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Engineering
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Environmental
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Corrective Measures Plan
NYSDEC Site #828062

Location:

560 Salt Road
Webster, New York

Prepared for:

RD Specialties, Inc.
560 Salt Road
Webster, New York 14580

LaBella Project No. 2161127

December 2016

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1.0 INTRODUCTION & BACKGROUND

LaBella Associates, D.P.C. ("LaBella") on behalf of R.D. Specialties, Inc. (RDS) is pleased to submit this Corrective Measures Plan (CMP) to excavate and dispose of off-site source area chromium impacted soils located at 560 Salt Road, Webster, NY, hereinafter referred to as the "Site". A project location map is included as Figure 1. The objective of this CMP is to detail proposed activities necessary to remove to the extent feasible source area chromium impacted soils and groundwater at the Site. The Site was assigned as New York State Department of Environmental Conservation (NYSDEC) Site #828062.

The Site is listed as a Class 4 Inactive Hazardous Waste Disposal Site (IHWDS) by the NYSDEC. RDS conducted chrome plating of metal rods beginning in 1966. The plated rods were rinsed and the rinsate was drained to a dry well. This practice continued until sometime in 1982, when the rinsate was treated and disposed of off-site. In addition, the NYSDEC Record of Decision (ROD) indicated that in the 1970s 40-50 gallons of plating solution (with approximately 47 pounds of chromium) was also discharged to the dry well. The NYSDEC previously completed a removal of impacted soil at the Site and subsequently a foundation drainage system was installed to remove impacted groundwater and treat it prior to discharge. The foundation drain system has decreased the groundwater plume; however, the concentrations are still above the NYSDEC Groundwater Standards. The NYSDEC sent a letter June 3, 2011 requiring additional investigation be conducted to assess source areas in relation to groundwater contamination.

In July 2016, LaBella conducted a supplemental investigation inside the building at RDS in an effort to delineate the potential source area of chromium impact. A series of thirteen (13) soil borings were drilled through the building floor using a direct-push Geoprobe 6620 DT drill rig. Soil borings were advanced to the presumed top of bedrock, which averaged approximately five (5) feet below the concrete floor surface. An Olympus Innov-X Delta X-Ray Fluorescence (XRF) meter was used to screen subsurface soils collected from the borings for chromium content. Representative soil samples were collected from select borings and sent for laboratory analysis of total and hexavalent chromium. Soil sample results revealed significantly elevated concentrations of total chromium which represent a continuing source to groundwater within the former drywell area. Figure 2 illustrates the recent locations and summarizes the XRF and laboratory data.

1.1 Site Description

The Site consists of one (1) 4.9 acre parcel that currently has a manufacturing building on it which includes office space. A Site Location Map is attached as Figure 1.

2.0 WORK PLAN RATIONALE

This CMP describes the scope of activities proposed to remove source area material from the Site. The goals of the CMP are to:

- Remove source area soils impacted with chromium (hexavalent and total chromium) to the extent feasible from the approximate area shown on the attached Figure 2.

- Characterize and dispose of source area soils and concrete at appropriately licensed landfill(s). It is anticipated that a portion of the excavated soils will be classified as hazardous and the remainder will be non-hazardous.
- Dewater the excavation to the extent necessary to reduce the contaminant mass as much as possible and treat water on site prior to discharge to the local sanitary sewer system.

The goal of the CMP is to provide long term effectiveness, permanently reduce the toxicity and mobility of contamination and reduce potential human health exposure.

3.0 CORRECTIVE MEASURE PLAN

3.1 Pre-Removal Work Zone Set Up

Prior to initiating the removal work, the area within the building for removal will be sealed off from the remaining portions of the building by constructing a temporary wall around the area with poly sheeting and lumber. The wall will be constructed along the western side of the concrete removal area (refer to Figure 2) and extend out to allow for removal of soil through the overhead doors to the exterior. The other openings (doors and HVAC vents/intakes) will also be sealed. The work will be completed under negative pressure through the use of HEPA filtration equipment. If necessary an air lock area will be created for the hauling route in/out of the work zone in order to maintain the negative pressure. This will allow the work to proceed without impacting the on-going business operations; however, the work will be completed in off-hours in order to minimize potential issues.

3.2 Concrete Removal

The concrete floor overlying the area of anticipated soil removal will be removed with a hoe-ram mounted to an excavator or equivalent. The area of floor removal will extend beyond the planned area of soil removal in order to remove concrete flooring back to existing discrete floor slab areas (refer to Figure 2). The concrete will be hammered into manageable pieces. During concrete removal, visual observations will be made to assess potential yellow-green staining typically associated with hexavalent chromium contamination. A X-ray fluorescence (XRF) meter will also be used to screen the concrete for chromium concentration to assist with waste characterization for proper disposal. Removed concrete will be placed into a lined roll-off bin and co-mingled with chromium-impacted soil of similar concentrations (see Section 3.3 and 3.7 below for segregation, characterization and disposal of materials).

3.3 Impacted Soil Excavation

Based on the information collected during previous investigations, the highest concentrations of chromium detected in soil during recent investigation work were in the general location of the former drywell (borings SB-4 and SB-7). Figure 2 and 3 illustrates the approximate area from which soils will be removed by excavation following removal of the concrete floor. This area equates to approximately 600 sq. ft. It is anticipated that soils will be removed by excavation to the underlying bedrock surface, which ranges in depth between approximately four (4) and five and a half (5.5) feet below the concrete floor. The depth to presumed bedrock averaged 5.2 feet below the concrete floor.

It is estimated that up to 120 cubic yards (+/- 200 tons) of chromium-impacted soil will be removed for disposal. In addition, weathered bedrock will also be excavated, if practicable, in areas of staining or areas with elevated chromium concentrations based on XRF readings in order to remove additional source material within the weathered bedrock zone. Excavated soils will be loaded from an excavator into a skidsteer bucket (or equivalent) and transferred into lined roll-off bins awaiting characterization sampling and proper disposal. A XRF meter will be used to screen soils as they are removed and to screen the sidewalls of the excavation prior to completing confirmatory sampling. Though elevated Photoionization device (PID) readings were not observed during the supplemental investigation, a PID will be used to screen excavated soils for elevated volatile organic compounds (VOCs).

Three (3) classes of soil are expected to be generated at the Site. Each class of material will be managed and handled in a manner dictated by evidence of environmental impairment and waste characterization sample data. The three (3) classes of material are described in the following table:

Table 1: Excavated Material Classifications

Class of Material	Description	Field Screening Parameter	Laboratory Characterization	Management/Disposition of Material
Class 1	Apparent Non-hazardous	No obvious discoloration; XRF readings generally below 500 ppm	At least 1 Total Chromium and 1 TCLP Chromium per roll-off (and any additional characterization required for disposal facility)	Stage on-site in lined roll-off, based on characterization sampling dispose off-site in accordance with applicable regulations.
Class 2	Apparent Non-hazardous	No obvious discoloration; XRF readings between 500 to 1,000 ppm		
Class 3	Hazardous	Yellow-green staining observed; XRF readings above 1,000 ppm		

LaBella will record observations of Site conditions during the remedial excavation activities and record on daily field logs. LaBella will continuously assess for evidence of visible impairment, elevated chromium readings using an XRF meter, and/or indication of detectable VOCs with a PID. Positive indications from any of these screening methods are collectively referred to as “evidence of impairment.” LaBella will segregate the soils in accordance with Table 1.

During non-working hours, one layer of 6-mil polyethylene sheeting will be used as a cover for excavated materials. The covers will be anchored or weighted at the edges to prevent storm water and wind borne erosion. This procedure is to prevent precipitation from creating impacted runoff.

3.4 Groundwater Management

Groundwater infiltrating the excavation during soil removal will be pumped with a double diaphragm pump into a staged polyethylene holding tank and allowed to settle. Following a settling period, if the stored groundwater has low enough turbidity it will be pumped into the on-Site water treatment system. If the groundwater is too turbid for the on-Site treatment system an in-line filter will be placed in the transfer hose to prevent the accumulation of sediment in the treatment system. Fines that settle out in the poly tank will be placed in the hazardous roll-off bin at the completion of the job to be included for disposal as a solid waste.

3.5 Confirmatory Soil Sampling

Subsequent to completion of the soil removal activity, confirmatory soil samples will be collected from the excavation sidewalls consistent with the protocols outlined in the NYSDEC DER-10 / Technical Guidance for Site Investigation and Remediation document. It is anticipated that soil is going to be removed to the bedrock surface and weathered bedrock may also be removed for disposal, therefore, it is anticipated that excavation floor sampling will not be required. Samples will be submitted to an appropriately accredited laboratory for analysis of total chromium via United States Environmental Protection Agency (USEPA) Method 6010 at a rate of one sample per 30 linear feet of sidewall.

3.6 Excavation Backfilling & Amendment Application

Once the soil removal activity is complete and confirmatory sampling has taken place, the excavation will be backfilled with clean stone. During backfilling, an amendment will be added to the bottom portion of the excavation to treat residual chromium. The amendment will consist of 400 lbs of 3-D Microemulsion and 120 lbs. of HRC Primer both provided by Regenesis. 3-D Microemulsion is designed to provide three unique electron donor materials in a single product. This design produces a beneficial and sequential, staged-release of its three individual electron donor components, which are Lactate, Polylactate Esters, and Free Fatty Acids/Fatty Acid Esters. This results in an immediate, mid-range and long-term, controlled-release supply of organic acids for long-term reducing conditions. These reducing conditions are intended to reduce hexavalent chromium to trivalent chromium which will also immobilize the chromium. The staged-release provides electron donors for periods of up to 2-4 years on a single application. Appendix 4 provides the following information on the amendment to be added to the backfill.

