US Army Corps of Engineers

3800 Area PCE Site

In-Situ Chemical Oxidation Remedial Action Work Plan

Fort Drum Installation Restoration Program
Fort Drum, New York

April 2017

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Prepared For:

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Remedial Action Work Plan
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Acronyms and Abbreviations

bgs	below ground surface
bldg.	building
BTEX	benzene, toluene, ethyl benzene, and xylenes
CVOC	chlorinated volatile organic compound
DER	Division of Environmental Remediation
DMP	Data Management Plan
DNAPL	dense non-aqueous phase liquid
DO	dissolved Oxygen
DPW	Department of Public Works
ECD	electron capture detector
ELAP	Environmental Laboratory Approval Program
ft	feet
gpm	gallons per minute
ISCO	in-situ chemical oxidation
JP	jet propulsion
JSA	job safety analysis
JV	joint venture
LNAPL	light non-aqueous phase liquid
MAES	Multiple Award Environmental Services
MIP	membrane interface probe
MNA	monitored natural attenuation
NOD	natural oxidant demand

NYSDEC	New York State Department of Environmental Conservation
ORP	oxidation-reduction potential
OSL	Old Sanitary Landfill
PCE	tetrachloroethene
PID	photoionization detector
psi	pounds per square inch
RI	Remedial Investigation
ROD	Record of Decision
ROI	radius of influence
QAPP	quality assurance project plan
SOP	standard operating procedures
TAL	Target Analyte List
TCMI	temporary central mixing and injection
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VOCs	volatile organic compounds
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µg/m^3	micrograms per cubic meter

1. Introduction

The PIKA - MP Joint Venture (JV), LLC[1] (hereinafter referred to as the JV) has prepared this Work Plan to document the activities, procedures, and metrics by which the performance objectives of the Installation Restoration Program (IRP) at Fort Drum, New York will be achieved for an in-situ chemical oxidation (ISCO) remedial action and associated groundwater monitoring at the 3800 Area PCE Site (the Site). These metrics are detailed in the performance work statement (PWS) from the United States Army Corps of Engineers (USACE) Baltimore District, and all amendments and question and answer sets under the Multiple Award Environmental Services (MAES) contract, Award No. W912DR-12-D-0007, Delivery Order 0003. The remedial action will be conducted pursuant to the approval of, and coordination with, the New York State Department of Environmental Conservation (NYSDEC). The site is regulated by the NYSDEC as Class 2 Inactive Hazardous Waste Disposal Site Division of Environmental Remediation (DER) Registry #623008 (i.e., under the State Superfund Program). The purpose of this Work Plan is to present the methods and procedures by which the Army will implement the selected remedy for the 3800 Area PCE site, as described in the Record of Decision (ROD; NYSDEC, 2016). The selected remedy involves in situ chemical oxidation (ISCO) followed by monitored natural attenuation (MNA) to reduce chlorinated volatile organic compound (CVOC) concentrations in groundwater.

This Work Plan was prepared in accordance with the provisions of Chapter 4 of the NYSDEC Division of Environmental Remediation (DER) Technical Guidance for Site Investigation and Remediation (DER-10) guidance document. This Work Plan is supported by and to be used in conjunction with the Quality Assurance Project Plan (QAPP), the Data Management Plan (DMP), and the Basewide Monitoring Plan, submitted as Appendix A, Appendix B, and Appendix C, respectively, to the *Work Plan, Installation Restoration Program, Fort Drum, New York* (IRP Work Plan; PIKA-MP JV, 2015a). The QAPP contains field and laboratory standard operating procedures (SOPs) that will be followed during execution of the 3800 Area PCE Site remedy. Applicable SOP references to the planned scope of work at the 3800 Area PCE Site are summarized in **Table 1**. Field SOPs that are specific to the 3800 Area PCE Site and are not included in the IRP Work Plan are provided in Appendix A of this document. The DMP details the procedures to be followed for management and

[1] The PIKA-MP LLC Joint Venture is comprised of PIKA International, Inc. and its mentor ARCADIS-U.S. Inc.

presentation of data collected during the 3800 Area PCE Site field work. The Basewide Monitoring Plan describes procedures for long-term groundwater monitoring to be initiated after completion of the ISCO portion of the remedy to support the MNA evaluation. All field work will be performed following the health and safety procedures described in the *Accident Prevention Plan, Installation Restoration Program, Fort Drum, New York* (PIKA-MP JV, 2015b).

2. Site Background

A comprehensive background history of the Site, including former uses and investigations, is presented in the *Remedial Investigation Report for Chlorinated Solvent Contaminants at Fort Drum, New York* (PARS, 2013a). Information pertinent to the basis, rationale, and design of the remedy is presented in the Feasibility Study (PIKA-MP JV, 2015c) and in the ROD (NYSDEC, 2016) and is summarized below.

2.1 General Site Description

Fort Drum encompasses approximately 168 square miles, and is located approximately 10 miles northeast of Watertown, 80 miles north of Syracuse, and 25 miles southeast of the United States and Canadian border (**Figure 1**). Fort Drum occupies a large portion of northeastern Jefferson County, a portion of western Lewis County, and abuts the southern edge of St. Lawrence County. The Site is located southeast of Ontario Avenue and Eighth Street West in the southwest portion of Fort Drum (**Figure 2**).

The Fort Drum “Gasoline Alley” has been used for fuel storage and dispensing since at least the 1940s when Fort Drum was expanded. Nine fuel dispensing areas were located along Gasoline Alley, where kerosene, gasoline, diesel fuel, and jet propulsion (JP)-4 fuel were stored and dispensed from 22 underground storage tanks (USTs) ranging in capacity size from 5,000 to 25,000 gallons. The dispensing areas are referred to as Areas 1195, 1295, 1395, 1495, 1595, 1795, 1895, 1995, and 3805. The USTs, fuel dispensers, and associated piping were removed in 1994 and 1995. The Site includes Fort Drum Areas 1700, 1800, 1900, 3800; associated buildings; and portions of the Old Sanitary Landfill (OSL) (**Figure 2**).

2.2 3800 Area PCE Site History

The historical land use of the Site has been predominantly industrial since the installation was established. The location of the ISCO treatment area was primarily used for vehicle storage, maintenance, and refueling purposes according to historical aerial photography and records. There was documented historical use and storage of hazardous materials, including chlorinated solvents, south of Gasoline Alley (PARS, 2013a). In 2012, a concrete parking area was constructed on the majority of the Site as part of a facilities upgrade project. The new parking/staging area covers areas with the highest CVOC detections.

2.3 Site Geology and Hydrogeology

The geology and hydrogeology descriptions provided below are based on data collected during a remedial investigation (RI) conducted between 2010 and 2012 (PARS, 2013a). Details of the RI are further discussed in Section 2.1.4.

The stratigraphic unit present at the ground surface is comprised of unconsolidated, Pleistocene-age, glacially-derived deltaic deposits. These surface deposits are referred to as the Pine Plains Delta. The Pine Plains Delta complex is bordered on the northwest and south by previously deposited till and ground moraine, and on the east by a metamorphic-igneous bedrock complex (EA, 2000).

During drilling activities at the Site, the primary geologic materials encountered were the Pine Plains deltaic sands and the underlying Pleistocene-age lacustrine deposits of silt and silty clay. The Pine Plains deltaic sands form a fining downward sequence that grades into the lacustrine silts and clays that form the confining unit at the base of the unconfined surficial aquifer. The depth to clay encountered during the RI drilling program ranged from 56 to 97 feet below ground surface (ft bgs) (PCERI-MW18D and –MW23D, respectively). The thickness of the clay confining unit at the base of the deltaic sands ranged from 12 ft at PCERI-MW19D to 30 ft at PCERI-MW01D where the unit was fully penetrated (PARS, 2013a) (see Figures 3-2 and 3-3 in Appendix B). The four major units in stratigraphic order (top to bottom) include the surficial sand and silty sand of the unconfined surficial aquifer, the basal lacustrine clay confining unit, and the calcareous mudstone bedrock unit. Hydraulic conductivity values range from 0.01 feet per day (ft/day) in the silt layer, which forms the regional aquitard of the surficial aquifer, to 21 ft/day in the upper portion of the surficial aquifer specific to the Site.

To characterize the hydrogeological framework of the unconfined surficial aquifer during the RI, the aquifer was sub-divided into three hydrostratigraphic units (shallow, intermediate, and deep). Due to the gradational nature of the fining downward sequence of the aquifer and the subsequent absence of a definable boundary between the sand and silty sand, the approximate vertical extent of the sub-units were defined as follows:

- Shallow zone – 20 ft from the base of the water table
- Intermediate zone – 20 ft from the base of the shallow zone
- Deep zone – from the base of the intermediate zone to the top of the clay confining unit

The water table elevations of the three unconfined surficial aquifer sub-units show that the general direction of groundwater flow at the Site is to the north and northeast, toward the stream running between the two OSL cells and along the eastern boundary of the OSL (PARS, 2013a). Water-level elevations measured in wells screened in alluvial and bedrock units indicate that the hydraulic head elevation is higher in the deltaic aquifer than in the underlying bedrock, indicating a downward groundwater flow gradient. However, tetrachloroethene (PCE) was not detected in these units during the RI (PARS, 2013a). Based on the results of historical aquifer pumping tests conducted in the area, the glacial outwash and underlying bedrock units do not appear to be hydraulically connected due to the presence of the clay aquitard (PARS, 2012).

2.4 Previous Investigations

A RI was conducted between 2010 and 2012 to characterize the extent of PCE and other CVOCs at the Site (PARS, 2013a). Prior to the RI, limited information regarding the nature and extent of PCE in the vicinity of the Site was collected during investigations of petroleum releases in nearby areas (i.e., Area 1995/3805). PCE was detected frequently in shallow, intermediate, and deep wells since 1995 during the investigation of the adjacent 3805 site (**Figure 2**).

The RI was conducted in seven phases to characterize the extent of CVOCs (in particular PCE) in soil, groundwater, and soil gas near the Site, as well as in the sub-slabs and indoor air of Buildings (Bldgs) 1880 and 1885. Detailed results of the RI are provided in the *Remedial Investigation Report for Chlorinated Solvent Contaminants at Fort Drum, New York* (PARS, 2013a). Summary figures from the RI are provided in Appendix B to this document. The salient findings are summarized as follows:

1. CVOC contamination in groundwater consists almost exclusively of PCE; limited concentrations of trichloroethene were detected, and no cis-1,2-dichloroethene, vinyl chloride, or ethene were detected.

2. The highest PCE concentration (906 µg/L) in groundwater during sampling specific to the RI was detected at PCERI MW-19S in the shallow aquifer zone. The extent of PCE contamination in the shallow and deep zones is delineated to the area south of Oneida Avenue. PCE in the intermediate aquifer zone extends from the upgradient portion of the shallow plume to the groundwater discharge point at the OSL Creek (see Figure 4-6 in Appendix B).

3. Although a definitive "source" of PCE was not identified in the RI report, the membrane interface probe (MIP) data, soil gas results, and sub-slab sampling results are indicative of PCE mass in soil in the vicinity and potentially beneath Bldg. 1885. Additionally, the highest PCE concentration in the intermediate zone (599 µg/L) was observed at PCERI-MW25I (screened at 35 to 45 feet bgs), 10 feet downgradient of Bldg. 1885. Bldg. 1885 may have been constructed over a historical PCE spill location as this area was historically used for vehicle storage, maintenance, and refueling purposes according to historical aerial photographs. Additionally, several smaller structures were present in the area before Bldg. 1885 was constructed in 2010.

2.5 ISCO Pilot Studies

2.5.1 November 2012 Permanganate ISCO Pilot Study

A sodium permanganate ($NaMnO_4$) ISCO pilot study was implemented at the Site in November 2012. The target area for the ISCO pilot study was a 0.5-acre area approximately 200 ft down-gradient of Building 1885 in the shallow zone (i.e., 30 to 40 ft bgs) (**Figure 3**). Forty injection wells were installed at variable spacing ranging from 15 to 25 ft with screened intervals at 30 to 40 ft bgs. Five-hundred gallons of 10% $NaMnO_4$ solution were injected at each well at flow rates that ranged from 1 to 8 gallons per minute (gpm) at pressures that ranged from 10 to 60 pounds per square inch (psi). Details of the November 2012 ISCO pilot study are provided in the *Draft Final Remedial Investigation Report – Addendum: Pilot Testing of Permanganate Injection* (PARS, 2013b).

2.5.2 May to July 2015 Permanganate ISCO Pilot Study

In mid-2015, the JV performed a second ISCO pilot study at the Site focused on the presumed source area in the vicinity of Bldg. 1885. The design for the second ISCO pilot study optimized the initial pilot approach by injecting a larger volume of $NaMnO_4$ solution to improve oxidant distribution. To focus resources on volume distribution, the injected $NaMnO_4$ concentration was reduced from 10% $NaMnO_4$, used for the initial pilot study, to approximately 2.6% $NaMnO_4$. Approximately 1,460 pounds of 40% by weight (wt%) of $NaMnO_4$ solution were applied per injection well, as compared to approximately 1,100 pounds of 40 wt% $NaMnO_4$ applied per injection well during the 2012 pilot study (note: liquid NaMnO4 is obtained from the manufacturer as a 40 wt% solution). Two dose response monitoring wells (IMW-05 and IMW-06) were installed and monitoring well PCERI-MW19S was replaced on May 12 and 13, 2015. Thirty-five

ISCO injection wells were installed in May and June 2015. Monitoring and injection well construction details are shown on **Figure 4**; additional injection details are provided in the *Final Injection Completion Report* (PIKA-MP JV, 2015d).

Baseline groundwater monitoring was conducted in June 2015. Oxidant injections took place in June and July 2015. A total of 98,934 gallons of 2.6% $NaMnO_4$ solution was injected into the 35 newly installed injection wells (**Figure 3**). With the exception of IW-10, which received 2,714 gallons of solution, all the injection wells achieved the target volume of 2,800 gallons. The average injection rate was 3.55 gpm, with the minimum average rate observed at IW-16 (1.46 gpm) and the maximum average rate observed at IW-07 (9.03 gpm).

Monitoring wells IMW-03, IMW-05, IMW-06, PCERI-MW25S, and PCERI-MW25I were used as dose response wells. The injection volume required to influence a particular radius of influence was established by analyzing the specific conductance and pH response at respective dose response wells, compared to the inject $NaMnO_4$ solution volume. Additionally, grab samples were analyzed for visual evidence of permanganate (i.e., via visual color analysis) and using field test kits for permanganate. Positive dose response was observed at IM-03, IMW-05, and PCERI-MW25S with both conductivity measurements and visual confirmation of permanganate arrival.

Three rounds of ISCO pilot study performance monitoring were conducted between August and November 2015. Groundwater samples were collected for VOCs and metals analysis from 10 performance monitoring wells. Groundwater sampling procedures and results are discussed in the *Performance Monitoring Data Summary Report – In-Situ Chemical Oxidation Pilot Study, 3800 Area PCE Site* (PIKA-MP JV, 2016). **Table 2** presents a summary of the pilot study analytical data for CVOCs and redox-sensitive metals.

The conclusions of the pilot study were as follows:

- Positive dose response for permanganate was observed at three of the five dose-response monitoring wells: IMW-03, IMW-05 and PCERI-MW25S. The positive dose response was verified with both conductivity measurements and visual confirmation of permanganate arrival.

- The baseline PCE concentrations at two of the dose response wells, PCERI-MW25S and PCERI-MW25I were significantly lower (nearly an order of magnitude) than during the 2011 RI sampling. Therefore, even though a

positive dose-response was observed at PCERI-MW25S, the VOC concentration reduction in August was fairly small (i.e., a reduction of 8.2 ug/L PCE at baseline, to 6 ug/L in August 2015).

- A significant reduction in VOC concentrations was observed at IMW-03, where PCE concentrations decreased from 130 ug/L at baseline (June 2015) to 61.5 ug/L in November 2015.

- Although there was an initial reduction in VOC concentrations at IMW-05, VOC concentrations rebounded above the baseline concentrations, indicating that there may be some sorbed PCE mass in this area.

- PCE concentrations at downgradient monitoring wells PCERI-MW19S and PCERI-MW19D, both located in the previous pilot study treatment area, were significantly lower than measured during the 2011 RI (see **Figure 3**), indicating that the effects of the previous permanganate application are long-term. Additionally, visible unreacted permanganate continues to provide oxidation treatment in the vicinity of PCERI-MW19I.

- Concentrations of redox-sensitive metals were generally below the GA standards. There were a few exceptions for chromium, lead, and selenium. Manganese concentrations exceeded the GA standards at the locations where unreacted permanganate was observed.

- In most cases, field and laboratory data have shown that the metals liberated by oxidation are readily attenuated to background conditions (ITRC, 2005). Therefore, the few groundwater quality criteria exceedances should not impede further ISCO treatment at the Site.

3. ISCO Remedy

The JV will implement the selected ISCO remedy for the 3800 Area PCE Site, as described in the ROD (NYSDEC, 2016). The remedy utilizes the existing injection well network with optimization via installation of additional injection wells and refinement of the injection strategy. Injection design parameters are based on the data from the RI (PARS, 2013a), the 2012 and 2015 pilot test injections discussed in Section 2.5, and baseline sampling conducted in May 2016 (see discussion below in **Section 3.2**). The ISCO program focuses treatment on the silty sands in the lower shallow and upper intermediate zones, where the bulk of the PCE mass is located, and which is the primary source for the PCE mass flux down-gradient. The scope of work for the remedial action includes the following major tasks:

1. Baseline sampling (conducted in May 2016)
2. Installation of additional injection wells to optimize the injection network
3. $NaMnO_4$ application and concurrent process monitoring
4. Performance monitoring
5. Reporting

3.1 Baseline Groundwater Sampling

Baseline groundwater sampling was conducted in May 2016 to establish pre-injection baseline conditions. Groundwater samples were collected from the same 10 monitoring wells that were monitored during the 2015 pilot study. A summary of the sampling results is shown on **Figure 3** and in **Table 2**; **Appendix D** contains a table presenting all of the laboratory analytical data.

The following observations are made based on a review of the May 2016 baseline data:

1. PCE concentrations rebounded at PCERI-MW25S and IMW-05 compared to the November 2015 data. The highest concentration of PCE measured at all of the wells was at IMW-05 (380 ug/L).
2. VOC concentrations at the remainder of the wells were similar to November 2015 results.
3. Manganese concentrations declined at all of the monitoring wells compared to the 2015 data, with the exception of PCERI-MW-19I, where unreacted permanganate was observed in May 2016.

3.2 Injection Well Installation

Based on the results of work done to date, seven additional injection wells will be installed to augment the existing injection well network, which includes 75 wells (**Figure 5**). Three new injection wells (IW-76, IW-77, and IW-78) are proposed on the northern boundary of Bldg. 1885 to improve permanganate distribution near and beneath Bldg. 1885 and in the vicinity of PCERI-MW25S and PCERI-MW25I. Four new injection wells (IW-79 to IW-82) are proposed in the northwest portion of the Site, near IMW-04, to augment the existing injection well network. The new injection wells will be screened from approximately 32 ft bgs to 42 ft bgs to target the same vertical intervals that were treated in the two previous pilot studies. This interval bridges the lower part of the shallow zone and the upper part of the intermediate zone. Since permanganate is more dense than water, it is expected that there will be additional vertical distribution of the oxidant below the target screened interval. This section discusses specific components of the injection well installation including utility clearance, drilling and well installation, well development, surveying, and waste characterization.

3.2.1 Permitting and Utility Clearance

Borehole and well construction permits will be secured through the Fort Drum Department of Public Works (DPW). Prior to drilling activities, a minimum of three lines of evidence will be used to clear utilities. The following lines of evidence will be used:

- A Fort Drum Dig Permit will be obtained and known utilities will be marked by Fort Drum personnel.
- Dig Safely New York One-Call will be notified (required even though drilling will take place on Fort Drum property).
- Site-specific markout using a privately contracted utility locator using ground penetrating radar and magnetic locating equipment (if needed) to identify utilities not included by Fort Drum PW.
- Hand clear each boring location to 5 feet vertical depth using air-knife or other soft-dig technology.

Injection well locations (**Figure 3**) will be field identified prior to utility mark-out. All field activities will be coordinated with current tenants of Bldg. 1885 and the surrounding parking areas.

3.2.2 Drilling and Well Installation

Seven injection wells are proposed to be installed. The target permanganate injection depths are based on RI results and the total depth of monitoring wells in the area. Injection well construction details are as follows:

- Separate boreholes will be advanced using hollow stem auger drilling methods for each well using 6.25-inch inner diameter steel augers. Total depth of the injection wells will be approximately 42 ft bgs.

- Based on the subsurface geology characterization from the 2015 pilot study, the injection wells will target the vertical interval from approximately 32 to 42 ft bgs. This interval bridges the lower part of the shallow zone and the upper part of the intermediate zone.

- The injection wells will be constructed of 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) casing and five feet of PVC wire-wrapped screen. The screen slot size will be 0.020 based on the results of a sieve analysis performed during the 2015 pilot study. Approximately six inches of sand will be placed in the borehole prior to installing the screen. After installing the sand pack, a two-ft layer of choker sand will be placed above the sand pack. The wells will then be grouted with neat cement using the tremie pipe method, which will be placed above the choker sand to within two ft bgs.

- The injection wells will be fitted with locking, steel protective casings (flush-mount), set in concrete well pads. The location and elevations of ground surface and the well measuring point (top of casing) for each well location will be surveyed as discussed below.

Injection well construction details are depicted on **Figure 4**. The SOP for well installation included in the IRP Work Plan (PIKA-MP JV, 2015) is referenced in **Table 1**.

3.2.3 Well Development

The wells will be developed to improve their hydraulic properties by removing sediment and clearing the well screen of fine particles. Well development will be performed no sooner than 24 hours after well installation to allow the neat cement to set and no later than five days after the well has been installed. Prior to developing each injection well, the initial water level and total depth will be measured. Following well development, the total depth will again be measured to evaluate the quantity of sediment removed (if any).

Well development will proceed with repeated alternating sequences of surging and removal of water from the well. The effectiveness of the development procedure will be monitored after each well volume has been removed by measurements of field parameters, such as turbidity, pH, oxidation-reduction potential (ORP), temperature, and specific conductivity. These field measurements and other observations will be recorded on a Well Development Log. Injection well development will be discontinued after a minimum of 10 well volumes have been removed. An SOP for well development is included in the IRP Work Plan (PIKA-MP JV, 2015) and referenced in **Table 1**.

3.2.4 Surveying

The horizontal coordinates of the new injection wells will be surveyed using a GeoPro XH handheld global positioning system unit. The unit has a sub-meter post-processing accuracy. The survey information will be tied into the existing site survey and Geographical Information System database for the project.

3.2.5 Waste Characterization

Drill cuttings and well development water will be retained on-site in 10-15 cubic yard roll offs or 55-gal drums pending waste characterization and appropriate off-site disposal. It is anticipated that the roll off and drums will be staged at the Site for no longer than six weeks from the start of waste accumulation.

3.3 Injection Equipment and Methodology

This section discusses the required procedure and equipment necessary to implement the oxidant injection, and presents details on the injection design and implementation.

3.3.1 Permitting

The existing United States Environmental Protection Agency (USEPA) Inventory of Injection Wells Form 7520-16, dated April 2015, will be updated and filed with the USEPA Underground Injection Control Section, USEPA Region II Offices in New York City for approval prior to ISCO implementation. NYSDEC acceptance of this Work Plan will be taken as permission for implementing the remedial action.

3.3.2 Injection Equipment

Oxidant injections will be performed using a temporary central mixing and injection (TCMI) system. Therefore, no permanent injection solution mixing and distributing infrastructure will be needed. Injection mixing infrastructure will be located as shown on **Figure 5**; however, the injection equipment can be staged at another location if necessary to minimize impact to building and base operations. The injection system will consist of a large mixing tank, injection/mixing pump, injection manifold, and well head assemblies (flow meter and pressure gauge). In consultation with Fort Drum DPW, injection water will be obtained from one or more of the fire hydrants located near the injection wells (**Figure 5**). A certified Reduced Pressure Zone backflow device will be placed between the hydrant and discharge hose to prevent backflow of water into the distribution system. The injection solution will be distributed via above grade hose/pipe to each injection area. Each injection area will have a manifold, allowing concurrent injection of at least half of the injection wells. $NaMnO_4$ will be delivered in 275 gallon totes or in bulk shipping tankers as a 40% solution. The TCMI system will be used to dilute the delivered solution down to the target solution concentrations.

3.3.3 Injection Design and Implementation

An oxidant loading evaluation was conducted using the analytical data from the RI and the bench-testing data from the 2012 pilot study. This evaluation included stoichiometric consideration of the contaminant mass based on analytical data, the laboratory-determined natural oxidant demand (NOD), and a safety factor of 20%. Potassium permanganate NOD testing was completed by Carus Remediation Technologies in November 2012 following ASTM D7262-07 Test Method A (PARS, 2013b). The results of the test showed the NOD of the soil is between 0.615 grams per kilogram (g/kg) and 0.664 g/kg. Generally, an oxidant demand less than 20 g/kg is favorable (PARS, 2013b), and the low NOD of the soils will result in minor $NaMnO_4$ utilization by competing organic material. Based on the stoichiometric evaluation, the target injection concentration is approximately 3% $NaMnO_4$ by weight. Based on the

analytical and investigation data provided from the RI and the previous oxidant injections, the target injection concentration was increased to 5% $NaMnO_4$ by weight for select injection wells located in the area near Bldg. 1885 (i.e., presumed source area) and in the area near PCERI-MW-04 (**Figure 5**).

The injection wells installed during the 2012 pilot study are spaced from 15 to 25 feet apart and have 10 ft screens. The injection wells installed during the 2015 pilot study are spaced 25 feet apart and have 5 ft screens. The target injection volume, $V_{injection}$, necessary to achieve breakthrough of a working strength concentration of permanganate at the injection radius for each injection well was estimated using the following equation, based on the volume of a cylinder:

$$V_{injection} = z*\pi*r^{2*}N_m$$

Where: $V_{injection}$ = Required injection volume

z = Saturated injection interval (5 ft for the 2015 wells and proposed 2017 wells; 10 ft for 2012 wells)
r = Target radius of influence (12.5 ft for the 2015, 2017, and some of the 2012 wells; average of 9 ft for some of the 2012 injection wells)
N_m= Mobile fraction of soils (15 percent [%])

For example:

$V_{injection} = 5\ ft * \pi * (12.5)^2 * 0.15 = 368\ ft^3 * 7.48\ gal/ft^3 = 2{,}752\ gallons$

The 15% mobile fraction determination for the injection volume is based on site soil conditions presented in historical documents as well as the JV's experience at Fort Drum.

The target volume of oxidant solution estimated for the injection well ranges from 2,800 gallons to 5,500 gallons, as shown in **Table 3**. The target volume was increase by 50% (i.e., to 4,200 gallons) at IW-01 to IW-07, with a target permanganate concentration of 3% to improve oxidant distribution beneath Bldg. 1885.

Following mobilization and setup of the ISCO distribution equipment, initial injection activities will include injection startup/shakedown procedures, operation, and performance monitoring. Startup/shakedown procedures will be conducted using clean water prior to injecting reagent solutions through the mixing and delivery system.

During startup/shakedown operation, system piping, valves, and appurtenances will be checked for leaks and proper operation.

After the clean water injection is completed and the injection piping is primed, oxidant will be mixed and injected. During mixing, oxidant will be handled in accordance with manufacturer's instructions and with appropriate personal protective equipment. The $NaMnO_4$ solution will be mixed on-site in batches in a temporary tank prior to injection. $NaMnO_4$, at the target injection concentrations of 3% to 5% by weight, is soluble and gentle agitation/stirring with a solution recirculation with a pump will achieve adequate dissolution. Field parameters will be measured in the injection solution to verify pH, specific conductivity, dissolved oxygen (DO), temperature, ORP and $NaMnO_4$ concentration (using field kits and visually checked against a serial dilution for color changes).

Concentrated $NaMnO_4$ solution will be pumped into a batch tank and mixed with potable water. The concentrated $NaMnO_4$ is delivered as a 40% by weight solution. **Table 3** shows the volume amount of 40% $NaMnO_4$ solution to be mixed with water to achieve the desired solution concentrations at each location. The diluted $NaMnO_4$ injection solution will be gravity fed or pumped to the injection well manifold. Injection solution flow rate, cumulative injected volume, and observed wellhead pressure will be monitored and recorded at each injection well periodically throughout the injection (e.g., once per every few hundred gallons injected per well). Injection pressure will be monitored to reduce the risk of well failure or surfacing of the injection solution. Based on the 2015 pilot study experience, injection pressures are not anticipated to exceed 5 psi; however, if process monitoring demonstrates that higher injection flow rates may be achieved without a corresponding increase in risk of failure, higher injection pressures may be implemented at select locations in a responsible manner. The piping components conveying the injection solution will be chemically compatible hose or PVC (compatible with $NaMnO_4$) and will be connected via cam locks with tethers or coder pins. No solution will be discharged to the ground surface. Flow meters and pressure gauges with chemically compatible wetted components will be used to determine injection flow rates, injection pressures, and cumulative volume injected. The calibration of the flow meters will be confirmed prior to the start of injection by conducting a flow check by running water into a five-gallon bucket to confirm the meters are reading correctly.

The exact duration of the injection is closely related to the relationship between injection pressure and injection flow rate, which may be limited by the variable geology

at the Site. Changes to the injection strategy may be made in the field to increase productivity so long as even distribution of reagent is achieved over the treatment area.

3.3.4 Permanganate Injection Health and Safety

Field work will be performed following the health and safety procedures described in the *Accident Prevention Plan, Installation Restoration Program, Fort Drum, New York* (PIKA-MP JV, 2015b) and the sodium permanganate injection Job Safety Analysis (JSA) provided in **Appendix A**. The appropriate Fort Drum department, including public works, environmental, and fire departments will be notified of the oxidant delivery and use before mobilizing to the Site. This will include providing a site plan of where the oxidant will be stored and quantity of reagent. In addition, the Safety Data Sheet for $NaMnO_4$ (**Appendix C**) will be provided to site personnel and taped to the mixing tank while work is conducted onsite.

Upon mobilization to the site, traffic barrels, cones, and/or caution tape will be used cordon off the work area and chemical storage/mixing areas. Secondary containment will be utilized at the mixing area and each manifold location. Secondary containment will be designed in consultation with Fort Drum to meet storage volume requirements. Based on lessons learned from the 2015 pilot study, the required secondary containment dimensions are 30 ft by 50 ft for each 6,900-gallon mixing tank. Personal protective equipment will be utilized as described in the JSA.

In the event of a spill of the 40% $NaMnO_4$, the product will be diluted with water to approximately 6%. Then a neutralizing agent consisting of 3 parts water, 4 parts vinegar, and 3 parts 3% hydrogen peroxide will be applied to the spill (see JSA in **Appendix A**).

3.3.5 ISCO Process Monitoring

Groundwater monitoring will be performed during the ISCO injection by monitoring real-time for field parameters, specifically specific conductivity, color, and pH, to evaluate the arrival of the injection solution. The dilute $NaMnO_4$ injection solution will have a specific conductivity greater than the ambient specific conductivity in groundwater at the Site. In addition, the dilute $NaMnO_4$ injection solution has a purple color that can be used as a qualitative assessment of the presence of the $NaMnO_4$ injection solution. Additionally, grab samples will be analyzed using field test kits for $NaMnO_4$ and visual inspection against a serial dilution will accompany specific conductivity and pH measurements to confirm the delivery of the injected solution. Lastly, manual depth to

water measurements will be recorded to understand the aquifer response to the applied hydraulic pressure.

On at least a weekly basis, JV staff will provide graphs to Army personnel showing specific conductivity measurements at monitoring wells near the active injection areas. The specific conductivity data are indicative of sodium and permanganate distribution during injection. Water level data and permanganate concentration data (both qualitative observations and qualitative measurements) will also be provided to Army personnel during the ISCO injection.

3.3.6 Demobilization

After completion of injection activities, JV personnel will remove all equipment, materials, and supplies from the Site. Incidental spills of permanganate that may occur during system breakdown will be addressed using a neutralizing agent as specified in the JSA included in **Appendix A**.

3.3.7 Post Injection Performance Monitoring

Three rounds of ISCO performance monitoring will be conducted at approximately 45 days, 90 days, and 180 days after injection, respectively. Wells included in the performance monitoring network are presented in **Table 4**. If groundwater samples contain visible evidence of unreacted permanganate (i.e., pink or purple color), the samples will be quenched using ascorbic acid before being sent to the laboratory for analysis. The preservation process will be conducted in accordance with the *USEPA Ground Water Sample Preservation at In-Situ Chemical Oxidation Sites – Recommended Guidelines* (**Appendix A**). Samples from these wells will also be field-analyzed for MnO_4 (via field colorimeter and visual comparison to serial dilution). Groundwater samples will be collected in a manner consistent with purging and sampling procedures used during the baseline sampling event. Water quality parameters including pH, ORP, conductivity, turbidity, and dissolved oxygen will be recorded during groundwater sample collection. The Fort Drum UFP-QAPP contains SOPs for groundwater sampling via several methods (e.g., low-flow, passive diffusion bags [PDBs]). These SOPs are referenced in **Table 1.**

Groundwater samples will be submitted to ALS Laboratories and analyzed for the following analytes:

- VOCs by USEPA SW-846 Method 8260 (compounds listed in Worksheet #15 of the QAPP)

- General Chemistry and Metals Analysis (Aluminum, Arsenic, Beryllium, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Nickel, Sodium, and Zinc)

Analytical results will be reported on a standard turnaround basis and validated in accordance with the QAPP (IRP Work Plan, Appendix A).

4. Schedule and Reporting

An Injection Completion Report will be prepared shortly after completion of the permanganate injection activities. The Injection Completion Report will provide an overview of the following topics:

- Permits obtained for the oxidant injection;
- Injection well installation procedures including drilling activities, as-built well details, and well development;
- Documentation of the disposal of soil cuttings and development water; and
- Discussion of oxidant injection equipment and injection implementation, including process monitoring results; and

Field logs will be attached documenting volumes of oxidant applied at each injection well.

After completion of the third planned groundwater monitoring event, a Remedial Action Construction Completion Report will be prepared to present the performance monitoring results of the ISCO remedy at the 3800 Area PCE Site. The Remedial Action Construction Completion Report will discuss the following topics:

- Remedial action objectives;
- A brief summary of the oxidant injection activities (details will have been provided in the Injection Completion Report);
- Groundwater sampling procedures;
- A data usability summary;
- Presentation and discussion of VOC concentrations over time at the 3800 Area PCE Site;
- Evaluation of the effects of the full-scale ISCO application on VOC concentrations at the 3800 Area PCE Site; and
- Conclusions based on the data evaluation and recommendations for future actions, if needed.

The proposed schedule for implementing the remedial action is provided on **Figure 6**. However, the final schedule will be dependent on the logistical requirements of the unit currently occupying the facility. A final updated schedule will be provided prior to the injection event.

5. References

EA Engineering, Science, and Technology, 2000. *Comprehensive Contaminant Assessment Report Volume I, Introduction and Overview Gasoline Alley, Fort Drum, New York*. September.

New York State Department of Environmental Conservation (NYSDEC) Division of Environmental Remediation, 2016. *Record of Decision, Fort Drum – Waste Disposal Areas, Operable Unit Number 02: 3800 PCE Site. State Superfund Project Fort Drum, Jefferson County, Site No. 623008*. March.

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Reynolds, R.J., 1986. Hydrogeology of the Fort Drum Area, Jefferson, Lewis, and St. Lawrence Counties, New York. U.S. Geological Survey Water-Resources Investigation Report 85-4119. U.S. Geological Survey, Albany, New York.

