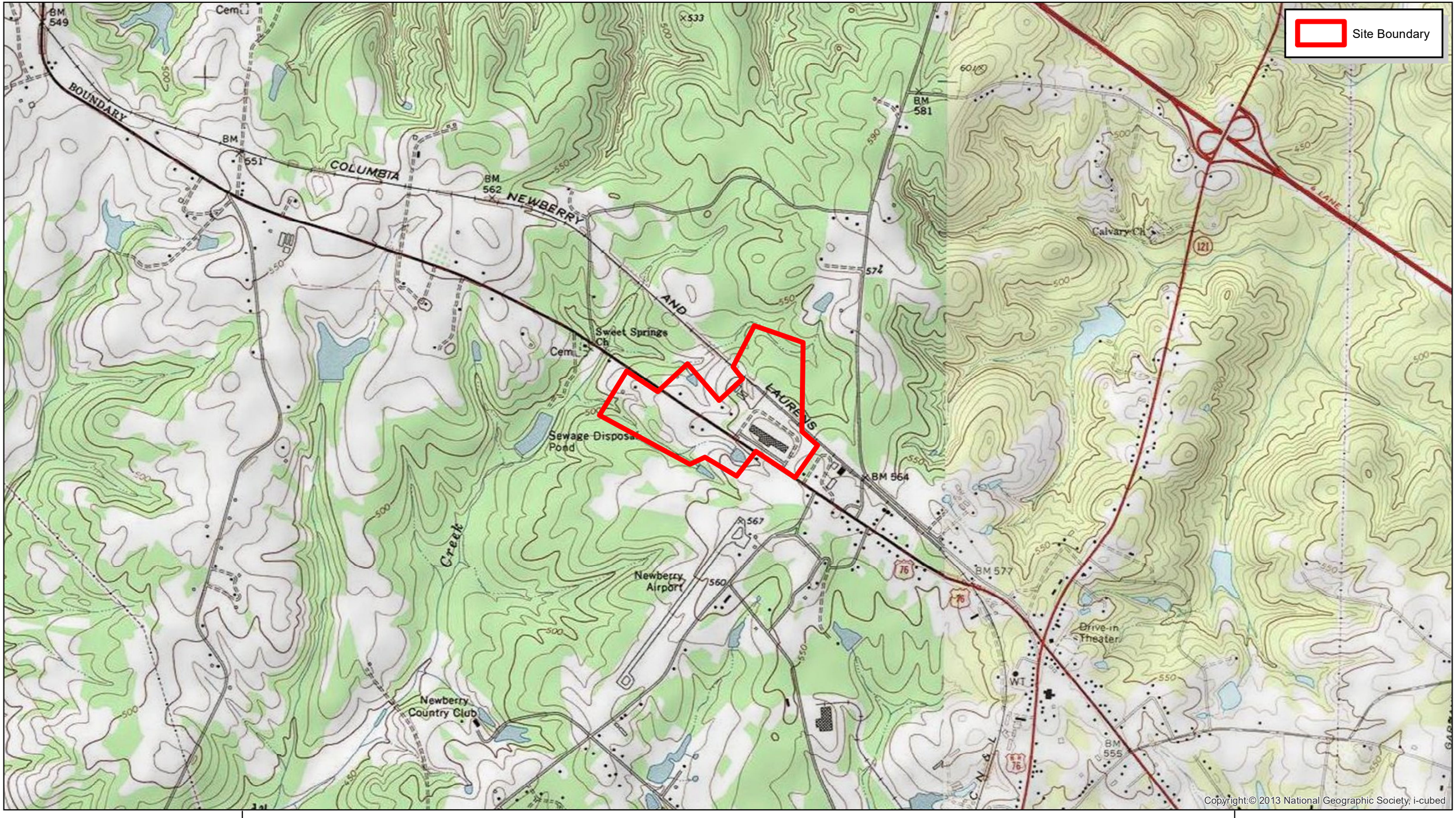

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Figure 7: Site Location Map

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 9/10/20

N
W E
S

0 750 1,500 3,000 Feet

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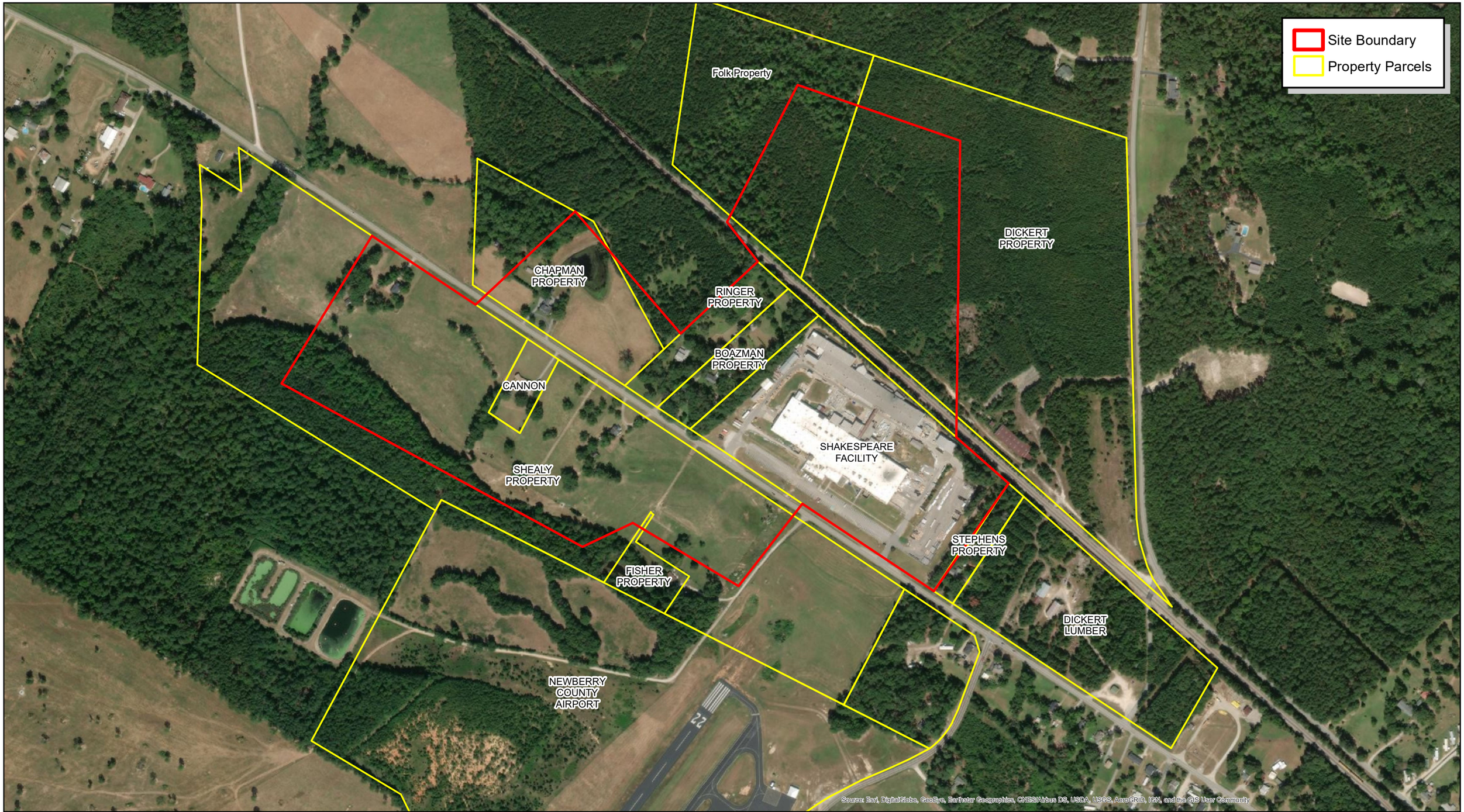

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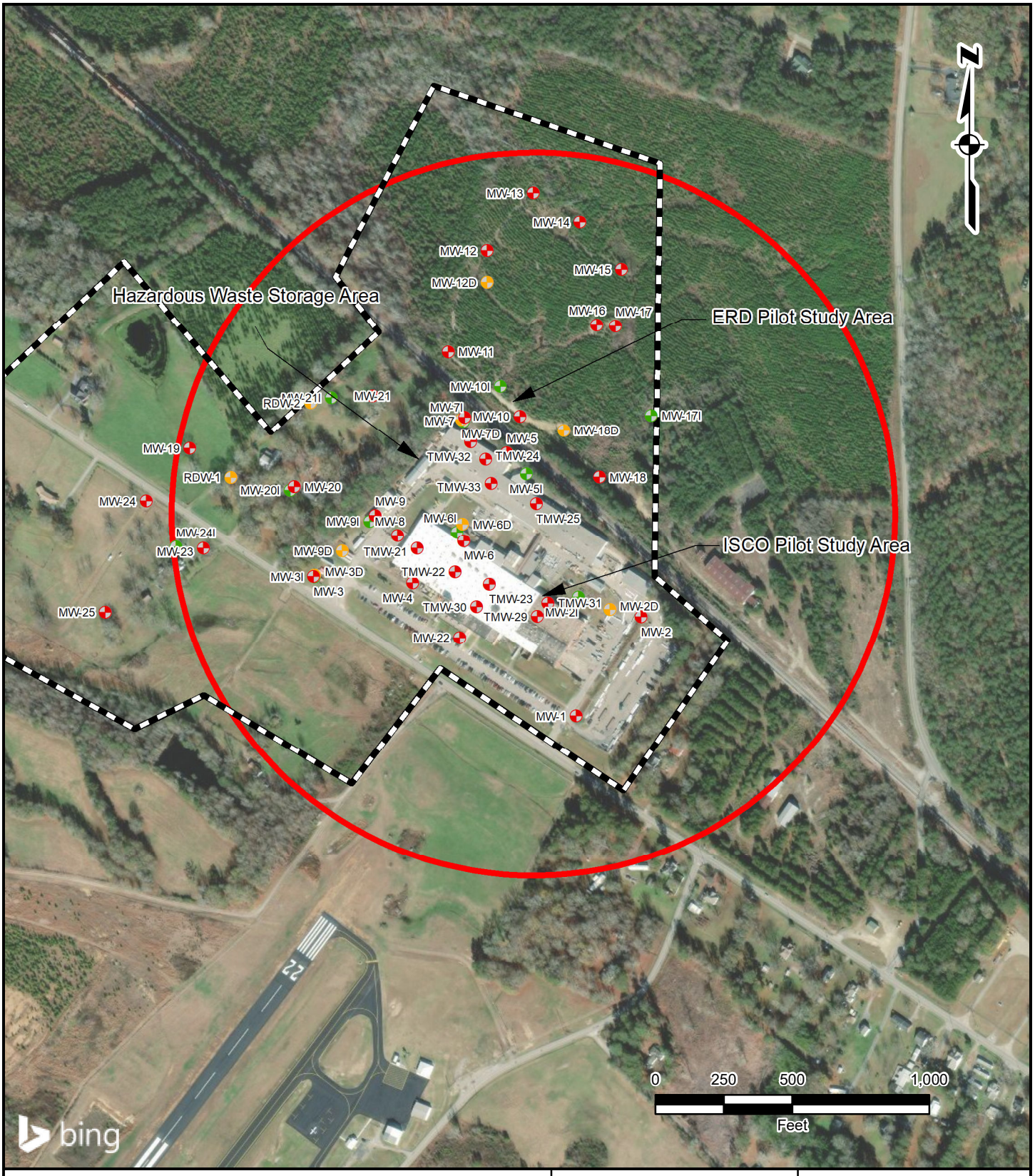
Figure 8: Site Plan

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/10/20

N
W E
S

0 225 450 900 Feet



Shallow Well
Intermediate Well
Bedrock Well
Site Boundary
Area of Review

Service Layer Credits (Aerial):
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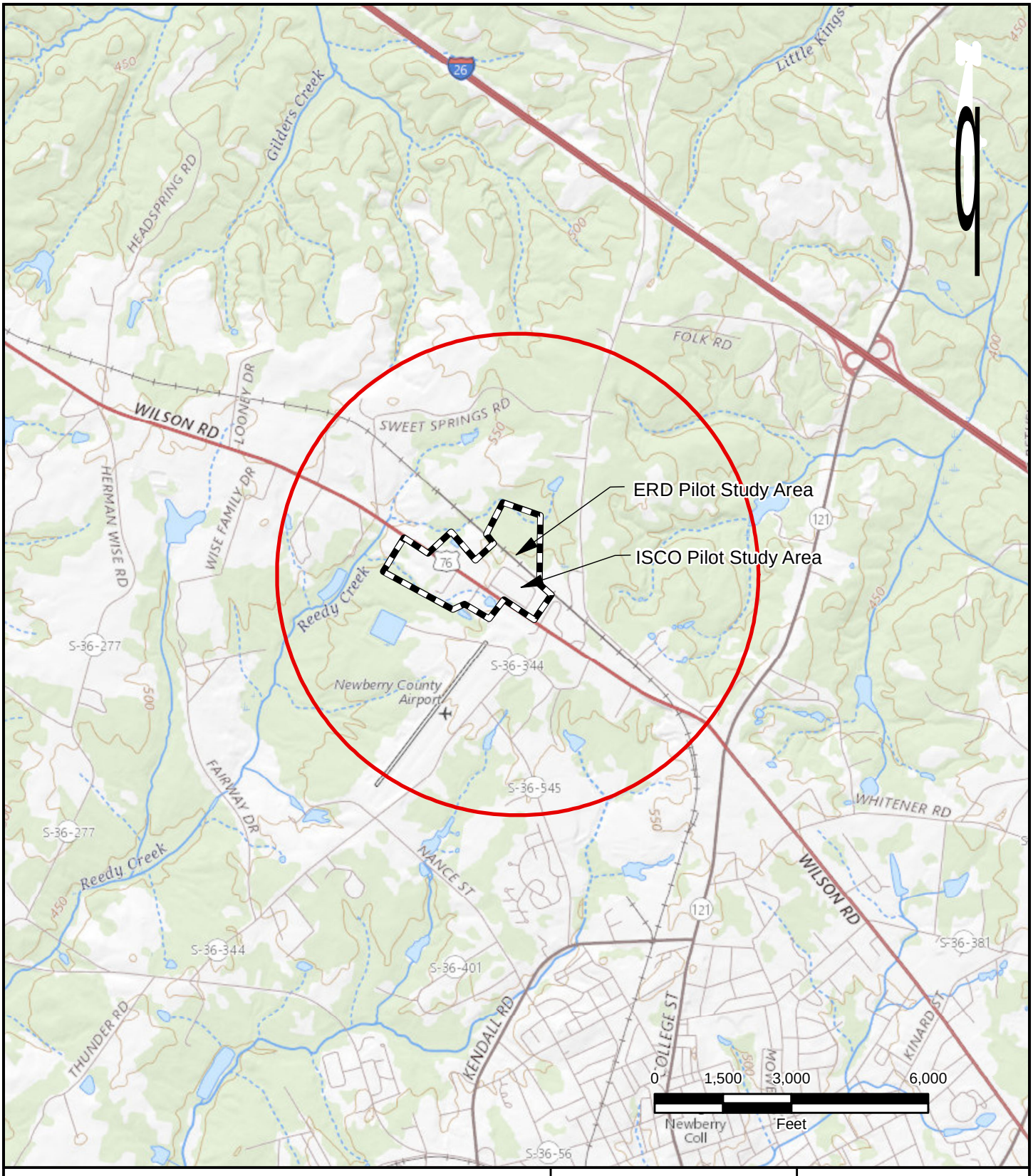
FIGURE 9
Full Scale Area of Review

Shakespeare Composite Structures Site
Newberry, South Carolina

60635197



1-Mile Radius

Site Boundary

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FIGURE 10
Topographic Map

Shakespeare Composite Structures Site
Newberry, South Carolina

60635197

Service Layer Credits (Topo):
USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program.