- Regenesis Application Design Summary – this provides the basis for the quantity of 3-D Microemulsion and HRC Primer recommended by Regenesis.
- USEPA Notification – A cover letter and USEPA Inventory of Injection Wells is attached providing notification to USEPA of the activities.
- Material Safety Data Sheets for 3-D Microemulsion – This provides health and safety and material composition information on the products.
- Case Study - Regenesis provided a case study for the technical basis for their recommendation on the use of 3-D Microemulsion and HRC Primer for use on hexavalent chromium.

In addition to the above, a network of perforated HDPE pipe (or equivalent) will be installed near the base of the excavation to allow for future introduction of a chemical treatment agent to promote reduction of residual hexavalent chromium in remaining soils and groundwater. The pipe network will likely include solid PVC (or equivalent) riser(s) that will extend up to the floor surface and provide a conduit through which the remedial agent can be applied. The infrastructure to be installed is shown on Figure 3. The extent of the infrastructure (i.e., exact location of horizontal piping and risers) will be determined in the field at the time of removal based on field observations (e.g., biased towards staining and/or observed fractures). The remainder of the excavation will then be backfilled with clean stone up to a sufficient level at which a new concrete floor can be poured.

3.7 Soil Disposal

During soil removal activity, composite soil samples will be collected and submitted to an appropriately accredited laboratory for waste characterization analysis. Sample collection will be biased toward worst case contamination levels including observations of staining associated with hexavalent chromium impacts, and elevated XRF readings. The analytical parameters tested will be based on landfill requirements, however it is anticipated this will include at a minimum total chromium and chromium subsequent to Toxicity Characteristic Leaching Procedure (TCLP) extraction. A waste profile form will be completed and approval for receipt of waste will be secured. It is anticipated that there will be two (2) waste stream classifications for the soil, hazardous and non-hazardous, which will likely result in transportation of the waste to two (2) different waste disposal facilities.

4.0 AIR MONITORING

Air monitoring will be conducted during all ground-intrusive remedial activities on site and while placing soils in the lined roll-off bins. The NYSDOH Generic Community Air Monitoring Plan (CAMP) and Fugitive Dust and Particulate Monitoring will be utilized for this remedial activity and is included as Appendix 1. Based on the nature of the work some modifications/clarifications are warranted for the CAMP monitoring. These are provided below:

- All work will be completed within the building and thus upwind/downwind monitoring will be modified. Specifically, a background reading for VOCs and fugitive dust will be established within the containment area and outside of the containment area prior to conducting any subsurface penetrations and then monitoring will be conducted within the work zone (approximate 5-ft. radius area around excavation) and periodically on the exterior of the work zone. The action levels will be applied to the exterior of the work zone (i.e., outside the containment area).
- Subsequent to completing excavation work a reading for VOCs and fugitive dust will be recorded to confirm background levels have been established both within and exterior to the containment area.
- Fugitive dust monitoring will be completed in accordance with the NYSDOH Guidance and as noted above; however, it should be noted that hammering the concrete floor for removal will likely create some minimal dust for a short duration and therefore wet techniques will be employed to minimize this issue.

5.0 HEALTH AND SAFETY PLAN

A Site-specific Health and Safety Plan (HASP) has been prepared for the remedial phase of work and is included as Appendix 2 of this CMP. The HASP outlines general safety precautions, policies and procedures necessary to ensure worker safety during remedial activities, and includes emergency information such as the route to the nearest hospital and emergency contacts/phone numbers. It is noted that personal air monitoring will be conducted during the soil removal activity to ensure workers have the appropriate PPE on for adequate protection. Air monitoring details are provided in the HASP.

6.0 QUALITY ASSURANCE PROJECT PLAN

A Site-specific Quality Assurance Project Plan (QAPP) has been prepared for the remedial phase of work and is included as Appendix 3 of this CMP. The QAPP establishes Quality Control (QC) objectives in an effort to provide accurate and reliable data, provide safe working conditions for on-Site workers, and contains procedures which allow for the proper collection and evaluation of data resulting from the remedial actions conducted at the Site.

7.0 CORRECTIVE MEASURES REPORT

A Corrective Measures Report will be prepared subsequent to completing the removal activities that will present a detailed account of the activities completed at the Site including; site specific mapping, analytical data tables presenting the conformation/documentation sampling results, materials handling summary (both shipped off-site and imported to the Site), and field reports. The Corrective Measure Report will be prepared so that it specifically addresses all areas where remedial action was implemented so it can be evaluated by the NYSDEC.

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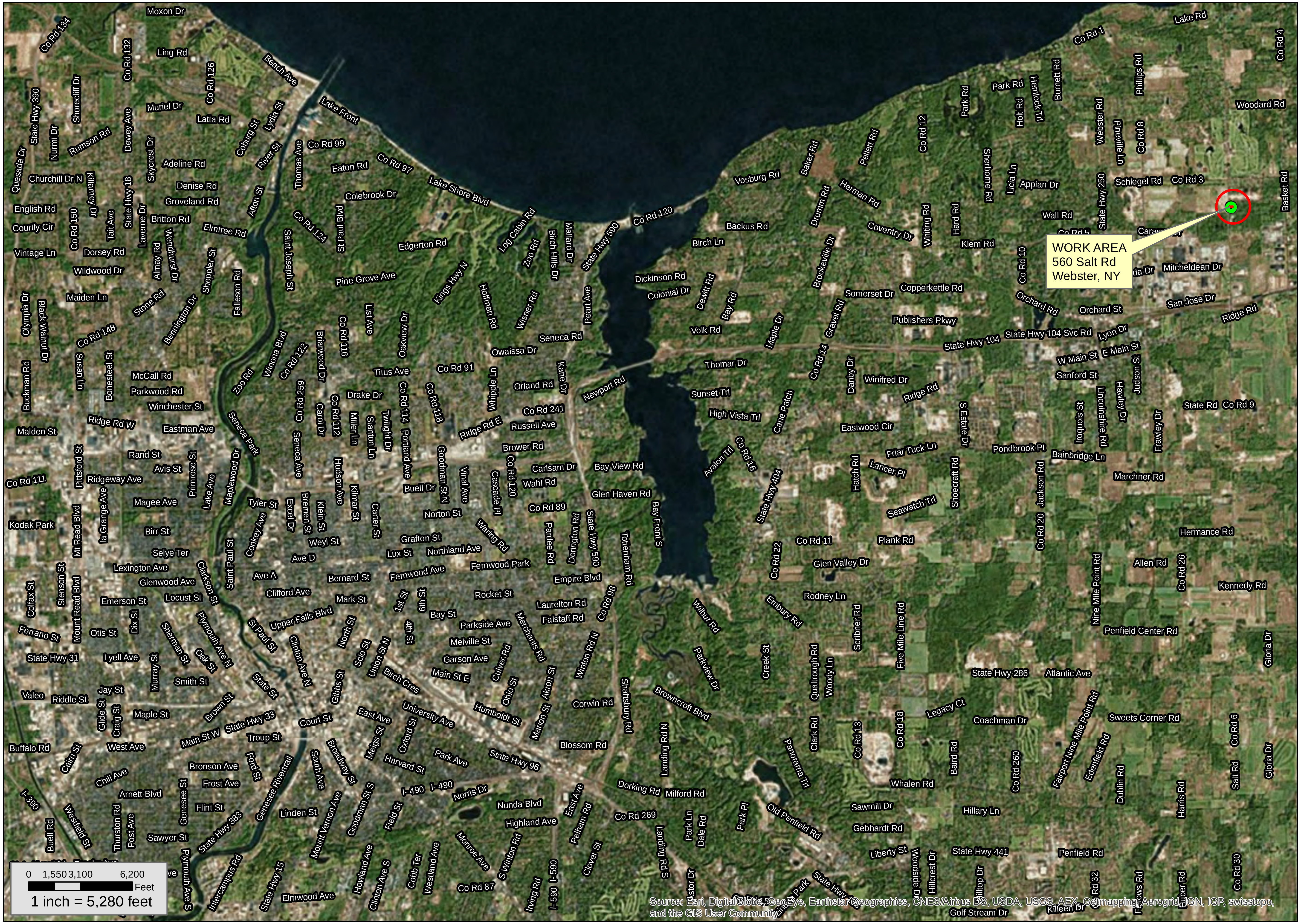
FIGURES



1 inch = 5,280 feet

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

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PROJECT/CLIENT

Corrective Measures Plan
Remedial Phase

RDS
R.D. SPECIALTIES
560 Salt Rd, Webster, NY

DRAWING TITLE

560 Salt Rd
Webster, NY
Location Map

ISSUED FOR
DRAFT
DATE: 12/20/2016

DESIGNED BY: --
DRAWN BY: DRP
REVIEWED BY: --

PROJECT/DRAWING NUMBER

2161127

FIGURE 1

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Path: J:\RD Specialties\2161127 - Supplemental Chromium Investigation\Drawings\ENVIRONMENTAL\remedial phase\FIGURE 2.mxd