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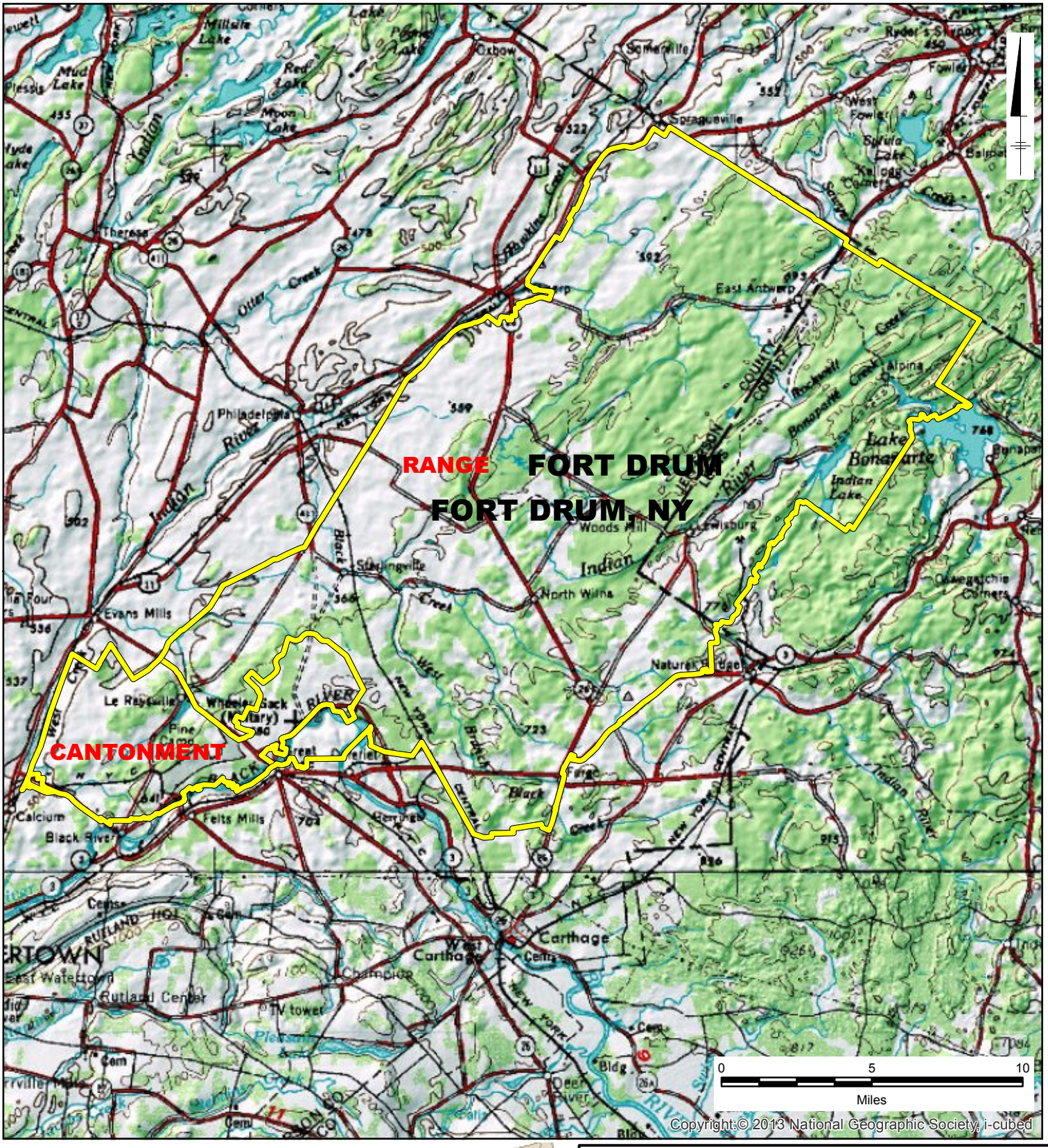
Figures



FORT DRUM
FORT DRUM, NEW YORK
3800 AREA PCE SITE - ISCO REMEDIAL ACTION WORK PLAN

SITE LOCATION MAP

FIGURE
1

CITY: MPLS DIV/GROUP: IM DB: MG LD: CK MADISON-KIPP
Z:\GISPROJECTS_ENV\ENV_FORTDRUM_IRP\MXD\PCE Work Plan\F1 SITE_LOCATION.mxd

LEGEND

Approximate 3800 Area PCE Site Boundary

0 400 800

GRAPHIC SCALE

FORT DRUM
FORT DRUM, NEW YORK

3800 AREA PCE SITE - ISCO REMEDIAL ACTION WORK PLAN

3800 AREA PCE SITE AND VICINITY

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FIGURE 2

CITY:(CHARLOTTE) DIV/GROUP:(ENV/GIS) DB:ssutton LD:S.SUTTON PIC: PM: TM:
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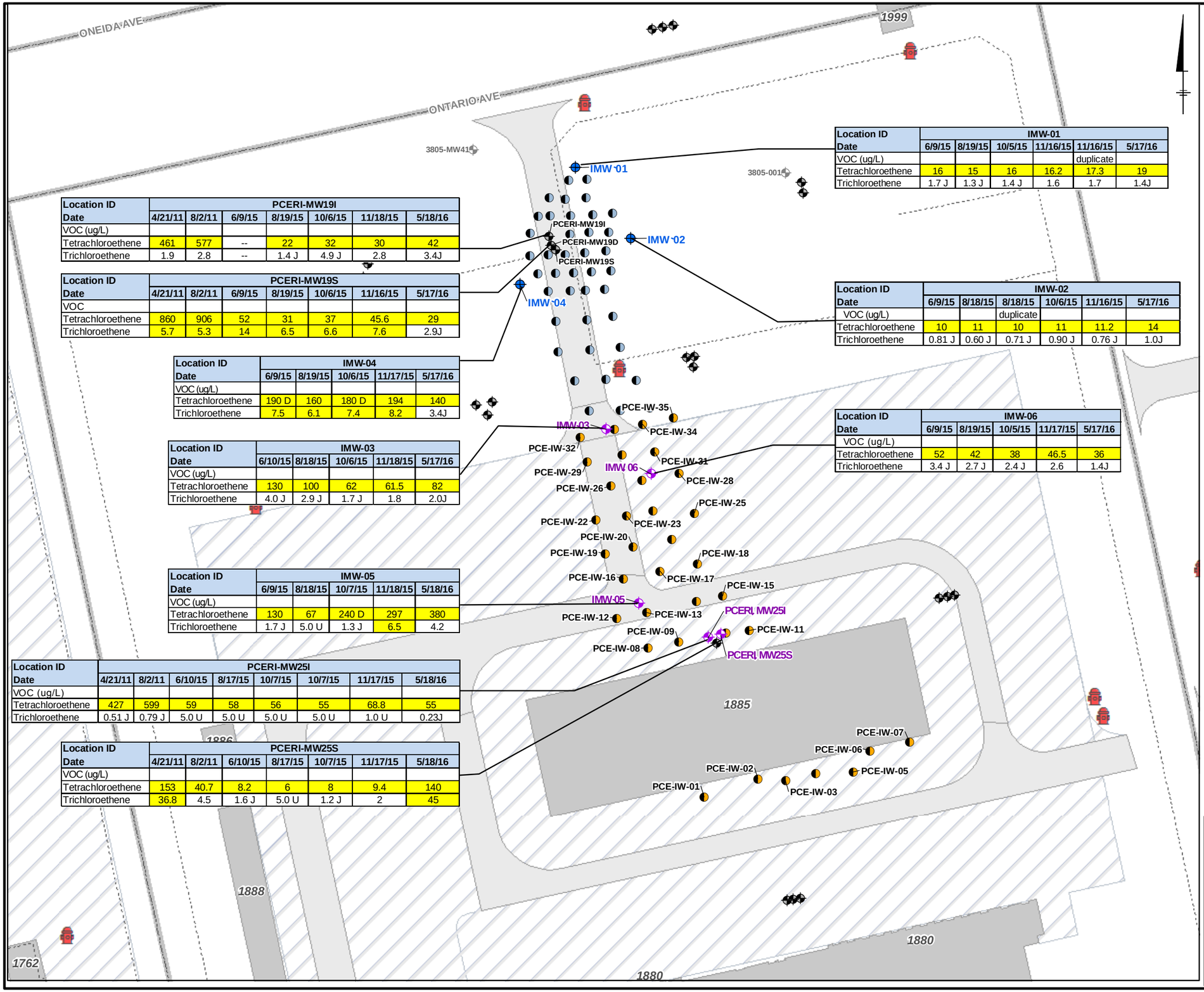

Location ID	PCERI-MW19I						
Date	4/21/11	8/2/11	6/9/15	8/19/15	10/6/15	11/18/15	5/18/16
VOC (ug/L)							
Tetrachloroethene	461	577	--	22	32	30	42
Trichloroethene	1.9	2.8	--	1.4 J	4.9 J	2.8	3.4J

Location ID	PCERI-MW19S						
Date	4/21/11	8/2/11	6/9/15	8/19/15	10/6/15	11/16/15	5/17/16
VOC							
Tetrachloroethene	860	906	52	31	37	45.6	29
Trichloroethene	5.7	5.3	14	6.5	6.6	7.6	2.9J

Location ID	IMW-04				
Date	6/9/15	8/19/15	10/6/15	11/17/15	5/17/16
VOC (ug/L)					
Tetrachloroethene	190 D	160	180 D	194	140
Trichloroethene	7.5	6.1	7.4	8.2	3.4J

Location ID	IMW-03				
Date	6/10/15	8/18/15	10/6/15	11/18/15	5/17/16
VOC (ug/L)					
Tetrachloroethene	130	100	62	61.5	82
Trichloroethene	4.0 J	2.9 J	1.7 J	1.8	2.0J

Location ID	IMW-05				
Date	6/9/15	8/18/15	10/7/15	11/18/15	5/18/16
VOC (ug/L)					
Tetrachloroethene	130	67	240 D	297	380
Trichloroethene	1.7 J	5.0 U	1.3 J	6.5	4.2

Location ID	PCERI-MW25I							
Date	4/21/11	8/2/11	6/10/15	8/17/15	10/7/15	10/7/15	11/17/15	5/18/16
VOC (ug/L)								
Tetrachloroethene	427	599	59	58	56	55	68.8	55
Trichloroethene	0.51 J	0.79 J	5.0 U	5.0 U	5.0 U	5.0 U	1.0 U	0.23J

Location ID	PCERI-MW25S						
Date	4/21/11	8/2/11	6/10/15	8/17/15	10/7/15	11/17/15	5/18/16
VOC (ug/L)							
Tetrachloroethene	153	40.7	8.2	6	8	9.4	140
Trichloroethene	36.8	4.5	1.6 J	5.0 U	1.2 J	2	45

Location ID	IMW-01					
Date	6/9/15	8/19/15	10/5/15	11/16/15	11/16/15	5/17/16
VOC (ug/L)					duplicate	
Tetrachloroethene	16	15	16	16.2	17.3	19
Trichloroethene	1.7 J	1.3 J	1.4 J	1.6	1.7	1.4J

Location ID	IMW-02					
Date	6/9/15	8/18/15	8/18/15	10/6/15	11/16/15	5/17/16
VOC (ug/L)			duplicate			
Tetrachloroethene	10	11	10	11	11.2	14
Trichloroethene	0.81 J	0.60 J	0.71 J	0.90 J	0.76 J	1.0J

Location ID	IMW-06				
Date	6/9/15	8/19/15	10/5/15	11/17/15	5/17/16
VOC (ug/L)					
Tetrachloroethene	52	42	38	46.5	36
Trichloroethene	3.4 J	2.7 J	2.4 J	2.6	1.4J

LEGEND

- 2012 ISCO PILOT DOSE-RESPONSE WELLS
- 2015 ISCO PILOT DOSE-RESPONSE WELLS
- 2015 ISCO INJECTION WELLS
- MONITORING WELL
- PCE SITE RI MONITORING WELL
- 2012 ISCO PILOT INJECTION WELLS
- HYDRANT
- FENCE LINE
- ROAD CENTERLINE
- BUILDING
- PARKING AREA

0 80 160

GRAPHIC SCALE

FORT DRUM
FORT DRUM, NEW YORK
3800 AREA PCE SITE ISCO REMEDIAL ACTION WORK PLAN

ISCO PILOT STUDY AND BASELINE (MAY 2016) SAMPLING RESULTS

FIGURE
3

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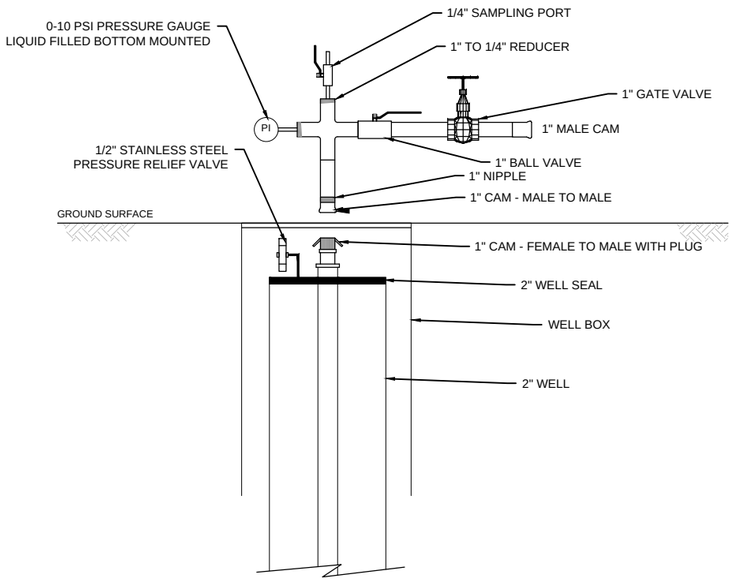
NOTES:

- WELL SEAL CONSISTS OF NEAT CEMENT GROUT WITH NO BENTONITE SEAL. CEMENT MUST BE ALLOWED TO SET UP FOR A MINIMUM OF 24-HOURS PRIOR TO DEVELOPMENT.
- FINE SAND PLACED ABOVE WELL SAND PACK TO PREVENT MIGRATION OF NEAT CEMENT TO WELL SCREEN.
- SAND PACK SIZE AND WELL SCREEN SLOT SIZE WERE SELECTED BASED ON AQUIFER FORMATION GRAIN SIZE ANALYSIS PERFORMED IN 2015.
- WELL MATERIALS MUST BE SELECTED TO BE COMPATIBLE WITH INJECTION FLUIDS.
- PROTECTIVE COVER TO BE DESIGNED TO MEET PROJECT SPECIFICATIONS. TRAFFIC RATED COVERS TO BE USED IN HIGH TRAFFIC AREAS. TRAFFIC RATED COVERS REQUIRE REINFORCED CONCRETE PADS.
- FINAL WELL DEPTH TO BE DETERMINED BY GEOLOGIST INSTALLING THE WELL.

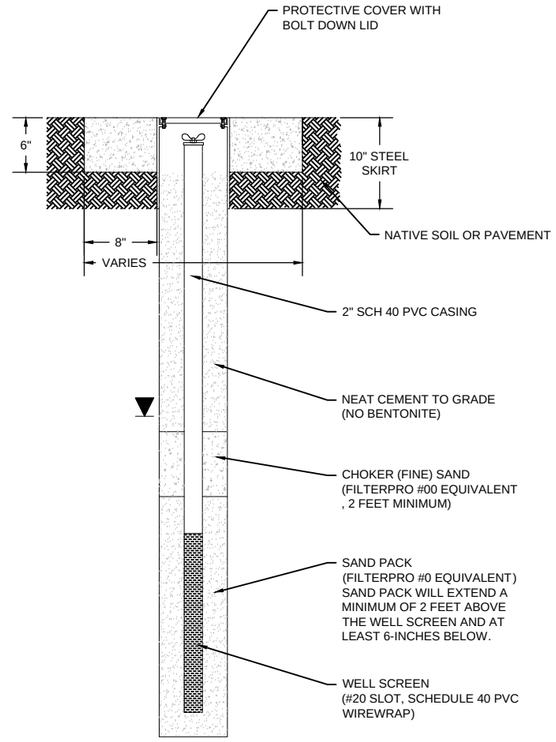
WELL ID	DIAMETER/MATERIAL	SCREEN LENGTH (FT)	WELL DEPTH (FT BGS)	SCREEN DEPTH (FT BGS)		SLOT SIZE (INCH)	SCREEN MATERIAL
				FROM (TOP)	TO (BOTTOM)		
INJECTION WELL							
IW-01	2" PVC	10	42 (APPROX.)	32	42	0.020	PVC-WIRE WRAP

NOTES:
1. DETAILS FOR ALL 7 INJECTION WELLS ARE TYPICAL OF IW-01



INJECTION WELLHEAD CONSTRUCTION DETAIL

NOT TO SCALE



INJECTION WELL CONSTRUCTION

NOT TO SCALE

U.S. ARMY CORPS OF ENGINEERS • FORT DRUM, NY

3800 AREA PCE SITE - ISCO REMEDIAL ACTION WORK PLAN

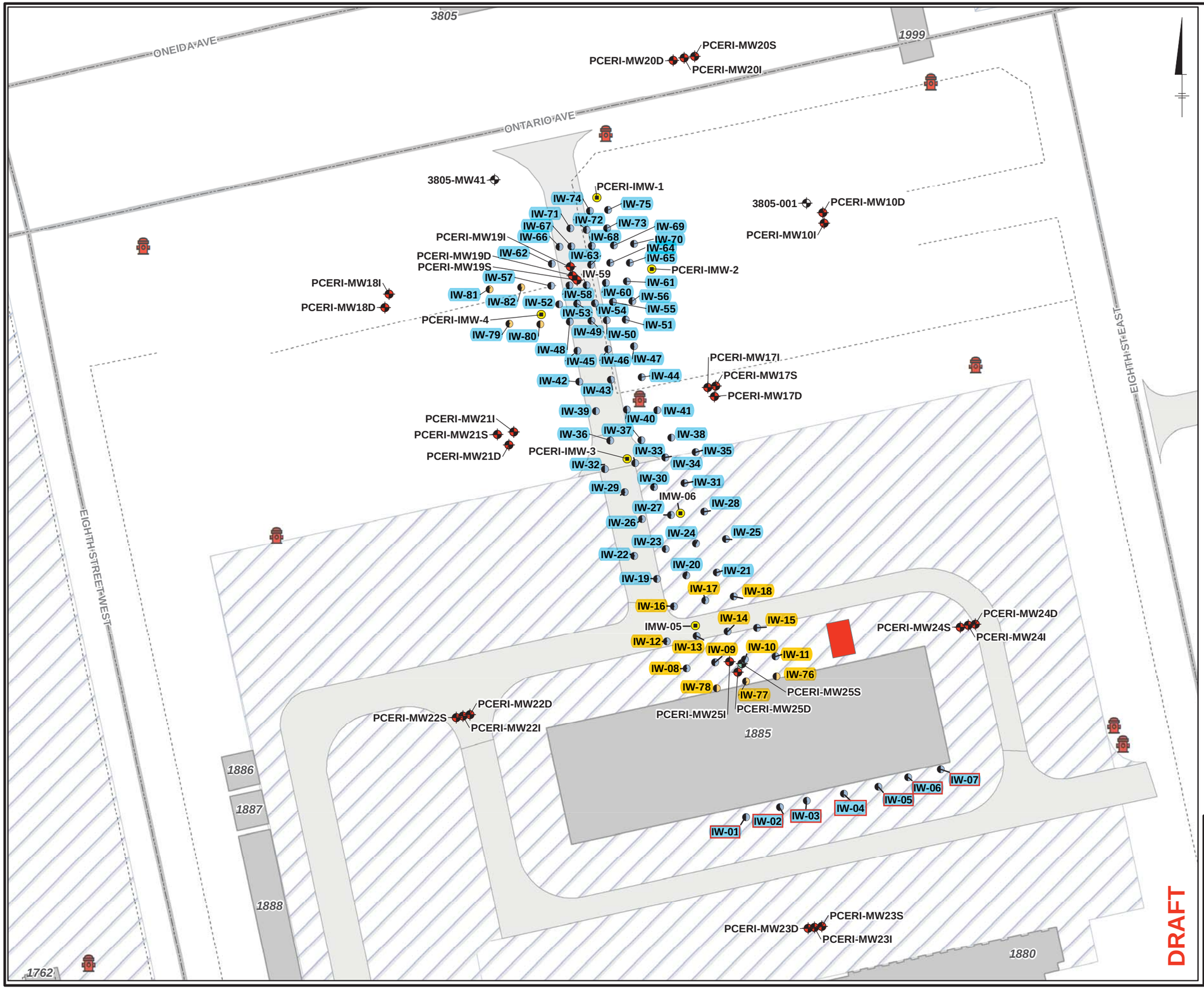
INJECTION WELL CONSTRUCTION DETAIL

MECHANICAL

Project No. GP14DRUM.0001

Date MARCH, 2017

PIKA - MP JV LLC
12723 CAPRICORN DRIVE
SUITE 500
STAFFORD, TEXAS 77477



LEGEND

- EXISTING ISCO INJECTION WELLS
- PROPOSED INJECTION WELLS
- ISCO DOSE-RESPONSE WELLS
- MONITORING WELL
- PCE SITE RI MONITORING WELL
- PROPOSED INJECTION MIXING EQUIPMENT LOCATION
- HYDRANT
- FENCE LINE
- DRUM ROAD CENTERLINE
- BUILDING
- PARKING AREA
- IW-35 3% TARGET $NaMnO_4$ SOLUTION
- IW-35 5% TARGET $NaMnO_4$ SOLUTION
- IW-35 3% TARGET $NaMnO_4$ SOLUTION WITH 50% ADDITIONAL VOLUME

NOTES:

1. Injection wells IW-01 to IW-35 were installed in May to June, 2015.
2. Injection wells IW-36 to IW-75 were installed in October to November, 2012.
3. Injection wells IW-76 to IW-82 are proposed for installation in April 2017.

0 80 160

GRAPHIC SCALE

FORT DRUM
FORT DRUM, NEW YORK
3800 AREA PCE SITE-ISCO REMEDIAL ACTION WORK PLAN

ISCO INJECTION AND DOSE RESPONSE WELLS

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FIGURE 5

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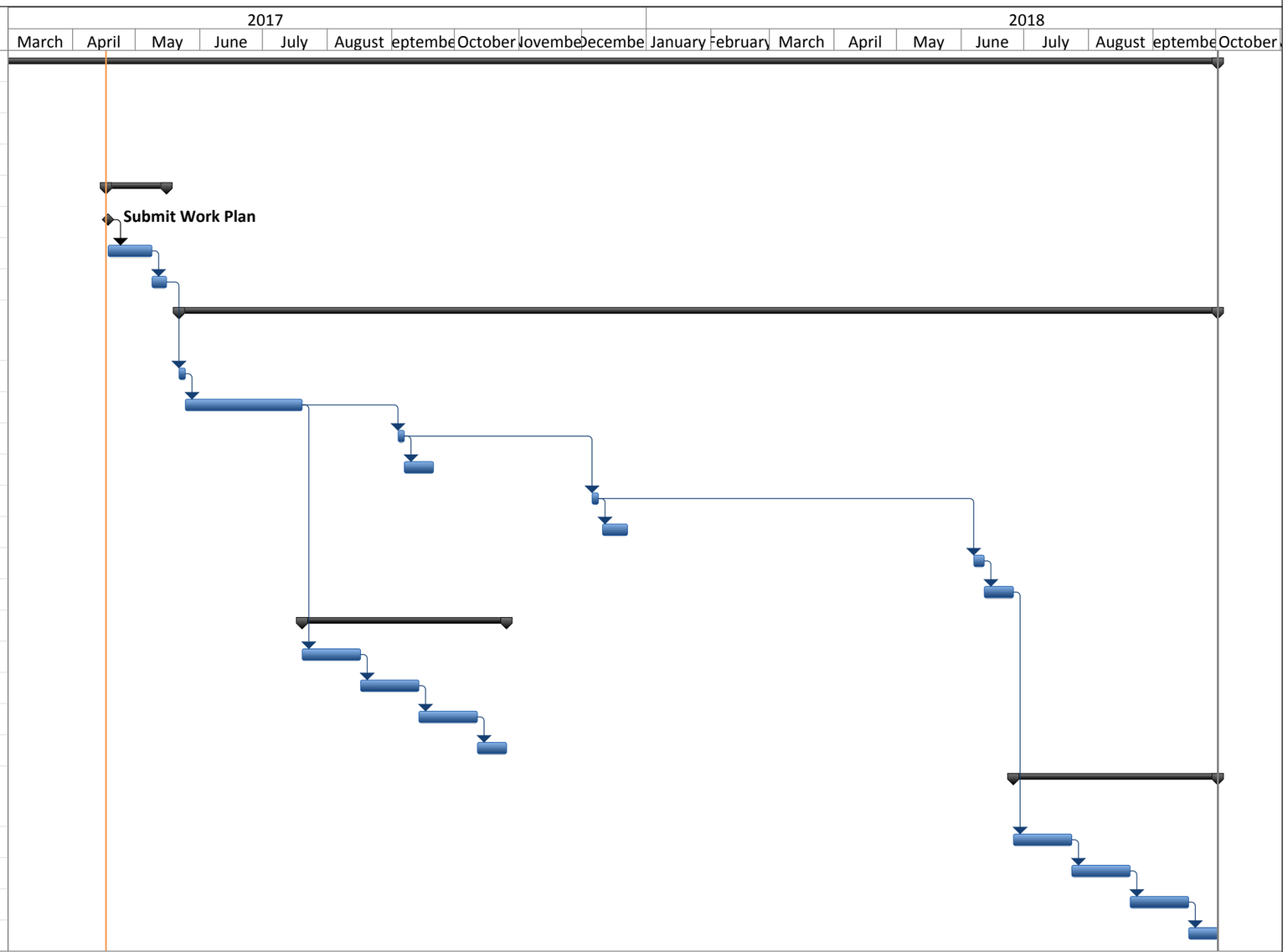
Figure 6
Schedule for In-Situ Chemical Oxidation Remedial Action at the 3800 Area PCE Site
Fort Drum Installation Restoration Program
Fort Drum, New York

ID	Task Name	Start	Finish
1	**Remedial Action at 3800 Area PCE Site**	**Mon 5/23/16**	**Mon 10/1/18**
2	**Task 1: Groundwater Sampling - Current Conditions**	**Mon 5/23/16**	**Fri 6/10/16**
3	Field Sampling	Mon 5/23/16	Fri 5/27/16
4	Laboratory Analysis	Mon 5/30/16	Fri 6/10/16
5	**Task 2: Remedial Action Work Plan**	**Mon 4/17/17**	**Mon 5/15/17**
6	Submit Work Plan	Mon 4/17/17	Mon 4/17/17
7	NYSDEC Review	Tue 4/18/17	Mon 5/8/17
8	Final Work Plan	Tue 5/9/17	Mon 5/15/17
9	**Task 3: Implement Remedial Action and Performance Monitoring**	**Mon 5/22/17**	**Mon 10/1/18**
10	Mobilization and Set-up	Mon 5/22/17	Wed 5/24/17
11	Permanganate Injection	Thu 5/25/17	Wed 7/19/17
12	Performance Monitoring Event 1 (Approx. +45 days)	Mon 9/4/17	Wed 9/6/17
13	Laboratory Analysis	Thu 9/7/17	Wed 9/20/17
14	Performance Monitoring Event 2 (Approx. +90 days)	Wed 12/6/17	Fri 12/8/17
15	Laboratory Analysis	Mon 12/11/17	Fri 12/22/17
16	Performance Monitoring Event 3 (Approx. +180 days)	Thu 6/7/18	Mon 6/11/18
17	Laboratory Analysis	Tue 6/12/18	Mon 6/25/18
18	**Task 4: Injection Completion Report**	**Thu 7/20/17**	**Wed 10/25/17**
19	Draft Report	Thu 7/20/17	Wed 8/16/17
20	Army Review and Document Revisions	Thu 8/17/17	Wed 9/13/17
21	NYSDEC Review	Thu 9/14/17	Wed 10/11/17
22	Final Report	Thu 10/12/17	Wed 10/25/17
23	**Task 5: Remedial Action Construction Completion Report**	**Tue 6/26/18**	**Mon 10/1/18**
24	Draft Report	Tue 6/26/18	Mon 7/23/18
25	Army Review and Document Revisions	Tue 7/24/18	Mon 8/20/18
26	NYSDEC Review	Tue 8/21/18	Mon 9/17/18
27	Final Report	Tue 9/18/18	Mon 10/1/18



Project: 3800 PCE Site Remedial A
Date: Mon 4/17/17

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	
Summary	Inactive Task	Duration-only	Finish-only	

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Tables

Table 1 - Fort Drum IRP UFP-QAPP – Applicable Field SOPs
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

SOP # or reference[1]	Title, Revision, Date, and URL (if available)	SOP option or Equipment Type (if SOP provides different options)	Modified for Project? Y/N	Comments
1213199	Field Equipment Decontamination, Revision 3, April 2010	Applies to all general field equipment	N	N/A
1343199	Measuring Basic Water Quality In-SItu, Revision 1, April 2005	Horiba U-10 or equivalent	Y	Likely, a Horiba U-52 or U-53 will be used
1663199	Chain of Custody, Handling, Packing and Shipping, Revision 2, March 2009	N/A	N	N/A
1673199	Hazardous Materials Handling, Revision 0, August 2003	N/A	N	N/A
3136199	Investigation-Derived Waste Handling and Storage, Revision # 2, 2009	55 gal. drum, polyethylene storage tank	N	N/A
4098782	Field Log Book Entries, Revision # 0, August 2009	N/A	N	N/A
1763199	Photoionization Detector and Field Screening, Revision #1, November 2009	PID & Cal. canisters	N	N/A
1643199	Water Level Measurement, Revision # 2, February 2011	N/A	N	N/A
1833199	Standard Groundwater Sampling for Monitoring Wells, Revision # 1, July 2008	Bladder and Peristaltic Pumps	N	N/A
2003199	Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells, Revision # 4, February 2011	Bladder and Peristaltic Pumps, QED MP10 Controller/Compressor	N	N/A
9098782	Hazardous Weather Procedures, Revision # 2, June 2014	N/A	N	N/A

SOP # or reference[1]	Title, Revision, Date, and URL (if available)	SOP option or Equipment Type (if SOP provides different options)	Modified for Project? Y/N	Comments
0751011022	Monitoring Well Development, Revision # 2.2, March 2010	N/A	N	N/A
1603199	Drilling Procedures for Collecting and Screening of Soil Samples, Revision # 2, March 2008	N/A	N	N/A
1643199	Water Level and NAPL Thickness Measurement Procedures, Revision # 0, February 2009	N/A	N	N/A
1723199	Monitoring Well Installation, Revision # 3, February 2011	N/A	N	N/A
1733199	Multiple Gas Air Monitoring and Field Screening	N/A	N	N/A
298782	Monitoring Well Integrity Survey, Revision # 0, February 2009	N/A	N	N/A
315199	Soil Drilling and Sample Collection, Revision # 3, September 2014	N/A	N	N/A
7098782	Bailer-Grab Groundwater Sampling, Revision # 0, March 2009	N/A	N	N/A
SS-00188782	Soil Description, Revision # 0, May 2008	N/A	N	N/A
1623199	Heavy Equipment Decontamination, Revision # 1, May 2008	N/A	N	N/A
01092939	Ground Penetrating Radar, Revision # 2, May 2009	N/A	N	N/A
11042010	Utility Locating Using Radio Frequency Methods, Revision # 00, November 2010	N/A	N	N/A
ALS Website	Passive Diffusion Bags (PDB) Samplers Instructions	N/A	N	N/A

Notes: 1. Copies of the field SOPs are included in the Fort Drum IRP UFP-QAPP.

Table 2 - Summary of 2015 Pilot Study and 2016 Baseline Sampling Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW01 06/09/15	PCERI-IMW01 08/19/15	PCERI-IMW01 10/05/15	PCERI-IMW01 11/16/15	PCERI-IMW01 05/17/16
Volatile Organics								
Tetrachloroethene	127-18-4	5	ug/L	**16**	**15**	**16**	**16.2 [17.3]**	**19**
Trichloroethene	79-01-6	5	ug/L	1.7 J	1.3 J	1.4 J	1.7 [1.6]	1.4 J
Redox-Sensitive Metals								
Arsenic	7440-38-2	25	ug/L	10 U	4.6 J	3.9 J	3 U [3 U]	10 U
Barium	7440-39-3	1,000	ug/L	33.8	32.6	57	35 [34]	36.9
Cadmium	7440-43-9	5	ug/L	5 U	5 U	5 U	1.1 U [1.1 U]	5 U
Chromium	7440-47-3	50	ug/L	6 J	5.4 J	22.7	4.3 [4.2]	0.3 J
Iron	7439-89-6	300***	ug/L	**358**	**335**	**4,060**	300 [260]	11.1 J
Lead	7439-92-1	25	ug/L	2.3 J	2.3 J	1.7 J	2.2 U [2.2 U]	5 U
Manganese	7439-96-5	300***	ug/L	70.1	55.1	**423**	32 [32]	2.3 J
Selenium	7782-49-2	10	ug/L	10 U	10 UE	10 U	5.6 U [5.6 U]	10 U
Silver	7440-22-4	50	ug/L	10 U	1.9 J	1.6 J	2.2 U [2.2 U]	10 U
Sodium	7440-23-5	20,000	ug/L	**51,800**	**59,700**	**61,400**	**64,600 [65,800]**	**70,000**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

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UB - Compound considered non-detect at the listed value due to associated blank contamination.

Table 2 - Summary of 2015 Pilot Study and 2016 Baseline Sampling Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW02 06/09/15	PCERI-IMW02 08/18/15	PCERI-IMW02 10/06/15	PCERI-IMW02 11/16/15	PCERI-IMW02 05/17/16
Volatile Organics								
Tetrachloroethene	127-18-4	5	ug/L	**10**	**11 [10]**	**11**	**11.2**	**14**
Trichloroethene	79-01-6	5	ug/L	0.81 J	0.6 J [0.71 J]	0.9 J	0.76 J	1 J
Redox-Sensitive Metals								
Arsenic	7440-38-2	25	ug/L	10 U	4.5 J [5.4 J]	3 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	26.2	25.1 [26]	25.6	27	25.4
Cadmium	7440-43-9	5	ug/L	5 U	5 U [5 U]	5 U	1.1 U	5 U
Chromium	7440-47-3	50	ug/L	13.5	18.9 J [32.2 J]	5.6 J	8.7	7.3 J
Iron	7439-89-6	300***	ug/L	227	**514 J [854 J]**	**534**	**350**	**715**
Lead	7439-92-1	25	ug/L	3 J	2 J [2.5 J]	5 U	2.2 U	5 U
Manganese	7439-96-5	300***	ug/L	5.5 J	9.6 J [13.3]	8.4 J	9.5	10.1
Selenium	7782-49-2	10	ug/L	10 U	10 UE [10 UE]	10 U	5.6 U	10 U
Silver	7440-22-4	50	ug/L	10 U	1.9 J [1.9 J]	1.4 J	2.2 U	10 U
Sodium	7440-23-5	20,000	ug/L	**76,300**	**75,600 [77,200]**	**79,100**	**80,300**	**86,900**

* Guidance Value

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Table 2 - Summary of 2015 Pilot Study and 2016 Baseline Sampling Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW03 06/10/15	PCERI-IMW03 08/18/15	PCERI-IMW03 10/06/15	PCERI-IMW03 11/18/15	PCERI-IMW03 05/17/16
Volatile Organics								
Tetrachloroethene	127-18-4	5	ug/L	**130**	**100**	**62**	**61.5 J-**	**82**
Trichloroethene	79-01-6	5	ug/L	4 J	2.9 J	1.7 J	1.8 J-	2 J
Redox-Sensitive Metals								
Arsenic	7440-38-2	25	ug/L	10 U	5.1 J	5 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	37.6	36.6	34.6	36	31.4
Cadmium	7440-43-9	5	ug/L	5 U	5 U	5 U	1.1 U	5 U
Chromium	7440-47-3	50	ug/L	45.6	34.3	**75.9**	**73**	28.7
Iron	7439-89-6	300***	ug/L	**804**	**628**	**348**	**770**	**501**
Lead	7439-92-1	25	ug/L	3.4 J	2 J	1.9 J	2.2 U	5 U
Manganese	7439-96-5	300***	ug/L	29.1	**1,400**	**111,000**	220	56.8
Selenium	7782-49-2	10	ug/L	10 U	10 UE	5.3 J	1.9 J	10 U
Silver	7440-22-4	50	ug/L	10 U	2.6 J	4.1 J	2.2 U	10 U
Sodium	7440-23-5	20,000	ug/L	**120,000**	**130,000**	**161,000**	**239,000**	**147,000**

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Table 2 - Summary of 2015 Pilot Study and 2016 Baseline Sampling Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW04 06/09/15	PCERI-IMW04 08/19/15	PCERI-IMW04 10/06/15	PCERI-IMW04 11/17/15	PCERI-IMW04 05/17/16
Volatile Organics								
Tetrachloroethene	127-18-4	5	ug/L	**190 D**	**160**	**180 D**	**194**	**140**
Trichloroethene	79-01-6	5	ug/L	**7.5**	**6.1**	**7.4**	**8.2**	3.4 J
Redox-Sensitive Metals								
Arsenic	7440-38-2	25	ug/L	10 U	5.3 J	4.6 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	22.5	33.6	28.8	26	35.3
Cadmium	7440-43-9	5	ug/L	5 U	5 U	5 U	1.1 U	5 U
Chromium	7440-47-3	50	ug/L	4.5 J	8.8 J	6.8 J	8.2	11.9
Iron	7439-89-6	300***	ug/L	**1,040**	**1,840**	**912**	**1,000**	**975**
Lead	7439-92-1	25	ug/L	4.7 J	3.2 J	5 U	2.2 U	5 U
Manganese	7439-96-5	300***	ug/L	26.3	40.1	33	22	20.8
Selenium	7782-49-2	10	ug/L	10 U	10 UE	10 U	5.6 U	10 U
Silver	7440-22-4	50	ug/L	0.634 J	3.5 J	1.7 J	0.86 J	0.5 J
Sodium	7440-23-5	20,000	ug/L	**98,400**	**106,000**	**99,000**	**96,800**	**126,000**

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Table 2 - Summary of 2015 Pilot Study and 2016 Baseline Sampling Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW05 06/10/15	PCERI-IMW05 08/18/15	PCERI-IMW05 10/07/15	PCERI-IMW05 11/18/15	PCERI-IMW05 05/18/16
Volatile Organics								
Tetrachloroethene	127-18-4	5	ug/L	**130**	**67**	**240 D**	**297 J-**	**380 D**
Trichloroethene	79-01-6	5	ug/L	1.7 J	5 U	1.3 J	**6.5**	4.2 J
Redox-Sensitive Metals								
Arsenic	7440-38-2	25	ug/L	10 U	9.9 J	3.4 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	31.5	35	22.8	76	23.4
Cadmium	7440-43-9	5	ug/L	5 U	5 U	5 U	1.1 U	5 U
Chromium	7440-47-3	50	ug/L	0.779 J	31.1	1.7 J	2.9	10 U
Iron	7439-89-6	300***	ug/L	15.1 J	**1,160**	19.8 J	**1,300**	218
Lead	7439-92-1	25	ug/L	2.7 J	7.7	5 U	2.2 U	5 U
Manganese	7439-96-5	300***	ug/L	32.2	**38,600**	**537**	**4,200**	287
Selenium	7782-49-2	10	ug/L	10 U	100 UE	10 U	5.6 U	10 U
Silver	7440-22-4	50	ug/L	10 U	8.9 J	1.5 J	0.99 J	10 U
Sodium	7440-23-5	20,000	ug/L	**110,000**	**149,000**	**105,000**	**89,000**	**63,500**

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Table 2 - Summary of 2015 Pilot Study and 2016 Baseline Sampling Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW06 06/10/15	PCERI-IMW06 08/18/15	PCERI-IMW06 10/06/15	PCERI-IMW06 11/17/15	PCERI-IMW06 05/17/16
Volatile Organics								
Tetrachloroethene	127-18-4	5	ug/L	**52**	**42**	**38**	**46.5**	**36**
Trichloroethene	79-01-6	5	ug/L	3.4 J	2.7 J	2.4 J	2.6	1.4 J
Redox-Sensitive Metals								
Arsenic	7440-38-2	25	ug/L	2.2 J	5.4 J	3.7 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	25.5	29.8	26.4	28	37.7
Cadmium	7440-43-9	5	ug/L	5 U	5 U	5 U	1.1 U	5 U
Chromium	7440-47-3	50	ug/L	4.1 J	2.6 J	2 J	3.8	3 J
Iron	7439-89-6	300***	ug/L	**506**	**1,590**	**499**	**830**	**1,530**
Lead	7439-92-1	25	ug/L	3.1 J	3 J	5 U	2.2 U	5 U
Manganese	7439-96-5	300***	ug/L	54.7	38.2	34.3	26	27.2
Selenium	7782-49-2	10	ug/L	10 U	10 UE	10 U	5.6 J	10 U
Silver	7440-22-4	50	ug/L	10 U	1.8 J	1.3 J	2.2 U	10 U
Sodium	7440-23-5	20,000	ug/L	**114,000**	**108,000**	**105,000**	**112,000**	**99,200**

