



MOVE YOUR ENVIRONMENT FORWARD

REMEDIAL ACTION WORK PLAN

Former Garden Photoengraving (OU-1) - Site # 130174

40 Roselle Street
Mineola, New York 11501

Prepared For:

Contract# D009808, Work Assignment No. 20
New York State Department of Environmental Conservation
Division of Environmental Remediation
625 Broadway
Albany, New York 12233-7012

Prepared By:

HRP Associates, Inc.
1 Fairchild Square, Suite 110
Clifton Park, NY 12065

HRP #: DEC1020.RA

Issued On: August 10, 2023



TABLE OF CONTENTS

1.0 INTRODUCTION 1

1.1 Site Background 2

1.2 Conceptual Site Model 3

1.3 Remedial Action and Green Remediation Objectives 3

1.4 Standards, Criteria, and Guidance 4

2.0 SCOPE OF WORK 5

2.1 Roles and Responsibilities 5

2.2 Planning Documents and Mobilization/Demobilization 9

2.2.1 Preparation and Review of Planning Documents 9

2.2.2 Project Meetings 10

2.2.3 Mobilization and Site Preparation Activities 11

2.3 In-Situ Injection and Chemical Oxidation 12

2.4 Groundwater Monitoring 14

2.4.1 Baseline Sampling 14

2.4.2 Performance Monitoring 14

3.0 PROJECT SCHEDULE 16

4.0 PROJECT CONTACTS 18

Figure

Figure 1	Site Location
Figure 2	ISCO Injection Treatment Area
Figure 3	South-North Cross Section (A-A')

Table

Table 1	Green Remediation Objectives
---------	------------------------------

Appendices

Appendix A	Bench-Test Report
Appendix B	Community Air Monitoring Plan
Appendix C	Oxidant Information
Appendix D	Injection Design Drawings

General Information

Project/Site Information:

Former Garden Photoengraving (OU-1)
Site # 130174
40 Roselle Street
Mineola, New York 11501

Consultant Information:

HRP Associates, Inc.
1 Fairchild Square, Suite 110
Clifton Park, NY 12065
Phone: 518-877-7101
Fax: 518-877-8561
E-mail: mark.wright@hrpassociates.com
Project Number: DEC1020.RA

Client Information:

New York State Department of Environmental
Conservation
Division of Environmental Remediation
625 Broadway
Albany, New York 12233-7012

Report Date: 8/10/2023

Report Author: 

Mark Wright

PE Certification:

*I **Glenn Netuschil** certify that I am currently a NYS registered professional engineer and that this Remedial Action Work Plan] was prepared in accordance with all applicable statutes and regulations and in substantial conformance with the DER Technical Guidance for Site Investigation and Remediation (DER-10) and that all activities were performed in full accordance with the DER-approved work plan and any DER-approved modifications.*



1.0 INTRODUCTION

HRP Associates, Inc. (HRP) was contracted by the New York State Department of Environmental Conservation (NYSDEC) to complete a Remedial Design at the Former Garden Photoengraving Facility, or "Site", located at 40 Roselle Street, Mineola, New York (**Figure 1**). This Remedial Action Work Plan (RAWP) includes drawings, figures, and relevant Site data required to implement in-situ chemical oxidation (ISCO) at the Site, as outlined in the NYSDEC Record of Decision (ROD) dated March 2017.

This site-specific RAWP describes relevant details to the proposed work scope, including required permits, field activities, laboratory analyses, and data quality assurance and quality control (QA/QC) evaluation that will be implemented during remedial activities at the Site. Remedial activities to be performed by the NYSDEC call-out contractor selected to perform the work (the Contractor) include, but are not limited to:

- Development and submittal of required construction work plans for HRP and NYSDEC approval prior to Site mobilization.
- Site preparation including mobilization of equipment, permitting, Site survey, and underground utility facilities protection notification.
- Procurement of Klozur® SP and 25% NaOH activator.
- Installation of direct-push technology (DPT) injection points.
- Injection of Klozur® SP and 25% NaOH activator.

Remedial activities to be performed by HRP include, but are not limited to:

- Review of Contractor work plans.
- Performance monitoring of groundwater for volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and target analyte list (TAL) metals.

The design elements of this RAWP were based on the ROD, Remedial Actions Objectives (RAOs), and the results of the Pre-Design Investigation, including a bench-scale test performed by Prima Environmental, Inc. (Prima) (**Appendix A**). **Section 1.0** of this RAWP includes a Site background, RAOs, standards criteria and guidance (SCGs), and the general responsibilities of NYSDEC, HRP, and the Contractor. **Section 2.0** consists of a detailed SOW for the remedial injection. **Section 3.0** consists of a summary of the overall remedial program including descriptions of each of the remedial actions to be performed, institutional controls, groundwater monitoring, and remedial program documentation including the Site Management Plan (SMP) and Final Engineering Report (FER). A preliminary project schedule and listing of project contacts are included in **Section 4.0** and **Section 5.0** respectively.

1.1 Site Background

A full Site description and detailed background history can be found in the Site's ROD, dated March 2017. The Site is located at 40 Roselle Street, in the Village of Mineola, Nassau County, New York. The 0.394-acre Site is currently occupied by Rapid Injection Systems, a dental supply store, and Bhatia Electrical Contracting Corporation, an electrician.

Previous investigations completed at the Site include:

- 2001 Phase II subsurface and groundwater investigation
- An environmental audit performed in May 2002
- 2004 Site Investigation performed on the eastern parking lot cesspools
- A Site Characterization (SC) of the Site and the adjacent property (50 Roselle Street) completed in 2009
- A Remedial Investigation (RI) conducted in February 2014, finalized in February 2017

The findings of these investigations are presented in the ROD dated March 2017. Based upon the resources and pathways identified in the OU-1 ROD, and the toxicity of the contaminants of ecological concern at this Site, a Fish and Wildlife Resources Impact Analysis (FWRIA) was deemed not necessary for the Site during the RI.

During the RI (2014), PCE and its associated degradation products, TCE and cis-1,2-DCE, were found in groundwater beneath the eastern parking lot at concentrations greater than the NYSDEC Technical Operational Guidance Series (TOGS) 1.1.1 Class GA criteria (5 parts per billion [ppb]), with a maximum concentration of 190 ppb adjacent to the screen interval from 40-50 feet below grade (ft bg) at MW-2. Non-aqueous phase liquid (NAPL) was first detected at the bottom on MW-2 in 2009 and again in 2014. The NAPL was gauged at a depth of 55.91 ft bg in 2014, which was described as a 2-inch layer of black product at the bottom of the well. A fingerprint analysis performed on the NAPL in 2014 indicated a reported PCE concentration of 33,000 ppb. The well has not been sampled since 2014. In 2004, NAPL was observed in a soil sample collected at a depth of 36-38 ft bg, from a former cesspool (CP-4) located adjacent to MW-2. The cesspool is believed to be the source of the NAPL.

Naphthalene was detected in monitoring well MW-4 at a concentration greater than the Class GA criteria (10 ppb) with a maximum concentration of 3,000 ppb. Pesticides aldrin and heptachlor were detected at concentrations of 0.31 ppb and 0.16 ppb, respectively, both of which are greater than their respective Class GA criteria of 0.067 ppb and 0.04 ppb. Poly-chlorinated biphenyls (PCBs) and SVOCs (other than naphthalene) were not detected in the groundwater above their respective Class GA criteria.

During the RI (2014), soil vapor samples were collected from beneath the eastern (SV-10) and western (SV-11) parking lots to evaluate the potential for off-site migration of soil vapors. PCE and TCE were detected in soil vapor beneath the eastern parking lot at concentrations of 240 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and 55 $\mu\text{g}/\text{m}^3$, respectively. PCE and TCE were detected in soil vapor beneath the western parking lot at concentrations of 71 $\mu\text{g}/\text{m}^3$ and 41 $\mu\text{g}/\text{m}^3$, respectively. The maximum concentrations of PCE detected in the sub-slab vapor and in the

indoor air, collected from the Site building in 2014, were 9,600 $\mu\text{g}/\text{m}^3$ and 60 $\mu\text{g}/\text{m}^3$, respectively. A maximum concentration of 5,900 $\mu\text{g}/\text{m}^3$ of TCE was found in the sub-slab vapor and 34 $\mu\text{g}/\text{m}^3$ in the indoor air. The results of the soil vapor intrusion study indicate actions are recommended to mitigate exposures from soil vapor intrusion at both properties. In addition, the New York State Department of Health (NYSDOH) soil vapor guidance was exceeded for both PCE and TCE at both properties. Soil vapor intrusion for properties beyond 40 and 50 Roselle Street will be addressed under OU-2.

1.2 Conceptual Site Model

Previous investigations indicate that NAPL and elevated concentrations of chlorinated VOCs have been identified in monitoring well MW-2, which according to previous reports is located "in close proximity" to the location of the former cesspool CP-4. Although MW-2 was installed in 2004, NAPL was not observed until 2014. NAPL was also observed in a soil boring installed at the location of the former cesspool in 2004. The NAPL in the vadose zone has been identified as the source of groundwater contamination at the Site.

1.3 Remedial Action and Green Remediation Objectives

RAOs established for the Site represent media-specific goals that are protective of public health and the environment that have been developed through consideration of the results of the Site investigation activities and with reference to potential SCGs, as well as current and foreseeable future anticipated uses of the Site. The RAOs presented in the ROD have been used in the preparation of this RAWP. The selected remedy shall eliminate or mitigate significant threats to public health and the environment presented by the impacts identified at the Site through the proper application of scientific and engineering principles.

RAOs for the Site established as a part of the ROD to protect public health include:

- Preventing ingestion of groundwater with contaminant levels exceeding drinking water standards.
- Preventing contact with, or inhalation of, volatiles from contaminated groundwater.
- Mitigating impacts to public health resulting from existing, or the potential for, soil vapor intrusion into buildings at a Site.
- Preventing ingestion and direct contact with contaminated soil.

The RAOs for the Site established as a part of the ROD to protect the environment include:

- Preventing migration of contaminants that would result in groundwater or surface water contamination.
- Restoring groundwater aquifer to pre-disposal/pre-release conditions, to the extent practicable.
- Removing the source of ground or surface water contamination.

In addition to remedial objectives to protect human health and the environment, it is the policy of NYSDEC to approach remediation projects in a way that minimizes the environmental

footprint of a clean-up action. This concept, outlined in DEC Program Policy 31, is referred to as "Green Remediation." Additionally, *Commissioner's Policy CP-75 – DEC Sustainability*, seeks to have NYSDEC continue its "lead by example" approach to accelerate and guide the transition to the low-carbon sustainable economy of the future.

In consideration of these goals, the following Green Remediation Objectives have been identified and applied to this remedial design:

- Minimizing air emissions including greenhouse gas emissions
- Waste minimization

Green Remediation best management practices (BMPs) identified for implementation during this project are detailed in **Table 1**.

1.4 Standards, Criteria, and Guidance

SCGs are to be used to evaluate groundwater samples collected as part of performance monitoring both before implementation (baseline), and after each injection event. Specifically, VOC concentrations are to be compared to the Division on Water Technical and Operational Guidance Series (TOGS 1.1.1.) as defined as ambient water quality standards and guidance values.

2.0 SCOPE OF WORK

2.1 Roles and Responsibilities

The selected Contractor will be responsible for implementing the injection program. The Contractor will be responsible for, but not limited to, the following:

- Developing a Construction Work Plan which outlines the SOW and labor/equipment/materials needed to execute the selected elements of the remedy outlined in this RAWP in an efficient and timely fashion. The Construction Work Plan should also contain a preliminary remedial action schedule. The work plan shall be submitted to and approved by HRP and NYSDEC prior to mobilization.
- Acquiring all labor, equipment, and materials necessary to execute the selected elements of the remedy outlined in this RAWP in an efficient and timely fashion.
- Completing the work in accordance with NYSDEC DER-10 Technical Guidance, Occupational Safety and Health Administration (OSHA) regulations, and other applicable, local, state, and federal regulations.
- Ensuring that on-site personnel have OSHA 40-hour training (in accordance with 29 Code of Federal Regulations (CFR) 1910.120 and corresponding 8-hour refresher updates).
- Implementing the work as described in the specifications and drawings of this RAWP.
- Implementing the Special Requirements Community Air Monitoring Plan (SR-CAMP; **Appendix B**) at the perimeter of the Site boundaries and locations adjacent to air intake structures at occupied buildings within 20 feet of the work zone, and maintaining total particulates and VOC level below the levels stated in NYSDEC DER-10.
- Attending pre-construction, post-construction and periodic process meetings with the engineer (HRP) and NYSDEC.
- Obtaining any required permits needed, including permits at the municipal, state, and federal level.
- Communicating with HRP to obtain all necessary information related to coordination with the property owner, NYSDEC, the Village of Mineola Building Codes Department, as well as owners and/or operators of underground facilities, and needed to complete required work activities specified in this RAWP.
- Contacting Dig Safe New York, and other utility owners to identify potential underground utilities located within the Site boundaries, prior to any intrusive work, including drilling and injection activities.
- Confirming the location of utilities prior to initiation of any on-site work.

- Notifying HRP, NYSDEC, and utility owner (in writing) if an underground utility is uncovered or revealed at or contiguous to the Site, which was not shown or indicated in the Scope of Work (SOW). During such time, the Contractor shall be responsible for the safety and protection of such underground facility.
- Performing all survey work necessary for the completion of the work scope and provide survey data and updated "as-built" drawings to HRP for inclusion in record drawings and plans.
- Notifying HRP and NYSDEC for any conditions that may alter the design and implementation of the remedy as indicated in the SOW.
- Characterizing and disposing of all Investigation Derived Waste (IDW).
- Working between the hours of 8:00 AM and 6:00 PM, as required by the Village of Mineola General Legislation § 376-17.1, for construction work and repairs.

HRP will be responsible for, but not limited to:

- Transmitting payment applications to the DEC Project Manager with a cover memorandum recommending payment of the application in question.
- Conducting pre-bid, pre-construction, and post-construction meetings with the Contractor and NYSDEC and preparing meeting minutes for distribution to attendees.
- Attending project progress meetings and preparing minutes for distribution to attendees.
- Completing appropriate Underground Injection Control (UIC) registration and notification with the United States Environmental Protection Agency (US EPA). Copies of the registration should be sent to NYSDEC.
- Coordinating with the property owner, NYSDEC, the Village of Mineola Building Codes Department, as well as owners and/or operators of underground facilities, as necessary, to complete required work activities.
- Reviewing Contractor submittals for compliance with project plans and specifications and design concept, inclusive of review of shop drawings, materials, soil tests, construction tests, progress payment requests, and any other documents generated by Contractor. Submittal review must be completed within 14 days.
- Maintaining complete and detailed records related to construction activities, including:
 - Work completed and important conversations.
 - Daily inspection reports.
 - Documentation of Contractors deviation from work as specified in the contract documents with actions and resolutions.