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PROJECT/CLIENT

Corrective Measures Plan
Remedial Phase

R.D. SPECIALTIES, INC.
560 Salt Rd, Webster, NY
NYSDEC Site #828062

DRAWING TITLE

Hauling Route and Excavation
Containment Plan

ISSUED FOR
DRAFT

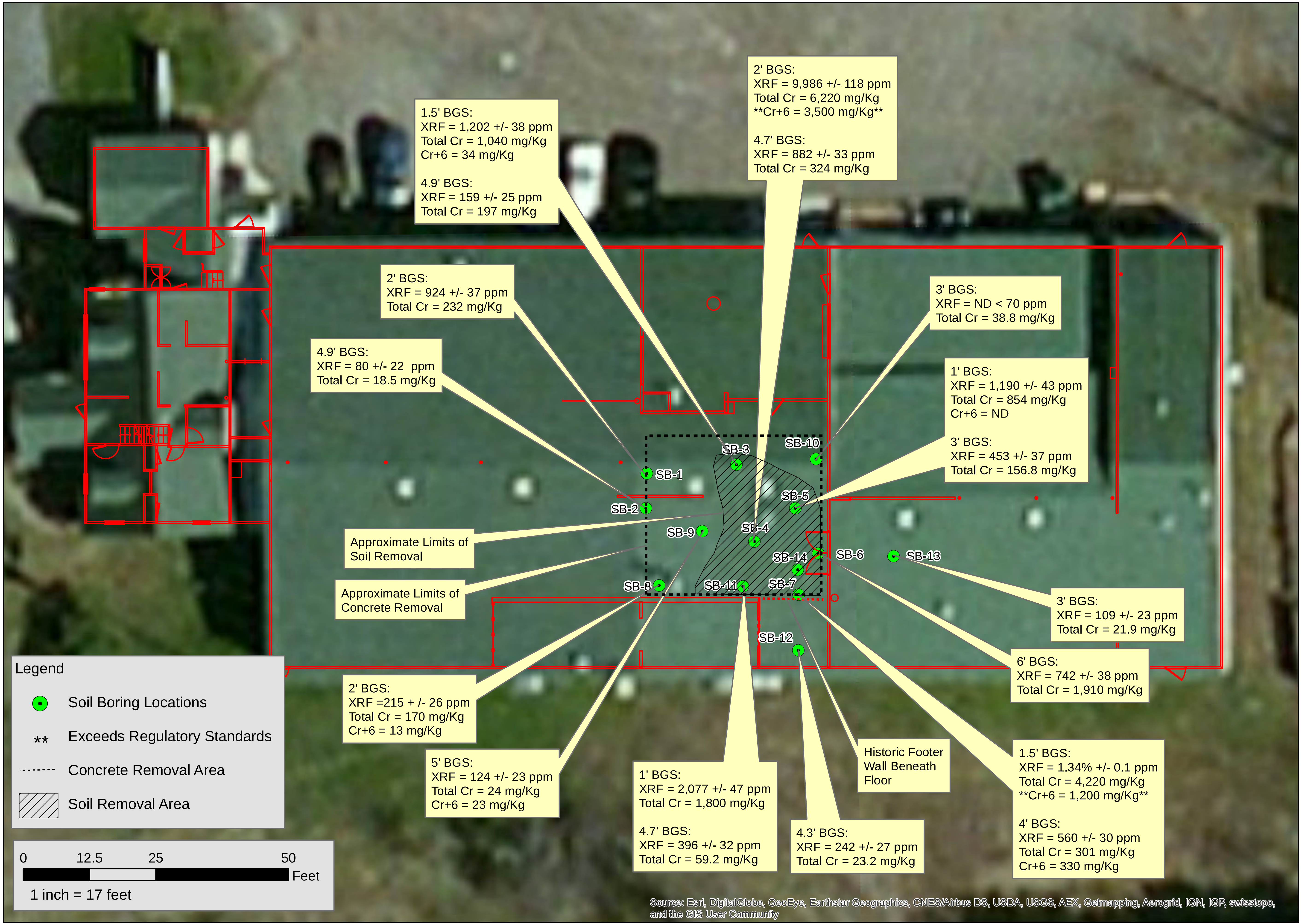
DATE: 12/28/2016

DESIGNED BY: --
DRAWN BY: DRP
REVIEWED BY: --

PROJECT/DRAWING NUMBER

2161127

FIGURE 2



2' BGS:
XRF = 9,986 +/- 118 ppm
Total Cr = 6,220 mg/Kg
Cr+6 = 3,500 mg/Kg

4.7' BGS:
XRF = 882 +/- 33 ppm
Total Cr = 324 mg/Kg

1.5' BGS:
XRF = 1,202 +/- 38 ppm
Total Cr = 1,040 mg/Kg
Cr+6 = 34 mg/Kg

4.9' BGS:
XRF = 159 +/- 25 ppm
Total Cr = 197 mg/Kg

2' BGS:
XRF = 924 +/- 37 ppm
Total Cr = 232 mg/Kg

3' BGS:
XRF = ND < 70 ppm
Total Cr = 38.8 mg/Kg

4.9' BGS:
XRF = 80 +/- 22 ppm
Total Cr = 18.5 mg/Kg

1' BGS:
XRF = 1,190 +/- 43 ppm
Total Cr = 854 mg/Kg
Cr+6 = ND

3' BGS:
XRF = 453 +/- 37 ppm
Total Cr = 156.8 mg/Kg

Approximate Limits of Soil Removal

Approximate Limits of Concrete Removal

3' BGS:
XRF = 109 +/- 23 ppm
Total Cr = 21.9 mg/Kg

6' BGS:
XRF = 742 +/- 38 ppm
Total Cr = 1,910 mg/Kg

2' BGS:
XRF =215 + /- 26 ppm
Total Cr = 170 mg/Kg
Cr+6 = 13 mg/Kg

5' BGS:
XRF = 124 +/- 23 ppm
Total Cr = 24 mg/Kg
Cr+6 = 23 mg/Kg

1' BGS:
XRF = 2,077 +/- 47 ppm
Total Cr = 1,800 mg/Kg

4.7' BGS:
XRF = 396 +/- 32 ppm
Total Cr = 59.2 mg/Kg

4.3' BGS:
XRF = 242 +/- 27 ppm
Total Cr = 23.2 mg/Kg

Historic Footer Wall Beneath Floor

1.5' BGS:
XRF = 1.34% +/- 0.1 ppm
Total Cr = 4,220 mg/Kg
Cr+6 = 1,200 mg/Kg

4' BGS:
XRF = 560 +/- 30 ppm
Total Cr = 301 mg/Kg
Cr+6 = 330 mg/Kg

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Path: J:\RD Specialties\2161127 - Supplemental Chromium Investigation\Drawings\ENVIRONMENTAL\remedial phase\FIGURE 3.mxd

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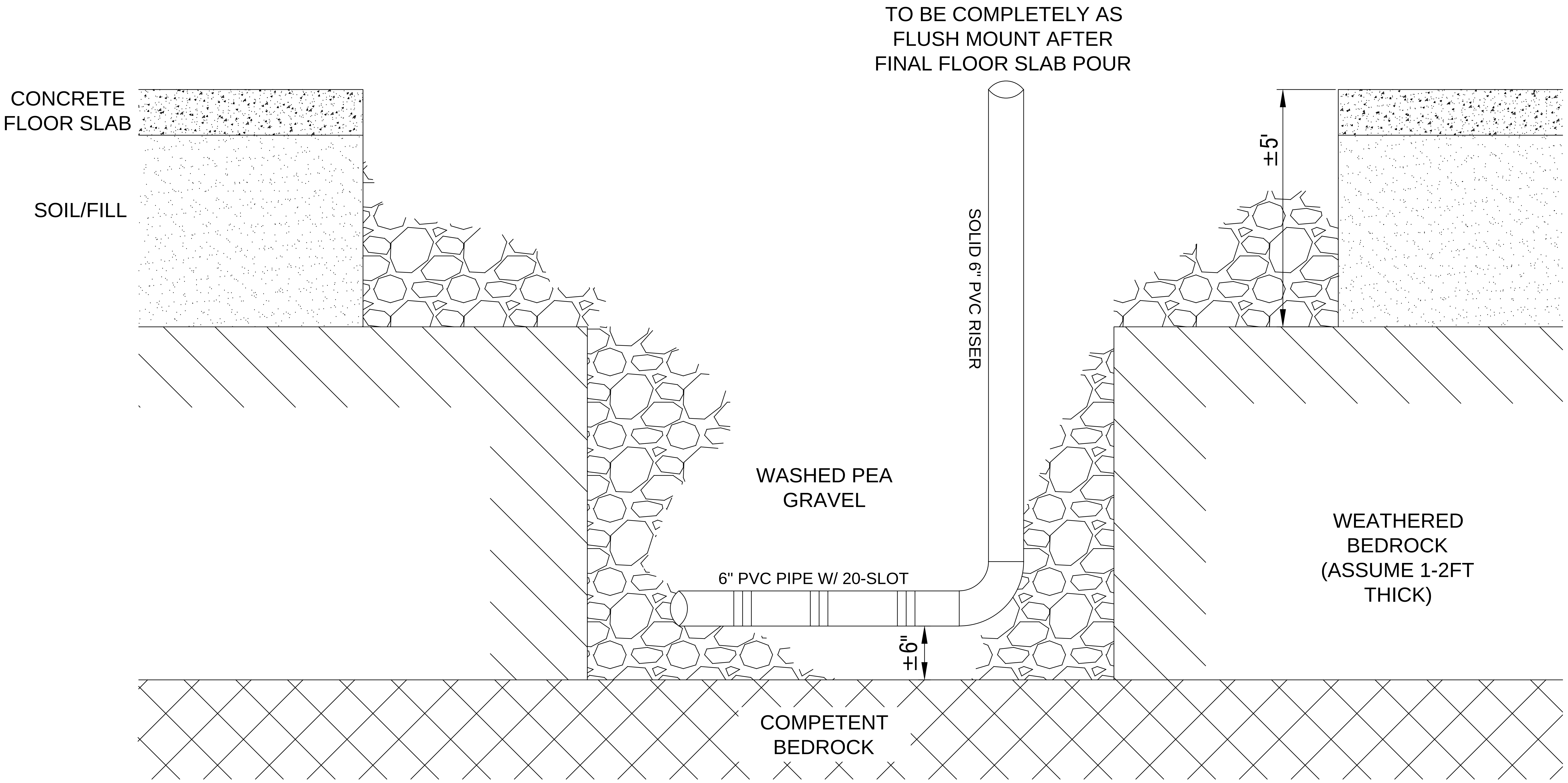
PROJECT/CLIENT
Corrective Measures Plan
Remedial Phase

