In-Situ Chemical Oxidation Work Plan
Champaign Former MGP Site
Champaign, Illinois

March 2013

Prepared for:

AMEREN ILLINOIS COMPANY

St. Louis, Missouri

Columbia, Illinois

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TABLE OF CONTENTS

REFERENCES

LIST OF TABLES

LIST OF FIGURES

APPENDIX A PORTIONS OF IN-SITU OXIDATIVE TECHNOLOGIES, INC.'S *PROPOSAL TO PROVIDE IN-SITU CHEMICAL OXIDATION REMEDIATION PROGRAM*

1 INTRODUCTION

PSC Industrial Outsourcing, LP (PSC) has been retained by Ameren Illinois (Ameren) to prepare this *In-Situ Chemical Oxidation Work Plan* (Work Plan) for the former Manufactured Gas Plant (MGP) located at 308 N. 5th Street in Champaign, Illinois.

Impact to soil and groundwater was identified during site investigation activities at levels that exceeded Tier 1 Remedial Objectives (ROs). Ameren Illinois has addressed the onsite impact through soil excavation and disposal. Remedial activities were performed at the site between June 2009 and September 2011. Impacted soil within the remediation site boundaries was excavated from ground surface to approximately 16 to 28 feet (ft). Soil confirmation samples contained exceedances of Tier 1 ROs following the remediation activities; therefore, In-Situ Chemical Oxidation (ISCO) treatment was selected as the treatment technology to address the perimeter exceedances. A Project Status Report dated March 2013 was submitted to the IEPA that detailed the soil excavation activities and confirmation sampling results.

The objective of this Work Plan is to describe in detail the ISCO injections that are proposed for the site. Following the completion of the ISCO activities, a Remedial Action Completion Report (RACR) will be submitted that will provide a final evaluation of the site as required to obtain a No Further Remediation (NFR) letter for the site from the Illinois Environmental Protection Agency (IEPA).

2 SITE INFORMATION

The following section presents information relative to site setting, site history, and previous site remediation measures.

2.1 Site Setting

The remediation site (site) consists of a vacant lot on which the former Champaign MGP operated. The site is located at 308 North Fifth Street (formerly 502 East Hill Street) in Champaign, Illinois (Figure 2-1). The site is located in the northeast quarter of the southwest quarter of Section 7, Township 19 North, Range 9 East of the Third Principal Meridian.

Ameren is the current owner of the property. The site is approximately 2.4 acres in size and is secured by a chain link fence and locked gates. The topography is generally flat and grass-covered. The structures associated with MGP operations have been removed. Remedial activities, which included the excavation and disposal of approximately 187,000 tons of impacted soil, were performed at the site between June 2009 and September 2011.

A railroad right-of-way (Norfolk-Southern) borders the site to the north and several residential properties are located north of the active track. The Sixth Street right-of-way is adjacent to the east; however, Sixth Street was previously abandoned between the railroad right-of-way and the alley south of the site. During remedial activities, the eastern portion of the site was extended to encompass the abandoned portion of the Sixth Street right-of-way to effectively address the subsurface impact in that area. Other property east of the Sixth Street right-of-way is zoned commercial and consists of vacant land and parking lots. Residential properties to the south are separated from the site by a chain link fence and an alleyway. Fifth Street borders the site to the west and separates the site from residential properties. The surrounding neighborhood is anticipated to remain zoned as residential and light-commercial. The future use of the site is uncertain at this time.

2.2 Site History

The history of the site was developed by review of available historic information. The following sources were used to develop the site history: Sanborn Fire Insurance Maps (Sanborn maps); *Browns' Directories of American Gas Companies (Browns' Directories)*; Ameren site records; and other miscellaneous sources.

Historical information indicates that gas was manufactured on the site as early as 1869 and continued through 1933. Gas was produced by coal carbonization, oil gasification, and carbureted water gas methods during various periods of operation. After operations ceased, the plant was maintained for stand-by production purposes until about 1955. Plant facilities were demolished between 1955 and 1960, with the exception of the booster house, which was demolished in December 2008. Although the property remained vacant, Illinois Power, a predecessor of Ameren Illinois, maintained ownership of the property until 1979 when it was sold to the American Legion. Illinois Power repurchased the property from the American Legion in 1991 after preliminary environmental investigations indicated the presence of MGP related impacts at the site.

Past site features included the former gas plant and associated buildings, three tar wells, two gas holders (GH-1 and GH-2) and two oil tanks located on the northern portion of the site. The former booster house, a third gas holder (GH-3) three purifiers, and seven oil tanks were located on the southern portion of the site.

2.3 Subsurface Geology

The general subsurface geology for the remediation site consists of surficial fill material, a weathered till unit, unweathered till unit, and lower silty sand unit of the Glasford Formation. A brief description of the geologic units are provided below.

2.3.1 Surficial Fill Layer

The surficial fill layer is typically 3 to 4 feet thick and covers the entire site. The fill consists of gravelly silt and sand, with cinders, bricks and debris. Much of the fill was placed on the site after demolition of the MGP facilities was completed. Some topsoil encountered may have been classified as fill material based on a dark organic appearance which resembles the known fill on site. Topsoil was also placed over portions of the site where CSI test pits were excavated. The fill is thickest in an isolated area along the northern portion of the site near the railroad tracks.

2.3.2 Weathered Till Unit

The first natural subsurface material encountered is a weathered till unit. The unit is continuous beneath the study area and is believed to be part of the Batestown Till Member of the Wisconsinan Wedron Formation. The Weathered Till Unit was contacted at various depths beneath the study area. The unit averages 10 to 15 feet thick beneath the site.

The Weathered Till Unit is comprised of brown to gray silty clay with some oxidation evident along clay fractures. MGP residual staining is present along some of these fractures. Numerous minor sand and silty sand layers were encountered; however, the sand layers are laterally discontinuous. Residual impacts are frequently associated with sandy and silty layers. The distinction between the weathered and unweathered till units was often difficult to distinguish.

2.3.3 Unweathered Till Unit

The Unweathered Till Unit is also believed to be part of the Batestown Till Member of the Wisconsinan Wedron Formation. The unit is generally differentiated from the Weathered Till Unit by the gray color and lack of weathering along fractures. The Unweathered Till was encountered at depths ranging from 9 to 20.5 feet bgs. Sand and gravel layers were also encountered within the Unweathered Till Unit; however, these layers were not laterally continuous beneath the site.

2.3.4 Lower Silty Sand Unit

Three deep boreholes drilled during the Phase II investigation encountered thick sand, silty sand, and gravel units at depths below 100 feet. These deeper deposits are believed to be the upper units of the Illinoisan Glasford Formation. The actual contact between Wedron and Glasford was not delineated due to the similarities between the units and the rotary wash drilling method used in the deeper boreholes.

2.4 Hydrogeologic Conditions

The following paragraphs provide a brief description of the groundwater bearing units and the groundwater flow conditions at the site. The groundwater bearing units consist of shallow, intermediate, and deep systems.

2.4.1 Site Hydrogeology

The shallow groundwater system at the site is an unconfined water-bearing zone with the saturation depth (water table) found in the surficial fill layer or the uppermost till unit. Shallow groundwater is monitored by a network of nineteen wells located on and around the remediation site. Groundwater in the shallow system beneath most of the study area generally flows in a somewhat radial pattern from the site. Depth to the shallow groundwater system typically ranges from 3 to 10 feet bgs.

Slug testing was performed on five of the shallow groundwater monitoring wells in June of 2011. The hydraulic conductivity results of the June 2011 testing ranged from a low of 2.6 x 10-6 cm/sec at well UMW-109 to a high of 9.6 x 10-5 cm/sec at well UMW-107, with a geometric mean value for all five wells of 3.1 x 10-5 cm/sec. The shallow groundwater meets the IEPA definition of Class II groundwater.

The intermediate groundwater system is monitored by a network of nine wells located on and around the remediation site. Depth to the intermediate groundwater system typically ranges from 27 to 31 feet bgs. Slug testing was performed in four of the eight intermediate wells (UMW-301, UMW-302, UMW-303, and UMW-304) during the off-site investigation in 2008. The horizontal hydraulic conductivity values ranged from 2.80 x 10-2 centimeters per second to 8.63 x 10-2 centimeters per second. The mean hydraulic conductivity calculated using data from the four wells was 4.85 x 10-2 centimeters per second or 137.5 feet per day. The intermediate groundwater meets the IEPA definition of Class I groundwater. Groundwater generally flows in a southeast direction.

The deepest groundwater system that has been monitored at the site is a sand and gravel zone within the Lower Glasford Formation beginning at a depth of about 151 feet bgs to a depth greater than 177 feet bgs. The sand and gravel layers encountered in this zone were much thicker and laterally continuous than the silty sand and sand units encountered in the weathered and unweathered till units. The water levels for the three wells screened in this zone stabilized at depths of approximately 120 feet bgs. The regional gradient is the west-southwest. The deep groundwater monitoring wells were monitored from 1992 to 1998 and were abandoned in 1999.

2.5 Site Remediation

Remedial activities were completed at the site between June 2009 and September 2011. Impacted soil within the remediation site boundaries was excavated approximately 16 to 28 feet (ft) below ground surface (bgs). The soil excavation was completed beneath a temporary tent structure to contain emissions for the work completed within the structure. Due to the size of the property, the remediation was completed in nine individual phases and the tent structure was relocated for each phase.

Following the completion of the original nine phases, excavation of the site perimeter (approximately 10-25 feet in width) was conducted in areas that were not covered by the tent structure. The perimeter excavations were separated into six areas that included the entire northern and western boundaries and a portion of the southern and eastern boundaries. The tent structure was not necessary for the shallow perimeter soil excavations as confirmed by continuous air quality monitoring; therefore, the perimeter excavation areas were conducted in "open air." The perimeter excavations were completed to a depth of three feet bgs, with the exception of Area 2 located in the area of the former oil tanks, which was excavated to a depth of 10 feet bgs.

The results of each remediation phase and perimeter excavations were compiled to determine the effectiveness of the remedial actions for the site as a whole. Soil confirmation samples contained exceedances of Tier 1 ROs following the remediation activities; therefore, In-Situ Chemical Oxidation (ISCO) treatment will be completed on-site to address the exceedances. Table 2-1 presents a summary of the soil analytical data for the samples that exceed Tier 1 ROs.

Additional information regarding the 2009 – 2011 site remediation are presented in the Project Status Report dated March 2013.

3 ISCO PROJECT OBJECTIVES

The goal of the proposed remedial activity is to implement ISCO at the perimeter locations (Figure 3-1) where concentrations of organic constituents of concern (COCs) exceed Tier 1 ROs for the soil inhalation exposure pathway in the upper 10 feet of soil. The perimeter areas located within the site boundaries have been excavated to a depth of three feet bgs during the site remediation in 2009 – 2011. However, concentrations of COCs in the 3 to 10 foot depth interval in exceedance of the soil inhalation exposure pathway for residential property use have been identified and will be addressed using ISCO.

3.1 Tier 1 Remediation Objectives

The onsite treatment areas around the site perimeter have exceedances for the BTEX and naphthalene compounds in the 3 to 10 foot depth interval. The goal of the ISCO injections for the onsite areas is to reduce the BTEX and naphthalene concentrations until they meet the Tier 1 inhalation ROs for residential property use.

3.2 Soil Attenuation

As stated in the Project Completion Report, three soil confirmation samples collected during the site remediation exceeded the soil attenuation capacity for the site. The exceedances are presented in Table 3-2. ISCO will be applied to the area where soil confirmation floor sample P2-D4-F (22) was collected in order to reduce the soil impact. The injections will be performed until the sum of the organic compounds is below the site-specific f_{oc} value of 10,400 mg/kg.