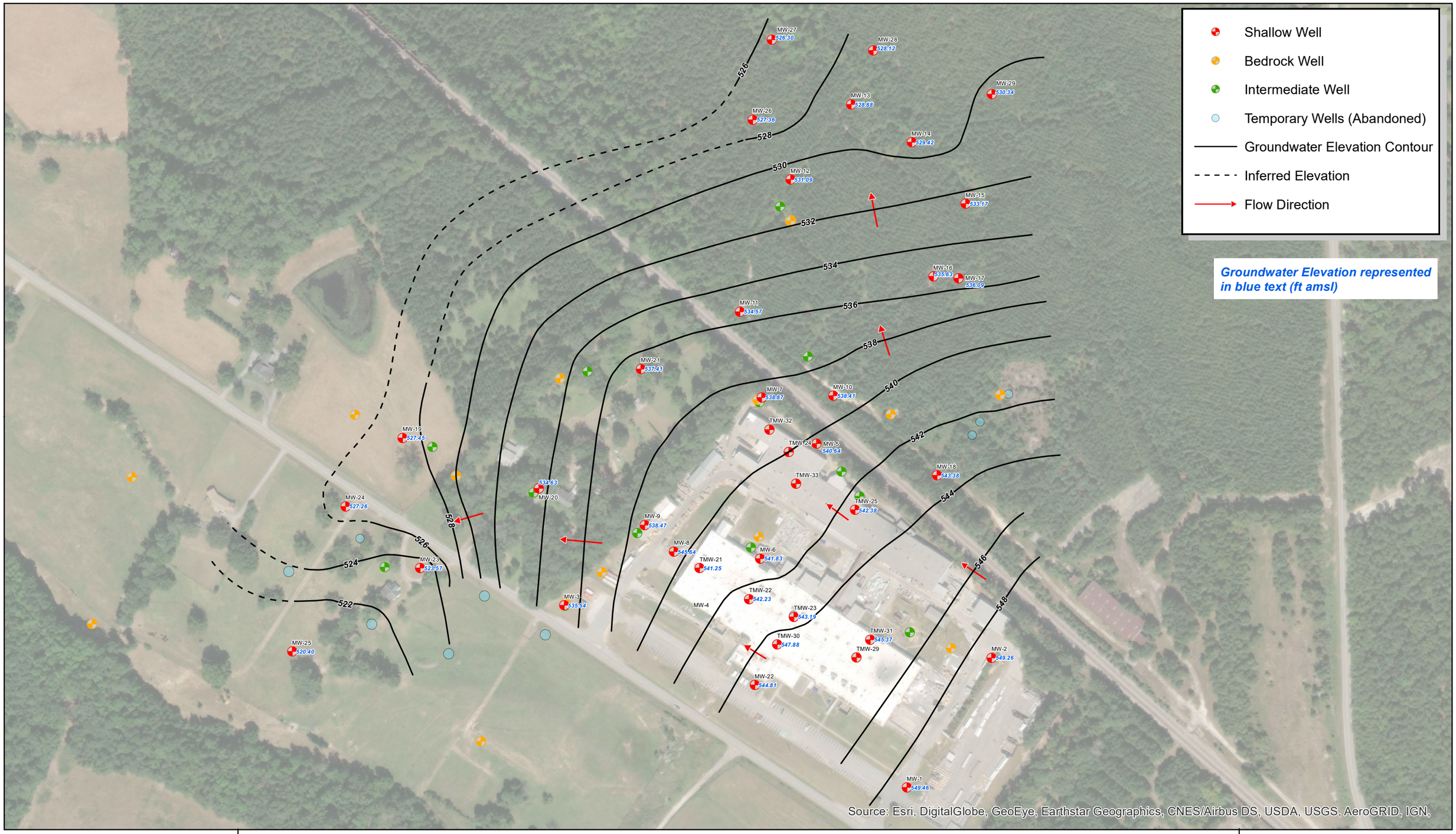

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Figure 11: Shallow Zone Groundwater Elevation Map - June 2018

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/21/20.

Note:
ft amsl - Feet Above Mean Sea Level

N
W E
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0 125 250 500 Feet

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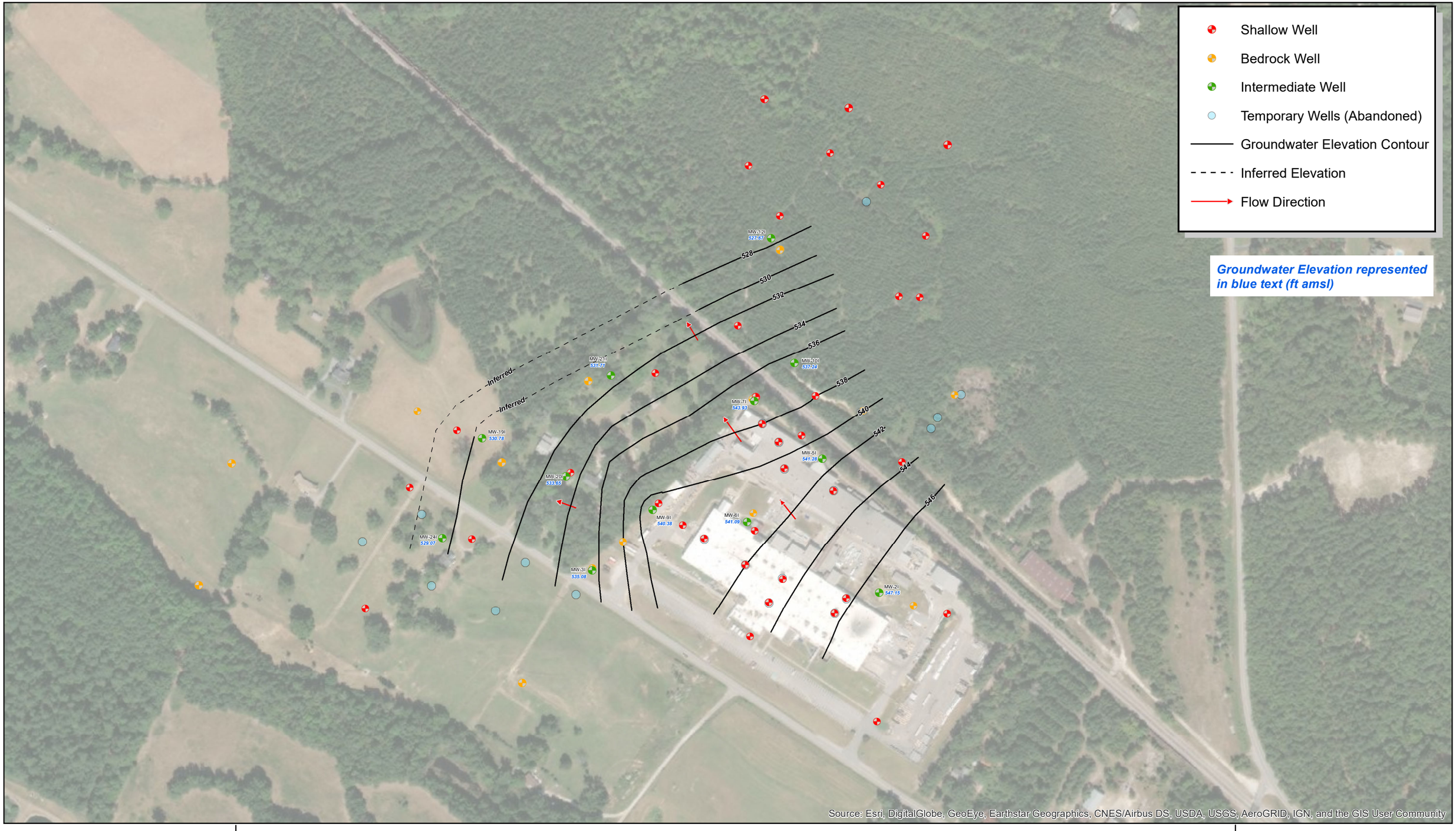

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Figure 12: Intermediate Zone Groundwater Elevation Map - June 2018

Shakespeare Composition Structures
Newberry, South Carolina

Project No.: 60635197; Prepared by: KA; Date: 09/21/20

Note:
ft amsl - Feet Above Mean Sea Level

N
W E
S

0 150 300 600
Feet

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TABLES

Table 1
Permanent Monitoring Well Construction Details
Shakespeare Composite Structures Site
Newberry, South Carolina

Well ID	Date of Installation	Location and Purpose	TD	Screen Interval (feet)	Diameter	Material	TOC Elevation (ft amsl)	Ground Elevation (ft amsl)	Depth to Bedrock (feet)	Top of Bedrock Elevation (ft amsl_	TD Elevation (ft amsl)
Shallow Wells											
MW-1	4/10/2014	Former Shakespeare property. Permanent well installed at former location of TMW-8	14.2	4.2 - 14.2	2 inch	Sch 40 PVC	561.85	561.85	15	546.85	547.65
MW-2	4/10/2014	Former Shakespeare property, Permanent well installed at former location of TMW-7	24.7	14.7-24.7	"	"	558.42	558.42	----	----	533.72
MW-3	4/10/2014	Former Shakespeare facility property - southwest corner of plant property	26	14.7-24.7	"	"	549.00	549.00	----	----	523.00
MW-4	4/11/2014	Former Shakespeare property. Permanent well installed at former location of TMW-3	26	15.2-25.2	"	"	560.13	560.13	----	-----	534.13
MW-5	4/14/2014	Former Shakespeare property. Permanent well installed at former location of TMW-11	26	15.8-25.8	"	"	557.74	557.74	----	-----	531.74
MW-6	4/14/2014	Former Shakespeare property. Permanent well installed at former location of TMW-5	26	15.7-25.7	"	"	561.32	561.32	----	----	535.32
MW-7	4/15/2014	Former Shakespeare property. Permament well installed at former location of TMW-16	26	14.8-24.8	"	"	554.72	554.72	----	----	528.72
MW-8	4/15/2014	Former Shakespeare property. Permament well installed at former location of TMW-13	26	15.5-25.5	"	"	558.27	558.27	----	-----	532.27
MW-9	4/16/2014	Former Shakespeare property. Permament well installed at former location of TMW-17	26	15.8-25.8	"	"	556.36	556.36	----	----	530.36
TMW-21	5/21/2014	Former Shakespeare property - west end of main building. Temporary well converted to permanent well.	23.5	13.5-23.5	1 inch	"	550.96	550.96	----	-----	527.46
TMW-22	5/21/2014	Former Shakespeare property - west end of main building. Temporary well converted to permanent well.	25	15-25	"	"	548.23	548.23	----	-----	523.23
TMW-23	5/27/2014	Former Shakespeare property - central portion of main building. Temporary wel onverted to permanent well.	25	15-25	"	"	537.03	537.03	----	-----	512.03
TMW-24	5/29/2014	Former Shakespeare property - west end of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	531.12	531.12	----	-----	506.12
TMW-25	5/29/2014	Former Shakespeare property - central portion of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	532.07	532.07	----	-----	507.07
TMW-29	6/3/2014	Former Shakespeare properrty - east central portion of main building. Temporary well converted to permanent well.	13	8-13	"	"	536.41	536.41	----	-----	523.41
TMW-30	6/3/2014	Fomrer Shakespeare property - Inside south central portion of main building. Temporary well converted to permanent well.	25	15-25	"	"	543.34	543.34	----	-----	518.34
TMW-31	6/3/2014	Former Shakespeare property - Inside north portion of main building. Temporary well converted to permanent well.	21	11-21	"	"	542.24	542.24	----	-----	521.24
TMW-32	6/4/2014	Former Shakespeare property - Inside northwest corner of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	551.59	551.59	----	-----	526.59
TMW-33	6/4/2014	Former Shakespeare property - Inside west central portion of pole winder building. Temporary well converted to permanent well.	25	15-25	"	"	531.58	531.58	----	-----	506.58
MW-10	8/4/2015	Dickert property - Former Location of TMW-42	30.32	20.3 - 30.3	2 inch	Sch 40 PVC	550.96	550.96	42	508.96	520.64
MW-11	"	Dickert property - Former Location of TMW-87	30.32	20.3 - 30.3	"	"	548.24	548.24	----	----	517.92
MW-12	"	Dickert property - Former Location of TMW-73	31.37	20.37 - 30.37	"	"	537.03	537.31	----	----	505.94
MW-13	"	Dickert property - Former Location of TMW-89	25.29	15.29 - 25.29	"	"	531.19	531.16	14	517.16	505.87
MW-14	8/5/2015	Dickert property - Former Location of TMW-95	20.22	10.22 - 20.22	"	"	532.07	531.97	----	----	511.75
MW-15	"	Dickert property - Former Location of TMW-98	11.63	1.63 - 11.63	"	"	536.41	536.32	----	----	524.69
MW-16	"	Dickert property - Fomer Location of TMW-99	20.29	10.29 - 20.29	"	"	543.35	543.23	----	----	522.94
MW-17	"	Dickert property - east of MW16	30.27	10.59 - 20.59	"	"	542.37	542.36	----	----	512.09
MW-18	8/3/2015	Dcikert property - Former Location of TMW 72	23.67	13.67 - 23.67	"	"	551.58	551.6	18	533.60	527.93
MW-19	8/6/2015	Chapman property - Former Location of TMW-105	14.77	4.77 - 14.77	"	"	531.58	531.59	11	520.59	516.82
MW-20	"	Boazman property - Former Location of TMW -38/102	35.3	25.3 - 35.3	"	"	541.92	541.86	----	----	506.56
MW-21	8/7/2015	Ringer property - South of TMW-39	24.17	14.17 - 24.17	"	"	548.24	548.28	----	----	524.11
MW-22	8/26/2015	Former Shakespeare property - South of entrance to main building	26.2	16.2 - 26.2	"	"	560.01	560.2	----	----	534
MW-23	12/15/2015	Shealy property - Former Location of TMW-107	25	10-20	"	"	543.48	543.75	----	----	518.75
MW-24	12/16/2015	Shealy property - Former Location of TMW-109	30	20 - 30	"	"	541.35	541.35	----	----	511.35
MW25	2/27/2016	Shealy property - Southwest of MW24I and MW23	30	20 - 30	"	"	535.60	535.5	30	505.50	505.5
MW-26	3/26/2018	Dickert property - north of MW-13	24.5	14.5 - 24.5	1 inch	Sch 40 PVC	533.67	533.88	---	---	509.38
MW-27	3/27/2018	Dickert property - north of MW-14	30	20 - 30	"	"	530.65	530.62	----	----	500.62
MW-28	3/27/2018	Folk property - west-northwest of MW-12	23.5	13.5 - 23.5	"	"	532.43	532.23	----	----	508.73
MW-29	3/27/2018	Folk property - northwest of MW-12	24	14 - 24	"	"	539.53	539.79	----	----	515.79
Intermediate Wells											
MW-2I	8/18/2015	Former Shakespeare property - west of MW-2	46.5	36.5 - 46.5	"	"	559.97	560.19	50	510.19	513.69
MW-3I	8/11/2015	Former Shakespeare property - adjacent to MW-3	54.73	44.7 - 54.7	"	"	548.84	548.96	----	----	494.23
MW-5I	8/19/2015	Fomer Shakespeare property - east of MW-5	57	47 - 57	"	"	559.70	559.6	56	503.60	502.6
MW-6I	8/21/2015	Former Shakespeare property - adjacent to MW-6	50	40 - 50	"	"	560.28	560.19	----	----	510.19
MW-7I	8/20/2015	Fomrer Shakespeare property - adjacent to MW-7	47.1	37.1 - 47.1	"	"	560.07	555.3	----	----	508.2
MW-9I	8/21/2015	Former Shakespeare property - adjacent to MW-9	47.6	37.6 - 47.6	"	"	556.07	556.08	----	----	508.48
MW-10I	8/24/2015	Dickert property - northwest of MW-10	41	31 - 41		"	548.4	548.5	----	----	507.5
MW-12I	6/12/2017	Dickert property - south of MW-12	47	36.8 - 46.8			536.6	536.44	----	----	489.44
MW-19I	5/6/2017	Chapman property - east of MW-19	23	17.6 - 22.6			536.4	536.51	----	----	513.51
MW-20I	8/11/2015	Boazman property - adjacent to MW-20, former Location of TMW-36	53.11	43.1 - 53.1	"	"	541.25	541.51	----	----	488.4
MW-21I	8/10/2015	Ringer property - adjacent to MW-2I	54.83	44.8 - 54.8	"	"	552.82	552.9	49	503.90	498.07
MW24I	2/18/2016	Shealy property - southwest of MW23	35	35 - 30	"	"	544.99	545.06	31	514.06	510.06

Notes:

Monitoring well targeted by ISCO pilot study.
Monitoring wells targeted by ERD pilot study.

ft amsl - feet above mean sea level
ERD - Enhanced Reductive Dechlorination
ISCO - In Situ Chemical Oxidation
PVC - polyvinyl chloride

Table 2
ISCO Injection Design and Reagent Demand Summary
Shakespeare Composite Structures Site
Newberry, South Carolina

Shallow Groundwater Zone ISCO Injection - Near TMW-31		
Injection Design Parameter	**Units**	**Injection Zone Details**
Targeted Injection Interval	feet bgs	11 to 21
Interval	feet	10
Area	square feet	550
Total Treatment Volume	cubic feet	5,500
Total Volume	cubic yards	204
Total Volume	cubic meters	155.74
Estimated Effective Porosity		0.25
Pore Volume	cubic feet	1,375
Number of Injection Points	----	3
Estimated Injection Point ROI	feet	8.0
Targeted % of Pore Volume		0.22
Total Injection Volume	gallons	2,263
Total Injection Volume (Rounded)	**gallons**	**2,260**
Volume Per Injection Point	gallons	754
Volume Per Injection Point (Rounded)	**gallons**	**750**
Number of Injection Intevals	----	5
Volume Per Injection Interval	**gallons**	**150**
Estimated Soil Density	kilograms per cubic meter	1,600
Plume Soil Mass	kilograms	249,188
Estimated TOD	grams per kilogram	1.50
Total RemOx®S	grams	373,782
Total RemOx®S	pounds	824
Total RemOx®S (Rounded)	**pounds**	**830**
RemOx®S per Injection Location	**pounds**	**277**
Estimated Injection Duration	days	2

Notes:

bgs - below ground surface

DPT - direct push technology

ISCO - In-Situ Chemical Oxidation

RemOx®S - RemOx®S ISCO Reagent

ROI - Radius of Influence

TOD - total oxidant demand

Table 3
ERD Design Details - Initial Injection Event
Shakespeare Composite Structures Site
Newberry, South Carolina

	Shallow GW Zone (MW-10 Area)	Intermediate GW Zone (MW-10I Area)	Total
Targeted Treatment Areas and DPT Injection Point Details			
Area (square feet)	1,500	1,500	3,000
Shallow Groundwater Zone Depth (20 to 30 ft bgs)	10	-----	-----
Shallow Groundwater Zone Depth (31 to 41 ft bgs)	-----	10	
Aquifer Volume (cubic feet)	15,000	15,000	30,000
Estimated Radius of Influence	10	10	-----
Number of Injection Points	5	5	10
Average Horizontal Hydraulic Gradient (ft/ft)	0.016	0.014	-----
Average Hydraulic Conductivity (ft/day)	0.80	0.72	-----
Estimated Effective Porosity (unitless)	0.25	0.3	-----
Groundwater Seepage Velocity (ft/day)	0.05	0.03	-----
Estimated Injection Duration (days)	2	2	4
Total Quantities of ERD Injection Substrate Chemicals			
ABC®+Ole (50% by wt ZVI/50% by wt ABC®-Ole; pounds)	5,000	5,000	10,000
Water (gallons)	2,500	2,500	5,000
Micro-scale ZVI (pounds)	2,500	2,500	5,000
ABC®-Ole (lbs)	2,500	2,500	5,000
Long-Chain Fermentable Carbon (Oleic Acid; 60%)	1,500	1,500	3,000
Magnesium Oxide (pounds)	250	250	500
Guar (pounds)	50	50	100
Total Quantities per DPT Injection Point			
ABC®+Ole (50% by wt ZVI/50% by wt ABC®-Ole; pounds)	1000	1000	-----
Water (gallons)	500	500	-----
Micro-scale ZVI (pounds)	500	500	-----
ABC®-Ole (pounds)	500	500	-----
Long-Chain Fermentable Carbon (Oleic Acid; 60%)	300	300	-----
Magnesium Oxide (pounds)	50	50	-----
Guar (pounds)	10	10	-----
Total Quantities per DPT Point Injection Interval			
No. of Injection Intervals (20, 17.5, 15, 12.5, 10 ft bgs)	5	-----	-----
No. of Injection Intervals (41, 38.5, 36, 33.5, 31 ft bgs)	-----	5	-----
ABC®+Ole (50% by wt ZVI/50% by wt ABC®-Ole; pounds)	200	200	-----
Water (gallons)	100	100	-----
Micro-scale ZVI (pounds)	100	100	-----
ABC-Ole (pounds)	100	100	-----
Long-Chain Fermentable Carbon (Oleic Acid; 60%)	60	60	-----
Magnesium Oxide (pounds)	10	10	-----
Guar (pounds)	2	2	-----

Notes:
DPT - direct push technology
ERD - enhanced reductive dechlorination
ft bgs - feet below ground surface
ft/day - feet per day
ft/ft - feet per foot
GW - groundwater
lbs - pounds
wt - weight
ZVI - zero valent iron

Table 4
ERD Design Details - Bioaugmentation Event
Shakespeare Composite Structures Site
Newberry, South Carolina

	Shallow Zone GW (MW-10 Area)	Intermediate Zone GW (MW-10I Area)	Total
Targeted Treatment Areas and DPT Injection Point Details			
Area (square feet)	1,500	1,500	3,000
Shallow Groundwater Zone Depth (20 to 30 ft bgs)	10	-----	-----
Shallow Groundwater Zone Depth (31 to 41 ft bgs)	-----	10	
Aquifer Volume (cubic feet)	15,000	15,000	30,000
Estimated Radius of Influence	10	10	-----
Number of Injection Points	5	5	10
Average Horizontal Hydraulic Gradient (ft/ft)	0.016	0.014	-----
Average Hydraulic Conductivity (ft/day)	0.80	0.72	-----
Estimated Effective Porosity (unitless)	0.25	0.3	-----
Groundwater Seepage Velocity (ft/day)	0.05	0.03	-----
Estimated Injection Duration (days)	0.5	0.5	1
Total Quantities of ERD Injection Substrate Chemicals			
ABC®-Ole (pounds)	500	500	1,000
Water (gallons)	500	500	1,000
Magnesium Oxide (pounds)	250	250	500
RTB-1 (liters)	10	10	20
Sodium Sulfite (pounds)	1	1	2
Total Quantities per DPT Injection Point			
ABC®-Ole (pounds)	100	100	-----
Water (gallons)	100	100	-----
Magnesium Oxide (pounds)	50	50	-----
RTB-1 (liters)	2	2	-----
Sodium Sulfite (pounds)	0.20	0.20	-----
Total Quantities per DPT Point Injection Interval			
No. of Injection Intervals (20, 17.5, 15, 12.5, 10 ft bgs)	5	-----	-----
No. of Injection Intervals (41, 38.5, 36, 33.5, 31 ft bgs)	-----	5	-----
ABC®-Ole (pounds)	20	20	-----
Water (gallons)	20	20	-----
Magnesium Oxide (pounds)	10	10	-----
RTB-1 (liters)	0.4	0.4	-----
Sodium Sulfite (pounds)	0.04	0.04	-----

Notes:
DPT - direct push technology
ERD - enhanced reductive dechlorination
ft bgs - feet below ground surface
ft/day - feet per day
ft/ft - feet per foot
GW - groundwater
lbs - pounds
wt - weight
ZVI - zero valent iron

Table 5
Summary of Groundwater Sampling Equipment
Shakespeare Composite Structures Site
Newberry, South Carolina

Equipment	Required	Calibration
Solinist water level probe, or equivalent	X	
Peristaltic pump	X	
YSI 556 water quality meter, or equivalent -pH, specific conductivity, temperature, DO, and ORP	X	X
HF Scientific DRT-15 turbidity meter, or equivalent	X	X

Notes *: DO - dissolved oxygen ORP - oxidation-reduction potential*

Table 6
Pilot Study Performance Monitoring Program
Shakespeare Composite Structures Site
Newberry, South Carolina

Monitoring Well Details			Monitoring Event				
ID	**Location**	**Screen Depth (ft bgs)**	**Baseline**	**30 Days****	**4 Months****	**8 Months****	**12 Months****
Background Well							
MW-2	Upgradient well	14-24	1,2,3.4	1	1,2,3,4	1	1,2,3,4
ISCO Pilot Study Perfomance Monitoring Well Network - Shallow Groundwater Zone							
TMW-29	Sidegradient of injection area	8-13	1,2,3	1	1,2,3	1,2,3	1,2,3
TMW-31	Within injection area	11-21	1,2,3	1	1,2,3	1,2,3	1,2,3
ISCO-OBSW-1S	Downgradient from injection area	11-21*	1,2,3	1	1,2,3	1,2,3	1,2,3
ERD Pilot Study Perfomance Monitoring Well Network - Shallow Groundwater Zone							
MW-10	Within injection area	20.3-30.3	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5
ERD-OBSW-1S	Downgradient of injection area	20-30*	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5
ERD Pilot Study Perfomance Monitoring Well Network - Intermediate Groundwater Zone							
MW-10	Within injection area	31-41	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5
ERD-OBSW-1I	Downgradient of injection area	31-41*	1,2,4,5	1,2,4,5	1,2,4,5	1,2,4	1,2,4,5

Field and Analytical Laboratory Parameter Monitoring Legend:

*Proposed well screen depth

**Post-injection monitoring events

1 = Field indicator parameters (color, turbidity, temperature, specific conductivity, pH, DO, ORP, and groundwater elevation).
2 = VOCs by SW 846, Method 8260B.
3 = Additional ISCO parameters (TDS by SW-846, Method 2540C and Chloride by SW 9056A).
4 = Biogeochemical parameters (Nitrate/Nitrite/Sulfate/Chloride by SW 9056A, Dissolved [lab filtered] and Total Iron by SW 6020A, Methane/Ethane/Ethene by RSK-175, Alkalinity by SM 2320B, and TOC by SW 9060A).
5 = *dehalococcoides, dehalobacter spp.* , vinyl chloride reductases via CENSUS® qPCR analysis.

Abbreviations:

DO - Dissolved Oxygen
ERD - Enhanced Re
ft bgs - Feet Below Ground Surface
ID - Monitoring Well Identification
ISCO - In Situ Chemical Oxidation
OBSW - observation well
ORP - Oxidation/Reduction Potential
qPCR - Quantitative Polymerase Chain Reaction
TDS - Total Dissolved Solids
TOC - Total Organic Carbon

Table 7
Summary of Groundwater Sampling Protocol
Shakespeare Composite Structures Site
Newberry, South Carolina

Analytical Group	Analytical Method	Containers (number, size, type)	Preservation Requirements	Maximum Holding Time
VOCs	SW-846 8260B	3 x 40 mL VOC vial	Cool, ≤6°C, HCL, pH<2 No Headspace	14 days (7 days for no HCl)
Anions	SW-846 9056A	1 x 250 mL poly bottle	Cool, ≤6°C	28 days
Dissolved Gases	RSK-175	2 x 40 mL VOC vial	Cool, ≤6°C, No Headspace	14 days
TDS	SW-846 2540C	2 x 40 mL VOC vial	Cool, ≤6°C, No Headspace	14 days
TOC	SW-846 9060A	2 x 40 mL VOC vial	Cool, ≤6°C, pH<2 No Headspace	28 days
Alkalinity	SW-846 2320B	1 x 250 mL poly bottle	Cool, ≤6°C	14 days
Total Iron	SW-846 6020A	1 x 500 mL poly bottle	Cool, ≤6°C, HNO_3, pH<2, No Headspace	180 days
Dissolved Iron **(Lab Filtered)**	SW-846 6020A	1 x 500 mL poly bottle	Cool, ≤6°C, No Headspace	180 days
Microbial Analysis qPCR for *dehalococcoides* and *dehalobacter*	qPCR	1 liter poly or Bio-flo filter	Cool, ≤6°C	24 - 48 hours

Notes *:*
HCl - hydrochloric acid
mL - milliliters
TDS - total dissolved solids
TOC - total organic carbon
VOCs - volatile organic compounds

APPENDIX A

SAFETY DATA SHEETS

SAFETY DATA SHEET

1. Identification

Product identifier	**RemOx® S ISCO Reagent**
Other means of identification	Not available.
Recommended use	Remediation of soils and groundwater.
Recommended restrictions	Use in accordance with supplier's recommendations.

Manufacturer / Importer / Supplier / Distributor information

Manufacturer/Supplier	CARUS CORPORATION
Address	315 Fifth Street, Peru, IL 61354, USA
Telephone	815 223-1500 - All other non-emergency inquiries about the product should be directed to the company
E-mail	salesmkt@caruscorporation.com
Website	www.caruscorporation.com
Contact person	Dr. Chithambarathanu Pillai
Emergency Telephone	For Hazardous Materials [or Dangerous Goods] Incidents ONLY (spill, leak, fire, exposure or accident), call CHEMTREC at CHEMTREC®, USA: 001 (800) 424-9300 CHEMTREC®, Mexico (Toll-Free - must be dialed from within country): 01-800-681-9531 CHEMTREC®, Other countries: 001 (703) 527-3887

2. Hazard(s) identification

Physical hazards	Oxidizing solids	Category 2
Health hazards	Acute toxicity, oral	Category 4
	Skin corrosion/irritation	Category 1B
	Specific target organ toxicity, single exposure	Category 1 (Respiratory System)
	Specific target organ toxicity, repeated exposure	Category 1 (Respiratory System, central nervous system)

OSHA defined hazards Not classified.

Label elements

Signal word Danger

Hazard statement May intensify fire; oxidizer. Harmful if swallowed. Causes severe skin burns and eye damage. Causes damage to organs (Respiratory System). Causes damage to organs (Respiratory System, central nervous system) through prolonged or repeated exposure.

Precautionary statement

Prevention Keep away from heat. Take any precaution to avoid mixing with combustibles/ Keep/Store away from clothing//combustible materials. Wash thoroughly after handling. Do not breathe dust. Wear protective gloves/protective clothing/eye protection/face protection. Do not eat, drink or smoke when using this product.

Response In case of fire: Use water for extinction. If swallowed: Rinse mouth. Do NOT induce vomiting. If on skin (or hair): Take off immediately all contaminated clothing. Rinse skin with water/shower. Wash contaminated clothing before reuse. If inhaled: Remove person to fresh air and keep comfortable for breathing. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor.

Storage Store locked up.

Disposal Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazard(s) not otherwise classified (HNOC) Not classified.

Environmental hazards	Hazardous to the aquatic environment, long-term hazard	Category 1

3. Composition/information on ingredients

Substances

Chemical name	Common name and synonyms	CAS number	%
Potassium permanganate		7722-64-7	> 97.5

Composition comments All concentrations are in percent by weight unless ingredient is a gas. Gas concentrations are in percent by volume.

4. First-aid measures

Inhalation Remove victim to fresh air and keep at rest in a position comfortable for breathing. For breathing difficulties, oxygen may be necessary. Get medical attention immediately.

Skin contact Take off immediately all contaminated clothing. Immediately flush skin with plenty of water. Get medical attention immediately. Wash contaminated clothing before reuse.

Contact with skin may leave a brown stain of insoluble manganese dioxide. This can be easily removed by washing with a mixture of equal volume of household vinegar and 3% hydrogen peroxide, followed by washing with soap and water.

Eye contact Immediately flush with plenty of water for up to 15 minutes. Remove any contact lenses and open eyelids wide apart. Continue rinsing. Get medical attention immediately.

Ingestion Immediately rinse mouth and drink plenty of water. Never give anything by mouth to a victim who is unconscious or is having convulsions. Do not induce vomiting. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs. Get medical attention immediately.

Most important symptoms/effects, acute and delayed Contact with this material will cause burns to the skin, eyes and mucous membranes. Permanent eye damage including blindness could result.

Indication of immediate medical attention and special treatment needed Provide general supportive measures and treat symptomatically. In case of shortness of breath, give oxygen. Decomposition products are alkaline. Brown stain is insoluble manganese dioxide.

General information In the case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media Flood with water from a distance, water spray or fog.

Unsuitable extinguishing media The following extinguishing media are ineffective: Dry chemical. Foam. Carbon dioxide (CO2). Halogenated materials.