R.D. SPECIALTIES, INC.
560 Salt Rd, Webster, NY
NYSDEC Site #828062

DRAWING TITLE
Soil Removal Plan

ISSUED FOR
DRAFT
DATE: 12/28/2016
DESIGNED BY: --
DRAWN BY: DRP
REVIEWED BY: --

PROJECT/DRAWING NUMBER
2161127
FIGURE 3



NOTES:
1. NOT TO SCALE (DIMENSIONS ONLY AS SHOWN)
2. SECOND NAPL MONITORING/EXTRACTION INFRASTRUCTURE CONSTRUCTED SAME EXCEPT 6" SLOTTED PIPE SET ABOUT 3' INTO BEDROCK.

NO.	REVISION	BY	DATE
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PROJECT/CLIENT

CORRECTIVE MEASURE PLAN
REMEDIAL PHASE

R.D. SPECIALTIES, INC
560 SALT RD, WEBSTER, NY
NYSDEC SITE #828062

DRAWING TITLE

INFRASTRUCTURE CROSS SECTION
DETAIL

ISSUED FOR

DESIGNED BY: --
DRAWN BY: DRP
REVIEWED BY: --

DATE: DECEMBER, 2016

J:\RD Specialties\2161127 - Supplemental Chromium Investigation\Drawings\ENVIRONMENTAL\remedial Phase\FIGURE 4.dwg

PROJECT/DRAWING NUMBER

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FIGURE 4

APPENDIX 1

Community Air Monitoring Plan (CAMP)

Appendix 1A
New York State Department of Health
Generic Community Air Monitoring Plan

Overview

A Community Air Monitoring Plan (CAMP) requires real-time monitoring for volatile organic compounds (VOCs) and particulates (i.e., dust) at the downwind perimeter of each designated work area when certain activities are in progress at contaminated sites. The CAMP is not intended for use in establishing action levels for worker respiratory protection. Rather, its intent is to provide a measure of protection for the downwind community (i.e., off-site receptors including residences and businesses and on-site workers not directly involved with the subject work activities) from potential airborne contaminant releases as a direct result of investigative and remedial work activities. The action levels specified herein require increased monitoring, corrective actions to abate emissions, and/or work shutdown. Additionally, the CAMP helps to confirm that work activities did not spread contamination off-site through the air.

The generic CAMP presented below will be sufficient to cover many, if not most, sites. Specific requirements should be reviewed for each situation in consultation with NYSDOH to ensure proper applicability. In some cases, a separate site-specific CAMP or supplement may be required. Depending upon the nature of contamination, chemical- specific monitoring with appropriately-sensitive methods may be required. Depending upon the proximity of potentially exposed individuals, more stringent monitoring or response levels than those presented below may be required. Special requirements will be necessary for work within 20 feet of potentially exposed individuals or structures and for indoor work with co-located residences or facilities. These requirements should be determined in consultation with NYSDOH.

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

Community Air Monitoring Plan

Depending upon the nature of known or potential contaminants at each site, real-time air monitoring for VOCs and/or particulate levels at the perimeter of the exclusion zone or work area will be necessary. Most sites will involve VOC and particulate monitoring; sites known to be contaminated with heavy metals alone may only require particulate monitoring. If radiological contamination is a concern, additional monitoring requirements may be necessary per consultation with appropriate DEC/NYSDOH staff.

> **Continuous monitoring** will be required for all <u>ground intrusive</u> activities and during the demolition of contaminated or potentially contaminated structures. Ground intrusive activities include, but are not limited to, soil/waste excavation and handling, test pitting or trenching, and the installation of soil borings or monitoring wells.
>
> **Periodic monitoring** for VOCs will be required during <u>non-intrusive</u> activities such as the collection of soil and sediment samples or the collection of groundwater samples from existing monitoring wells. "Periodic" monitoring during sample collection might reasonably consist of taking a reading upon arrival at a sample location, monitoring while opening a well cap or

overturning soil, monitoring during well baling/purging, and taking a reading prior to leaving a sample location. In some instances, depending upon the proximity of potentially exposed individuals, continuous monitoring may be required during sampling activities. Examples of such situations include groundwater sampling at wells on the curb of a busy urban street, in the midst of a public park, or adjacent to a school or residence.

VOC Monitoring, Response Levels, and Actions

Volatile organic compounds (VOCs) must be monitored at the downwind perimeter of the immediate work area (i.e., the exclusion zone) on a continuous basis or as otherwise specified. Upwind concentrations should be measured at the start of each workday and periodically thereafter to establish background conditions, particularly if wind direction changes. The monitoring work should be performed using equipment appropriate to measure the types of contaminants known or suspected to be present. The equipment should be calibrated at least daily for the contaminant(s) of concern or for an appropriate surrogate. The equipment should be capable of calculating 15-minute running average concentrations, which will be compared to the levels specified below.

1. If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities must be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities can resume with continued monitoring.

2. If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities must be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities can resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.

3. If the organic vapor level is above 25 ppm at the perimeter of the work area, activities must be shutdown.

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

Particulate Monitoring, Response Levels, and Actions

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

1. If the downwind PM-10 particulate level is 100 micrograms per cubic meter (mcg/m^3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques must be employed. Work may continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 150 mcg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.

2. If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 150 mcg/m^3 above the upwind level, work must be stopped and a re-evaluation of activities initiated. Work can resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 150 mcg/m^3 of the upwind level and in preventing visible dust migration.

3. All readings must be recorded and be available for State (DEC and NYSDOH) and County Health personnel to review.

December 2009

Appendix 1B
Fugitive Dust and Particulate Monitoring

A program for suppressing fugitive dust and particulate matter monitoring at hazardous waste sites is a responsibility on the remedial party performing the work. These procedures must be incorporated into appropriate intrusive work plans. The following fugitive dust suppression and particulate monitoring program should be employed at sites during construction and other intrusive activities which warrant its use:

1. Reasonable fugitive dust suppression techniques must be employed during all site activities which may generate fugitive dust.

2. Particulate monitoring must be employed during the handling of waste or contaminated soil or when activities on site may generate fugitive dust from exposed waste or contaminated soil. Remedial activities may also include the excavation, grading, or placement of clean fill. These control measures should not be considered necessary for these activities.

3. Particulate monitoring must be performed using real-time particulate monitors and shall monitor particulate matter less than ten microns (PM10) with the following minimum performance standards:

(a) Objects to be measured: Dust, mists or aerosols;
(b) Measurement Ranges: 0.001 to 400 mg/m3 (1 to 400,000 :ug/m3);
(c) Precision (2-sigma) at constant temperature: +/- 10 :g/m3 for one second averaging; and +/- 1.5 g/m3 for sixty second averaging;
(d) Accuracy: +/- 5% of reading +/- precision (Referred to gravimetric calibration with SAE fine test dust (mmd= 2 to 3 :m, g= 2.5, as aerosolized);
(e) Resolution: 0.1% of reading or 1g/m3, whichever is larger;
(f) Particle Size Range of Maximum Response: 0.1-10;
(g) Total Number of Data Points in Memory: 10,000;
(h) Logged Data: Each data point with average concentration, time/date and data point number
(i) Run Summary: overall average, maximum concentrations, time/date of maximum, total number of logged points, start time/date, total elapsed time (run duration), STEL concentration and time/date occurrence, averaging (logging) period, calibration factor, and tag number;
(j) Alarm Averaging Time (user selectable): real-time (1-60 seconds) or STEL (15 minutes), alarms required;
(k) Operating Time: 48 hours (fully charged NiCd battery); continuously with charger;
(l) Operating Temperature: -10 to 50^{o} C (14 to 122^{o} F);
(m) Particulate levels will be monitored upwind and immediately downwind at the working site and integrated over a period not to exceed 15 minutes.

4. In order to ensure the validity of the fugitive dust measurements performed, there must be appropriate Quality Assurance/Quality Control (QA/QC). It is the responsibility of the remedial party to adequately supplement QA/QC Plans to include the following critical features: periodic instrument calibration, operator training, daily instrument performance (span) checks, and a record keeping plan.

5. The action level will be established at 150 ug/m3 (15 minutes average). While conservative,

this short-term interval will provide a real-time assessment of on-site air quality to assure both health and safety. If particulate levels are detected in excess of 150 ug/m3, the upwind background level must be confirmed immediately. If the working site particulate measurement is greater than 100 ug/m3 above the background level, additional dust suppression techniques must be implemented to reduce the generation of fugitive dust and corrective action taken to protect site personnel and reduce the potential for contaminant migration. Corrective measures may include increasing the level of personal protection for on-site personnel and implementing additional dust suppression techniques (see paragraph 7). Should the action level of 150 ug/m3 continue to be exceeded work must stop and DER must be notified as provided in the site design or remedial work plan. The notification shall include a description of the control measures implemented to prevent further exceedances.