Two wall confirmation soil samples, P4-A1-W (20) and PA5-08(3), also exceeded the soil attenuation capacity. Each of these samples are located within perimeter areas where ISCO injections are proposed. Oxidant will be injected at these depths and additional confirmation samples will be collected to ensure that the concentrations are below the site-specific f_{oc} value following the ISCO injections.

3.3 Intermediate Groundwater System

Groundwater samples collected from monitoring well UMW-302, located on the adjacent property to the south of the remediation site and screened in the intermediate depth groundwater system, have concentrations of benzene and naphthalene above Class I groundwater standards. ISCO injections will be applied onsite to an area located along the southern property boundary to address the soil impact from the 3 to 10 foot depth interval. ISCO injections will also be applied at depths of approximately 36 to 44 feet bgs in order to contact the intermediate groundwater system and potentially reduce constituent concentrations in monitoring well UMW-302. The ISCO injection locations are shown on Figure 3-1.

4 IN-SITU CHEMICAL OXIDATION

PSC has contracted with In-Situ Oxidative Technologies, Inc. (ISOTEC), of Arvada Colorado, to perform the ISCO treatment at the Champaign site. Utilizing the soil data collected from the site and information from the pilot study conducted in 2009, ISOTEC selected a neutral pH modified Fenton's reagent to treat the Champaign site. The following sections provide a description of the in-situ process proposed for the site. Appendix A contains excerpts from ISOTEC's *Proposal To Provide In-Situ Chemical Oxidation Remediation Program* that were used as reference for the following sections.

4.1 Neutral pH Modified Fenton's Reagent

Fenton's chemistry was first documented by H.J.H. Fenton in 1894. It is characterized by the combination of soluble iron with low concentrations of hydrogen peroxide to produce hydroxyl radicals ($OH^{\bullet}$). These hydroxyl radicals are very powerful and short-lived oxidizers. Similar to the reaction of other oxidizers, the hydroxyl radicals attack the carbon double bonds of the chlorinated hydrocarbon molecule. Under certain conditions reductive species can also be formed by Fenton's chemistry. This gives Fenton's reagent two separate pathways to attack a wide range of contaminants. The summary equation for Fenton's chemistry is shown below.

$$\mathbf{Fe^{+2} + H_2O_2 \rightarrow Fe^{+3} + OH^- + OH^{\bullet}}$$

Where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, Fe^{+3} is ferric iron, $OH^{\bullet}$ is hydroxyl free radical and OH^- is hydroxide ion.

Iron is used to catalyze the reaction. Maintaining iron in solution is important for the process to be successful in an in-situ application. To eliminate the necessity of performing the reaction under low pH conditions, as is the case with traditional Fenton's chemistry; complexed iron is used in in-situ applications via the ISOTEC process. The hydrogen peroxide and dissolved iron solutions are injected through a site-specific delivery system providing sufficient distribution to selectively treat the area of concern. Reaction time is very fast, with oxidation capacity of the reagent being used up in a matter of a few days. Hydrogen peroxide breaks down into water and oxygen and the iron catalyst is oxidized and precipitates out of solution. It is important to note that the concentration of hydrogen peroxide will be relatively dilute, generally less than 17%, which eliminates the potential for significant exothermic reactions that are associated with higher concentrations of hydrogen peroxide. Experience with this process using low hydrogen peroxide concentrations and complexed iron has resulted in less than a 25° F temperature increase in field applications.

Fenton-based oxidation processes have been shown to effectively treat a wide range of contaminants including hard-to-treat compounds such as chlorinated solvents, petroleum hydrocarbons, gasoline additives including benzene, toluene, ethylbenzene and xylene (BTEX), and pesticides. Hydroxyl radicals and reductive species generated by the

Fenton-based reagent will treat nearly all contaminants with carbon/carbon double bonds and single bonded contaminants with extractable hydrogen.

The stoichiometric relationship between benzene oxidation and hydrogen peroxide consumption can be predicted from the oxidative reaction:

$$\mathbf{C_6H_6 + H_2O_2 \rightarrow 6CO_2 + H_2O + 3H^+}$$

Where C_6H_6 is benzene, H_2O_2 is hydrogen peroxide, CO_2 is carbon dioxide, and H^+ is hydrogen ion. Hydrogen peroxide not consumed in the above reaction will continue to oxidize the groundwater contaminants and will naturally degrade along with the contaminant to oxygen and water.

The ISCO process consists of injecting stabilized hydrogen peroxide and complexed iron catalysts into contaminated aquifers or vadose zones. As compared to conventional Fenton's Reagent which requires acidic conditions ($pH \leq 3$) the ISOTEC process is effective at neutral ($pH = 7$) conditions. This is an important consideration in full-scale application since acidifying an aquifer is typically impractical. ISOTEC's oxidation method utilizes a site-specific delivery system(s) designed to treat organic contaminants within an area of concern. The oxidants and catalysts generate hydroxyl radicals, which react with the organic contaminants within the subsurface producing innocuous by-products such as carbon dioxide and water.

4.2 ISCO Remediation Program

The specific target treatment interval for the treatment areas is from 3 to 10 feet bgs around the site perimeter. Two treatment areas, located at confirmation sample locations P2-D4-F(22) and P4-A1-W(20), have target treatment intervals of approximately 20 to 25 feet bgs. The target treatment interval for the area located along the southern property boundary, north of monitoring well UMW-302, is from approximately 36 to 44 feet bgs (Figure 3-1). Based upon the site geology and the results of the pilot study, multiple injection events may be required.

ISOTEC proposes to utilize their patented neutral pH chelated iron catalyst and stabilized 8% hydrogen peroxide to implement an ISCO program. ISOTEC will utilize direct-push technology (DPT) to introduce reagents into the subsurface at the site. The ISCO program has been designed to address vadose zone and saturated zone soils within the treatment areas.

In order to meet the project objectives, the following are proposed: 1) injection locations be closely spaced, 2) two injection screens, each targeting a separate injection interval be utilized across the treatment interval 3) injection screens be installed by a direct push technology (DPT) drill rig, and 4) multiple injection events be completed. The multiple injection events are needed to deliver the necessary volumes of reagent while limiting the reagent volume injected during each event. The injection locations will be closely spaced in order to have overlapping treatment areas with smaller volumes of reagent which will limit the potential for one vertical surfacing conduit to impact injection at numerous injection points. Utilizing two separate screens at each injection location will ensure reagent delivery across the entire vertical extent of the target treatment interval. The use of DPT ensures that no single injection location will be used more than once during each injection event. Furthermore, injection locations will be moved laterally from the first injection event locations during each subsequent injection event.

During the initial perimeter injection event, temporary injection screens will be installed at approximately 120 injection locations within the on-site treatment areas (Figure 4-1). The temporary injection screens will be installed using DPT. Two separate direct-push rods will be installed at each location; one screen will deployed from approximately 3 to 6 feet bgs to target the upper shallow vadose zone soils and the second screen will be deployed from approximately 6 to 10 feet bgs to target the lower shallow vadose/saturated zone soils. As previously stated, screens will be deployed from approximately 20 to 25 feet in the areas of P2-D4-F(22) and P4-A1-W(20), and 36 to 44 feet at the southern property boundary location. The direct-push injection screen installation is described in Section 4.4.6 below.

The injection locations within the ISCO treatment areas will be spaced approximately 15 feet apart based on an anticipated 7.5-foot radius of influence (ROI). The actual spacing for the locations may vary due to underground utilities, above-ground impediments and other associated field conditions. The injection locations will be placed on a triangular grid-like pattern across the treatment area. A conceptual injection location map depicting the injection locations is included as Figure 4-1.

The subsequent injection event locations will be shifted laterally from the initial locations. A multiple event injection location layout schematic illustrating the shifting of locations within the treatment area (7.5-foot ROI) is included as Figure 4-2.

4.3 Limiting Factors

Limiting factors at the site include the presence of previous investigative penetrations and the fact that the majority of the target treatment interval is shallow vadose zone soils (3 to 10 feet bgs). These factors, in unison, may present potential problems for the injection of modified Fenton’s reagent. The presence of previous penetrations in the treatment area may provide vertical conduits through which produced gas can travel to the surface. Surfacing of Fenton’s reagent was a significant issue during the 2009 ISCO pilot test and will most certainly occur during the full scale implementation. Chemical oxidation remediation is a dissolved phase/saturated zone technology. Since the majority of the target treatment interval is shallow vadose zone soils, ISOTEC will have to attempt to saturate the vadose zone soils with reagent in order to achieve the project objectives, which will result in varying amounts of surfacing. In order to achieve project success, the site’s limiting factors were taken into account when the injection program was designed.

4.4 Reagent Injection Procedures

ISOTEC's Modified Fenton's Reagent (MFR) reagents consist of their patented neutral pH chelated iron catalyst (catalyst) and dilute stabilized hydrogen peroxide (oxidizer). The following sections detail ISOTEC's procedures for reagent preparation, injection method and estimated volumes.

4.4.1 Reagent Preparation

ISOTEC will utilize an oxidizer concentration of 8%. Hydrogen peroxide at a concentration of approximately 30% will be shipped directly to the site immediately prior to field injection activities and stored in Department of Transportation (DOT) approved 55-gallons drums. The 30% hydrogen peroxide will be diluted on-site to a 8% concentration. The 30% hydrogen peroxide will be diluted in 300-gallon bulk tanks with water obtained on-site. The ISOTEC series catalyst consists of a pH buffered (pH of approximately 7) ferrous iron complex. At post-reaction concentrations the iron complex is similar and comparable to naturally occurring metals within the soil matrix (i.e., ppm range). The catalyst will be shipped to the site in dry form and mixed on-site in 300-gallon bulk tanks with water obtained on-site.

All reagents will be either injected during each injection event or removed from the site at the completion of each event.

4.4.2 Injection Equipment

Chemical application equipment consists of varying size storage containers, pneumatic double-diaphragm pumps, regulators, flow meters, 3/4-inch diameter (3/4") reinforced PVC tubing, valves, and cam-lock connectors. Transfer of the reagents from the storage and/or mixing containers to the point of injection will be performed via a double-diaphragm pump. Reagents are conveyed through 3/4" reinforced PVC tubing and connected to the probe rod with a wellhead containing ball valves, fittings and a pressure gauge.

4.4.3 Injection Method

Reagents will be injected into the subsurface at the site using specially designed direct-push screens. Injection of reagents into the injection screens is a five-step process. ISOTEC will set up on an injection wellhead and inject water into the subsurface, followed by the patented chelated iron catalyst. Water will then be injected to flush the reagent away from the screen. Following the water flush, ISOTEC will inject stabilized 8% hydrogen peroxide into the subsurface. A final water injection is completed to flush the oxidizer from the injection equipment. This process is repeated for each injection screen. By using multiple pump setups it will be possible to inject reagents through 3 different injection screens at once, allowing for the injection of target reagent quantities at 9 to 12 locations (18 to 24 screens) each day.

4.4.4 Reagent Quantities

ISOTEC will attempt to inject between 100 and 200 gallons of reagent at each location. Specifically, ISOTEC will attempt to inject between 25 and 50 gallons of catalyst and between 25 and 50 gallons of oxidizer into each lower and upper screen. It is important to note that the actual volume injected will depend upon the lithology, potential surfacing, injection flow rate, pressure and radial effects noted during injection.

4.4.5 Injection Rate and Pressures

The injection rates and volumes are interrelated to the reaction rates of hydroxyl radicals with the contaminants, the distribution of contaminants in the subsurface, and the rate of hydrogen peroxide decomposition. The rate at which the reagents are injected into the subsurface is initially determined by the soil/aquifer characteristics. Based upon review of the provided data, ISOTEC expects injection flow rates between 2 and 3 gallons per minute (gpm) and injection pressures of between 10 and 40 pounds per square inch (psi).