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3800 Area PCE Site
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Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19I 04/21/11	PCERI-MW19I 08/02/11	PCERI-MW19I 06/09/15	PCERI-MW19I 08/19/15	PCERI-MW19I 10/06/15	PCERI-MW19I 11/18/15	PCERI-MW19I 05/18/16
Volatile Organics										
Tetrachloroethene	127-18-4	5	ug/L	**461**	**577**	NA	**22**	**32**	**30 J-**	**42**
Trichloroethene	79-01-6	5	ug/L	1.9	2.8	NA	1.4 J	4.9 J	2.8 J-	3.4 J
Redox-Sensitive Metals										
Arsenic	7440-38-2	25	ug/L	NA	NA	5.2 J	**78.3**	**26.5**	27 U	10 U
Barium	7440-39-3	1,000	ug/L	NA	NA	4.4 J	20 U	20 U	50 U	12.4 J
Cadmium	7440-43-9	5	ug/L	NA	NA	5 U	5 U	5 U	9.9 U	5 U
Chromium	7440-47-3	50	ug/L	NA	NA	35.4	**323**	**230**	**90**	50 U
Iron	7439-89-6	300***	ug/L	NA	NA	51.8 J	100 U	500 U	500 U	144
Lead	7439-92-1	25	ug/L	NA	NA	8.6	**77.3**	**35.2**	20 U	**30**
Manganese	7439-96-5	300***	ug/L	NA	NA	**52,100**	**569,000**	**593,000**	**406,000**	**333,000**
Selenium	7782-49-2	10	ug/L	NA	NA	**42.1**	5,000 UE	**175**	50 U	**108**
Silver	7440-22-4	50	ug/L	NA	NA	14.7	**99.1**	43.6	20 U	10 U
Sodium	7440-23-5	20,000	ug/L	NA	NA	**312,000**	**1,140,000**	**369,000**	**390,000**	**364,000**

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3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19S 04/21/11	PCERI-MW19S 08/02/11	PCERI-MW19S 06/09/15	PCERI-MW19S 08/19/15	PCERI-MW19S 10/06/15	PCERI-MW19S 11/16/15	PCERI-MW19S 05/17/16
Volatile Organics										
Tetrachloroethene	127-18-4	5	ug/L	**860**	**906**	**52**	**31**	**37**	**45.6**	**29 [32]**
Trichloroethene	79-01-6	5	ug/L	**5.7**	**5.3**	**14**	**6.5**	**6.6**	**7.6**	2.9 J [3.1 J]
Redox-Sensitive Metals										
Arsenic	7440-38-2	25	ug/L	NA	NA	1.3 J	6.8 J	4.7 J	3 U	10 U [10 U]
Barium	7440-39-3	1,000	ug/L	NA	NA	26	45	40.7	60	37.9 [38.3]
Cadmium	7440-43-9	5	ug/L	NA	NA	5 U	5 U	5 U	1.1 U	5 U [5 U]
Chromium	7440-47-3	50	ug/L	NA	NA	2 J	1.9 J	0.671 J	2 J	10 U [10 U]
Iron	7439-89-6	300***	ug/L	NA	60 U	**326**	**2,210**	**775**	**450**	**477 [414]**
Lead	7439-92-1	25	ug/L	NA	NA	2.5 J	2.9 J	3.9 J	2.2 U	5 U [5 U]
Manganese	7439-96-5	300***	ug/L	NA	NA	70.2	68.2	39.7	25	12.1 [12.1]
Selenium	7782-49-2	10	ug/L	NA	NA	10 U	10 UE	10 U	5.6 U	10 U [10 U]
Silver	7440-22-4	50	ug/L	NA	NA	10 U	2.1 J	1.4 J	2.2 U	10 U [10 U]
Sodium	7440-23-5	20,000	ug/L	NA	NA	**108,000**	**115,000**	**103,000**	**98,300**	**10,000 [111,000**

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3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW25I 04/21/11	PCERI-MW25I 08/02/11	PCERI-MW25I 06/10/15	PCERI-MW25I 08/17/15	PCERI-MW25I 10/07/15	PCERI-MW25I 11/17/15	PCERI-MW25I 05/18/16
Volatile Organics										
Tetrachloroethene	127-18-4	5	ug/L	**427**	**599**	**59**	**58**	**56 [55]**	**68.8**	**55**
Trichloroethene	79-01-6	5	ug/L	0.51 J	0.79 J	5 U	5 U	5 U [5 U]	1 U	0.23 J
Redox-Sensitive Metals										
Arsenic	7440-38-2	25	ug/L	NA	NA	10 U	7.6 J	2.8 J [3.2 J]	3 U	10 U
Barium	7440-39-3	1,000	ug/L	NA	NA	29.9	25.2	24.9 [25.6]	27	29
Cadmium	7440-43-9	5	ug/L	NA	NA	5 U	5 U	5 U [5 U]	1.1 U	5 U
Chromium	7440-47-3	50	ug/L	NA	NA	4.3 J	16.8	2.7 J [6.7 J]	2.8	1.3 J
Iron	7439-89-6	300***	ug/L	NA	NA	**856**	212	**329 [548]**	280	158
Lead	7439-92-1	25	ug/L	NA	NA	3 J	5.1	5 U [5 U]	2.2 U	5 U
Manganese	7439-96-5	300***	ug/L	NA	NA	42.3	**19,400**	75.4 [76.7]	43	16.4
Selenium	7782-49-2	10	ug/L	NA	NA	10 U	50 UE	10 U [10 U]	5.6 U	10 U
Silver	7440-22-4	50	ug/L	NA	NA	10 U	5.2 J	1.8 J [1.3 J]	2.2 U	10 U
Sodium	7440-23-5	20,000	ug/L	NA	NA	**141,000**	**148,000**	**143,000 [138,000]**	**159,000**	**166,000**

* Guidance Value

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3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW25S 04/21/11	PCERI-MW25S 08/02/11	PCERI-MW25S 06/10/15	PCERI-MW25S 08/17/15	PCERI-MW25S 10/07/15	PCERI-MW25S 11/17/15	PCERI-MW25S 05/18/16
Volatile Organics										
Tetrachloroethene	127-18-4	5	ug/L	**153**	**40.7**	**8.2**	**6**	**8**	**9.4**	**140**
Trichloroethene	79-01-6	5	ug/L	**36.8**	4.5	1.6 J	5 U	1.2 J	2	**45**
Redox-Sensitive Metals										
Arsenic	7440-38-2	25	ug/L	NA	NA	10 U	4 J	2.5 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	NA	NA	16.2 J	7 J	10.5 J	92	21.7
Cadmium	7440-43-9	5	ug/L	NA	NA	5 U	5 U	5 U	1.1 U	5 U
Chromium	7440-47-3	50	ug/L	NA	NA	1.1 J	4.7 J	0.996 J	2.1 J	10 U
Iron	7439-89-6	300***	ug/L	**8,260**	141	142	46.3 J	119	**340**	103
Lead	7439-92-1	25	ug/L	NA	NA	1.6 J	2.7 J	5 U	2.2 U	5 U
Manganese	7439-96-5	300***	ug/L	NA	NA	38.4	**2,400**	187	**320**	220
Selenium	7782-49-2	10	ug/L	NA	NA	10 U	10 UE	10 U	5.6 U	10 U
Silver	7440-22-4	50	ug/L	NA	NA	10 U	2.1 J	1.6 J	2.2 U	10 U
Sodium	7440-23-5	20,000	ug/L	NA	NA	**76,800**	**62,200**	**52,800**	**50,300**	**62,300**

* Guidance Value

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Table 3 - Target Oxidant Application Volumes
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Injection Well	IW Screen Length (feet)	IW Spacing (feet)	$NaMnO_4$ Target Concentration (%)	Target Injectate Volume (gallons)	Target Volume of 40% $NaMnO_4$ (gallons)	Target Volume of Water (gallons)	Mass of 40% NaMnO4 (pounds)
2015 ISCO Pilot Study Injection Wells							
IW-01[2]	5	25	3	4200	225	3975	2574
IW-02[2]	5	25	3	4200	225	3975	2574
IW-03[2]	5	25	3	4200	225	3975	2574
IW-04[2]	5	25	3	4200	225	3975	2574
IW-05[2]	5	25	3	4200	225	3975	2574
IW-06[2]	5	25	3	4200	225	3975	2574
IW-07[2]	5	25	3	4200	225	3975	2574
IW-08	5	25	5	2800	250	2550	2860
IW-09	5	25	5	2800	250	2550	2860
IW-10	5	25	5	2800	250	2550	2860
IW-11	5	25	5	2800	250	2550	2860
IW-12	5	25	5	2800	250	2550	2860
IW-13	5	25	5	2800	250	2550	2860
IW-14	5	25	5	2800	250	2550	2860
IW-15	5	25	5	2800	250	2550	2860
IW-16	5	25	5	2800	250	2550	2860
IW-17	5	25	5	2800	250	2550	2860
IW-18	5	25	5	2800	250	2550	2860
IW-19	5	25	3	2800	150	2650	1716
IW-20	5	25	3	2800	150	2650	1716
IW-21	5	25	3	2800	150	2650	1716
IW-22	5	25	3	2800	150	2650	1716
IW-23	5	25	3	2800	150	2650	1716
IW-24	5	25	3	2800	150	2650	1716
IW-25	5	25	3	2800	150	2650	1716
IW-26	5	25	3	2800	150	2650	1716
IW-27	5	25	3	2800	150	2650	1716
IW-28	5	25	3	2800	150	2650	1716
IW-29	5	25	3	2800	150	2650	1716
IW-30	5	25	3	2800	150	2650	1716
IW-31	5	25	3	2800	150	2650	1716
IW-32	5	25	3	2800	150	2650	1716
IW-33	5	25	3	2800	150	2650	1716
IW-34	5	25	3	2800	150	2650	1716
IW-35	5	25	3	2800	150	2650	1716
2012 ISCO Pilot Study Injection Wells							
IW-36	10	25	3	5500	293	5207	3352
IW-37	10	25	3	5500	293	5207	3352
IW-38	10	25	3	5500	293	5207	3352
IW-39	10	25	3	5500	293	5207	3352
IW-40	10	25	3	5500	293	5207	3352
IW-41	10	25	3	5500	293	5207	3352
IW-42	10	25	3	5500	293	5207	3352
IW-43	10	25	3	5500	293	5207	3352
IW-44	10	25	3	5500	293	5207	3352
IW-45	10	25	3	5500	293	5207	3352
IW-46	10	25	3	5500	293	5207	3352
IW-47	10	25	3	5500	293	5207	3352
IW-48	10	18	3	2850	150	2700	1716

Table 3 - Target Oxidant Application Volumes
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Injection Well	IW Screen Length (feet)	IW Spacing (feet)	$NaMnO_4$ Target Concentration (%)	Target Injectate Volume (gallons)	Target Volume of 40% $NaMnO_4$ (gallons)	Target Volume of Water (gallons)	Mass of 40% NaMnO4 (pounds)
IW-49	10	18	3	2850	150	2700	1716
IW-50	10	18	3	2850	150	2700	1716
IW-51	10	18	3	2850	150	2700	1716
IW-52	10	18	3	2850	150	2700	1716
IW-53	10	18	3	2850	150	2700	1716
IW-54	10	18	3	2850	150	2700	1716
IW-55	10	18	3	2850	150	2700	1716
IW-56	10	18	3	2850	150	2700	1716
IW-57	10	18	3	2850	150	2700	1716
IW-58	10	18	3	2850	150	2700	1716
IW-59	10	18	3	2850	150	2700	1716
IW-60	10	18	3	2850	150	2700	1716
IW-61	10	18	3	2850	150	2700	1716
IW-62	10	18	3	2850	150	2700	1716
IW-63	10	18	3	2850	150	2700	1716
IW-64	10	18	3	2850	150	2700	1716
IW-65	10	18	3	2850	150	2700	1716
IW-66	10	18	3	2850	150	2700	1716
IW-67	10	18	3	2850	150	2700	1716
IW-68	10	18	3	2850	150	2700	1716
IW-69	10	18	3	2850	150	2700	1716
IW-70	10	18	3	2850	150	2700	1716
IW-71	10	18	3	2850	150	2700	1716
IW-72	10	18	3	2850	150	2700	1716
IW-73	10	18	3	2850	150	2700	1716
IW-74	10	18	3	2850	150	2700	1716
IW-75	10	18	3	2850	150	2700	1716
2016 Remedial Action ISCO Injection Wells							
IW-76	10	25	5	5500	481	5019	5503
IW-77	10	25	5	5500	481	5019	5503
IW-78	10	25	5	5500	481	5019	5503
IW-79	10	25	3	5500	293	5207	3352
IW-80	10	25	3	5500	293	5207	3352
IW-81	10	25	3	5500	293	5207	3352
IW-82	10	25	3	5500	293	5207	3352
TOTALS				**292,100**	**17,206**	**274,894**	**196,837**

Notes:

1. The target volume of solution to be injected at each well is computed as follows:

$V_{injection} = z*\pi*r^2*N_m$

Where: $V_{injection}$ = Required injection volume

z = Saturated injection interval (5 ft or 10 ft)

r = Target radius of influence (9 ft or 12.5 ft)

Nm= Mobile fraction of soils (15 percent [%])

2. The target volume is increased by 50% at IW-01 to IW-07, and the target concentration is 3% to optimize oxidant distribution beneath Bldg. 1885

Table 4 - Monitoring Well Sampling Matrix
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

			Sampling Parameters			
Area of Concern	Monitoring Well Identification	Monitoring Frequency	Field Parameters [1]	$NaMnO_4$ (Field Kits and Visual Inspection)	VOCs	Metals
3800 Area PCE Site	PCERI-MW19S	Baseline Sampling, Process Monitoring, and Post Injection Performance Monitoring[2]	B, PM, PI		B, PI	B, PI
	PCERI-MW19I		B, PM, PI		B, PI	B, PI
	PCERI-MW25S		B, PM, PI	PM, PI	B, PI	B, PI
	PCERI-MW25I		B, PM, PI	PM. PI	B, PI	B, PI
	IMW-01		B, PM, PI		B, PI	B, PI
	IMW-02		B, PM, PI		B, PI	B, PI
	IMW-03		B, PM, PI	PM, PI	B, PI	B, PI
	IMW-04		B, PM, PI		B, PI	B, PI
	IMW-05		B, PM, PI	PM, PI	B, PI	B, PI
	IMW-06		B, PM, PI	PM, PI	B, PI	B, PI

Notes:

[1] - Field Parameters include pH, dissolved oxygen, oxidation reduction potential, specific conductivity, and temperature

[2] - Post injection performance monitoring will be completed approximately 30, 75 and 120 days following injection completion

B - Baseline Sampling - to be conducted prior to the injection of permanganate (conducted May 2016)

PM - Process Monitoring Sampling - to be conducted during the injection and to include manual measurements of field parameters and permanganate as well as injection parameters (cumulative injection volume, injection pressure, and injection flow rate)

PI - Post Injection Performance Monitoring - to measure the efficacy of the injection at reducing PCE concentrations in the target area

APPENDIX A

Standard Operating Procedures
Specific to 3800 Area PCE Site

APPENDIX A-1

Recommended Operating Procedures – Preservation of Groundwater Samples at ISCO Sites Using Ascorbic Acid (USEPA, 2012)

EPA United States Environmental Protection Agency

Ground Water Issue

Ground Water Sample Preservation at In-Situ Chemical Oxidation Sites – Recommended Guidelines

Saebom Ko[1], Scott G. Huling[2,*], Bruce Pivetz[3]

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1. INTRODUCTION

In-situ chemical oxidation (ISCO) involves the introduction of a chemical oxidant into the subsurface for the purpose of transforming ground water and/or soil contaminants into less harmful chemical by-products (Huling and Pivetz, 2006; Rivas, 2006; Ferrarese *et al.,* 2008; Kao *et al.,* 2008). Often, ground water samples collected specifically to analyze organic contaminants may contain the oxidant and the organic contaminants in a "binary mixture" (Huling *et al.,* 2011a; Johnson *et al.,* 2012). When organic contaminants and oxidants are commingled in the ground water sample, there is significant potential for oxidative transformation of contaminants to occur after the sample is collected and the results of the sample analysis to become non-representative of in-situ conditions at the time of sampling. Consequently, the quality of the ground water sample may be compromised and a false negative result may occur.

An integral component of ISCO is the collection and analysis of ground water samples to assess ISCO treatment performance. A technical issue faced by Remedial Project Managers is the collection and analysis of representative, high quality ground water samples that can be used to support a site assessment and remedial performance monitoring at sites where ISCO is being deployed. The purpose of this *Issue Paper* is to provide background information and general guidelines involving methods and procedures that can be used to detect whether an oxidant (i.e., permanganate or persulfate) is present in ground water, to approximate the oxidant concentration, and to estimate and deliver the volume or mass of preservative, specifically ascorbic acid, required to preserve the binary mixture ground water sample. The focus of this *Issue Paper* is on permanganate and persulfate, two oxidants that can persist for long periods of time in the subsurface and therefore represent the greatest potential for binary mixture ground water samples. An Appendix to this *Issue Paper* (Recommended Operating Procedures - Preservation of Ground Water Samples at ISCO Sites Using Ascorbic Acid) provides specific details regarding the preservation procedures for use by EPA Regional personnel, contractors, and other environmental professionals engaged in ground water sample collection and analysis.

The guidelines are also applicable to bench-scale studies where oxidants are used to investigate the feasibility of ISCO treatment. For

example, aqueous samples collected from bench-scale soil reactors are analyzed for organic contaminants, but may also contain the oxidant amended to the reactor to destroy the contaminant. Consequently, the guidelines described below also extend to bench-scale studies where the potential for binary mixture aqueous samples may occur, and are analyzed for organic contaminants.

1.1. Reasons to Sample and Analyze Binary Mixtures

It is often desirable for oxidants in ground water to fully react prior to collecting and analyzing ground water samples for organic contaminants. However, there are circumstances where the collection and analysis of binary mixture ground water samples may not be avoided. These reasons vary widely and some examples include the need to:

(1) conduct an immediate preliminary assessment of ISCO to validate in-progress treatment performance,
(2) establish design parameters from interim ISCO pilot-scale studies needed to design full-scale ISCO deployment,
(3) assess the potential redistribution of the ground water contaminant plume as affected by ISCO activities, and
(4) evaluate reaction kinetics during oxidative treatment.

Rapid turnaround of field data and information may be needed to meet specified milestones and deadlines for full-scale remedy selection, design, construction, and implementation. In addition, regulatory-driven goals and associated timelines may require rapid completion of pilot-scale testing and full-scale deployment of ISCO. Therefore, a significant emphasis may be placed on the collection of ground water samples at ISCO sites prior to complete reaction of the oxidant (Huling *et al.,* 2011a).

1.2. Binary Mixtures of Oxidant and Organic Contaminants in Ground Water Samples

Heterogeneous distribution of oxidant and contaminants, and hydraulic conductivity variations in heterogeneous aquifers are two main causes of binary mixtures (Figure 1) (Huling *et al.,* 2011a). For example, oxidants and contaminants can enter a monitoring well screen from different lithologic zones. These solutes may be captured as separate solutes from different lithologic zones, or as separate or commingled solutes from the same lithologic zone. Insufficient contact time (i.e., reaction time) between the oxidant and contaminants prior to, or after, entering the well leads to binary mixtures in the ground water sample.

Commingling of organic contaminants and oxidants in the ground water sample impacts the quality of the ground water sample, but may also impact the analytical instruments used to measure the concentration of analyte(s) in the ground water sample (Johnson *et al.,* 2012). Although rarely reported and documented, the impact of oxidants on analytical instruments is exclusively reported for permanganate and predominantly involves instrument malfunction resulting from MnO_2(s)-clogged lines and ports. No information was found that documented the impact of hydrogen peroxide or persulfate on analytical instruments despite numerous studies where binary mixtures were analyzed.

1.3. Impact of Binary Mixtures – Previous Studies

A detailed study involving the impact of residual persulfate on the quality of ground water samples was performed (Huling *et al.,* 2011a). A significant decline (49 to 100 percent (%)) in volatile organic compound (VOC) concentrations was measured in unpreserved binary mixture samples using gas chromatography (GC) purge and trap, and GC mass spectroscopy (MS) headspace analytical methods. In that study, preservation of the binary mixture samples was achieved through the addition of ascorbic acid and resulted in 99 to 100% VOC average recovery relative to oxidant-free control samples. Adding high concentrations of ascorbic acid (42 to 420 millimolar (mM)) to the samples did not interfere in the measurement of the VOCs and did not negatively impact the analytical instruments. These results indicated that if persulfate is present in the sample, and the binary sample is not appropriately preserved, the quality of the sample will be compromised. A companion study involving the impact of permanganate on the quality of ground water samples and analytical instruments, and the use of ascorbic acid yielded similar results (Johnson *et al.,* 2012). The results of these studies (Huling *et al.,* 2011a; Johnson *et al.,* 2012) serve as the basis for the guidelines provided in this *Issue Paper*.

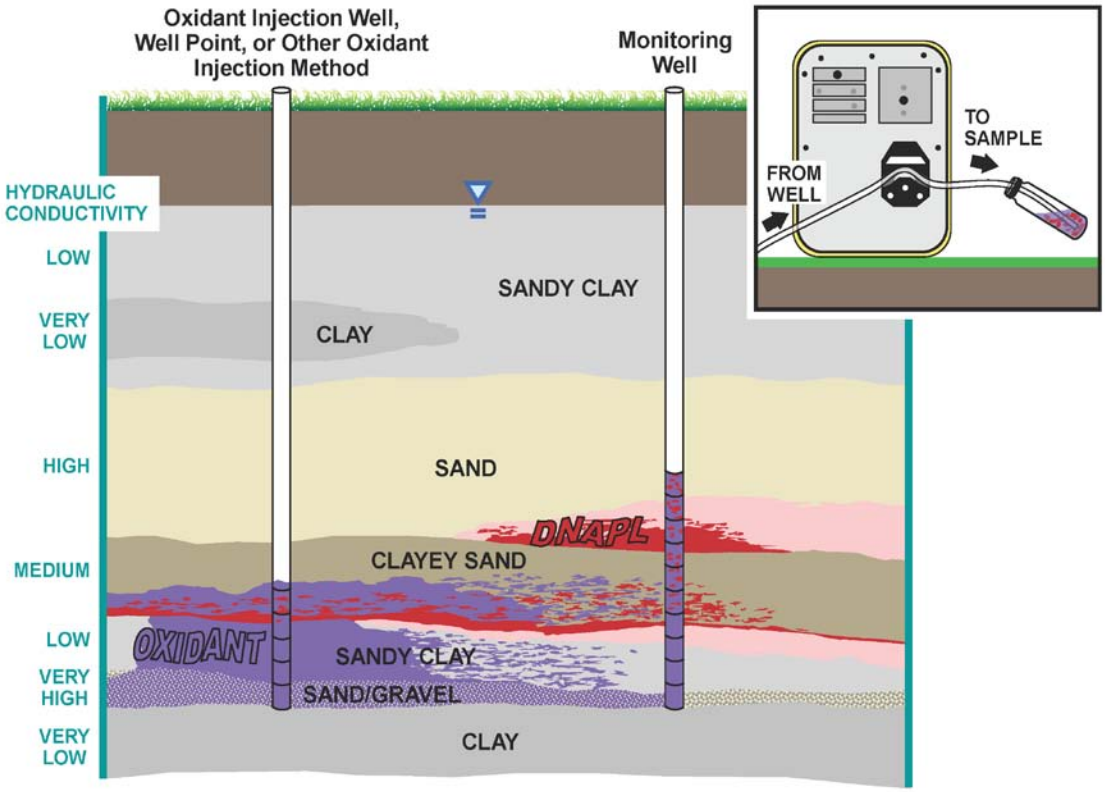


Figure 1. Conceptual model of hydrogeologic, and oxidant and contaminant fate and transport conditions that contribute to binary mixture ground water samples. The oxidant illustrated in purple, conceptually represents any oxidant (permanganate, persulfate) used for in-situ chemical oxidation (Huling *et al.,* 2011a).

The analytical methods used in these studies are commonly used in commercial analytical laboratories. The analytes, including benzene, toluene, xylene (BTX), perchloroethylene (PCE), and trichloroethylene (TCE), are representative of contaminants commonly found at hazardous waste sites. Similarly, empirical results were obtained in the analysis of binary mixtures comprised of persulfate and pentachlorophenol (PCP) by high performance liquid chromatography (HPLC) where significant loss of PCP was measured in unpreserved samples relative to persulfate-free control samples and ascorbic acid-preserved samples (data not included). Currently, we do not have a firm explanation for a viable mechanism responsible for persulfate activation and PCP oxidation in these samples.

Overall, results are applicable to a broad set of analytical methods, analytes, and site conditions. It is unclear to what extent these results extend to analytical methods and contaminants that were not tested in these studies, however. Additional specific studies are needed in cases where different analytical methods and ground water contaminants are involved.

Specifically, analysis involved the measurement of (1) BTX, PCE, and TCE using the GC/MS headspace method, and (2) BTX using the GC purge and trap method (Huling *et al.,* 2011a). The GC/MS headspace method is involved in EPA Method Nos. 8260C and 5021A. The automated headspace GC/MS method is used to confirm the identity and quantity of purgeable VOCs in water samples in 40 mL volatile organic analysis (VOA) vials. This method is used to quantify over sixty VOCs in drinking water, including aromatics, haloalkenes, haloalkanes, haloaromatics, and fuel oxygenates. This automated method involves the transfer of an aqueous sub-sample (10 mL) to a sealed headspace vial which is heated from room temperature to 80 degrees Celsius (°C) in 30 minutes. A sample of the headspace gas is then transferred to the capillary column in the GC. After separation on the GC column and introduction into the MS, the VOCs are identified and

quantified using the MS. We propose that contaminant loss occurs during the heating step of the sub-sample where residual persulfate is thermally activated resulting in VOC oxidation.

The automated purge and trap GC (Agilent, Model 6890, Wilmington, DE) method was used to quantify BTX in water samples (40 mL VOA vials). This method is most similar to EPA Methods 602 and 8020, but shares similarities with several other EPA methods that involve purge and trap, including: EPA 501, 502.2, 503.1, 524.2, 601, 602, 624, 8010, 8020, 8021, 8240, and 8260. In this method, a sub-sample (10 mL) is transferred to a sparge chamber and purged with helium (6 minutes). The VOCs are transferred to a K VOCARB 3000 Encon trap and dry purged with helium to remove water vapor. The VOCs are thermally desorbed and transferred to the GC column for separation and measurement. Sample transfer is through a heated 1.9 mm×1.0 m Silcosteel (Restek, Bellefonte, PA) transfer line coupled directly to the analytical column. Following separation on the column, the presence of VOCs is determined and quantified with photoionization and flame ionization detectors. It was proposed that the contaminant loss was due to the helium sparging step where aerosols are formed containing persulfate and are transfered to the VOC granular activated carbon trap (Huling *et al.,* 2011a). Subsequently, during the VOC thermal desorption step where the trap is heated from room temperature to 260 °C (25 min), the persulfate residing in the trap is thermally activated resulting in the oxidation of the VOCs immobilized and concentrated on the trap. Similarly, highly efficient oxidation of organics immobilized in solid media (i.e., granular activated carbon) by thermally activated persulfate has been demonstrated (Huling *et al.,* 2011b).

The impact of residual permanganate was evaluated in water samples prepared in the lab using a multi-component standard, and in ground water samples collected at ISCO sites (Johnson *et al.,* 2012). Binary mixture aqueous samples were prepared that contained a 52-component standard of organic compounds and permanganate. Ascorbic acid was added to the binary mixture which reacted rapidly with the MnO_4^-, preserved the sample, and limited the reaction between MnO_4^- and the organic compounds. Consequently, the concentrations of the majority of the compounds in the multi-component standard were within the control limits established for quality assurance. However, despite timely efforts to preserve the laboratory-prepared binary mixture samples, the quality of the sample was impacted; concentrations were generally lower than oxidant-free controls, and the concentration of several compounds (*cis*-1,3-dichloropropene, styrene, *trans*-1,2-dichloroethene, *trans*-1,3-dichloropropene, vinyl chloride) fell below the applicable lower control limit.

Concentrations of VOCs measured in field-preserved binary mixture ground water samples were greater than in replicate samples refrigerated in the field and preserved with ascorbic acid upon arrival at the lab (Johnson *et al.,* 2012). These results indicate that the VOCs reacted in transit despite refrigeration. Excess ascorbic acid did not negatively impact the quality of the simulated ground water samples containing a 52-component stock standard, or actual ground water samples collected from two field sites, and did not negatively impact the GC/MS instruments used in the analysis.

2. GROUND WATER SAMPLE COLLECTION, OXIDANT MEASUREMENT, AND OXIDANT NEUTRALIZATION/SAMPLE PRESERVATION

Specific details regarding the procedures used in amending ground water samples with ascorbic acid are provided in the Appendix entitled, "Recommended Operating Procedures - Preservation of Ground Water Samples at ISCO Sites Using Ascorbic Acid".

It is recommended that a representative ground water sample be collected at the well head in a test vial for the specific purpose of measuring the oxidant concentration. Ground water sample collection for this purpose should follow the normal ground water sampling protocol established at the site. This initial screening ground water sample is not collected for the purpose of measuring organic contaminant concentrations. If contaminant analysis of the ground water sample is desired, additional samples must be subsequently collected and preserved, if necessary. Normal sampling procedures appropriate for site conditions and regulatory acceptance are recommended. Sample preservation and handling requirements are based on the type of analyses being performed and should be specified in project-specific documents such as the quality assurance project plan, field sampling

plan, or in general EPA documents such as the Resource Conservation and Recovery Act (RCRA) guidance document (U.S. EPA, 1992) or EPA SW-846 (U.S. EPA, 1982). Additional direction on ground water sampling techniques can be found in Yeskis and Zavala (2002).

2.1. Permanganate (MnO_4^-)

Data and information presented below are reported in terms of the permanganate anion (MnO_4^-; 118.9 grams per mole (g/mol)). Permanganate is purchased either as sodium permanganate ($NaMnO_4$; 141.9 g/mol) or potassium permanganate ($KMnO_4$; 158.0 g/mol) and as a result conversion to the permanganate anion concentration is needed to determine sample preservation needs as per the *Issue Paper*. Specifically, the ratios 118.9/141.9 (g-mole/g-mole) and 118.9/158.0 (g-mole/g-mole) are used to convert $NaMnO_4$ and $KMnO_4$, respectively to MnO_4^-.

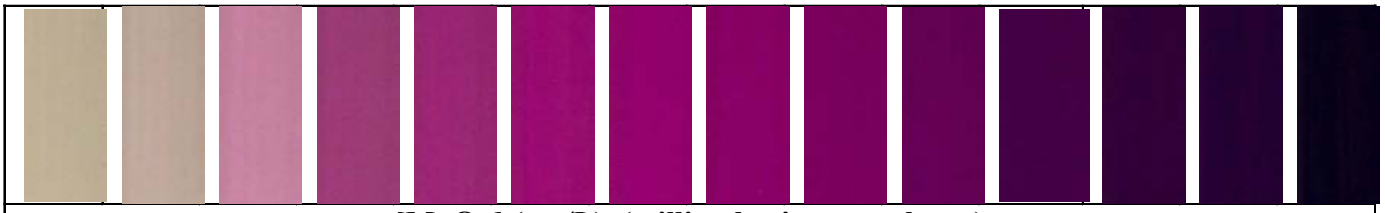
2.1.1. Analysis by Visual Observation

The characteristic pink or purple color of MnO_4^- in a 40 mL VOA vial can be used as a general guideline to estimate the concentration by using the MnO_4^- colorimetric scale (Table 1). This method should be used with caution because ground water turbidity and colloidal manganese dioxide solids (MnO_2(s)) can affect sample color and result in deviations from the tabulated color scale. Field filtration can help minimize these interferences, but may not fully remove all color if sub-micron colloidal and/or dissolved constituents are present.

2.1.2. Spectrophotometric Analysis

The permanganate concentration can be determined using commercially available field test kits (SenSafe™, 2011; CHEMetrics, 2011). Additionally, an accurate measurement of the permanganate concentrations can be determined using a field spectrophotometer (maximum absorbance wavelength (λ) = 525 nanometers (nm) (A_{525})) and a calibration curve involving a linear correlation between MnO_4^- concentration and A_{525} (Figure 2, Table 1). Filtered samples (0.2-0.45 micron) may be required to eliminate background colloidal or suspended solid materials that can absorb light at 525 nm and interfere with permanganate measurement. Volatilization of

Table 1. Permanganate concentration, spectrophotometric absorbance at 525 nm, and required amount of ascorbic acid required to neutralize the oxidant in a 40 mL vial. The color scale represents actual photos of MnO_4^- vials and is included for conceptual guidance. Actual colors vary based on background lighting, and color printers. Additionally, photographs of low concentrations (i.e., clear solutions) do not accurately capture transparency.



[MnO_4^-] (mg/L) (millimolar in parentheses)													
0 (0)	0.75 (0.01)	3.8 (0.03)	7.5 (0.06)	11.3 (0.09)	18.8 (0.16)	30.1 (0.25)	37.6 (0.32)	56.4 (0.47)	75.3 (0.63)	113 (0.95)	151 (1.27)	188 (1.58)	376 (3.16)
Absorbance[1], wavelength (λ) = 525 nm													
0	0.011	0.059	0.134	0.197	0.329	0.516	0.627	NL	NL	NL	NL	NL	NL
Ascorbic Acid Stock Solution (M)[2]													
-	0.015	0.015	0.15	0.15	0.15	0.15	0.15	1.5	1.5	1.5	1.5	1.5	1.5
Volume of Ascorbic Acid solution (µL)													
0	30	150	30	46	76	121	152	23	30	46	61	76	152
Mass of Ascorbic Acid (mg)													
0	0.08	0.4	0.79	1.21	2.1	3.32	4.17	6.1	7.9	12.2	16.1	20.1	40.2

(1) [MnO_4^-] (mg/L) = 58.8 × A_{525}; A_{525} is the absorbance at 525 nm; non-linear above 38 mg/L MnO_4^-.
(2) To minimize sample dilution, the ascorbic acid stock solution used was 0.015, 0.15, and 1.5 M.

contaminants is not a concern since the initial screening ground water sample is used specifically to determine the concentration of permanganate.

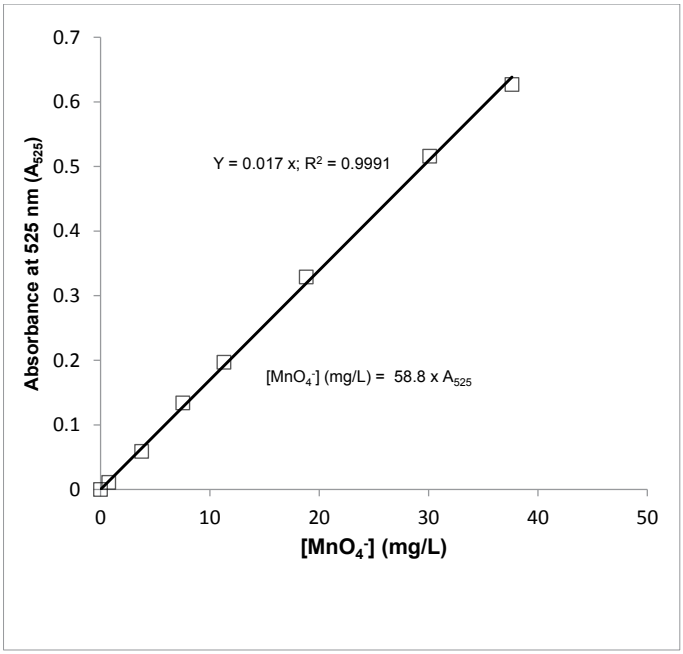


Figure 2. Calibration curve of MnO_4^- concentration versus absorbance at wavelength (λ) of 525 nm.

2.1.3. Results

If MnO_4^- is not detected in the ground water sample, it is recommended that normal ground water sampling and analysis procedures be used. If MnO_4^- is detected, there are two general options to consider. The first option is to delay the collection and analysis of the ground water sample for a sufficient time allowing the MnO_4^- concentration to fully diminish in the subsurface, if desired. In some cases, MnO_4^- persistence is lengthy and this option is not possible (as discussed above in Section 1.1). Due to the site-specific time-dependency of contaminant mass transfer and transport, the time required to approach chemical equilibrium in ground water will likely require additional time after the oxidant is fully consumed. Subsequently, ground water sampling would follow routine guidelines and requirements. The second option is to collect and preserve the ground water sample (i.e., neutralize the oxidant) prior to analysis to minimize the impact of the commingled oxidant. The second option may be desirable for a number of reasons described in Section 1.1.

2.1.4. Oxidant Neutralization and Sample Preservation

Given the MnO_4^- concentration, the volume of ascorbic acid stock solution (0.015, 0.15, or 1.5 mol/L), or weight of crystalline ascorbic acid (176.12 g/mol) required to preserve the binary mixture is determined (Table 1). Sample preservation involves the addition of the appropriate amount of ascorbic acid to preserve a binary mixture in a 40 mL VOA vial. In a lab study (Johnson *et al.,* 2012), the mass of ascorbic acid required to neutralize MnO_4^- ranging in concentration from 1-750 milligrams per liter (mg/L) was determined empirically. The average molar ratio (n=14) was 1.64 mol ascorbic acid/mol MnO_4^- and values ranged from 1.45 to 1.75 mol/mol. Therefore, the weight of ascorbic acid that corresponded with the MnO_4^- colorimetric scale was conservatively based on a stoichiometric ratio of 1.8 mol ascorbic acid/mol MnO_4^-, since, as noted below, no negative side-effects were noted with over-dosing. Detailed recommended operating procedures are provided in the Appendix to estimate the volume of crystalline ascorbic acid or ascorbic acid stock solution required to neutralize the MnO_4^-. Once the oxidant is neutralized, it is recommended that normal ground water sample handling and procedures be followed.

The recommended volume and mass of ascorbic acid included in Table 1 is a guideline. The addition of ascorbic acid will rapidly reduce the MnO_4^- concentration and eliminate the pink/purple color. The formation of colloidal or particulate MnO_2(s) (i.e., Mn^{+4}) may occur causing a brown tinge appearance of the solution. Incremental amendment of ascorbic acid is required to further reduce the Mn^{+4} to Mn^{+2}, and eliminate the brownish tinge color. Mn^{+2} is highly soluble and the most desirable form of Mn to minimize the impact of colloidal or particulate matter on the laboratory analytical instruments. Overall, Table 1 is used as a guideline but the actual amount of ascorbic acid to be added should be based on the amount required to fully eliminate the MnO_4^- and MnO_2(s), and to achieve a clear solution.

Excess ascorbic acid did not have a negative impact on the quality of the ground water sample involving GC and GC/MS analysis of a broad range of organic chemicals (Johnson *et al.,* 2012). The volume of ascorbic acid solution added to the sample vial should be recorded so

appropriate dilution calculations can be performed to obtain an accurate estimate of the contaminant concentrations. Pre-amending sample vials with ascorbic acid is also an option and is discussed further in Section 7.F of the Appendix. Other sample preservation requirements are based on the analyses being performed and are specified in the quality assurance project plan, field sampling plan, RCRA guidance document (U.S. EPA, 1992) or EPA SW-846 (U.S. EPA, 1982). Additional direction on ground water sampling techniques can be found in Yeskis and Zavala (2002)

2.2. Persulfate ($S_2O_8^{2-}$)

The data and information below are presented in terms of the persulfate anion ($S_2O_8^{2-}$; 192.0 g/mol). However, persulfate is predominantly purchased as sodium persulfate ($Na_2S_2O_8$; 238.1 g/mol). As a result, conversion of sodium persulfate to persulfate anion concentrations is necessary to determine sample preservation needs as per the *Issue Paper*. Specifically, the ratio of 192.0/238.1 (g-mol/g-mol) is used to convert $Na_2S_2O_8$ to $S_2O_8^{2-}$. Persulfate is colorless and requires field measurement at the well head to determine its presence and concentration in the ground water sample.