Specific hazards arising from the chemical May intensify fire; oxidizer. May ignite combustibles (wood, paper, oil, clothing, etc.). Contact with incompatible materials or heat (135 ºC / 275 ºF) could result in violent exothermic chemical reaction. Oxidizing agent, may cause spontaneous ignition of combustible materials. By heating and fire, corrosive vapors/gases may be formed.

Special protective equipment and precautions for firefighters Self-contained breathing apparatus and full protective clothing must be worn in case of fire. Selection of respiratory protection for firefighting: follow the general fire precautions indicated in the workplace.

Fire-fighting equipment/instructions Move container from fire area if it can be done without risk. Cool containers exposed to flames with water until well after the fire is out. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply. Dike fire control water for later disposal. Water runoff can cause environmental damage.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures Keep unnecessary personnel away. Keep upwind. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Avoid inhalation of vapors and contact with skin and eyes. Wear protective clothing as described in Section 8 of this safety data sheet. Local authorities should be advised if significant spillages cannot be contained.

Methods and materials for containment and cleaning up

Keep combustibles (wood, paper, oil, etc.) away from spilled material. Should not be released into the environment. This product is miscible in water. Stop leak if possible without any risk. Dike the spilled material, where this is possible. Clean up spills immediately by sweeping or shoveling up the material. Do not return spilled material to the original container; transfer to a clean metal or plastic drum. To clean up potassium permanganate solutions, follow either of the following two options:

Option # 1: Dilute to approximately 6% with water, and then reduce with sodium thiosulfate, a bisulfite or ferrous salt solution. The bisulfite or ferrous salt may require some dilute sulfuric acid (10% w/w) to promote reduction. Neutralize with sodium carbonate to neutral pH, if acid was used. Decant or filter and deposit sludge in approved landfill. Where permitted, the sludge may be drained into sewer with large quantities of water.

Option # 2: Absorb with inert media like diatomaceous earth or inert floor dry, collect into a drum and dispose of properly. Do not use saw dust or other incompatible media. Disposal of all materials shall be in full and strict compliance with all federal, state, and local regulations pertaining to permanganates.

To clean contaminated floors, flush with abundant quantities of water into sewer, if permitted by federal, state, and local regulations. If not, collect water and treat as described above.

Never return spills in original containers for re-use. For waste disposal, see Section 13 of the MSDS.

Environmental precautions

Do not allow to enter drains, sewers or watercourses. Contact local authorities in case of spillage to drain/aquatic environment.

7. Handling and storage

Precautions for safe handling

Take any precaution to avoid mixing with combustibles. Keep away from clothing and other combustible materials. Do not get this material in your eyes, on your skin, or on your clothing. Do not breathe dust or mist or vapor of the solution. If clothing becomes contaminated, remove and wash off immediately. When using, do not eat, drink or smoke. Good personal hygiene is necessary. Wash hands and contaminated areas with water and soap before leaving the work site. Avoid release to the environment.

Conditions for safe storage, including any incompatibilities

Store locked up. Keep container tightly closed and in a well-ventilated place. Store in a cool, dry place. Store away from incompatible materials (See Section 10). Follow applicable local/national/international recommendations on storage of oxidizers. Store in accordance with NFPA 430 requirements for Class II oxidizers.

Before using, read Material Safety Data Sheet (MSDS) for this product.

8. Exposure controls/personal protection

Occupational exposure limits

US. OSHA Table Z-1 Limits for Air Contaminants (29 CFR 1910.1000)

Components	Type	Value
Potassium permanganate (CAS 7722-64-7)	Ceiling	5 mg/m3

US. ACGIH Threshold Limit Values

Components	Type	Value
Potassium permanganate (CAS 7722-64-7)	TWA	0.2 mg/m3

US NIOSH Pocket Guide to Chemical Hazards: Recommended exposure limit (REL)

Components	Type	Value	Form
Potassium permanganate (CAS 7722-64-7)	TWA	1 mg/m3	Fume.

US NIOSH Pocket Guide to Chemical Hazards: Short Term Exposure Limit (STEL)

Components	Type	Value	Form
Potassium permanganate (CAS 7722-64-7)	STEL	3 mg/m3	Fume.

Biological limit values

No biological exposure limits noted for the ingredient(s).

Exposure guidelines

Follow standard monitoring procedures.

Appropriate engineering controls

Provide adequate general and local exhaust ventilation. An eye wash and safety shower must be available in the immediate work area.

Individual protection measures, such as personal protective equipment

Eye/face protection

Wear safety glasses with side shields (or goggles). Wear face shield if there is risk of splashes.

Skin protection	
Hand protection	Use protective gloves made of: Rubber or plastic. Suitable gloves can be recommended by the glove supplier.
Other	Wear chemical-resistant, impervious gloves.
Respiratory protection	In case of inadequate ventilation or risk of inhalation of dust, use suitable respiratory equipment with particle filter. In the United States of America, if respirators are used, a program should be instituted to assure compliance with OSHA 29 CFR 1910.134. Measurement Element: Manganese (Mn) 10 mg/m3 Any particulate respirator equipped with an N95, R95, or P95 filter (including N95, R95, and P95 filtering facepieces) except quarter-mask respirators. The following filters may also be used: N99, R99, P99, N100, R100 or P100. Any supplied-air respirator. 25 mg/m3 Any supplied-air respirator operated in a continuous-flow mode. Any powered, air-purifying respirator with a high-efficiency particulate filter. 50 mg/m3 Any air-purifying, full-face piece respirator equipped with an N100, R100, or P100 filter. Any supplied-air respirator with a tight-fitting face piece that is operated in a continuous-flow mode. Any powered, air-purifying respirator with a tight-fitting face piece and a high-efficiency particulate filter. Any self-contained breathing apparatus with a full face piece. Any supplied-air respirator with a full face piece. 500 mg/m3 Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode. Emergency or planned entry into unknown concentrations or IDLH conditions - Any self-contained breathing apparatus that has a full face piece and is operated in a pressure-demand or other positive-pressure mode. Escape Any air-purifying, full-face piece respirator equipped with an N100, R100, or P100 filter. Any appropriate escape-type, self-contained breathing apparatus.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	When using, do not eat, drink or smoke. Keep from contact with clothing and other combustible materials. Remove and wash contaminated clothing promptly. Wash hands before breaks and immediately after handling the product. Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Appearance	Dark purple solid with metallic luster.
Physical state	Solid.
Form	Solid.
Color	Dark purple.
Odor	Odorless.
Odor threshold	Not available.
pH	Not applicable.
Melting point/freezing point	Starts to decompose with evolution of oxygen (O2) at temperatures above 150 °C. Once initiated, the decomposition is exothermic and self sustaining.
Initial boiling point and boiling range	Not applicable.
Flash point	Not applicable.
Evaporation rate	Not applicable.
Flammability (solid, gas)	Non flammable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not applicable.
Flammability limit - upper (%)	Not applicable.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.

Vapor pressure	Not applicable.
Vapor density	Not applicable.
Relative density	2.7 (20 °C) (Water = 1)
Solubility(ies)	6 % (20 °C) 20 % (65 °C)
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not applicable.
Other information	
Explosive properties	Not explosive. Can explode in contact with sulfuric acid, peroxides and metal powders.
Molecular weight	158.03
Oxidizing properties	Strong oxidizing agent.

10. Stability and reactivity

Reactivity	The product is non-reactive under normal conditions of use, storage and transport.
Chemical stability	Stable at normal conditions.
Possibility of hazardous reactions	Contact with combustible material may cause fire. Can explode in contact with sulfuric acid, peroxides and metal powders. Starts to decompose with evolution of oxygen (O2) at temperatures above 150 °C. Once initiated, the decomposition is exothermic and self sustaining.
Conditions to avoid	Contact with incompatible materials or heat (135 °C / 275 °F) could result in violent exothermic chemical reaction.
Incompatible materials	Acids. Peroxides. Reducing agents. Combustible material. Metal powders. Contact with hydrochloric acid liberates chlorine gas.
Hazardous decomposition products	By heating and fire, corrosive vapors/gases may be formed.

11. Toxicological information

Information on likely routes of exposure

Ingestion	Harmful if swallowed.
Inhalation	May cause irritation to the respiratory system.
Skin contact	Causes severe skin burns.
Eye contact	Causes serious eye damage.
Symptoms related to the physical, chemical and toxicological characteristics	Contact with this material will cause burns to the skin, eyes and mucous membranes. Permanent eye damage including blindness could result.

Information on toxicological effects

Acute toxicity Harmful if swallowed.

Components	Species	Test Results
Potassium permanganate (CAS 7722-64-7)		
Acute		
Oral		
LD50	Rat	780 mg/kg, 14 days, (Male)
		525 mg/kg, 14 days, (Female)

Skin corrosion/irritation	Causes severe skin burns.
Serious eye damage/eye irritation	Causes serious eye damage.
Respiratory sensitization	Not classified.
Skin sensitization	Not classified.
Germ cell mutagenicity	Not classified.
Carcinogenicity	Not classified.
Reproductive toxicity	Not classified.
Specific target organ toxicity - single exposure	Causes damage to organs (respiratory system).

Specific target organ toxicity - repeated exposure	Causes damage to organs (respiratory system, central nervous system) through prolonged or repeated exposure.
Aspiration hazard	Not classified.
Chronic effects	May cause damage to respiratory system. Prolonged exposure, usually over many years, to manganese oxide fume/dust can lead to chronic manganese poisoning, chiefly affecting the central nervous system.
Further information	No other specific acute or chronic health impact noted.

12. Ecological information

Ecotoxicity Very toxic to aquatic life with long lasting effects.

Components		Species	Test Results
Potassium permanganate (CAS 7722-64-7)			
Aquatic			
Fish	LC50	Bluegill (Lepomis macrochirus)	2.7 mg/l, 96 hours, static
			2.3 mg/l, 96 hours, flow through
			2.3 mg/l, 96 hours
			1.8 - 5.6 mg/l
		Carp (Cyprinus carpio)	3.16 - 3.77 mg/l, 96 hours
			2.97 - 3.11 mg/l, 96 hours
		Goldfish (Carassius auratus)	3.3 - 3.93 mg/l, 96 hours, static
		Milkfish, salmon-herring (Chanos chanos)	> 1.4 mg/l, 96 hours
		Rainbow trout (Oncorhynchus mykiss)	1.8 mg/l, 96 hours
			1.08 - 1.38 mg/l, 96 hours
			0.77 - 1.27 mg/l, 96 hours
		Rainbow trout,donaldson trout (Oncorhynchus mykiss)	0.275 - 0.339 mg/l, 96 hours

Persistence and degradability	Expected to be readily converted by oxidizable materials to insoluble manganese oxide.
Bioaccumulative potential	Potential to bioaccumulate is low.
Mobility in soil	Not available.
Mobility in general	The product is water soluble and may spread in water systems.
Other adverse effects	None known.

13. Disposal considerations

Disposal instructions	Dispose of contents/container in accordance with local/regional/national/international regulations.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	D001: Ignitable waste The Waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Do not allow this material to drain into sewers/water supplies. Dispose in accordance with all applicable regulations.
Contaminated packaging	Since emptied containers may retain product residue, follow label warnings even after container is emptied. Rinse container at least three times to an absence of pink color before disposing. Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport information

DOT

UN number	UN1490
UN proper shipping name	Potassium permanganate
Transport hazard class(es)	5.1
Subsidiary class(es)	-
Packing group	II
Special precautions for user	Read safety instructions, MSDS and emergency procedures before handling.
Labels required	5.1
Special provisions	IB8, IP2, IP4, T3, TP33
Packaging exceptions	152
Packaging non bulk	212
Packaging bulk	240

IATA

UN number	UN1490
UN proper shipping name	Potassium permanganate
Transport hazard class(es)	5.1
Subsidiary class(es)	-
Packaging group	II
Environmental hazards	Yes
Labels required	5.1
ERG Code	5L
Special precautions for user	Read safety instructions, MSDS and emergency procedures before handling.

IMDG

UN number	UN1490
UN proper shipping name	POTASSIUM PERMANGANATE
Transport hazard class(es)	5.1
Subsidiary class(es)	-
Packaging group	II
Environmental hazards	
Marine pollutant	Yes
Labels required	5.1
EmS	F-H, S-Q
Special precautions for user	Read safety instructions, MSDS and emergency procedures before handling.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code This substance/mixture is not intended to be transported in bulk.

15. Regulatory information

US federal regulations This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200.
All components are on the U.S. EPA TSCA Inventory List.

CERCLA/SARA Hazardous Substances - Not applicable.

Drug Enforcement Administration (DEA) (21 CFR 1310.02 (b) 8: List II chemical.

Department of Homeland Security (DHS) Chemical Facility Anti-Terrorism Standards (6 CFR 27, Appendix A): Listed.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories	Immediate Hazard - Yes Delayed Hazard - Yes Fire Hazard - Yes Pressure Hazard - No Reactivity Hazard - No
SARA 302 Extremely hazardous substance	No
SARA 311/312 Hazardous chemical	Yes

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Potassium permanganate (CAS 7722-64-7)

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Clean Water Act (CWA) Section 112(r) (40 CFR 68.130)	Hazardous substance
Safe Drinking Water Act (SDWA)	Not regulated.

Drug Enforcement Administration (DEA). List 2, Essential Chemicals (21 CFR 1310.02(b) and 1310.04(f)(2) and Chemical Code Number

Potassium permanganate (CAS 7722-64-7) 6579

Drug Enforcement Administration (DEA). List 1 & 2 Exempt Chemical Mixtures (21 CFR 1310.12(c))

Potassium permanganate (CAS 7722-64-7) 15 % wt

DEA Exempt Chemical Mixtures Code Number

Potassium permanganate (CAS 7722-64-7) 6579

Food and Drug Administration (FDA) Not regulated.

US state regulations This product does not contain a chemical known to the State of California to cause cancer, birth defects or other reproductive harm.

California OSH Hazardous Substance List: Listed.

US. Massachusetts RTK - Substance List

Potassium permanganate (CAS 7722-64-7)

US. New Jersey Worker and Community Right-to-Know Act

Potassium permanganate (CAS 7722-64-7) 500 lbs

US. Pennsylvania RTK - Hazardous Substances

Potassium permanganate (CAS 7722-64-7)

US. Rhode Island RTK

Not regulated.

US. California Proposition 65

US - California Proposition 65 - Carcinogens & Reproductive Toxicity (CRT): Listed substance

Not listed.

International Inventories

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates this product complies with the inventory requirements administered by the governing country(s).
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date 04-03-2013

Revision date -

Version # 01

Further information Not available.

List of abbreviations LD50: Lethal Dose, 50%.
LC50: Lethal Concentration, 50%.

References HSDB® - Hazardous Substances Data Bank
Registry of Toxic Effects of Chemical Substances (RTECS)
ACGIH
EPA: AQUIRE database
NLM: Hazardous Substances Data Base
US. IARC Monographs on Occupational Exposures to Chemical Agents
IARC Monographs. Overall Evaluation of Carcinogenicity
National Toxicology Program (NTP) Report on Carcinogens
ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices

Disclaimer

This safety data sheet was prepared in accordance with the Safety Data Sheet for Chemical Products (JIS Z 7250:2005). The information contained herein is accurate to the best of our knowledge. However, data, safety standards and government regulations are subject to change and, therefore, holders and users should satisfy themselves that they are aware of all current data and regulations relevant to their particular use of product. CARUS CORPORATION DISCLAIMS ALL LIABILITY FOR RELIANCE ON THE COMPLETENESS OR ACCURACY OR THE INFORMATION INCLUDED HEREIN. CARUS CORPORATION MAKES NO WARRANTY, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY WARRANTIES OF MERCHANTIABILITY OR FITNESS FOR PARTICULAR USE OR PURPOSE OF THE PRODUCT DESCRIBED HEREIN. All conditions relating to storage, handling, and use of the product are beyond the control of Carus Corporation, and shall be the sole responsibility of the holder or user of the product.

SAFETY DATA SHEET
ABC-Olé

1. PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **ABC-Olé**
GENERAL USE: **Bioremediation of halogenated organics and metals**

MANUFACTURER:

Redox Tech, LLC
200 Quade Drive
Cary, NC 27513
919-678-0140

EMERGENCY TELEPHONE:

Within USA and Canada: 1-800-424-9300
+1 703-527-3887 (collect calls accepted)

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW: Product is generally recognized as safe. May cause irritation exposure to eyes. Long term contact to skin may cause some drying and minor irritation.