4.4.6 Direct Push Injection Screen Installation

ISTOEC will utilize DPT to install temporary injection screens at the site. A DPT subcontractor will use a direct-push rig to advance 1.5-inch diameter threaded steel rods to a desired depth within the target treatment interval. After a sufficient number of steel rods have been advanced into the subsurface to reach the desired depth, an ISOTEC designed injection screen will be lowered to the bottom of the rod string. While the injection screen is held in place, the rod string will be retracted to expose the screen to impacted soils in the target treatment interval. ISOTEC reagents will then be injected through the temporary injection screen and into the subsurface.

Two separate direct-push rods will be installed at each location within the treatment areas; one screen will deployed from approximately 3 to 6 feet bgs to target the upper shallow vadose zone soils and the second screen will be deployed from approximately 6 to 10 feet bgs to target the lower shallow vadose/saturated zone soils. This method of selective vertical injection will ensure reagent delivery across the entire vertical extent of the target treatment interval. A direct-push injection screen schematic is shown in Figure 4-3.

ISOTEC anticipates completing injection activities at 9 to 12 injection locations (18 to 24 injection screens) per day. Three separate pneumatic double-diaphragm pumps will be used to inject reagents into three injection screens simultaneously.

4.4.7 Direct Push Boring Abandonment

Following removal of the rod string and injection screen by the DPT subcontractor, bentonite chips will be slowly dropped down the open borehole. Bentonite chips will be dropped down the borehole until they are at approximately 10 inches below grade surface. The bentonite will then be hydrated. Following hydration, concrete will poured into the 10-inches of exposed hole. This procedure allows the bentonite to swell out into the soil over time forming a tight seal because the overlying cement plug will prevent the bentonite from swelling vertically. This method provides for an excellent seal across both the vadose zone and the saturated zone, preventing fluids from migrating down through the vadose zone and also prevents gas bubbles from entering the probe hole in the saturated zone.

4.4.8 Material Handling and Storage

ISOTEC employees will handle and store hydrogen peroxide and catalyst to complete this project. All ISOTEC employees have received training in the proper handling and storage of these chemicals. They have also received specific training in the PPE required to handle these chemicals safely. A fire extinguisher will be on-site in each box truck at all times.

Chemicals will be stored according to the requirements of the DOT. In brief, the hydrogen peroxide and the catalyst will be stored in such a way that if a spill were to occur, the two would not come into contact with each other. To accomplish this, the peroxide will be stored in a location separate from the catalyst. Specifically the peroxide will be stored on-site in DOT-approved 55-gallon drums in a designated and secure area. The hydrogen peroxide storage area will be surrounded by security fencing and contain an emergency response station. Diluting the peroxide will be performed in a dilution tank. Water will be added to the dilution tank along with dry stabilizer in a predetermined volume to create a 8% concentration after the addition of a predetermined volume of hydrogen peroxide. An electric drum pump or an air operated double diaphragm pump will be used to transfer the peroxide into the dilution tank. Two technicians are required to complete this process. One operates the pump and one holds the transfer wand in the dilution tank. Both technicians will wear splash resistant aprons, face-shields and chemical resistant gloves while completing the transfer.

Liquid catalyst and the dry chemicals necessary to mix it will be stored inside of a box truck. To mix catalyst, iron will be added to the mixing tank followed by a predetermined quantity of water. An electric mixer is used to mix the solution. ISOTEC's patented chelating agents are then added to the solution and mixing continues. Although the chemicals are non-hazardous and the mixing process is generally dust free, the technician completing the mixing will wear nitrile gloves and a NIOSH approved N95 particulate respirator as a precautionary measure.

Combustion issues associated with the presence of hydrogen peroxide, a strong oxidizer, are minimized since a maximum solution of 30% will be delivered to the site. The peroxide will be stored in DOT-approved 55-gallon drums. Flammable materials, i.e., gasoline, will not be stored near the peroxide or in locations where a peroxide spill could occur.

The ISOTEC reagents are not combined at the surface. The peroxide and catalyst only come into contact with one another in the subsurface. Precautions are taken by flushing all equipment with water between separate injections of each reagent.

4.4.9 Spill Prevention

Site personnel should be aware of potential conditions that could cause a spill and take preventative measures before a spill occurs. Safe storage and handling procedures are discussed above.

Hydrogen peroxide and catalyst will be stored in such a way that if a spill of either were to occur, the two would not come into contact with each other. The tanks used to dilute the peroxide and to mix and store the catalyst are oversized to prevent spillage from the tanks. If a small spill, less than five gallons, of peroxide occurs to the ground surface water will be used to dilute it further and actions taken to prevent the fluid from entering any storm drains or drainage ditches, while the fluid is soaked up with clay sorbent. If a larger spill of peroxide occurs the same procedure will be followed and any excess liquid will be pumped into a clean empty storage tank. If a small spill, less than 5 gallons, of catalyst occurs it should be contained and soaked up with sorbent pads then placed in a steel or poly drum. If a large spill of catalyst occurs it will be contained and pumped into the storage tank with an air diaphragm pump. If a spill of dry catalyst occurs it will be swept up and placed in a poly bag.

If any spill occurs work will stop immediately until the spill is cleaned up and the cause of the spill is determined and corrected. All spilled materials will be disposed of properly.

5 SOIL SAMPLING AND DATA EVALUATION

The effectiveness of the ISCO injections will be monitored and evaluated with soil confirmation samples collected from a series of boring locations. Soil samples will be collected from the target treatment interval following each injection event. Specifically, soil samples will be collected from the 3 to 6 foot depth interval and the 6 to 10 foot depth interval from each sample location. Soil confirmation samples will also be collected from depths of 20 to 25 feet in the areas of P2-D4-F(22) and P4-A1-W(20).

5.1 Sample Collection and Analysis

The samples will be placed in laboratory provided containers and labeled according to sample location, date, and analytical method upon collection. The samples will be protected from breakage and placed in ice-filled coolers after collection. Ice will be used to maintain a temperature of 4 degrees C. Each cooler will be sealed with custody seals and covered with clear tape, so that any opening of the cooler during transport will be indicated. All samples will be shipped or delivered to Teklab, Inc. in Collinsville, Illinois. Chain of custody forms will be completed for all sample shipments and deliveries.

A sample is considered to be in custody if the sample is in the physical possession of the sampler or other designated person, or stored in a locked place. An original chain-of-custody (COC) form will be filled out at the time of sampling. All information in the upper part of the COC must be filled in clearly and legibly. Every sample container must be accounted for on the COC. The signature blocks will be completed at the time of sample transfer.

Copies of the COC forms will be placed in the project file. The original COC form will accompany the samples during transportation to the carrier and upon arrival at the laboratory. A second copy of the COC form will be retained at PSC's Columbia, Illinois office.

Any person accepting responsibility for the samples will sign and date the form on the date accepted. The courier service (if used), however, will only be designated on the COC form and no signature will be required. Custody seals will be utilized to identify possible tampering during the transportation process.

The laboratory will provide a data quality objective (DQO) level III data package upon completion of analysis.

Soil confirmation samples collected from the onsite perimeter areas will be analyzed for the four BTEX compounds (benzene, toluene, ethylbenzene, and xylene), using SW-846 Method 8260 and naphthalene SW-846 Method 8270 SIM.

5.2 Soil Data Evaluation

The soil analytical data will be compared to the Tiered Approach to Corrective Action (TACO) Tier 1 Remediation Objectives. Soil samples with concentrations above the Tier 1 Objectives will be included in the next injection event to reduce constituent concentrations. In the event that a specific post-injection soil sample reports all of the target COC concentrations at or below the Tier 1 ROs for the soil inhalation exposure pathway, that specific boring location and/or depth interval will no longer be sampled and injections in the immediate vicinity of the boring(s) and/or depth interval(s) will be eliminated from the subsequent injection applications. These soil sampling and evaluation procedures will be repeated following each of the injection applications.

5.3 Reporting

Following the completion of the ISCO injection process, PSC will submit a RACR outlining the details of the ISCO program. The report will detail the in-situ chemical oxidation process, field activities, and chemical analyses. Specifically, the reagent injection quantities, injection pressures, and injection rates will be discussed in the report and presented in tables. Analytical data obtained during the program will be discussed in detail. The report will also present in detail the effectiveness of each of the site remediation measures on soil and groundwater impact and pathway exclusions.

6 ILLINOIS LICENSED PROFESSINAL ENGINEER REVIEW

The work performed at the Champaign property to date was completed before I assumed responsibility for site activities. However:

I have reviewed documentation of the prior investigation activities and believe the data is suitable for compliance with the Act, 35 Ill. Adm. Code 740, and generally accepted engineering practices. I attest that to the best of my knowledge and belief, the work described in this plan or report has been designed or completed in accordance with the Act, 35 Ill. Adm. Code 740, and the information presented is accurate and complete.

37277
3/15/2013

Signature: Mark Kroenig

Mark H. Kroenig, P.E.
Licensed Professional Engineer

Date: 3/15/2013

License No. 37277

License Expiration Date: 11/30/2013

References

In-Situ Oxidative Technologies, Inc., August 28, 2012. *Proposal To Provide In-Situ Chemical Oxidation Remediation Program*. Pages 2-1, 2-2, 3-1, 3-2, 3-3, 3-4, 3-5, and 3-6. Figures 3, 4, and 7.

List of Tables

Table 2-1
Exceedances of Tier 1 Remedial Objectives for Residential Inhalation and Ingestion
Perimeter Wall Samples in the 3 to 10 foot Depth Interval
Champaign MGP

	Tier 1 Remediation Objectives*	Sample ID:	P1-A1-W (5-8)	P1-A2-W (5-6)	P1-A3-W (10)	P1-A4-W (8)	P1-A5-W(8)	P2-A1-W (8)	P3-A1-W (10)	P3-A1.5-W (8)	P3-A2-W (8)	P3-A2.5-W (8)	P3-A3-W (6)	P3-A.5-W (8)	P3-B-W (8)	P3-B.5-W (8)	P3-C1-W (10)	P3-C.5-W (8)	P3-D-W (8)	P3-D.5-W (8)
	Residential Inhalation	Date:	6/30/2009	6/30/2009	7/7/2009	7/7/2009	7/15/2009	10/23/2009	1/12/2010	1/27/2010	1/12/2010	1/27/2010	1/12/2010	1/20/2010	1/20/2010	1/14/2010	1/14/2010	1/20/2010	1/20/2010	1/27/2010
	(mg/kg)	Depth (feet):	5-8'	5-6'	10'	8'	8	8	10	8	8	8	6	8	8	8	10	8	8	8
BTEX Constituents (mg/kg)																				
Benzene	0.8		2.42	2.47	0.86	1.89	1.35	3.59	15.7	39.7	3.62	2.27	2.62	11.7	16.4	81.8	146	7.84	21.3	8.87
Ethylbenzene	400		18.9	18.5	1.83	3.83	13.2	8.48	6	11.8	<6.33	2.5	1.76	<26	<27.2	9.7	34.6	3.9	32	0.94
Toluene	650		<5.48	<7.340	<1.54	0.410	<4.16	<5.69	26.6	65.5	3.3	4.3	0.059	18	23	123	311	6.89	44.1	6.39
Xylenes	320		12.460	17.690	0.950	2.570	12.660	7.3	54.8	108.3	2.7	10.71	1.415	29.2	27.7	124.8	416	26.89	82.4	7.79
PNA Constituents (mg/kg)																				
Acenaphthylene	---		5	1.79	2.2	3.7	1.01	4.58	9.05	8.1	0.054	12.3	0.01	25.5	101	96.5	209	9.01	68.6	5.4
Benzo(a)anthracene	---		9.08	3.26	6.4	8.2	1.65	4.97	5.34	4.73	<0.004	7.06	0.014	15.4	69.6	60.5	100	9.36	22.9	3.52
Benzo(a)pyrene	---		8.38	2.94	5.7	8.4	1.39	4.92	3.81	2.78	<0.004	4.07	0.023	11.4	55.1	48.2	79.1	11.3	22.2	2.76
Benzo(b)fluoranthene	---		6.73	2.36	4.6	6.3	1.08	3.91	4.04	3.1	<0.004	4.31	0.025	12.1	57.8	54.9	90.7	9.32	19.9	2.96
Benzo(k)fluoranthene	---		2.4	0.856	1.6	2.1	0.34	1.28	1.69	1.17	<0.004	1.82	0.022	4.87	20.8	21.5	29.8	3.19	6.75	1.15
Chrysene	---		9.37	3.38	6.3	8.5	1.57	5.68	4.61	3.78	<0.004	6.51	0.013	14.5	68.5	58.1	102	8.83	22.4	3.22
Dibenzo(a,h)anthracene	---		0.786	0.261	0.65	0.92	<0.381	0.48	<1.23	<0.888	<0.004	0.6	0.025	1.24	6.17	6.65	10.8	1.35	2.69	0.461
Indeno(1,2,3-cd)pyrene	---		2.29	0.795	2	2.8	0.449	1.51	1.71	1.32	<0.004	1.8	0.031	3.25	16.9	19	28.4	4.3	7.88	1.49
Naphthalene	170		74.8	26.3	73	65	33.5	58.2	43.7	48.6	3.53	87.4	1.35	254	528	748	1380	124	593	34.8
Phenanthrene	---		68.2	23.2	40	54	13.8	37.8	27.5	21.4	0.324	26.4	0.018	95.2	386	313	489	37.5	112	18.6