2.2.1. Analysis by Field Test Kit Colorimetry

Field test kits are commercially available to measure persulfate concentration in aqueous samples (CHEMetrics, 2011; FMC, 2012). CHEMetrics persulfate test kits are available for two sodium persulfate concentration ranges (0-7, 7-70 mg/L). Given the high concentrations of persulfate injected into the subsurface at ISCO sites, significant dilution may be required in the use of these test kits. FMC commercial test kits are dependent on whether the persulfate activator is base or thermal (test kit "K"), or whether persulfate is activated by iron chelates or H_2O_2 (test kit "C") (FMC, 2012). The lower detection limit of persulfate using the current FMC test kits is 500 mg/L, a sufficient quantity of oxidant to significantly impact the concentrations of VOCs and the quality of the sample. Based on the current detection limit using the FMC test kit, it is recommended that the minimum amount of ascorbic acid added to the sample vessel should conservatively account for 500 mg/L persulfate.

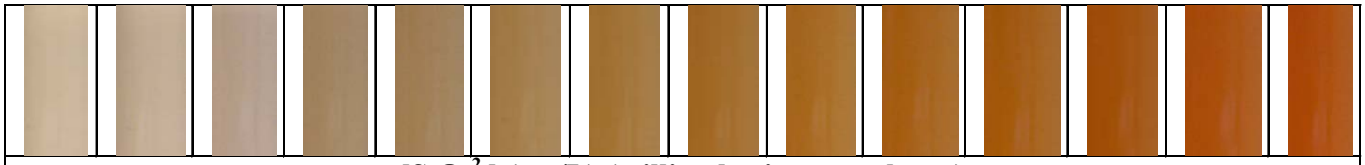
2.2.2. Analysis by Spectrophotometric Analysis (Ferrous Ammonium Sulfate (FAS) Method)

A spectrophotometric method can be used to analyze the persulfate concentration in aqueous samples. The ground water sample should be filtered (0.2-0.45 micron) to eliminate background material (i.e., turbidity) that may interfere with $S_2O_8^{2-}$ analysis. A small volume of de-ionized (DI) water (0.9 mL) and sulfuric acid (H_2SO_4) (10 mL, 2.5 normal (N)) (or, add 10.9 mL of 2.3 N H_2SO_4) is placed in a 20 mL glass or plastic test vessel. These can be prepared prior to transport to the field. A blank is prepared by mixing 1 mL DI water with H_2SO_4 (10 mL, 2.5 N). The filtered sample (0.1 mL) is placed in the test vessel, followed by the addition of ferrous ammonium sulfate (FAS) ($Fe(SO_4)_2(NH_4)_2 \cdot 6H_2O$) (0.1 mL, 0.4 N) (prepared immediately before use). Adding a couple drops of H_2SO_4 (conc.) to the FAS reagent increases the stability of the ferrous iron for several more hours (5 to 10 hours). The mixture is swirled/mixed and allowed to react for 30 to 40 minutes. Subsequently, the mixture is amended with ammonium thiocyanate (NH_4SCN) (0.2 mL, 0.6 N) and the absorbance of the solution is analyzed immediately with a spectrophotometer at a wavelength of λ = 450 nm (A_{450}) (Huang *et al.,* 2002; Huling *et al.,* 2011a; b). The general colorimetric scale provided below can be used to estimate the persulfate concentration in a ground water sample (Table 2) analyzed by the FAS method. Alternatively, a calibration curve involving a linear correlation between $S_2O_8^{2-}$ concentration and A_{450} can be used to determine a more precise estimate of the persulfate concentration (Figure 3).

2.2.3. Results

If $S_2O_8^{2-}$ is not detected in the ground water sample, it is recommended to proceed using normal ground water sampling and analysis procedures. If $S_2O_8^{2-}$ is detected, there are two general options to consider. The first is to delay collection and analysis of the ground water sample for sufficient time which allows the persulfate concentration to fully diminish in the subsurface, if desired. Due to the site-specific time-dependency of contaminant mass transfer and transport, the time required to approach chemical equilibrium in ground water will likely require additional time after the oxidant is fully consumed. Subsequently, ground water sampling would follow routine guidelines. The second option is to collect and

Table 2. Persulfate concentrations resulting from the ferrous ammonium sulfate analytical method involving the spectrophotometric measurement (λ = 450 nm) of the solution, and the required amount of ascorbic acid required to neutralize the oxidant in a 40 mL vial. The color scale represents actual photos of $S_2O_8^{2-}$ vials and is included for conceptual guidance. Actual colors vary based on background lighting, and color printers. Additionally, photographs of low concentrations (i.e., clear solutions) do not accurately capture transparency.



$[S_2O_8^{2-}]$ (mg/L) (millimolar in parentheses)													
0 0	80 (0.42	200 (1.1)	400 (2.1)	610 (3.2)	810 (4.2)	1210 (6.3)	1610 (8.4)	2020 (10.5)	2420 (12.6)	2820 (14.7)	3230 (16.8)	3630 (18.9)	4030 (21.0)
Absorbance[(1)], wavelength (λ) = 450 nm													
0	0.011	0.019	0.04	0.062	0.076	0.121	0.164	0.204	0.245	0.275	0.313	0.349	0.397
Volume of Ascorbic Acid solution (mL)													
0	0.04	0.11	0.22	0.34	0.45	0.67	0.89	1.12	1.34	1.57	1.79	2.02	2.24
Mass of Ascorbic Acid (176.12 g/mol) (g)													
0	0.01	0.03	0.06	0.09	0.12	0.18	0.24	0.3	0.35	0.41	0.47	0.53	0.59

(1) Solubility of ascorbic acid in water = 330 g/L (1.87 mol/L); 80% solubility (1.5 mol/L) used as stock solution; $[S_2O_8^{2-}]$ (mg/L) = 10,000 × A_{450}; where A_{450} is the absorbance at 450 nm.

preserve the ground water sample prior to analysis to minimize the impact of persulfate on the ground water sample. The second option may be desirable for a number of reasons described in Section 1.1.

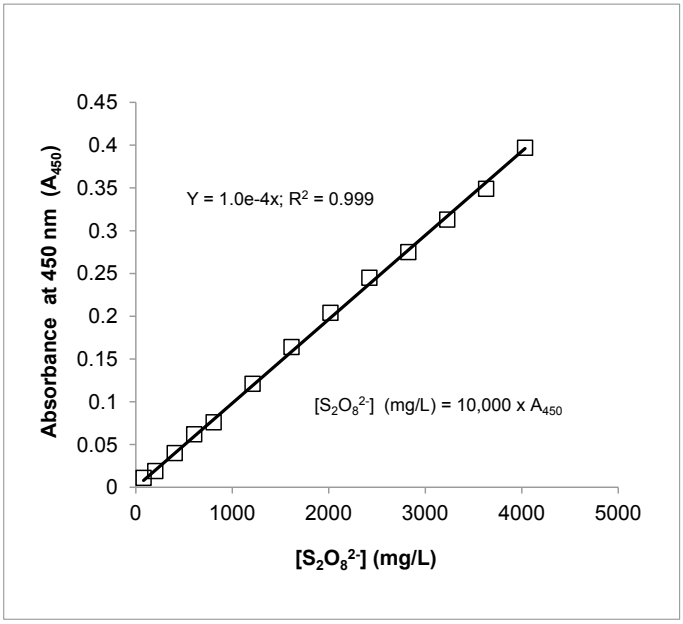


Figure 3. Calibration curve for $S_2O_8^{2-}$ concentration versus absorbance at wavelength 450 nm using the ferrous ammonium sulfate method.

2.2.4. *Oxidant Neutralization and Sample Preservation*

Guidelines for the volume of ascorbic acid stock solution (1.5 mol/L) or the weight of crystalline ascorbic acid (176.1 g/mol) required to preserve the binary mixture in a 40 mL sample vial are provided (Table 2). The mass of ascorbic acid that corresponds with the persulfate colorimetric scale is based on a stoichiometric ratio of 4 mol ascorbic acid/mol persulfate and was determined empirically in a laboratory study (Huling *et al.,* 2011a). Detailed recommended operating procedures are provided in the Appendix to estimate the volume of crystalline ascorbic acid or ascorbic acid stock solution required to neutralize the $S_2O_8^{2-}$. This stoichiometric ratio is in excess of the ideal stoichiometry for mineralization of persulfate by ascorbic acid. Excess ascorbic acid (4 – 40 mol ascorbic acid/mol persulfate) did not have a negative impact on the quality of the ground water sample involving GC and GC/MS analysis of BTX, TCE, and PCE (Huling *et al.,* 2011a). The basis for this quantity of ascorbic acid is to achieve favorable reaction kinetics between $\cdot SO_4^-$ and ascorbic acid, relative to the reaction between the sulfate radical ($\cdot SO_4^-$) and the VOCs. Following oxidant neutralization, it is recommended that other approved sample preservation and handling methods

in ground water sample handling be performed. For example, acidification of the sample is normally carried out to minimize biochemical and reduction reactions. Other sample preservation requirements are based on the analyses being performed and are specified in the quality assurance project plan, field sampling plan, RCRA guidance document (U.S. EPA, 1992) or EPA SW-846 (U.S. EPA, 1982). Additional direction on ground water sampling techniques can be found in Yeskis and Zavala (2002).

3. ADDITIONAL INFORMATION

It is recommended that the analytical laboratory be notified that the aqueous samples contain residual persulfate or permanganate and were preserved with ascorbic acid. The volume of ascorbic acid solution added to the sample should be recorded so the appropriate calculations can be used to correct for dilutions. If MnO_2(s) has settled on the bottom of the VOA vial, it is important that the sample not be disturbed prior to analysis. This precaution in sample handling prevents the suspension of the MnO_2(s) particles and the potential for accidental injection into the analytical instruments.

Other preservatives have been used to successfully neutralize these oxidants, but may negatively impact the quality of the sample (Huling *et al.,* 2011a). Despite efforts used to neutralize the oxidant and to preserve the quality of the ground water sample, the presence of oxidant in ground water samples introduces uncertainty in the precise measurement of contaminant concentrations in the subsurface. This is attributed to the potential impact of the oxidant on contaminant concentrations in the ground water sample prior to neutralization, the transient nature of contaminant fate and transport in the subsurface where ISCO activities were deployed, and the site-specific oxidant injection and hydrogeologic conditions contributing to binary mixtures. Consequently, additional ground water sample collection and analysis will likely be required to achieve an accurate evaluation of post-ISCO performance, and regulatory adherence with US EPA ground water compliance monitoring requirements.

Numerous examples exist where elevated permanganate and VOC concentrations have been measured in ground water samples collected over extended periods of time at hazardous waste sites. It can be concluded from a simple kinetic analysis that long term VOC persistence can primarily be explained by spatial separation between the ground water containing the oxidant and contaminant (Figure 1) (Johnson *et al.,* 2012). Ground water samples derived from wells screened over spatially separate vertical intervals indicate an in-well mixture of ground water containing either oxidants or contaminants. Limited contact between the oxidant and contaminant within the same lithologic unit can be due to specific mass transfer or mass transport conditions including the dissolution of non-aqueous phase liquids (NAPLs) or slow diffusion of contaminants from low permeability materials. These fate and transport conditions indicate the oxidant has not been uniformly delivered to the contaminated zone(s). A critical analysis of screened intervals, injection intervals, contaminated intervals, oxidant and contaminant transport characteristics, and ground water sample results from analyzing preserved binary mixtures, could provide valuable insight for the development of a more accurate site conceptual model that could be used to design and deploy a more effective oxidant delivery system.

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Appendix Recommended Operating Procedures - Preservation of Ground Water Samples at ISCO Sites Using Ascorbic Acid

Table of Contents

1. PURPOSE (SCOPE AND APPLICATION)

The commingling of organic contaminants and oxidants in ground water or aqueous samples represents a condition in which there is significant potential for oxidative transformation of the contaminants after the sample is collected. Consequently, the quality of the ground water or aqueous sample may be compromised and a false negative result may occur. These recommended operating procedures describe the steps used to preserve ground water samples containing the oxidants permanganate (MnO_4^-), or persulfate ($S_2O_8^{2-}$) and organic contaminants of concern (COCs) prior to analysis. It is applicable for ground water samples containing volatile and non-volatile organic contaminants to be analyzed by gas chromatography (GC), or gas chromatography-mass spectroscopy (GC-MS), using either the purge and trap or headspace sample introduction methods, and high performance liquid chromatography (HPLC).

These procedures are also applicable to bench-scale studies where oxidants are used to investigate the feasibility of ISCO treatment. For example, aqueous samples collected from bench-scale soil reactors are analyzed for organic contaminants, but may also contain the oxidant amended to the reactor to destroy the contaminant. Consequently, the guidelines and general procedures described below also extend to bench-scale studies where the potential for binary mixture aqueous samples may occur, and are analyzed for organic contaminants.

2. METHOD SUMMARY

Based on the measured or estimated oxidant concentration in a ground water or aqueous sample, a specific quantity of the preservative, ascorbic acid, is added to the ground water or aqueous sample to either neutralize or to limit the impact of the residual oxidant on the quality of the sample. Tables 1 and 2 in the *Issue Paper* are used as guidelines to estimate the amount of ascorbic acid to add to a 40 mL VOA vial to preserve binary mixture ground water and/or aqueous samples.

3. REAGENTS

Ascorbic Acid ($C_6H_8O_6$; 176.1 g mol^{-1})

De-ionized (DI) water

Ferrous amonium sulfate (FAS) reagents – sulfuric acid (H_2SO_4), ferrous ammonium sulfate ($Fe(SO_4)_2(NH_4)_2{\cdot}6H_2O$), ammonium thiocyanate (NH_4SCN).

4. EQUIPMENT/APPARATUS

Pipette, volumetric flasks, spectrophotometer (or field test kits)

SenSafe™ or CHEMetrics field test kits for permanganate measurement (if used), or direct measurement.

CHEMetrics or FMC field test kits for persulfate measurement (if used), or measurement using FAS method.

5. HEALTH AND SAFETY PRECAUTIONS

The Materials Safety Data Sheet for ascorbic acid indicates potentially acute health effects: slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. In case of skin contact: wash

with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops. Cold water may be used. Other guidelines are available based on exposure (http://www.sciencelab.com/msds.php?msdsId=9922972). It is recommended to wear gloves and safety glasses during all of the procedures described herein due to the potential for exposure to oxidants, impacted ground water sample, and other chemicals involved in these procedures. Always consult site-specific health and safety plans prior to sampling.

6. INTERFERENCES

Colloidal and/or suspended solids in ground water samples may adsorb light and interfere with the measurement of oxidant concentration. For this reason, the ground water sample may require filtration (0.2-0.45 µm) to eliminate background material (i.e., turbidity).

7. PROCEDURES

A. Ascorbic Acid

Prepare ascorbic acid stock solution either in the lab prior to ground water sampling, or in the field. The appropriate use of these stock solutions is dependent on concentrations of the oxidant measured in the ground water samples. The stock solution should be stored in a refrigerator or cooler until used, and discarded after 150 days.

High Concentration Stock Solution: 1.5 M ascorbic acid (e.g., add 264 g of ascorbic acid (MW=176.1 g/mol) to 1L volumetric flask and fill with DI water). This stock solution can be diluted in the preparation of 0.015 and 0.15 M ascorbic acid stock solutions.

Medium Concentration Stock Solution: 0.15 M ascorbic acid: Dilute 1.5 M ascorbic acid stock solution 1:10 (e.g., dilute 100 mL of 1.5 M stock solution to 1L with DI water).

Low Concentration Stock Solution: 0.015 M ascorbic acid: Dilute 1.5 M ascorbic acid stock solution 1:100 (e.g., dilute 10 mL of 1.5 M stock solution to 1L with DI water).

B. Sample Filtration

Filter the ground water or aqueous sample using 0.2–0.45 µm filter (as needed in accordance with the site QAPP or Sampling and Analysis Plan) to eliminate background material (i.e., turbidity) that may interfere with oxidant analysis.

C. Concentration Measurement

Determine the oxidant concentrations (permanganate or persulfate) through one of three methods below.

1) Commercially available test kits
   a. Permanganate: SenSafe™ or CHEMetrics
   b. Persulfate: CHEMetrics or FMC
2) UV-VIS absorbance
   a. Permanganate (direct measurement): wavelength = 525 nm
   b. Persulfate (Ferrous Ammonium Sulfate method): wavelength = 450 nm (Huang *et al.,* 2002; Huling *et al.,* 2011)
3) Colorimetric scales presented in Tables 1 and 2.

Based on the oxidant concentration determined, ascorbic acid stock solution is added to an empty sample vial according to Tables 1 and 2.

D. Quality Assurance and Quality Control (QA/QC)

Quality control includes regularly scheduled analysis of method blanks and sample replicates, and the verification of stock solutions of known concentration via the analysis for concentrations of secondary solutions prepared from the stocks. Results of the analyses of method blanks, replicate analyses, and the verification of stock solution concentrations are logged and maintained in record books specific to the research being conducted. The frequency, control limits, and corrective actions should be appropriately developed for specific applications.

E. Calculations

1) Concentration conversion
   a. Permanganate.

The concentrations of permanganate (MnO_4^-) have been presented in terms of the permanganate anion (118.9 g/mol) (Table 1). However, permanganate is purchased either as sodium permanganate ($NaMnO_4$; 141.9 g/mol) or potassium permanganate ($KMnO_4$; 158.0 g/mol) and as a result conversion to permanganate anion concentrations may be desired to determine

adequate sample preservation needs. Specifically, the ratios 118.9/141.9 (0.84) and 118.9/158.0 (0.75) are used to convert $NaMnO_4$ and $KMnO_4$ respectively, to MnO_4^- (Table A1).

Because 1 mmole of either sodium or potassium permanganate produces 1 mmole of permanganate (Eqs 1 and 2), the molar concentrations of sodium and potassium permanganate are the same as permanganate (Table 3).

$$NaMnO_4 \rightarrow Na^+ + MnO_4^- \quad (1)$$

$$KMnO_4 \rightarrow K^+ + MnO_4^- \quad (2)$$

Converting sodium and potassium permanganate concentrations from mg/L to millimolar, and calculating their permanganate equivalence,

X mg/L $NaMnO_4$ =
(X mg/L) × (1 mmol/141.9 mg) =
X/141.9 mM $NaMnO_4$ =
X/141.9 mM MnO_4^- X/141.9 mM MnO_4^- =
((X/141.9) mmol/L) × (118.9 mg/mmol) =
0.84X mg/L MnO_4^-

NOTE: 1 mmol = 0.001 mol; mM= mmol/L

Y mg/L $KMnO_4$ =
(Y mg/L) × (1 mmol/158.0 mg) =
Y/158.0 mM $KMnO_4$ =
Y/158.0 mM MnO_4^-

Y/158.0 mM MnO_4^- =
((Y/158.0) mmol/L) × (118.9 mg/mmol) =
0.75Y mg/L MnO_4^-

NOTE: 1 mmol = 0.001 mol; mM= mmol/L

b. Persulfate.

The concentration of persulfate is presented in terms of the persulfate anion ($S_2O_8^{2-}$; 192.0 g/mol) (Table A2). However, persulfate is purchased as sodium persulfate ($Na_2S_2O_8$; 238.1 g/mol) and as a result a conversion may be desired to correct for the anionic form of the oxidant and to determine adequate sample preservation needs. Specifically, the ratio of 192.0/238.1 (0.81) is used to convert $Na_2S_2O_8$ to $S_2O_8^{2-}$. Persulfate is colorless and requires field measurement at the well head to determine its presence and concentration in the ground water sample.

Converting sodium persulfate concentrations from mg/L to millimolar, and calculating the persulfate equivalence,

$$Na_2S_2O_8 \rightarrow 2Na^+ + S_2O_8^{2-} \quad (3)$$

Z mg/L $Na_2S_2O_8$ =
(Z mg/L) × (1 mmole/238.1 mg) =
Z/238.1 mM $Na_2S_2O_8$ =
Z/238.1 mM $S_2O_8^{2-}$

Z/238.1 mM $S_2O_8^{2-}$ =
(Z/238.1) mmole/L) × (192 mg/mmole) =
0.81Z mg/L $S_2O_8^{2-}$

2) Required volume and mass of ascorbic acid to neutralize oxidants.

a. Permanganate.

1.8 mole ascorbic acid per mole of permanganate was empirically determined to effectively neutralize permanganate in an aqueous sample containing VOCs (Johnson *et al.*, 2012). Therefore, the mass balance equation (Eq 4) can be set up as follows,

$$1.8C_{MnO4-}V_{MnO4-} = C_{H2A}V_{H2A} \quad (4)$$

Where,
C_{MnO4-} = permanganate concentration determined in step 7.C,

Table A1. Corresponding concentration of sodium permanganate and potassium permanganate to permanganate.

$NaMnO_4$	mg/L	0.90	4.5	9.0	13.5	22.4	35.9	44.9	67.3	89.9	135	180	224	449
	mM	0.006	0.032	0.063	0.095	0.16	0.25	0.32	0.47	0.63	0.95	1.27	1.58	3.16
$KMnO_4$	mg/L	1.00	5.0	10.0	15.0	25.0	40.0	50.0	74.9	100	150	201	250	500
	mM	0.006	0.032	0.063	0.095	0.16	0.25	0.32	0.47	0.63	0.95	1.27	1.58	3.16
MnO_4^-	mg/L	0.75	3.8	7.5	11.3	18.8	30.1	37.9	56.4	75.3	113	151	188	376
	mM	0.006	0.032	0.063	0.095	0.16	0.25	0.32	0.47	0.63	0.95	1.27	1.58	3.16

Table A2. Corresponding concentration of sodium persulfate to persulfate ($S_2O_8^{2-}$).

$Na_2S_2O_8$	mg/L	99	248	496	756	1004	1500	1996	2504	3000	3496	4004	4500	4996
	mM	0.42	1.0	2.1	3.2	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0
$S_2O_8^{2-}$	mg/L	80	200	400	610	810	1210	1610	2020	2420	2820	3230	3630	4030
	mM	0.42	1.0	2.1	3.2	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0

V_{MnO4-} = volume of permanganate solution in the VOA vial (0.04 L),

C_{H2A} = ascorbic acid concentration (0.015, 0.15 or 1.5 M), and

V_{H2A} = volume of ascorbic acid required to neutralize permanganate.

V_{H2A} can be calculated (Eq 5) through rearranging Eq. (4)

$$\mathbf{V_{H2A} = (1.8 \times C_{MnO4-} \times V_{MnO4-})/C_{H2A}} \quad (5)$$

For example, a 40 mL permanganate concentration of 1.27mM (151 mg/L) is neutralized using 1.5 M ascorbic acid. The volume of stock solution and mass of ascorbic acid can be calculated as follows.

$$V_{H2A} = (1.8 \times 1.27 \text{ mmol/L} \times 0.04\text{L}/1.5 \text{ mol/L}) \times (1 \text{ mol}/1000 \text{ mmol}) \times (10^6 \text{ µL}/1\text{L}) = 61 \text{ µL}$$

$$M_{H2A} = 1.5 \text{ mol/L} \times 61 \text{ µL} \times (1\text{L}/10^6 \text{ µL}) \times (176.12 \text{ g/mol}) \times (1000 \text{ mg/g}) = 16.1 \text{ mg}$$

Where,

M_{H2A} = mass of ascorbic acid

The formation of colloidal or particulate MnO_2(s) (i.e., Mn^{+4}) may occur causing a brown tinge appearance of the solution. Incremental amendment of ascorbic acid may be required to further reduce the Mn^{+4} to Mn^{+2}, and eliminate the brownish tinge color. Mn^{+2} is highly soluble and the most desirable form of Mn to minimize the impact of colloidal or particulate matter on the laboratory analytical instruments. Overall, Table 1 is used as a guideline but the actual amount should be based on the amount required to fully eliminate the MnO_4^- and MnO_2(s), and to achieve a clear solution. The volume of ascorbic acid solution added to the sample vial should be recorded so appropriate dilution calculations can be performed to obtain an accurate estimate of the contaminant concentrations.

b. Persulfate.

4 mole of ascorbic acid per mole of persulfate was empirically determined to effectively limit the impact of the oxidant on VOCs in aqueous samples (Huling *et al.*, 2011). Therefore, the mass balance equation (Eq 6) can be set up as follows,

$$4C_{S2O82-}V_{S2O82-} = C_{H2A}V_{H2A} \quad (6)$$

Where,

C_{S2O82-} = persulfate concentration determined in step 7.C,

V_{S2O82-} = volume of persulfate solution in the VOA vial 0.04 L,

C_{H2A} = ascorbic acid concentration (1.5 M),

V_{H2A} = volume of ascorbic acid required to neutralize persulfate

V_{H2A} can be calculated (Eq 7) through rearranging Eq. (6)

$$\mathbf{V_{H2A} = (4 \times C_{S2O82-} \times V_{S2O82-})/C_{H2A}} \quad (7)$$

For example, persulfate concentration is 10.5 mM (2020 mg/L) and neutralized using 1.5 M ascorbic acid. The volume of stock solution and mass of ascorbic acid can be calculated as follows.

$$V_{H2A} = (4 \times 10.5 \text{ mmol/L} \times 0.04\text{L} / 1.5 \text{ mol/L}) \times (1 \text{ mol}/1000 \text{ mmol}) \times (1000 \text{ mL}/1\text{L}) = 1.12 \text{ mL}$$

$$M_{H2A} = 1.5 \text{ mol/L} \times 1.12 \text{ mL} \times (1 \text{ L}/1000 \text{ mL}) \times (176.12 \text{ g/mol}) = 0.3 \text{ g}$$

Where,

M_{H2A} = mass of ascorbic acid

The volume of ascorbic acid solution added to the sample vial should be recorded so appropriate dilution calculations can be performed to obtain an accurate estimate of the contaminant concentrations.

F. Pre-amending Sample Vials With Preservative

Pre-amending the 40 mL sample vials prior to performing ground water sample collection in the field is one step that may help simplify sample preservation procedures. The advantage is that all sample vials are

amended with the preservative in a uniform manner, and this reduces the number of steps and time required during ground water sampling activities in the field. Specifically, this would involve amending the sample vial with an appropriate quantity of ascorbic acid using the procedures recommended above. Successful sample preservation would be immediately obvious in the case with permanganate binary mixtures as the pink/purple color would disappear and the sample would become clear. A persistent pink/purple or brown tinge color would indicate the need for additional preservative. The immediate visual feedback would not occur in the preservation of persulfate binary mixtures due to the absence of oxidant coloration. Success of the preservation method will most likely require prior knowledge of oxidant concentrations in ground water samples to support the selection of an appropriate quantity of preservative. A quality assurance step could include the collection of duplicate samples, and subsequent analysis for persulfate, when time permits, to confirm that a sufficient quantity of preservative was amended. Other appropriate quality assurance steps could be developed.

8. REFERENCES

Huang, K.C., Couttenye, R.A., and Hoag, G.E. 2002. Kinetics of heat-assisted persulfate oxidation of methyl *tert*-butyl ether, *Chemosphere* 49(4), 413-420.

Huling, S.G., Ko, S., and Pivetz, B. 2011. Ground water sampling at ISCO sites – binary mixtures of volatile organic compounds and persulfate. *Ground Water Monit. Remed.* 31(2), Spring 72-79.

Johnson, K.T., Wickham-St. Germain, M., Ko, S. and Huling, S.G. 2012. Binary Mixtures of Permanganate and Chlorinated Volatile Organic Compounds in Groundwater Samples: Sample Preservation and Analysis. *Ground Water Monit. Remed.*, 32(3), Summer 84–92.

9. DISCLAIMER

This recommended operating procedure has been prepared for general use. This is not an official approved U.S. Environmental Protection Agency method and has not undergone the Agency's peer review process.

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Agency

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August 2012

APPENDIX A-2

Determination of ISCO Reagent Residual Using the Hach DR 890 Colorimeter

Determination of RemOx® ISCO Reagent Residual Using the Hach DR 890 Colorimeter

FACT SHEET

OBJECTIVE

This method can be used to determine the residual permanganate in water using standard spectrophotometric methods.

NOTE

If the instrument is being used for the first time, a calibration curve needs to be stored in the instrument. The absorbance is measured at 520 nm. A minimum of three standards should be used to generate this curve. (See instructions in the DR 890 instruction manual).

PROCEDURE

1. Obtain a water sample of unknown permanganate concentration and filter through a 0.45 um oxidant-resistant syringe filter (recommended examples are Whatman 0.45 um syringe filters or Millipore Millex GV syringe filters). This is to remove any turbidity and MnO_2 that may be present.

2. The sample may need to be diluted at this time. The acceptable range for reading residual permanganate on the DR 890 is approximately 1-50 mg/L. The sample should be diluted with deionized water to read within this range.

3. Enter program number 102 for the stored program on the instrument.

4. Zero the colorimeter using either deionized water or filtered, untreated groundwater. Fill the vial to the 25 mL mark and face the diamond shape on the sample cell towards the keypad. Note: Be sure to wipe the vial so it is clean, free of streaks, and dry. Place the light shield over the sample cell and press zero on the instrument.

5. Fill a second vial to the 25 mL mark with filtered groundwater containing an unknown concentration of permanganate. Note: Be sure to wipe the vial so it is clean, free of streaks, and dry. Place the light shield over the sample cell and press read on the instrument. The program will give the result in mg/L as either $KMnO_4$ or $NaMnO_4$. All Carus rental units read the results as $KMnO_4$. If a dilution was used, multiply the colorimeter reading by the dilution factor.

CALCULATION

If analyzing for RemOx® L ISCO reagent (sodium permanganate) use the following equation to convert: mg/L $KMnO_4$ X 0.895 = mg/L $NaMnO_4$

RETURN INFORMATION

Please be sure all vials are empty and clean before shipping the kit back to Carus. No liquids should be shipped. Please send colorimeter back to the address listed below and insure shipment for $1,500. Thank you!

Carus Corporation
Attention: CRT
315 5th Street
Peru, IL 61354

Carus Corporation
Peru, IL U.S.A.
Tel. + 1 815 223 1500
1 800 435 6856 (Toll free US Only)
Fax + 1 815 224 6697

Carus Europe
Asturias, Spain
Tel + 34 985 78 55 13
Fax + 34 985 78 55 10

Web: www.caruscorporation.com
E-Mail: salesmkt@caruscorporation.com

APPENDIX A-3

Job Safety Analysis – Sodium Permanganate Injections

Job Safety Analysis

General

JSA ID	7491	**Status**	(2) Review
Job Name	Environmental-Introductions - carbon source or chemical	**Created Date**	1/28/2015
Task Description	Sodium Permanganate Injections	**Completed Date**	
Template	False	**Auto Closed**	False

Client / Project

Client	USACE, BALTIMORE DISTRICT
Project Number	GP14DRUM.0001
Project Name	FT DRUM IRP PBC
PIC	MAYERS, JENNIFER
Project Manager	VITOLINS, ANDREW

Job Steps

Job Step No.	Job Step Description		Potential Hazard	Critical Action	H&S Reference
1	Site Staging and Setup	1	Site workers or equipment can be struck by vehicular traffic.	Wear a Class II traffic vest and set up traffic control devices.	
2	Setting up the injection and gravity feed system.	1	Slips, trips/falls can occur from hoses running from injection tank to the wells.	Route all hoses and connections in an organized fashion to reduce the potential for slips/trips.	
		2	Heavy Lifting	Use proper lifting techniques. Do not lift more than your personal limits. Request assistance with heavy lifting.	
		3	Mixing the Sodium Permanganate	Wear all appropriate PPE which includes a chemical apron, rubber gloves, goggles and faceshield. Add the Sodium Permanganate to the water once the tank is full. Keep neutralizing solution nearby in case of any spills. Keep the hose used to fill the tank within reach in case of a fire as a Sodium Permanganate fire must be put out with water, not an extinguisher. Use spill containment where appropriate.	
3	Injecting or gravity feeding the Sodium Permanganate solution	1	Spills	Make sure all fittings/joints are tight before turning on the pumps. Start with the return line to the tank in the fully open position. Make sure spill containment is at all appropriate locations and that neutralizing solution and absorbent booms are within reach. Once the pumps are running check for leaks first and then begin adjusting the flowrate at the well. Before neutralizing a spill of 40% permanganate, dilute it with water to approximately 6%.	
		2	Pressure buildup can cause well attachment to pop off causing possibly strike injury and spill.	Watch flow rates to be sure the solution is flowing, not building up pressure. Do not stand directly over the well fittings. If one does pop off turn of the pump and shut the hose valves as soon as possible to reduce spillage. Keep the neutralizing solution and booms within reach.	
4	Site Cleanup	1	Spills/Splashes	When finished injecting let the wells sit for a few minutes to relive the pressure. Shut all of the valves on the hoses. Carefully roll the hoses up into the back of the truck. Secure all of the wells after every injection event and make the traffic control removal the last item every day.	

PPE — Personal Protective Equipment

Type	Personal Protective Equipment	Description	Required
Dermal Protection	splash apron	When mixing the Sodium Permanganate	Required
Eye Protection	faceshield	When mixing the Sodium Permanganate	Required
	safety glasses		Required
	safety goggles	When mixing the Sodium Permanganate	Required
Foot Protection	steel-toe boots		Required
Hand Protection	chemical resistant gloves (specify type)	When mixing the Sodium Permanganate	Required
	work gloves (specify type)	Nitrile at all times	Required
Hearing Protection	ear plugs	When working near the generator	Required
Miscellaneous PPE	traffic vest--Class II or III		Required

Supplies

Type	Supply	Description	Required
Communication Devices	mobile phone		Required
Decontamination	Decon supplies (specify type)	Neutralizing Agent. Use a solution of 3 parts water, 4 parts vinegar, and 3 parts 3% hydrogen peroxide.	Required
Miscellaneous	fire extinguisher		Required
	first aid kit		Required
	Other	Keep water supply live in case of chemical fire	Required
Personal	eye wash (specify type)		Required
	sunscreen		Recommended

APPENDIX A-4

Field Forms

ISCO Field Log: Injection Well

Well ID:________________
(Record readings hourly, or more frequently, as needed.)

Date	Time	Depth to Water (ft)	Pressure (psi)	Flow Rate (gpm)	Cumulative Volume Injected (gallons)	Observed Color of Water	Conductivity (µS/cm)	pH

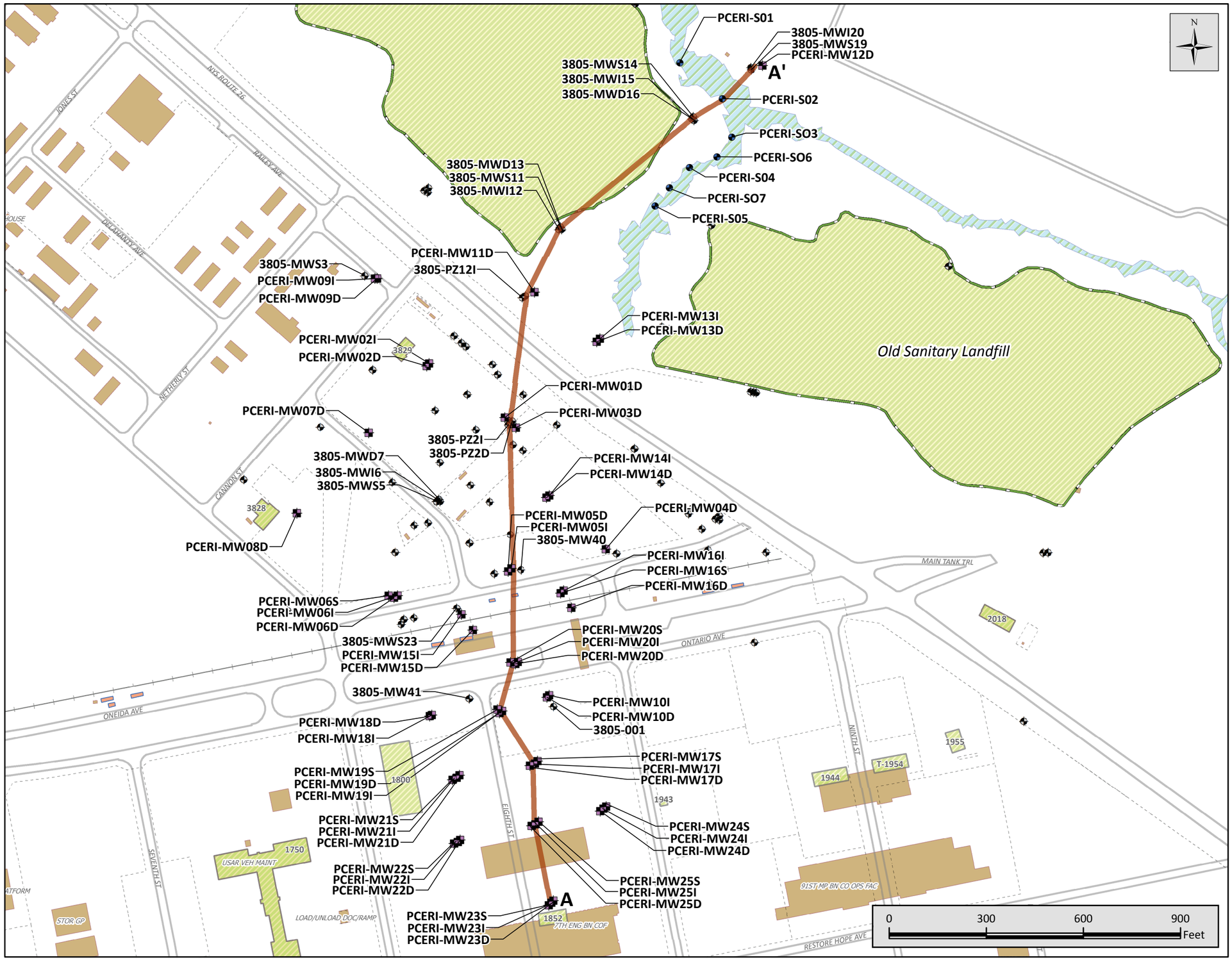
ISCO Field Log: Monitoring Well

Well ID:________________
(Record readings hourly, or more frequently, as needed.)