6. It must be recognized that the generation of dust from waste or contaminated soil that migrates off-site, has the potential for transporting contaminants off-site. There may be situations when dust is being generated and leaving the site and the monitoring equipment does not measure PM10 at or above the action level. Since this situation has the potential to allow for the migration of contaminants off-site, it is unacceptable. While it is not practical to quantify total suspended particulates on a real-time basis, it is appropriate to rely on visual observation. If dust is observed leaving the working site, additional dust suppression techniques must be employed. Activities that have a high dusting potential--such as solidification and treatment involving materials like kiln dust and lime--will require the need for special measures to be considered.

7. The following techniques have been shown to be effective for the controlling of the generation and migration of dust during construction activities:

(a) Applying water on haul roads;
(b) Wetting equipment and excavation faces;
(c) Spraying water on buckets during excavation and dumping;
(d) Hauling materials in properly tarped or watertight containers;
(e) Restricting vehicle speeds to 10 mph;
(f) Covering excavated areas and material after excavation activity ceases; and
(g) Reducing the excavation size and/or number of excavations.

Experience has shown that the chance of exceeding the 150ug/m3 action level is remote when the above-mentioned techniques are used. When techniques involving water application are used, care must be taken not to use excess water, which can result in unacceptably wet conditions. Using atomizing sprays will prevent overly wet conditions, conserve water, and provide an effective means of suppressing the fugitive dust.

8. The evaluation of weather conditions is necessary for proper fugitive dust control. When extreme wind conditions make dust control ineffective, as a last resort remedial actions may need to be suspended. There may be situations that require fugitive dust suppression and particulate monitoring requirements with action levels more stringent than those provided above. Under some circumstances, the contaminant concentration and/or toxicity may require additional monitoring to protect site personnel and the public. Additional integrated sampling and chemical analysis of the dust may also be in order. This must be evaluated when a health and safety plan is developed and when appropriate suppression and monitoring requirements are established for protection of health and the environment.

APPENDIX 2

Health and Safety Plan (HASP)

Site Health and Safety Plan

NYSDEC Site # 828062

Location:

RD Specialties, Inc.
560 Salt Road
Webster, New York 14580

Prepared For:

RD Specialties, Inc.
560 Salt Road
Webster, New York 14580

LaBella Project No. 2161127

December 2016

Site Health and Safety Plan

Location:

RD Specialties, Inc.
560 Salt Road
Webster, New York 14580

Prepared For:

RD Specialties, Inc.
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Webster, New York 14580

LaBella Project No. 2161127

December 2016

LaBella Associates, P.C.
300 State Street
Rochester, New York 14614

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SITE HEALTH AND SAFETY PLAN

Project Title:	560 Salt Road
Project Number:	2161127
Project Location (Site):	560 Salt Road, Webster, New York 14580-9718
Environmental Director:	Gregory Senecal, CHMM
Project Manager:	Dan Noll, P.E.
Plan Review Date:	12/23/2016
Plan Approval Date:	12/23/2016
Plan Approved By:	R Rote Mr. Richard Rote, CIH
Site Safety Supervisor:	Eric Detweiler
Site Contact:	Peter Krasucki
Safety Director:	Rick Rote, CIH
Proposed Date(s) of Field Activities:	1/9/17 – 1/13/17
Site Conditions:	Soil removal work to be conducted inside manufacturing building.
Site Environmental Information Provided By:	NYSDEC ROD dated February 1992. Supplemental Chromium Investigation by LaBella Associates, P.C., dated July 2016.
Air Monitoring Provided By:	LaBella Associates, P.C.
Site Control Provided By:	Curran Excavating, Inc.

EMERGENCY CONTACTS

	Name	**Phone Number**
Ambulance:	As Per Emergency Service	911
Hospital Emergency:	Rochester General Hospital	585-922-4000
Poison Control Center:	Finger Lakes Poison Control	585-273-4621
Police (local, state):	Monroe County Sheriff	911
Fire Department:	Webster Fire Department	911
Site Contact:	Peter Krasucki	Cell: 585-265-0220
Agency Contact:	NYSDEC – Todd Caffoe, P.E. Finger Lakes Poison Control MCDOH – John Frazer	585-226-5350 1-800-222-1222 585-753-5904
Environmental Director:	Greg Senecal, CHMM	Direct: 585-295-6243 Cell: 585-752-6480 Home: 585-323-2142
Project Manager:	Dan Noll, P.E.	Direct: 585-295-611 Cell: 585-301-8458
Site Safety Supervisor:	Eric Detweiler	Direct: 585-278-8202
Safety Director	Rick Rote, CIH	Direct: 585-295-6241

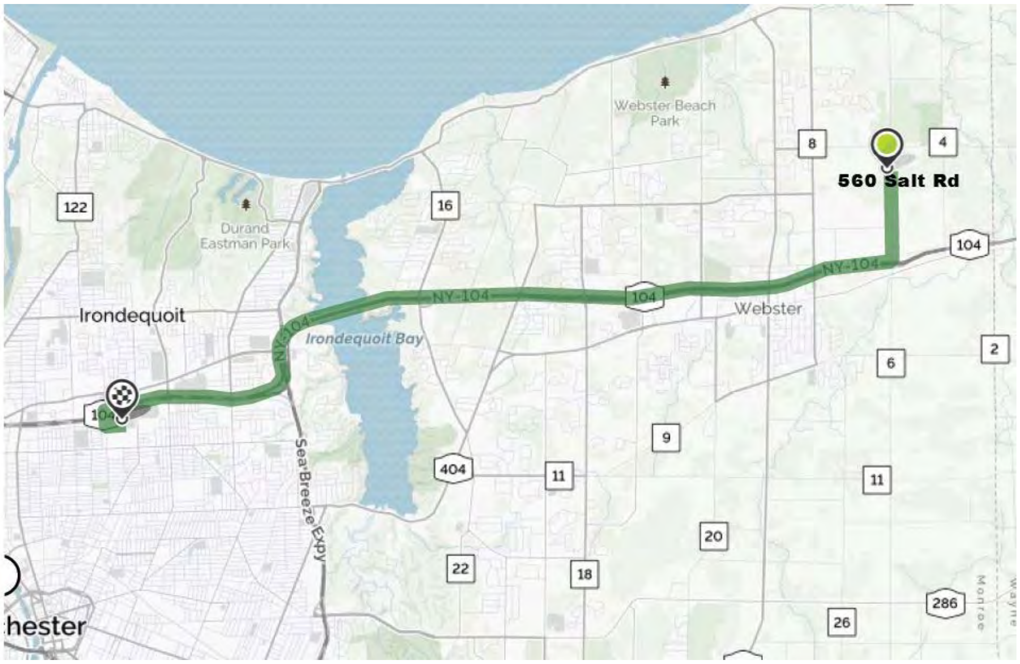
MAP AND DIRECTIONS TO THE MEDICAL FACILITY - ROCHESTER GENERAL HOSPITAL

Total Time: 8 minutes
Total Distance: 3.50 miles

Start: 560 Salt Road, Webster, NY 14580-9718

START	1:	Start out going SOUTH on SALT RD/COUNTY HWY-6 toward WELWYN RD.	1.09 mi
↑↑	2:	MERGE onto NY-104 W.	10.20 mi
EXIT ↗	3:	Take the EXIT toward CARTER ST/HUDSON AVE..	0.18 mi
↑↑	4:	MERGE onto KEELER EXPRESSWAY SERVICE RD.	0.12 mi
←	5:	Take the 1st LEFT onto CARTER ST.	0.19 mi
←	6:	Take the 2nd LEFT onto ROCHESTER GENERAL HOSPITAL DR.	0.18 mi
↑	7.	Go STRAIGHT	0.09 mi
END	7:	End at 1425 Portland Ave Rochester, NY 14621-3001	

End: 1425 Portland Ave, Rochester, NY 14621-3001



1.0 Introduction

The purpose of this Health and Safety Plan (HASP) is to provide guidelines for responding to potential health and safety issues that may be encountered during the completion of the Corrective Measures Plan (CMP) at the Site located at 560 Salt Road in the Town of Webster, Monroe County, New York. This HASP only reflects the policies of LaBella Associates D.P.C. and other entities working at the Site are responsible for their own health and safety. The requirements of this HASP are applicable to all approved LaBella personnel at the work site. This document's project specifications and the Community Air Monitoring Plan (CAMP) are to be consulted for guidance in preventing and quickly abating any threat to human safety. The provisions of the HASP were developed in general accordance with 29 CFR 1910 and 29 CFR 1926 and do not replace or supersede any regulatory requirements of the USEPA, NYSDEC, OSHA or any other regulatory body.

2.0 Responsibilities

This HASP presents guidelines to minimize the risk of injury and potential for contaminant exposure to project personnel, and to provide rapid response in the event of injury. The HASP is applicable only to activities of approved LaBella personnel and their authorized visitors. The Project Manager shall implement the provisions of this HASP for the duration of the project. It is the responsibility of each LaBella employee to follow the requirements of this HASP, and all applicable company safety procedures.

3.0 Activities Covered

The activities covered under this HASP are limited to the following:

- ☐ Management of environmental remediation activities
- ☐ Environmental Monitoring
- ☐ Collection of confirmatory, waste characterization and personal air monitoring samples
- ☐ Management of excavated soil and fill.