Notes:

* The objective of ISCO treatment for the onsite perimeter areas in the 3 to 10 foot depth interval is for COC concentrations to meet Tier 1 objectives for soil inhalation for residential

'--- No objective has been published for this constituent by the IEPA, or the sample was not analyzed for this constituent.

🟦 Concentration exceeds one or more project remediation objective.

Table 2-1
Exceedances of Tier 1 Remedial Objectives for Residential Inhalation and Ingestion
Perimeter Wall Samples in the 3 to 10 foot Depth Interval
Champaign MGP

	Tier 1 Remediation Objectives*	Sample ID:	P3-E-W (8)	P3-E.5-W (8)	P3-F-W (8)	P3-F.5-W (8)	P4-A1-W (8)	P4-A3-W (8)	P4-A4-W (8)	P4-A5-W (8)	P7-CD1-SW (8)	P7-D1-W (8)	P7-DE1-W (8)
	Residential Inhalation	Date:	1/27/2010	1/27/2010	1/27/2010	2/3/2010	3/31/2010	3/29/2010	3/26/2010	3/26/2010	2/17/2011	3/2/2011	3/2/2011
	(mg/kg)	Depth (feet):	8	8	8	8	8	8	8	8	8	8	8
BTEX Constituents (mg/kg)													
Benzene	0.8		9.29	222	56.3	7.44	2.08	2.52	1.73	2.86	1.25	28.2	2.78
Ethylbenzene	400		2.9	62.9	6.88	<4.64	14.9	15.2	11.3	13.5	16.9	63.6	4.08
Toluene	650		8.06	156	4.4	<4.64	<4.84	<12.5	<6.47	<6.52	1.5	9.27	0.28
Xylenes	320		27.13	439	80.6	5.1	8.9	11.64	8.0	<6.52	19.52	128.8	6.46
PNA Constituents (mg/kg)													
Acenaphthylene	---		4.84	4.26	3.7	0.833	2.03	1.01	2.41	2.1	5.91	2.01	3.85
Benzo(a)anthracene	---		5.4	3.64	13.5	1.28	5.67	2.96	5.99	4.91	15.3	6	8.5
Benzo(a)pyrene	---		3.85	2.6	9.38	0.963	5.05	2.45	5.21	4.26	15.5	5.63	8.55
Benzo(b)fluoranthene	---		3.62	2.33	10.3	0.978	4.05	1.97	4.24	3.41	11.7	4.96	7.38
Benzo(k)fluoranthene	---		1.3	0.84	3.85	0.365	1.3	0.587	1.36	0.993	3.66	1.59	2.19
Chrysene	---		4.07	3.05	10.8	1.08	5.61	2.88	5.8	4.93	15	5.9	9
Dibenzo(a,h)anthracene	---		<0.839	<0.854	1.43	<0.224	0.536	0.27	0.548	0.47	1.58	0.386	0.558
Indeno(1,2,3-cd)pyrene	---		2.05	1.19	4.94	0.358	1.57	0.791	1.6	1.41	5.42	1.23	1.76
Naphthalene	170		98.7	290	204	26.3	70	37.1	70	62.1	104	113	152
Phenanthrene	---		25.5	16	61.3	5.77	40.3	22.4	42.4	34.6	87.3	28.8	63.3

Notes:

* The objective of ISCO treatment for the onsite perimeter areas in the 3 to 10 foot depth interval is for COC concentrations to meet Tier 1 objectives for soil inhalation for residential

'--- No objective has been published for this constituent by the IEPA, or the sample was not analyzed for this constituent.

🟦 Concentration exceeds one or more project remediation objective.

Table 3-1
Evaluation for Soil Attenuation
Champaign Former MGP
Ameren Illinois

Sample Identification	Total Organic Compounds Using 50% of Detection Limit (1) (mg/kg)	Total Petroleum Hydrocarbons (2) (mg/kg)	Site-Specific Soil f_{oc} (3) (mg/kg)
P2-D4-F(22)	16911.42	3359.00	10,400
P4-A1-W (20)	73,138.55	14,690	10,400
PA5-08 (3)	---	33,535	23,200

Notes:

--- Not measured.

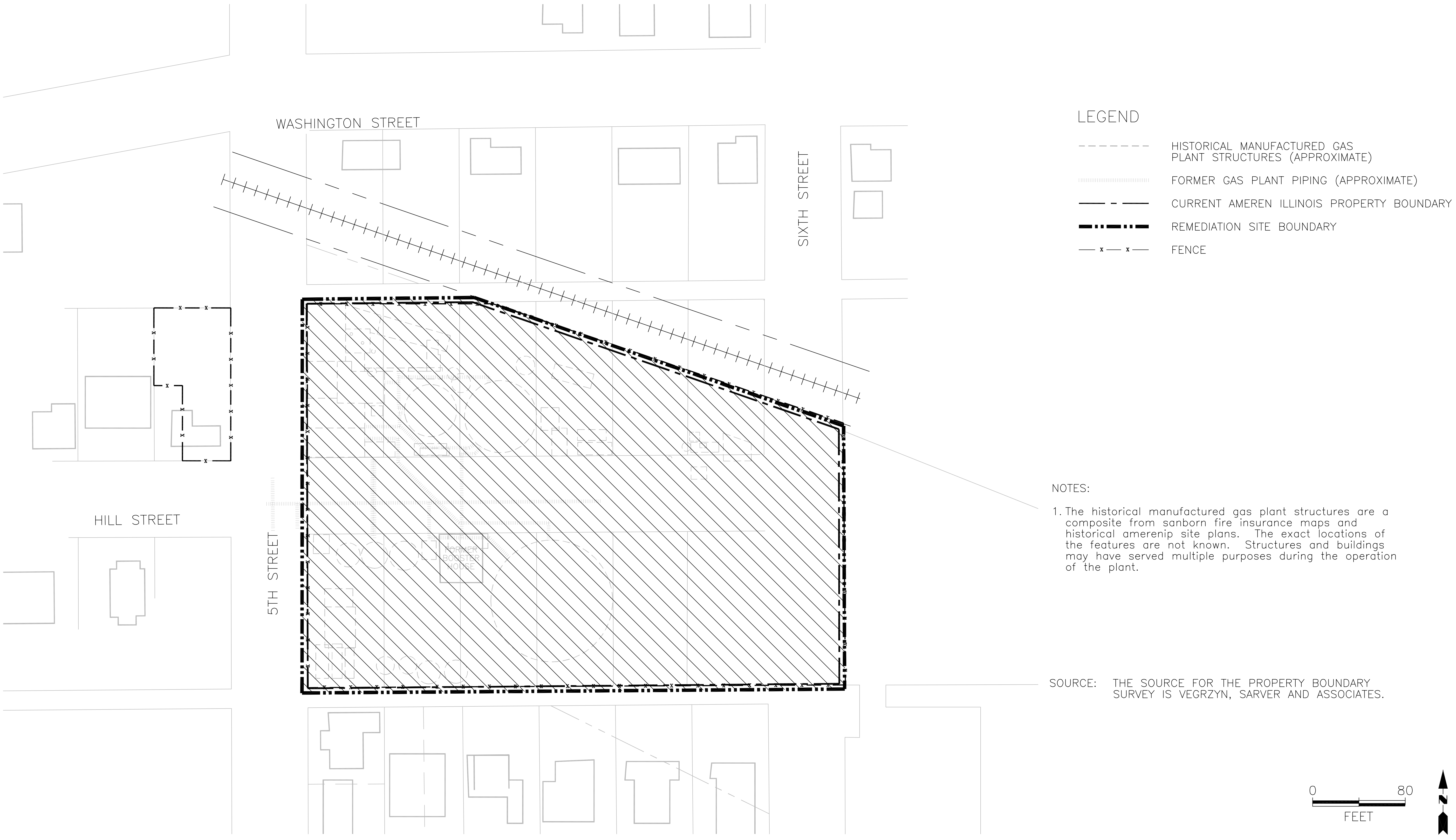
(1) Total Organic Compounds is the sum of the detected compounds and 50% of the detection limit for non-detected compounds for PNAs (8270 SIMS), SVOCs (8270), and VOCs (8260).

(2) Total Petroleum Hydrocarbons (OA-2) by 3550B, 8015B for diesel, kerosene, mineral spirits, and motor oil and 50% of the detection limit for non-detected compounds.

(3) The foc value for the 0 to 3 foot depth interval was obtained from soil boring B-817 at 2' - 3' bgs. The foc value for the greater than 10 foot depth interval was obtained from soil boring B-851 from 19' - 20' bgs.

○ Value exceeds the soil attenuation capacity.

List of Figures



LEGEND

- - - - - -	HISTORICAL MANUFACTURED GAS PLANT STRUCTURES (APPROXIMATE)
┈┈┈	FORMER GAS PLANT PIPING (APPROXIMATE)
— - —	CURRENT AMEREN ILLINOIS PROPERTY BOUNDARY
━·━·━	REMEDIATION SITE BOUNDARY
—x—x—	FENCE

NOTES:

1. The historical manufactured gas plant structures are a composite from sanborn fire insurance maps and historical amerenip site plans. The exact locations of the features are not known. Structures and buildings may have served multiple purposes during the operation of the plant.

SOURCE: THE SOURCE FOR THE PROPERTY BOUNDARY SURVEY IS VEGRZYN, SARVER AND ASSOCIATES.