3. COMPOSITION INFORMATION ON INGREDIENTS

Proprietary mixture of fatty acids, glycerol, hydrolyzed vegetable oil, emulsifying agent and dipotassium phosphate.

4. FIRST AID MEASURES

EYES: Immediately flush with water for up to 15 minutes. If irritation persists, seek medical attention.

SKIN: Rinse with water. Irritation is unlikely, but if irritation occurs or persists, seek medical attention.

INGESTION: Generally safe to ingest but not recommended.

INHALATION: No first aid required.

5. FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA: Deluge with water

FIRE/EXPLOSION HAZARDS: Product is combustible only at temperatures above 600C

FIRE FIGHTING PROCEDURES: Use flooding with plenty of water, carbon dioxide or other inert gasses. Wear full protective clothing and self-contained breathing apparatus. Deluging with water is the best method to control combustion of the product.

FLAMMABILITY LIMITS: non-combustible

SENSITIVITY TO IMPACT: non-sensitive

SENSITIVITY TO STATIC DISCHARGE: non-senstive

6. ACCIDENTAL RELEASE MEASURES

Confine and collect spill. Transfer to an approved DOT container and properly dispose. Do not dispose of or rinse material into sewer, stormwater or surface water. Discharge of product to surface water could result in depressed dissolved oxygen levels and subsequent biological impacts.

7. HANDLING AND STORAGE

HANDLING: Protective gloves and safety glasses are recommended.

STORAGE: Keep dry. Use first in, first out storage system. Keep container tightly closed when not in use. Avoid contamination of opened product. Avoid contact with reducing agents.

8. EXPOSURE CONTROLS – PERSONAL PROTECTION

EXPOSURE LIMITS

Chemical Name	ACGIH	OSHA	Supplier
ABC	**NA**	**NA**	**NA**

ENGINEERING CONTROLS: None are required

PERSONAL PROTECTIVE EQUIPMENT

EYES and FACE: Safety glasses recommended
RESPIRATOR: none necessary
PROTECTIVE CLOTHING: None necessary
GLOVES: rubber, latex or neoprene recommended but not required

9. PHYSICAL AND CHEMICAL PROPERTIES

Odor:	none to mild pleasant organic odor
Appearance:	milky
Auto-ignition Temperature	Non-combustible
Boiling Point	>600 C

Melting Point	NA
Density	0.90 gram/cc
Solubility	infinite (miscible)
pH	6-8

10. STABILITY AND REACTIVITY

CONDITIONS TO AVOID: Do not contact with strong oxidizers
STABILITY: product is stable
POLYMERIZATION: will not occur
INCOMPATIBLE MATERIALS: strong oxidizers
HAZARDOUS DECOMPOSITION PRODUCTS:

11. TOXICOLOGICAL INFORMATION

Acute Toxicity
A: General Product Information
Acute exposure may cause mild skin and eye irritation.
B: Component Analysis - LD50/LC50

No information available.

B: Component Analysis - TDLo/LDLo
TDLo (Oral-Man) none

Carcinogenicity
A: General Product Information
No information available.
B: Component Carcinogenicity
Product is not listed by ACGIH, IARC, OSHA, NIOSH, or NTP.

Epidemiology
No information available.

Neurotoxicity
No information available.

12. ECOLOGICAL INFORMATION

Ecotoxicity
Discharge to water may cause depressed dissolved oxygen and subsequent ecological stresses
Environmental Fate
No potential for food chain concentration

13. DISPOSAL CONSIDERATIONS

DISPOSAL METHOD: Material is not considered hazardous, but consult with local, state and federal agencies prior to disposal to ensure all applicable laws are met.

14. TRANSPORT INFORMATION

NOTE: The shipping classification information in this section (Section 14) is meant as a guide to the overall classification of the product. However, transportation classifications may be subject to change with changes in package size. Consult shipper requirements under I.M.O., I.C.A.O. (I.A.T.A.) and 49 CFR to assure regulatory compliance.

US DOT Information
Shipping Name: Not Regulated
Hazard Class: Not Classified
UN/NA #: Not Classified
Packing Group:None
Required Label(s):None

50thEdition International Air Transport Association (IATA):
Not hazardous and not regulated

INTERNATIONAL MARITIME DANGEROUS GOODS (IMDG)

Material is not regulated under IMDG

15. REGULATORY INFORMATION

UNITED STATES

SARA TITLE III
SECTION 311 No Hazard for Immediate health Hazard
SECTION 312 No Threshold Quanitity
SECTION 313 Not listed

CERCLA NOT REGULATED UNDER CERCLA

TSCA NOT REGULATED UNDER TSCA

CANADA (WHIMS): NOT REGULATED

16. OTHER INFORMATION

HMIS:

Health	0
Flammability	0
Physical Hazard	0
Personal Protection	E

E: Safety Glasses, gloves

SAFETY DATA SHEET
Zero Valent Iron (ZVI)

Section 1. PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: **ZVI**
GENERAL USE: Chemical reduction of halogenated organics and-or metals

MANUFACTURER:

Redox Tech, LLC
200 Quade Drive
Cary, NC 27513
919-678-0140

EMERGENCY TELEPHONE:

Within USA and Canada: 1-800-424-9300
+1 703-527-3887 (collect calls accepted)

Section 2. HAZARDS IDENTIFICATION

Physical state : Solid (Powder)
Emergency Overview : Potential dust explosion. Avoid contact with oxidizing agents. USE WITH CARE. Follow good industrial hygiene practice

Routes of entry : Demal contact. Eye contact. Inhalation. Ingestion.

Potential acute health effects
- Eyes : May cause eye irritation.
- Skin : No known significant effects or critical hazards
- Inhalation : May cause respiratory tract irritation.
- Ingestion : No known significant effects or critical hazards.

Potential Chronic Effects: : Carcinogenic effects: Not classified or listed by IARC, NTP, OSHA, EU AND ACGIH.
Mutagenic effects: Not available
: Teratogenic effects: Not Available
Medical conditions : Repeated exposure of the eyes to a low level of dust can produce eye irritation

Section 3. COMPOSITION INFORMATION ON INGREDIENTS

Greater than 98% Iron CAS# 7439-89-6
Contains carbon, sulfur and other metal impurities.

Section 4. FIRST AID MEASURES

Eye contact : Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 20 minutes. Get medical attention if irritation occurs
Skin contact : Wash with soap and water. Get medical attention if irritation occurs.
Inhalation : Move person to fresh air. Get medical attention if breathing difficulty persists

Ingestion	:	Do not induce vomiting. Never give anything by mouth to an unconscious person. Get medical attention if symptoms appear.
Notes to physician:		No specific antidote. Material is used as an iron supplement in food and vitamins. Treatment would be the same as for iron overdose.

Section 5. FIRE FIGHTING MEASURES

Flammability of the product	Generally non-flammable but susceptible to dust explosion.
Fire-fighting media	Use a fog nozzle to spray water.
Special protective Equipment for fire-fighters	Fire-fighters should wear appropriate protective equipment.
Special remarks on fire	As with any finely granulated product, a risk of dust explosion is present should the material be dispersed in air and exposed to a source of ignition. Fine powder can form flammable and explosive mixtures in air.

Section 6. ACCIDENTAL RELEASE MEASURES

In case of a significant release, take immediate efforts to minimize discharge to surface water (storm drains, streams, lakes, rivers, etc). If the release occurs in a closed area, take steps to improve ventilation. If improvement of ventilation is not possible, call the fire department. The material can be swept up and placed into approved storage containers. Do not use a vacuum to gather the material because this may result in dispersion of dust particles and increase the risk for a dust explosion.

Section 7. HANDLING AND STORAGE

The material should be stored in a cool, dry, environment. It is not recommended to store the material in the proximity of oxidants. When handling the product, wear a dusk mask, eye protection and gloves. The product should always be handled in a well ventilated environment.

Section 8. EXPOSURE CONTROLS – PERSONAL PROTECTION

Engineering controls	:	Use process enclosures, local exhaust ventilation or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fumes or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.
Personal protection		
Eyes	:	Safety eyewear complying with an approved standard should be used and selected based on the t ask being performed and the risks involved (avoid exposure to liquid splashed, mists, gases or dusts). Where there is a risk of exposure to high velocity particles safety glasses or face shield complying with an approved standard should be used to protect against impact. Where there is a risk of exposure to dusts, goggles should be used. Recommended: Safety glasses.
Respiratory	:	Dusk mask or respirator is recommended.
Hands	:	Gloves are recommended

Skin/Body	:	Personal protective equipment for the body should be selected based on the task being performed and the risks involved. Risk from dermal contact is minimal.

Section 9. PHYSICAL AND CHEMICAL PROPERTIES

Physical State	:	Solid (Powder)
Color	:	Gray
Melting/freezing point	:	1535ºC (2795ºF)
Specific gravity	:	7.88
Bulk density	:	2.4 to 3.2 g/cm³
Solubility	:	Insoluble in water

Section 10. STABILITY AND REACTIVITY

The product is reactive with oxidizers. Precautions should be taken not to store or contact the product with oxidizers.

Fine particles of this product (not widely found in this grade) have a potential for a dust explosion. The product should be handled in a well ventilated area where dust generation is minimized.

Section 11. TOXICOLOGICAL INFORMATION

Acute Effects

Eyes	May cause eye irritation.
Skin	No known significant effects or critical hazards.
Inhalation	May cause respiratory tract irritation.
Ingestion	No known significant effects or critical hazards.

Chronic Health Effects:	Carcinogenic effects: Not classified or listed by IARC, NTP, OSHA, EU and ACGIH

Section 12. ECOLOGICAL INFORMATION

Will reduce dissolved oxygen levels in aquatic ecosystems. Direct discharge to surface water should be avoided.

Section 13. DISPOSAL CONSIDERATIONS

The generation of waste should be avoided or minimized to the extent practical. Disposal of this product, solutions and any by-products should be completed in an environmentally responsible manner that complies with all local, state and federal laws.

Section 14. TRANSPORT INFORMATION

Classification:

AND/ADR/TDG/DOT/IMDG/IATA:	Not regulated.

Section 15. REGULATORY INFORMATION

This product is not regulated in the United States and Canada. The user should ensure this product is not regulated where used.

Section 16. OTHER INFORMATION

Health	0
Fire Hazard	2
Reactivity	1
Personal Protection	C

9.2 Other information

Molecular weight	126.04 g/mol

SECTION 10: Stability and reactivity

10.1 Reactivity

- no data available

10.2 Chemical stability

- Stable under recommended storage conditions.

10.3 Possibility of hazardous reactions

- no data available

10.4 Conditions to avoid

- Heat.
- Exposure to moisture.

10.5 Incompatible materials

- Water
- Acids
- Oxidizing agents

10.6 Hazardous decomposition products

- Sulphur dioxide
- Sulfur oxides

SECTION 11: Toxicological information

11.1 Information on toxicological effects

Acute toxicity

Acute oral toxicity	LD50 : 820 mg/kg - Mouse
	LD50 : > 2,000 mg/kg - Rat
Acute inhalation toxicity	no data available
Acute dermal toxicity	no data available
Acute toxicity (other routes of administration)	no data available
Skin corrosion/irritation	Rabbit No skin irritation
Serious eye damage/eye irritation	Rabbit Eye irritation

Respiratory or skin sensitization	no data available

Mutagenicity

Genotoxicity in vitro	In vitro tests showed mutagenic effects
Genotoxicity in vivo	no data available
Carcinogenicity	no data available

This product does not contain any ingredient designated as probable or suspected human carcinogens by:
NTP
IARC
OSHA
ACGIH

Toxicity for reproduction and development

Toxicity to reproduction / fertility	no data available
Developmental Toxicity/Teratogenicity	no data available

STOT

STOT-single exposure	no data available
STOT-repeated exposure	no data available
Aspiration toxicity	no data available
Further information	Harmful if swallowed. Moderate eye irritation May cause sensitization of susceptible persons by inhalation of aerosol or dust.

SECTION 12: Ecological information

12.1 Toxicity

Aquatic Compartment

Acute toxicity to fish	LC50 - 96 h : 100 mg/l - Carassius auratus (goldfish)

12.2 Persistence and degradability

Biodegradation

Biodegradability	Method: Biochemical Oxygen Demand (BOD) instantaneous reaction

12.3 Bioaccumulative potential

Bioconcentration factor (BCF)	Bioaccumulative potential
12.4 Mobility in soil	no data available
12.5 Results of PBT and vPvB assessment	no data available
12.6 Other adverse effects	no data available
Remarks	oxygen scavenger, Ecological injuries are not known or expected under normal use.

SECTION 13: Disposal considerations

13.1 Waste treatment methods

Product Disposal

- Respect local/federal and national regulations for:
- Hazardous waste
- Contact waste disposal services.

Advice on cleaning and disposal of packaging

- To avoid treatments, as far as possible, use dedicated containers.
- Containers that cannot be cleaned must be treated as waste.
- In accordance with local and national regulations.

SECTION 14: Transport information

DOT
not regulated

TDG
not regulated

NOM
no data available

IMDG
not regulated

IATA
not regulated

Note: The above regulatory prescriptions are those valid on the date of publication of this sheet. Given the possible evolution of transportation regulations for hazardous materials, it would be advisable to check their validity with your sales office.

SECTION 15: Regulatory information

15.1 Notification status

Inventory Information	Status
United States TSCA Inventory	Listed on Inventory
New Zealand. Inventory of Chemical Substances	In compliance with the inventory
Canadian Domestic Substances List (DSL)	Listed on Inventory
Australia Inventory of Chemical Substances (AICS)	Listed on Inventory
Japan. CSCL - Inventory of Existing and New Chemical Substances	Listed on Inventory
Korea. Korean Existing Chemicals Inventory (KECI)	Listed on Inventory
China. Inventory of Existing Chemical Substances in China (IECSC)	Listed on Inventory
Philippines Inventory of Chemicals and Chemical Substances (PICCS)	Listed on Inventory

15.2 Federal Regulations

US. EPA EPCRA SARA Title III

SARA Hazard Designation Sections 311/312 (40 CFR 370)

Fire Hazard	no
Reactivity Hazard	no
Sudden Release of Pressure Hazard	no
Acute Health Hazard	yes
Chronic Health Hazard	yes

Section 313 Toxic Chemicals (40 CFR 372.65)

This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

Section 302 Emergency Planning Extremely Hazardous Substance Threshold Planning Quantity (40 CFR 355)

No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

Section 302 Emergency Planning Extremely Hazardous Substance Reportable Quantity (40 CFR 355)

This material does not contain any components with a SARA 302 RQ.

Section 304 Emergency Release Notification Reportable Quantity (40 CFR 355)

This material does not contain any components with a section 304 EHS RQ.

US. EPA CERCLA Hazardous Substances and Reportable Quantities (40 CFR 302.4)

This material does not contain any components with a CERCLA RQ.

15.3 State Regulations

US. California Safe Drinking Water & Toxic Enforcement Act (Proposition 65)

This product does not contain any chemicals known to the State of California to cause cancer, birth, or any other reproductive defects.

SECTION 16: Other information

NFPA (National Fire Protection Association) - Classification

Health	2 moderate
Flammability	0 minimal
Instability or Reactivity	1 slight
Special Notices	None

HMIS (Hazardous Materials Identification System (Paint & Coating)) - Classification

Health	2 moderate
Flammability	0 minimal
Reactivity	1 slight
PPE	Determined by User; dependent on local conditions

Further information

- Product evaluated under the US GHS format.