4.0 Work Area Access and Site Control

The contractor(s) will have primary responsibility for work area access and site control. However, a minimum requirement for work area designation and control will consist of:

- placing orange fencing around the work area;
- placing orange fencing around any excavation required to be left open overnight;
- donning Level D PPE including high visibility vests, hard hats, safety glasses, and steel toe boots, and gloves on-site during remedial activities; and,
- donning half-face respirators during concrete and soil removal activities until a worker exposure assessment has been completed; respirators to be worn until monitoring and personnel sampling indicates that respirators are not required.

5.0 Potential Health and Safety Hazards

This section lists some potential health and safety hazards that project personnel may encounter at the project site and some actions to be implemented by approved personnel to control and reduce the associated risk to health and safety. This is not intended to be a complete listing of any and all potential health and safety hazards. New or different hazards may be encountered as site environmental and site work conditions change. The suggested actions to be taken under this plan are not to be substituted for good judgment on the part of project personnel. At all times, the Site Safety Officer has responsibility for site safety and his or her instructions must be followed.

5.1 Hazards Due to Heavy Machinery

Potential Hazard:
Heavy machinery including trucks, excavators, backhoes, etc will be in operation at the site. The presence of such equipment presents the danger of being struck or crushed. Use caution when working near heavy machinery.

Protective Action:
Make sure that operators are aware of your activities, and heed operator's instructions and warnings. Wear bright colored clothing and walk safe distances from heavy equipment. Always make eye contact with operator before walking around heavy equipment. A hard hat, safety glasses and steel toe shoes are required.

5.2 Excavation Hazards

Potential Hazard:
Excavations and trenches can collapse, causing injury or death. Edges of excavations can be unstable and collapse. Toxic and asphyxiant gases can accumulate in confined spaces and trenches. Activities that require working within the excavation will require air monitoring in the breathing zone (refer to Section 9.0).

Excavations left open create a fall hazard which can cause injury or death.

Protective Action:
Personnel must receive approval from the Project Manager to enter an excavation for any reason. Subsequently, approved personnel are to receive authorization for entry from the Site Safety Officer. Approved personnel are not to enter excavations over 4 feet in depth unless excavations are adequately sloped. Additional personal protective equipment may be required based on the air monitoring.

Personnel should exercise caution near all excavations at the site as it is expected that excavation sidewalls will be unstable. The excavation will be attended during the work day.

Fencing and/or barriers accompanied by "caution" or "no trespassing" signs should be placed around all excavations when left open for any period of time when work is not being conducted.

5.3 Cuts, Punctures and Other Injuries

Potential Hazard:
In any excavation or construction work site there is the potential for the presence of sharp or jagged edges on concrete, rock, metal materials, and other sharp objects. Serious cuts and punctures can result in loss of blood and infection.

Protective Action:
The Project Manager is responsible for making First Aid supplies available at the work site to treat minor injuries. The Site Safety Officer is responsible for arranging the transportation of authorized on-site personnel to medical facilities when First Aid treatment in not sufficient. Do not move seriously injured workers. All injuries requiring treatment are to be reported to the Project Manager. Serious injuries are to be reported immediately to the Site Safety Officer

5.4 *Injury Due to Exposure to Chemical Hazards*

Potential Hazards:
Though not detected during Site investigation, exposure hazards may include volatile organic vapors from petroleum products, chlorinated solvents, heavy metals (see Section 5.7) or other chemicals encountered during excavation activities at the project work site. Inhalation of high concentrations of organic vapors can cause headache, stupor, drowsiness, confusion and other health effects. Skin contact can cause irritation, chemical burn, or dermatitis.

Protective Action:
The presence of organic vapors may be detected by their odor and by monitoring instrumentation. Approved employees will not work in environments where hazardous concentrations of organic vapors are present. Air monitoring (refer to Section 9.0 and to the Site specific CAMP in Appendix 7 of the IRM Work Plan) of the work area will be performed at least every 60 minutes or more often using a Photoionization Detector (PID). Personnel are to leave the work area whenever PID measurements of ambient air exceed 25 ppm for a 5 minute average. In the event that an ambient air reading for total volatile organic compound (VOC) of 25 ppm is encountered for a 5 minute average, personnel should upgrade personal protective equipment to Level C (refer to Section 8.0) and an Exclusion Zone should be established around the work area to limit and monitor access to this area (refer to Section 6.0).

5.5 *Injuries Due to Extreme Hot or Cold Weather Conditions*

Potential Hazards:
Extreme hot weather conditions can cause heat exhaustion, heat stress and heat stroke or extreme cold weather conditions can cause hypothermia. These conditions are not anticipated at the Site because the remedial work is being conducted indoors.

Protective Action:
Precaution measures should be taken such as dress appropriately for the weather conditions and drink plenty of fluid. If personnel should suffer from any of the above conditions, proper techniques should be taken to cool down or heat up the body and taken to the nearest hospital if needed.

5.6 *Potential Exposure to Asbestos*

Potential Hazards:
During ground intrusive activities (e.g., concrete and soil removal) soil containing asbestos may be encountered. Asbestos can be friable when dry and can be inhaled when disturbed and made airborne.

Protective Action:
The presence of asbestos can be identified through visual observation of a white magnesium silicate material. If encountered, work should be halted and a sample of the suspected asbestos material should be collected by an appropriately certified worker and placed in a sealed plastic bag. This sample should be sent to the asbestos laboratory at LaBella Associates for analysis.

5.7 Potential Exposure to Hexavalent Chromium

Potential Hazards:
The primary contaminant of concern at the Site is chromium and in particular hexavalent chromium in concrete and soil, therefore, exposure to chromium-containing fugitive dust is the primary potential exposure hazard during concrete floor demolition and soil removal activities. Hexavalent chromium is a known carcinogen associated with lung, nasal, and sinus cancer. Potential exposures include inhalation through airborne dust and particulate, and skin contact. Exposure to hexavalent chromium can cause other symptoms including skin irritation and dermatitis.

Protective Action:
Instrument monitoring for airborne particulates will be conducted during all intrusive work, including concrete floor demolition. Hexavalent chromium has been detected in concrete and soil at the site, as a precaution workers are to don half-face respirators during the initial concrete demolition and soil removal activity. Personal air monitors and samplers will be used to monitor levels of fugitive dust and chromium exposure. Respirators use may be stopped and becomes optional when the results from two consecutive monitoring events indicate levels of hexavalent chromium are below the OSHA Permissible Exposure Limit (PEL). A N95 particulate filter or better is to be worn to filter hexavalent chromium particulates that may become airborne during excavation.

Nitrile gloves are to be worn to prevent skin contact if there is a need to handle soil. Remove accumulated dust and dirt from bare skin by washing or other appropriate means. Wash exposed skin immediately upon redness or irritation.

6.0 Work Zones

In the event that conditions warrant establishing various work zones (i.e., based on hazards - Section 5.4), the following work zones should be established:

Exclusion Zone (EZ):
The EZ will be established in the immediate vicinity of soil removal activities that elevate breathing zone dust or potential VOC concentrations to unacceptable levels based on field screening. These site activities include contaminated concrete demolition, soil excavation and soil sampling activities. If access to the site is required to accommodate non-project related personnel then an EZ will be established by constructing a barrier around the work area (yellow caution tape and/or construction fencing and if necessary poly sheeting containment). The EZ barrier shall encompass the work area and any equipment staging/soil staging areas necessary to perform the associated work. The contractor(s) will be responsible for establishing the EZ and limiting access to approved personnel. Depending on the condition for establishing the EZ, access to the EZ may require adequate PPE (e.g., Level C).

Contaminant Reduction Zone (CRZ):
If deemed necessary, the CRZ will be the area where personnel entering the EZ will don proper PPE prior to entering the EZ and the area where PPE may be removed. The CRZ will also be the area where decontamination of equipment and personnel will be conducted as necessary. Heavy equipment will be used to complete the remedial activities, therefore it is not anticipated that workers will enter the excavation or come in direct contact with impacted concrete or soil.

7.0 Decontamination Procedures

Upon leaving the work area, approved personnel shall decontaminate footwear as needed. Under normal work conditions, detailed personal decontamination procedures will not be necessary. Work clothing may become contaminated in the event of an unexpected splash or spill or contact with a contaminated substance. Minor splashes on clothing and footwear can be rinsed with clean water. Heavily contaminated clothing should be removed if it cannot be rinsed with water. Personnel assigned to this project should be prepared with a change of clothing whenever on site.

Personnel will use the contractor’s disposal container for disposal of PPE.

8.0 Personal Protective Equipment

Generally, site conditions at this work site require level of protection of Level D or modified Level D. However, air monitoring will be conducted to determine if up-grading to Level C PPE is required (refer to Section 9.0). Descriptions of the typical safety equipment associated with Level D and Level C are provided below:

Level D:
Hard hat, safety glasses, rubber nitrile sampling gloves, steel toe construction grade boots, etc.

Level C:
Level D PPE and full or ½-face respirator and tyvek suit (if necessary). [*Note: Organic vapor cartridges are to be changed after each 8-hours of use or more frequently, and dust filters are to be changed weekly or when breathing becomes difficult.*]

9.0 Air Monitoring

In accordance with 29 CFR 1910.120(h), air monitoring shall be used to identify and quantify airborne levels of hazardous substances and health hazards in order to determine the appropriate level of employee protection required for personnel working onsite. Air monitoring will consist at a minimum of the procedures described in Appendix 1 “Site Specific CAMP”. Please refer to the Site Specific CAMP for further details on air monitoring at the Site.