COL. J:\624\02647D-014

PSC

TITLE:

REMEDIATION SITE MAP
IN-SITU CHEMICAL OXIDATION WORK PLAN
CHAMPAIGN FORMER MGP SITE

DWN: TMM	DES: MRC
CHKD: LH	APPD: LH
DATE: 6/27/08	REV: 12/10/12

PROJECT NO: 62412010008
AMEREN ILLINOIS
CHAMPAIGN, ILLINOIS

FIGURE 2–1

LEGEND

- ——— EXISTING STRUCTURES (APPROXIMATE)
- — - — NORFOLK SOUTHERN RAILWAY CORPORATION PROPERTY BOUNDARY
- —··—··— REMEDIATION SITE BOUNDARY
- —x—x— FENCE
- 🟧 TREAT AREAS WITHIN FOR INHALATION TO DEPTHS FROM 3 TO 10 FEET BGS
- 🟪 TREAT AREAS TO DEPTHS GREATER THAN 20 FEET BGS

SOURCE: THE SOURCE FOR THE PROPERTY BOUNDARY SURVEY IS VEGRZYN, SARVER AND ASSOCIATES.

COL. 624\02647S-006

TITLE:

PROPOSED ISCO TREATMENT AREAS
IN-SITU CHEMICAL OXIDATION WORK PLAN
CHAMPAIGN FORMER MGP SITE

DWN: TMM	DES: TE
CHKD: LH	APPD: MHK
DATE: 1/30/13	REV: 0

PROJECT NO: 62409080008
AMEREN ILLINOIS
CHAMPAIGN, ILLINOIS

FIGURE 3-1

COL. S:\SHARED\MGP\IP\JOB FILES\CHAMPAIGN\62403053 CHAMPAIGN SITE INVESTIGATION, SIR AND ROR PREPARATION\15.0 REPORTS\ISCO WORK PLAN\FIGURE 3 (7.5)

LEGEND

☐	Existing Structure
●	Soil Boring Location
-·-·-·-	Fence (and Remediation Site Boundary)
🟥	Areas of Organic Constituents of Concern That Exceed Tier 1 Remedial Objectives (Treatment Interval = 3 to 10 Feet BGS)
☐	Areas of Organic Constituents of Concern That Exceed Tier 1 Remedial Objectives (Treatment Interval = greater than 10 Feet BGS)
•	Phase 2A Direct–Push Injection Location
○	Conceptual Radius of Influence (7.5 feet)

NOTE:

DRAWING PROVIDED BY IN–SITU OXIDATIVE TECHNOLOGIES, INC.'s FIGURE 3.

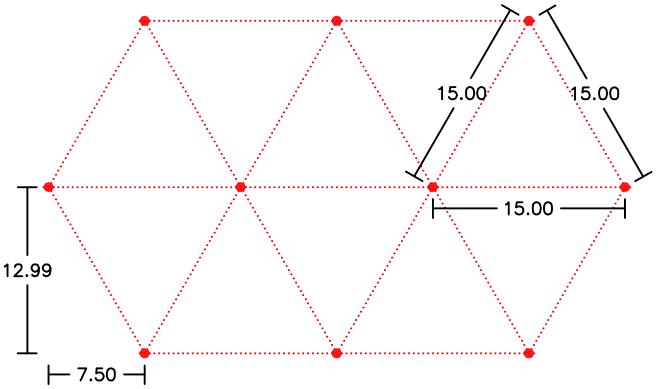
0 60
FEET

N

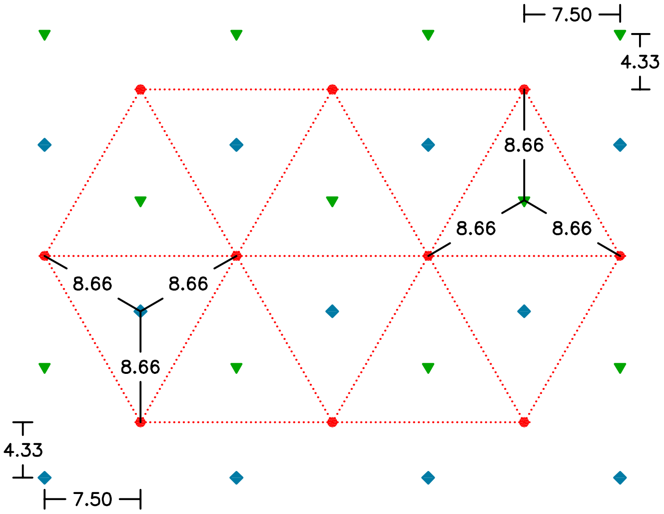
TITLE:
PROPOSED INJECTION LOCATION MAP – ISCO REMEDIATION PROGRAM
IN–SITU CHEMICAL OXIDATION WORK PLAN
CHAMPAIGN FORMER MGP SITE

DWN: TMM	DES: TE	PROJECT NO: 62409080008	
CHKD: LH	APPD: MHK	AMEREN ILLINOIS CHAMPAIGN, ILLINOIS	
DATE: 1/30/13	REV: 0	FIGURE 4–1	

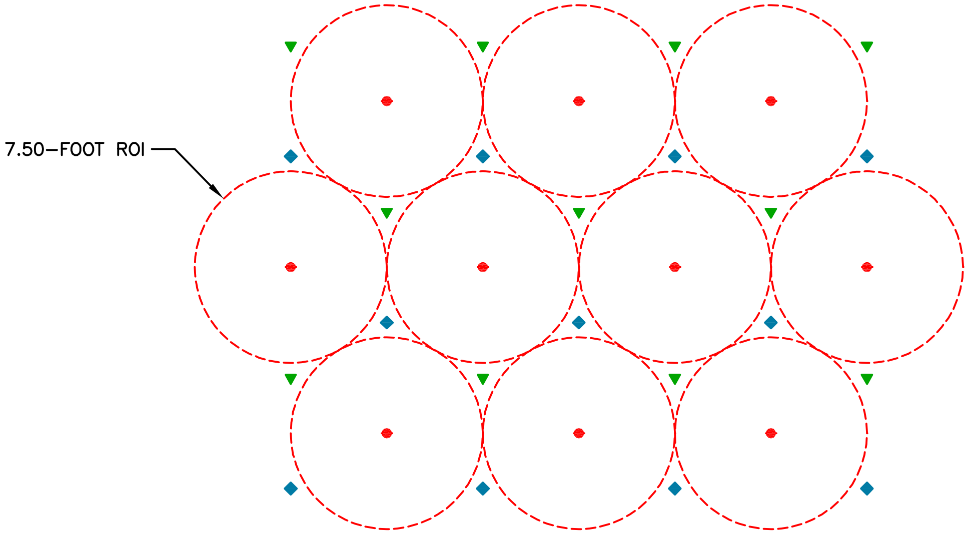
Typical Single Event Injection Location Layout



Typical Multiple Event Injection Location Layout



ISCO Reagent Radius of Influence



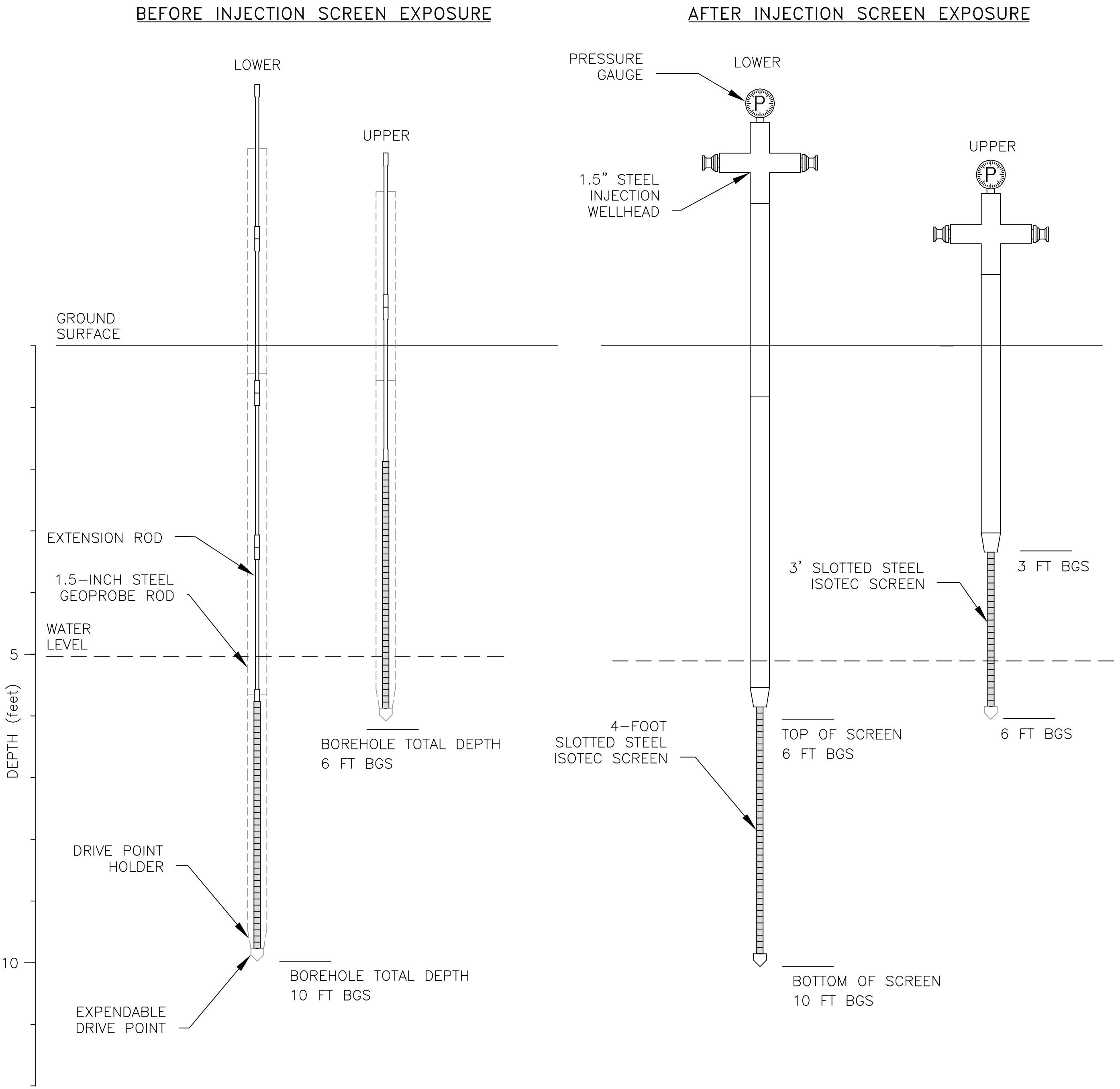
LEGEND

●	Phase 2A Injection Location
▼	Phase 2B Injection Location
◆	Phase 2C Injection Location
◯	Radius of Influence (ROI)

NOTE: DRAWING PROVIDED BY IN–SITU OXIDATIVE TECHNOLOGIES, INC.'S FIGURE 4.

PSC	TITLE: MULTIPLE EVENT INJECTION LOCATION LAYOUT SCHEMATIC IN–SITU CHEMICAL OXIDATION WORK PLAN CHAMPAIGN FORMER MGP SITE	DWN: KH	DES.:	PROJECT NO.: 62409080008 AMEREN ILLINOIS CHAMPAIGN, ILLINOIS
		CHKD: SH	APPD: MHK	
		DATE: 8/15/12	REV.: 2	FIGURE 4–2

COL. S:\SHARED\MGP\IP\JOBFILES\CHAMPAIGN\62403053 CHAMPAIGN SITE INVESTIGATION, SIR AND ROR PREPARATION\15.0 REPORTS\ISCO WORK PLAN\REVISION OF FIGURE 4–INJECTION LOCATION LAYOUT SCHEMATIC



NOTE: DRAWING PROVIDED BY IN-SITU OXIDATIVE TECHNOLOGIES, INC.'S FIGURE 7.