Date Prepared: 04/02/2015

- ACGIH	American Conference of Governmental Industrial Hygienists
- OSHA	Occupational Safety and Health Administration
- NTP	National Toxicology Program
- IARC	International Agency for Research on Cancer
- NIOSH	National Institute for Occupational Safety and Health

MG Ingredients
401 N Parsons Ave, STE 107B
Brandon, FL 33511
Ph: (813) 661-7048 Fax: (813) 354-4647

Date: 10/07/2015

SECTION 1: Identification

Product Identifier	Product form: Substance
Substance name:	Guar gum
CAS No.:	900030-0
Molecular weight:	1-2 X 106 DALTONS
Synonyms:	Guar Cyamopsis, Guar Flour
Use of the substance/mixture:	Thickener, Stabilizer and Emulsifier
Supplier:	MG Ingredients 401 N parsons Ave. STE 107B Brandon, FL 33510
Phone:	1-813-661-7048
Email:	vimal@mgingredients.com
Emergency number:	1-813-817-5899

SECTION 2: Hazards identification

Classification of the substance

GHS-US classification: Not Classified

Label elements

GHS-US labeling: Not required

Hazard pictograms (GHS-US): Not required

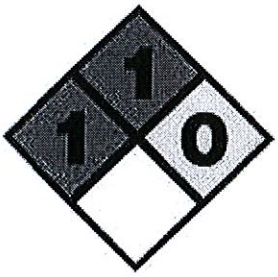
Signal word (GHS-US): No signal word

Hazard statements (GHS-US): Not applicable

Precautionary statements (GHS-US):

If in Eyes:	Rinse cautiously with water for several minutes. Remove contact lenses, if present, Continue rinsing.
If swallowed:	Call a doctor if you feel unwell.
If on skin:	Wash with plenty of water.
If inhaled:	Move to fresh air and seek medical advice.

NFPA RATING



HMIS Classification

HEALTH	1
FLAMMABILITY	1
REACTIVITY	0
PERSONAL PROTECTION	E

MG Ingredients
401 N Parsons Ave, STE 107B
Brandon, FL 33511
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SECTION 3: Composition/information on ingredients

Component Name	Product Identifier	Weight %
Guar Gum	(CAS No. 9000-30-0) (EINECS No. 232-536-8)	100

SECTION 4: First aid measures

Description of first aid measures

First-aid measures general: No Special precaution needed
First-aid measures after inhalation: If large quantities of dust are inhaled, keep the airway open. Move immediately to fresh air and seek Medical advice.
First-aid measures after skin contact: After contact with skin, wash with warm soapy water. If any irritation persists, seek medical advice
First-aid measures after eye contact: After contact with eyes, flush immediately with plenty of water. If irritation develops, seek medical advice.
First-aid measures after ingestion: If Guar gum powder is swallowed, seek medical attention may cause gastrointestinal blockage. Do not give laxatives. Do not induce vomiting unless directed to do so by medical personnel.

Most important symptoms and effects, both acute and delayed

Symptoms/injuries: Eye irritation.
Symptoms/injuries after inhalation: Coughing, Sore throat, Nasal Congestion, Sneezing and shortness of breath.
Symptoms/injuries after ingestion: Irritation of the digestive tract, choking, suffocation.

SECTION 5: Firefighting measures

Extinguishing media

Suitable extinguishing media: Water, foam or CO_2 extinguishers may be used on fires involving Guar Gum.
Unsuitable extinguishing media: Do not use streams of water as dust dispersed by water streams can explode.

Special hazards arising from the substance or mixture

Fire hazard: Carbon oxides
Explosion hazard: - There is a risk of dust explosion if fine particles mix with air.

Advice for firefighters

Firefighting instructions: Guar gum will burn when in contact with flame but self-extinguishes when the flame is removed. Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers form fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.
Protection during firefighting: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

SECTION 6: Accidental release measures

Personal precautions, protective equipment and emergency procedures

Spilled material may cause a slipping hazard. Avoid dust formation. Keep unnecessary and unprotected personnel from entering the area. For additional information, refer to section-8: Exposure controls and personal protection.

Environmental precautions

There is a risk of dust explosion if fine particles mix with air. Prevent from entering into soil, ditches, sewers, waterways and/or ground water. For additional information, refer to section-12: Ecological information.

Methods and material for containment and cleaning up

For containment: Clean up spills immediately, sweep up or vacuum, then place in to a suitable clean, dry and properly labeled closed container for disposal. Do not flush affected area with water unless absolutely necessary. Wetted surfaces can become extremely slippery. If wetted, flush thoroughly with water until all products is removed.

Methods for cleaning up: Recover dry product by vacuum or brush and shovel.

SECTION 7: Handling and storage

Precautions for safe handling:

Handling: No smoking, open flames or sources of ignition in handling and storage area. Wear appropriate personal protective equipment. Minimize dust generation and accumulation. Avoid contact with eyes, skin, and clothing. Keep container tightly closed. Avoid ingestion and inhalation. Ensure adequate ventilation.

Conditions for safe storage, including any incompatibilities:

Storage conditions: Store in a dry, cool and well-ventilated place. Keep container closed when not in use.
Incompatible with: Strong-oxidizing agents

SECTION 8: Exposure controls/personal protection

Exposure Limits: Contains no substances with occupational exposure limit

Exposure controls

Appropriate engineering controls : Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use adequate ventilation to keep airborne concentrations low.

Hand protection : Not normally necessary but standard work gloves recommended.

Eye protection : The use of goggles is recommended if there are heavy dust concentrations.

Skin and body protection : Wear appropriate protective clothing to prevent skin exposure.

Respiratory protection : A dust respirator is recommended if handling the product generates concentrations of dust

SECTION 9: Physical and chemical properties

Information on basic physical and chemical properties

Physical state	:	Solid
Appearance	:	Powder
Color	:	White to Creamy white
Odor	:	Slight.
pH	:	A 1% aqueous solution is approx neutral
Melting point	:	Decomposed
Freezing point	:	Not applicable
Boiling point	:	Not applicable
Flash Point	:	No data available

Auto-ignition temperature	:	>200^0 C
Decomposition Temperature	:	No data available
Flammability (solid, gas)	:	No data available
Vapor pressure	:	Not applicable
Vapor density	:	Not applicable
Density	:	550-850 kg/m^3 (depending upon grade)
Solubility	:	Soluble but forms very viscous solutions, which become pasty at concentrations greater than 5%.
Viscosity	:	Forms viscous solutions with water

Other information

No additional information available

SECTION 10: Stability and reactivity

Reactivity : No data available.
Chemical Stability : Guar gum is stable if stored under cool, dry conditions.
Possibility Of Hazardous Polymerization: Will not occur
Conditions To Avoid: Dust Generation
Incompatible Materials: Strong-oxidizing agents.
Hazardous Decomposition Products: Thermal decomposition may produce carbon monoxide and dioxide.

SECTION 11: Toxicological information

Guar gum is natural food additive. Guar gum is widely used in food and in pet food as a thickener, stabilizer and emulsifier

Information on toxicological effects

Acute toxicity

LD50 oral	>5000 mg/kg (rat)
LD50 dermal	No data available
LC50 inhalation (mg/m^3)	No data available

Skin corrosion/irritation: Repeated contact may cause flaking and softening of skin
Eye irritation: The dry powder may cause foreign body irritation in the eyes of some individuals. Corneal injury is unlikely.
Germ cell mutagenicity: No Data Available
Carcinogenicity: Not classified
Reproductive toxicity: Not classified
Specific target organ toxicity (single exposure): May cause respiratory sensitization.
Specific target organ toxicity (repeated exposure): Excessive inhalation of dust may cause slight irritation and can impede respiration owing to the hydrophilic nature of the gum, which can form a gel in the airway.
Aspiration hazard: Not classified
Symptoms/injuries after inhalation: Coughing, Sore throat, Nasal Congestion, Sneezing and shortness of breath.
Symptoms/injuries after eye contact: eye irritation.
Symptoms/injuries after ingestion: Irritation of the digestive tract, choking, suffocation.

SECTION 12: Ecological information

Eco Toxicity

Guar Gum is not expected to be harmful to the ecology.

Persistence and degradability

Guar gum is biodegradable in waste treatment facilities when well diluted.

Bio accumulative potential

No data available

Mobility in soil

No data available

SECTION 13: Disposal considerations

Waste treatment methods: Guar gum does not meet the criteria of a hazardous waste if discarded in its purchased form. Under RCRA, it is the responsibility of the user of the product to determine at the time of disposal, whether the product meet RCRA criteria for hazardous waste. This is because product user, transformations, mixtures, processes etc., may render the resulting materials hazardous.

Empty containers retain residues. All labeled precautions must be observed.

Waste disposal recommendations: Dispose of in a permitted industrial landfill. Ensure that containers are empty prior to disposal in a permitted industrial landfill. Do not dump down in sewers or drainage as this may cause blockage.

SECTION 14: Transport information

Not regulated as hazardous material No special requirements and no restrictions on transportation by land, sea or air.

U.S. Department of Transportation (DOT): Not Regulated

IMDG CODE: Not Regulated

IATA: Not Regulated

SECTION 15: Regulatory information

Guar gum is an EC permitted Food Additive (E-412).
Guar gum is approved as a direct food additive by WHO/FAO and in the United States by FDA regulation 121.104 - "Generally Recognized as Safe" (GRAS)

TSCA Inventory status	: All ingredients are listed on the TSCA inventory.
DSCL (EEC)	: All ingredients are listed on the DSCL Inventory.
California Propusition65	: Not listed
SARA 302	: Not listed
SARA 311	: Not listed
SARA 312	: Not listed
SARA 313	: Not listed
WHMIS Canada	: Not listed

SECTION 16: Other information

Creation Date: 15/05/2015

Revision/Review Date: No previous revision/review.

Disclaimer: The information and recommendations contained in this Safety Data Sheet have been compiled from sources believed to be reliable and to represent the most reasonable current opinion on the subject when the SDS was prepared. No warranty, guaranty or representation is made as to the correctness or sufficiency of the information. The user of this product must decide what safety measures are necessary to safety use this product, either alone or in combination with other products, and determine its environmental regulatory compliance obligations under any applicable federal or state laws.

MG Ingredients
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Ph: (813) 661-7048 Fax: (813) 354-4647

Abbreviations:

CAS	Chemical Abstract Service
GHS	Globally Harmonized System of Classification and Labeling of Chemicals
NFPA	National Fire Protection Association
HMIS	Hazardous Material Information System
LD50	Lethal Dose expected to cause death in 50% of the test animals
FDA	United States Food and Drug Administration
WHO	World Health Organization
FAO	Food and Agriculture Organization of the United Nations
IATA	International Air Transport Association
EINECS	European Inventory of Existing Commercial Chemical Substances
OSHA	U.S. Department of Labor, Occupational safety and health administration
IMDG	International Maritime Dangerous Goods.
RCRA	Resource Conservation and Recovery Act

Safety Data Sheet

Shaw Environmental, Inc.

17 PRINCESS ROAD
LAWRENCEVILLE, N.J. 08648
(609) 895-5340

SECTION 1 - MATERIAL IDENTIFICATION AND INFORMATION

Material Name: DHC microbial consortium (RTB-1 SDC-9) MSDS #: ENV 1033

Date Prepared: 10/06/2003 CAS #: N/A (Not Applicable)

Prepared By: Simon Vainberg Formula #: N/A

Material Description: Non-hazardous, naturally occurring non-altered anaerobic microbes and enzymes in a water-based medium.

24 HOUR EMERGENCY RESPONSE PHONE NUMBER (800)424-9300

SECTION 2 - INGREDIENTS

Components	%	OSHA PEL	ACGIH TLV	OTHER LIMITS
Non-Hazardous Ingredients	100	N/A	N/A	N/A

SECTION 3 - PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point: 100° C (water) Specific Gravity (H_2O = 1): 0.9 - 1.1

Vapor Pressure @ 25° C: 24 mm Hg (water) Melting Point: 0° C (water)

Vapor Density: N/A Evaporation Rate (H_2O = 1): 0.9 - 1.1

Solubility in Water: Soluble Water Reactive: No

pH: 6.0 - 8.0

Appearance and Odor: Murky, yellow water. Musty odor.

SECTION 4 - FIRE AND EXPLOSION HAZARD DATA

Flash Point: N/A

Flammable Limits: N/A

Extinguishing Media: Foam, carbon dioxide, water

Special Fire Fighting Procedures: None

Unusual Fire and Explosion Hazards: None

SECTION 5 - REACTIVITY DATA

Stability: Stable

Conditions to Avoid: None

Incompatibility (Materials to Avoid): Water-reactive materials

Hazardous Decomposition Byproducts: None

SECTION 6 - HEALTH HAZARD DATA

HEALTH EFFECTS

The effects of exposure to this material have not been determined. Safe handling of this material on a long-term basis will avoid any possible effect from repetitive acute exposures. Below are possible health effects based on information from similar materials. Individuals hyper allergic to enzymes or other related proteins should not handle.

Ingestion: Ingestion of large quantities may result in abdominal discomfort including nausea, vomiting, cramps, diarrhea, and fever.

Inhalation: Hypersensitive individuals may experience breathing difficulties after inhalation of aerosols.

Skin Absorption: N/A

SECTION 8 - HANDLING AND STORAGE

Hand Protection: Rubber gloves.

Eye Protection: Safety goggles with side splash shields.

Protective Clothing: Use adequate clothing to prevent skin contact.

Respiratory Protection: Surgical mask.

Ventilation: Provide adequate ventilation to remove odors.

Storage & Handling:
Material may be stored for up to 3 weeks at 2-4° C without aeration.

Other Precautions: An eyewash station in the work area is recommended.

Safety Data Sheet

according to 29CFR1910/1200 and GHS Rev. 3

Effective date : 10.24.2014

Magnesium Oxide

SECTION 1 : Identification of the substance/mixture and of the supplier

Product name : **Magnesium Oxide**

Manufacturer/Supplier Trade name:

Manufacturer/Supplier Article number: **S25413**

Recommended uses of the product and uses restrictions on use:

Manufacturer Details:

AquaPhoenix Scientific
9 Barnhart Drive, Hanover, PA 17331

Supplier Details:

Fisher Science Education
15 Jet View Drive, Rochester, NY 14624

Emergency telephone number:

Fisher Science Education Emergency Telephone No.: 800-535-5053

SECTION 2 : Hazards identification

Classification of the substance or mixture:

Not classified for physical or health hazards under GHS.

Hazard statements:

Precautionary statements:

If medical advice is needed, have product container or label at hand
Keep out of reach of children
Read label before use

Other Non-GHS Classification:

WHMIS
NFPA/HMIS

NFPA SCALE (0-4)

HMIS RATINGS (0-4)

SECTION 3 : Composition/information on ingredients

Ingredients:		
CAS 1309-42-8	Magnesium hydroxide	>98 %

Percentages are by weight

SECTION 4 : First aid measures

Description of first aid measures

After inhalation: Loosen clothing as necessary and position individual in a comfortable position.Move exposed to fresh air. Give artificial respiration if necessary. If breathing is difficult give oxygen.Get medical assistance if cough or other symptoms appear.

After skin contact: Rinse/flush exposed skin gently using soap and water for 15-20 minutes.Seek medical advice if discomfort or irritation persists.

After eye contact: Protect unexposed eye. Rinse/flush exposed eye(s) gently using water for 15-20 minutes. Remove contact lens(es) if able to do so during rinsing. Seek medical attention if irritation persists or if concerned.

After swallowing: Rinse mouth thoroughly. Do not induce vomiting. Have exposed individual drink sips of water. Seek medical attention if irritation, discomfort or vomiting persists.Never give anything by mouth to an unconscious person.

Most important symptoms and effects, both acute and delayed:

Irritation, Nausea,Headache, Shortness of breath.;

Indication of any immediate medical attention and special treatment needed:

If seeking medical attention, provide SDS document to physician.Physician should treat symptomatically.

SECTION 5 : Firefighting measures

Extinguishing media

Suitable extinguishing agents: Use appropriate fire suppression agents for adjacent combustible materials or sources of ignition. Use water, dry chemical, chemical foam, carbon dioxide, or alcohol-resistant foam.

For safety reasons unsuitable extinguishing agents:

Special hazards arising from the substance or mixture:

Combustion products may include carbon oxides or other toxic vapors.Thermal decomposition can lead to release of irritating gases and vapors.Magnesium oxide

Advice for firefighters:

Protective equipment: Use NIOSH-approved respiratory protection/breathing apparatus.

Additional information (precautions): Move product containers away from fire or keep cool with water spray as a protective measure, where feasible.Use spark-proof tools and explosion-proof equipment.Avoid generating dust; fine dust dispersed in air in sufficient concentrations, and in the presence of an ignition source is a potential dust explosion hazard.Avoid inhaling gases, fumes, dust, mist, vapor, and aerosols.Avoid contact with skin, eyes, and clothing.

SECTION 6 : Accidental release measures

Personal precautions, protective equipment and emergency procedures:

Wear protective equipment. Ensure that air-handling systems are operational.Ensure adequate ventilation.