The Air Monitor will utilize a photoionization Detector (PID) to screen the ambient air in the work areas for total Volatile Organic Compounds (VOCs) and DustTrak Model 8520 aerosol monitors or equivalent for measuring particulates. Personal exposure monitoring will be completed to determine hexavalent chromium exposure concentrations. Battery power air pumps and filter cassettes will be used to collect the samples.

Work area ambient air will generally be monitored in the work area and downwind of the work area. Air monitoring of the work areas and downwind of the work areas will be performed at least every 60 minutes or more frequently using a PID, and the DustTrak meter.

If ambient air PID readings of greater than 25 ppm are recorded in the breathing zone for a 5 minute average, then either personnel are to leave the work area until satisfactory readings are obtained or approved personnel may re-enter the work areas wearing at a minimum a ½ face respirator with organic vapor cartridges for an 8-hour duration (i.e., upgrade to Level C PPE). Organic vapor cartridges are to be changed after each 8-hours of use or more frequently, if necessary. If PID readings are sustained, in the work area, at levels above 25 ppm for a 5 minute average, work will be stopped immediately until safe levels of VOCs are encountered or additional PPE will be required (i.e., Level B).

If dust concentrations exceed the upwind concentration by 150 $\mu g/m^3$ (0.15 mg/m^3) consistently for a 10 minute period within the work area or at the downwind location, then LaBella personnel may not re-enter the work area until dust concentrations in the work area decrease below 150 $\mu g/m^3$ (0.15 mg/m^3), which may be accomplished by the construction manager implementing dust control or suppression measures.

Dust filtering respirators are to be used until exposure concentrations, as determined by 2 consecutive monitoring events, are below the hexavalent chromium PEL of 5 $\mu g/m^3$. Personal monitoring shall be repeated whenever work methods or conditions change, presenting new exposure conditions.

10.0 Emergency Action Plan

In the event of an emergency, employees are to turn off and shut down all powered equipment and leave the work areas immediately. Employees are to walk or drive out of the Site as quickly as possible and wait at the assigned 'safe area'. Follow the instructions of the Site Safety Officer.

Employees are not authorized or trained to provide rescue and medical efforts. Rescue and medical efforts will be provided by local authorities.

11.0 Medical Surveillance

Medical surveillance will be provided to all employees who are injured due to overexposure from an emergency incident involving hazardous substances at this site.

12.0 Employee Training

Personnel who are not familiar with this site plan will receive training on its entire content and organization before working at the Site.

LaBella staff involved with the remedial activities must be 40-hour OSHA HAZWOPER trained with current 8-hour refresher certification.

Table 1
Exposure Limits and Recognition Qualities

Compound	PEL-TWA (ppm)(b)(d)	TLV-TWA (ppm)(c)(d)	STEL	LEL (%)(e)	UEL (%)(f)	IDLH (ppm)(g)(d)	Odor	Odor Threshold (ppm)	Ionization Potential
Acetone	750	500	NA	2.15	13.2	20,000	Sweet	4.58	9.69
Anthracene	0.2	0.2	NA	NA	NA	NA	Faint aromatic	NA	NA
Benzene	1	0.5	5	1.3	7.9	3000	Pleasant	8.65	9.24
Benzo (a) pyrene (coal tar pitch volatiles)	0.2	0.1	NA	NA	NA	700	NA	NA	NA
Benzo (a)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (b) Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (g,h,i)perylene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo (k) Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromodichloromethane	NA	NA	NA	NA	NA	NA	NA	NA	10.88
Carbon Disulfide	20	1	NA	1.3	50	500	Odorless or strong garlic type	0.096	10.07
Chlorobenzene	75	10	NA	1.3	9.6	2,400	Faint almond	0.741	9.07
Chloroform	50	2	NA	NA	NA	1,000	ethereal odor	11.7	11.42
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichloroethylene	200	200	NA	9.7	12.8	400	Acrid	NA	9.65
1,2-Dichlorobenzene	50	25	NA	2.2	9.2		Pleasant		9.07
Ethylbenzene	100	100	NA	1	6.7	2,000	Ether	2.3	8.76
Fluoranthene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Methylene Chloride	500	50	NA	12	23	5,000	Chloroform-like	10.2	11.35
Naphthalene	10, Skin	10	NA	0.9	5.9	250	Moth Balls	0.3	8.12
n-propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
p-Isopropylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
sec-Butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tetrachloroethane	NA	NA	NA	NA	NA	NA	Sweet	NA	NA
Toluene	100	100	NA	0.9	9.5	2,000	Sweet	2.1	8.82
Trichloroethylene	100	50	NA	8	12.5	1,000	Chloroform	1.36	9.45
1,2,4-Trimethylbenzene	NA	25	NA	0.9	6.4	NA	Distinct	2.4	NA
1,3,5-Trimethylbenzene	NA	25	NA	NA	NA	NA	Distinct	2.4	NA
Vinyl Chloride	1	1	NA	NA	NA	NA	NA	NA	NA
Xylenes (o,m,p)	100	100	NA	1	7	1,000	Sweet	1.1	8.56
Metals									
Arsenic	0.01	0.2	NA	NA	NA	100, Ca	Almond	NA	NA
Cadmium	0.2	0.5	NA	NA	NA	NA	NA	NA	NA
Chromium	1	0.5	NA	NA	NA	NA	NA	NA	NA
Lead	0.05	0.15	NA	NA	NA	700	NA	NA	NA
Mercury	0.05	0.05	NA	NA	NA	28	Odorless	NA	NA
Selenium	0.2	0.02	NA	NA	NA	Unknown	NA	NA	NA
Other									
Asbestos	0.1 (f/cc)	NA	1.0 (f/cc)	NA	NA	NA	NA	NA	NA

(a) Skin = Skin Absorption
(b) OSHA-PEL Permissible Exposure Limit (flame weighted average, 8-hour): NIOSH Guide, June 1990
(c) ACGIH – 8 hour time weighted average from Threshold Limit Values and Biological Exposure Indices for 2003.
(d) Metal compounds in mg/m3

(e) Lower Exposure Limit (%)
(f) Upper Exposure Limit (%)
(g) Immediately Dangerous to Life or Health Level: NIOSH Guide, June 1990.

Notes:
1. All values are given in parts per million (PPM) unless otherwise indicated
2. Ca = Possible Human Carcinogen, no IDLH information

APPENDIX 3

Quality Assurance Project Plan (QAPP)

LABELLA
Associates, D.P.C.
Engineering
Architecture
Environmental
Planning

Quality Assurance Project Plan

Location:

560 Salt Road
Webster, New York

Prepared For:

RD Specialties, Inc.
560 Salt Road
Webster, New York 14580

LaBella Project No. 2161127

December 2016

Quality Assurance Project Plan

Location:

560 Salt Road
Webster, New York

Prepared For:

RD Specialties, Inc.
560 Salt Road
Webster, New York 14580

LaBella Project No. 2161127

December 2016

LaBella Associates, D.P.C.
300 State Street
Rochester, New York 14614

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Quality Assurance Project Plan 4

1.0 Introduction

LaBella's Quality Assurance Project Plan (QAPP) is an integral part of its approach to environmental investigations and remediation. By maintaining a rigorous quality control (QC), our firm is able to provide accurate and reliable data. QC also provides safe working conditions for all on-Site workers.

The QAPP contains procedures which allow for the proper collection and evaluation of data and documents that QC procedures have been followed during field investigations. The QAPP presents the methodology and measurement procedures used in collecting quality field data. This methodology includes the proper use of equipment, documentation of sample collection, and sample handling procedures.

Procedures used in the firm's QAPP are compatible with federal, state, and local regulations, as well as, appropriate professional and technical standards.

This QAPP has been organized into the following areas:

- QC Objectives and Checks
- Field Equipment, Handling, and Calibration
- Sampling Techniques
- Sample Handling and Packaging

It should be noted that project-specific work plans (e.g., Corrective Measures Work Plan) may have project specific details that will differ from the procedures in this QAPP. In such cases, the project-specific work plan should be followed (subsequent to regulatory approval).

2.0 Quality Control Objectives

The United States Environmental Protection Agency (EPA) has identified five general levels of analytical data quality as being potentially applicable to site investigations conducted under CERCLA. These levels are summarized below:

- **Level I -** Field screening. This level is characterized by the use of portable instruments, which can provide real-time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.
- **Level II -** Field analysis. This level is characterized by the use of portable analytical instruments, which can be used on site or in mobile laboratories stationed near a site (close-support labs). Depending upon the types of contaminants, sample matrix, and personnel skills, qualitative and quantitative data can be obtained.
- **Level III -** Laboratory analysis using methods other than the Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily in support of engineering studies using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS, without the CLP requirements for documentation.
- **Level IV -** CLP Routine Analytical Services. This level is characterized by rigorous QC protocols and documentation and provides qualitative and quantitative analytical data. Some regions have obtained similar support via their own regional laboratories, university

laboratories, or other commercial laboratories.

- **Level V -** Non-standard methods. Analyses, which may require method modification and/or development. CLP Special Analytical Services (SAS) are considered Level V.

Unless stated otherwise, all data will be generated in accordance with Level IV. When CLP methodology is not available, federal and state approved methods will be utilized. Level III will be utilized, as necessary, for non-CLP RAS work which may include ignitability, corrosivity, reactivity, EP toxicity, and other state approved parameters for characterization. Level I will be used throughout the RI for health and safety monitoring activities.