INJECTION SCREEN INSTALLATION

1. Two separate borings will be utilized at each injection location. One boring will be the LOWER injection screen and will be installed by advancing probe rod to a depth of 10 feet below ground surface (bgs) by a direct-push subcontractor. The second boring will be the UPPER injection screen and will be installed by advancing probe rod to a depth of 6 feet bgs.
2. Once at the desired depth, a 4-foot injection screen (LOWER) or a 3-foot injectin screnen (UPPER) will be lowered to the bottom of the rod string and held in place with extension rod.
3. The rod string will be extracted 4 feet or 3 feet to expose the screen to impacted soils in the target treatment interval.

TITLE: DIRECT-PUSH INJECTION SCHEMATIC IN-SITU CHEMICAL OXIDATION WORK PLAN CHAMPAIGN FORMER MGP SITE	DWN: KH	DES.:	PROJECT NO.: 62409080008 AMEREN ILLINOIS CHAMPAIGN, ILLINOIS	
	CHKD: SH	APPD: MHK	FIGURE 4-3	
	DATE: 8/15/12	REV.: 2		

COL. S:\SHARED\MGP\IP\JOBFILES\CHAMPAIGN\62403053 CHAMPAIGN SITE INVESTIGATION, SIR AND ROR PREPARATION\15.0 REPORTS\ISCO WORK PLAN\REVISION OF FIGURE 7-DIRECT-PUSH INJECTION SCHMATIC

APPENDIX A

Portions of In-Situ Oxidative Technologies, Inc.’s *Proposal To Provide In-Situ Chemical Oxidation Remediation Program*

2.0 THE ISOTEC PROCESS

The ISOTEC process is an in-situ remedial technology that destroys organic contamination using Fenton's reagent-based oxidation chemistry. Fenton's chemistry was first documented by H.J.H. Fenton in 1894. It is characterized by the combination of soluble iron with low concentrations of hydrogen peroxide to produce hydroxyl radicals ($OH^{\bullet}$). These hydroxyl radicals are very powerful and short-lived oxidizers. Similar to the reaction of other oxidizers, the hydroxyl radicals attack the carbon double bonds of the chlorinated hydrocarbon molecule. Under certain conditions reductive species can also be formed by Fenton's chemistry. This gives Fenton's reagent two separate pathways to attack a wide range of contaminants. The summary equation for Fenton's chemistry is shown below.

$$\mathbf{Fe^{+2} + H_2O_2 \rightarrow Fe^{+3} + OH^- + OH^{\bullet}}$$

Where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, Fe^{+3} is ferric iron, $OH^{\bullet}$ is hydroxyl free radical and OH^- is hydroxide ion.

Iron is used to catalyze the reaction. Maintaining iron in solution is important for the process to be successful in an in-situ application. To eliminate the necessity of performing the reaction under low pH conditions, as is the case with traditional Fenton's chemistry; complexed iron is used in in-situ applications via the ISOTEC process. The hydrogen peroxide and dissolved iron solutions are injected through a site-specific delivery system providing sufficient distribution to selectively treat the area of concern. Reaction time is very fast, with oxidation capacity of the reagent being used up in a matter of a few days. Hydrogen peroxide breaks down into water and oxygen and the iron catalyst is oxidized and precipitates out of solution. It is important to note that the concentration of hydrogen peroxide will be relatively dilute, generally less than 17%, which eliminates the potential for significant exothermic reactions that are associated with higher concentrations of hydrogen peroxide. Experience with this process using low hydrogen peroxide concentrations and complexed iron has resulted in less than a 25° F temperature increase in field applications.

Fenton-based oxidation processes have been shown to effectively treat a wide range of contaminants including hard-to-treat compounds such as chlorinated solvents, petroleum hydrocarbons, gasoline additives including benzene, toluene, ethylbenzene and xylene (BTEX), and pesticides. Hydroxyl radicals and reductive species generated by the Fenton-based reagent will treat nearly all contaminants with carbon/carbon double bonds and single bonded contaminants with extractable hydrogen.

The stoichiometric relationship between benzene oxidation and hydrogen peroxide consumption can be predicted from the oxidative reaction:

$$\mathbf{C_6H_6 + H_2O_2 \rightarrow 6CO_2 + H_2O + 3H^+}$$

Where C_6H_6 is benzene, H_2O_2 is hydrogen peroxide, CO_2 is carbon dioxide, and H^+ is hydrogen ion. Hydrogen peroxide not consumed in the above reaction will continue to oxidize the groundwater contaminants and will naturally degrade along with the contaminant to oxygen and water.

The ISOTEC process consists of injecting stabilized hydrogen peroxide and complexed iron catalysts into contaminated aquifers or vadose zones. As compared to conventional Fenton's Reagent which requires acidic conditions ($pH \leq 3$) the ISOTEC process is effective at neutral ($pH = 7$) conditions. This is an important consideration in full-scale application since acidifying an aquifer is typically impractical. ISOTEC's oxidation method utilizes a site-specific delivery system(s) designed to treat organic contaminants within an area of concern. ISOTEC oxidants and catalysts generate hydroxyl radicals, which react with the organic contaminants within the subsurface producing innocuous by-products such as carbon dioxide and water (and chloride ions if chlorinated compounds are being treated).

2.1 IN-SITU CHEMICAL OXIDATION OF CHLORINATED COMPOUNDS

The remediation process for treating chlorinated compounds in the subsurface is straight forward from a chemical standpoint but complicated in practice. The major oxidants available for in-situ application are:

- Fenton's Reagent,
- Modified Fenton's Reagent,
- Ozone,
- Permanganate,
- Persulfate, and
- Catalyzed persulfate.

These oxidants have varying oxidation potentials, or "oxidation strength". In simple terms, the oxidant contacts with the solvent and the solvent molecule is oxidized, gives up an electron, and forms new compounds from the original elements. For example, TCE oxidizes into carbon dioxide and chlorine ions. There can be short lived intermediaries, but they do not persist long enough to measure.

The remediation process is very simple for compounds in the dissolved phase. For instance, a beaker filled with a 5,000 µg/L solution of TCE in water can be oxidized by adding the appropriate mass of any of the above oxidants to non-detectable levels in a very short period, from hours to several days. Because of the varying oxidation potentials, the same is not true for a solution of TCA, only the Fenton's based oxidants and ozone will treat the dissolved TCA mass.

3.0 FULL-SCALE ISCO REMEDIATION PROGRAM

The following summarizes PSC's scope of work (SOW) detailed in the RFP to conduct an ISCO remediation program at the former Champaign MGP site. Based on the results of the Phase 1 ISCO pilot test conducted in 2009 by a different contractor, ISCO was determined to be the most effective and suitable technology for the full-scale ISCO remediation of saturated soils and groundwater at the site.

According to the RFP, the full-scale ISCO program has been designed by PSC to address vadose zone and saturated zone soils within the treatment areas specified by PSC (**Figure 2**). The specific target treatment interval for the on-site treatment areas is from 3 to 10 feet bgs. The target treatment interval for the limited off-site treatment area, located adjacent to the west of the site in 5th Street, is from 0 to 10 feet bgs.

Based on review of site data provided in the RFP, ISOTEC anticipates that two full-scale injection applications and one reduced application may be required. For proposal purposes, ISOTEC assumes that the full-scale ISCO remediation program will be designated Phase 2 and that each injection event will be given the following alphabetical designations:

- Phase 2A – First Injection Event (Entire Treatment Area)
- Phase 2B – Second Injection Event (Entire Treatment Area)
- Phase 2C – Third Injection Event (50% of the Treatment Area)

This scope is based on the contaminant concentrations in soil included in the RFP and the Tier 1 ROs for the soil inhalation exposure pathway discussed in **Section 1.2**. It is important to note that the actual number of injections locations for Phase 2B and Phase 2C will be determined following the review of the performance monitoring and evaluation of post-injection soil sampling results. A detailed discussion of performance monitoring and evaluation is described in **Section 5.0** below.

3.1 ISCO PROGRAM DESIGN

ISOTEC proposes to utilize our patented neutral pH chelated iron catalyst and stabilized 8% hydrogen peroxide to implement an MFR ISCO program. ISOTEC will utilize direct-push technology (DPT) to introduce reagents into the subsurface at the site. The ISCO program has been designed to address vadose zone and saturated zone soils within the treatment areas specified by PSC (**Figure 2**). The specific target treatment interval for the on-site treatment areas is from 3 to 10 feet bgs. The target treatment interval for the limited off-site treatment area is from 0 to 10 feet bgs.

The design is based upon data supplied by PSC and has several potentially limiting factors to implementation success. Limiting factors at the site include the presence of previous investigative penetrations and the fact that the majority of the target treatment interval is shallow vadose zone soils (3 to 10 feet bgs). These factors, in unison, present potential problems for the injection of modified Fenton's reagent. The presence of previous penetrations in the treatment area may provide vertical conduits through which produced gas can travel to the surface. Surfacing was a significant issue during the 2009

ISCO pilot test (Phase 1) and will most certainly occur during Phase 2. Chemical oxidation remediation is a dissolved phase/saturated zone technology. Since the majority of the Phase 2 target treatment interval is shallow vadose zone soils, ISOTEC will have to attempt to saturate the vadose zone soils with reagent in order to achieve the project objectives, which will result in varying amounts of surfacing. In order to achieve project success, the site's limiting factors must be taken into account when an injection program is designed.

Based on the limiting factors discussed above, ISOTEC proposes that: 1) Phase 2 include multiple injection events, 2) injection locations be closely spaced, 3) two injection screens, each targeting a separate injection interval be utilized across the treatment interval and 4) injection screens be installed by a DPT drill rig. The multiple injection events are needed to deliver the necessary volumes of reagent while limiting the reagent volume injected during each event. The injection locations will be closely spaced in order to have overlapping treatment areas with smaller volumes of reagent which will limit the potential for one vertical surfacing conduit to impact injection at numerous injection points. Utilizing two separate screens at each injection location will ensure reagent delivery across the entire vertical extent of the target treatment interval. The use of DPT ensures that no single injection location will be used more than once during each injection event. Furthermore, injection locations will be moved laterally from the first injection event locations during each subsequent injection event.

During Phase 2A, temporary injection screens will be installed at approximately 120 injection locations within the on-site treatment areas (**Figure 3**). The temporary injection screens will be installed using DPT. Two separate direct-push rods will be installed at each location; one screen will deployed from approximately 3 to 6 feet bgs to target the upper shallow vadose zone soils and the second screen will be deployed from approximately 6 to 10 feet bgs to target the lower shallow vadose/saturated zone soils. The direct-push injection screen installation is described in **Section 3.3** below.

In addition to the 120 on-site injection locations, ISOTEC will install approximately four injection locations within the off-site treatment area (**Figure 3**). Two separate direct-push rods will be installed at each location; one screen will deployed from approximately 0 to 5 feet bgs to target the upper shallow vadose zone soils and the second screen will be deployed from approximately 5 to 10 feet bgs to target the lower shallow vadose/saturated zone soils.

The injection locations within the on-site and off-site ISCO treatment areas will be spaced approximately 15 feet apart based on an anticipated 7.5-foot radius of influence (ROI). The actual spacing for the locations may vary due to underground utilities, above-ground impediments and other associated field conditions. The injection locations will be placed on a triangular grid-like pattern across the treatment area. A conceptual injection location map depicting the Phase 2A injection locations is included as **Figure 3**.

As discussed, the subsequent injection event locations (Phase 2B, and Phase 2C) will be shifted laterally from the Phase 2A locations. A multiple event injection location layout schematic illustrating the shifting of locations within the treatment area (7.5-foot ROI) is included as **Figure 4**.

3.2 ISOTEC REAGENT INJECTION PROCEDURES

ISOTEC's MFR reagents consist of our patented neutral pH chelated iron catalyst (catalyst) and dilute stabilized hydrogen peroxide (oxidizer). The following sections detail ISOTEC's procedures for reagent preparation, injection method and estimated volumes.