Date	Time	Depth to Water (ft)	Observed Color of Water	Conductivity (µS/cm)	pH

APPENDIX B

Select Figures from the Remedial Investigation Report (PARS, 2013a)



Legend

- PCERI Monitoring Wells
- SWIM/SW/Sediment Sample Location
- Cross-section Transect
- Monitoring Well Locations
- Landfill
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Paved Road
- Wetlands
- Building

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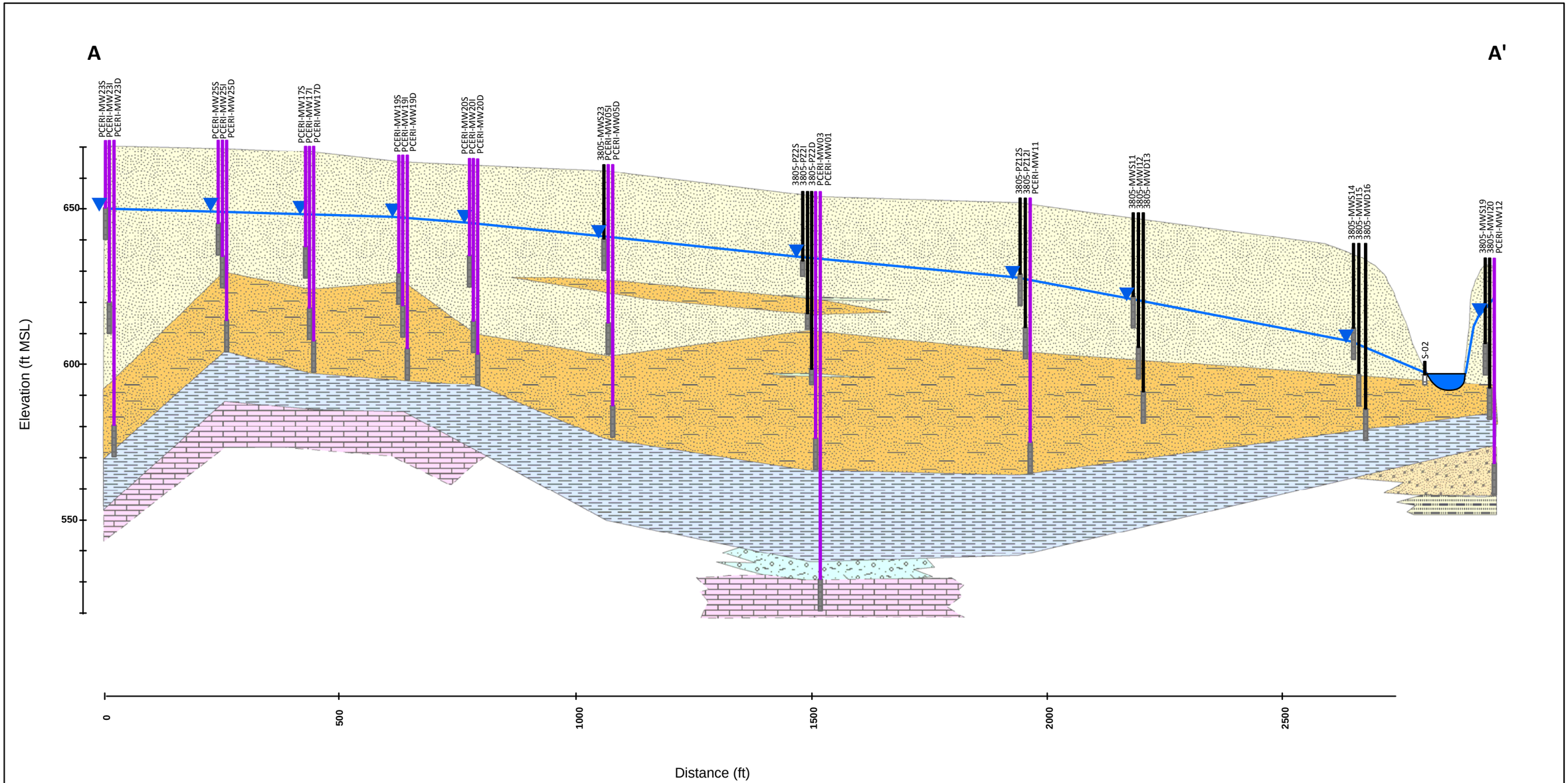
Date: May 2012

FIGURE 3-2

Geological Cross-Section Transect Map

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY



Lithology

- Sand
- Silty Sand
- Silt
- Clay
- Till
- Gravel
- Limestone
- Sandstone

3805-MW40 — Well ID — PCERI-MW01

Riser
Black - Existing Well
Purple - New Well

Well Screen

SWIM/SW/SED Location

Water Table (Basewide Fall 2011)

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FIGURE 3-3

PCERI Geological Cross-Section

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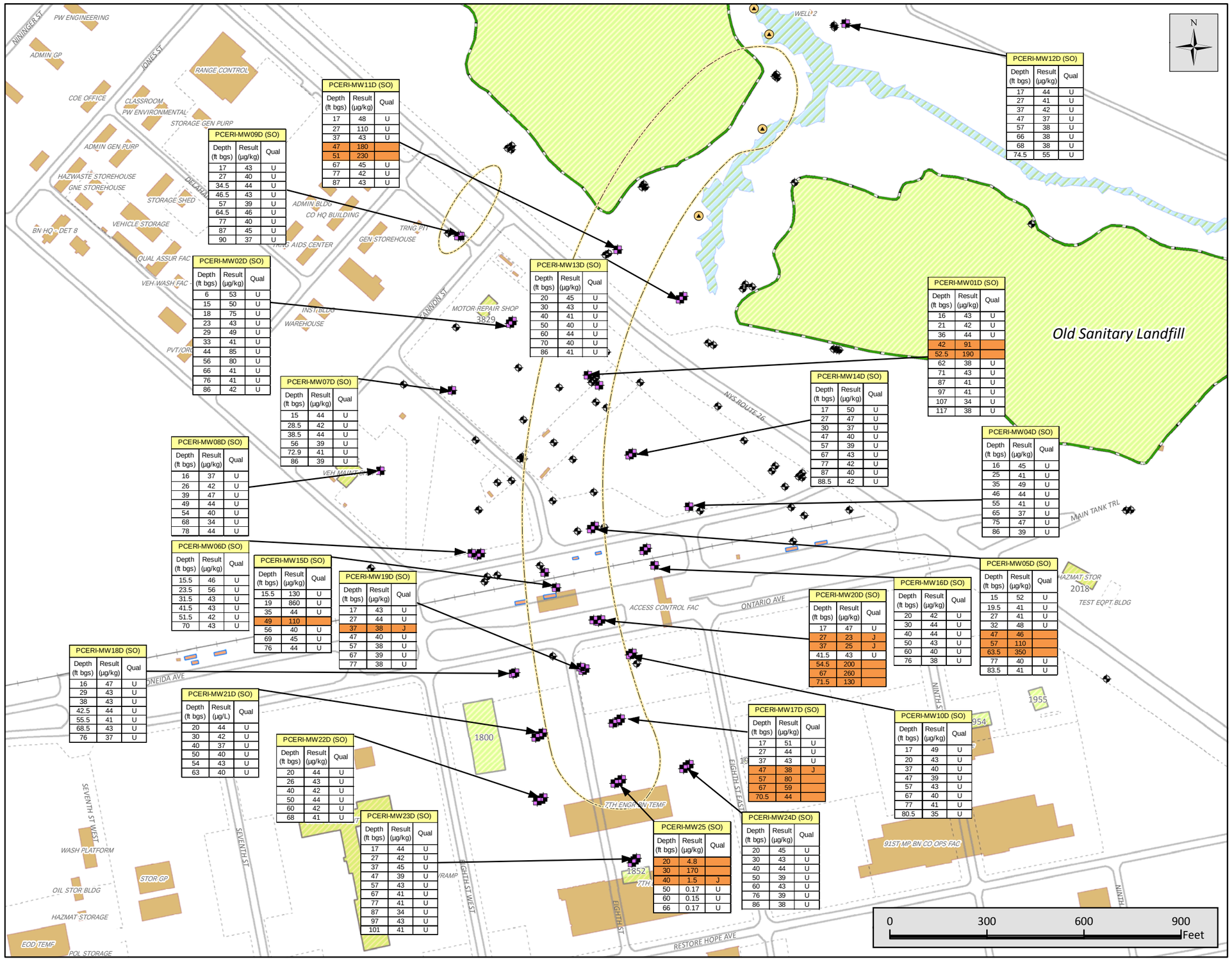
Fort Drum, NY



Legend

- PCERI Monitoring Wells
- Preliminary PCE Plume Outline
- Monitoring Well Locations
- Seep Sample Location
- Landfill
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Paved Road
- Wetlands
- Building

Highlight indicates a PCE detection

Acronym Key:
UST: Underground Storage Tank
MW: Monitoring Well
ft bgs: Feet Below Ground Surface
µg/L: Microgram per Liter
µg/kg: Microgram per Kilogram

Qualifier Key:
U: Non-detect
J: Result has been estimated
D: Sample has been diluted

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FIGURE 4-1

Soil PCE Results Fall 2010

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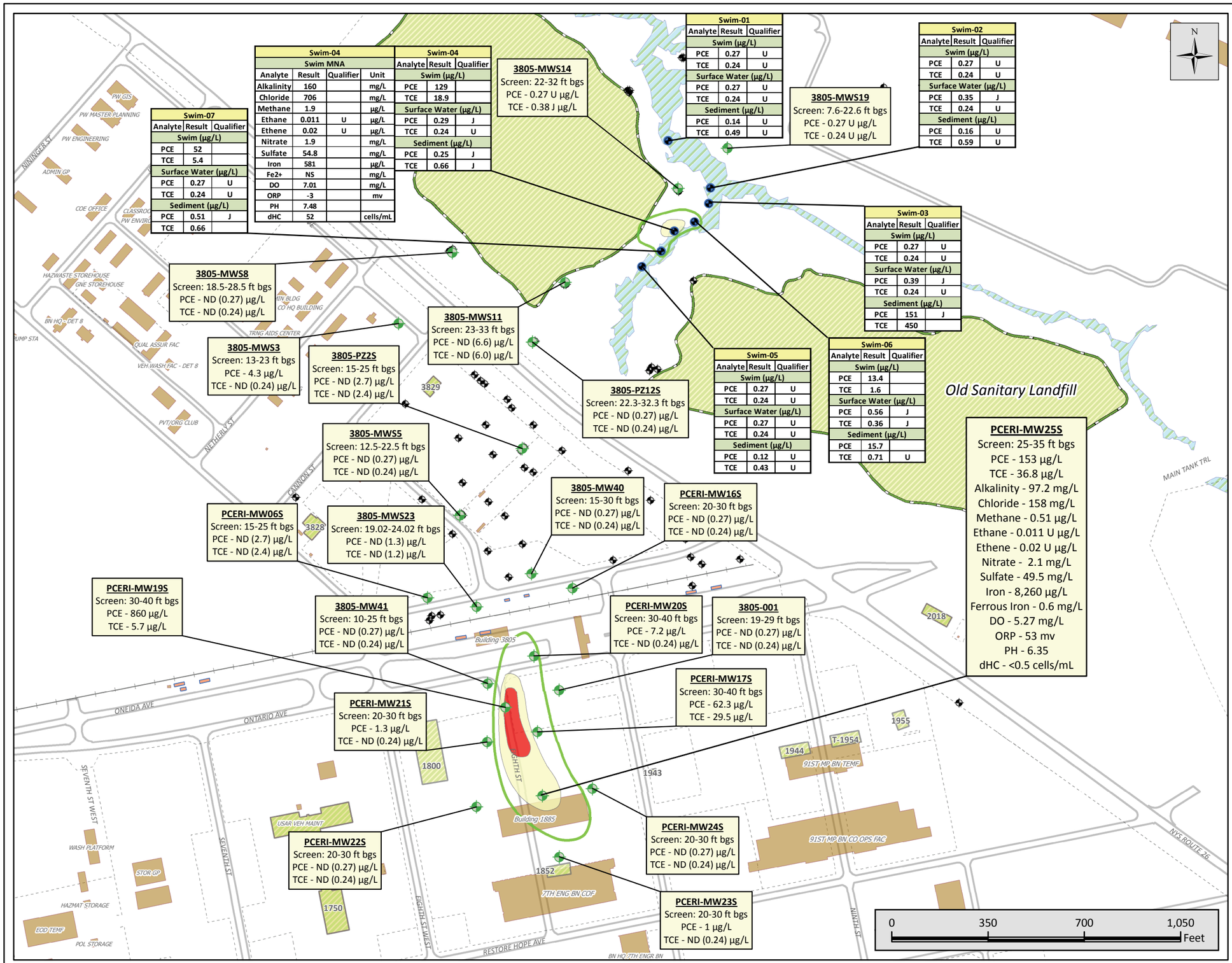
Fort Drum, NY



Legend

- Shallow Monitoring Wells
- SWIM/SD/SW Locations
- Monitoring Well Locations
- Former UST
- Landfill
- Potential Hazardous Waste Sources
- Fence Line
- Rail Road
- Paved Road
- Wetlands
- Building

Shallow PCE Plume (µg/L)

- 5-99
- 100-500
- >500

Acronym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/L - micrograms per Liter
mg/L - miligrams per Liter
NS - Not Sampled
ft bgs - Feet Below Ground Surface
cells/mL - Cells per mililiter
Fe2+ - Ferrous iron
DO - Dissolved Oxygen
ORP - Oxygen-Reduction Potential
dHC - Dehalococcoides
MNA - Monitored Natural Attenuation
SWIM - Surface Water Interface Monitoring

Qualifier Key:
U - Non detect
J - Result has been Estimated
<0.5 cells/mL is a Non-detect

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FIGURE 4-2

Shallow Aquifer Analytical Results Spring 2011

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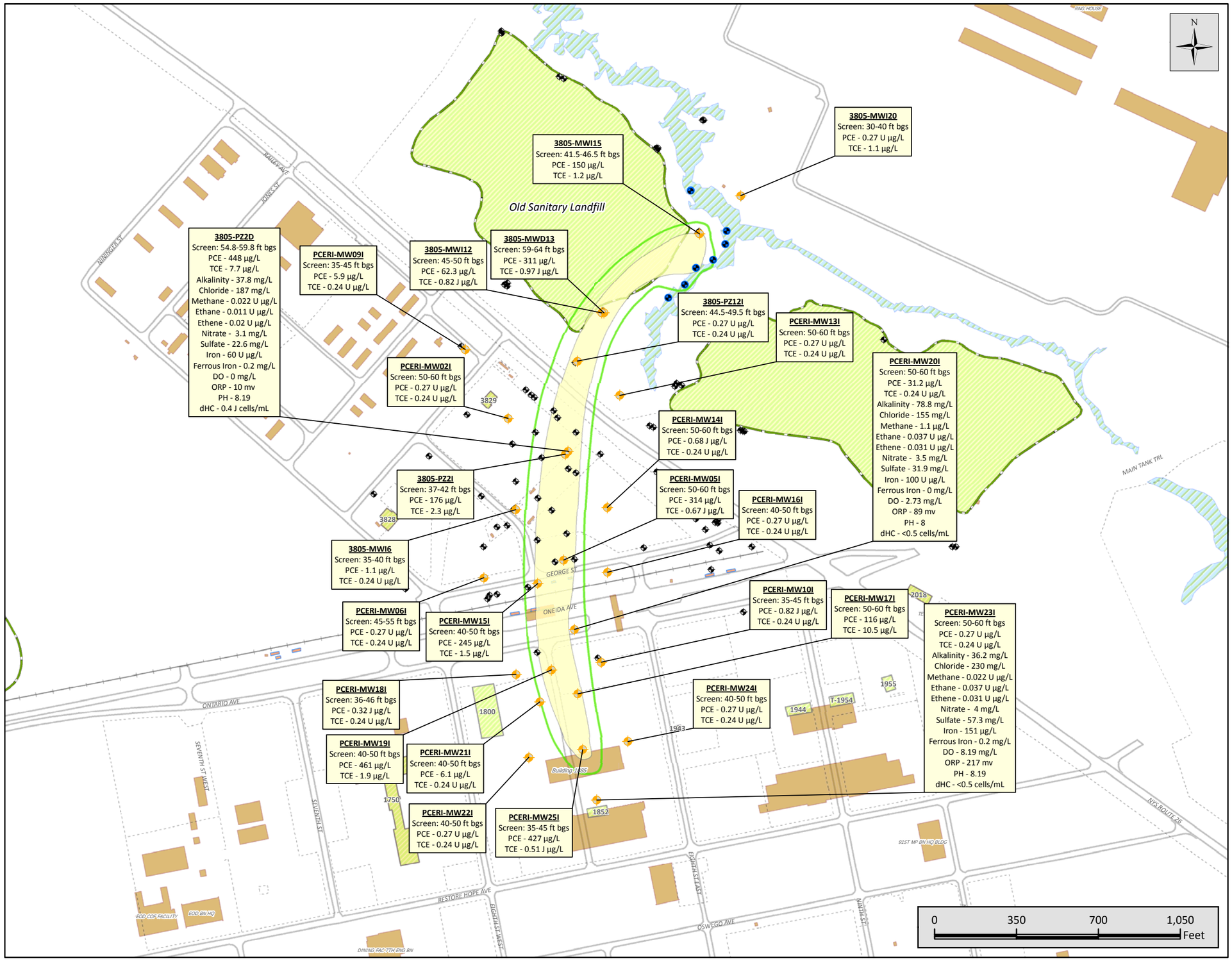
For Chlorinated Solvent Contaminants
Fort Drum, NY



Legend

- Intermediate Monitoring Wells
- SWIM/SD/SW Locations
- Monitoring Well Locations
- Landfill
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Wetlands
- Building
- Paved Road

Intermediate PCE Plume (µg/L)

- 5
- 100-500

Acronym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/L - micrograms per Liter
mg/L - miligrams per Liter
ft bgs - Feet Below Ground Surface
cells/mL - Cells per mililiter
DO - Dissolved Oxygen
ORP - Oxygen-Reduction Potential
dHC - Dehalococcoides
SWIM: Surface Water Interface Monitoring

Qualifier Key:
U - Non detect
J - Result has been Estimated
<0.5 cells/mL is a Non-detect

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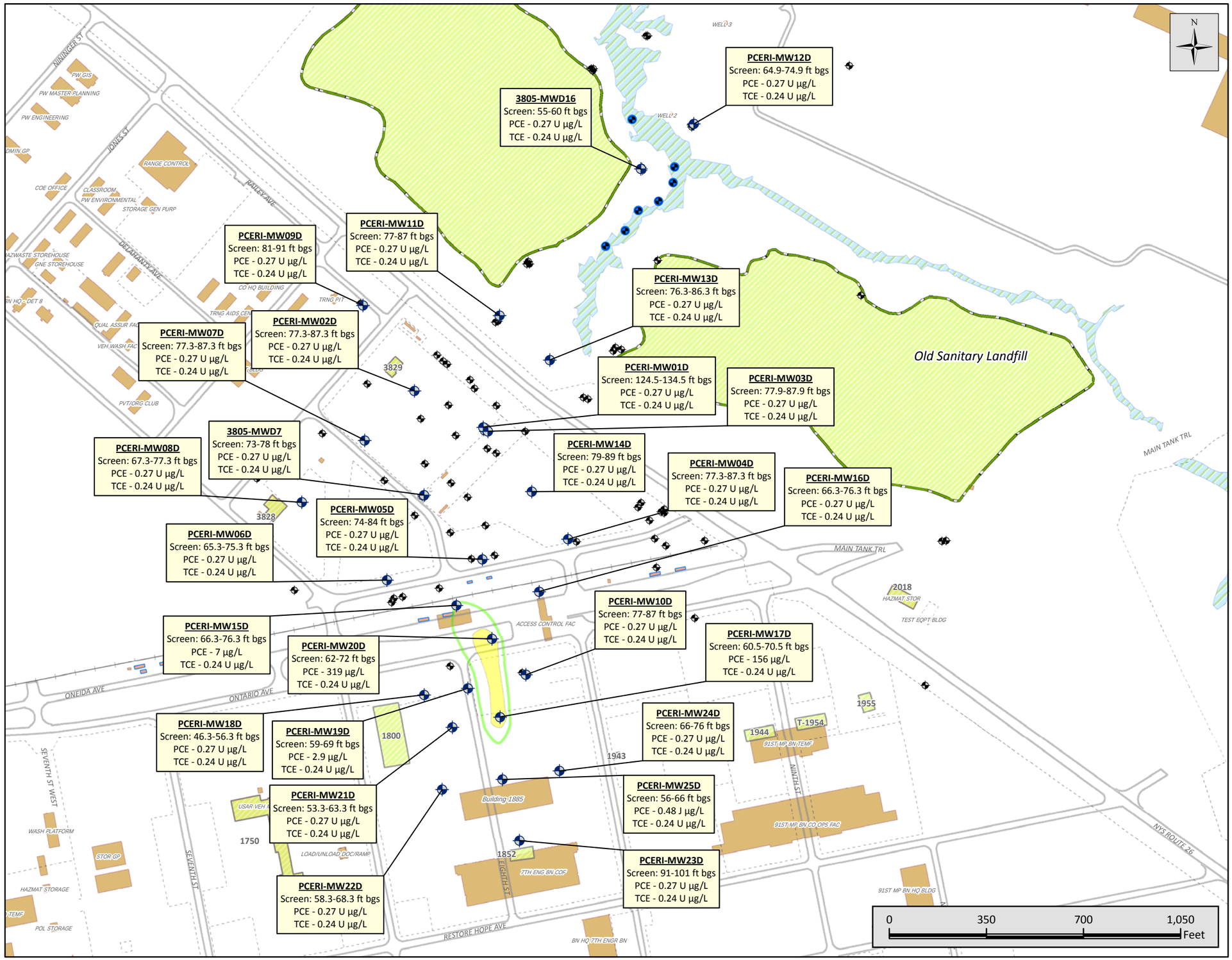
FIGURE 4-3

Intermediate Aquifer Analytical Results, Spring 2011

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY



Legend

- Deep Monitoring Wells
- SWIM/SD/SW Locations
- Monitoring Well Locations

Deep PCE Plume (µg/L)

- 5
- 100-500
- Landfill
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Paved Road
- Wetlands
- Building

Acornym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/L - micrograms per Liter
ft bgs - Feet Below Ground Surface
SWIM - Surface Water Interface Monitoring

Qualifier Key:
U - Non detect
J - Result has been Estimated

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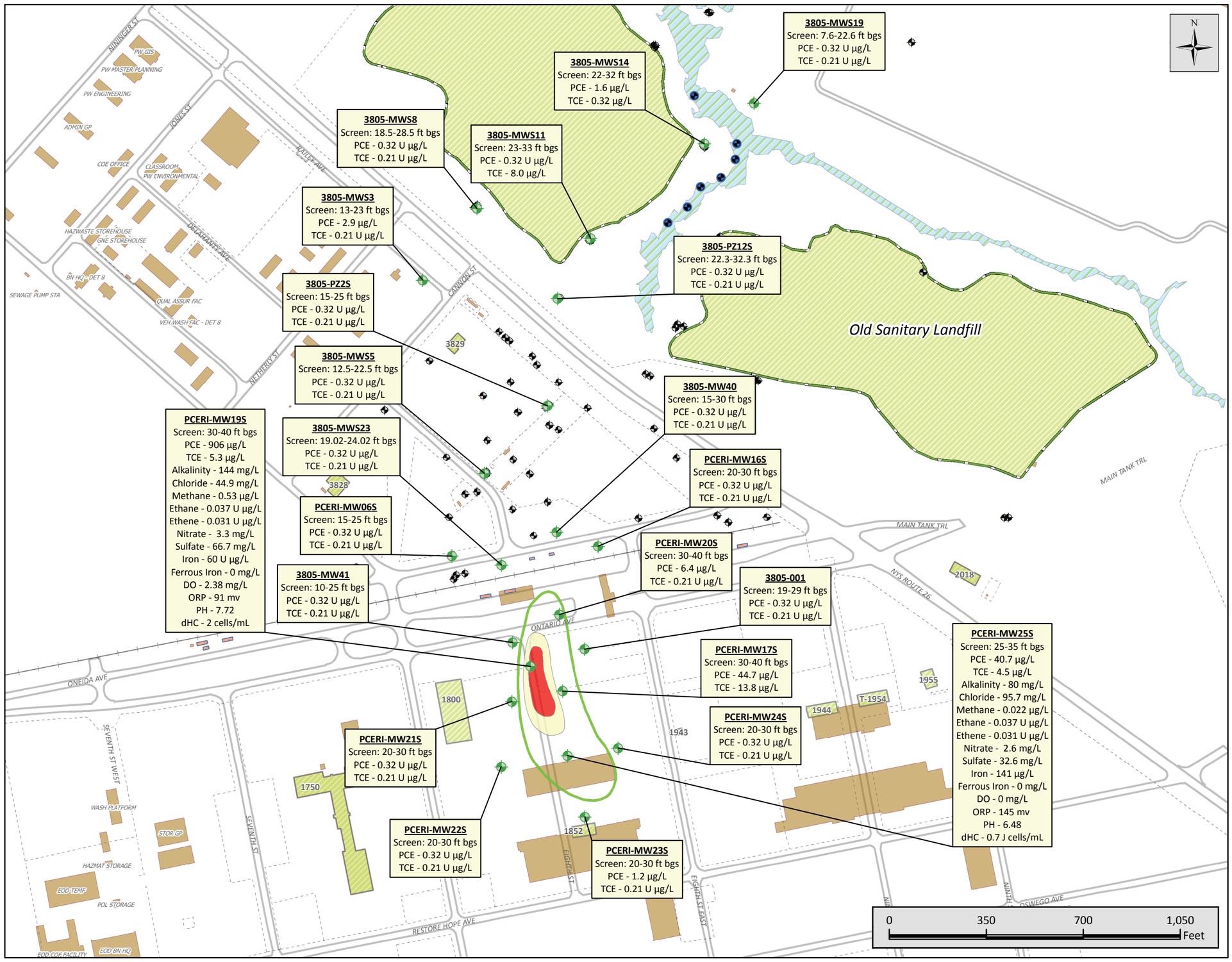
FIGURE 4-4

Deep Aquifer Analytical Results Spring 2011

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY



Legend

- Shallow Monitoring Wells
- SWIM/SD/SW Locations
- Monitoring Well Locations
- Landfill
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Paved Road
- Wetlands
- Building

Shallow PCE Plume (µg/L)

- 5-99
- 100-500
- >500

Acornym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/L - micrograms per Liter
mg/L - miligrams per Liter
ft bgs - Feet Below Ground Surface
cells/mL - Cells per mililiter
DO - Dissolved Oxygen
ORP - Oxygen-Reduction Potential
dHC - Dehalococcoides
SWIM - Surface Water Interface Monitoring

Qualifier Key:
U - Non detect
J - Result has been Estimated
<0.5 cells/mL is a Non-detect

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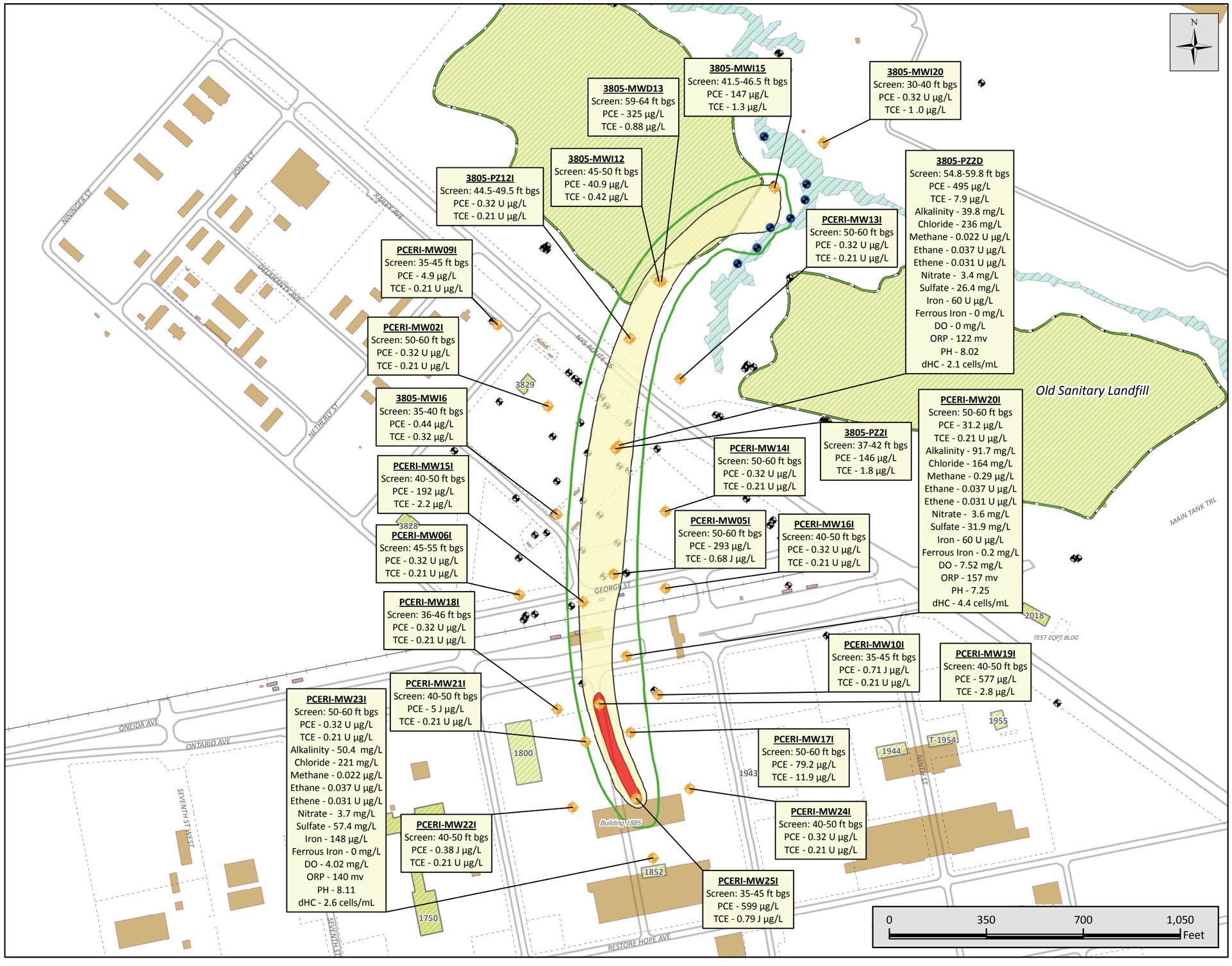
FIGURE 4-5

Shallow Aquifer Analytical Results Fall 2011

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY



Legend

- Intermediate Monitoring Wells
- SWIM/SD/SW Locations
- Monitoring Well Locations

Intermediate PCE Plume (µg/L)

- 5-99
- 100-500
- >500
- Landfill
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Paved Road
- Wetlands
- Building

Acornym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/L - micrograms per Liter
mg/L - miligrams per Liter
ft bgs - Feet Below Ground Surface
cells/mL - Cells per mililiter
DO - Dissolved Oxygen
ORP - Oxygen-Reduction Potential
dHC - Dehalococcoides
SWIM - Surface Water Interface Monitoring

Qualifier Key:
U - Non detect
J - Result has been Estimated
<0.5 cells/mL is a Non-detect

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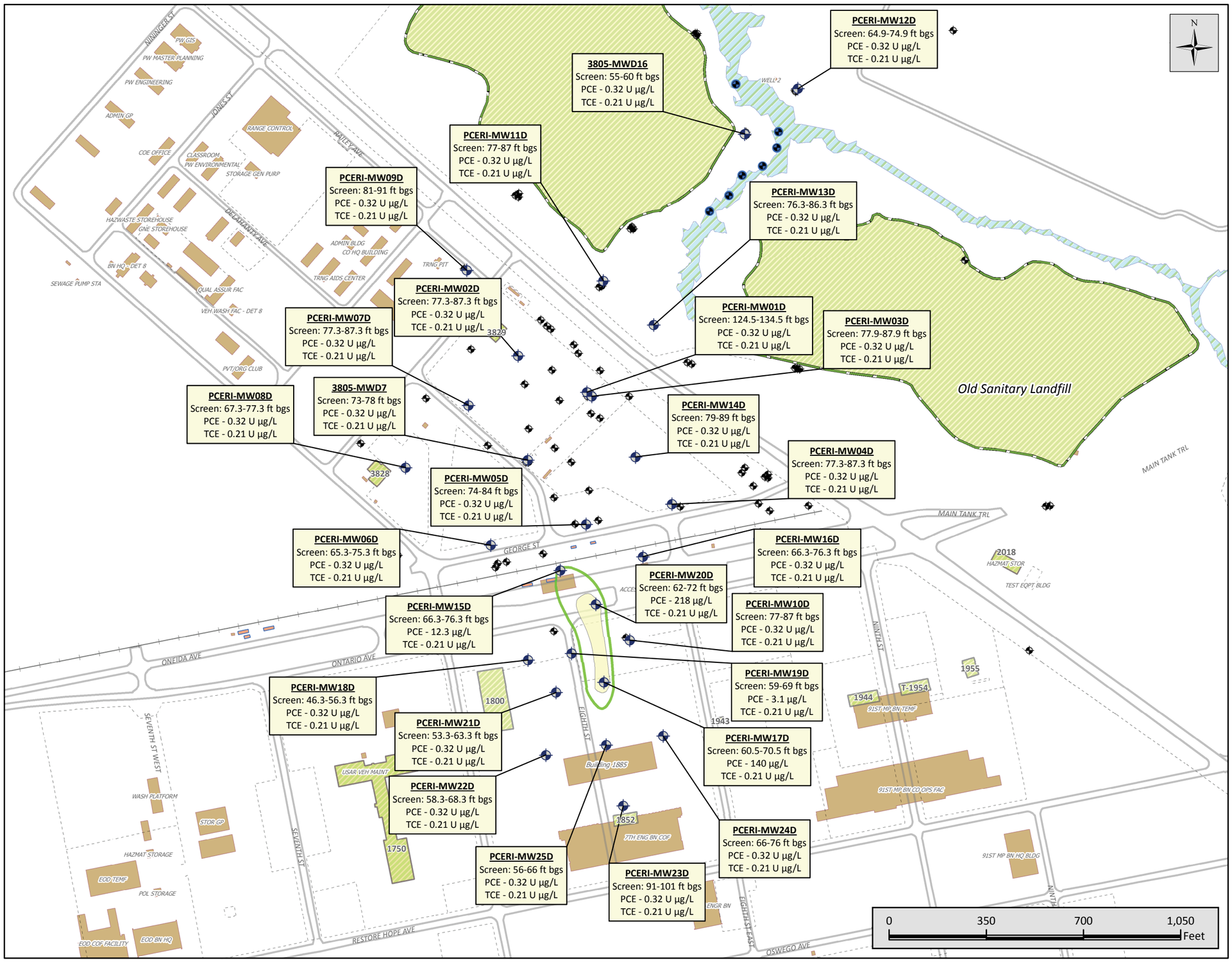
FIGURE 4-6

Intermediate Aquifer Analytical Results, Fall 2011

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY



Legend

- Deep Monitoring Wells
- SWIM/SD/SW Locations
- Monitoring Well Locations

Deep PCE Plume (µg/L)

- 5-99
- 100-500
- Landfill
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Paved Road
- Wetlands
- Building

Acronym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/L - micrograms per Liter
ft bgs - Feet Below Ground Surface
SWIM - Surface Water Interface Monitoring

Qualifier Key:
U - Non detect

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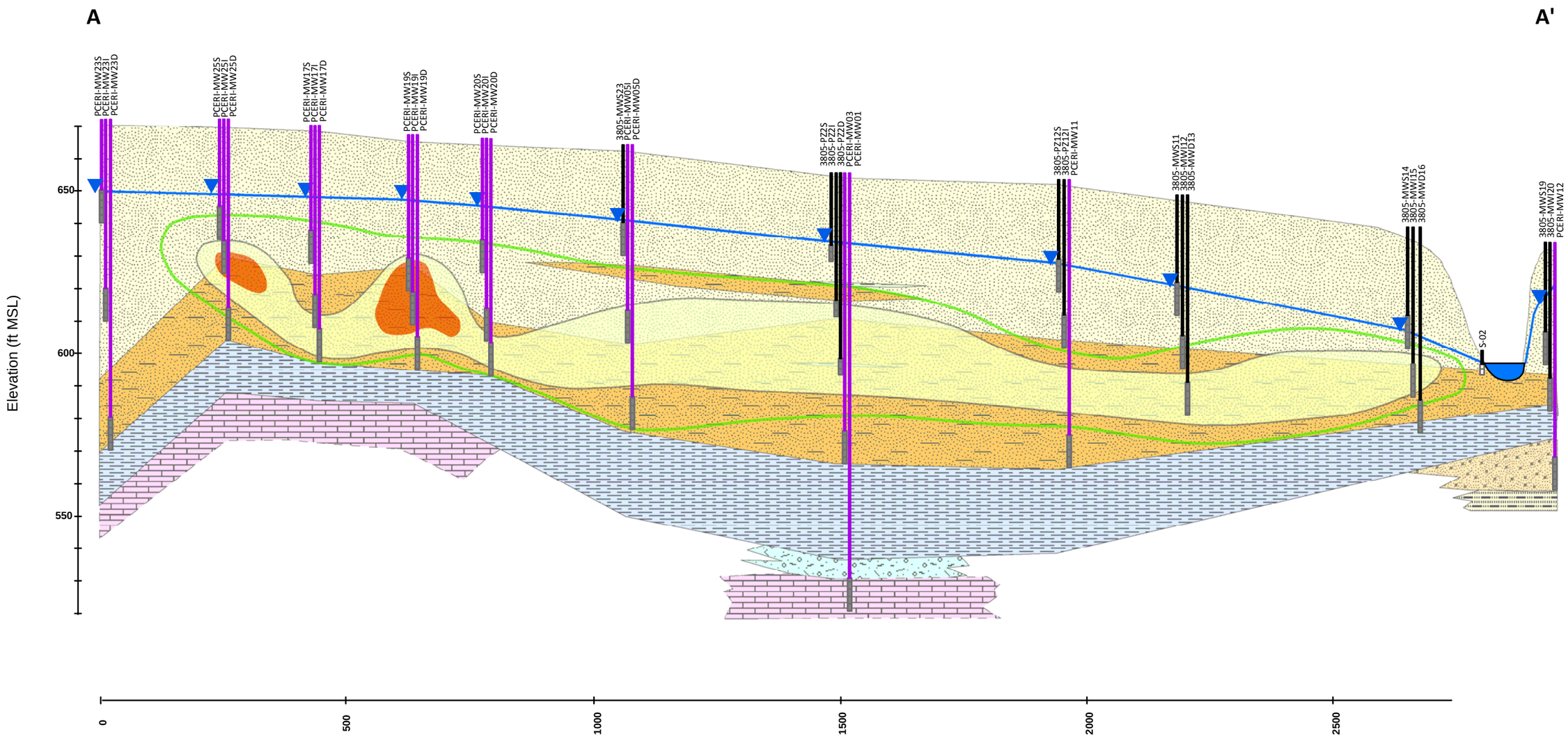
FIGURE 4-7