- Marked up drawings for verification of accuracy and completeness of contractor's record drawings.
 - Construction photos and video highlights.
 - Log of proposed and executed change orders, field orders, contractor application for payments, and shop drawing submittals.
 - General files including correspondence, manifests, bills of lading, contractor's logs, submittals, field orders, change orders, and job meeting minutes.
 - Summary records of date, location, sample ID, type, result, and action for sampling results, air monitoring results, and wastewater discharges.
 - Summary records of date, manifest number/bills of lading number, description, transported, disposal facility, and quantities for off-Site disposal.
- Performing daily inspections of work completed by Contractor during implementation of remedial action. A Daily Inspection Report will be completed and submitted to the DEC Project Manager, Supervisor, and Bureau Director by close of business (COB) the following business day. At a minimum, the report will include the following:
 - Report on issues concerning contractor's compliance with the Health and Safety Plan (HASP) as they would impact DEC personnel and the community.
 - Details of all actions by and conversations with public, news media, and representatives.
 - Report on contractor's performance, resolution/decisions on field deficiencies or observed variations from contract documents. Attention should be given to Contractor's performance with regard to the following:
 - Continuous dust monitoring, generation of visible dust, dust suppression techniques, and appropriate use of dust suppression water, fluids, or foams.
 - Visible tracking of soil or water on streets and precautions taken for prevention. Removal of spilled materials from transit roads, and immediate clean-up of public roadways.
 - Repair of visible oil or hydraulic fluid leaks on equipment and machinery used at the Site.
 - Real time and documentation monitoring (health and safety).
 - Turbidity and prevention of off-Site migration of any aqueous wastes moved from point to point. Storm water management and erosion control measures.
 - Minimizing adverse impacts to residences and adjacent property, including restoration of property.
 - Appropriate barriers to unauthorized entry to construction areas, maintenance of traffic and protection of installed work.
 - Compliance with discharge criteria and approval conditions.
 - Nuisance issues requiring work stoppage and corrective measures (i.e. noise, vibration, odor, traffic, dust) should be documented. DEC Project Manager, Supervisor, and Bureau Director should be notified immediately of any nuisance issues, complaints received from the community at large, or unusual issues requiring immediate response (i.e. unapproved subcontractors on-Site, health and

- safety issues, unacceptable conduct by Contractor, subcontractors, or suppliers, turbidity release, etc).
 - Coordination with property owners and involved local representatives must be accounted for, as well as protection of structures or utilities anticipated to be impacted by the work.
 - Issues related to water generated during construction and water handling.
 - Work down-time or idle equipment documentation.
 - Annotated photographs to illustrate issues/concerns.
 - Issues related to startup, testing, and operation of treatment systems should be documented.
 - Conversations with Contractor regarding failure to implement best management practices or meet contract requirements should be documented and reported to the DEC Project Manager. The Engineer should memorialize in field order or other appropriate written notice.
- Discussing progress with regard to contract specified work on a daily basis.
 - Maintaining a log of all contract document deficiencies for modifications to standard contract documents on future projects. DEC Project Manager will be informed of any deficiencies discovered in the contract documents.
 - Obtaining DEC Project Manager approval for field order issuance. Field orders can only be implemented on issues not involving cost or time. DEC Project Manger should be copied on any submittals, Requests for Information (RFIs), comments on Proposed Change Orders (PCOs), comments on Field Orders (FOs), and general emails received from Contractor in addition to final PCOs, final RFIs, and final FOs. Changes of Contractor personnel must also be requested from the DEC Project Manager and approved prior to implementation.
 - Coordinating project-related health concerns raised by the public with the New York State Department of Health (DOH). DEC Project Manager shall be included in all correspondence regarding project-related health concerns and Bureau Director and Section Supervisor should be copied on correspondence.
 - Preparing a certificate of substantial completion which defines substantial completion and includes a punch list of minor work items remaining to be completed. Coordinating substantial completion, final completion, and warranty inspections with the DEC Project Manager.

This section presents a task-by-task description of the Contractor's activities to implement the remedy at the Site. The Contractor's activities will be implemented under the following general work tasks:

- Planning Documents and Mobilization/Demobilization
- In-Situ Chemical Oxidation (ISCO)

This section also presents a task-by-task description of HRP's activities to implement the remedy at the Site. HRP's activities will be implemented under the following general work task:

- Groundwater Monitoring

2.2 Planning Documents and Mobilization/Demobilization

The Contractor will be responsible for conducting the following activities under this work task:

- Preparation, submittal, and revision (if needed) of relevant planning documents, including work plans, material specifications and cut sheets, drawings, and any other necessary information required by this RAWP.
- Attending a pre-construction meeting, daily health and safety meetings, periodic coordination meetings, and a post-construction meeting.
- Mobilization/demobilization of equipment, labor, and materials necessary to complete the selected remedial tasks.

Additional details for these activities are presented in the following sections.

2.2.1 Preparation and Review of Planning Documents

The Contractor shall submit appropriate planning documents to HRP and NYSDEC for review. The Contractor shall finalize the documents submitted based on comments provided by HRP and NYSDEC. Contractor shall not mobilize until planning documents have been reviewed and approved by HRP and NYSDEC.

The selected Contractor shall prepare work plans including, but not limited to:

- A SOW outline which details the methods and equipment which will be implemented to complete the remedial components in an efficient and timely fashion.
- Labor, equipment, and materials necessary to complete the remedial components in an efficient and timely fashion.
- A full project schedule, including the length of time it will take for the Contractor to complete each individual work activity.
- Sequence of operations and proposed hours of operation. Normal working hours shall be defined during the pre-injection meeting, or if none are set forth, shall be defined as beginning no earlier than 8:00 a.m. and ending at no later than 6:00 p.m.
- A plan to manage impacted groundwater, if generated, during field activities.
- A Health and Safety Plan (HASP):

- The HASP shall include all required elements of a HASP as outlined in 29 CFR 1901.120 and 29 CFR 1926.65.
 - The health and welfare of the Contractor's staff is the direct responsibility of the Contractor. The Contractor shall take necessary precautions for the health and safety of all on-site.
 - The Contractor shall designate a responsible representative at the Site to act as the Site's Health and Safety officer whose duties include executing and ensuring compliance with the approved HASP.
- A SR-CAMP will be required by the Contractor. Real-time monitoring for particulates (i.e., dust) and VOCs shall be conducted in accordance with NYSDEC DER-10. The SR-CAMP will be used to confirm that work activities do not impact the adjacent buildings and spread environmentally impacted materials off-site through the air. Dust control measures and monitoring will be detailed in SRC-AMP. The Contractor shall provide a daily data submittal from real-time monitoring from each day, before the start of work the following day.
 - Proposed method(s) of decontamination procedures for Contractor's small equipment and hand tools, waste material and personal protective equipment.
 - Materials and methods that will be used to temporarily store chemical reagents (if applicable).
 - Characterization and waste profile for IDW (if generated), and identification of proposed licensed and permitted disposal facilities within New York State, including letters of commitment and operating licenses, if applicable.
 - Site restoration including identification of the names of each injection point, and proper abandonment of DPT injection points in accordance with DER Commissioner's Policy-43 (CP-43) Guidance.

The Contractor shall revise the required submittals as necessary to address comments from HRP and NYSDEC. The Contractor shall submit the revised and/or final submittals to HRP and NYSDEC. HRP and NYSDEC's review do not relieve the Contractor of any responsibility to comply with applicable laws, rules, regulations, or agreements.

2.2.2 Project Meetings

The Contractor shall be responsible for attending project meetings as described below.

- Pre-Injection Briefing - Prior to Contractor mobilization, a pre-injection meeting will be held at the Site to introduce the project team members representing the Contractor, Subcontractors, NYSDEC, and HRP. The meeting will be scheduled by HRP, and will be conducted to review the SOW requirements; review responsibilities of the Contractor; establish a detailed schedule of operations including definition of normal working hours;

and resolve issues (if any) raised by attending parties. HRP will prepare a summary of the pre-injection meeting and distribute a copy to the Contractor and NYSDEC.

- Daily Health and Safety Meetings - The Contractor shall be responsible for coordinating ~~daily health and safety meetings~~, which will be attended by all Contractor personnel to discuss day to day project-related health and safety issues. NYSDEC and HRP reserve the right to attend daily health and safety meetings.
- Final Inspection - Following final completion of the remedial action, an inspection meeting ~~will be held at the Site~~ with the Contractor, NYSDEC, and HRP.

2.2.3 Mobilization and Site Preparation Activities

The Contractor shall initiate Site mobilization activities no later than three months after required submittals have been reviewed and approved by HRP and NYSDEC. The Contractor shall be responsible, at a minimum, for the following mobilization tasks:

- Provide notice to adjacent building owners regarding the injection event at a minimum of 10 business days before the injection event.
- Communicating with HRP regarding access to water and electrical service (if required). Access to other various municipal structures (i.e., hydrants, valves, manholes, fire alarms, etc.) shall not be obstructed by the Contractor to prevent use. The Contractor shall secure any required permits and abide by all applicable permit conditions.
- Verifying the existing Site conditions and identifying and marking the location(s) of all aboveground and underground utilities, equipment, and structures, as necessary to implement the work scope.
 - Prior to commencing on-site activities, the Contractor shall contact Dig Safe New York to obtain utility clearances. The Contractor shall be responsible for coordinating with the applicable utility companies, Village of Mineola, and the Site owner to ensure proper location of utilities. The Contractor shall also obtain and pay for the necessary permits to complete the work, if applicable.
 - If the Contractor damages existing utilities, equipment, or structures, the Contractor is responsible for notifying the appropriate utility company, HRP, and NYSDEC, and fully repairing damages at no additional cost to NYSDEC or HRP. Repairs, if necessary, shall be completed in accordance with the requirements of the utility company and to the satisfaction of NYSDEC and HRP.
- Mobilizing equipment, and materials to the Site as necessary to implement the remedy. Equipment mobilized to the Site will be subject to a visual inspection by HRP. Equipment that arrives at the Site in unsatisfactory condition (e.g., soiled, poor operating condition, etc.), in the opinion of HRP, shall be removed from the Site and replaced by the Contractor at no additional cost to NYSDEC. The Contractor shall be responsible for providing labor,

equipment, and materials needed to conduct decontamination activities (as necessary) of personnel and equipment associated with remedial activities outlined in the RAWP.

- Constructing additional remedial support area(s), on-site staging area(s), and decontamination area(s) on the property in accordance with the provisions of the reviewed documentation and plans.
- Decontamination activities shall be conducted on a decontamination pad constructed by the Contractor in an area approved by HRP.
- Decontamination procedures shall include scraping equipment of residual soil and a hot-water pressure washing of drilling equipment and injection equipment, as needed.
- Any decontamination fluids shall be containerized in an appropriate container for characterization and disposal off-site by the contractor.

Demobilization activities to be conducted by the Contractor include, at a minimum, decontamination, dismantling and removal from the Site of all equipment, additional materials not used by the Contractor, and other waste generated during remedial construction.

2.3 In-Situ Injection and Chemical Oxidation

The chemical oxidant will be applied to the contaminant source area, adjacent to MW-2, and the location of a former cesspool. Oxidant (**Appendix C**) will be applied to nine temporary injection points, spaced 10 feet on center to encompass the VOC source area (**Figure 2**). It is anticipated that there will be two injection events with the second event occurring 60 to 90 days after the initial event. The timing of the second event (if necessary) will be based on the results of the performance monitoring performed by HRP.

A series of detailed injection design drawings are provided to the Contractor in **Appendix D**. The Contractor shall be responsible, at a minimum, for the following injection tasks:

- The injection points will be spaced 10-feet on center to evenly distribute oxidant to the subsurface (**Figure 2**).
- The oxidant solution will be injected using direct-push injection methods using 2.25-inch diameter direct push rods, and ancillary equipment (oxidant mixing tanks, injection and mixing pumps, fittings, hoses, valves, etc.).
- The oxidant will be injected using a top-down method to facilitate oxidant distribution in the vadose zone in the identified onsite treatment area (**Appendix D**). The direct-push rods will be advanced to the top of the target depth 30 ft bg (**Figure 3**). Once the target depth is reached, a 1-foot screened section will be exposed and a prescribed volume of oxidant will be injected. Once the volume of oxidant for that interval is injected, the screened section will be covered, and the tooling will be lowered to the next depth interval. This process will be repeated until oxidant has been injected throughout the entire

targeted depth (30 – 45 ft bg). The proposed oxidant injection frequency is approximately 6.66% of the total alkaline activated sodium persulfate mixture (which equates to approximately 91.8 gallons of water and 163.27 pounds of alkaline activated sodium persulfate) per every 1 foot for a total of 15 ft (beginning with 30 – 31 ft bg and ending at 44 – 45 ft bg) in each injection location. However, the volume of oxidant to be injected and injection intervals are subject to variation at the discretion of the Engineer, as based on field observations. The Contractor shall follow guidance from HRP regarding alterations to the proposed injection frequency during implementation of this RAWP.

- Based on field conditions the injection method may be changed by the Engineer. The contractor shall have various types of tooling available on-site. The available injection tooling shall be attachments for the direct-push rods. A pressure activated injection tool, a retractable injection tool and an expendable point shall be available. It is the responsibility of the Contractor to ensure that the specified equipment is solicited and available for use, as needed, during the implementation of this RAWP.

- It is anticipated that the injections will be split between two events. 22,040 pounds of alkaline activated sodium persulfate is anticipated to be injected during each event for a total of 44,080 pounds of alkaline activated sodium persulfate injected.

- The persulfate shall be mechanically mixed and tested to ensure the proper ratio is achieved. The design ratio of water to persulfate for the Site is 1,377 gallons of water to 2,449 lbs.

- Sodium hydroxide will be added to the mixture to raise the pH to 10.5 or higher.

- Injection pressure shall not exceed 3 pounds per square inch (psi) during injection.

- During injection, the contractor shall record injection monitoring parameters including (but not limited to) pumping rate, pH, ORP, temperature, etc. SR-CAMP will be conducted by the Contractor up and downwind of the treatment area during the injection. Air monitoring will also be conducted by the Contractor near any building air intakes within 20 feet of the treatment area during injection.

- The contractor shall measure depth to water, injection pressure, and persulfate concentration during the injection. Depth to water should be measured at adjacent monitoring wells, to determine the radius of influence.

- An additional 50 gallons of flush water may be added to each injection point to help distribute the product further from each injection point.

- All chemicals should be stored in secondary containment, prior to use. The oxidant will be batched in polyethylene tanks as close to the injection areas as possible.

- During the injection, the contractor will implement, at a minimum, the following green remediation BMPs:

- Injection equipment shall not be permitted to idle for longer than five minutes.
- Use of temporary injection points. PVC plastic and silica sand will not be used to construct injection wells.

2.4 Groundwater Monitoring

Groundwater Sampling

To assess the performance of the ISCO injections, a groundwater monitoring program will be established. The groundwater monitoring program will include two components: baseline sampling and performance monitoring. The sampling, sample handling, decontamination, and field instrument calibration procedures will be performed in accordance with established procedures for the Site.

2.4.1 Baseline Sampling

The baseline groundwater samples were collected by Environmental Assessment and Remediation (EAR) in February 2022, and were submitted to Pace Analytical for analysis of:

- Target compound list (TCL) VOCs by USEPA Method 8260
- TCL SVOCs by USEPA Method 8270
- TAL metals by USEPA Method 6010/7000

In addition to laboratory analysis, the following field parameters were collected:

- Basic groundwater quality parameters: pH, alkalinity, sulfate
- Field Parameters including pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), and specific conductivity

The results of the initial sampling round were used to establish baseline conditions.

2.4.2 Performance Monitoring

- Following the completion of the ISCO injection program, performance monitoring samples will be collected from MW-2, MW-3, MW-4, and MW-13 to MW-17 (**Sheet S-1**).
- Each well will be sampled every other week for up to two months following the completion of an ISCO injection event.
- Prior to sample collection, each well will be monitored for light and dense non-aqueous phase liquids (LNAPLs and DNAPLs) using an oil/water interface probe. If NAPL is encountered in any monitoring well it shall be removed prior to sampling using a bailer or similar method.

- The monitoring wells will be sampled for field parameters listed above, a field test for persulfate and if persulfate is not detected VOCs.
- The wells will be sampled for the same set of parameters that were analyzed during the baseline sampling at one month and two months following the injection events and then quarterly thereafter for a period of 1-year following the initial injection event.
- Additional ISCO injection events may be required by NYSDEC pending the results of post-injection groundwater performance monitoring. NYSDEC will make the final determination when groundwater performance monitoring is no longer required or if remediation is complete.
- Groundwater samples will be collected from each monitoring well in accordance with low-flow groundwater sampling procedures outlined by the EPA. It is estimated that a total of 12 groundwater samples (8 normal samples, 1 duplicate sample, 1 trip blank, 1 matrix spike, and 1 matrix spike duplicate) will be analyzed by an ELAP certified laboratory analysis of the following parameters:
 - TCL VOCs by USEPA Method 8260
 - TCL SVOCs by USEPA Method 8270
 - TAL metals by USEPA Method 6010/7000
 - Basic groundwater quality parameters: pH, alkalinity, sulfate
 - Field Parameters including pH, DO, ORP, and specific conductivity

Analytical samples will be completed using QA/QC NYSDEC Method Category B. The laboratory will submit analytical results to HRP in NYSDEC Electronic Data Deliverable (EDD) format. IDW generated (if any) from the development and sampling of monitoring wells shall be handled in accordance with NYSDEC DER-10.

- During groundwater monitoring, HRP will implement, at a minimum, the following green remediation best management practices (BMPs):
 - Use of rechargeable batteries for monitoring equipment (water level meters, groundwater quality meter, etc.)
 - Should long-term monitoring be required, consider the use of no-purge collection methods (passive diffusion bags or similar) to reduce sampling efforts and waste materials.

3.0 PROJECT SCHEDULE

Preliminary schedules for completion of the in-situ injection activities described in this SOW is presented in the Table **below**. Prior to commencement of work the contractor responsible for performing the injection will prepare a detailed schedule for the SOW described in **Section 1.0** above.