3.2.1 ISOTEC Reagent Preparation

ISOTEC oxidizer consists of a pre-determined concentration of hydrogen peroxide, water and stabilizer. For Phase 2 of the ISCO remediation program, ISOTEC will utilize an oxidizer concentration of 8%. Hydrogen peroxide at a concentration of approximately 30% will be shipped directly to the site immediately prior to field injection activities and stored in Department of Transportation (DOT) approved 55-gallons drums. The 30% hydrogen peroxide will be diluted on-site to a 8% concentration. The 30% hydrogen peroxide will be diluted in 300-gallon bulk tanks with water obtained on-site. The ISOTEC series catalyst consists of a pH buffered (pH of approximately 7) ferrous iron complex. At post-reaction concentrations the iron complex is similar and comparable to naturally occurring metals within the soil matrix (i.e., ppm range). The catalyst will be shipped to the site in dry form and mixed on-site in 300-gallon bulk tanks with water obtained on-site. A reagent mixing schematic is included as **Figure 5**.

All reagents will be either injected during each injection event or removed from the site at the completion of each event.

3.2.2 Injection Equipment

Chemical application equipment consists of varying size storage containers, pneumatic double-diaphragm pumps, regulators, flow meters, 3/4-inch diameter (3/4") reinforced PVC tubing, valves, and cam-lock connectors. Transfer of the reagents from the storage and/or mixing containers to the point of injection will be performed via a double-diaphragm pump. Reagents are conveyed through 3/4" reinforced PVC tubing and connected to the probe rod with a wellhead containing ball valves, fittings and a pressure gauge.

3.2.3 Injection Method

ISOTEC reagents will be injected into the subsurface at the site using our specially designed direct-push screens. Injection of ISOTEC reagents into the injection screens is a five-step process. ISOTEC will setup on an injection wellhead and inject water into the subsurface, followed by our patented chelated iron catalyst. Water will then be injected to flush the reagent away from the screen. Following the water flush, ISOTEC will inject stabilized 8% hydrogen peroxide into the subsurface. A final water injection is completed to flush the oxidizer from the injection equipment. This process is repeated for each injection screen. By using multiple pump setups it will be possible to inject reagents through 3 different injection screens at once, allowing for the injection of target reagent quantities at 9 to 12 locations (18 to 24 screens) each day. A MFR injection method schematic detailing the injection method utilizing DPT is included as **Figure 6.**

3.2.4 Reagent Quantities

ISOTEC will attempt to inject between 100 and 200 gallons of reagent at each location. Specifically, ISOTEC will attempt to inject between 25 and 50 gallons of catalyst and between 25 and 50 gallons of oxidizer into each lower and upper screen. It is important to note that the actual volume injected will depend upon the lithology, potential surfacing, injection flow rate, pressure and radial effects noted during injection.

Reagent quantities will be recorded on daily log sheets, which will be made available to PSC at the end of each working day.

3.2.5 Injection Rates and Pressures

The ISOTEC process injection rates and volumes are interrelated to the reaction rates of hydroxyl radicals with the contaminants, the distribution of contaminants in the subsurface, and the rate of hydrogen peroxide decomposition. The rate at which the ISOTEC reagents are injected into the subsurface is initially determined by the soil/aquifer characteristics. Based upon review of the provided data, ISOTEC expects injection flow rates between 2 and 3 gallons per minute (gpm) and injection pressures of between 10 and 40 pounds per square inch (psi).

Injection rates and pressures will be recorded on daily log sheets, which will be made available to PSC at the end of each working day.

3.3 DIRECT-PUSH INJECTION SCREEN INSTALLATION

ISTOEC will utilize DPT to install temporary injection screens at the site. A DPT subcontractor will use a direct-push rig to advance 1.5-inch diameter threaded steel rods to a desired depth within the target treatment interval. After a sufficient number of steel rods have been advanced into the subsurface to reach the desired depth, an ISOTEC designed injection screen will be lowered to the bottom of the rod string. While the injection screen is held in place, the rod string will be retracted to expose the screen to impacted soils in the target treatment interval. ISOTEC reagents will then be injected through the temporary injection screen and into the subsurface.

Two separate direct-push rods will be installed at each location within the on-site treatment areas; one screen will deployed from approximately 3 to 6 feet bgs to target the upper shallow vadose zone soils and the second screen will be deployed from approximately 6 to 10 feet bgs to target the lower shallow vadose/saturated zone soils. This method of selective vertical injection will ensure reagent delivery across the entire vertical extent of the target treatment interval. A direct-push injection screen schematic for the on-site injection locations is shown in **Figure 7**.

As discussed in Section 3.1 above, the target treatment interval for the four off-site injection locations is from 0 to 10 feet bgs. As a result, one screen will deployed from approximately 0 to 5 feet bgs to target the upper shallow vadose zone soils and the second screen will be deployed from approximately 5 to 10 feet bgs to target the lower shallow vadose/saturated zone soils.

ISOTEC anticipates completing injection activities at 9 to 12 injection locations (18 to 24 injection screens) per day. To accomplish this, ISOTEC will ensure that the DPT subcontractor has enough direct-push rods to have all 12 injection locations (24 injection screens) installed each day. ISOTEC will then utilize three separate pneumatic double-diaphragm pumps to inject reagents into three injection screens simultaneously.

3.3.1 Direct-Push Boring Abandonment

The recommended abandonment material for the injection borings is 3/8-inch bentonite chips. Following removal of the rod string and injection screen by the DPT subcontractor, bentonite chips will be slowly dropped down the open borehole. Bentonite chips will be dropped down the borehole until they are at approximately 10 inches below grade surface. The bentonite will then be hydrated. Following hydration, concrete will poured into the 10-inches of exposed hole. This procedure allows the bentonite to swell out into the soil over time forming a tight seal because the overlying cement plug will prevent the bentonite from swelling vertically. This method provides for an excellent seal across both the vadose zone and the saturated zone, preventing fluids from migrating down through the vadose zone and also prevents gas bubbles from entering the probe hole in the saturated zone.

3.4 ISOTEC MATERIAL HANDLING AND STORAGE

ISOTEC employees will handle and store hydrogen peroxide and catalyst to complete this project. All ISOTEC employees have received training in the proper handling and storage of these chemicals. They have also received specific training in the PPE required to handle these chemicals safely. A fire extinguisher will be on-site in each box truck at all times.

Chemicals will be stored according to the requirements of the DOT. In brief, the hydrogen peroxide and the catalyst will be stored in such a way that if a spill were to occur, the two would not come into contact with each other. To accomplish this, the peroxide will be stored in a location separate from the catalyst. Specifically the peroxide will be stored on-site in DOT-approved 55-gallon drums in a designated and secure area. The hydrogen peroxide storage area will be surrounded by security fencing and contain an emergency response station. Diluting the peroxide will be performed in a dilution tank. Water will be added to the dilution tank along with dry stabilizer in a predetermined volume to create a 8% concentration after the addition of a predetermined volume of hydrogen peroxide. An electric drum pump or an air operated double diaphragm pump will be used to transfer the peroxide into the dilution tank. Two technicians are required to complete this process. One operates the pump and one holds the transfer wand in the dilution tank. Both technicians will wear splash resistant aprons, face-shields and chemical resistant gloves while completing the transfer.

Liquid catalyst and the dry chemicals necessary to mix it will be stored inside of a box truck. To mix catalyst, iron will be added to the mixing tank followed by a predetermined quantity of water. An electric mixer is used to mix the solution. ISOTEC's patented chelating agents are then added to the solution and mixing continues. Although the chemicals are non-hazardous and the mixing process is generally dust free, the technician completing the mixing will wear nitrile gloves and a NIOSH approved N95 particulate respirator as a precautionary measure.

Combustion issues associated with the presence of hydrogen peroxide, a strong oxidizer, are minimized since a maximum solution of 30% will be delivered to the site. The peroxide will be stored in DOT-approved 55-gallon drums. Flammable materials, i.e., gasoline, will not be stored near the peroxide or in locations where a peroxide spill could occur.

The ISOTEC reagents are not combined at the surface. The peroxide and catalyst only come into contact with one another in the subsurface. Precautions are taken by flushing all equipment with water between separate injections of each reagent.

3.5 SPILL PREVENTION

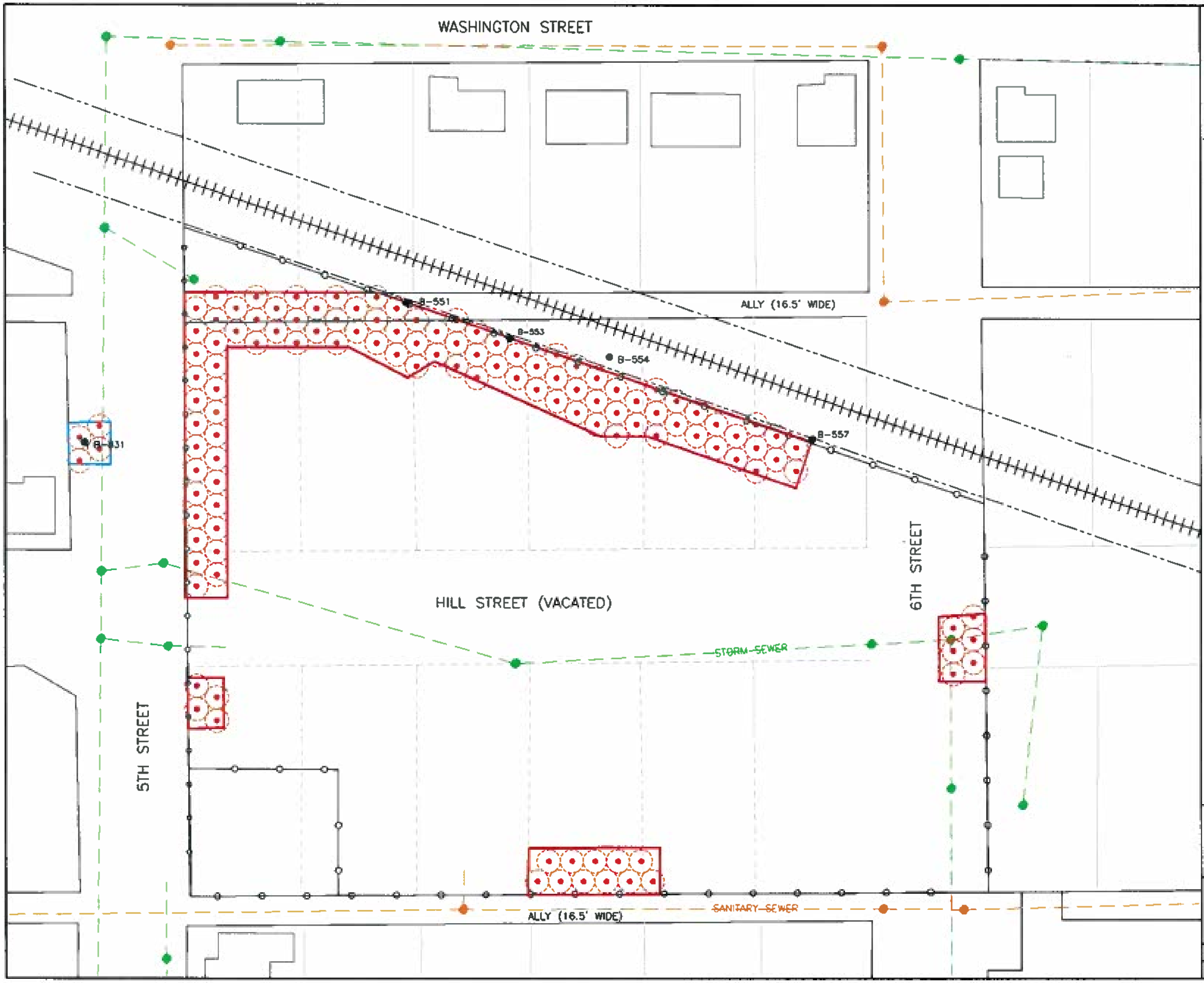
Site personnel should be aware of potential conditions that could cause a spill and take preventative measures before a spill occurs. Safe storage and handling procedures are discussed in **Section 4.5.1** above.