Environmental precautions:

Prevent from reaching drains, sewer or waterway. Collect contaminated soil for characterization per Section 13. Should not be released into environment.

Methods and material for containment and cleaning up:

Keep in suitable closed containers for disposal.Wear protective eyeware, gloves, and clothing. Refer to Section 8.Always obey local regulations.Dust deposits should not be allowed to accumulate on surfaces, as these may

form an explosive mixture if they are released into the atmosphere in sufficient concentration. Avoid dispersal of dust in the air (i.e., clearing dust surfaces with compressed air). Collect solids in powder form using vacuum with (HEPA filter). Evacuate personnel to safe areas.

Reference to other sections:

SECTION 7 : Handling and storage

Precautions for safe handling:

Minimize dust generation and accumulation. Follow good hygiene procedures when handling chemical materials. Refer to Section 8.Do not eat, drink, smoke, or use personal products when handling chemical substances. Avoid contact with eyes, skin, and clothing.

Conditions for safe storage, including any incompatibilities:

Store away from incompatible materials.Protect from freezing and physical damage.Keep away from food and beverages.Provide ventilation for containers. Avoid storage near extreme heat, ignition sources or open flame. Store in cool, dry conditions in well sealed containers. Store with like hazards

SECTION 8 : Exposure controls/personal protection

Control Parameters: , , OSHA PEL TWA (Total Dust) 15 mg/m3 (50 mppcf*)
, , ACGIH TLV TWA (inhalable particles) 10 mg/m3

Appropriate Engineering controls: Emergency eye wash fountains and safety showers should be available in the immediate vicinity of use/handling.Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapor or dusts (total/respirable) below the applicable workplace exposure limits (Occupational Exposure Limits-OELs) indicated above.It is recommended that all dust control equipment such as local exhaust ventilation and material transport systems involved in handling of this product contain explosion relief vents or an explosion suppression system or an oxygen deficient environment.Ensure that dust-handling systems (such as exhaust ducts, dust collectors, vessels, and processing equipment) are designed in a manner to prevent the escape of dust into the work area (i.e., there is no leakage from the equipment).Use under a fume hood

Respiratory protection: Not required under normal conditions of use. Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls.When necessary use NIOSH approved breathing equipment.

Protection of skin: Select glove material impermeable and resistant to the substance.Select glove material based on rates of diffusion and degradation.Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices.Use proper glove removal technique without touching outer surface. Avoid skin contact with used gloves.Wear protective clothing.

Eye protection: Wear equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).Safety glasses or goggles are appropriate eye protection.

General hygienic measures: Perform routine housekeeping.Wash hands before breaks and at the end of work.Avoid contact with skin, eyes, and clothing.Before wearing wash contaminated clothing.

SECTION 9 : Physical and chemical properties

Appearance (physical state,color):	White powder	**Explosion limit lower**: **Explosion limit upper**:	Not determined Not determined
Odor:	Not Determined	**Vapor pressure**:	Not determined
Odor threshold:	Not determined	**Vapor density**:	Not determined
pH-value:	Not determined	**Relative density**:	3.580 g/cm3
Melting/Freezing point:	2,852 deg C (5,166 deg F)	**Solubilities**:	insoluble
Boiling point/Boiling range:	3,600 deg C (6,512 deg F) at 1,013 hPa (760 mmHg)	**Partition coefficient (n-octanol/water)**:	Not determined
Flash point (closed cup):	Not determined	**Auto/Self-ignition temperature**:	Not determined
Evaporation rate:	Not determined	**Decomposition temperature**:	Not determined
Flammability (solid,gaseous):	Not determined	**Viscosity**:	a. Kinematic:Not determined b. Dynamic: Not determined
Density: Not determined			

SECTION 10 : Stability and reactivity

Reactivity: Nonreactive under normal conditions.
Chemical stability: Stable under normal conditions.
Possible hazardous reactions: None under normal processing
Conditions to avoid: Incompatible Materials.
Incompatible materials: Strong acids.Strong bases.Oxidizing agents.
Hazardous decomposition products:

SECTION 11 : Toxicological information

Acute Toxicity: No additional information.	
Chronic Toxicity: No additional information.	
Corrosion Irritation: No additional information.	
Sensitization:	No additional information.
Single Target Organ (STOT):	No additional information.
Numerical Measures:	No additional information.
Carcinogenicity:	No additional information.

Mutagenicity:	No additional information.
Reproductive Toxicity:	No additional information.

SECTION 12 : Ecological information

Ecotoxicity Persistence and degradability:
Bioaccumulative potential:
Mobility in soil:
Other adverse effects:

SECTION 13 : Disposal considerations

Waste disposal recommendations:

Contact a licensed professional waste disposal service to dispose of this material.Dispose of empty containers as unused product.Product or containers must not be disposed with household garbage.It is the responsibility of the waste generator to properly characterize all waste materials according to applicable regulatory entities (US 40CFR262.11).Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations. Ensure complete and accurate classification.

SECTION 14 : Transport information

UN-Number

Not Regulated.

UN proper shipping name

Not Regulated.

Transport hazard class(es)
Packing group:Not Regulated
Environmental hazard:
Transport in bulk:
Special precautions for user:

SECTION 15 : Regulatory information

United States (USA)

SARA Section 311/312 (Specific toxic chemical listings):

SARA Section 313 (Specific toxic chemical listings):

None of the ingredients is listed

RCRA (hazardous waste code):

None of the ingredients is listed

TSCA (Toxic Substances Control Act):

All ingredients are listed.

CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act):

None of the ingredients is listed

Proposition 65 (California):

Chemicals known to cause cancer:

None of the ingredients is listed

Chemicals known to cause reproductive toxicity for females:

None of the ingredients is listed

Chemicals known to cause reproductive toxicity for males:

None of the ingredients is listed

Chemicals known to cause developmental toxicity:

None of the ingredients is listed

Canada

Canadian Domestic Substances List (DSL):

All ingredients are listed.

Canadian NPRI Ingredient Disclosure list (limit 0.1%):

None of the ingredients is listed

Canadian NPRI Ingredient Disclosure list (limit 1%):

1309-42-8 Magnesium hydroxide

SECTION 16 : Other information

This product has been classified in accordance with hazard criteria of the Controlled Products Regulations and the SDS contains all the information required by the Controlled Products Regulations.Note:. The responsibility to provide a safe workplace remains with the user.The user should consider the health hazards and safety information contained herein as a guide and should take those precautions required in an individual operation to instruct employees and develop work practice procedures for a safe work environment.The information contained herein is, to the best of our knowledge and belief, accurate.However, since the conditions of handling and use are beyond our control, we make no guarantee of results, and assume no liability for damages incurred by the use of this material.It is the responsibility of the user to comply with all applicable laws and regulations applicable to this material.

GHS Full Text Phrases:

Abbreviations and acronyms:

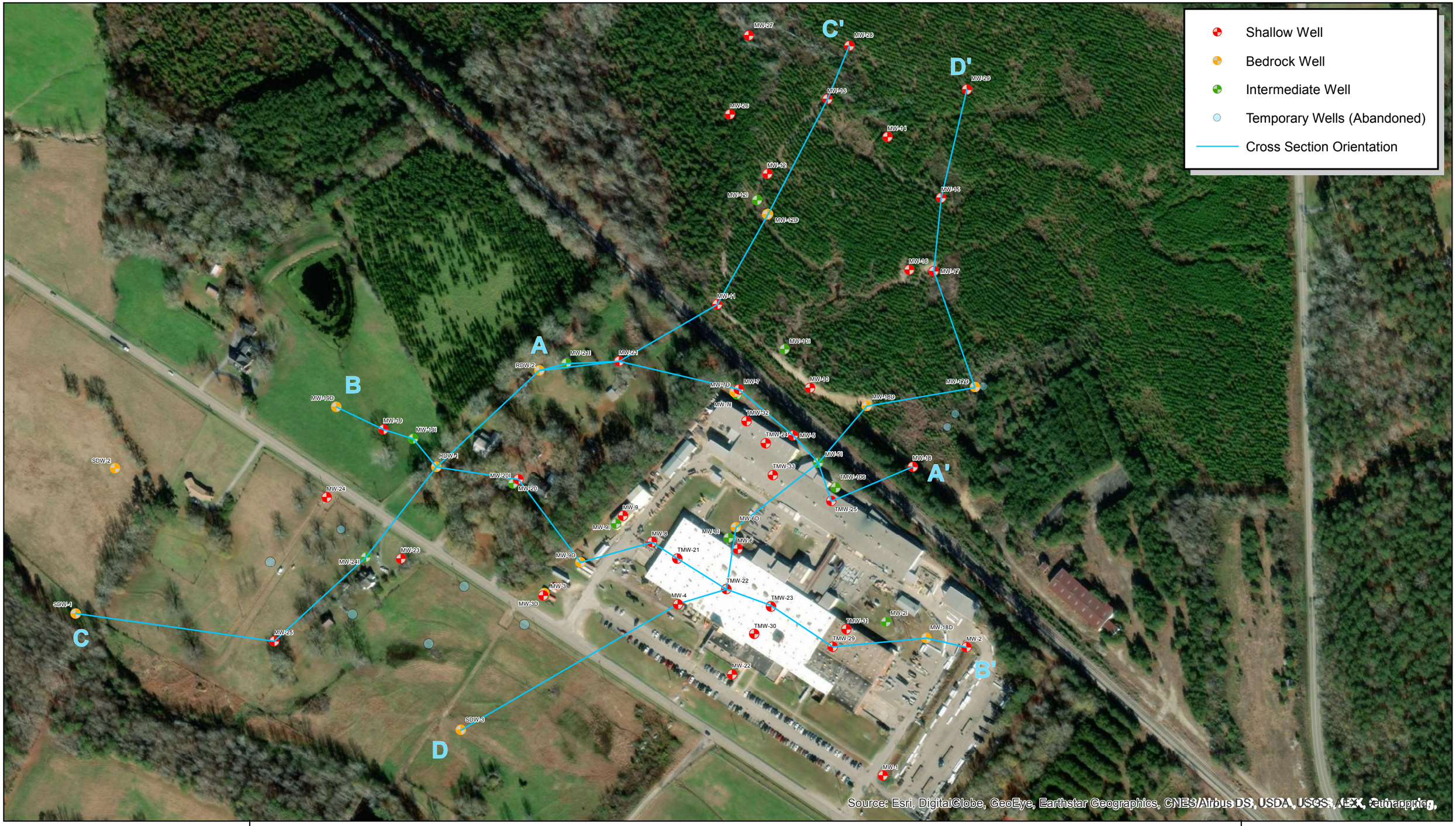
IMDG: International Maritime Code for Dangerous Goods
IATA: International Air Transport Association
GHS: Globally Harmonized System of Classification and Labelling of Chemicals
ACGIH: American Conference of Governmental Industrial Hygienists
CAS: Chemical Abstracts Service (division of the American Chemical Society)
NFPA: National Fire Protection Association (USA)
HMIS: Hazardous Materials Identification System (USA)
WHMIS: Workplace Hazardous Materials Information System (Canada)
DNEL: Derived No-Effect Level (REACH)
PNEC: Predicted No-Effect Concentration (REACH)
CFR: Code of Federal Regulations (USA)
SARA: Superfund Amendments and Reauthorization Act (USA)
RCRA: Resource Conservation and Recovery Act (USA)
TSCA: Toxic Substances Control Act (USA)
NPRI: National Pollutant Release Inventory (Canada)
DOT: US Department of Transportation

Effective date : 10.24.2014

Last updated : 03.19.2015

APPENDIX B

CROSS SECTION ORIENTATIONS AND ASSOCIATED CROSS SECTIONS



AECOM
101 Research Drive
Columbia, SC 29203-9389
T: (803) 254-4400 F: (803) 771-6676

Figure 4-2: Orientations of Cross Sections

Shakespeare Composition Structures Site
Newberry, South Carolina

Project No.: 60534283; Prepared by: JG; Date: 6/11/2018.

N
W E
S

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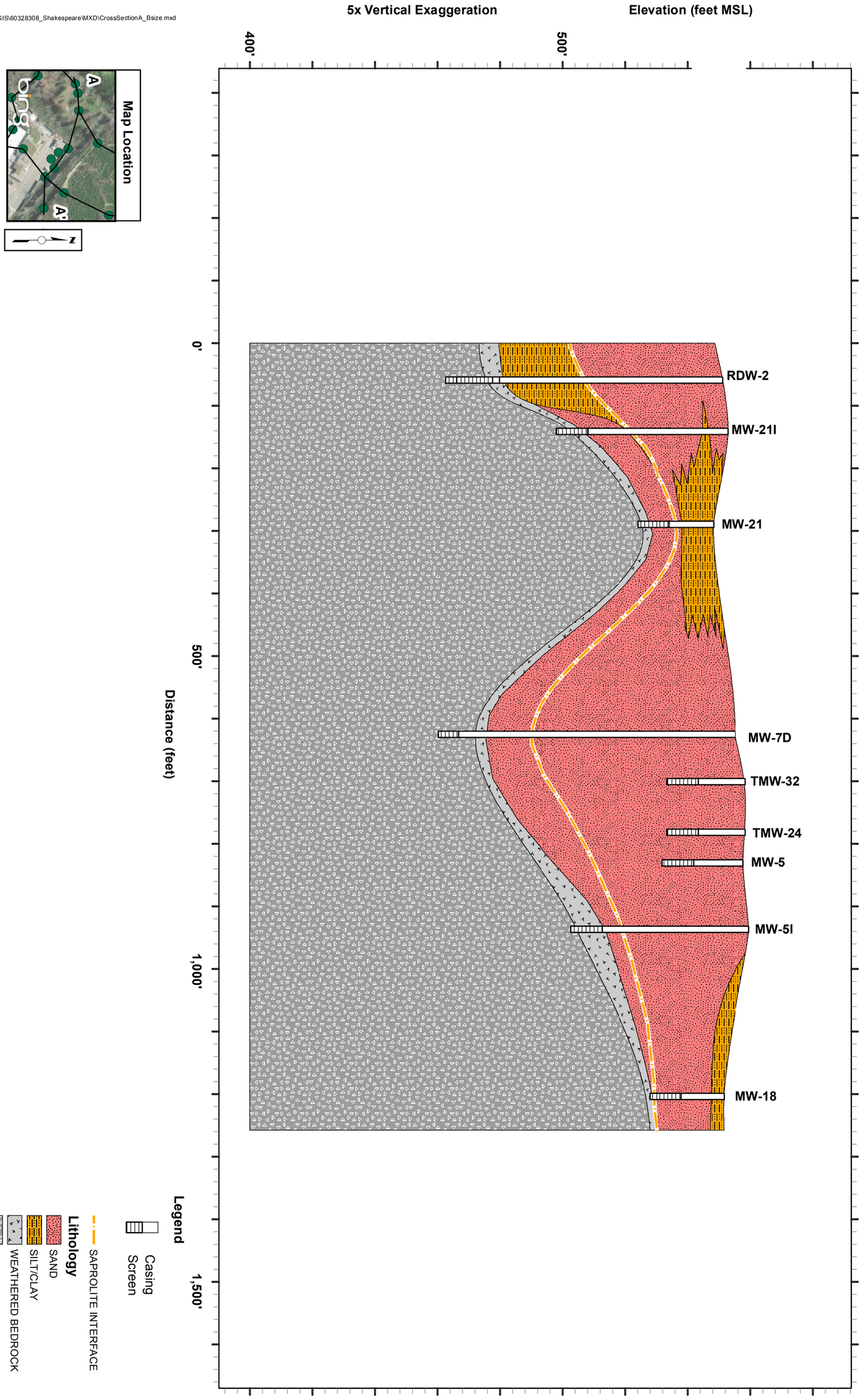


Newberry, South Carolina

Shakespeare Composition Structures
Project No.: 60534283 Date: 2018-06-14

CROSS-SECTION A-A'