Preliminary Remedial Action Schedule

Task	Sub-task	Duration (days)	Start	End
Complete ISCO Injection	Prepare and Revise RAWP		8/31/2022	4/27/2023
	Prepare and Revise All Call-Out Contractor Work Plans and Procurement of Relevant Permits by the Contractor	90	5/1/2023	8/5/2023
	Mobilization and Site Preparation	1	8/6/2023	8/7/2023
	In-Situ Injection (first event)	5	8/7/2023	8/12/2023
	Site Cleanup and Demobilization	1	8/12/2023	8/13/2023
	Contaminant Destruction	60	8/7/2023	8/6/2023
	Post Injection Monitoring	30	8/12/2023	9/11/2023
	Post Injection Monitoring	60	8/12/2023	9/11/2023
	Post Injection Monitoring	90	8/12/2023	9/10/2023
	Mobilization and Site Preparation	1	10/10/2023	10/11/2023
	In-Situ Injection (second event)	5	10/11/2023	10/16/2023
	Site Cleanup and Demobilization	1	10/16/2023	10/17/2023
	Contaminant Destruction	60	10/11/2023	12/10/2023
	Post Injection Monitoring	30	10/16/2023	11/15/2023
	Post Injection Monitoring	60	10/16/2023	12/15/2023
	Post Injection Monitoring	90	10/16/2023	1/14/2024
	SVI Post Injection Sampling	1	11/20/2023	11/20/2023

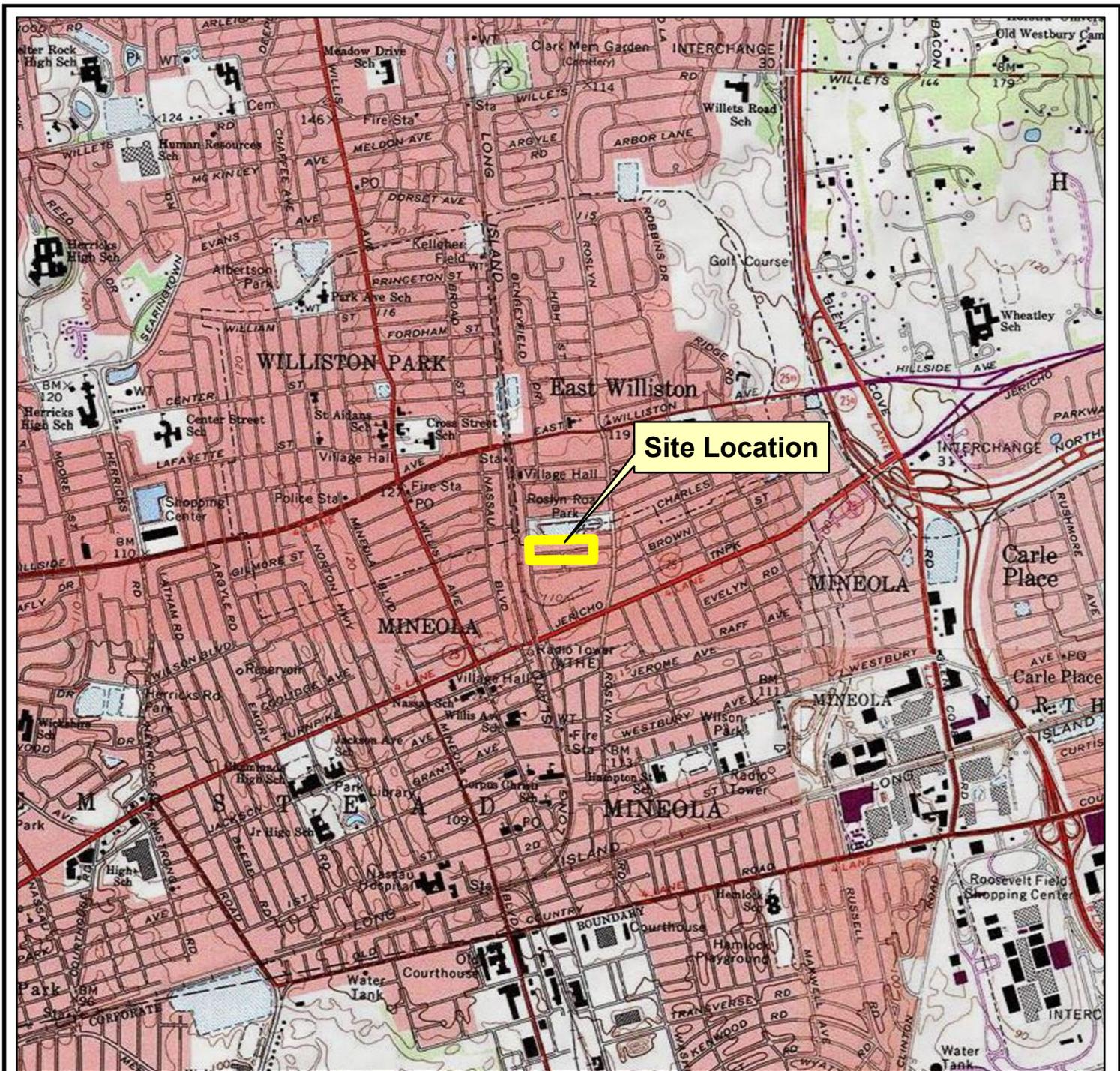
4.0 PROJECT CONTACTS

Project contacts for the NYSDEC and HRP are identified in the Table below.

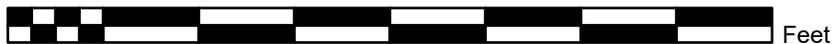
Project Roles and Contact Information

Name	Role	Email	Address	Phone
New York State Department of Environmental Conservation (NYSDEC)				
Benjamin Rung	DEC Project Manager	benjamin.rung@dec.ny.gov	625 Broadway, 12 th Floor, Albany, NY 12233-7015	518-402-9813
Elyse DuBois	DEC Site Project Manager	elyse.dubois@dec.ny.gov	625 Broadway, 12 th Floor, Albany, NY 12233-7017	518-402-0031
New York State Department of Health (NYSDOH)				
Renata Ockerby	Public Health 3 Specialist	renata.ockerby@health.ny.gov	Empire State Plaza, Corning Tower 1787 Albany, NY 12237	(518) 402-7860
HRP Associates, Inc.				
Glenn Netuschil	Professional Engineer	glenn.netuschil@hrpassociates.com	1 Fairchild Square, Suite 110 Clifton Park, NY 12065	518-877-7101
Mark Wright	HRP Senior Project Manager	mark.wright@hrpassociates.com	1 Fairchild Square, Suite 110 Clifton Park, NY 12065	518-877-7101
Mary Rommer	HRP Senior Project Consultant	mary.rommer@hrpassociates.com	1 Fairchild Square, Suite 110 Clifton Park, NY 12065	518-877-7101
John Gorman	HRP Project Consultant	john.gorman@hrpassociates.com	1 Fairchild Square, Suite 110 Clifton Park, NY 12065	518-877-7101
Site Owner				
Jeffrey Schwartzberg	Site Operator	jbs@pcrellc.com	1670 Old Country Road, Suite 219, Plainview, NY 11803	516-444-3356

FIGURES



0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000



Feet

1 Inch = 2,000 Feet



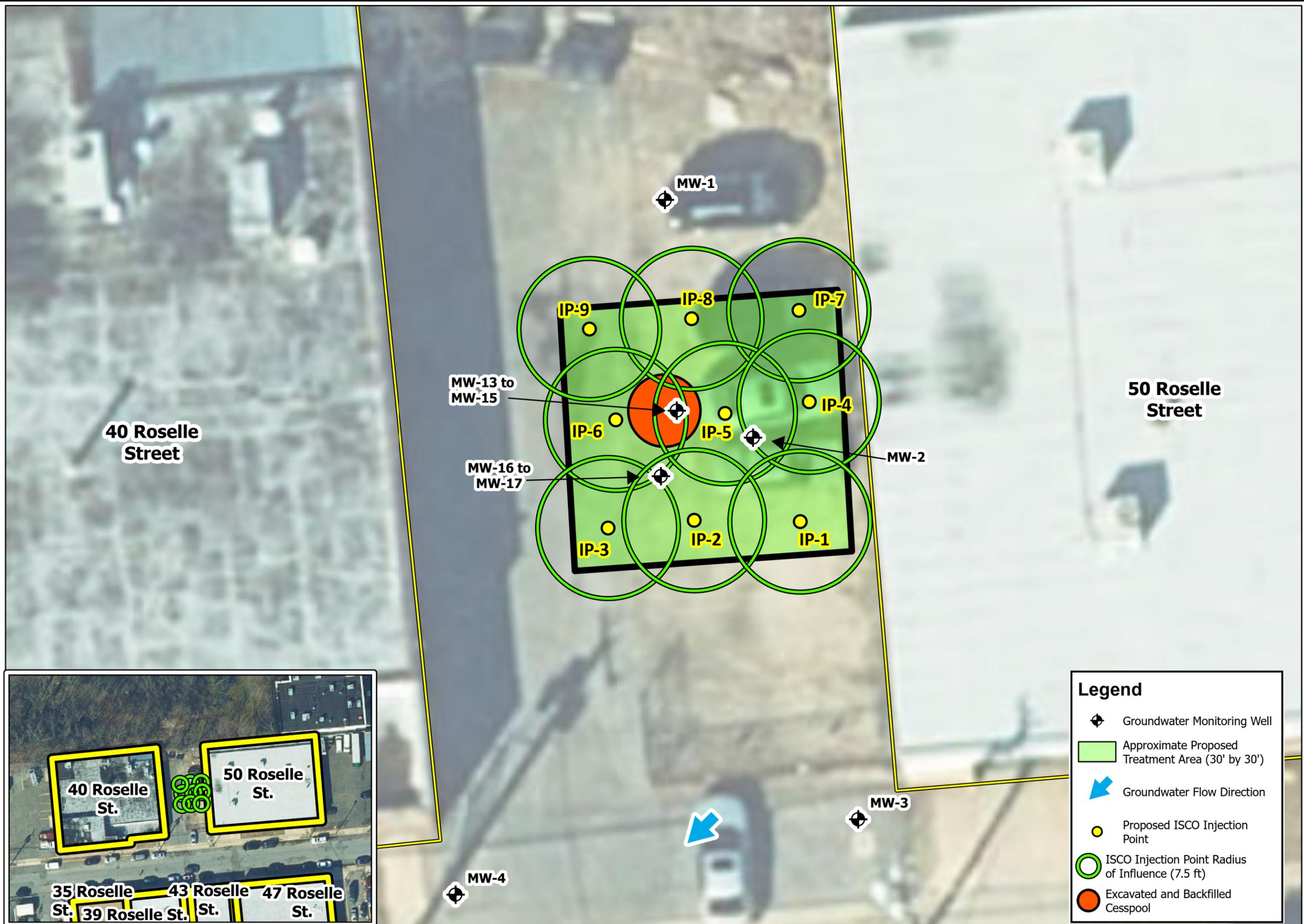
Figure 1
Site Location
NYSDEC Site #130174
40 Roselle Street
Mineola, New York
HRP #DEC1020.RA

USGS Quadrangle Information
 Quad ID: 40073-G6
 Name: Elmira, New York
 Date Rev: 1979
 Date Pub: 1976



MOVE YOUR ENVIRONMENT FORWARD

ONE FAIRCHILD SQUARE
 SUITE 110
 CLIFTON PARK, NY 12065
 (518) 877-7101
 HRPASSOCIATES.COM



Legend

- Groundwater Monitoring Well
- Approximate Proposed Treatment Area (30' by 30')
- Groundwater Flow Direction
- Proposed ISCO Injection Point
- ISCO Injection Point Radius of Influence (7.5 ft)
- Excavated and Backfilled Cesspool



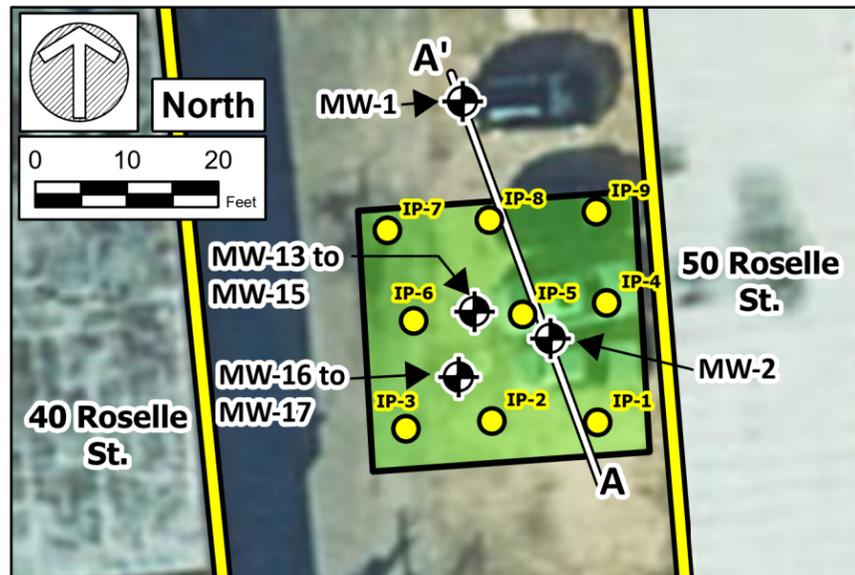
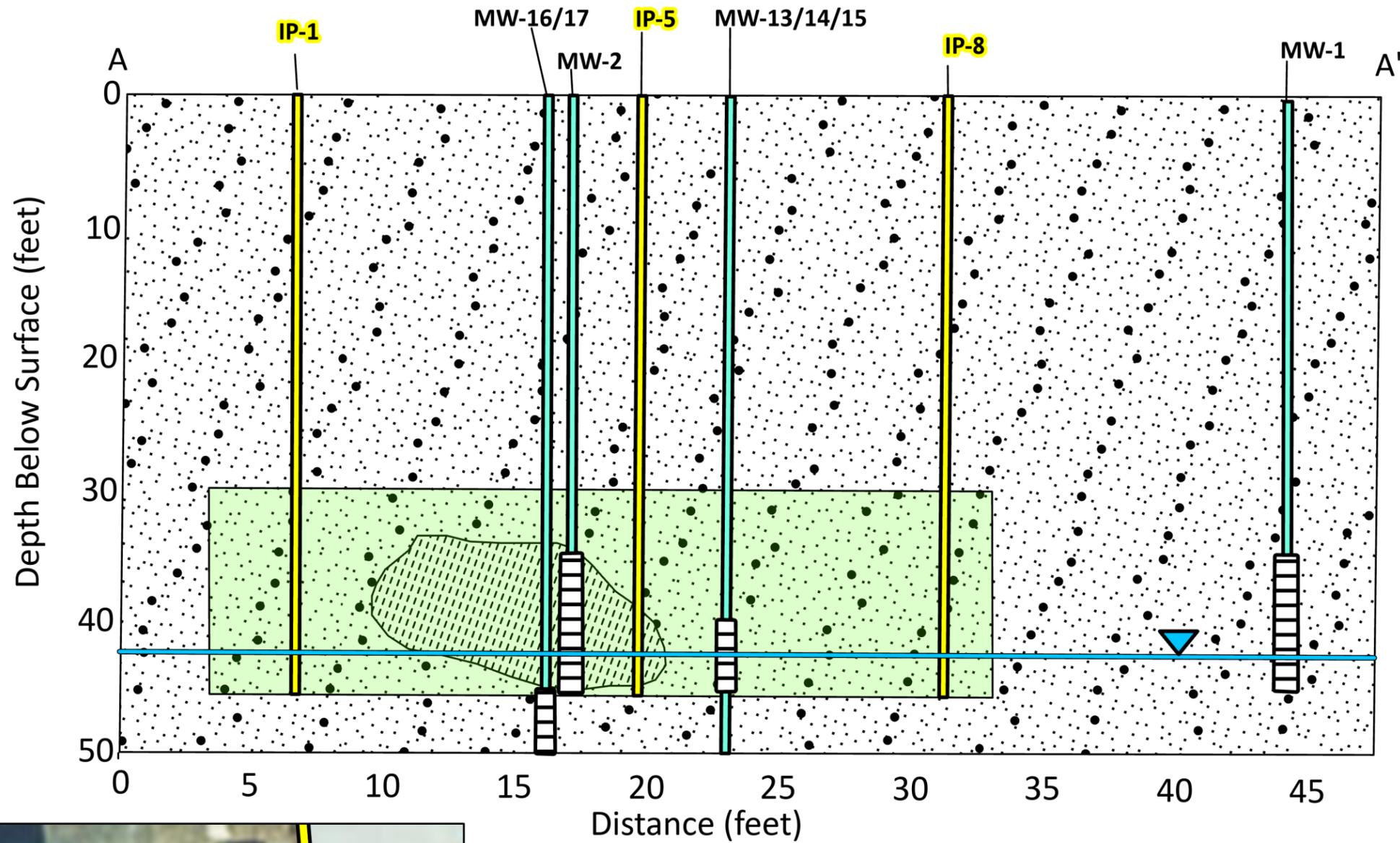
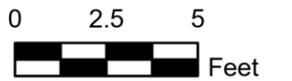
Revisions	No.	Date

Designed By:	SRT	Drawn By:	CMS	Reviewed By:	MEW
--------------	-----	-----------	-----	--------------	-----

Issue Date:	1/09/2023	Project No:	DEC1020.RA	Sheet Size:	11X17
-------------	-----------	-------------	------------	-------------	-------

ISCO Injection Treatment Area
 Former Garden Photoengraving
 Site #130174
 40 Roselle Street
 Mineola, New York

Figure No.
2



Legend

- Medium-Fine Sand with Some to Little Gravel
- Approximate Proposed Treatment Area (30' by 30')
- Medium Fine Sand, With Some Silt and Gravel
- Proposed ISCO Injection Point
- Monitoring Well Screen
- Groundwater Table

Revisions	No.	Date

Designed By:	SRT	Drawn By:	CMS	Reviewed By:	MEW
Issue Date:	1/09/2023	Project No:	DEC1020.RA	Sheet Size:	11x17

**South - North
Cross Section (A-A')**

Former Garden Photoengraving
 Site #130174
 40 Roselle Street
 Mineola, New York

Figure No.
3

TABLE

Table 1
Green Remediation Objectives
Former Garden Photoengraving
Site # 130174
40 Roselle Street
Mineola, New York 11501

In-Situ Chemical Oxidation				
Activity	Negative Impact	Green Remediation Option / BMP	Impact Reduction	Comments and Assumptions
In-Situ Chemical Injection	CO ₂ Emissions during equipment operation- 1,999.2 lbs.	Shut off equipment when not in use for more than 5 minutes	599.8 lbs. of CO ₂	<ul style="list-style-type: none"> Assume 18 hrs. (30% of 60 hrs.) idle time. Assumes use of 1.5 gallons³ of diesel per hour.¹
	Waste plastic and excess well materials (sand, PVC pipe)	Use temporary injection points instead of permanent injection wells	350 lbs. of plastic 2,000 lbs of Silica Fill Sand	<ul style="list-style-type: none"> 0.7 lbs/foot PVC², Assumes ten injection wells approx. 50 ft bg. Each. Four 50 lb bags per well.