Hydrogen peroxide and catalyst will be stored in such a way that if a spill of either were to occur, the two would not come into contact with each other. The tanks used to dilute the peroxide and to mix and store the catalyst are oversized to prevent spillage from the tanks. If a small spill, less than five gallons, of peroxide occurs to the ground surface water will be used to dilute it further and actions taken to prevent the fluid from entering any storm drains or drainage ditches, while the fluid is soaked up with clay sorbent. If a larger spill of peroxide occurs the same procedure will be followed and any excess liquid will be pumped into a clean empty storage tank. If a small spill, less than 5 gallons, of catalyst occurs it should be contained and soaked up with sorbent pads then placed in a steel or poly drum. If a large spill of catalyst occurs it will be contained and pumped into the storage tank with an air diaphragm pump. If a spill of dry catalyst occurs it will be swept up and placed in a poly bag.

If any spill occurs work will stop immediately until the spill is cleaned up and the cause of the spill is determined and corrected. All spilled materials will be disposed of properly.

3.6 PROPERTY ACCESS REQUIREMENTS

ISOTEC understands that PSC will obtain permission from property owners and adjoining property owners as well as complete public notification as necessary, prior to injection activities.



LEGEND

☐	Existing Structure
●	Soil Boring Location
—o—	Fence (and Remediation Site Boundary)
--●--	Storm Sewer Pipe and Manhole Cover
--●--	Sanitary Sewer Pipe and Manhole Cover
🟥	Areas of Organic Constituents of Concern That Exceed Tier 1 Remedial Objectives (Treatment Interval = 3 to 10 Feet BGS)
🟦	Areas of Organic Constituents of Concern That Exceed Tier 1 Remedial Objectives (Treatment Interval = 0 to 10 Feet BGS)
•	Phase 2A Direct-Push Injection Location
○	Conceptual Radius of Influence (7.5 feet)

N

0 30 60
1 INCH = 60 FEET

NOTE:

Base map provided by PSC Industrial Outsourcing, LP.

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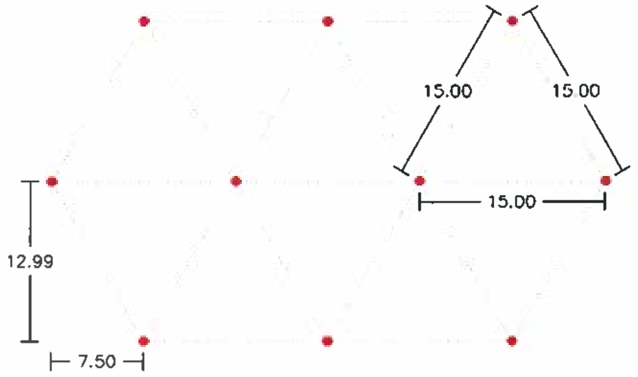
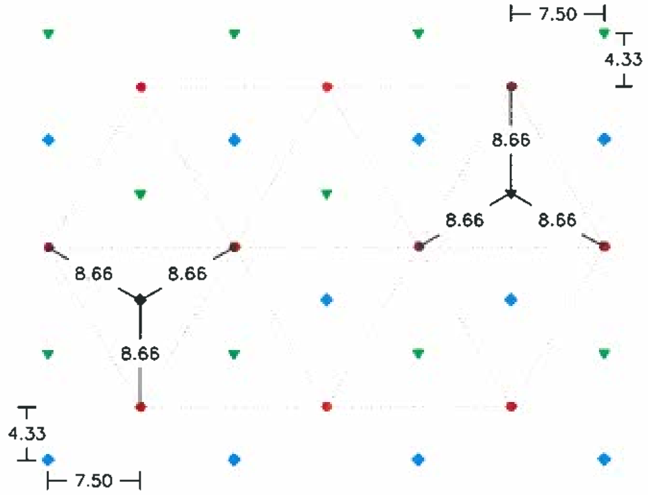
PHASE 2A INJECTION LOCATION MAP
ISCO REMEDIATION PROGRAM
Former Champaign MGP Site
Champaign, Illinois

DRAWN BY: TE	DATE: 8/15/2012	FIGURE 3
CHECKED BY: SH	PROPOSAL NO: 901144	

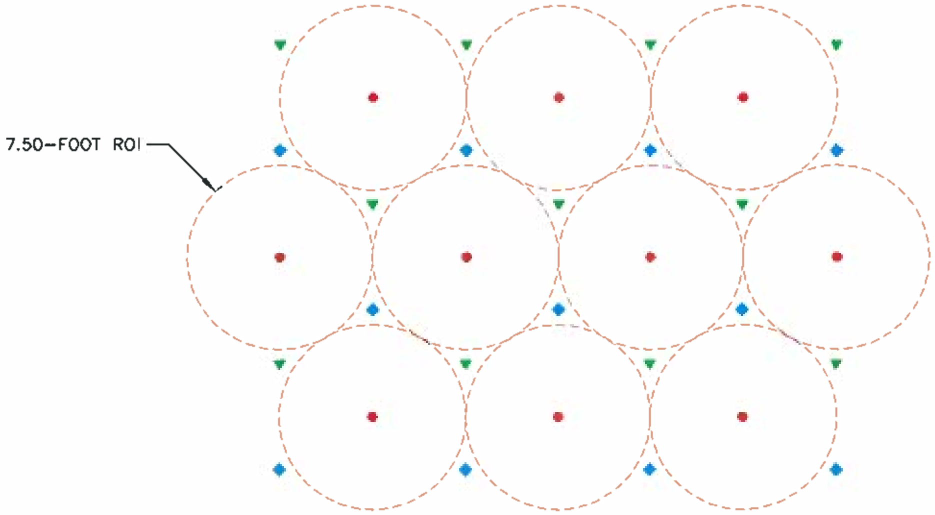
Typical Single Event Injection Location Layout



Typical Multiple Event Injection Location Layout



ISCO Reagent Radius of Influence



LEGEND

● Phase 2A Injection Location

▼ Phase 2B Injection Location

◆ Phase 2C Injection Location

○ Radius of Influence (ROI)

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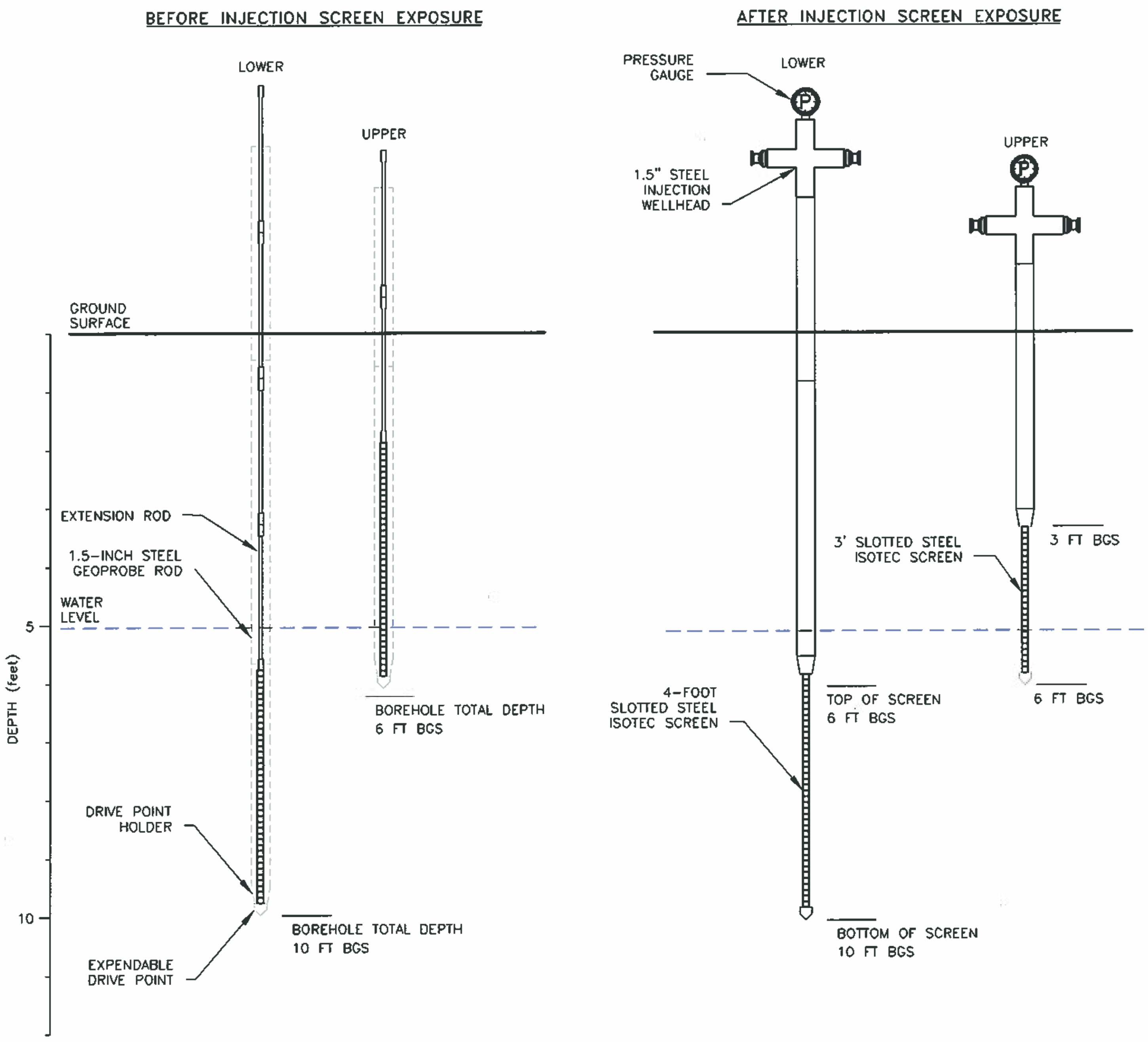
MULTILPLE EVENT INJECTION LOCATION LAYOUT SCHEMATIC
ISCO INJECTION PROGRAM
Fromer Champaign MGP Site
Champaign, Illinois

DRAWN BY: KH	DATE: 8/15/2012	FIGURE 4
CHECKED BY: SH	PROPOSAL NO: 901144	



INJECTION SCREEN INSTALLATION

1. Two separate borings will be utilized at each injection location. One boring will be the LOWER injection screen and will be installed by advancing probe rod to a depth of 10 feet below ground surface (bgs) by a direct-push subcontractor. The second boring will be the UPPER injection screen and will be installed by advancing probe rod to a depth of 6 feet bgs.
2. Once at the desired depth, a 4-foot injection screen (LOWER) or a 3-foot injectin screnen (UPPER) will be lowered to the bottom of the rod string and held in place with extension rod.
3. The rod string will be extracted 4 feet or 3 feet to expose the screen to impacted soils in the target treatment interval.

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DIRECT-PUSH INJECTION SCHEMATIC
ISCO REMEDIATION PROGRAM
Former Champaign MGP Site
Champaign, Illinois

DRAWN BY: KH	DATE: 8/15/12	FIGURE 7
CHECKED BY: SH	PROPOSAL NO: 901144	