Deep Aquifer Analytical Results Fall 2011

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY



Acronym Key:
µg/L - micrograms per Liter

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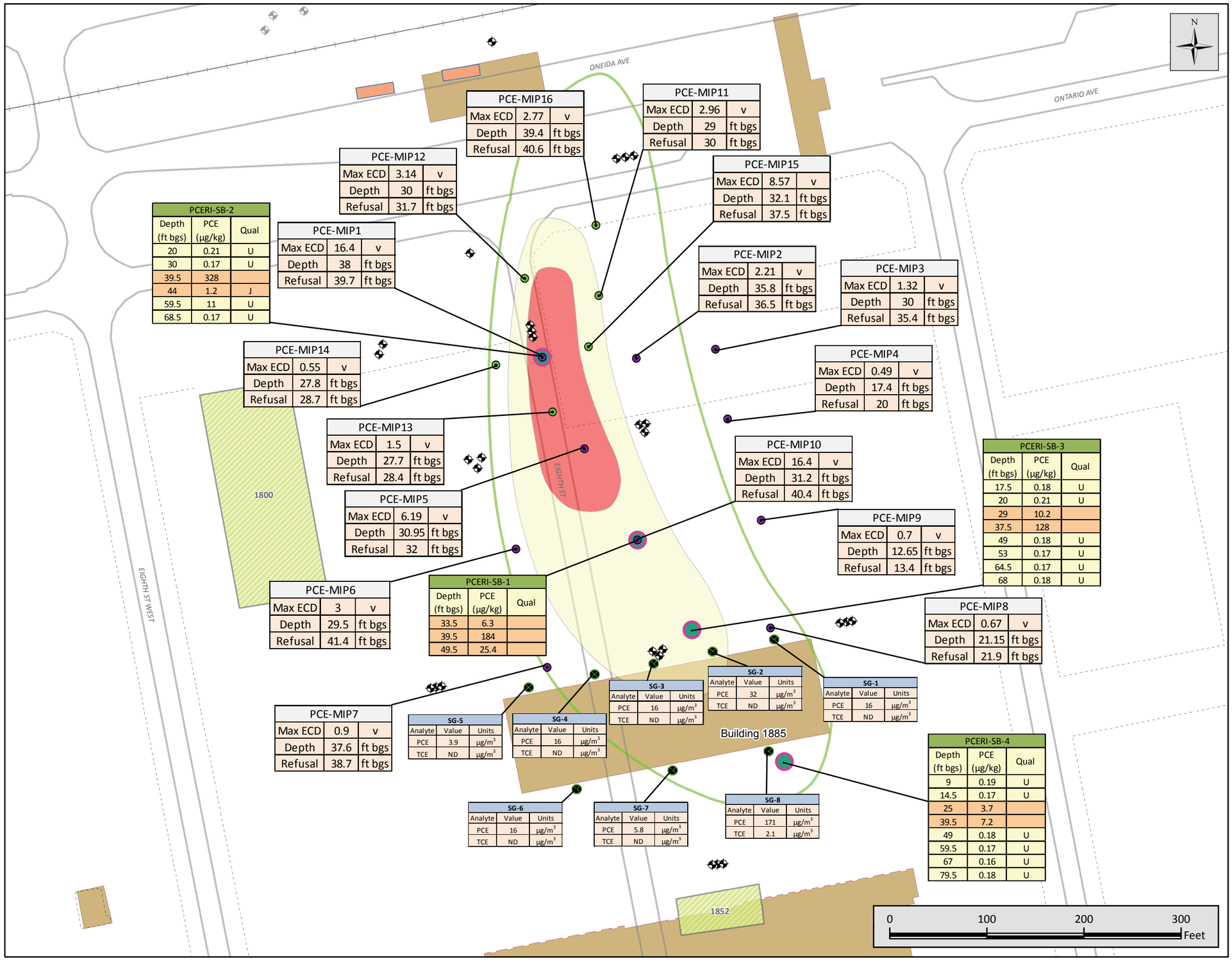
Date: June 2012

FIGURE 4-8

Cross-Section with PCE Groundwater Plume Fall 2011

Remedial Investigation Report For Chlorinated Solvent Contaminants Fort Drum, NY



PCE-MIP16		
Max ECD	2.77	v
Depth	39.4	ft bgs
Refusal	40.6	ft bgs

PCE-MIP11		
Max ECD	2.96	v
Depth	29	ft bgs
Refusal	30	ft bgs

PCE-MIP12		
Max ECD	3.14	v
Depth	30	ft bgs
Refusal	31.7	ft bgs

PCE-MIP15		
Max ECD	8.57	v
Depth	32.1	ft bgs
Refusal	37.5	ft bgs

PCERI-SB-2		
Depth (ft bgs)	PCE (µg/kg)	Qual
20	0.21	U
30	0.17	U
39.5	328	
44	1.2	J
59.5	11	U
68.5	0.17	U

PCE-MIP1		
Max ECD	16.4	v
Depth	38	ft bgs
Refusal	39.7	ft bgs

PCE-MIP2		
Max ECD	2.21	v
Depth	35.8	ft bgs
Refusal	36.5	ft bgs

PCE-MIP3		
Max ECD	1.32	v
Depth	30	ft bgs
Refusal	35.4	ft bgs

PCE-MIP14		
Max ECD	0.55	v
Depth	27.8	ft bgs
Refusal	28.7	ft bgs

PCE-MIP4		
Max ECD	0.49	v
Depth	17.4	ft bgs
Refusal	20	ft bgs

PCE-MIP13		
Max ECD	1.5	v
Depth	27.7	ft bgs
Refusal	28.4	ft bgs

PCE-MIP10		
Max ECD	16.4	v
Depth	31.2	ft bgs
Refusal	40.4	ft bgs

PCERI-SB-3		
Depth (ft bgs)	PCE (µg/kg)	Qual
17.5	0.18	U
20	0.21	U
29	10.2	
37.5	128	
49	0.18	U
53	0.17	U
64.5	0.17	U
68	0.18	U

PCE-MIP5		
Max ECD	6.19	v
Depth	30.95	ft bgs
Refusal	32	ft bgs

PCE-MIP9		
Max ECD	0.7	v
Depth	12.65	ft bgs
Refusal	13.4	ft bgs

PCE-MIP6		
Max ECD	3	v
Depth	29.5	ft bgs
Refusal	41.4	ft bgs

PCERI-SB-1		
Depth (ft bgs)	PCE (µg/kg)	Qual
33.5	6.3	
39.5	184	
49.5	25.4	

PCE-MIP8		
Max ECD	0.67	v
Depth	21.15	ft bgs
Refusal	21.9	ft bgs

SG-2		
Analyte	Value	Units
PCE	32	µg/m³
TCE	ND	µg/m³

SG-3		
Analyte	Value	Units
PCE	16	µg/m³
TCE	ND	µg/m³

SG-1		
Analyte	Value	Units
PCE	16	µg/m³
TCE	ND	µg/m³

SG-5		
Analyte	Value	Units
PCE	3.9	µg/m³
TCE	ND	µg/m³

SG-4		
Analyte	Value	Units
PCE	16	µg/m³
TCE	ND	µg/m³

PCE-MIP7		
Max ECD	0.9	v
Depth	37.6	ft bgs
Refusal	38.7	ft bgs

SG-6		
Analyte	Value	Units
PCE	16	µg/m³
TCE	ND	µg/m³

SG-7		
Analyte	Value	Units
PCE	5.8	µg/m³
TCE	ND	µg/m³

SG-8		
Analyte	Value	Units
PCE	171	µg/m³
TCE	2.1	µg/m³

PCERI-SB-4		
Depth (ft bgs)	PCE (µg/kg)	Qual
9	0.19	U
14.5	0.17	U
25	3.7	
39.5	7.2	
49	0.18	U
59.5	0.17	U
67	0.16	U
79.5	0.18	U

Legend

- Soil Gas Locations
- Initial MIP Points
- Step Out MIP Points
- Soil Borings
- PCE RI Monitoring Wells
- IRP Monitoring Wells

Shallow PCE Plume

(µg/L)

- 5
- 100-500
- >500
- Potential Hazardous Waste Sources
- Former UST
- Fence Line
- Rail Road
- Paved Road
- Building

Acronym Key:
MIP - Membrane Interface Probe
ECD - Electron Capture Detector
PID - Photoionization Detector
SG - Soil Gas Location
PCE - Tetrachloroethylene
TCE - Trichloroethylene
ft bgs - feet below ground surface
v - volts
µg/m³ - micrograms per cubic meter
µg/kg - micrograms per kilogram
µg/L - micrograms per Liter

Qualifier Key:
U - Non detect

25 years of excellence
PLEXUS scientific
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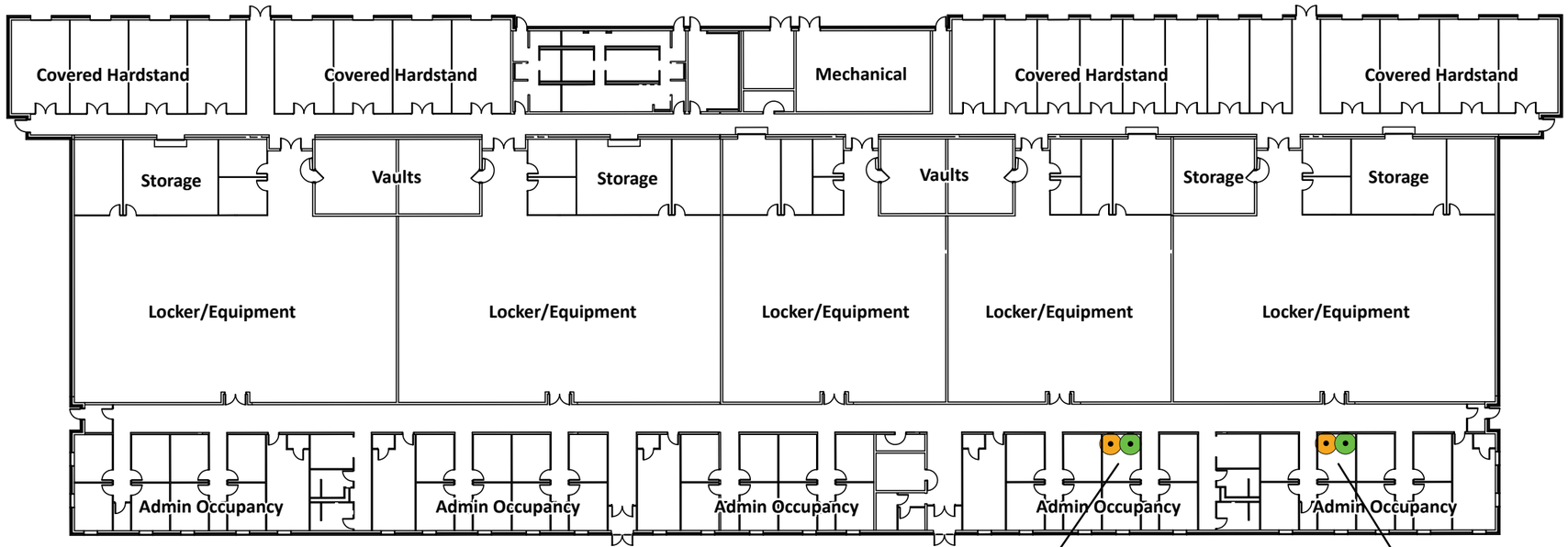
Created By: JRC
Date: May 2012

FIGURE 4-9

Source Area Investigation Results

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY



Sample Pair 5		
Sub-Slab Sample		
Analyte	Value	Units
PCE	4.7	µg/m³
TCE	0.13 U	µg/m³
Benzene	2.7	µg/m³
Ambient Air Sample		
Analyte	Value	Units
PCE	0.19 U	µg/m³
TCE	0.18 U	µg/m³
Benzene	0.19 J	µg/m³

Sample Pair 6		
Sub-Slab Sample		
Analyte	Value	Units
PCE	4.7	µg/m³
TCE	0.13 U	µg/m³
Benzene	6.1	µg/m³
Ambient Air Sample		
Analyte	Value	Units
PCE	0.19 U	µg/m³
TCE	0.18 U	µg/m³
Benzene	0.70	µg/m³

0 40 80 120 Feet

Legend

Vapor Intrusion Sample Locations

- Indoor Air Sample Location
- Sub-Slab Soil Vapor Sample Location

Acronym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/m³ - micrograms per cubic meter

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FIGURE 4-10

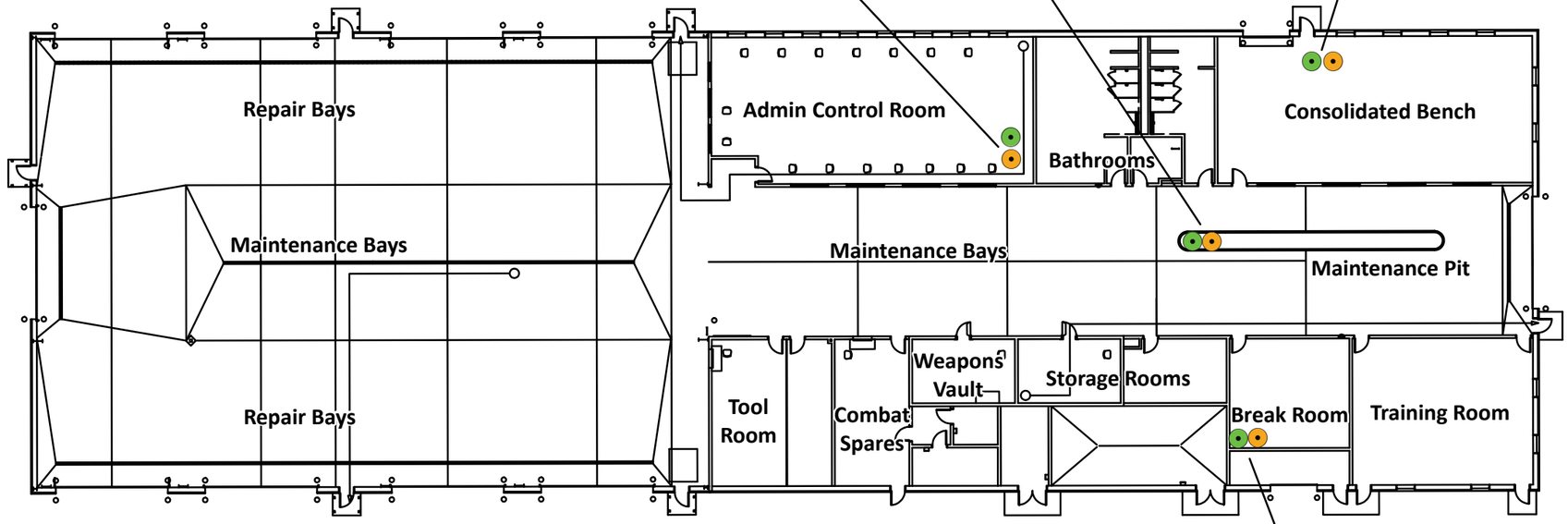
Building 1880 Indoor Air Sampling Results February 2012

Remedial Investigation Report For Chlorinated Solvent Contaminants Fort Drum, NY

Sample Pair 1		
Sub-Slab Sample		
Analyte	Value	Units
PCE	9.5	µg/m³
TCE	0.70 U	µg/m³
Benzene	26	µg/m³
Ambient Air Sample		
Analyte	Value	Units
PCE	0.19 U	µg/m³
TCE	0.18 U	µg/m³
Benzene	4.2	µg/m³

Sample Pair 3		
Sub-Slab Sample		
Analyte	Value	Units
PCE	151	µg/m³
TCE	1.7	µg/m³
Benzene	2.9	µg/m³
Ambient Air Sample		
Analyte	Value	Units
PCE	0.19 U	µg/m³
TCE	0.18 U	µg/m³
Benzene	8.9	µg/m³

Sample Pair 2		
Sub-Slab Sample		
Analyte	Value	Units
PCE	8.8	µg/m³
TCE	0.70 U	µg/m³
Benzene	3.1	µg/m³
Ambient Air Sample		
Analyte	Value	Units
PCE	0.19 U	µg/m³
TCE	0.18 U	µg/m³
Benzene	5.1	µg/m³



Sample Pair 4		
Sub-Slab Sample		
Analyte	Value	Units
PCE	8.8	µg/m³
TCE	1.8	µg/m³
Benzene	52.1	µg/m³
Ambient Air Sample		
Analyte	Value	Units
PCE	0.19 U	µg/m³
TCE	0.18 U	µg/m³
Benzene	7.3	µg/m³

0 30 60 90 Feet

Legend

1885 Floorplan

Vapor Intrusion Sample Locations

- Indoor Air Sample Location
- Sub-Slab Vapor Sample Location

Acronym Key:
PCE - Tetrachloroethene
TCE - Trichloroethene
µg/m³ - micrograms per cubic meter

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Date: May 2012

FIGURE 4-11

Building 1885 Indoor Air Sampling Results February 2012

Remedial Investigation Report
For Chlorinated Solvent Contaminants
Fort Drum, NY

APPENDIX C

Sodium Permanganate Fact Sheet and Safety Data Sheet

CARUS
REMEDIATION



CAS Registry No. 10101-50-5
EINECS No. 233-251-1

RemOx® L ISCO Reagent

FACT SHEET

RemOx® L ISCO reagent has been specifically manufactured for environmental applications such as remediation of soils and associated groundwater. This product can be used to degrade a variety of contaminants including chlorinated solvents, polyaromatic hydrocarbons, phenolics, organo-pesticides, and substituted aromatics. RemOx L is shipped with a certificate of analysis to document assay, pH, and trace metals.

PRODUCT SPECIFICATIONS

Assay
39.5-41.0% as $NaMnO_4$

pH
5.0-8.0

Trace Metals
(see Table 1)

CHEMICAL/PHYSICAL DATA

Formula	$NaMnO_4$
Formula Weight	141.93 g/mol
Appearance	Dark Purple Solution
Specific Gravity	1.365-1.385 g/mL
Freezing Point	-15° C/ 5° F
Solubility in Water	Miscible with water in all proportions.

Material will pass through a 10 micron filter.

APPLICATIONS

RemOx L is used for soil and groundwater remediation by *in situ* or *ex situ* chemical oxidation and as an active agent in subsurface reactive barriers for treatment of: chlorinated ethenes, phenolic compounds, polyaromatic hydrocarbons, RDX, HMX, and various pesticides.

SHIPPING CONTAINERS

5-gallon pail (20-L) (UN Specification: UN3H1/Y1.8/100) Made of high-density polyethylene (HDPE), weighs 3.5 lbs (1.6 kg). The net weight is 57 lbs (25.9 kg). The pail stands approximately 14.8 in (37.6 cm) tall, 10.6 in (26.9 cm) wide, and 11.0 in (27.9 cm) deep. (Domestic and international)

55-gallon drum (208-L) (UN Specification: UN1H1/Y1.41100) Made of high-density polyethylene (HDPE), weighs 22 lbs (10 kg). The net weight is 550 lbs (250 kg). The drum stands approximately 34.8 in (88.3 cm) tall, has an outside diameter of 23.3 in (59.1 cm). (Domestic and international)

SHIPPING CONTAINERS

275-gallon IBC (Intermediate Bulk Container) (1040-L) (UN Specification: UN31HA1/Y1.9/100) They are also marked "MX" for multi-trip. IBC weighs 139 lbs (65 kg). The net weight is 3000 lbs (1360 kg). The IBC contains 263 gallons (1000 L) of product. The IBC dimensions are 45.4 in (115.3 cm) high, 48 in (121.9 cm) long, and 40 in (101.6 cm) wide. The IBC has a 2 in (5 cm) butterfly valve with NPT threads in bottom sump. (Domestic)

275-gallon IBC (Intermediate Bulk Container) (1040-L) (UN Specification: UN31HA1/Y1.9/100) They are also marked "MX" for multi-trip. IBC weighs 132.5 lbs (60 kg). The net weight is 3000 lbs (1360 kg). The IBC contains 263 gallons (1000 L) of product. The IBC dimensions are 45.8 in (116.2 cm) high, 39.4 in (100.0 cm) long, and 47.3 in (120.0 cm) wide. The IBC has a 2 in (5 cm) butterfly valve with NPT threads in bottom sump. (International)

Bulk Shipping- Quantities up to 4000-gallons (15,142-L) are available. (Domestic only)

HANDLING, STORAGE, AND INCOMPATIBILITY

Like any strong oxidizer RemOx L should be handled with care. Protective equipment during handling should include face shields and/or goggles, rubber or plastic gloves, and rubber or plastic apron. If clothing becomes spotted, wash off immediately; spontaneous ignition can occur with cloth or paper. In cases where significant exposure exists use the appropriate NIOSH-MSHA dust or mist respirator.

Store in accordance with NFPA 30 requirements in the United States or the European Fire Protection Association in Europe for Class II oxidizers. Additional regulations in Europe are REACH (Regulation for Registration, Evaluation, Authorisation and Restriction of Chemicals), and CLP (Classification, Labeling, Packaging). REACH is a regulation that increases the responsibility of the industry to manage the risks that the chemical may pose. For REACH registration numbers refer to the eSDS. The product should be stored in a cool, dry area in closed containers. Concrete floors are preferred. Check local regulations to ensure proper storage. Avoid wooden decks. Spillage should be collected and disposed of properly. To clean up spills and leaks follow the steps recommended in our MSDS or eSDS.

Avoid contact with acids, peroxides, and all combustible organic or readily oxidizable materials including inorganic oxidizable materials and metal powders. With hydrochloric acid, chlorine gas is liberated. RemOx L is not combustible, but will support combustion. It may decompose if exposed to intense heat. Fires may be controlled and extinguished by using large quantities of water. Refer to the MSDS or eSDS for more information.

CARUS CORPORATION

ONE COMPANY, ENDLESS SOLUTIONS

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rev. 09/13
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CARUS REMEDIATION



CAS Registry No. 10101-50-5
EINECS No. 233-251-1

RemOx® L ISCO Reagent

FACT SHEET

RemOx® L ISCO reagent is classified as an oxidizer for both domestic and international transportation. Liquid permanganate is shipped domestically as Freight Class 70 and in E.U. as Class 5.1.

Proper Shipping Name: Permanganates, inorganic, aqueous solution n.o.s. (contains sodium permanganate).

Hazard Class: Oxidizer, Class 5.1
Identification Number: UN 3214
Division/APR/RID Class: 5.1
Label Requirements: Oxidizer, 5.1
Packaging Group: II
Packaging Requirements: 49 CFR Parts 171 to 180
Sections: 173.152, 173.202, 173.242
Quantity Limitations:

1 liter net for passenger aircraft or railcar:
5 liters net for cargo aircraft.

Vessel Stowage, (IMDG Regulation):

D-material must be stowed " on-deck" on a cargo vessel, but is prohibited on a passenger vessel. Other provisions: stow separately from ammonium compounds, hydrogen peroxide, peroxides, super-oxides, cyanide compounds, and powdered metal.

H.S. Code 28.41.69.00

SHIPPING CONTAINERS

RemOx L is compatible with many metals and synthetic materials. Natural rubbers and fibers are often incompatible. Solution pH and temperature are also important factors. The material selected for use with liquid permanganate must be compatible with any kind of acid or alkali being used.

In neutral and alkaline solutions, RemOx L is not corrosive to carbon steel and 316 stainless steel. However, chloride corrosion of metals may be accelerated when an oxidant such as liquid permanganate is present in solution. Plastics such as Teflon, polypropylene, and HDPE are also compatible with liquid permanganate.

Aluminum, zinc, copper, lead, and alloys containing these metals may be (slightly) affected by RemOx L. Actual corrosion or compatibility studies should be made under the conditions in which RemOx L will be used.

Table 1: Typical Trace Metal Content and Specifications

Element	Typical Analysis (mg/kg)	Specifications (mg/kg)	DL* (mg/kg)	Element	Typical Analysis (mg/kg)	Specifications (mg/kg)	DL* (mg/kg)
Ag	BDL	0.15	0.034	Fe	BDL	2.00	0.053
Al	BDL	2.00	0.24	Hg	BDL	0.03	0.003
As	BDL	4.00	0.006	Ni	BDL	0.1	0.03
Ba	2.96	15.00	0.016	Pb	BDL	0.70	0.16
Be	BDL	0.50	0.08	Sb	BDL	0.70	0.16
Cd	BDL	0.10	0.016	Se	0.0034	0.50	0.0003
Cr	3.2	5.00	0.031	Tl	BDL	3.50	0.80
Cu	BDL	0.10	0.022	Zn	0.034	0.40	0.011

DL* is detection limit
BDL is below detection limit

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rev. 09/13
form RX 1603

Section 1 Identification of the Substance/Preparation and of the Company/Undertaking

SUBSTANCE/PREPARATION NAME:	RemOx® L ISCO Reagent	
PRODUCT NAME:	RemOx® L ISCO Reagent	
TRADE NAME:	RemOx® L ISCO Reagent	
SYNONYMS:	Permanganic acid sodium salt, sodium permanganate solution	
USES OF SUBSTANCE: RemOx® L ISCO Reagent is a liquid oxidant recommended for applications that require a concentrated permanganate solution.		
COMPANY NAME (Europe): CARUS EUROPE	**COMPANY ADDRESS:**	C/ Secundino Roces, 3-Planta 1ª – Oficina 14, 33428 Cayes – Llanera, Asturias - Spain
	INFORMATION:	(34) 985-785-513
	EMERGENCY TELEPHONE:	(34) 985-785-513
COMPANY NAME (US): CARUS CORPORATION	**COMPANY ADDRESS:**	315 Fifth Street Peru, IL 61354, USA
	INFORMATION:	(815) 223-1500 (815) 224-6816 (FAX) www.caruscorporation.com (Web) salesmkt@caruscorporation.com (Email)
	EMERGENCY TELEPHONE:	(800) 435 –6856 (USA) (815) 223-1500 (Other countries) (800) 424-9300 (CHEMTREC®, USA) (703) 527-3887 (CHEMTREC®, Other countries)

Section 2 Hazards Identification

GLOBAL HARMONIZED SYSTEM (GHS) OF CLASSIFICATION OF THE PREPARATION

Oxidizing liquid, Category 2
Acute toxicity, Category 4
Aquatic toxicity (acute), Category 1
Aquatic toxicity (chronic), Category 1

GHS LABEL ELEMENTS, INCLUDING PRECAUTIONARY STATEMENTS

Signal Word: DANGER
Label Codes: GHS03, GHS07, GHS09
Hazard Statements: H272, H302, H400, H410

H272 - May intensify fire, oxidizer
H302 - Harmful, if swallowed
H400 - Very toxic to aquatic life
H410 - Very toxic to aquatic life with long lasting effects

EU LABEL

HAZARD SYMBOLS: **O, Xn, N**
RISK PHRASES: **R8, R22, R50/53**
SAFETY PHRASES: **S17,S24/25, S26, S60, S61**

Section 2 Hazards Identification (contd.)

OTHER HAZARDS

EYE CONTACT
RemOx® L ISCO Reagent may cause damage to the eye.

SKIN CONTACT
Momentary contact of solution at room temperature will leave brown stains and may be irritating to some who are more sensitive. Prolonged contact is damaging to the skin.

INHALATION
Acute inhalation toxicity data are not available. However, airborne concentrations of sodium permanganate in the form of mist may cause irritation to the respiratory tract for some.

INGESTION
RemOx® L ISCO Reagent, if swallowed, may cause burns to mucous membranes of the mouth, throat, esophagus, and stomach.

HAZARDOUS MATERIALS IDENTIFICATION SYSTEM (HMIS) RATINGS:
Health: 1 - Slight
Flammability: 0 - None
Reactivity: 0 - None
Personnel Protective Equipment: goggles face shield, apron, respirator and proper gloves.

Section 3 Composition/Information on Ingredients

HAZARDOUS COMPONENT	CAS NO.	EINECS	%	HAZARD DATA
Sodium Permanganate	10101-50-5	233-251-1	39.5-41.0	**PEL/C**5 mg Mn per m^3 of air **TLV-TWA** 0.2 mg Mn per m^3 of air

Section 4 First Aid Measures

EYES
Immediately flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Do not attempt to neutralize chemically. Seek medical attention immediately. **Note to physician**: Decomposition products are alkaline. Brown stain formed is insoluble manganese dioxide.

SKIN
Immediately wash contaminated areas with water. Remove contaminated clothing and footwear. (**Caution:** Solution may ignite certain textiles). Wash clothing and decontaminate footwear before reuse. Seek medical attention if irritation is severe or persistent.

INHALATION
Remove person from contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.

INGESTION
Never give anything by mouth to an unconscious or convulsing person. If person is conscious, give large quantities of water or milk. Seek medical attention immediately.

Section 5 Fire Fighting Measures

NFPA* HAZARD SIGNS

Health Hazard	1	=	Materials that under emergency conditions, can cause significant irritation. Materials that on the skin could cause irritation.
Flammability Hazard	0	=	Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone and sand.
Instability Hazard	0	=	Materials that in themselves are normally stable, even under fire conditions.
Special Hazard	OX	=	Oxidizer

***National Fire Protection Association 704 (USA)**

FIRST RESPONDERS

Wear protective gloves, boots, goggles, and respirator. In case of fire, wear positive pressure breathing apparatus. Approach incident with caution.

FLASHPOINT

None

FLAMMABLE OR EXPLOSIVE LIMITS

Lower: Nonflammable Upper: Nonflammable

EXTINGUISHING MEDIA

Use large quantities of water. Water will turn pink to purple when in contact with sodium permanganate. Dike to contain. Do not use dry chemicals, CO_2, Halon® or foams, because they are not effective.

SPECIAL FIREFIGHTING PROCEDURES

If material is involved in fire, flood with water. Cool all affected containers with large quantities of water. Apply water from as far a distance as possible. Wear self-contained breathing apparatus and full protective clothing.

UNUSUAL FIRE AND EXPLOSION

Powerful oxidizing material. May decompose spontaneously if exposed to heat (135°C / 275°F). May be explosive in contact with certain other chemicals (Section 10). May react violently with finely divided and readily oxidizable substances. Increases burning rate of combustible material. May ignite wood and cloth.

Section 6 Accidental Release Measures

PERSONAL PRECAUTIONS

Personnel should wear protective clothing suitable for the task. Remove all ignition sources and incompatible materials before attempting clean up.

ENVIRONMENTAL PRECAUTIONS

Do not flush into sanitary sewer system or surface water. If accidental release into the environment occurs, inform the responsible authorities. Keep the product away from drains, sewers, surface and ground water and soil.

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

NOTE: Do not use paper or cloth to clean up spills. It may catch fire. Contain spill by collecting the liquid in a pit or holding behind a dam (sand or soil). Proceed with either of the following two options depending upon the size of the spill and the availability of the neutralizing agents.

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

Section 6 Accidental Release Measures (contd.)

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

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

Section 7 Handling and Storage

WORK/HYGIENIC PRACTICES

Wash hands thoroughly with soap and water after handling permanganate solution. Do not eat, drink or smoke when working with sodium permanganate. Wear proper protective equipment. Remove clothing if it becomes contaminated.

VENTILATION REQUIREMENTS

Provide sufficient mechanical and/or local exhaust to maintain exposure below the TLV/TWA.

CONDITIONS FOR SAFE STORAGE

Store in accordance with NFPA 430 requirements for Class II oxidizers. Protect containers from physical damage. Store in a cool, dry area in closed containers. Segregate from acids, peroxides, formaldehyde, and all combustible, organic, or easily oxidizable materials including antifreeze and hydraulic fluid.

SPECIFIC USES

Refer to SECTION 1.

Section 8 Exposure Controls and Personal Protection

RESPIRATORY PROTECTION

In cases where overexposure to mist may occur, the use of an approved NIOSH-MSHA mist respirator or an air supplied respirator is advised. Engineering or administrative controls should be implemented to control mist.

EYE

Face shield, goggles, or safety glasses with side shields should be worn. Provide eyewash in working area.

GLOVES

Rubber or plastic gloves should be worn.

OTHER PROTECTIVE EQUIPMENT

Chemically resistant clothing covering arms and legs, and rubber or plastic apron should be worn. **Caution:** If clothing becomes contaminated, wash off immediately. Spontaneous ignition may occur with cloth or paper.

Section 9 Physical and Chemical Properties

APPEARANCE	Dark purple solution
ODOR	Odorless
pH OF THE PREPARATION (36%-38%)	5-9
BOILING POINT/BOILING RANGE	>101°C (at 760 mm Hg)
FLASH POINT	Does not flash
FLAMMABILITY (SOLID, GAS)	Not flammable
EXPLOSIVE PROPERTIES	Explosive in contact with sulfuric acid or peroxides, or readily oxidizable substances.
OXIDIZING PROPERTIES	Strong oxidizer. May ignite wood and cloth.

Section 9 Physical and Chemical Properties (contd.)

VAPOR PRESSURE	760 mm Hg at 105°C
RELATIVE DENSITY (AT 20◦C)	1.36-1.39 at 20°C
SOLUBILITY	
WATER SOLUBILITY	Miscible in all proportions with water
PARTITION COEFFICIENT: n-OCTONAL/WATER	
VISCOSITY	
VAPOUR DENSITY	
EVAPORATION RATE	Same as water
FREEZING POINT	<-4.0 °C

Section 10 Stability and Reactivity

STABILITY
Under normal conditions, the material is stable.

CONDITIONS TO AVOID
Contact with incompatible materials or heat (135°C / 275ºF) could result in violent exothermic chemical reaction.

MATERIALS TO AVOID
Acids, peroxides, and all combustible organic or readily oxidizable materials including inorganic oxidizable materials and metal powders. With hydrochloric acid, chlorine gas is liberated.

HAZARDOUS DECOMPOSITION PRODUCTS
When involved in a fire, sodium permanganate may form corrosive fumes.

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION
Material is not known to polymerize.

Section 11 Toxicological Information

EXPOSURE SYMPTOMS DESCRIPTION

INHALATION
The product may be absorbed into the body by inhalation of the mist. Airborne concentrations of sodium permanganate in the form of mist may cause irritation to the respiratory tract for some. Major effects of exposure: *possible* respiratory disorder, cough.

INGESTION
Harmful, if swallowed. Ingestion may cause nausea, vomiting, sore throat, stomach-ache, and eventually lead to a perforation of the intestine. Liver and kidney injuries may occur.

SKIN CONTACT
Momentary contact of solution at room temperature will leave brown stains and may be irritating to some who are more sensitive. Prolonged contact is damaging to the skin.

EYE CONTACT
RemOx® L ISCO Reagent may cause damage to the eye.

Section 11 Toxicological Information (contd.)

ACUTE TOXICITY

LD50 value is not available for sodium permanganate, but is expected to be similar to that of potassium permanganate on a dry weight basis. The toxicity data for potassium permanganate (CAS# 7722-64-7) is given below:
LD 50 oral rat: 780 mg/kg male (14 days); 525 mg/kg female (14 days).
Harmful if swallowed. ALD: 10g. Ingestion may cause nausea, vomiting, sore throat, stomach-ache and eventually lead to a perforation of the intestine. Liver and kidney injuries may occur.

CHRONIC TOXICITY

No known cases of chronic poisoning due to permanganates have been reported. Prolonged exposure, usually over many years, to heavy concentrations of manganese oxides in the form of dust and fumes may lead to chronic manganese poisoning, chiefly involving the central nervous system.

CARCINOGENICITY

Sodium permanganate has not been classified as a carcinogen by ACGIH, NIOSH, OSHA, NTP, or IARC.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE

Sodium permanganate solution will cause further irritation of tissue, open wounds, burns or mucous membranes.

Section 12 Ecological Information

ECO TOXICITY

No aquatic toxicity data is available for sodium permanganate. Toxicity is expected to be similar to that of potassium permanganate. The toxicity data for potassium permanganate (CAS# 7722-64-7) is given below:

Rainbow trout, 96 hour LC_{50} for potassium permanganate:	1.8 mg/L
Bluegill sunfish, 96 hour LC_{50} for potassium permanganate:	2.3 mg/L
Milk fish (Chanos Chanos)/ 96 hour LC_{50} for potassium permanganate:	>1.4mgl

MOBILITY

Miscible in water.

PERSISTENCE AND DEGRADABILITY

Permanganate has a low estimated lifetime in the environment, being readily converted by oxidizable materials to insoluble MnO_2.

BIOACCULUMATIVE POTENTIAL

In non-reducing and non-acidic environments, MnO_2 is insoluble and has a very low bioaccumulative potential.

OTHER ADVERSE EFFECTS

Harmful to aquatic organisms.

Section 13 Disposal Considerations

WASTE DISPOSAL

Offer surplus and non-recyclable product or solutions to a licensed disposal company. Disposal of all materials shall be in full and strict compliance with all federal, state, and local regulations. Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. When it becomes a waste, sodium permanganate is considered a D001 hazardous (ignitable) waste. For disposal of sodium permanganate solutions, follow procedures in Section 6. Dispose of it in a permitted landfill. Contact Carus Corporation for additional recommendations. Packaging materials must be triple rinsed to remove all RemOx® L ISCO Reagent prior to re-cycling or disposal.

RCRA P-Series: None listed. **RCRA U-Series:** None listed.

Section 14 Transport Information

USA (Land, DOT) and Canada (TDG)	**ID Number:** UN 3214 **Proper Shipping Name:** Permanganates, inorganic, aqueous solution, n.o.s. (contains sodium permanganate) **Hazard Class:** Oxidizer **Packing Group:** II **Division:** 5.1
European Labeling in accordance Road/Rail Transport (ADR/RID)	**ID Number:** UN 3214 **ADR/RID Class:** 5.1 **Packing Group:** II **Description of Goods:** Permanganates, inorganic, aqueous solution, n.o.s. (contains sodium permanganate) **Hazard Identification No.**50
European Labeling in accordance with EC directive (Water, IMDG)	**ID Number:** UN 3214 **Proper Shipping Name:** Permanganates, inorganic, aqueous solution, n.o.s. (contains sodium permanganate) **Hazard Class:** Oxidizer **Packing Group:** II **Division:** 5.1 **Marine Pollutant**: No
European Labeling in accordance with EC directive (Air, IATA)	**ID Number:** UN 3214 **Proper Shipping Name:** Permanganates, inorganic, aqueous solution, n.o.s. (contains sodium permanganate) **Hazard Class:** Oxidizer **Packing Group:** II **Division:** 5.1

Section 15 Regulatory Information

EUROPEAN AND INTERNATIONAL REGULATIONS

MARKINGS ACCORDING TO EU GUIDELINES

The product has been classified and marked in accordance with EU directives/ordinances on hazardous materials.

CHEMICAL NAME	CAS NO.	EINECS	UN NUMBER
Sodium Permanganate	10101-50-5	233-251-1	UN 3214

LABELING INFORMATION

O

Oxidizer

Xn

Harmful

N

Dangerous to the Environment

RISK PHRASES

8	Contact with combustibles may case fire.
22	Harmful if swallowed.
50/53	Very toxic to aquatic organisms may cause long-term effects in the aquatic environment.

Section 15 Regulatory Information (contd.)