Groundwater Monitoring				
Activity	Negative Impact	Green Remediation Option / BMP	Impact Reduction	Comments and Assumptions
Groundwater collection Pump	Waste batteries YSI/Horiba – 3 “C” batteries Geopump/bladder pump – One Car Battery	Rechargeable batteries will be used to power sampling equipment during sampling procedures.	6 “C” batteries and 1 car batteries /yr.	

¹ Default CO₂ Emission Factors and High Heat Values for Various Types of Fuel. https://www.law.cornell.edu/cfr/text/40/appendix-Table_C-1_to_subpart_C_of_part_98

² PVC and CPVC Pipe Sizes and Weights. <https://pvcpipesupplies.com/pvc-cpvc-pipe-sizes-and-weights>

³ Fuel Usage of Geoprobe 6610. Telecom with Geoprobe Technical Sales Representative, March 18, 2022

APPENDIX A

Bench-Test Report



February 16, 2022

Stefan R. Truex, P.G.
HRP Associates
1 Fairchild Square # 110
Clifton Park, NY 12065

RE: Final Report of Findings “Bench-scale Evaluation of Activated Persulfate for Destruction of COCs in Soil and Groundwater”
Client Project Name: 40 Roselle Street, Mineola, NY
Client Project No: DEC1020.RA
PRIMA Project ID: HRP Roselle

Dear Mr. Truex:

Enclosed is the Final Report of Findings entitled "Bench-scale Evaluation of Activated Persulfate for Destruction of COCs in Soil and Groundwater" that describes bench testing conducted on soil and groundwater from the 40 Roselle Street site located in Mineola, New York. If you have any questions, please contact me at cschreier@primaenvironmental.com. Thank you for the opportunity to be of service.

Sincerely,

PRIMA Environmental, Inc.

A handwritten signature in blue ink that reads 'Cindy G. Schreier'.

Cindy G. Schreier, Ph.D.

President and Chief Scientist



Report of Findings

**Bench-Scale Evaluation of Activated Persulfate for Removal of
COCs from Soil and Groundwater**

40 Roselle Street
Mineola, New York
Client ID 0.373679

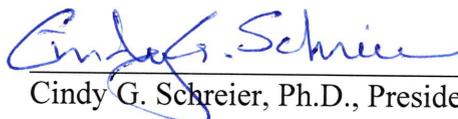
February 16, 2022

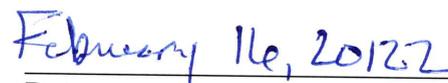
Submitted to
Stefan R. Truex, P.G.
HRP Associates
1 Fairchild Square # 110
Clifton Park, NY 12065

Submitted by



5070 Robert J Mathews Parkway, Suite 300
El Dorado Hills, CA 95762


Cindy G. Schreier, Ph.D., President


Date



EXECUTIVE SUMMARY

Bench-scale treatability testing was conducted on soil and water from the site located at 40 Roselle Street in Mineola, New York to evaluate the ability of activated persulfate to destroy chemicals of concern (COCs). The primary COCs at this site were tetrachloroethene (PCE), trichloroethene (TCE), naphthalene, 1,2,4-trimethylbenzene (1,2,4-TMB), and butylbenzenes. Two forms of activated persulfate were evaluated: PersulfOx® and alkaline activated persulfate (AP-pH). Most testing was performed using PersulfOx®, a proprietary form of activated persulfate that is known to be able to oxidize site COCs. Because PersulfOx® did not perform as expected in initial testing, additional testing was conducted to evaluate a higher concentration of PersulfOx® and a different persulfate activator. Laboratory testing measured soil oxidant demand, and evaluated the effect of PersulfOx® and AP-pH on COCs and secondary water quality.

Laboratory testing demonstrated that PersulfOx® could reduce concentrations of COCs in the aqueous phase within 28 days, and that high concentrations were needed to treat soil. In the PersulfOx® test using 20 g/L SP (22 g/L PersulfOx®), total VOCs decreased from 1,089 µg/L to 130 µg/L but soil only decreased from 73,000 µg/kg-dry to 72,000 µg/kg-dry, which equates to overall mass removal of 6% compared to Time 0 or the Control. However, in the PersulfOx® test using 50 g/L SP (56 g/L PersulfOx®) most aqueous COC were completely removed, while concentrations of soil VOCs decreased from 56,000 µg/kg-dry to 37,000 µg/kg-dry, an overall decrease in mass of 34% relative to the Control. About 75% of the SP was still present at 28 days in all three PersulfOx® tests, indicating that the oxidant was not limiting. Limited removal from the soil is presumably due to association of the COCs with NAPL, where they are less susceptible to oxidation. As long as oxidant is present, it is likely that soil COCs will eventually be destroyed as they slowly dissolve into the water.

Treatment with AP-pH was more effective than PersulfOx® in the timeframe of this study. Total VOCs decreased by 72% (relative to the control) within 28 days in the AP-pH-20g/L test and by 58% in the AP-pH-50g/L test compared to 34% for the 56 g/L PersulfOx® test. The greater removal in the AP-pH tests may be due to the higher pH, which enhanced removal of/from the NAPL or to the greater range of effectiveness of high pH activation compared to other persulfate activators. Although AP-pH was more effective than PersulfOx® in the time frame of this study, it is uncertain whether the



difference would persist (at least for the 56 g/L PersulfOx® test) given a longer reaction time since SP was still present, which would enable additional COC removal to occur given more time.

Treatment of soil and water with PersulfOx® generated a small amount of Cr(VI) - up to 0.012 mg/L. In addition, pH decreased to between 3.08 and 5.27 and sulfate increased to between 530 and 1,100 mg/L due to decomposition of SP.

The soil oxidant demand, measured on impacted soil, was 1.8 g SP/kg soil when the initial PersulfOx® concentration was 11 g/L and 25 g SP/kg soil when the initial PersulfOx® was 55 g/L. Consumption of SP in the COC Removal tests was 3.3 g SP/kg soil in the low dose test and 15 g SP/kg soil in the high dose test.

Based on the results of this study, PRIMA recommends that both PersulfOx® and AP-pH be considered for use at this site. If PersulfOx® is used, a dose on the order of 56 g/L PersulfOx®/L (50 g SP/L) in the groundwater after injection is recommended since 22 g/L (20 g SP/L) did not treat COCs in soil. Because PersulfOx® decreased pH to as low as pH 2 in the laboratory tests, it is recommended that a plan be developed to adjust groundwater pH, if needed. If AP-pH is used, a dose of 20 g/L SP in the groundwater after injection should be effective toward soil COCs, though a temporary increase in aqueous concentrations may be seen. pH will initially increase to over 11, but should return to near pre-treatment levels once SP has completely decomposed.



TABLE of CONTENTS

EXECUTIVE SUMMARY	i
List of Figures.....	iv
List of Tables	iv
ACRONYMS and ABBREVIATIONS.....	v
CHEMICAL FORMULAE.....	vi
1.0 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Study Objectives	2
2.0 MATERIALS and METHODS	4
2.1 Materials	4
2.2 Preparation and Characterization of Soil and Groundwater	4
2.3 Soil Oxidant Demand / Persistence.....	5
2.4 COC Removal / Secondary Effects.....	5
2.4.1 Initial Tests.....	5
2.4.2 Follow-up Tests	5
2.5 Analytical Methods.....	7
2.6 Calculations.....	8
2.6.1 Theoretical Oxidant Demand due to COCs	8
2.6.2 SOD.....	9
2.6.3 Percent Removed/Destroyed.....	9
3.0 RESULTS and DISCUSSION	11
3.1 Untreated Soil and Groundwater	11
3.2 Initial Tests.....	12
3.2.1 SOD/Persistence	12
3.2.2 COC Removal.....	12
3.2.3 Secondary Effects	17
3.3 Follow-up Tests	17
3.3.1 COC Removal.....	17
3.3.2 Secondary Parameters.....	18
4.0 SUMMARY and CONCLUSIONS	22
APPENDIX A (Chains of Custody)	
APPENDIX B (Subcontracted Analytical Results)	



LIST of FIGURES

Figure 1. COC Removal Reactors at Day 28 – Initial Tests.....	6
Figure 2. COC Removal Reactors at Day 28 – Follow-up Tests.....	7
Figure 3. SOD/Persistence.....	13
Figure 4. Post-treatment Total VOCs – Water.....	15
Figure 5. Post-treatment Total VOCs – Soil.....	15

LIST of TABLES

Table 1. Theoretical Stoichiometric Dose Requirements.....	2
Table 2. Initial Conditions for COC Removal Test – Initial Tests.....	6
Table 3. Initial Conditions for COC Removal Test – Follow-up Tests.....	7
Table 4. Analytical Methods.....	8
Table 5. COCs and Secondary Parameters in Untreated Soil and Water.....	11
Table 6. Post-Treatment VOC Concentrations – Initial Tests.....	14
Table 7. Mass Balance – Initial Tests.....	16
Table 8. Secondary Parameters Post-Treatment – Initial Tests.....	17
Table 9. Post-Treatment VOC Concentrations – Follow-up Tests.....	19
Table 10. Mass Balance – Follow-up Tests.....	20
Table 11. Secondary Parameters – Follow-up Tests.....	21



ACRONYMS and ABBREVIATIONS

AP-pH	alkaline activated persulfate
COCs	chemicals of concern
Cr(VI)	hexavalent chromium
g	grams
kg	kilograms
L	liters
mg	milligrams
mL	milliliters
mmol	millimoles
mV	millivolts
µg	micrograms
ORP	oxidation reduction potential
PCE	tetrachloroethene
PSOx	PersulfOx®
SOD	soil oxidant demand
SP	sodium persulfate
1,2,4-TMB	1,2,4-trimethylbenzene
TCE	trichloroethene
TOC	total organic carbon
VOCs	volatile organic compounds



CHEMICAL FORMULAE

C_2Cl_4	tetrachloroethene
C_2HCl_3	trichloroethene
C_9H_{12}	trimethylbenzene
$C_{10}H_{14}$	butylbenzene
$C_{10}H_8$	naphthalene
CO_2	carbon dioxide
H^+	acid/proton
H_2O	water
Na^+	sodium
O_2	oxygen
$NaOH$	sodium hydroxide
$Na_2S_2O_8$	sodium persulfate
SO_4^{2-}	sulfate

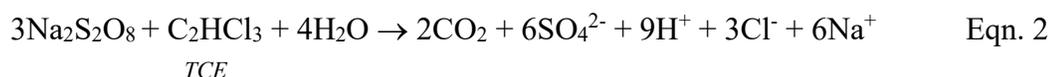


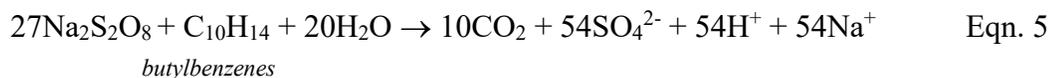
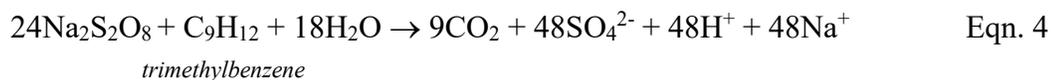
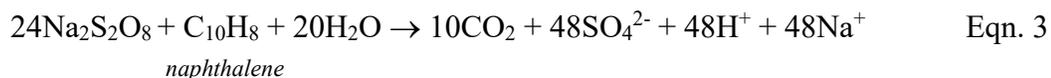
1.0 INTRODUCTION

Bench-scale treatability testing was conducted on soil and water from the site located at 40 Roselle Street in Mineola, New York to evaluate the ability of activated persulfate to destroy chemicals of concern (COCs). The primary COCs at this site were tetrachloroethene (PCE), trichloroethene (TCE), naphthalene, 1,24-trimethylbenzene (1,2,4-TMB), and butylbenzenes. Two forms of activated persulfate were evaluated: PersulfOx® and alkaline activated persulfate (AP-pH). Most testing was performed using PersulfOx®, a proprietary form of activated persulfate that is known to be able to oxidize site COCs. Because PersulfOx® did not perform as expected in initial testing, additional testing was conducted to evaluate a higher concentration of PersulfOx® and a different persulfate activator. Laboratory testing measured soil oxidant demand, and evaluated the effect of PersulfOx® and AP-pH on COCs and secondary water quality.

1.1 Background

Activated persulfate is an established technology for the oxidation of a wide range of organic compounds, including site COCs. Sodium persulfate (SP) alone is a strong oxidant, but activation generates the persulfate radical, which is a stronger oxidant than SP. Common activators include high pH, ferrous iron, chelated iron, hydrogen peroxide (HP), as well as proprietary compounds or mixtures such as those found in PersulfOx®, a proprietary all-in-one activated persulfate developed by Regenesis (San Clemente, California). **Equations 1-5** show theoretical reactions for conversion of PCE, TCE, naphthalene, 1,2,4-TMB, and butylbenzenes to carbon dioxide and water by SP ($\text{Na}_2\text{S}_2\text{O}_8$). The stoichiometric SP requirements based on these reactions are given in **Table 1** and are assumed to apply to both un-activated persulfate and activated persulfate. In practice, a greater-than-stoichiometric dose of SP will usually be required because SP is a non-selective oxidant that will react with natural organic matter and other non-target compounds and may naturally decompose.





Persulfate decomposes to generate sulfuric acid. The change in sulfate concentration and the effect on pH will depend upon the amount of persulfate used, the rate at which it decomposes, the activator used, the presence of cations that can precipitate sulfate, and the buffering ability of site soil and groundwater. Other potential secondary effects include oxidation of soil-bound chromium to water soluble hexavalent chromium [Cr(VI)] and mobilization of metals due to changes in pH. The magnitude, duration, and significance of any such changes are site specific.

Table 1. Theoretical Stoichiometric Dose Requirements.

COC	g SP /g COC
Tetrachloroethene	2.9
Trichloroethene	5.4
Naphthalene	45
Trimethylbenzene*	48
Butylbenzene*	48

* all isomers

1.2 Study Objectives

Batch tests were conducted on soil and water to evaluate activated persulfate. Initial tests were performed using PersulfOx®. Follow-up tests were performed using both PersulfOx® and AP-pH. Specific goals were:

Initial Testing

- Measure the soil oxidant demand/persistence for PersulfOx®



-
- Assess COC destruction by PersulfOx®
 - Evaluate the effect of PersulfOx® on secondary water quality parameters.

Follow-up Testing

- Determine whether a higher concentration of PersulfOx® can destroy COCs in soil
- Determine whether AP-pH is more effective than PersulfOx® at this site.