AECOM

Figure 4-3

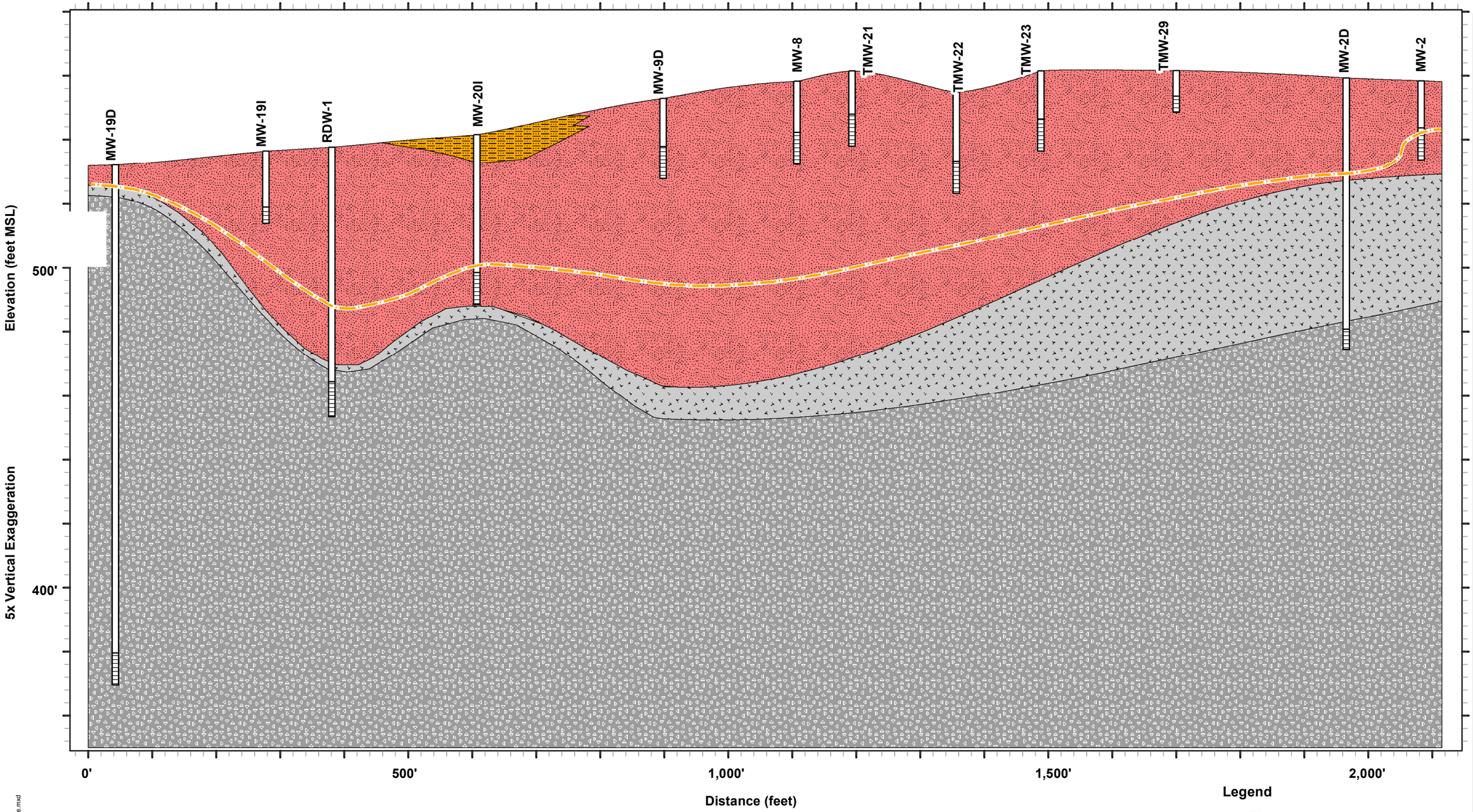
AECOM

Figure 4-4

CROSS-SECTION B-B'

Newberry, South Carolina

Shakespeare Composition Structures
Project No.: 60534283 Date: 2018-06-14



Legend

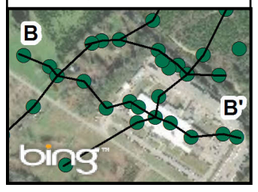
Casing
Screen

SAPROLITE INTERFACE

Lithology

SAND
SILT/CLAY
WEATHERED BEDROCK
BEDROCK

Map Location



N

Path: C:\GIS\60328308_Shakespeare\MXD\CrossSectionB_Bsize.mxd

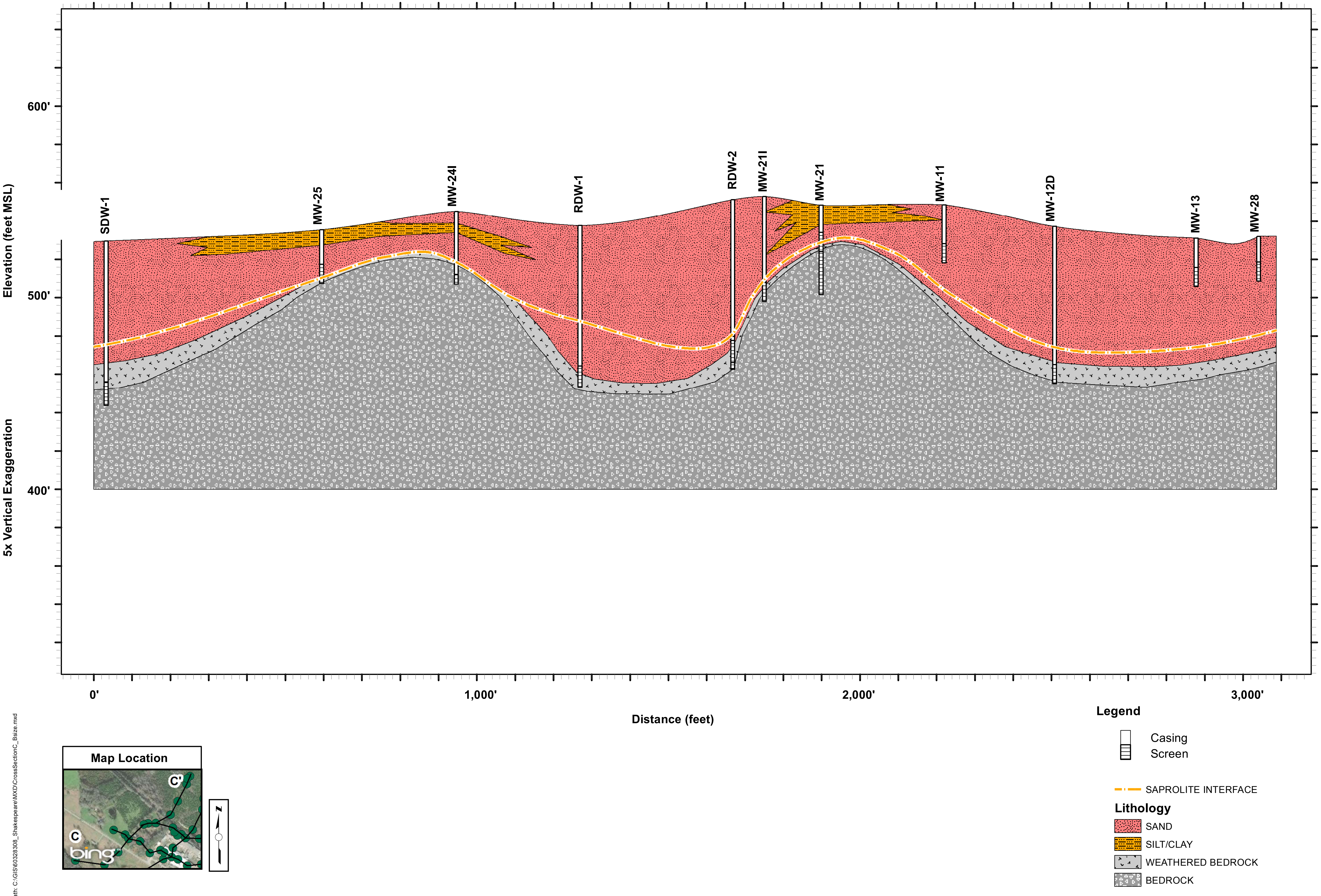


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Figure 4-5

CROSS-SECTION C-C'

Newberry, South Carolina

Shakespeare Composition Structures

Project No.: 60534283 Date: 2018-06-14

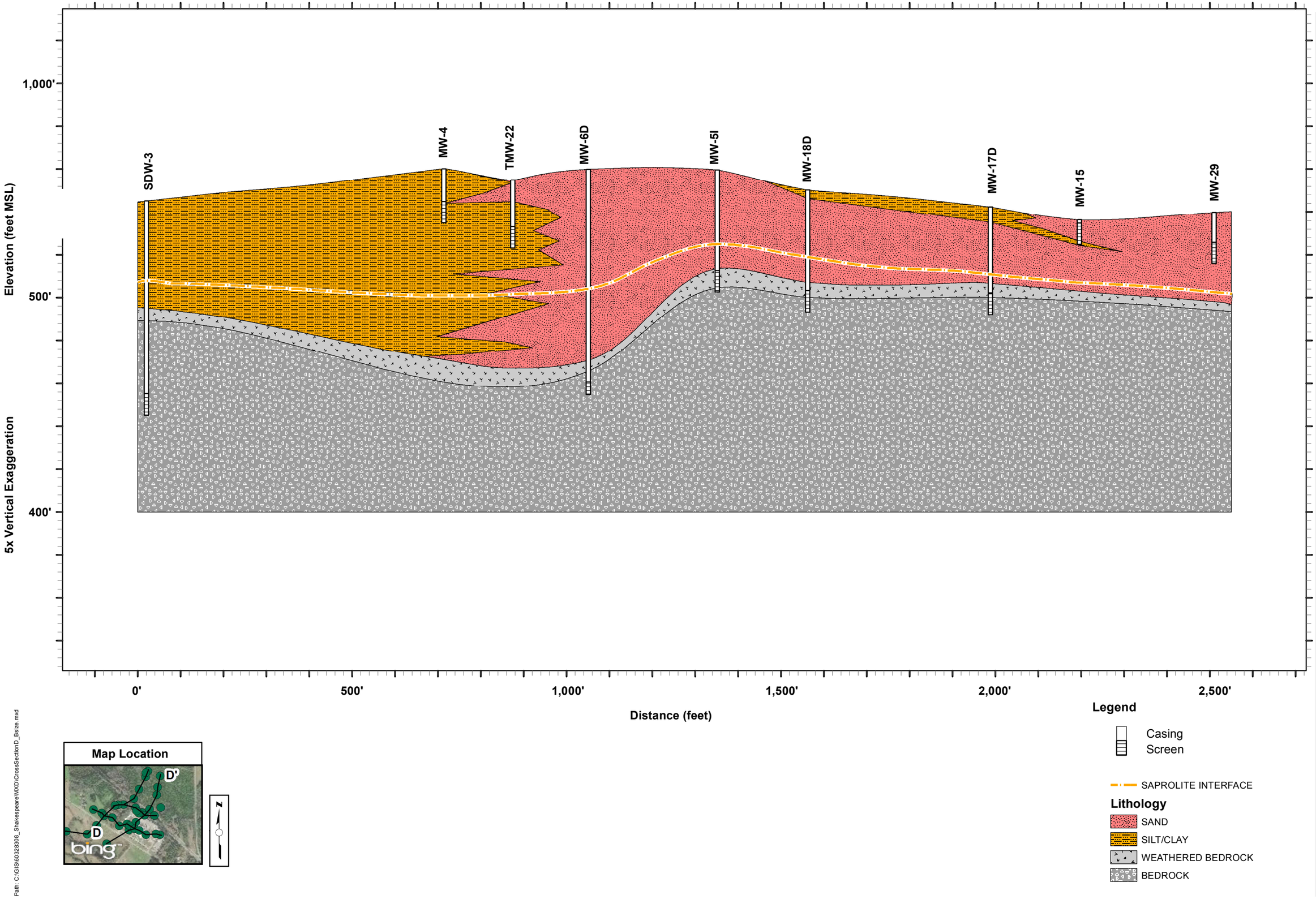

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Figure 4-6

CROSS-SECTION D-D'

Newberry, South Carolina

Shakespeare Composition Structures
Project No.: 60534283 Date: 2018-06-14

Path: C:\GIS\60328308_Shakespeare\MXD\CrossSectionD_Bsize.mxd

Attachment B

Monitoring Well Permit Application

Monitoring Well Application

1. Proposed Location of Monitoring Well(s):

Street Address: **Valmont Composite Structures 19845 US Hwy 76**

City (including Zip): **Newberry, SC 29108**

County: **Newberry**

Please attach Scaled Map or Plat

2. Well Owner's Information:

Name (Last then First): **Weeks, Dean**

Company: **Signify North America**

Complete Address: **200 Franklin Street Somerset, NJ 08873**

Telephone Number: **(908) 705-4743**

3. Property Owner's Information:

☐ Check if same as Well Owner

Name (Last then First): **Dickert, James L.**

Company: **N/A**

Address: **1156 Old Whitmire Highway Newberry, SC 29108**

Telephone Number: **(803) 924-7275**

4. Proposed Drilling Date:

5. Intended Purpose of Well(s):

Pre-Purchase ☐

Investigation ☑

NOTE: If this request is for an existing DHEC project, please enter the Program area and ID number below.

Program Area:
Project or Site ID #: **VCC No. 04-5483-RP**

6. Proposed number of monitoring wells: **5**

7. Proposed parameters to be analyzed (check all that apply), please specify analytical method beside check box:

VOCs	☑	8260B
BTEX	☐	
MtBE	☐	
Naphthalene	☐	
PAHs	☐	
Metals	☐	
Nitrates	☑	SW 9056A
Base, Neutral & Acid Ex.	☐	
Pesticides/Herbicides	☐	
Phenols	☐	
Radionuclides	☐	
PCBs	☐	
Other (specify below)	☑	Various

dissolved & total iron, sulfate, sulfide, methane, ethane, ethene, chloride, alkalinity, TOC

8. Proposed construction details (complete and attach proposed monitoring well schematics):

See attached Typical Well Construction Detail. One well installed to 21 ft bgs.

Monitoring Well Application

1. Proposed Location of Monitoring Well(s):

   Street Address: **Valmont Composite Structures 19845 US Hwy 76**

   City (including Zip): **Newberry, SC 29108**

   County: **Newberry**

   Please attach Scaled Map or Plat

2. Well Owner's Information:

   Name (Last then First): **Weeks, Dean**

   Company: **Signify North America**

   Complete Address: **200 Franklin Street Somerset, NJ 08873**

   Telephone Number: **(908) 705-4743**

3. Property Owner's Information:

   ☐ Check if same as Well Owner

   Name (Last then First): **Senn, Mike**

   Company: **Valmont Composite Structures**

   Address: **19845 US Hwy 76 Newberry, SC 29108**

   Telephone Number: **(803) 276-5504**

4. Proposed Drilling Date:

5. Intended Purpose of Well(s):

   Pre-Purchase ☐

   Investigation ☑

   NOTE: If this request is for an existing DHEC project, please enter the Program area and ID number below.

   Program Area:
   Project or Site ID #: **VCC No. 14-6271-RP**

6. Proposed number of monitoring wells: **2**

7. Proposed parameters to be analyzed (check all that apply), please specify analytical method beside check box:

VOCs	☑	8260B
BTEX	☐	
MtBE	☐	
Naphthalene	☐	
PAHs	☐	
Metals	☐	
Nitrates	☑	SW 9056A
Base, Neutral & Acid Ex.	☐	
Pesticides/Herbicides	☐	
Phenols	☐	
Radionuclides	☐	
PCBs	☐	
Other (specify below)	☑	Various

dissolved & total iron, sulfate, methane, ethane, ethene, chloride, alkalinity, TOC, qPCR.

8. Proposed construction details (complete and attach proposed monitoring well schematics):

See attached Typical Well Construction Detail. One well installed to 20 ft bgs and one well installed to 41 ft bgs.

About AECOM

AECOM is the world's premier infrastructure firm, delivering professional services throughout the project lifecycle – from planning, design and engineering to consulting and construction management. We partner with our clients in the public and private sectors to solve their most complex challenges and build legacies for generations to come. On projects spanning transportation, buildings, water, governments, energy and the environment, our teams are driven by a common purpose to deliver a better world. AECOM is a Fortune 500 firm with revenue of approximately $20.2 billion during fiscal year 2019. See how we deliver what others can only imagine at aecom.com and @AECOM.

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