SAFETY PHRASES

17	Keep away from combustible materials.
24/25	Avoid contact with skin and eyes.
26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
60	This material and its container must be disposed of as hazardous waste.
61	Avoid releases to the environment. Refer to special instructions / Safety data sheet.

US FEDERAL REGULATIONS:

CHEMICAL INVENTORY STATUS – PART 1

Ingredient	CAS. NO.	TSCA	EC	Japan	Australia	China
Sodium permanganate	10101-50-5	Yes	Yes	Yes	Yes	Yes

CHEMICAL INVENTORY STATUS – PART 2 --- CANADA --

Ingredient	CAS. NO.	Korea	DSL	NDSL	New Zealand	PHIL
Sodium permanganate	10101-50-5	Yes	No	Yes	Yes	

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulation (CPR, Canada) and the MSDS contains all of the information required by the CPR.

FEDERAL, STATE & INTERNATIONAL REGULATIONS – PART 1

		SARA 302		SARA 313	
Ingredient	CAS. NO.	RQ	TPQ	List	Chemical Category
Sodium permanganate	10101-50-5	N/A	N/A	No	Yes (Manganese compounds)

FEDERAL, STATE & INTERNATIONAL REGULATIONS – PART 2

Ingredient	CAS. NO.	CERCLA	RCRA	TSCA 8(d)
Sodium permanganate	10101-50-5	No	D001	No

Ingredient	CAS. NO.	CWC	TSCA 12(b)	CDTA	SARA 311/312
Sodium permanganate	10101-50-5	No	No		4545 Kg

Ingredient	CAS. NO.	Acute	Chronic	Fire	Pressure	Reactivity	Pure/Liquid
Sodium permanganate	10101-50-5	Yes	Yes	Yes	No	No	Liquid

Ingredient	CAS. NO.	Australian Hazchem	WHMIS	IDL
Sodium permanganate	10101-50-5	IYE	C, D2B	No

Section 16 Other Information

ADR/RID	Agreement on Dangerous Goods by Road /Regulations Concerning the International Transport of Dangerous Goods by Rail
C	Ceiling Exposure Limit
CAS	Chemical Abstract Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
EINECS	Inventory of Existing Chemical Substances (European)
DOT	Department of Transportation
DSL/NDSL	The Domestic Substances and the Non-Domestic Substances List (Canada)
IARC	International Agency for Research on Cancer
IATA	International Air Transport Association

Section 16 Other Information (contd.)

IDL	Ingredient Disclosure List
IMDG	International Maritime Dangerous Goods
OSHA	Occupational Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health
NTP	National Toxicology Program
MSHA	Mine Safety and Health Administration
PEL	Permissible Exposure Limit
SARA	Superfund Amendments and Reauthorization Act
TDG	Transport Dangerous Goods (Canada)
TSCA	Toxic substances control Act
TLV-TWA	Threshold Limit Value-Time Weighted Average
UN	United Nations
WHMIS	Workplace Hazardous Materials Information System

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

This safety data sheet was reviewed according to Annex II of the regulation of the European Parliament and European Council (EC) No. 1907/2006-REACH and 1272/2008.

CARUS CORPORATION, 315 5TH STREET, PERU, ILLINOIS 61354, USA
CARUS EUROPE IS A DIVISION OF CARUS CORPORATION

Chithambarathanu Pillai (S.O.F.)
August 2010

RESPONSIBLE CARE®
OUR COMMITMENT TO SUSTAINABILITY

APPENDIX D

Laboratory Analytical Data - May to July 2015 ISCO Pilot Study and May 2016 Baseline Data

Appendix D - Laboratory Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW01 06/09/15	PCERI-IMW01 08/19/15	PCERI-IMW01 10/05/15	PCERI-IMW01 11/16/15	PCERI-IMW01 05/17/16	PCERI-IMW02 06/09/15
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 UJ	5 U
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U	5 U	5 U	5 U [5 U]	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 UJ	5 U
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U	5 U	5 U	5 U [5 U]	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	NA	NA	2 U [2 U]	NA	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	10 U	10 U	10 U	5 U [5 U]	10 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	10 U	10 U	10 U	5 U [5 U]	10 U	10 U
Acetone	67-64-1	50*	ug/L	10 U	10 U	10 U	5 U [5 U]	10 U	10 U
Bromobenzene	108-86-1	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Bromoform	75-25-2	50*	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Bromomethane	74-83-9	5	ug/L	5 U	5 U	5 U	0.42 U [0.61 U]	5 U	5 U
Carbon Disulfide	75-15-0	60	ug/L	10 U	10 U	10 U	1 U [1 U]	10 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U

Appendix D - Laboratory Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW01 06/09/15	PCERI-IMW01 08/19/15	PCERI-IMW01 10/05/15	PCERI-IMW01 11/16/15	PCERI-IMW01 05/17/16	PCERI-IMW02 06/09/15
CFC-11	75-69-4	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
CFC-12	75-71-8	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Chlorobenzene	108-90-7	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Chloroethane	75-00-3	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Chloroform	67-66-3	7	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Chloromethane	74-87-3	5	ug/L	5 U	5 U	5 U	0.5 U [0.36 U]	5 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Dibromomethane	74-95-3	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Dichloromethane	75-09-2	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	NA	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
m&p-Xylenes	ARC-mpXyl	- -	ug/L	5 U	5 U	5 U	2 U [2 U]	5 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	10 U	10 U	10 U	NA	10 U	10 U
Naphthalene	91-20-3	10*	ug/L	5 U	5 U	5 U	1 U [1 U]	5 UJ	5 U
N-Butylbenzene	104-51-8	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
o-Xylene	95-47-6	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**16**	**15**	**16**	**16.2 [17.3]**	**19**	**10**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Trichloroethene	79-01-6	5	ug/L	1.7 J	1.3 J	1.4 J	1.7 [1.6]	1.4 J	0.81 J
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	NA	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Benzene	71-43-2	1	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Toluene	108-88-3	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Ethylbenzene	100-41-4	5	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U
Total Xylenes	1330-20-7	5	ug/L	5 U	5 U	5 U	0 U [0 U]	5 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	5 U	5 U	5 U	1 U [1 U]	5 U	5 U

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Inorganics									
Aluminum	7429-90-5	- -	ug/L	91.2 J	155	3,360	140 [120]	100 U	17.5 J
Antimony	7440-36-0	3	ug/L	**3.4 J**	60 U	1.7 J	2.2 U [2.2 U]	60 U	**3.4 J**
Arsenic	7440-38-2	25	ug/L	10 U	4.6 J	3.9 J	3 U [3 U]	10 U	10 U
Barium	7440-39-3	1,000	ug/L	33.8	32.6	57	35 [34]	36.9	26.2
Beryllium	7440-41-7	3	ug/L	3 U	3 U	0.227 J	1 U [1 U]	3 U	3 U
Boron	7440-42-8	1,000	ug/L	NA	34.4 J	NA	NA	NA	NA
Cadmium	7440-43-9	5	ug/L	5 U	5 U	5 U	1.1 U [1.1 U]	5 U	5 U
Calcium	7440-70-2	- -	ug/L	112,000	115,000	115,000	12,000 [118,000	116,000	91,000
Chromium	7440-47-3	50	ug/L	6 J	5.4 J	22.7	4.3 [4.2]	0.3 J	13.5
Cobalt	7440-48-4	- -	ug/L	0.561 J	50 U	1.2 J	5.6 U [5.6 U]	50 U	50 U
Copper	7440-50-8	200	ug/L	4.1 J	20 U	4.3 J	5.6 U [5.6 U]	20 U	3.7 J
Iron	7439-89-6	300***	ug/L	**358**	**335**	**4,060**	300 [260]	11.1 J	227
Lead	7439-92-1	25	ug/L	2.3 J	2.3 J	1.7 J	2.2 U [2.2 U]	5 U	3 J
Magnesium	7439-95-4	35,000*	ug/L	7,880	8,170	8,980	8,300 [8,400]	8,150	6,640
Manganese	7439-96-5	300***	ug/L	70.1	55.1	**423**	32 [32]	2.3 J	5.5 J
Mercury	7439-97-6	0.7	ug/L	0.2 U	0.2 U	0.2 U	NA	0.2 U	0.041 J
Nickel	7440-02-0	100	ug/L	1.9 J	40 U	6.7 J	5.6 U [5.6 U]	40 U	1.3 J
Potassium	7440-09-7	- -	ug/L	2,820	2,860	4,060	3,000 [3,000]	3,280	2,160
Selenium	7782-49-2	10	ug/L	10 U	10 UE	10 U	5.6 U [5.6 U]	10 U	10 U
Silver	7440-22-4	50	ug/L	10 U	1.9 J	1.6 J	2.2 U [2.2 U]	10 U	10 U
Sodium	7440-23-5	20,000	ug/L	**51,800**	**59,700**	**61,400**	**64,600 [65,800]**	**70,000**	**76,300**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW02 08/18/15	PCERI-IMW02 10/06/15	PCERI-IMW02 11/16/15	PCERI-IMW02 05/17/16	PCERI-IMW03 06/10/15	PCERI-IMW03 08/18/15
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	5 U [5 U]	5 U	1 U	5 UJ	5 U	5 U
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U [5 U]	5 U	5 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	5 U [5 U]	5 U	1 U	5 UJ	5 U	5 U
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U [5 U]	5 U	5 U	5 U	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	NA	2 U	NA	NA	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	10 U [10 U]	10 U	5 U	10 U	10 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	10 U [10 U]	10 U	5 U	10 U	10 U	10 U
Acetone	67-64-1	50*	ug/L	10 U [10 U]	10 U	5 U	10 U	10 U	2.9 J
Bromobenzene	108-86-1	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Bromoform	75-25-2	50*	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Bromomethane	74-83-9	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 UJ
Carbon Disulfide	75-15-0	60	ug/L	10 U [10 U]	10 U	1 U	10 U	10 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW02 08/18/15	PCERI-IMW02 10/06/15	PCERI-IMW02 11/16/15	PCERI-IMW02 05/17/16	PCERI-IMW03 06/10/15	PCERI-IMW03 08/18/15
CFC-11	75-69-4	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
CFC-12	75-71-8	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Chlorobenzene	108-90-7	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Chloroethane	75-00-3	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 UJ
Chloroform	67-66-3	7	ug/L	5 U [5 U]	5 U	1 U	5 U	0.79 J	0.76 J
Chloromethane	74-87-3	5	ug/L	5 U [5 U]	5 U	0.48 U	5 U	5 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Dibromomethane	74-95-3	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Dichloromethane	75-09-2	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	NA	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
m&p-Xylenes	ARC-mpXyl	- -	ug/L	5 U [5 U]	5 U	2 U	5 U	5 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	10 U [10 U]	10 U	NA	10 U	10 U	10 U
Naphthalene	91-20-3	10*	ug/L	5 U [5 U]	5 U	1 U	5 UJ	5 U	5 U
N-Butylbenzene	104-51-8	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
o-Xylene	95-47-6	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**11 [10]**	**11**	**11.2**	**14**	**130**	**100**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Trichloroethene	79-01-6	5	ug/L	0.6 J [0.71 J]	0.9 J	0.76 J	1 J	4 J	2.9 J
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	NA	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Benzene	71-43-2	1	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Toluene	108-88-3	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Ethylbenzene	100-41-4	5	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U
Total Xylenes	1330-20-7	5	ug/L	5 U [5 U]	5 U	0 U	5 U	5 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	5 U [5 U]	5 U	1 U	5 U	5 U	5 U

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Inorganics									
Aluminum	7429-90-5	- -	ug/L	324 J [465 J]	202	140	477	127	235
Antimony	7440-36-0	3	ug/L	60 U [60 U]	60 U	2.2 U	60 U	2.9 J	60 U
Arsenic	7440-38-2	25	ug/L	4.5 J [5.4 J]	3 J	3 U	10 U	10 U	5.1 J
Barium	7440-39-3	1,000	ug/L	25.1 [26]	25.6	27	25.4	37.6	36.6
Beryllium	7440-41-7	3	ug/L	3 U [3 U]	3 U	1 U	3 U	3 U	3 U
Boron	7440-42-8	1,000	ug/L	20.2 J [18 J]	NA	NA	NA	NA	14.7 J
Cadmium	7440-43-9	5	ug/L	5 U [5 U]	5 U	1.1 U	5 U	5 U	5 U
Calcium	7440-70-2	- -	ug/L	92,300 [93,000]	87,300	87,800	71,900	98,800	97,900
Chromium	7440-47-3	50	ug/L	18.9 J [32.2 J]	5.6 J	8.7	7.3 J	45.6	34.3
Cobalt	7440-48-4	- -	ug/L	50 U [50 U]	50 U	5.6 U	50 U	0.382 J	50 U
Copper	7440-50-8	200	ug/L	20 U [3.2 J]	20 U	5.6 U	20 U	5.2 J	3 J
Iron	7439-89-6	300***	ug/L	**514 J [854 J]**	**534**	**350**	**715**	**804**	**628**
Lead	7439-92-1	25	ug/L	2 J [2.5 J]	5 U	2.2 U	5 U	3.4 J	2 J
Magnesium	7439-95-4	35,000*	ug/L	6,500 [6,510]	6,520	6,700	4,860	6,400	6,080
Manganese	7439-96-5	300***	ug/L	9.6 J [13.3]	8.4 J	9.5	10.1	29.1	**1,400**
Mercury	7439-97-6	0.7	ug/L	0.2 U [0.2 U]	0.2 U	NA	0.2 U	0.2 U	0.2 U
Nickel	7440-02-0	100	ug/L	40 U [40 U]	40 U	5.6 U	40 U	3.4 J	13.9 J
Potassium	7440-09-7	- -	ug/L	2,160 [2,210]	2,310	2,000	2,350	2,580	2,760
Selenium	7782-49-2	10	ug/L	10 UE [10 UE]	10 U	5.6 U	10 U	10 U	10 UE
Silver	7440-22-4	50	ug/L	1.9 J [1.9 J]	1.4 J	2.2 U	10 U	10 U	2.6 J
Sodium	7440-23-5	20,000	ug/L	**75,600 [77,200]**	**79,100**	**80,300**	**86,900**	**120,000**	**130,000**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

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Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	5 U	1 UJ	5 UJ	5 U	5 U	5 U
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U	5 UJ	5 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	5 U	1 UJ	5 UJ	5 U	5 U	5 U
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U	5 UJ	5 U	5 U	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	2 UJ	NA	NA	NA	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	10 U	5 UJ	10 U	10 U	10 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	10 U	5 UJ	10 U	10 U	10 U	10 U
Acetone	67-64-1	50*	ug/L	8.3 J	5 UJ	10 U	10 U	10 U	10 U
Bromobenzene	108-86-1	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Bromoform	75-25-2	50*	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Bromomethane	74-83-9	5	ug/L	5 U	0.46 UJ	5 U	5 U	5 U	5 U
Carbon Disulfide	75-15-0	60	ug/L	10 U	1 UJ	10 U	10 U	10 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U

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CFC-11	75-69-4	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
CFC-12	75-71-8	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Chlorobenzene	108-90-7	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Chloroethane	75-00-3	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Chloroform	67-66-3	7	ug/L	0.63 J	0.68 J-	1.1 J	1.7 J	1.1 J	0.92 J
Chloromethane	74-87-3	5	ug/L	5 U	0.72 UJ	5 U	5 U	5 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Dibromomethane	74-95-3	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Dichloromethane	75-09-2	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	NA	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
m&p-Xylenes	ARC-mpXyl	- -	ug/L	5 U	2 UJ	5 U	5 U	5 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	10 U	NA	10 U	10 U	10 U	10 U
Naphthalene	91-20-3	10*	ug/L	0.33 J	1 UJ	5 UJ	5 U	5 U	5 U
N-Butylbenzene	104-51-8	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
o-Xylene	95-47-6	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**62**	**61.5 J-**	**82**	**190 D**	**160**	**180 D**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Trichloroethene	79-01-6	5	ug/L	1.7 J	1.8 J-	2 J	**7.5**	**6.1**	**7.4**
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	NA	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Benzene	71-43-2	1	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Toluene	108-88-3	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Ethylbenzene	100-41-4	5	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U
Total Xylenes	1330-20-7	5	ug/L	5 U	0 UJ	5 U	5 U	5 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	5 U	1 UJ	5 U	5 U	5 U	5 U

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Inorganics									
Aluminum	7429-90-5	- -	ug/L	500 U	300	265	468	1,690	640
Antimony	7440-36-0	3	ug/L	2.2 J	2.2 U	60 U	**3.5 J**	60 U	60 U
Arsenic	7440-38-2	25	ug/L	5 J	3 U	10 U	10 U	5.3 J	4.6 J
Barium	7440-39-3	1,000	ug/L	34.6	36	31.4	22.5	33.6	28.8
Beryllium	7440-41-7	3	ug/L	3 U	1 U	3 U	3 U	3 U	3 U
Boron	7440-42-8	1,000	ug/L	NA	NA	NA	NA	200 U	NA
Cadmium	7440-43-9	5	ug/L	5 U	1.1 U	5 U	5 U	5 U	5 U
Calcium	7440-70-2	- -	ug/L	105,000	58,000	77,800	71,800	80,600	88,700
Chromium	7440-47-3	50	ug/L	**75.9**	**73**	28.7	4.5 J	8.8 J	6.8 J
Cobalt	7440-48-4	- -	ug/L	50 U	5.6 U	50 U	13.5 J	8.6 J	8.8 J
Copper	7440-50-8	200	ug/L	2.3 J	5.4 J	1.4 J	20.6	11.7 J	9.9 J
Iron	7439-89-6	300***	ug/L	**348**	**770**	**501**	**1,040**	**1,840**	**912**
Lead	7439-92-1	25	ug/L	1.9 J	2.2 U	5 U	4.7 J	3.2 J	5 U
Magnesium	7439-95-4	35,000*	ug/L	6,400	4,000	5,040	6,320	6,100	6,740
Manganese	7439-96-5	300***	ug/L	**111,000**	220	56.8	26.3	40.1	33
Mercury	7439-97-6	0.7	ug/L	**0.796**	NA	0.2 U	0.2 U	0.2 U	0.048 J
Nickel	7440-02-0	100	ug/L	29.7 J	7.4	40 U	4.6 J	10.2 J	8.1 J
Potassium	7440-09-7	- -	ug/L	3,120	2,300	2,490	2,470	2,910	2,760
Selenium	7782-49-2	10	ug/L	5.3 J	1.9 J	10 U	10 U	10 UE	10 U
Silver	7440-22-4	50	ug/L	4.1 J	2.2 U	10 U	0.634 J	3.5 J	1.7 J
Sodium	7440-23-5	20,000	ug/L	**161,000**	**239,000**	**147,000**	**98,400**	**106,000**	**99,000**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

Appendix D - Laboratory Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW04 11/17/15	PCERI-IMW04 05/17/16	PCERI-IMW05 06/10/15	PCERI-IMW05 08/18/15	PCERI-IMW05 10/07/15	PCERI-IMW05 11/18/15
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,1-Dichloroethane	75-34-3	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,1-Dichloroethene	75-35-4	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,1-Dichloropropene	563-58-6	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U	5 U	5 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,3-Dichloropropane	142-28-9	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
1,3-Dichloropropene	542-75-6	- -	ug/L	2 U	NA	NA	NA	NA	2 U
1,4-Dichlorobenzene	106-46-7	3	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
2,2-Dichloropropane	594-20-7	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
2-Butanone (MEK)	78-93-3	50	ug/L	5 U	10 U	10 U	10 U	10 U	5 U
2-Chlorotoluene	95-49-8	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
4-Chlorotoluene	106-43-4	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	5 U	10 U	10 U	10 U	10 U	5 U
Acetone	67-64-1	50*	ug/L	5 U	10 U	10 U	10	1.6 J	5 U
Bromobenzene	108-86-1	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Bromochloromethane	74-97-5	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Bromodichloromethane	75-27-4	50*	ug/L	1 U	5 U	5 U	5 U	5 UJ	1 U
Bromoform	75-25-2	50*	ug/L	1 U	5 U	5 U	5 U	5 UJ	1 U
Bromomethane	74-83-9	5	ug/L	1 U	5 U	5 U	5 UJ	5 U	0.5 U
Carbon Disulfide	75-15-0	60	ug/L	1 U	10 U	10 U	10 U	10 U	1 U
Carbon Tetrachloride	56-23-5	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U

Appendix D - Laboratory Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW04 11/17/15	PCERI-IMW04 05/17/16	PCERI-IMW05 06/10/15	PCERI-IMW05 08/18/15	PCERI-IMW05 10/07/15	PCERI-IMW05 11/18/15
CFC-11	75-69-4	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
CFC-12	75-71-8	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Chlorobenzene	108-90-7	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Chlorodibromomethane	124-48-1	50	ug/L	1 U	5 U	5 U	5 U	5 UJ	1 U
Chloroethane	75-00-3	5	ug/L	1 U	5 U	5 U	5 UJ	5 U	1 U
Chloroform	67-66-3	7	ug/L	1 U	0.49 J	5 U	5 U	5 U	1 U
Chloromethane	74-87-3	5	ug/L	0.33 U	5 U	5 U	5 U	5 U	0.36 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Dibromomethane	74-95-3	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Dichloromethane	75-09-2	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	NA	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Isopropylbenzene	98-82-8	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
m&p-Xylenes	ARC-mpXyl	- -	ug/L	2 U	5 U	5 U	5 U	5 U	2 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	NA	10 U	10 U	10 U	10 U	NA
Naphthalene	91-20-3	10*	ug/L	1 U	5 U	5 U	5 U	3.9 J	1 U
N-Butylbenzene	104-51-8	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
N-Propylbenzene	103-65-1	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
o-Xylene	95-47-6	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
sec-Butylbenzene	135-98-8	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Styrene (Monomer)	100-42-5	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
tert-Butylbenzene	98-06-6	- -	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Tetrachloroethene	127-18-4	5	ug/L	**194**	**140**	**130**	**67**	**240 D**	**297 J-**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Trichloroethene	79-01-6	5	ug/L	**8.2**	3.4 J	1.7 J	5 U	1.3 J	**6.5**
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	NA	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Benzene	71-43-2	1	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Toluene	108-88-3	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Ethylbenzene	100-41-4	5	ug/L	1 U	5 U	5 U	5 U	5 U	1 U
Total Xylenes	1330-20-7	5	ug/L	0 U	5 U	5 U	5 U	5 U	0 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	1 U	5 U	5 U	5 U	5 U	1 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW04 11/17/15	PCERI-IMW04 05/17/16	PCERI-IMW05 06/10/15	PCERI-IMW05 08/18/15	PCERI-IMW05 10/07/15	PCERI-IMW05 11/18/15
Inorganics									
Aluminum	7429-90-5	- -	ug/L	390	657	100 U	5,000 U	100 U	730
Antimony	7440-36-0	3	ug/L	2.2 U	60 U	2.7 J	60 U	2.3 J	2.2 U
Arsenic	7440-38-2	25	ug/L	3 U	10 U	10 U	9.9 J	3.4 J	3 U
Barium	7440-39-3	1,000	ug/L	26	35.3	31.5	35	22.8	76
Beryllium	7440-41-7	3	ug/L	1 U	3 U	3 U	3 U	3 U	1 U
Boron	7440-42-8	1,000	ug/L	NA	NA	NA	21.9 J	NA	NA
Cadmium	7440-43-9	5	ug/L	1.1 U	5 U	5 U	5 U	5 U	1.1 U
Calcium	7440-70-2	- -	ug/L	82,600	93,500	73,900	66,600	64,700	74,700
Chromium	7440-47-3	50	ug/L	8.2	11.9	0.779 J	31.1	1.7 J	2.9
Cobalt	7440-48-4	- -	ug/L	5.9	4.2 J	50 U	50 U	50 U	5.6 U
Copper	7440-50-8	200	ug/L	8.1	5 J	2.6 J	2.1 J	20 U	3.6 J
Iron	7439-89-6	300***	ug/L	**1,000**	**975**	15.1 J	**1,160**	19.8 J	**1,300**
Lead	7439-92-1	25	ug/L	2.2 U	5 U	2.7 J	7.7	5 U	2.2 U
Magnesium	7439-95-4	35,000*	ug/L	6,500	6,540	3,590	3,270	3,390	4,100
Manganese	7439-96-5	300***	ug/L	22	20.8	32.2	**38,600**	**537**	**4,200**
Mercury	7439-97-6	0.7	ug/L	NA	0.2 U	0.2 U	0.358	0.2 U	NA
Nickel	7440-02-0	100	ug/L	4.7 J	1.5 J	40 U	4.8 J	40 U	2.4 J
Potassium	7440-09-7	- -	ug/L	2,300	2,870	1,970 J	2,800	1,830 J	2,000
Selenium	7782-49-2	10	ug/L	5.6 U	10 U	10 U	100 UE	10 U	5.6 U
Silver	7440-22-4	50	ug/L	0.86 J	0.5 J	10 U	8.9 J	1.5 J	0.99 J
Sodium	7440-23-5	20,000	ug/L	**96,800**	**126,000**	**110,000**	**149,000**	**105,000**	**89,000**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW05 05/18/16	PCERI-IMW06 06/10/15	PCERI-IMW06 08/18/15	PCERI-IMW06 10/06/15	PCERI-IMW06 11/17/15	PCERI-IMW06 05/17/16
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 UJ
1,2,3-Trichloropropane	96-18-4	- -	ug/L	10 U	5 U	5 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 UJ
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	10 U	5 U	5 U	5 U	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	NA	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	NA	NA	NA	2 U	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	20 U	10 U	10 U	10 U	5 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	20 U	10 U	10 U	10 U	5 U	10 U
Acetone	67-64-1	50*	ug/L	20 U	10 U	10 U	10 U	5 U	10 U
Bromobenzene	108-86-1	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Bromoform	75-25-2	50*	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Bromomethane	74-83-9	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Carbon Disulfide	75-15-0	60	ug/L	20 U	10 U	10 U	10 U	1 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW05 05/18/16	PCERI-IMW06 06/10/15	PCERI-IMW06 08/18/15	PCERI-IMW06 10/06/15	PCERI-IMW06 11/17/15	PCERI-IMW06 05/17/16
CFC-11	75-69-4	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
CFC-12	75-71-8	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Chlorobenzene	108-90-7	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Chloroethane	75-00-3	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Chloroform	67-66-3	7	ug/L	10 U	1 J	1 J	0.68 J	1 U	0.7 J
Chloromethane	74-87-3	5	ug/L	10 U	5 U	5 U	5 U	0.34 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Dibromomethane	74-95-3	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Dichloromethane	75-09-2	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	NA	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
m&p-Xylenes	ARC-mpXyl	- -	ug/L	10 U	5 U	5 U	5 U	2 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	20 U	10 U	10 U	10 U	NA	10 U
Naphthalene	91-20-3	10*	ug/L	10 U	5 U	5 U	5 U	1 U	5 UJ
N-Butylbenzene	104-51-8	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
o-Xylene	95-47-6	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**380 D**	**52**	**42**	**38**	**46.5**	**36**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Trichloroethene	79-01-6	5	ug/L	4.2 J	3.4 J	2.7 J	2.4 J	2.6	1.4 J
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	NA	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Benzene	71-43-2	1	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Toluene	108-88-3	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Ethylbenzene	100-41-4	5	ug/L	10 U	5 U	5 U	5 U	1 U	5 U
Total Xylenes	1330-20-7	5	ug/L	10 U	5 U	5 U	5 U	0 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	10 U	5 U	5 U	5 U	1 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-IMW05 05/18/16	PCERI-IMW06 06/10/15	PCERI-IMW06 08/18/15	PCERI-IMW06 10/06/15	PCERI-IMW06 11/17/15	PCERI-IMW06 05/17/16
Inorganics									
Aluminum	7429-90-5	- -	ug/L	152	180	1,220	189	420	1,190
Antimony	7440-36-0	3	ug/L	60 U	**3.4 J**	60 U	1.4 J	2.2 U	60 U
Arsenic	7440-38-2	25	ug/L	10 U	2.2 J	5.4 J	3.7 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	23.4	25.5	29.8	26.4	28	37.7
Beryllium	7440-41-7	3	ug/L	3 U	3 U	3 U	3 U	1 U	3 U
Boron	7440-42-8	1,000	ug/L	NA	NA	15.1 J	NA	NA	NA
Cadmium	7440-43-9	5	ug/L	5 U	5 U	5 U	5 U	1.1 U	5 U
Calcium	7440-70-2	- -	ug/L	71,600	81,800	73,800	68,300	62,600	71,600
Chromium	7440-47-3	50	ug/L	10 U	4.1 J	2.6 J	2 J	3.8	3 J
Cobalt	7440-48-4	- -	ug/L	50 U	0.425 J	50 U	50 U	5.6 U	50 U
Copper	7440-50-8	200	ug/L	20 U	3.7 J	20 U	2.5 J	1.9 J	0.7 J
Iron	7439-89-6	300***	ug/L	218	**506**	**1,590**	**499**	**830**	**1,530**
Lead	7439-92-1	25	ug/L	5 U	3.1 J	3 J	5 U	2.2 U	5 U
Magnesium	7439-95-4	35,000*	ug/L	3,390	5,000	4,570	4,150	4,200	4,210
Manganese	7439-96-5	300***	ug/L	287	54.7	38.2	34.3	26	27.2
Mercury	7439-97-6	0.7	ug/L	0.2 U	0.2 U	0.2 U	0.2 U	NA	0.2 U
Nickel	7440-02-0	100	ug/L	40 U	40 U	40 U	40 U	5.6 U	40 U
Potassium	7440-09-7	- -	ug/L	1,700 J	2,230	2,430	2,050	1,900	2,420
Selenium	7782-49-2	10	ug/L	10 U	10 U	10 UE	10 U	5.6 J	10 U
Silver	7440-22-4	50	ug/L	10 U	10 U	1.8 J	1.3 J	2.2 U	10 U
Sodium	7440-23-5	20,000	ug/L	**63,500**	**114,000**	**108,000**	**105,000**	**112,000**	**99,200**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

Appendix D - Laboratory Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19I 04/21/11	PCERI-MW19I 08/02/11	PCERI-MW19I 06/09/15	PCERI-MW19I 08/19/15	PCERI-MW19I 10/06/15	PCERI-MW19I 11/18/15
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	0.22 U	0.24 U	NA	5 U	5 U	1 UJ
1,1,1-Trichloroethane	71-55-6	5	ug/L	0.26 U	0.24 U	NA	5 U	5 U	1 UJ
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	0.24 U	0.2 U	NA	5 U	5 U	1 UJ
1,1,2-Trichloroethane	79-00-5	1	ug/L	0.23 U	0.23 U	NA	5 U	5 U	1 UJ
1,1-Dichloroethane	75-34-3	5	ug/L	0.29 U	0.19 U	NA	5 U	5 U	1 UJ
1,1-Dichloroethene	75-35-4	5	ug/L	0.4 U	0.28 U	NA	5 U	5 U	1 UJ
1,1-Dichloropropene	563-58-6	- -	ug/L	0.24 U	0.36 U	NA	5 U	5 U	1 UJ
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	0.47 U	0.69 U	NA	5 U	5 U	1 UJ
1,2,3-Trichloropropane	96-18-4	- -	ug/L	0.49 U	0.54 U	NA	5 U	5 U	5 UJ
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	0.56 U	0.15 U	NA	5 U	5 U	1 UJ
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	0.28 U	0.18 U	NA	5 U	5 U	1 UJ
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	1.1 U	1.3 U	NA	5 U	5 U	5 UJ
1,2-Dibromoethane	106-93-4	0.0006	ug/L	0.39 U	0.21 U	NA	5 U	5 U	1 UJ
1,2-Dichlorobenzene	95-50-1	3	ug/L	0.26 U	0.18 U	NA	5 U	5 U	1 UJ
1,2-Dichloroethane	107-06-2	0.6	ug/L	0.33 U	0.18 U	NA	5 U	5 U	1 UJ
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	0.22 U	0.22 U	NA	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	0.27 U	0.22 U	NA	5 U	5 U	1 UJ
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	0.3 U	0.23 U	NA	5 U	5 U	1 UJ
1,3-Dichlorobenzene	541-73-1	3	ug/L	0.25 U	0.29 U	NA	5 U	5 U	1 UJ
1,3-Dichloropropane	142-28-9	- -	ug/L	0.25 U	0.19 U	NA	5 U	5 U	1 UJ
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	NA	NA	NA	NA	2 UJ
1,4-Dichlorobenzene	106-46-7	3	ug/L	0.28 U	0.26 U	NA	5 U	5 U	1 UJ
2,2-Dichloropropane	594-20-7	- -	ug/L	0.6 U	0.26 U	NA	5 U	5 U	1 UJ
2-Butanone (MEK)	78-93-3	50	ug/L	1.6 U	NA	NA	10 U	10 U	5 UJ
2-Chlorotoluene	95-49-8	- -	ug/L	0.31 U	0.19 U	NA	5 U	5 U	1 UJ
4-Chlorotoluene	106-43-4	- -	ug/L	0.26 U	0.19 U	NA	5 U	5 U	1 UJ
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	0.86 U	1.2 U	NA	10 U	10 U	5 UJ
Acetone	67-64-1	50*	ug/L	2.9 U	7.6 U	NA	**54**	15	29 J-
Bromobenzene	108-86-1	- -	ug/L	0.24 U	0.18 U	NA	5 U	5 U	1 UJ
Bromochloromethane	74-97-5	- -	ug/L	0.33 U	0.4 U	NA	5 U	5 U	1 UJ
Bromodichloromethane	75-27-4	50*	ug/L	0.28 J	0.27 J	NA	5 U	5 U	1 UJ
Bromoform	75-25-2	50*	ug/L	0.23 U	0.24 U	NA	5 U	5 U	1 UJ
Bromomethane	74-83-9	5	ug/L	0.3 U	0.31 U	NA	5 UJ	5 U	0.44 UJ
Carbon Disulfide	75-15-0	60	ug/L	0.74 U	0.18 U	NA	10 U	10 U	1 UJ
Carbon Tetrachloride	56-23-5	5	ug/L	0.26 U	0.19 U	NA	5 U	5 U	1 UJ

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19I 04/21/11	PCERI-MW19I 08/02/11	PCERI-MW19I 06/09/15	PCERI-MW19I 08/19/15	PCERI-MW19I 10/06/15	PCERI-MW19I 11/18/15
CFC-11	75-69-4	5	ug/L	0.54 U	0.35 U	NA	5 U	5 U	1 UJ
CFC-12	75-71-8	5	ug/L	0.92 U	0.31 U	NA	5 U	5 U	1 UJ
Chlorobenzene	108-90-7	5	ug/L	0.39 U	0.22 U	NA	5 U	5 U	1 UJ
Chlorodibromomethane	124-48-1	50	ug/L	0.22 U	0.2 U	NA	5 U	5 U	1 UJ
Chloroethane	75-00-3	5	ug/L	0.37 U	0.37 U	NA	5 UJ	5 U	1 UJ
Chloroform	67-66-3	7	ug/L	4.7	5.8	NA	1.4 J	1.3 J	1.5 J-
Chloromethane	74-87-3	5	ug/L	0.29 U	0.22 U	NA	5 U	5 U	0.84 UJ
cis-1,2-Dichloroethene	156-59-2	5	ug/L	0.22 U	0.22 U	NA	5 U	5 U	1 UJ
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	0.25 U	0.22 U	NA	5 U	5 U	1 UJ
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	0.69 U	0.19 U	NA	5 U	5 U	1 UJ
Dibromomethane	74-95-3	- -	ug/L	0.24 U	0.46 U	NA	5 U	5 U	1 UJ
Dichloromethane	75-09-2	5	ug/L	0.3 U	0.2 U	NA	5 U	5 U	1 UJ
Diethyl ether	60-29-7	- -	ug/L	0.72 U	0.71 U	NA	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	0.67 U	0.23 U	NA	5 U	5 U	1 UJ
Isopropylbenzene	98-82-8	5	ug/L	0.57 U	0.19 U	NA	5 U	5 U	1 UJ
m&p-Xylenes	ARC-mpXyl	- -	ug/L	0.25 U	0.32 U	NA	5 U	5 U	2 UJ
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	1.4 U	3 U	NA	10 U	10 U	NA
Naphthalene	91-20-3	10*	ug/L	0.97 U	0.68 U	NA	5 U	0.58 J	1 UJ
N-Butylbenzene	104-51-8	- -	ug/L	0.47 U	0.33 U	NA	5 U	5 U	1 UJ
N-Propylbenzene	103-65-1	5	ug/L	0.24 U	0.17 U	NA	5 U	5 U	1 UJ
o-Xylene	95-47-6	- -	ug/L	0.25 U	0.17 U	NA	5 U	5 U	1 UJ
sec-Butylbenzene	135-98-8	5	ug/L	0.22 U	0.2 U	NA	5 U	5 U	1 UJ
Styrene (Monomer)	100-42-5	5	ug/L	0.58 U	0.23 U	NA	5 U	5 U	1 UJ
tert-Butylbenzene	98-06-6	- -	ug/L	0.21 U	0.24 U	NA	5 U	5 U	1 UJ
Tetrachloroethene	127-18-4	5	ug/L	**461**	**577**	NA	**22**	**32**	**30 J-**
Tetrahydrofuran	109-99-9	- -	ug/L	1.5 U	1.8 U	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	0.25 U	0.31 U	NA	5 U	5 U	1 UJ
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	0.21 U	0.19 U	NA	5 U	5 U	1 UJ
Trichloroethene	79-01-6	5	ug/L	1.9	2.8	NA	1.4 J	4.9 J	2.8 J-
Vinyl acetate	108-05-4	- -	ug/L	1.3 U	2.6 U	NA	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	0.44 U	0.27 U	NA	5 U	5 U	1 UJ
Benzene	71-43-2	1	ug/L	0.23 U	0.22 U	NA	5 U	5 U	1 UJ
Toluene	108-88-3	5	ug/L	0.3 U	0.15 U	NA	5 U	5 U	1 UJ
Ethylbenzene	100-41-4	5	ug/L	0.27 U	0.21 U	NA	5 U	5 U	1 UJ
Total Xylenes	1330-20-7	5	ug/L	0.25 U	0.17 U	NA	5 U	5 U	0 UJ
Methyl-tert-butylether	1634-04-4	10*	ug/L	NA	NA	NA	5 U	5 U	1 UJ