The tests conducted to achieve these goals are described in **Section 2.0** of this report. Results and Summary/Conclusions are presented in **Sections 3.0 and 4.0**, respectively.



2.0 MATERIALS and METHODS

2.1 Materials

PersulfOx®. PersulfOx® was obtained from Regenesis (www.regenesis.com). Stock slurries were prepared as needed by adding the appropriate amount of solid material to deionized (DI) water.

Sodium Persulfate, SP. Klozur® brand SP was obtained from Peroxychem (www.evonik.com). Stock solutions were prepared as needed by adding the appropriate amount of solid material to DI water.

2.2 Preparation and Characterization of Soil and Groundwater

Four soil samples – B-A (35-45 ftbg); B-B (35-45 ftbg); B-C (35-45 ftbg); and B-D (35-45 ftbg) – were received on August 20, 2021. The soil was composited into a single sample by sieving to remove particles greater than 4 mesh (3/16 inches), then mixing until visually homogeneous. Homogenized soil was brown sand with a strong odor. It was analyzed for volatile organic compounds (VOCs), Cr(VI), metals (chromium, iron, manganese), and moisture content using the laboratories and methods described in **Section 2.5**.

One groundwater sample (8.30.21 MW-2) consisting of 10 1-liter (L) amber bottles was received on August 31, 2021. Prior to testing, the sample was homogenized by pumping chilled water from each bottle into a large Tedlar bag, mixing, then pumping the water back into the amber bottles. The water in the Tedlar bag was slightly cloudy and contained particles that looked like “rag” (mixture of fine soil particles and an emulsion of non-aqueous liquid and water); the rag was excluded to the extent possible when water was returned to the amber bottles. Homogenized groundwater was analyzed for VOCs, anions (chloride, nitrate, sulfate), Cr(VI), and metals (chromium, iron, and manganese) using the laboratories and methods described in **Section 2.5**.



2.3 Soil Oxidant Demand / Persistence

The PersulfOx® SOD/oxidant persistence was measured. Two series of four reactors were prepared. Each reactor contained 60 grams (g) soil, 60 milliliters (mL) DI water and dry PersulfOx® as needed such that the initial SP concentration was approximately 10 g/L in one series and 50 g/L in the other series. Reactors were shaken continuously. One replicate from each series was destructively sampled at 2, 5, 8 and 21 days and the water analyzed for residual SP per **Section 2.5**. SOD was calculated as described in **Section 2.6.2**.

2.4 COC Removal / Secondary Effects

2.4.1 Initial Tests

Batch tests were conducted to evaluate the ability of PersulfOx® to destroy COCs and assess its effect on secondary water quality. Seven (7) reactors were prepared by combining soil, groundwater and PersulfOx® as appropriate to give the initial conditions shown in **Table 2**. PersulfOx® dosing was based on the results of the SOD test (**Section 2.3**), the concentration of COCs in groundwater and soil (**Section 3.1**) and the stoichiometry of **Equations 1-5**. Reactors were destructively sampled at the specified times and the soil and water each analyzed for VOCs. Water was also analyzed for Cr(VI), dissolved chromium, ORP, pH, residual SP, and sulfate. Moisture content of soil was measured. **Figure 1** shows the reactors prior to sampling at Days 28.

2.4.2 Follow-up Tests

Because PersulfOx® did not perform as well as expected on soil in the initial tests (see **Section 3.2.2**), additional testing was performed to determine whether a higher concentration of PersulfOx® and/or a different persulfate activator (high pH) would be more effective. Batch tests were conducted to evaluate the PersulfOx® and AP-pH in the similar manner as described in **Section 2.4.2**. Soil, water and reagents were combined to Initial conditions as shown in **Table 3**. A 2:1 mole ratio of sodium hydroxide (NaOH) to SP was used to adjust pH in the AP-pH tests. At 28 days, reactors were destructively sampled and the soil and water each analyzed for VOCs. Water was



also analyzed for pH, residual SP, and sulfate. **Figure 2** shows the reactors prior to sampling.

Table 2. Initial Conditions for COC Removal Test – Initial Tests.

Test	Soil	GW	Reps	Initial PersulfOx®		Sample Time
	g	mL	#	g/L as PSOx	g/L as SP	days
Time 0	317	950	1	0	0	0
Control	317	950	2	0	0	7, 28
PSOx-Low	317	950	2	5.6	5.0	7, 28
PSOx-High	317	950	2	22	20	7, 28

PSOx = PersulfOx



Figure 1. COC Removal Reactors at Day 28 – Initial Tests. From left: Control, PersulfOx® Low, PersulfOx® High.



Table 3. Initial Conditions for COC Removal Test – *Follow-up Tests.*

Test	Soil	GW	Initial SP	Initial pH	Total Liquid [^]
	g	mL	g/L	--	mL
Control	85	245	0	ambient	255
PSOx-50	85	245.0	50*	ambient	255
AP-pH-20	85	245.0	20	> 11**	255
AP-pH-50	85	245	50	> 11**	255

* Added as PersulfOx[®]

** pH adjusted using 2:1 mole ratio of NaOH:SP

[^] Added groundwater plus liquid reagents.



Figure 2. COC Removal Reactors at Day 28 – *Follow-up Tests.* From left: Control, PersulfOx[®] 50 g/L, AP-pH-20 g/L, AP-pH-50 g/L.

2.5 Analytical Methods

The methods for each analysis and the laboratory that performed the analyses are summarized in **Table 4**. All subcontracted samples were collected in appropriately preserved containers and shipped on ice under chain of custody via overnight delivery to the analytical laboratory. Soil and water were separated by allowing water to settle overnight, then siphoning as much water as possible directly into sample containers. Samples for anions, Cr(VI), and dissolved metals were filtered by PRIMA through a 0.45



micron polyethersulfone (PES) filter. Soil was centrifuged to remove excess water before being homogenized and placed in a sample container with minimal headspace.

Table 4. Analytical Methods.

Analyte	Method	Laboratory*
Anions	EPA 300	Alpha
Cr(VI)	EPA 7199/218.6	McC Campbell
Metals	EPA 6020	Alpha
Moisture	Gravimetric	PRIMA
ORP	Probe	PRIMA
pH	Probe	PRIMA
Residual persulfate	FAS/KMnO4 titration	PRIMA
Sulfate	Hach**	PRIMA
VOCs	EPA 8260B	Alpha

* Alpha Analytical (Sparks, NV); McC Campbell Analytical (Pittsburg, CA)

** Hach DR2800 spectrophotometer and appropriate Hach test reagents.

2.6 Calculations

2.6.1 Theoretical Oxidant Demand due to COCs

The theoretical amount of oxidant needed to convert a COC to carbon dioxide, water and chloride is the concentration of the COC in the matrix (soil or water, see **Section 3.1**) times the stoichiometric requirement (**Table 1**). The total theoretical demand is the sum of the individual COC demands, as shown in **Equation 6**.

$$OD_{COCs} = \sum_1^i COC_i \times SR_i$$

Eqn. 6

where

- OD_{COCs} is total theoretical oxidant demand due to COCs, in g/kg for soil or g/L for water
- $[COC]_i$ is concentration of i th COC in matrix, in g/kg for soil or g/L for water



- SR_i is the stoichiometric oxidant requirement (g oxidant / g COC) of the i th COC based on theoretical equations for conversion of the COC to CO_2 .

2.6.2 SOD

SOD was calculated according to **Equation 7**.

$$SOD = ([Ox]_{init} - [Ox]_t) \times (V/M) \quad \text{Eqn. 7}$$

where

- SOD is soil oxidant demand, in g (or mg) oxidant/kg soil
- $[Ox]_{init}$ is the initial concentration of oxidant, in g (or mg) oxidant/L
- $[Ox]_t$ is the concentration of oxidant at time, t, in g (or mg) oxidant/L
- V is total volume of the aqueous phase, in L
- M is mass of soil, in kg

2.6.3 Percent Removed/Destroyed

For the Initial COC Removal tests, the percent remaining and destroyed were calculated by comparing the mass of each COC in the test reactor to the mass in the Time 0 reactor according to **Equations 8-10**. Concentrations in soil are on a dry weight basis.

$$\text{Percent Remaining in Water} = 100 \times (C_{aq}V_{aq}) / (C_{aq,T0}V_{aq} + C_{s,T0}M_s) \quad \text{Eqn. 8}$$

$$\text{Percent Remaining in Soil} = 100 \times (C_s M_s) / (C_{aq,T0}V_{aq} + C_{s,T0}M_s), \quad \text{Eqn. 9}$$

$$\text{Percent Destroyed} = 100 - (\% \text{ Remaining in Water} + \% \text{ Remaining in Soil}) \quad \text{Eqn. 10}$$

where

- C_{aq} is the aqueous concentration ($\mu\text{g/L}$) in the control or test,
- $C_{aq,T0}$ is the aqueous concentration ($\mu\text{g/L}$) in the Time 0 sample on a dry basis
- C_s is the soil concentration (mg/kg) in the control or test
- $C_{s,T0}$ is the soil concentration (mg/kg) at Time 0
- V_{aq} is the aqueous volume of the control or test
- M_s is the mass (kg) of the soil in the control or test on a dry basis



For the Follow-up COC Removal tests, the percent remaining was calculated by comparing the mass of each COC in the test reactor to the mass in the Control reactor according to **Equations 11-12**, where $C_{aq,Con}$ is the aqueous concentration in the Control and $C_{s,Con}$ is the soil concentration in the Control. Concentrations in soil are on a dry weight basis. .

$$\text{Percent Remaining in Water} = 100 \times (C_{aq}V_{aq}) / (C_{aq,Con}V_{aq} + C_{s,Con}M_s) \quad \text{Eqn. 11}$$

$$\text{Percent Remaining in Soil} = 100 \times (C_sM_s) / (C_{aq,Con}V_{aq} + C_{s,Con}M_s), \quad \text{Eqn. 12}$$



3.0 RESULTS and DISCUSSION

Tables in this section contain data from subcontracted analytical laboratories.
Complete analytical data packages are in **Appendix B**.

3.1 Untreated Soil and Groundwater

The concentrations of COCs and secondary parameters in untreated soil and groundwater are shown in **Table 5**. Groundwater contained 58 micrograms (μg)/L TCE, 86 μg /L n-butylbenzene, and 2,200 μg /L naphthalene, while soil contained 850 μg /kilogram (kg) TCE, 9,100 μg /kg PCE, 1,300 μg /kg 1,2,4-TMB, 15,000 μg /L sec-butylbenzene, 7,700 μg /L n-butylbenzene, and 62,000 μg /kg naphthalene. The theoretical oxidant demand due to these COCs is 4.0 g SP/kg soil and 0.1 g SP/L groundwater.

Table 5. COCs and Secondary Parameters in Untreated Soil and Water.

Analyte	Units	Soil	Groundwater
Trichloroethene	$\mu\text{g}/\text{kg}$ or $\mu\text{g}/\text{L}$	850	58
Tetrachloroethene	$\mu\text{g}/\text{kg}$ or $\mu\text{g}/\text{L}$	9,100	< 20
1,2,4-Trimethylbenzene	$\mu\text{g}/\text{kg}$ or $\mu\text{g}/\text{L}$	1,300	< 20
sec-Butylbenzene	$\mu\text{g}/\text{kg}$ or $\mu\text{g}/\text{L}$	15,000	< 20
n-butylbenzene	$\mu\text{g}/\text{kg}$ or $\mu\text{g}/\text{L}$	7,700	86
Naphthalene	$\mu\text{g}/\text{kg}$ or $\mu\text{g}/\text{L}$	62,000	2,200
<i>total VOCs</i>	<i>$\mu\text{g}/\text{kg}$ or $\mu\text{g}/\text{L}$</i>	<i>95,950</i>	<i>2,344</i>
<i>Metals*</i>			
Chromium	mg/kg or mg/L	13	< 0.010
Cr(VI)	mg/kg or mg/L	0.47	< 0.00040
Iron	mg/kg or mg/L	2,000	1.8
Manganese	mg/kg or mg/L	32	0.013
<i>Anions</i>			
Chloride	mg/L	n.m.	12
Nitrate	$\text{mg}/\text{L-N}$	n.m.	< 0.25
Sulfate	mg/L	n.m.	1.1

* Total metals in soil, dissolved metals in water.



3.2 Initial Tests

3.2.1 SOD/Persistence

The amount of SP remaining and consumed in the PersulfOx® SOD / persistence tests are shown in **Figure 3**. When the initial SP concentration was 9.2 g/L (11 g/L PersulfOx®), the 21-day SOD was 1.8 g SP/kg soil, but when the initial SP concentration was 46 g/L (55 g/L PersulfOx®), the amount of SP consumed was 25 g SP/kg soil. Increased SOD with higher initial concentration of oxidant is a common phenomenon.

3.2.2 COC Removal

The concentrations of COCs in treated soil and water are shown in **Table 6**. The concentration of total VOCs is also depicted in **Figures 4 and 5** for water and soil, respectively. The mass balance is given in **Table 7**. Treatment with PersulfOx® decreased aqueous concentrations of COCs, but did not significantly affect soil concentrations or overall mass removal. Total aqueous VOCs decreased from 1,089 µg/L at Time 0 to 936 µg/L in the Day 28 PSOx Low test and to 130 µg/L at Day 28 PSOx High test, but soil VOCs increased from 73,000 µg/kg-dry at Time 0 to 79,000 µg/kg-dry in the day 28 PSOx-Low test and decreased to 72,000 µg/kg-dry in the PSOx High test. These changes equate to -6% destruction in the low dose test and 6% destruction in the high dose test. Aqueous phase total VOCs decreased in the Control (to 883 µg/L by Day 28), but not in the soil. Losses in the Control were somewhat greater than losses in the PSOx Low test (see **Figure 3**) and may have been due to biodegradation in the Control, which would have been inhibited by the oxidizing nature of PersulfOx®.

The reason for the poor removal of VOCs from soil may be due to their presence as a components of a non-aqueous phase liquid (NAPL) that coats the soil and prevents the VOCs from rapidly moving into the water phase where they are more easily oxidized. The presence of “rag” in untreated groundwater (see **Section 2.2**) suggests a NAPL is present. The high concentrations of VOCs in soil imply this NAPL is associated with the soil, since the soil is primarily sand and unlikely to strong sorb VOCs under the high (3:1) water to soil ratio used in these tests. Persulfate was still present at 28 days (**Section 3.4.1**), so it is likely that additional removal could occur given a longer reaction time, which would allow VOCs to dissolve from the NAPL into the water.



Time, Days	SP Remaining, g/L Soln.		SP Consumed, g/kg Soil	
	Low Dose	High Dose	Low Dose	High Dose
0	9.2	46	0	0
2	8.3	42	0.9	4.0
5	8.0	39	1.2	7.0
8	7.7	33	1.5	13
21	7.4	21	1.8	25

Note: SP = sodium persulfate

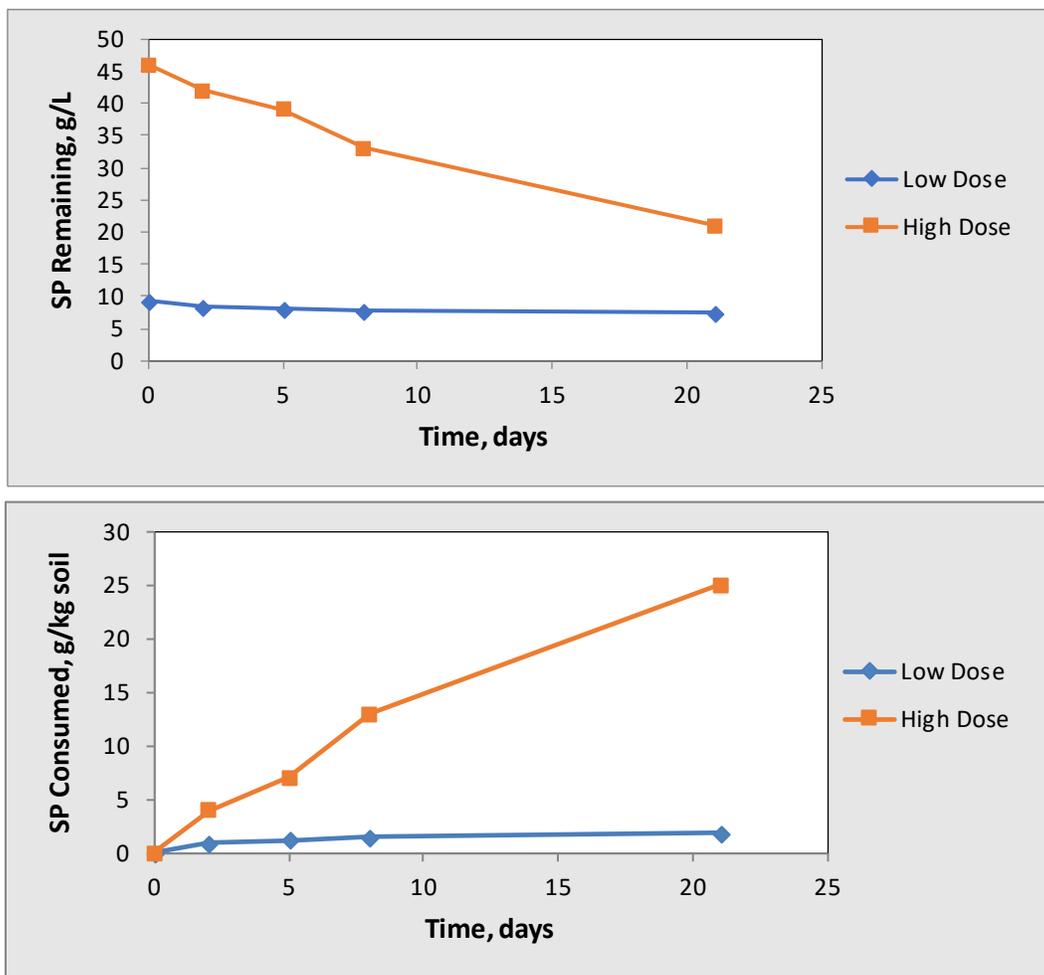


Figure 3. SOD/Persistence.



Table 6. Post-Treatment VOC Concentrations – Initial Tests

Analyte	Units	T0	Control		PSOx - Low (5 g/L SP; 5.6 g/L PSOx)		PSOx - High (20 g/L SP; 22 g/L PSOx)	
			Day 7	Day 28	Day 7	Day 28	Day 7	Day 28
			<i>VOCs - Aqueous</i>					
Trichloroethene	µg/L	99	97	94	86	73	61	19
Tetrachloroethene	µg/L	190	240	240	230	220	190	100
1,2,4-Trimethylbenzene	µg/L	11	14	11	10	< 10	< 10	< 10
sec-Butylbenzene	µg/L	43	43	36	46	47	31	11
n-butylbenzene	µg/L	26	14	12	15	16	11	< 10
Naphthalene	µg/L	720	560	490	620	580	190	< 40
<i>total VOCs</i>	<i>µg/L</i>	<i>1,089</i>	<i>968</i>	<i>883</i>	<i>1,007</i>	<i>936</i>	<i>483</i>	<i>130</i>
<i>VOCs - Soil - Wet basis</i>								
Trichloroethene	µg/kg	< 800	< 800	< 800	< 800	< 800	< 800	< 800
Tetrachloroethene	µg/kg	5,900	4,000	6,600	3,900	5,600	4,000	4,600
1,2,4-Trimethylbenzene	µg/kg	960	800	990	< 800	910	830	900
sec-Butylbenzene	µg/kg	12,000	10,000	12,000	9,400	11,000	10,000	10,000
n-butylbenzene	µg/kg	7,100	5,600	6,300	5,200	5,700	5,700	5,200
Naphthalene	µg/kg	33,000	22,000	41,000	22,000	40,000	24,000	37,000
<i>total VOCs</i>	<i>µg/kg</i>	<i>58,960</i>	<i>42,400</i>	<i>66,890</i>	<i>40,500</i>	<i>63,210</i>	<i>44,530</i>	<i>57,700</i>
<i>VOCs - Soil - Dry basis</i>								
Trichloroethene	µg/kg	< 1,000	< 1,000	< 890	< 1,000	< 994	< 978	< 1,000
Tetrachloroethene	µg/kg	7,300	5,000	7,300	4,900	7,000	4,900	5,800
1,2,4-Trimethylbenzene	µg/kg	1,200	1,000	1,100	< 1,000	1,100	1,000	1,100
sec-Butylbenzene	µg/kg	15,000	13,000	13,000	12,000	14,000	12,000	13,000
n-butylbenzene	µg/kg	8,800	7,000	7,000	6,600	7,100	7,000	6,500
Naphthalene	µg/kg	41,000	28,000	46,000	28,000	50,000	29,000	46,000
<i>total VOCs</i>	<i>µg/kg</i>	<i>73,000</i>	<i>53,000</i>	<i>74,000</i>	<i>51,000</i>	<i>79,000</i>	<i>54,000</i>	<i>72,000</i>

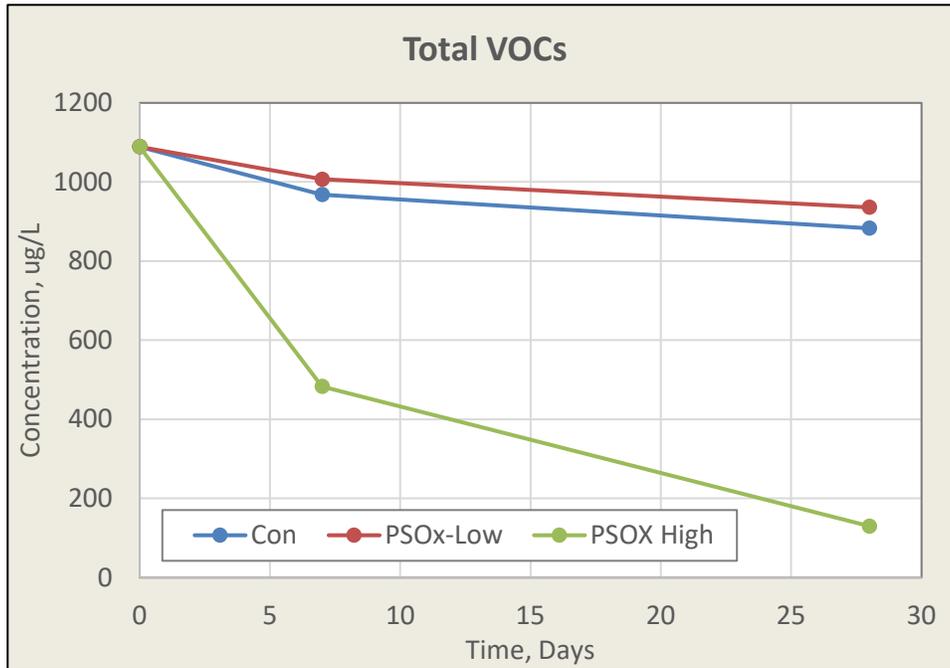


Figure 4. Post-treatment Total VOCs – Water.

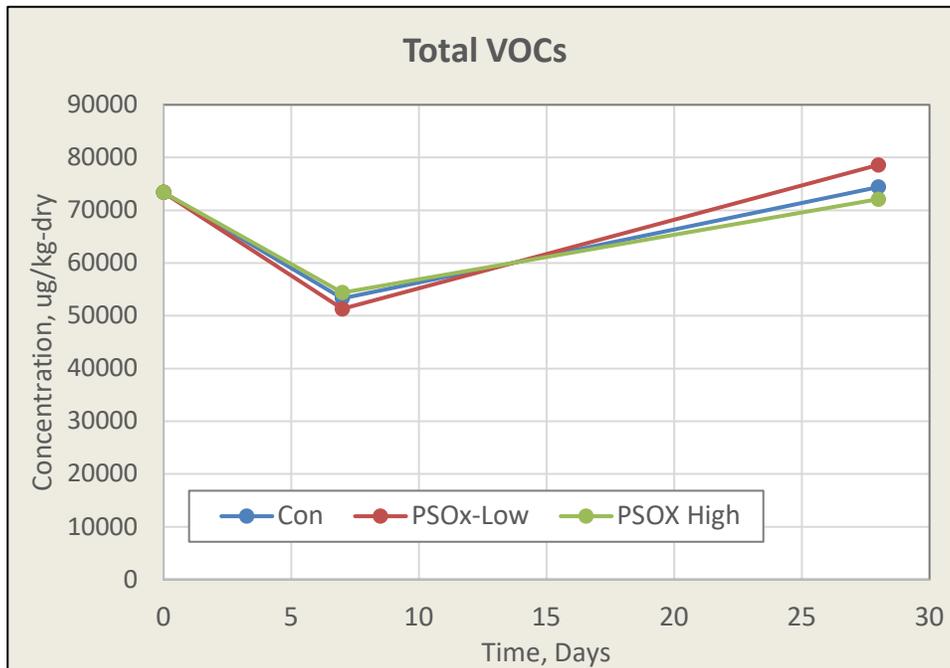


Figure 5. Post-treatment Total VOCs – Soil.



Table 7. Mass Balance – Initial Tests.

Analyte	Control		PSOx - Low (5 g/L SP; 5.6 g/L PSOx)		PSOx - High (20 g/L SP; 22 g/L PSOx)	
	Day 7	Day 28	Day 7	Day 28	Day 7	Day 28
<i>Percent of Total Remaining in Rater (Relative to Time 0)</i>						
Trichloroethene	98	95	87	74	62	19
Tetrachloroethene	9.8	9.8	9.4	9.0	7.8	4.1
1,2,4-Trimethylbenzene	3.7	2.9	2.7	< 2.7	< 2.7	< 2.7
sec-Butylbenzene	0.93	0.78	1.0	1.0	0.67	0.24
n-butylbenzene	0.51	0.44	0.55	0.59	0.40	< 0.37
Naphthalene	4.2	3.7	4.7	4.4	1.4	< 0.30
<i>Total VOCs</i>	<i>4.1</i>	<i>3.8</i>	<i>4.3</i>	<i>4.0</i>	<i>2.1</i>	<i>0.6</i>
<i>Percent of Total Remaining in Soil (Relative to Time 0)</i>						
Trichloroethene	0 - 100	0 - 100	0 - 100	0 - 100	0 - 100	0 - 100
Tetrachloroethene	63	92	62	87	61	72
1,2,4-Trimethylbenzene	82	89	< 82	92	82	91
sec-Butylbenzene	83	89	79	91	81	83
n-butylbenzene	79	79	74	79	78	73
Naphthalene	64	105	64	114	68	106
<i>Total VOCs</i>	<i>69</i>	<i>97</i>	<i>67</i>	<i>102</i>	<i>71</i>	<i>94</i>
<i>Percent of Total Removed (Relative to Time 0)</i>						
Trichloroethene	0-100	0-100	0-100	0-100	0-100	0-100
Tetrachloroethene	27	-2	29	3.6	31	24
1,2,4-Trimethylbenzene	15	7.6	15 - 97	5-8	15-18	6-9
sec-Butylbenzene	16	11	20	8	18	17
n-butylbenzene	21	21	26	20	22	27
Naphthalene	32	-9	31	-19	31	-6
<i>Total VOCs</i>	<i>27</i>	<i>0</i>	<i>29</i>	<i>-6</i>	<i>27</i>	<i>6</i>



3.2.3 Secondary Parameters

The effect of treatment on secondary water quality parameters is shown in **Table 8**. Cr(VI) was not detected in the low dose PersulfOx® test, but was detected at 0.012 mg/L Cr(VI) in the Day 28 high dose test. Treatment with PersulfOx® decreased pH (from 6.05 at Time 0 to 5.9 low dose test and 3.08 in the high dose test) and increased sulfate (from 8 mg/L to 530-1,100 mg/L by Day 28) due to the decomposition of persulfate. About 75% of the SP initially added was still present by Day 28, implying that additional COC removal could occur given a longer reaction time.

The amount of SP consumed in the low dose test was 1.1 g SP/L (3.3 g SP/kg soil), while the amount consumed in the high dose test was 5 g SP/L (15 g SP/kg soil). These values are comparable to the amount consumed in the 21-day SOD tests (**Section 3.3.1**).

Table 8. Secondary Parameters Post-Treatment – Initial Tests.

Analyte	Units	T0	Control		PSOx - Low (5 g/L SP; 5.6 g/L PSOx)		PSOx - High (20 g/L SP; 22 g/L PSOx)	
			Day 7	Day 28	Day 7	Day 28	Day 7	Day 28
Moisture	%-dry	24.5	25.8	11.3	26.7	24.3	22.2	25.0
Chromium, dissolved	mg/L	<0.010	0.025	<0.010	0.038	0.014	<0.010	0.025
Chromium, hexavalent	mg/L	<0.00040	<0.00080	<0.00040	<0.010	<0.0040	<0.010	0.012
ORP	mV	104	75	28	193	306	354	567
pH	--	6.05	6.10	6.15	5.90	5.27	4.84	3.08
Residual SP	g/L	n.a.	n.a.	n.a.	4.0	3.9	16	15
Sulfate	mg/L	8.0	65	36	265	1100	160	530

n.a. = not applicable

3.3 Follow-up Tests

3.3.1 COC Removal

The post-treatment concentrations of COCs in soil and water from the follow-up tests are shown in **Table 9**. The mass balance is given in **Table 10**. Treatment with 56 g/L PersulfOx® (PSOx-50g/L) completely removed most target VOCs from the aqueous



phase within 28 days and decreased total target VOCs in soil from 56,000 $\mu\text{g}/\text{kg-dry}$ in the Control to 37,000 $\mu\text{g}/\text{kg-dry}$, resulting in 34% reduction in target VOCs (compared to the Control). The results indicate that increasing the PersulfOx[®] concentration from 22 g/L (PSOx-High, **Section 3.2.2**) to 56 g/L (PSOx-50g/L, **this section**) enhances overall mass removal of VOCs. (Note: Although the mass balance of the initial tests in **Section 3.2.2** was calculated relative to Time 0 while the mass balance of these follow-up tests was calculated relative to the Control, the two sets of data can be compared. In the initial tests, the degree of removal relative to the Control is the difference between the degree of removal (relative to Time 0) of a treatment and the degree of removal (relative to Time 0) of the Control. As can be seen in **Table 7**, the Day 28 Percent Removed was similar for the Control and PSOx tests, indicating that treatment with 5.6-22 g/L PersulfOx[®] had little effect compared to no treatment.

Treatment with AP-pH increased aqueous concentrations of target VOCs, but decreased soil concentrations. Aqueous concentrations increased from 701 $\mu\text{g}/\text{L}$ in the Control to 5,950 $\mu\text{g}/\text{L}$ in the AP-pH-20 g/L test and to 1,033 $\mu\text{g}/\text{L}$ in the AP-pH-50 g/L test) within 28 days, while soil target VOCs decreased from 56,000 $\mu\text{g}/\text{kg-dry}$ to 14,000 $\mu\text{g}/\text{kg-dry}$ in the AP-pH-20g/L test and to 23,000 $\mu\text{g}/\text{kg-dry}$ in the AP-pH -50g/L test. Overall, target total VOC mass decreased by 72% in the AP-pH-20g/L test and by 58% in the AP-pH-50g/L test.

Non-target VOCs were detected in the PSOx-50g/L and AP-pH-50g/L tests. Acetone, a common by-product of chemical oxidation, was detected at up to 1,200 mg/L. Acetone is susceptible to biodegradation and therefore is not likely to persist in the field.

Chloroethane, bromomethane, and chloroform were seen at concentrations up to 57 mg/L. Haloethanes and methanes are known reactive intermediates of persulfate oxidation and are not expected to persist.

3.3.2 Secondary Parameters

The effect of treatment on secondary water quality parameters is shown in **Table 11**. Treatment with PersulfOx[®] decreased pH (from 6.92 to 1.96) and increased sulfate (from 48 mg/L to 3,100 mg/L) by Day 28 due to the decomposition of persulfate, while treatment with AP-pH increased pH to above 12 and increased sulfate to up to 18,000 mg/L. About 72% of the SP initially added was still present by Day 28 in the PSOx-50g/L test and about 30% was present in the AP-pH tests, implying that additional COC



removal could occur given a longer reaction time. The lower residual concentration of SP in the AP-pH tests compared to the PersulfOx® test is consistent with greater COC removal in the AP-pH tests.