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19I 04/21/11	PCERI-MW19I 08/02/11	PCERI-MW19I 06/09/15	PCERI-MW19I 08/19/15	PCERI-MW19I 10/06/15	PCERI-MW19I 11/18/15
Inorganics									
Aluminum	7429-90-5	- -	ug/L	NA	NA	100 U	50,000 U	20,000 U	800 U
Antimony	7440-36-0	3	ug/L	NA	NA	**4.1 J**	2 J	**5.5 J**	20 U
Arsenic	7440-38-2	25	ug/L	NA	NA	5.2 J	**78.3**	**26.5**	27 U
Barium	7440-39-3	1,000	ug/L	NA	NA	4.4 J	20 U	20 U	50 U
Beryllium	7440-41-7	3	ug/L	NA	NA	3 U	3 U	3 U	9 U
Boron	7440-42-8	1,000	ug/L	NA	NA	NA	35.1 J	NA	NA
Cadmium	7440-43-9	5	ug/L	NA	NA	5 U	5 U	5 U	9.9 U
Calcium	7440-70-2	- -	ug/L	NA	NA	48,000	65,600	48,000	82,000
Chromium	7440-47-3	50	ug/L	NA	NA	35.4	**323**	**230**	**90**
Cobalt	7440-48-4	- -	ug/L	NA	NA	50 U	50 U	50 U	50 U
Copper	7440-50-8	200	ug/L	NA	NA	5.5 J	20 U	20 U	50 U
Iron	7439-89-6	300***	ug/L	NA	NA	51.8 J	100 U	500 U	500 U
Lead	7439-92-1	25	ug/L	NA	NA	8.6	**77.3**	**35.2**	20 U
Magnesium	7439-95-4	35,000*	ug/L	NA	NA	6,060	7,020	3,520	12,100
Manganese	7439-96-5	300***	ug/L	NA	NA	**52,100**	**569,000**	**593,000**	**406,000**
Mercury	7439-97-6	0.7	ug/L	NA	NA	0.458	0.285	0.451	NA
Nickel	7440-02-0	100	ug/L	NA	NA	4.1 J	52.8	34.1 J	50 U
Potassium	7440-09-7	- -	ug/L	NA	NA	7,890	8,620	9,710	6,900
Selenium	7782-49-2	10	ug/L	NA	NA	**42.1**	5,000 UE	**175**	50 U
Silver	7440-22-4	50	ug/L	NA	NA	14.7	**99.1**	43.6	20 U
Sodium	7440-23-5	20,000	ug/L	NA	NA	**312,000**	**1,140,000**	**369,000**	**390,000**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

Appendix D - Laboratory Analytical Results
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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19I 05/18/16	PCERI-MW19S 04/21/11	PCERI-MW19S 08/02/11	PCERI-MW19S 06/09/15	PCERI-MW19S 08/19/15	PCERI-MW19S 10/06/15
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	5 U	0.22 U	0.24 U	5 U	5 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	5 U	0.26 U	0.24 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	5 U	0.24 U	0.2 U	5 U	5 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	5 U	0.23 U	0.23 U	5 U	5 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	5 U	0.29 U	0.19 U	5 U	5 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	5 U	0.4 U	0.28 U	5 U	5 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	5 U	0.24 U	0.36 U	5 U	5 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	5 UJ	0.47 U	0.69 U	5 U	5 U	5 U
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U	0.49 U	0.54 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	5 UJ	0.56 U	0.15 U	5 U	5 U	5 U
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	5 U	0.28 U	0.18 U	5 U	5 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U	1.1 U	1.3 U	5 U	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	5 U	0.39 U	0.21 U	5 U	5 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	5 U	0.26 U	0.18 U	5 U	5 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	5 U	0.33 U	0.18 U	5 U	5 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	0.22 U	0.22 U	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	5 U	0.27 U	0.22 U	5 U	5 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	5 U	0.3 U	0.23 U	5 U	5 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	5 U	0.25 U	0.29 U	5 U	5 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	5 U	0.25 U	0.19 U	5 U	5 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	5 U	0.28 U	0.26 U	5 U	5 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	5 U	0.6 U	0.26 U	5 U	5 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	10 U	1.6 U	NA	10 U	10 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	5 U	0.31 U	0.19 U	5 U	5 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	5 U	0.26 U	0.19 U	5 U	5 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	10 U	0.86 U	1.2 U	10 U	10 U	10 U
Acetone	67-64-1	50*	ug/L	24	2.9 U	7.6 U	10 U	10 U	10 U
Bromobenzene	108-86-1	- -	ug/L	5 U	0.24 U	0.18 U	5 U	5 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	5 U	0.33 U	0.4 U	5 U	5 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	5 U	0.22 U	0.23 U	5 U	5 U	5 U
Bromoform	75-25-2	50*	ug/L	5 U	0.23 U	0.24 U	5 U	5 U	5 U
Bromomethane	74-83-9	5	ug/L	5 U	0.3 U	0.31 U	5 U	5 U	5 U
Carbon Disulfide	75-15-0	60	ug/L	10 U	0.74 U	0.18 U	10 U	10 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	5 U	0.26 U	0.19 U	5 U	5 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19I 05/18/16	PCERI-MW19S 04/21/11	PCERI-MW19S 08/02/11	PCERI-MW19S 06/09/15	PCERI-MW19S 08/19/15	PCERI-MW19S 10/06/15
CFC-11	75-69-4	5	ug/L	5 U	0.54 U	0.35 U	5 U	5 U	5 U
CFC-12	75-71-8	5	ug/L	5 U	0.92 U	0.31 U	5 U	5 U	5 U
Chlorobenzene	108-90-7	5	ug/L	5 U	0.39 U	0.22 U	5 U	5 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	5 U	0.22 U	0.2 U	5 U	5 U	5 U
Chloroethane	75-00-3	5	ug/L	5 U	0.37 U	0.37 U	5 U	5 U	5 U
Chloroform	67-66-3	7	ug/L	2.3 J	5.5	3.6	1.4 J	0.67 J	0.67 J
Chloromethane	74-87-3	5	ug/L	5 U	0.29 U	0.22 U	5 U	5 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	5 U	0.22 U	0.22 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	5 U	0.25 U	0.22 U	5 U	5 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	5 U	0.69 U	0.19 U	5 U	5 U	5 U
Dibromomethane	74-95-3	- -	ug/L	5 U	0.24 U	0.46 U	5 U	5 U	5 U
Dichloromethane	75-09-2	5	ug/L	5 U	0.3 U	0.2 U	5 U	5 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	0.72 U	0.71 U	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	5 U	0.67 U	0.23 U	5 U	5 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	5 U	0.57 U	0.19 U	5 U	5 U	5 U
m&p-Xylenes	ARC-mpXyl	- -	ug/L	5 U	0.25 U	0.32 U	5 U	5 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	10 U	1.4 U	3 U	10 U	10 U	10 U
Naphthalene	91-20-3	10*	ug/L	5 UJ	0.97 U	0.68 U	5 U	5 U	5 U
N-Butylbenzene	104-51-8	- -	ug/L	5 U	0.47 U	0.33 U	5 U	5 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	5 U	0.24 U	0.17 U	5 U	5 U	5 U
o-Xylene	95-47-6	- -	ug/L	5 U	0.25 U	0.17 U	5 U	5 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	5 U	0.22 U	0.2 U	5 U	5 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	5 U	0.58 U	0.23 U	5 U	5 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	5 U	0.21 U	0.24 U	5 U	5 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**42**	**860**	**906**	**52**	**31**	**37**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	1.5 U	1.8 U	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	5 U	0.25 U	0.31 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	5 U	0.21 U	0.19 U	5 U	5 U	5 U
Trichloroethene	79-01-6	5	ug/L	3.4 J	**5.7**	**5.3**	**14**	**6.5**	**6.6**
Vinyl acetate	108-05-4	- -	ug/L	NA	1.3 U	2.6 U	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	5 U	0.44 U	0.27 U	5 U	5 U	5 U
Benzene	71-43-2	1	ug/L	5 U	0.23 U	0.22 U	5 U	5 U	5 U
Toluene	108-88-3	5	ug/L	5 U	0.3 U	0.15 U	5 U	5 U	5 U
Ethylbenzene	100-41-4	5	ug/L	5 U	0.27 U	0.21 U	5 U	5 U	5 U
Total Xylenes	1330-20-7	5	ug/L	5 U	0.25 U	0.17 U	5 U	5 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	5 U	NA	NA	5 U	5 U	5 U

Appendix D - Laboratory Analytical Results
3800 Area PCE Site
ISCO Remedial Action Work Plan
Fort Drum, New York

Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19I 05/18/16	PCERI-MW19S 04/21/11	PCERI-MW19S 08/02/11	PCERI-MW19S 06/09/15	PCERI-MW19S 08/19/15	PCERI-MW19S 10/06/15
Inorganics									
Aluminum	7429-90-5	- -	ug/L	166	NA	NA	165	1,690	474
Antimony	7440-36-0	3	ug/L	60 U	NA	NA	**3.5 J**	60 U	60 U
Arsenic	7440-38-2	25	ug/L	10 U	NA	NA	1.3 J	6.8 J	4.7 J
Barium	7440-39-3	1,000	ug/L	12.4 J	NA	NA	26	45	40.7
Beryllium	7440-41-7	3	ug/L	3 U	NA	NA	3 U	3 U	3 U
Boron	7440-42-8	1,000	ug/L	NA	NA	NA	NA	33.3 J	NA
Cadmium	7440-43-9	5	ug/L	5 U	NA	NA	5 U	5 U	5 U
Calcium	7440-70-2	- -	ug/L	58,300	NA	NA	88,400	120,000	125,000
Chromium	7440-47-3	50	ug/L	50 U	NA	NA	2 J	1.9 J	0.671 J
Cobalt	7440-48-4	- -	ug/L	50 U	NA	NA	50 U	50 U	50 U
Copper	7440-50-8	200	ug/L	1.9 J	NA	NA	3.7 J	20 U	53.6
Iron	7439-89-6	300***	ug/L	144	NA	60 U	**326**	**2,210**	**775**
Lead	7439-92-1	25	ug/L	**30**	NA	NA	2.5 J	2.9 J	3.9 J
Magnesium	7439-95-4	35,000*	ug/L	6,810	NA	NA	6,670	8,220	8,550
Manganese	7439-96-5	300***	ug/L	**333,000**	NA	NA	70.2	68.2	39.7
Mercury	7439-97-6	0.7	ug/L	0.092 J	NA	NA	0.2 U	0.2 U	0.2 U
Nickel	7440-02-0	100	ug/L	3 J	NA	NA	40 U	40 U	40 U
Potassium	7440-09-7	- -	ug/L	5,820	NA	NA	3,840	6,980	5,280
Selenium	7782-49-2	10	ug/L	**108**	NA	NA	10 U	10 UE	10 U
Silver	7440-22-4	50	ug/L	10 U	NA	NA	10 U	2.1 J	1.4 J
Sodium	7440-23-5	20,000	ug/L	**364,000**	NA	NA	**108,000**	**115,000**	**103,000**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

Appendix D - Laboratory Analytical Results
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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19S 11/16/15	PCERI-MW19S 05/17/16	PCERI-MW25I 04/21/11	PCERI-MW25I 08/02/11	PCERI-MW25I 06/10/15	PCERI-MW25I 08/17/15
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	1 U	5 U [5 U]	0.22 U	0.24 U	5 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	1 U	5 U [5 U]	0.26 U	0.24 U	5 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	1 U	5 U [5 U]	0.24 U	0.2 U	5 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	1 U	5 U [5 U]	0.23 U	0.23 U	5 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	1 U	5 U [5 U]	0.29 U	0.19 U	5 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	1 U	5 U [5 U]	0.4 U	0.28 U	5 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	1 U	5 U [5 U]	0.24 U	0.36 U	5 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	1 U	5 UJ [5 UJ]	0.47 U	0.69 U	5 U	5 U
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U	5 U [5 U]	0.49 U	0.54 U	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	1 U	5 UJ [5 UJ]	0.56 U	0.15 U	5 U	5 U
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	1 U	5 U [5 U]	0.28 U	0.18 U	5 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U	5 U [5 U]	1.1 U	1.3 U	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	1 U	5 U [5 U]	0.39 U	0.21 U	5 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	1 U	5 U [5 U]	0.26 U	0.18 U	5 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	1 U	5 U [5 U]	0.33 U	0.18 U	5 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	0.22 U	0.22 U	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	1 U	5 U [5 U]	0.27 U	0.22 U	5 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	1 U	5 U [5 U]	0.3 U	0.23 U	5 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	1 U	5 U [5 U]	0.25 U	0.29 U	5 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	1 U	5 U [5 U]	0.25 U	0.19 U	5 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	2 U	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	1 U	5 U [5 U]	0.28 U	0.26 U	5 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	1 U	5 U [5 U]	0.6 U	0.26 U	5 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	5 U	10 U [10 U]	NA	2.9 U	10 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	1 U	5 U [5 U]	0.31 U	0.19 U	5 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	1 U	5 U [5 U]	0.26 U	0.19 U	5 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	5 U	10 U [10 U]	0.86 U	1.2 U	10 U	10 U
Acetone	67-64-1	50*	ug/L	5 U	10 U [10 U]	2.9 U	7.6 U	10 U	3.4 J
Bromobenzene	108-86-1	- -	ug/L	1 U	5 U [5 U]	0.24 U	0.18 U	5 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	1 U	5 U [5 U]	0.33 U	0.4 U	5 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	1 U	5 U [5 U]	1.4	1.2	0.32 J	0.98 J
Bromoform	75-25-2	50*	ug/L	1 U	5 U [5 U]	0.23 U	0.24 U	5 U	5 U
Bromomethane	74-83-9	5	ug/L	1 U	5 U [5 U]	0.3 U	0.31 U	5 U	5 U
Carbon Disulfide	75-15-0	60	ug/L	1 U	10 U [10 U]	0.74 U	0.18 U	10 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	1 U	5 U [5 U]	0.26 U	0.19 U	5 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19S 11/16/15	PCERI-MW19S 05/17/16	PCERI-MW25I 04/21/11	PCERI-MW25I 08/02/11	PCERI-MW25I 06/10/15	PCERI-MW25I 08/17/15
CFC-11	75-69-4	5	ug/L	1 U	5 U [5 U]	0.54 U	0.35 U	5 U	5 U
CFC-12	75-71-8	5	ug/L	1 U	5 U [5 U]	0.92 U	0.31 U	5 U	5 U
Chlorobenzene	108-90-7	5	ug/L	1 U	5 U [5 U]	0.39 U	0.22 U	5 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	1 U	5 U [5 U]	0.22 U	0.2 U	5 U	5 U
Chloroethane	75-00-3	5	ug/L	1 U	5 U [5 U]	0.37 U	0.37 U	5 U	5 U
Chloroform	67-66-3	7	ug/L	1 U	0.28 J [0.3 J]	**17.2**	**13.6**	1.4 J	5.1
Chloromethane	74-87-3	5	ug/L	0.43 U	5 U [5 U]	0.29 U	0.22 U	5 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	1 U	5 U [5 U]	0.22 U	0.22 U	5 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	1 U	5 U [5 U]	0.25 U	0.22 U	5 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	1 U	5 U [5 U]	0.69 U	0.19 U	5 U	5 U
Dibromomethane	74-95-3	- -	ug/L	1 U	5 U [5 U]	0.24 U	0.46 U	5 U	5 U
Dichloromethane	75-09-2	5	ug/L	1 U	5 U [5 U]	0.3 U	0.2 U	5 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	0.72 U	0.71 U	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	1 U	5 U [5 U]	0.67 U	0.23 U	5 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	1 U	5 U [5 U]	0.57 U	0.19 U	5 U	5 U
m&p-Xylenes	ARC-mpXyl	- -	ug/L	2 U	5 U [5 U]	0.25 U	0.32 U	5 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	NA	10 U [10 U]	1.4 U	3 U	10 U	10 U
Naphthalene	91-20-3	10*	ug/L	1 U	5 UJ [5 UJ]	0.97 U	0.68 U	5 U	5 U
N-Butylbenzene	104-51-8	- -	ug/L	1 U	5 U [5 U]	0.47 U	0.33 U	5 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	1 U	5 U [5 U]	0.24 U	0.17 U	5 U	5 U
o-Xylene	95-47-6	- -	ug/L	1 U	5 U [5 U]	0.25 U	0.17 U	5 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	1 U	5 U [5 U]	0.22 U	0.2 U	5 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	1 U	5 U [5 U]	0.58 U	0.23 U	5 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	1 U	5 U [5 U]	0.21 U	0.24 U	5 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**45.6**	**29 [32]**	**427**	**599**	**59**	**58**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	1.5 U	1.8 U	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	1 U	5 U [5 U]	0.25 U	0.31 U	5 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	1 U	5 U [5 U]	0.21 U	0.19 U	5 U	5 U
Trichloroethene	79-01-6	5	ug/L	**7.6**	2.9 J [3.1 J]	0.51 J	0.79 J	5 U	5 U
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	1.3 U	2.6 U	NA	NA
Vinyl chloride	75-01-4	2	ug/L	1 U	5 U [5 U]	0.44 U	0.27 U	5 U	5 U
Benzene	71-43-2	1	ug/L	1 U	5 U [5 U]	0.23 U	0.22 U	5 U	5 U
Toluene	108-88-3	5	ug/L	1 U	5 U [5 U]	0.39 J	0.15 U	5 U	5 U
Ethylbenzene	100-41-4	5	ug/L	1 U	5 U [5 U]	0.27 U	0.21 U	5 U	5 U
Total Xylenes	1330-20-7	5	ug/L	0 U	5 U [5 U]	0.25 U	0.17 U	5 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	1 U	5 U [5 U]	NA	NA	5 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW19S 11/16/15	PCERI-MW19S 05/17/16	PCERI-MW25I 04/21/11	PCERI-MW25I 08/02/11	PCERI-MW25I 06/10/15	PCERI-MW25I 08/17/15
Inorganics									
Aluminum	7429-90-5	- -	ug/L	260	363 [308]	NA	NA	249	2,000 U
Antimony	7440-36-0	3	ug/L	2.2 U	60 U [60 U]	NA	NA	**3.6 J**	60 U
Arsenic	7440-38-2	25	ug/L	3 U	10 U [10 U]	NA	NA	10 U	7.6 J
Barium	7440-39-3	1,000	ug/L	60	37.9 [38.3]	NA	NA	29.9	25.2
Beryllium	7440-41-7	3	ug/L	1 U	3 U [3 U]	NA	NA	3 U	3 U
Boron	7440-42-8	1,000	ug/L	NA	NA	NA	NA	NA	19.9 J
Cadmium	7440-43-9	5	ug/L	1.1 U	5 U [5 U]	NA	NA	5 U	5 U
Calcium	7440-70-2	- -	ug/L	131,000	05,000 [105,000	NA	NA	56,900	73,700
Chromium	7440-47-3	50	ug/L	2 J	10 U [10 U]	NA	NA	4.3 J	16.8
Cobalt	7440-48-4	- -	ug/L	5.6 U	50 U [50 U]	NA	NA	50 U	50 U
Copper	7440-50-8	200	ug/L	5.6 U	20 U [20 U]	NA	NA	5.1 J	2.5 J
Iron	7439-89-6	300***	ug/L	**450**	**477 [414]**	NA	NA	**856**	212
Lead	7439-92-1	25	ug/L	2.2 U	5 U [5 U]	NA	NA	3 J	5.1
Magnesium	7439-95-4	35,000*	ug/L	8,500	6,970 [7,220]	NA	NA	3,810	6,360
Manganese	7439-96-5	300***	ug/L	25	12.1 [12.1]	NA	NA	42.3	**19,400**
Mercury	7439-97-6	0.7	ug/L	NA	0.2 U [0.2 U]	NA	NA	0.2 U	0.2 U
Nickel	7440-02-0	100	ug/L	5.6 U	40 U [40 U]	NA	NA	40 U	3.5 J
Potassium	7440-09-7	- -	ug/L	3,900	4,030 [4,090]	NA	NA	4,620	5,000
Selenium	7782-49-2	10	ug/L	5.6 U	10 U [10 U]	NA	NA	10 U	50 UE
Silver	7440-22-4	50	ug/L	2.2 U	10 U [10 U]	NA	NA	10 U	5.2 J
Sodium	7440-23-5	20,000	ug/L	**98,300**	**10,000 [111,000**	NA	NA	**141,000**	**148,000**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW25I 10/07/15	PCERI-MW25I 11/17/15	PCERI-MW25I 05/18/16	PCERI-MW25S 04/21/11	PCERI-MW25S 08/02/11	PCERI-MW25S 06/10/15
Volatile Organics									
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	5 U [5 U]	1 U	5 U	0.22 U	0.24 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	5 U [5 U]	1 U	5 U	0.26 U	0.24 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	5 U [5 U]	1 U	5 U	0.24 U	0.2 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	5 U [5 U]	1 U	5 U	0.23 U	0.23 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	5 U [5 U]	1 U	5 U	0.29 U	0.19 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	5 U [5 U]	1 U	5 U	0.4 U	0.28 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	5 U [5 U]	1 U	5 U	0.24 U	0.36 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	5 U [5 U]	1 U	5 UJ	0.47 U	0.69 U	5 U
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U [5 U]	5 U	5 U	0.49 U	0.54 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	5 U [5 U]	1 U	5 UJ	0.56 U	0.15 U	5 U
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	5 U [5 U]	1 U	5 U	0.28 U	0.18 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U [5 U]	5 U	5 U	1.1 U	1.3 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	5 U [5 U]	1 U	5 U	0.39 U	0.21 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	5 U [5 U]	1 U	5 U	0.26 U	0.18 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	5 U [5 U]	1 U	5 U	0.33 U	0.18 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	NA	1	0.22 U	NA
1,2-Dichloropropane	78-87-5	1	ug/L	5 U [5 U]	1 U	5 U	0.27 U	0.22 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	5 U [5 U]	1 U	5 U	0.3 U	0.23 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	5 U [5 U]	1 U	5 U	0.25 U	0.29 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	5 U [5 U]	1 U	5 U	0.25 U	0.19 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	2 U	NA	NA	NA	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	5 U [5 U]	1 U	5 U	0.28 U	0.26 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	5 U [5 U]	1 U	5 U	0.6 U	0.26 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	10 U [10 U]	5 U	10 U	NA	2.9 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	5 U [5 U]	1 U	5 U	0.31 U	0.19 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	5 U [5 U]	1 U	5 U	0.26 U	0.19 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	10 U [10 U]	5 U	10 U	0.86 U	1.2 U	10 U
Acetone	67-64-1	50*	ug/L	10 U [10 U]	5 U	10 U	2.9 U	7.6 U	10 U
Bromobenzene	108-86-1	- -	ug/L	5 U [5 U]	1 U	5 U	0.24 U	0.18 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	5 U [5 U]	1 U	5 U	0.33 U	0.4 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	0.38 J [0.49 J]	0.65 J	0.38 J	0.22 U	0.23 U	5 U
Bromoform	75-25-2	50*	ug/L	5 U [5 U]	1 U	5 U	0.23 U	0.24 U	5 U
Bromomethane	74-83-9	5	ug/L	5 U [5 UJ]	0.51 U	5 U	0.3 U	0.31 U	5 U
Carbon Disulfide	75-15-0	60	ug/L	10 U [10 U]	1 U	10 U	0.74 U	0.18 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	5 U [5 U]	1 U	5 U	0.26 U	0.19 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW25I 10/07/15	PCERI-MW25I 11/17/15	PCERI-MW25I 05/18/16	PCERI-MW25S 04/21/11	PCERI-MW25S 08/02/11	PCERI-MW25S 06/10/15
CFC-11	75-69-4	5	ug/L	5 U [5 U]	1 U	5 U	0.54 U	0.35 U	5 U
CFC-12	75-71-8	5	ug/L	5 U [5 U]	1 U	5 U	0.92 U	0.31 U	5 U
Chlorobenzene	108-90-7	5	ug/L	5 U [5 U]	1 U	5 U	0.39 U	0.22 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	5 U [5 U]	1 U	5 U	0.22 U	0.2 U	5 U
Chloroethane	75-00-3	5	ug/L	5 U [5 U]	1 U	5 U	0.37 U	0.37 U	5 U
Chloroform	67-66-3	7	ug/L	1.8 J [1.8 J]	2.9	2.9 J	0.72 J	0.21 U	5 U
Chloromethane	74-87-3	5	ug/L	5 U [5 U]	0.43 U	5 U	0.29 U	0.22 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	5 U [5 U]	1 U	5 U	1	0.22 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	5 U [5 U]	1 U	5 U	0.25 U	0.22 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	5 U [5 U]	1 U	5 U	0.69 U	0.19 U	5 U
Dibromomethane	74-95-3	- -	ug/L	5 U [5 U]	1 U	5 U	0.24 U	0.46 U	5 U
Dichloromethane	75-09-2	5	ug/L	5 U [5 U]	1 U	5 U	0.3 U	0.2 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	NA	0.72 U	0.71 U	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	5 U [5 U]	1 U	5 U	0.67 U	0.23 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	5 U [5 U]	1 U	5 U	0.57 U	0.19 U	5 U
m&p-Xylenes	ARC-mpXy	- -	ug/L	5 U [5 U]	2 U	5 U	0.25 U	0.32 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	10 U [10 U]	NA	10 U	1.4 U	3 U	10 U
Naphthalene	91-20-3	10*	ug/L	5 U [5 U]	1 U	5 UJ	0.97 J	0.68 U	5 U
N-Butylbenzene	104-51-8	- -	ug/L	5 U [5 U]	1 U	5 U	0.47 U	0.33 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	5 U [5 U]	1 U	5 U	0.24 U	0.17 U	5 U
o-Xylene	95-47-6	- -	ug/L	5 U [5 U]	1 U	5 U	0.25 U	0.17 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	5 U [5 U]	1 U	5 U	0.22 U	0.2 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	5 U [5 U]	1 U	5 U	0.58 U	0.23 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	5 U [5 U]	1 U	5 U	0.21 U	0.24 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**56 [55]**	**68.8**	**55**	**153**	**40.7**	**8.2**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	NA	1.5 U	2.2 J	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	5 U [5 U]	1 U	5 U	0.25 U	0.31 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	5 U [5 U]	1 U	5 U	0.21 U	0.19 U	5 U
Trichloroethene	79-01-6	5	ug/L	5 U [5 U]	1 U	0.23 J	**36.8**	4.5	1.6 J
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	NA	1.3 U	2.6 U	NA
Vinyl chloride	75-01-4	2	ug/L	5 U [5 U]	1 U	5 U	0.44 U	0.27 U	5 U
Benzene	71-43-2	1	ug/L	5 U [5 U]	1 U	5 U	0.23 U	0.22 U	5 U
Toluene	108-88-3	5	ug/L	5 U [5 U]	1 U	5 U	0.3 U	0.15 U	5 U
Ethylbenzene	100-41-4	5	ug/L	5 U [5 U]	1 U	5 U	0.27 U	0.21 U	5 U
Total Xylenes	1330-20-7	5	ug/L	5 U [5 U]	0 U	5 U	0.25 U	0.17 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	5 U [5 U]	1 U	5 U	NA	NA	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW25I 10/07/15	PCERI-MW25I 11/17/15	PCERI-MW25I 05/18/16	PCERI-MW25S 04/21/11	PCERI-MW25S 08/02/11	PCERI-MW25S 06/10/15
Inorganics									
Aluminum	7429-90-5	- -	ug/L	68.7 J [288 J]	96	88.6 J	NA	NA	31.8 J
Antimony	7440-36-0	3	ug/L	1.6 J [1.3 J]	2.2 U	60 U	NA	NA	2.7 J
Arsenic	7440-38-2	25	ug/L	2.8 J [3.2 J]	3 U	10 U	NA	NA	10 U
Barium	7440-39-3	1,000	ug/L	24.9 [25.6]	27	29	NA	NA	16.2 J
Beryllium	7440-41-7	3	ug/L	3 U [3 U]	1 U	3 U	NA	NA	3 U
Boron	7440-42-8	1,000	ug/L	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	5	ug/L	5 U [5 U]	1.1 U	5 U	NA	NA	5 U
Calcium	7440-70-2	- -	ug/L	55,700 E [55,700]	57,800	64,500	NA	NA	35,500
Chromium	7440-47-3	50	ug/L	2.7 J [6.7 J]	2.8	1.3 J	NA	NA	1.1 J
Cobalt	7440-48-4	- -	ug/L	50 U [50 U]	5.6 U	50 U	NA	NA	50 U
Copper	7440-50-8	200	ug/L	20 U [2.4 J]	2.3 J	20 U	NA	NA	20 U
Iron	7439-89-6	300***	ug/L	**329 [548]**	280	158	**8,260**	141	142
Lead	7439-92-1	25	ug/L	5 U [5 U]	2.2 U	5 U	NA	NA	1.6 J
Magnesium	7439-95-4	35,000*	ug/L	4,040 [3,940]	4,500	4,110	NA	NA	1,950
Manganese	7439-96-5	300***	ug/L	75.4 [76.7]	43	16.4	NA	NA	38.4
Mercury	7439-97-6	0.7	ug/L	0.2 U [0.2 U]	NA	0.2 U	NA	NA	0.2 U
Nickel	7440-02-0	100	ug/L	40 U [2.3 J]	5.6 U	40 U	NA	NA	40 U
Potassium	7440-09-7	- -	ug/L	5,170 [5,130]	4,400	3,570	NA	NA	1,500 J
Selenium	7782-49-2	10	ug/L	10 U [10 U]	5.6 U	10 U	NA	NA	10 U
Silver	7440-22-4	50	ug/L	1.8 J [1.3 J]	2.2 U	10 U	NA	NA	10 U
Sodium	7440-23-5	20,000	ug/L	**143,000 [138,000]**	**159,000**	**166,000**	NA	NA	**76,800**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.

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Volatile Organics							
1,1,1,2-Tetrachloroethane	630-20-6	- -	ug/L	5 U	5 U	1 U	5 U
1,1,1-Trichloroethane	71-55-6	5	ug/L	5 U	5 U	1 U	5 U
1,1,2,2-Tetrachloroethane	79-34-5	5	ug/L	5 U	5 U	1 U	5 U
1,1,2-Trichloroethane	79-00-5	1	ug/L	5 U	5 U	1 U	5 U
1,1-Dichloroethane	75-34-3	5	ug/L	5 U	5 U	1 U	5 U
1,1-Dichloroethene	75-35-4	5	ug/L	5 U	5 U	1 U	5 U
1,1-Dichloropropene	563-58-6	- -	ug/L	5 U	5 U	1 U	5 U
1,2,3-Trichlorobenzene	87-61-6	- -	ug/L	5 U	5 U	1 U	5 UJ
1,2,3-Trichloropropane	96-18-4	- -	ug/L	5 U	5 U	5 U	5 U
1,2,4-Trichlorobenzene	120-82-1	5	ug/L	5 U	5 U	1 U	5 UJ
1,2,4-Trimethylbenzene	95-63-6	5	ug/L	5 U	5 U	1 U	5 U
1,2-Dibromo-3-chloropropane	96-12-8	0.04	ug/L	5 U	5 U	5 U	5 U
1,2-Dibromoethane	106-93-4	0.0006	ug/L	5 U	5 U	1 U	5 U
1,2-Dichlorobenzene	95-50-1	3	ug/L	5 U	5 U	1 U	5 U
1,2-Dichloroethane	107-06-2	0.6	ug/L	5 U	5 U	1 U	5 U
1,2-Dichloroethene, Total	540-59-0	- -	ug/L	NA	NA	NA	NA
1,2-Dichloropropane	78-87-5	1	ug/L	5 U	5 U	1 U	5 U
1,3,5-Trimethylbenzene	108-67-8	5	ug/L	5 U	5 U	1 U	5 U
1,3-Dichlorobenzene	541-73-1	3	ug/L	5 U	5 U	1 U	5 U
1,3-Dichloropropane	142-28-9	- -	ug/L	5 U	5 U	1 U	5 U
1,3-Dichloropropene	542-75-6	- -	ug/L	NA	NA	2 U	NA
1,4-Dichlorobenzene	106-46-7	3	ug/L	5 U	5 U	1 U	5 U
2,2-Dichloropropane	594-20-7	- -	ug/L	5 U	5 U	1 U	5 U
2-Butanone (MEK)	78-93-3	50	ug/L	10 U	10 U	5 U	10 U
2-Chlorotoluene	95-49-8	- -	ug/L	5 U	5 U	1 U	5 U
4-Chlorotoluene	106-43-4	- -	ug/L	5 U	5 U	1 U	5 U
4-Methyl-2-Pentanone	108-10-1	- -	ug/L	10 U	10 U	5 U	10 U
Acetone	67-64-1	50*	ug/L	2.8 J	10 U	5 U	1.6 J
Bromobenzene	108-86-1	- -	ug/L	5 U	5 U	1 U	5 U
Bromochloromethane	74-97-5	- -	ug/L	5 U	5 U	1 U	5 U
Bromodichloromethane	75-27-4	50*	ug/L	5 U	5 U	1 U	5 U
Bromoform	75-25-2	50*	ug/L	5 U	5 U	1 U	5 U
Bromomethane	74-83-9	5	ug/L	5 U	5 U	1 U	5 U
Carbon Disulfide	75-15-0	60	ug/L	10 U	10 U	1 U	10 U
Carbon Tetrachloride	56-23-5	5	ug/L	5 U	5 U	1 U	5 U

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CFC-11	75-69-4	5	ug/L	5 U	5 U	1 U	5 U
CFC-12	75-71-8	5	ug/L	5 U	5 U	1 U	5 U
Chlorobenzene	108-90-7	5	ug/L	5 U	5 U	1 U	5 U
Chlorodibromomethane	124-48-1	50	ug/L	5 U	5 U	1 U	5 U
Chloroethane	75-00-3	5	ug/L	5 U	5 U	1 U	5 U
Chloroform	67-66-3	7	ug/L	5 U	5 U	1 U	5 U
Chloromethane	74-87-3	5	ug/L	5 U	5 U	1 U	5 U
cis-1,2-Dichloroethene	156-59-2	5	ug/L	5 U	5 U	1 U	5 U
cis-1,3-Dichloropropene	10061-01-5	0.4**	ug/L	5 U	5 U	1 U	5 U
Cymene (p-Isopropyltoluene)	99-87-6	5	ug/L	5 U	5 U	1 U	5 U
Dibromomethane	74-95-3	- -	ug/L	5 U	5 U	1 U	5 U
Dichloromethane	75-09-2	5	ug/L	5 U	5 U	1 U	5 U
Diethyl ether	60-29-7	- -	ug/L	NA	NA	NA	NA
Hexachloro-1,3-butadiene	87-68-3	0.5	ug/L	5 U	5 U	1 U	5 U
Isopropylbenzene	98-82-8	5	ug/L	5 U	5 U	1 U	5 U
m&p-Xylenes	ARC-mpXy	- -	ug/L	5 U	5 U	2 U	5 U
Methyl N-Butyl Ketone (2-Hexanone)	591-78-6	50*	ug/L	10 U	10 U	NA	10 U
Naphthalene	91-20-3	10*	ug/L	5 U	5 U	1 U	0.3 J-
N-Butylbenzene	104-51-8	- -	ug/L	5 U	5 U	1 U	5 U
N-Propylbenzene	103-65-1	5	ug/L	5 U	5 U	1 U	5 U
o-Xylene	95-47-6	- -	ug/L	5 U	5 U	1 U	5 U
sec-Butylbenzene	135-98-8	5	ug/L	5 U	5 U	1 U	5 U
Styrene (Monomer)	100-42-5	5	ug/L	5 U	5 U	1 U	5 U
tert-Butylbenzene	98-06-6	- -	ug/L	5 U	5 U	1 U	5 U
Tetrachloroethene	127-18-4	5	ug/L	**6**	**8**	**9.4**	**140**
Tetrahydrofuran	109-99-9	- -	ug/L	NA	NA	NA	NA
trans-1,2-Dichloroethene	156-60-5	5	ug/L	5 U	5 U	1 U	5 U
trans-1,3-Dichloropropene	10061-02-6	0.4**	ug/L	5 U	5 U	1 U	5 U
Trichloroethene	79-01-6	5	ug/L	5 U	1.2 J	2	**45**
Vinyl acetate	108-05-4	- -	ug/L	NA	NA	NA	NA
Vinyl chloride	75-01-4	2	ug/L	5 U	5 U	1 U	5 U
Benzene	71-43-2	1	ug/L	5 U	5 U	1 U	5 U
Toluene	108-88-3	5	ug/L	5 U	5 U	1 U	5 U
Ethylbenzene	100-41-4	5	ug/L	5 U	5 U	1 U	5 U
Total Xylenes	1330-20-7	5	ug/L	5 U	5 U	0 U	5 U
Methyl-tert-butylether	1634-04-4	10*	ug/L	5 U	5 U	1 U	5 U

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Location ID: / Date Collected:	CAS Number	NYSDEC Class GA Standard or Guidance Values		PCERI-MW25S 08/17/15	PCERI-MW25S 10/07/15	PCERI-MW25S 11/17/15	PCERI-MW25S 05/18/16
Inorganics							
Aluminum	7429-90-5	- -	ug/L	200 U	38.8 J	130	60.4 J
Antimony	7440-36-0	3	ug/L	60 U	60 U	2.2 U	60 U
Arsenic	7440-38-2	25	ug/L	4 J	2.5 J	3 U	10 U
Barium	7440-39-3	1,000	ug/L	7 J	10.5 J	92	21.7
Beryllium	7440-41-7	3	ug/L	3 U	3 U	1 U	3 U
Boron	7440-42-8	1,000	ug/L	30.2 J	NA	NA	NA
Cadmium	7440-43-9	5	ug/L	5 U	5 U	1.1 U	5 U
Calcium	7440-70-2	- -	ug/L	41,800	44,600	38,800	66,300
Chromium	7440-47-3	50	ug/L	4.7 J	0.996 J	2.1 J	10 U
Cobalt	7440-48-4	- -	ug/L	50 U	50 U	5.6 U	50 U
Copper	7440-50-8	200	ug/L	20 U	20 U	5.6 U	20 U
Iron	7439-89-6	300***	ug/L	46.3 J	119	**340**	103
Lead	7439-92-1	25	ug/L	2.7 J	5 U	2.2 U	5 U
Magnesium	7439-95-4	35,000*	ug/L	2,100	2,380	2,200	3,440
Manganese	7439-96-5	300***	ug/L	**2,400**	187	**320**	220
Mercury	7439-97-6	0.7	ug/L	0.2 U	0.2 U	NA	0.2 U
Nickel	7440-02-0	100	ug/L	40 U	40 U	5.6 U	40 U
Potassium	7440-09-7	- -	ug/L	1,480 J	1,460 J	1,400	1,640 J
Selenium	7782-49-2	10	ug/L	10 UE	10 U	5.6 U	10 U
Silver	7440-22-4	50	ug/L	2.1 J	1.6 J	2.2 U	10 U
Sodium	7440-23-5	20,000	ug/L	**62,200**	**52,800**	**50,300**	**62,300**

* Guidance Value

** Sum of these compounds can not exceed 0.4 ug/L

***Sum of these compounds can not exceed 300 ug/L.

Exceeds NYSDEC Class GA Standard or Guidance Value

Footnotes:

U - The compound was analyzed for but not detected. The associated value is the compound quantitation limit.

B - The compound has been found in the sample as well as its associated blank; its presence in the sample may be suspect.

J - The compound was positively identified; however, the associated numerical value is an estimated concentration.

UJ - The compound was not detected above the reported sample quantitation limit. However, the reported limit is approximate and may or may not represent the actual limit of quantitation.

UB - Compound considered non-detect at the listed value due to associated blank contamination.