Table 9. Post-Treatment VOC Concentrations – Follow-up Tests

Analyte	Units	Control	PSOx (50 g/L SP; 56 g/L PSOx)	AP-pH (20 g/L SP, pH >11)	AP-pH (50 g/L SP, pH >11)
		Day 28	Day 28	Day 28	Day 28
<i>Target VOCs - Aqueous</i>					
Trichloroethene	µg/L	27	< 1.0	< 100	23
Tetrachloroethene	µg/L	110	20	510	120
1,2,4-Trimethylbenzene	µg/L	10	< 1.0	< 100	< 20
sec-Butylbenzene	µg/L	36	< 1.0	1200	170
n-butylbenzene	µg/L	18	< 1.0	940	130
Naphthalene	µg/L	500	< 4.0	3,300	590
<i>total Target VOCs</i>	<i>mg/L</i>	<i>701</i>	<i>20</i>	<i>5,950</i>	<i>1,033</i>
<i>Non-Target VOCs - Aqueous</i>					
Acetone	µg/L	< 160	1,200	< 2,000	490
Chloroethane	µg/L	< 8.0	57	< 100	< 20
Bromomethane	µg/L	< 32	37	< 400	< 80
Chloroform	µg/L	< 8.0	1.4	< 100	21
<i>VOCs - Soil - Wet basis</i>					
Trichloroethene	µg/kg	< 800	< 800	< 400	< 800
Tetrachloroethene	µg/kg	3,100	1,400	940	1,900
1,2,4-Trimethylbenzene	µg/kg	1,000	< 800	< 400	< 800
sec-Butylbenzene	µg/kg	7,100	4,800	2,600	4,400
n-butylbenzene	µg/kg	4,900	3,400	1,700	2,900
Naphthalene	µg/kg	30,000	21,000	6,300	9,900
<i>total VOCs</i>	<i>µg/kg</i>	<i>46,100</i>	<i>30,600</i>	<i>11,540</i>	<i>19,100</i>
<i>VOCs - Soil - Dry basis</i>					
Trichloroethene	µg/kg	< 970	< 960	< 480	< 960
Tetrachloroethene	µg/kg	3,800	1,700	1,100	2,300
1,2,4-Trimethylbenzene	µg/kg	1,200	< 960	< 480	< 960
sec-Butylbenzene	µg/kg	8,600	5,800	3,100	5,300
n-butylbenzene	µg/kg	5,900	4,100	2,000	3,500
Naphthalene	µg/kg	36,000	25,000	7,500	12,000
<i>total VOCs</i>	<i>µg/kg</i>	<i>56,000</i>	<i>37,000</i>	<i>14,000</i>	<i>23,000</i>



Table 10. Mass Balance – Follow-up Tests

Analyte	PSOx (50 g/L SP; 56 g/L PSOx)	AP-pH (20 g/L SP, pH >11)	AP-pH (50 g/L SP, pH >11)
	Day 28	Day 28	Day 28
<i>Percent of Total Remaining in Water (Relative to Control)</i>			
Trichloroethene	< 3.7	0-100	85
Tetrachloroethene	0.17	4.4	1.0
1,2,4-Trimethylbenzene	< 0.027	< 2.7	< 0.54
sec-Butylbenzene	< 0.004	4.6	0.65
n-butylbenzene	< 0.006	5.2	0.72
Naphthalene	< 0.004	3.0	0.53
<i>Total VOCs</i>	0.012	3.5	0.60
<i>Percent of Total Remaining in Soil (Relative to Control)</i>			
Trichloroethene	0 - 100	0 - 100	0 - 100
Tetrachloroethene	44	30	60
1,2,4-Trimethylbenzene	< 79	< 39	< 79
sec-Butylbenzene	67	36	62
n-butylbenzene	69	34	59
Naphthalene	69	21	33
<i>Total VOCs</i>	66	25	41
<i>Percent of Total Removed (Relative to Control)</i>			
Trichloroethene	0-100	0-100	0-100
Tetrachloroethene	56	66	39
1,2,4-Trimethylbenzene	> 21	> 58	> 20
sec-Butylbenzene	33	59	38
n-butylbenzene	31	61	41
Naphthalene	31	76	67
<i>Total VOCs</i>	34	72	58



Table 11. Secondary Parameters – Follow-up Tests

Analyte	Units	Control	PSOx - 50 g/L (50 g/L SP; 56 g/L PSOx)	AP-pH - 20g/L (20 g/L SP, pH >11)	AP-pH - 50 g/L (50 g/L SP, pH >11)
		Day 28	Day 28	Day 28	Day 28
Moisture	%-dry	21.2	20.1	19.4	20.5
pH	--	6.92	1.96	12.30	12.2
Residual SP	g/L	n.a.	36	7.1	16
Sulfate	mg/L	48	3,100	9,000	18,000



4.0 SUMMARY and CONCLUSIONS

Laboratory testing demonstrated that PersulfOx® could reduce concentrations of COCs in the aqueous phase within 28 days, and that high concentrations were needed to treat soil. In the PersulfOx® test using 20 g/L SP (22 g/L PersulfOx®), total VOCs decreased from 1,089 µg/L to 130 µg/L but soil only decreased from 73,000 µg/kg-dry to 72,000 µg/kg-dry, which equates to overall mass removal of 6% compared to Time 0 or the Control. However, in the PersulfOx® test using 50 g/L SP (56 g/L PersulfOx®) most aqueous COC were completely removed, while concentrations of soil VOCs decreased from 56,000 µg/kg-dry to 37,000 µg/kg-dry, an overall decrease in mass of 34% relative to the Control. About 75% of the SP was still present at 28 days in all three PersulfOx® tests, indicating that oxidant was not limiting. Limited removal from the soil is presumably due to association of the COCs with a NAPL, where they are less susceptible to oxidation. As long as oxidant is present, it is likely that soil COCs will eventually be destroyed as they slowly dissolve into the water.

Treatment with AP-pH was more effective than PersulfOx® in the timeframe of this study. Total VOCs decreased by 72% (relative to the control) within 28 days in the AP-pH-20g/L test and by 58% in the AP-pH-50g/L test compared to 34% for the 56 g/L PersulfOx® test. The greater removal in the AP-pH tests may be due to the higher pH, which enhanced removal of/from the NAPL or to the greater range of effectiveness of high pH activation compared to other persulfate activators. Although AP-pH was more effective than PersulfOx® in the time frame of this study, it is uncertain whether the difference would persist (at least for the 56 g/L PersulfOx® test) given a longer reaction time since SP was still present, which would enable additional COC removal to occur given more time.

Treatment of soil and water with PersulfOx® generated a small amount of Cr(VI) - up to 0.012 mg/L. In addition, pH decreased to between 3.08 and 5.27 and sulfate increased to between 530 and 1,100 mg/L due to decomposition of SP.

The soil oxidant demand, measured on impacted soil, was 1.8 g SP/kg soil when the initial PersulfOx® concentration was 11 g/L and 25 g SP/kg soil when the initial PersulfOx® was 55 g/L. Consumption of SP in the COC Removal tests was 3.3 g SP/kg soil in the low dose test and 15 g SP/kg soil in the high dose test.



Based on the results of this study, PRIMA recommends that both PersulfOx® and AP-pH be considered for use at this site. If PersulfOx® is used, a dose on the order of 56 g/L PersulfOx®/L (50 g SP/L) in the groundwater after injection is recommended since 22 g/L (20 g SP/L) did not treat COCs in soil. Because PersulfOx® decreased pH to as low as pH 2 in the laboratory tests, it is recommended that a plan be developed to adjust groundwater pH, if needed. If AP-pH is used, a dose of 20 g/L SP in the groundwater after injection should be effective toward soil COCs, though a temporary increase in aqueous concentrations may be seen. pH will initially increase to over 11, but should return to near pre-treatment levels once SP has completely decomposed.



APPENDIX A
(Chains of Custody)



APPENDIX B
(Subcontracted Analytical Reports)

APPENDIX B

Special Requirements Community Air Monitoring Plan (SR-CAMP)

Special Requirement Community Air Monitoring Plan
40 Roselle Street, Mineola, New York

This Special Requirement Community Air Monitoring Plan (SR-CAMP) requires real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress during remedial activities at the site.

If work is performed within 20 feet of an occupied structure, additional continuous monitoring locations will be established at the nearest air intake locations (e.g. windows, doors, vent intakes) for nearby structures. It is anticipated that several planned injection locations will be within 20 feet of the 50 Roselle Street building. During these activities monitoring locations will be established adjacent to all first floor windows and building air intakes within 20 feet of the work area or the air intake structure located closest to the work zone.

The SR-CAMP is not intended for use in establishing action levels for workers respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, the SR-CAMP helps to confirm that work activities did not spread contamination off-site through the air.

Reliance on the SR-CAMP should not preclude simple, common sense measures to keep VOCs, dust, and odors at a minimum around the work areas.

Depending on the nature of known or potential contaminants at the site, real-time air monitoring for VOCs and/or particulate levels at the perimeter of the exclusion zone or work area will be necessary.

Continuous monitoring will be required for all ground intrusive activities and during the demolition of contaminated or potentially contaminated structures. Ground intrusive activities include, but are not limited to, soil/waste excavation and handling, test pitting or trenching, the installation of soil borings or monitoring wells, and during the application of the In Situ Chemical Oxidation (ISCO) injections.

Periodic monitoring for VOCs will be required during non-intrusive activities such as the collection of soil samples. "Periodic" monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap or overturning soil, monitoring during well baling/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals, continuing monitoring may be required during sampling activities.

Particulate Monitoring, Response Levels, and Actions

Particulate concentrations will be monitored continuously at the upwind and downwind perimeters of the exclusion zone, and adjacent to first floor windows and building air intakes within 20 feet of the work area at temporary particulate monitoring stations. The particulate monitoring will be performed using real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) for comparison to the airborne particulate action level. The equipment will be equipped with an audible alarm to indicate exceedance of the action level. In addition, fugitive dust migration will be visually assessed during all work activities.

- If the downwind PM-10 particulate level is 100 micrograms per cubic meter (mcg/m³) greater than the background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques will be employed. Work may continue

with dust suppression techniques provided that no visible dust is migrating from the work area.

- If total particulate concentrations opposite the walls of occupied structures or next to intake vents exceed 150 mcg/m^3 , work activities should be suspended until controls are implemented and are successful in reducing the total particulate concentration to 150 mcg/m^3 or less at the monitoring point.
- If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 mcg/m^3 above the upwind level, work will be stopped and a re-evaluation of activities initiated. Work can resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 mcg/m^3 of the upwind level and in preventing visible dust migration.

All readings will be recorded and be available for State (DEC and DOH) personnel to review.

VOC Monitoring, Response Levels, and Actions

VOCs will be monitored at the downwind perimeter of the immediate work area (i.e., the exclusion zone), and adjacent to first floor windows and building air intakes within 20 feet of the work area on a continuous basis or as otherwise specified. Upwind concentrations will be measured at the start of each workday and periodically thereafter to establish background conditions. The monitoring work will be performed using a photo ionization detector (PID) equipped with a 10.2 eV bulb. The PID will be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate. The equipment will be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

- If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.
- If total VOC concentrations opposite the walls of occupied structures or next to intake vents exceed 1 ppm above established background readings, monitoring should occur within the occupied structure(s). Background readings in the occupied spaces must be taken prior to commencement of the planned work. Any unusual background readings should be discussed with NYSDOH prior to commencement of the work.
- If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities will be halted, the source of the vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less- but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.
- If the organic vapor level is above 25 ppm at the perimeter of the work area, activities will be shutdown.

All 15-minute readings will be recorded and be available for State (DEC and DOH) personnel to review. Instantaneous readings, if any, used for decision purposes will also be recorded.

APPENDIX C

Oxidant Information



29-Sep-2022

Customer: HRP Associates
 Contact: Jessica Kruczek
 Site Location: Mineola, NY
 Proposal Number: CRM 24545

Prepared by: John Valkenburg, PE
 1-517-669-5400
 John.Valkenburg@evonik.com

Klozur® SP Demand Calculations and Cost Estimate

Item	Packaging Type	Quantity (lbs)	Unit Rate (\$USD / lb)	Cost in \$USD (FOB Origin)
Klozur® SP	55.1 lb bags	44,080	1.53	\$67,442
Klozur® Activator(s) 25% NaOH	Totes (delivered pricing)	65,000	0.515	\$33,475
		Number of Deliveries	Estimated Cost Per Delivery⁴	
		Shipping	N/A	N/A
		Taxes³		Not Included
			Total:	\$100,917

1) Number of packages needed is rounded up to nearest whole unit.
 2) Price valid for 30 days from date at top of document. Terms: net 30 days. Prices are FOB Origin.
 3) Any applicable taxes not included. Please provide a copy of your tax exempt certificate or resale tax number when placing your order. In accordance with the law, applicable state and local taxes will be applied at the time of invoicing if Evonik has not been presented with your fully executed tax exemption documentation.
 4) If shipping not included, estimated freight rates available upon request. Freight rates provided are estimates only. Standard delivery time can vary from 1-3 weeks from time of order, depending upon volume. Expedited transport can be arranged at extra cost.
 5) Return Policy: Within 90 days of sale and following written approval by Evonik, products in their unopened containers, which by analysis meet the original specifications and are in the same condition as they were shipped, will be accepted for return at invoiced price, less a 25% handling charge and return freight paid by buyer. Products that are made to order or custom blended are non-returnable. Returned products that are not received back by Evonik in the same condition as they were shipped or that have been stored outside, may be subject to a higher restocking fees or no refund at all.
 6) All sales are per Evonik's Terms and Conditions.
 7) All disclaimers within the standard proposal/demand calculator attachments apply to any and all estimates.

PROPOSAL ATTACHMENTS

PRODUCT OVERVIEW

Klozur® SP is an environmental grade sodium persulfate which has been delivered safely and cost effectively to treat a wide variety of common contaminants of concern with an unmatched combination of power and control. With proper activation, Klozur SP can generate both oxidative and reductive pathways delivering the power to destroy the most recalcitrant of contaminants.

For more information on activated Klozur® SP, please contact your Evonik technical representative or www.klozur.com.

SITE INFORMATION

	<u>Value</u>	<u>Unit</u>	<u>Note</u>
Target Area Width (perpendicular to GW flow direction)	30	ft	customer supplied
Target Area Length (Parallel to GW flow direction)	30	ft	customer supplied
Area of Treatment	900	ft ²	customer supplied
Top of Treatment Zone	30	ft bgs	customer supplied
Base of Treatment Zone	45	ft bgs	customer supplied
Treatment Zone Thickness	15	ft	customer supplied
Treatment Volume	13,500	ft ³	calculated value
Porosity	35	%	default value
Ground Water Volume	35,341	USG	calculated value
Soil Density	100	lbs/ft ³	default value
Soil Mass	1,350,000	lb	calculated value
Fraction Soil Mass Contacted*	100	%	default value
Base Buffering Capacity (Alkaline Activation only)	3	g 25 percent NaOH / kg soil	estimated value, it is recommend that this be analytically determined
Soil Oxidant Demand	1.8	g Klozur / kg soil	estimated value, it is recommend that this be analytically determined

* Fraction soil mass contacted may be less for sites with contact limitations such as fractured bedrock or those with low permeable materials.

Disclaimer:

The estimated dosage and recommended application methodology described in this document are based on the site information provided to Evonik, but are not meant to constitute a guaranty of performance or a predictor of the speed at which a given site is remediated. Klozur® persulfate and activator demand calculations do not take into account the kinetics, speed of the reaction, or ability to establish contact between the reagents and contamination in the subsurface. These calculations represent the minimum anticipated amount needed to treat the contaminants of concern (COCs). As a result, these calculations should be used as a general approximation for purposes of an initial economic assessment. Evonik recommends that oxidant demand and treatability testing be performed to verify the quantities of oxidant needed.

CONTAMINANTS OF CONCERN* (COCs)

Concentrations:

The following are estimates of the contaminant concentration in soil and groundwater within the target area. The total COC mass was calculated including estimated COC mass in groundwater, soil and NAPL, if present, within the targeted area.

<u>Contaminant</u>	<u>GW (mg/L)</u>	<u>Soil (mg/kg)</u>	<u>NAPL (lbs)</u>	<u>Total COC Mass** (lb)</u>
naphthalene	0.2	41.0	554.0	609.4
PCE	1.8	7.3	99.0	109.4
DCE	0.08	0	0	0
TCA	0.001	0	0	0
trimethylbenzene	0	1	0	2
butylbenzene	0	24	321	354

Remedial Goals and Target Mass Reductions:

The target demand is determined by also accounting for remedial goals for each contaminant and represents the estimated mass reductions targeted for each contaminant.

<u>Contaminant</u>	<u>GW (mg/L)</u>	<u>Soil (mg/kg)</u>	<u>NAPL (lbs)</u>	<u>Total COC Mass Targeted*** (lbs)</u>
naphthalene	0	0	0	609.4
PCE	0	0	0	109.4
DCE	0	0	0	0
TCA	0	0	0	0
trimethylbenzene	0	0	0	2
butylbenzene	0	0	0	354

*Unless provided, sorbed concentrations were roughly estimated based on expected groundwater concentrations, foc and Koc values. For a more refined estimate, it is recommended that actual values be verified via direct sampling of the targeted treatment interval.

** Includes estimated contaminant mass in soil, groundwater, and NAPL (if provided) at the site.

*** Includes estimated contaminant mass in soil, groundwater, and NAPL (if provided) at the site with the remedial goals subtracted from the total mass onsite.

KLOZUR® PERSULFATE DEMAND

The estimated mass of Klozur® SP accounts for target demand with the COCs, non-target demand associated with the soils (SOD) and a safety factor applied to each. The safety factor is intended to account for potential variability in the COC and SOD estimates and any other uncertainties associated with the application or site.

The demand from COCs was estimated using: **Degradation Ratio**

The degradation ratio should be determined/verified in a bench or field test

	Klozur SP Demand	Safety Factor	Klozur SP Demand with Factor
Demand from COCs	20,181	2.0	40,362 lb
Demand from SOD	2,430	1.5	3,645 lb
Total Klozur® SP Demand:	44,007 lb	To be applied in	2 applications
Klozur® SP Per Application:	22,004 lb		

KLOZUR® SP PACKAGING OPTIONS AND PRICING

Klozur® SP can be delivered to your site in a variety of packages including in bags, or two sizes of super sacks for your handling convenience. Pricing below is exclusive of shipping and any applicable taxes.

Estimate for : **Total Project Demand**

Packaging Type	# of packages / pallet	lb Klozur® SP / pallet	# of packages needed
55.1 lb bags	40	2,204	800

Packaging Type	Unit Rate (\$USD / lb)	Quantity (lbs)	Cost in \$USD (FOB Origin)
55.1 lb bags	1.53	44,080	\$67,442

KLOZUR® ACTIVATION CHEMISTRIES

Klozur® activation chemistries are used to convert Klozur® SP into the highly reactive radicals. Choosing the right activator chemistry for your contaminants of concern is important in obtaining a successful site remediation. The choice of activator will be dependent upon the target contaminants, site lithology and hydrogeology, and other site conditions. While activator demand quantities for all methods are given, not all activation methods are recommended for your given contaminant or site conditions. Please consult with an Evonik technical representative for proper selection of activation chemistry.

Note: Only one type of activator is typically needed.

*Evonik Industries AG is the owner or licensee under various patent applications relating to the use of activation chemistries

Alkaline (High pH) Activation

Alkaline activated persulfate is the most commonly used activation method. Alkaline demand is a function of the alkalinity needed to neutralize generate HSO_4^- from persulfate decomposition plus the amount needed to raise ground water / soil to a pH > 10. Common alkaline sources include 25% NaOH, hydrated lime, and Portland cement.

Calculation for NaOH (high pH) demand:

Sodium hydroxide is a highly soluble form of alkalinity that is commonly used for injection events with Klozur® SP. Evonik recommends using 25% NaOH solutions as it has higher solubilities and minimal heat of dissolution issues.

	Application		Units
NaOH Solution Concentration		25	% w/w
NaOH demand for HSO ₄ neutralization	29,621	59,242	lb Solution
Soil buffering amount	4,050	4,050	lb Solution
Package Type	Totes	Package Mass	2,500 lb Solution
Number of Packages	14	26	
Total NaOH demand	35,000	65,000	lb Solution

** note: the addition of highly concentrated or crystalline NaOH to water is very exothermic. Add NaOH slowly to water, and allow for excess heat to dissipate.

Hydrated Lime [Ca(OH)₂]

Hydrated Lime [Ca(OH)₂] is a solid alkali with a low solubility. It is well suited for soil mixing and for solid state emplacement applications. When selecting hydrated lime, evaluate impurities to maximize hydrated lime content and minimize carbonate content.

	Application		Total	Units
Assumed purity of Ca(OH) ₂ to Activate Klozur® SP:			92	%
Package Type	50 lb Bag	Package Mass		50 lb
Number of Packages		170	319	
Mass of Ca(OH) ₂ to Activate Klozur® SP:		8,500	15,950	lb

** Ca(OH)₂ has a low solubility and will typically be applied as a solid/slurry. As with any chemical material, it is recommended that precautions in the SDS be followed. Hydrated lime purity should be confirmed at time of order and masses adjusted as necessary.

INSTALLATION VIA INJECTION

Klozur[®] SP will be delivered as a dry powder, packaged in 55.1-lb (25 Kg) bags, and 2,204 lb (1,000 Kg) supersacks (1,102 lbs, or 500 Kg, supersacks are available as special order items). Klozur[®] SP is highly soluble in water and can be injected via fixed wells, open boreholes or using direct push technology (DPT). Klozur[®] SP is typically batched at a concentration of between 50 to 450 g/L (5 to 35%) and Evonik recommends injecting at a concentration between 50 and 250 g/L, depending upon site design and conditions. Effective treatment requires establishing contact between a sufficient amount of activated persulfate and the contaminant in the subsurface. A key element of establishing this contact in a source zone is the injection volume used to inject the activated persulfate reagents. Depending on the application method employed and site conditions, between 20% and 100% (with >50% typical) of the effective porosity is normally targeted during Klozur[®] SP injection, with a higher percent pore fill normally targeted for sites with slow permeability.

Below is an example injection scenario for the proposed mass Klozur[®] SP for this site. The suggested injection volumes may be altered based on the site specific conditions.

Number of Applications 2

<u>Klozur SP Dosage</u>	<u>Project Totals</u>		<u>Per Application</u>	
Mass of Klozur [®] SP	44,080	lb	22,040	lb
Concentration in Total Pore Volume	150	g/L	75	g/L
	13.7	% w/w	7.1	% w/w
Application rate by soil mass (dry weight)	32.7	g/kg	16.3	g/kg

Injection Locations

Number of Injection Locations	4	locations
Radius of Influence		
Design ¹	10.0	ft
Injection ²	7.7	ft
Overlapping Design ROI ³	17	%
Approximate Spacing between locations ⁴	15.0	ft

Injection Details

	<u>Project Totals</u>		<u>Per Application</u>	
Total Injection Volume	24,800	gal	12,400	gal
Percentage of Effective Pore Volume			82	%
Volume per Injection Location	6,200	gal	3,100	gal
Klozur [®] SP Injection Concentration			213	g/L
			18.9	% w/w
Mass per Injection Location				
Klozur [®] SP	11,020	lb	5,510	lb
25% NaOH	16,250	Lbs Solution	8,750	Lbs Solution

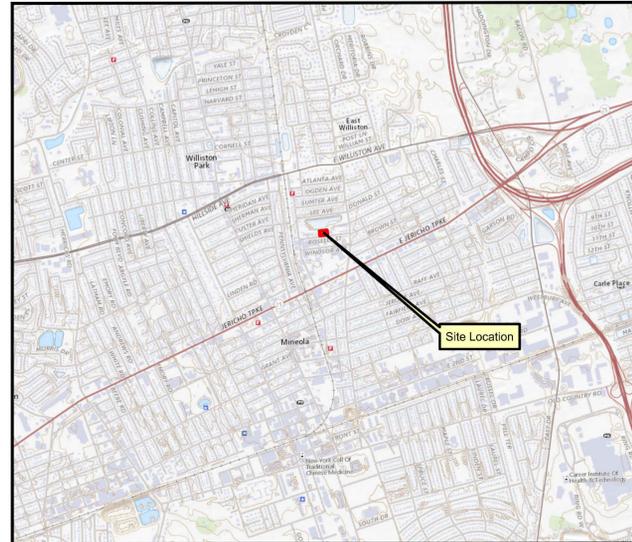
Design parameters should be considered approximations and suggestions. Site design engineers and contractors are ultimately responsible for the field application and design.

Values are based upon client supplied data and other assumed values. Changes in any of the input values will affect and alter other

- Notes:
1. Design radius of influence corresponds to the desired treatment radius from each injection location.
 2. Injection radius of influence corresponds to the distance from each injection point the injection volume would distribute assuming uniform (cylindrical) distribution in the effective pore volume.
 3. Approximate percentage of overlap between the Design ROI from the various injection locations. Actually percent overlap will depend upon injection location layout.
 4. Approximate distance between injection locations. Actual distance will depend upon site layout.

APPENDIX D

Injection Design Drawings



SITE LOCATION MAP
SCALE: 1" = 2000'

GENERAL NOTES

1. ALL DIMENSIONS, ELEVATIONS, AND EXISTING CONDITIONS SHALL BE FIELD VERIFIED BY THE CONTRACTOR PRIOR TO INJECTIONS. ANY DISCREPANCIES DISCOVERED DURING THE COURSE OF INJECTIONS SHALL BE PROMPTLY REPORTED TO THE ENGINEER.
2. SHOULD ANY OF THE ASSUMPTIONS REGARDING SITE CONDITIONS OR ABILITY TO IMPLEMENT THE REMEDY AS DESIGNED CHANGE DURING PROJECT MOBILIZATION OR EXECUTION, THE CONTRACTOR SHALL BE RESPONSIBLE FOR NOTIFYING THE NYSDEC AND ENGINEER BEFORE MAKING ANY CHANGES TO THE SCOPE OR DESIGN.
3. THE CONTRACTOR IS RESPONSIBLE FOR DETERMINING, PRIOR TO BIDDING, THE LOCATIONS OF ALL UTILITIES AND SHALL BE RESPONSIBLE FOR ALL DAMAGE TO SAID UTILITIES. THE CONTRACTOR SHALL CONTACT "DIG SAFELY NT" (811), AT LEAST 72 HOURS PRIOR TO STARTING CONSTRUCTION. THE CONTRACTOR SHALL COORDINATE ACTIVITIES WITH INDIVIDUAL UTILITY COMPANIES.
4. THE CONTRACTOR SHALL ENSURE ALL WORK DONE AS A PART OF THIS CONTRACT IS DONE WITHIN ALL APPLICABLE LAWS, CODES, AND REGULATIONS
5. CONTRACTOR TO ENSURE ALL APPLICABLE PERMITS ARE SECURED PRIOR TO INITIATING WORK.
6. THE CONTRACTOR SHALL WORK IN COOPERATION WITH THE NYSDEC TO SECURE SITE ACCESS AND MAKE NOTIFICATIONS TO THE SITE OWNER NO LESS THAN ONE MONTH PRIOR TO THE COMMENCEMENT OF FIELD ACTIVITIES.

JANUARY 13, 2023

GARDEN PHOTOENGRAVING (OU-1)
SITE # 130174
IN-SITU CHEMICAL OXIDATION INJECTION PLAN

40 ROSELLE STREET
MINEOLA, NEW YORK
HRP PROJECT NO. DEC1020.RA

Prepared By:

HRP
MOVE YOUR ENVIRONMENT FORWARD
ONE FAIRCHILD SQUARE
SUITE 110
CLIFTON PARK, NY 12065
(518) 877-7101
HRPASSOCIATES.COM

Prepared For:

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
625 BROADWAY
ALBANY, NY 12233

SHEET INDEX

SHEET	TITLE / DESCRIPTION	CREATED	REVISED
	TITLE SHEET	06/23/2022	01/13/2023
S-1	SITE PLAN	06/23/2022	01/13/2023
S-2	NOTES	06/23/2022	01/13/2023
D-1	DETAILS	06/23/2022	01/13/2023

REMEDIATION ENGINEERING COST ESTIMATE

SUMMARY OF COSTS

App.Ver. 3.1

	Cost
Total Cost of Remedial Construction	\$194,200

Note: All Totals and Subtotals are Rounded Up to the Next \$100.

SITE INFORMATION	Values
Site/Spill No. PIN:	130174
Site/Spill Name:	Former Garden Photoengraving
Distance to Site (Miles):	20
Site DEC Region:	2
Drilling Subcontractor Wage Schedule:	Prevailing Wage
Additional Notes:	
Remedial action consisting of 2 ISCO injection events and post-injection monitoring. Cost inclusive of labor, materials, laboratory costs, and mobilization.	
Project Duration	12 Months

Project Scope

The expected scope of work includes 2 ISCO injection events. 22,040 pounds of alkaline activated sodium persulfate is anticipated to be injected per event for a total of 44,080 pounds injected at the Site. Injections are expected to be made at 9 locations per event from 30 feet below grade (ft bg) to 45 ft bg. The scope is also inclusive of post injection groundwater monitoring and post injection SVI sampling.

CALCULATION OF AVERAGE HOURLY LABOR RATE

Calculation of Current Weighted Average Hourly Rate

Labor Category	Labor Distribution by Category	Current Hourly Rates
IX	0 %	190
VIII	1 %	170
VII	3 %	145
VI	20 %	125
V	10 %	110
IV	6 %	95
III	20 %	80
II	30 %	65
I	10 %	55
Total	100 %	
Current Weighted Average Hourly Labor Rate		88.75
Assumed CPI Adjustment (%)		3

Calculation of Project Term Weighted Average Hourly Labor Rate

Year	Percentage of Work	Labor Rate Average (\$/hr)
Current	100 %	89
2	0 %	91
3	0 %	94
4	0 %	97
5	0 %	100
Total	100 %	

Project Term Weighted Average Hourly Labor Rate **\$89**

Work Element - Remedial Construction

Task 1: Preliminary Activities			
Total Cost for Task 1:		\$13,700	
Item	Values	Hours	Cost
File Review		0	\$0
One Trip to the Site		16	\$1,420
Travel Expenses			\$500
One Trip to Albany for Scope Mgt.		16	\$1,420
Travel Expenses			\$500
Develop Schedule 2.11's		55	\$4,881
Site Specific Project Requirements		11	\$976
Progress Schedule		4	\$355
Executive Summary Required for Repository?	No	40	\$3,550
Subtotal			\$13,700
Notes:			
0			

Task 2: Construction Management and Inspection Services		
Total Cost of Task 2:		\$101,100
Component 1: PreBid and Pre Construction		
Item	Hour	Value
PreBid		
Meeting Attendance	20	\$1,775
PM		Yes
Inspector		Yes
Other		Yes
Addenda	80	\$7,100
Travel		\$500
Notes:		
0		
Bid Submittal Document Review		
Review	80	\$7,228
Notes:		
0		
PreConstruction		
Meeting Attendance	20	\$1,775
Meeting Minutes	2	\$178
Travel		\$500
Notes:		
0		

Component 2: Submittals		
Item	Hours	Value
Site Specific Activities	300	\$26,625
Travel		\$5,000
Shop Drawings		Yes
Analytical		No
Testing		No
Or-Equals		No
Payment Applications		No
As-Builts		Yes
DUSR		Yes
Schedules		Yes
Substitutions		No
Materials		Yes
Notes:		
Call out contractor plan review and coordinaiton		
Component 3: Inspections		
Item	Hours	Value
Site Specific Activities	500	\$44,375
Travel		\$3,000
Substantial Completion		No
Final Inspection		Yes
Biweekly Meetings		Yes
Meeting Minutes		Yes
Warranty		No
Daily Inspection Reports		Yes
Digital Photos		Yes
Videotape		No
Notes:		
Contrcator oversight, coordination, daily reports (2 events), Groundwater monitoring, meetings		
Component 4: Clarifications/Changes to the Work		
Item	Hours	Cost
Field Orders	0	\$0
Proposed Change Orders	0	\$0
Change Orders	0	\$0
Travel		\$3,000
Notes:		
0		

Task 3: Site Management Plan Development		
Total Cost for Task 3:	\$22,200	
Item	Hours	Value
Plan Development	250	\$22,188
Plan Type(s)		
Operation		No
Maintenance		No

Monitoring	Yes
Inspection	
Frequency	Value
Weekly	No
Monthly	No
Quarterly	No
Annual	Yes
Other	No
Daily Inspection Reports	Yes
Digital Photography	Yes
Institutional Controls	Yes
Permit or Access Agreement	Yes
Notes:	
0	
Site Maintenance	
Snow Removal	No
Mowing and Fertilization	No
Fence Repair Control	No
Erosion Control	No
Drainage Control	
Redevelopment or Replacement	No
Well Repair	No
Access Road	No
Vermin	No
Revegetation	No
Well	
Redevelopment/Replacement	No
Notes:	
0	
Treatment System O & M	
Equipment and Maintenance	
Operation	No
Filter Media Changes	No
Development & Implementation	
of evaluation Protocols	No
Pump and Control Repairs	No
Conveyance System	
Maintenance	No
Electric Repairs	No
General Maintenance (e.g.,	
painting)	No
Plumbing Repairs	No
Notes:	
0	
Leachate Collection Facility	
Transportation and Disposal	No

Pump Outs	No
Tracking Quality and Volume	No
Notes:	
0	
Reporting	
Evaluation of Monitoring Data	Yes
Monthly	No
Quarterly	Yes
Recommendations	Yes
Website	
Establishment/Maintenance	No
Operation and Maintenance Logs	No
Notes:	
Quarterly Groundwater reports	

Task 4 - Final Report	Cost
Total Cost for Task 4:	\$22,200
Item	Value
Final Report	250 \$22,188
Survey	No
Record Drawings	Yes
Recommendation(s) for Need for Additional Work	Yes
NYSPE Certification	Yes
Notes:	
No survey, injection points located via GPS	
Variances	
Total Cost of Variances:	\$35,000
Item 1	Cost
Laboratory Analytical	\$35,000
Notes:	
0	