All measurements will be made to provide that analytical results are representative of the media and conditions measured. Unless otherwise specified, all data will be calculated and reported in units consistent with other organizations reporting similar data to allow comparability of data bases among organizations. Data will be reported in micrograms per liter (µg/L) and milligrams (mg)/L for aqueous samples, and µg/ kilogram (kg) and mg/kg (dry weight) for soils, or otherwise as applicable.

The characteristics of major importance for the assessment of generated data are accuracy, precision, completeness, representativeness, and comparability. Application of these characteristics to specific projects is addressed later in this document. The characteristics are defined below.

2.1 Accuracy

Accuracy is the degree of agreement of a measurement or average of measurements with an accepted reference or "true" value and is a measure of bias in the system.

2.2 Precision

Precision is the degree of mutual agreement among individual measurements of a given parameter.

2.3 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount expected to be obtained under correct normal conditions.

2.4 Representativeness

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition

Careful choice and use of appropriate methods in the field will ensure that samples are representative. This is relatively easy with water or air samples since these components are homogeneously dispersed. In soil and sediment, contaminants are unlikely to be evenly distributed, and thus it is important for the sampler and analyst to exercise good judgment when removing a sample.

2.5 Comparability

Comparability expresses the confidence with which one data set can be compared to another. The data sets may be inter- or intra- laboratory.

3.0 Measurement of Data Quality

3.1 Accuracy

Accuracy of a particular analysis is measured by assessing its performance with "known" samples. These "knowns" take the form of EPA standard reference materials, or laboratory prepared solutions of target analytes spiked into a pure water or sample matrix. In the case of gas chromatography (GC) or GC/MS (mass spectrometry) analyses, solutions of surrogate compounds are used. These solutions can be spiked into every sample and are designed to mimic the behavior of target analytes without interfering with their determination.

In each case the recovery of the analyte is measured as a percentage, correcting for analytes known to be present in the original sample if necessary, as in the case of a matrix spike analysis. For EPA supplied known solutions, this recovery is compared to the published data that accompany the solution.

For the firm's prepared solutions, the recovery is compared to EPA-developed data or the firm's historical data as available. For surrogate compounds, recoveries are compared to EPA CLP acceptable recovery tables.

If recoveries do not meet required criteria, then the analytical data for the batch (or, in the case of surrogate compounds, for the individual sample) are considered potentially inaccurate. The analyst or his supervisor must initiate an investigation of the cause of the problem and take corrective action. This can include recalibration of the instrument, reanalysis of the QC sample, reanalysis of the samples in the batch, or flagging the data as suspect if the problems cannot be resolved. For highly contaminated samples, recovery of the matrix spike may depend on sample homogeneity. As a rule, analyses are not corrected for recovery of matrix spike or surrogate compounds.

3.2 Precision

Precision of a particular analysis is measured by assessing its performance with duplicate or replicate samples. Duplicate samples are pairs of samples taken in the field and transported to the laboratory as distinct samples. Their identity as duplicates is typically not known to the laboratory. For most purposes, precision is determined by the analysis of replicate pairs (i.e., two samples prepared at the laboratory from one original sample). Often in replicate analysis the sample chosen for replication does not contain target analytes so that quantitation of precision is impossible. For EPA CLP analyses, replicate pairs of spiked samples, known as matrix spike/matrix spike duplicate samples, are used for precision studies. This has the advantage that two real positive values for a target analyte can be compared.

Precision is calculated in terms of Relative Percent Difference (RPD).

- Where X_1 and X_2 represent the individual values found for the target analyte in the two replicate analyses or in the matrix spike/matrix spike duplicate analyses.
- RPDs must be compared to the method RPD for the analysis. The analyst or his supervisor must investigate the cause of RPDs outside stated acceptance limits. This may include a

visual inspection of the sample for non-homogeneity, analysis of check samples, etc. Follow-up action may include sample reanalysis or flagging of the data as suspect if problems cannot be resolved.

- During the data review and validation process, field duplicate RPDs are assessed as a measure of the total variability of both field sampling and laboratory analysis.

3.3 Completeness

Completeness for each parameter is calculated as follows:

- The firm's target value for completeness for all parameters is 100%. A completeness value of 95% will be considered acceptable. Incomplete results will be reported to the site managers. In planning the field sample collection, the site manager will plan to collect field duplicates from identified critical areas. This procedure should assure 100% completeness for these areas.

3.4 Representativeness

The characteristic of representativeness is not quantifiable. Subjective factors to be taken into account are as follows:

- The degree of homogeneity of a site;
- The degree of homogeneity of a sample taken from one point in a site; and
- The available information on which a sampling plan is based.

To maximize representativeness of results, sampling techniques and sample locations will be carefully chosen so that they provide laboratory samples representative of the site and the specific area. Within the laboratory, precautions are taken to extract from the sample bottle an aliquot representative of the whole sample. This includes premixing the sample and discarding pebbles from soil samples.

4.0 Quality Control Targets

Target values for detection limit, percent spike recovery and percent "true" value of known check standards, and RPD of duplicates/replicates are included in the QAPP, Analytical Procedures. Note that tabulated values are not always attainable. Instances may arise where high sample concentrations, non-homogeneity of samples, or matrix interferences preclude achievement of target detection limits or other quality control criteria. In such instances, the firm will report reasons for deviations from these detection limits or noncompliance with quality control criteria.

5.0 Sampling Procedures

This section describes the sampling procedures to be utilized for each environmental medium that will be collected and analyzed in accordance with appropriate state and federal requirements. All procedures described are consistent with EPA sampling procedures as described in SW-846, third edition, September 1986, and subsequent updates. All samples will be delivered to the laboratory and analyzed within the holding times specified by the analytical method.

6.0 Soil Excavation and Sampling

All excavation sites will be cleared with appropriate utility companies to avoid potential accidents relating to underground utilities before ground intrusive work is to occur.

Prior to excavation, pertinent equipment will be steam cleaned or washed with an alconox and water solution. These activities will be performed in a designated on-site decontamination area. Throughout and after the cleaning processes, direct contact between the equipment and the ground surface will be avoided. Plastic sheeting and/or clean support structures (e.g., pallets, sawhorses) will be used. The equipment will be steam cleaned or washed with an alconox and water solution upon completion of remediation and prior to leaving the site. Sampling devices will be decontaminated according to procedures outlined in the Decontamination section of this document.

Soils will be evaluated for visual and olfactory evidence of impairment (i.e., staining, odors, elevated PID readings, and XRF Readings) by a geologist, engineer or qualified Environmental Professional.
When required, samples will be stored in glass jars until they are needed for testing or the project is complete. Any investigative derived waste generated will be containerized and characterized for proper disposal. During the excavation, a properly calibrated photoionization detector (PID) and X-ray Fluorescence meter (XRF) will be used to screen soils. .

Confirmatory soil samples will be taken in accordance to DER-10 Technical Guidance for Site Investigation and Remediation, specifically section 5.4(b)(2). Sampling frequency is dependent on the size of the excavation. If the perimeter is less than 20 feet, confirmation sampling is to include one bottom sample and one sidewall sample biased in the direction of surface runoff. If the perimeter of the excavation ranges from 20 – 300 feet in perimeter, one sample from each sidewall for every 30 linear feet and one sample from the excavation bottom for every 900 square feet is required. If the excavation is any larger the same sampling frequency can be applied or a reduced sampling frequency can be used if approved by the NYSDEC.

Surveying
Coordinates and elevations will be established for the extent of the excavation and sample locations. These elevations shall be referenced to a regional, local, or project-specific datum. USGS benchmarks will be used whenever available. The location, identification, coordinates, and elevations will be plotted on maps with a scale large enough to show location of excavated material with reference to other structures at each site.

7.0 Groundwater Sampling Procedures

During excavation activities, if groundwater is encountered and there is a need to dewater the open excavation, a groundwater sample will be taken and submitted for laboratory analysis. Laboratory data will be submitted to Monroe County in order to discharge to the sanitary sewer system. Accumulated groundwater will be pumped from the open excavation and put through an activated carbon unit for treatment prior to discharge.

Grab Sampling:

- Sample containers will be filled directly from hosing, sample ports, or holding tanks associated with the setup for pumping and treating water.
- Any observable physical characteristics of the groundwater (e.g., color, sheen, odor, turbidity) will be recorded at the time of sampling.

8.0 Management of Remediation-Derived Waste

Purpose:

The purposes of these guidelines are to ensure the proper holding, storage, transportation, and disposal of materials that may contain hazardous wastes. Remediation-derived waste included the following:

- Drill cuttings, discarded soil samples, drilling mud solids, and used sample containers;
- Well development and purge waters and discarded groundwater samples;
- Decontamination waters and associated solids;
- Soiled disposable personal protective equipment (PPE);
- Used disposable sampling equipment;
- Used plastic sheeting and aluminum foil;
- Other equipment or materials that either contain or have been in contact with potentially-impacted environmental media.
- Because these materials may contain regulated chemical constituents, they must be managed as a solid waste. This management may be terminated if characterization analytical results indicate the absence of these constituents.

Procedure:

1. Contain all remediation-derived wastes in Department of Transportation (DOT)-approved 55-gallon drums, roll-off boxes, or other containers suitable for the wastes.
2. Containerize wastes from separate borings or wells in separate containers (i.e. do not combine wastes from several borings/wells in a single container, unless it is a container used specifically for transfer purposes, or unless specific permission to do so has been provided by the LaBella Project Manager. Unused samples from surface sample locations within a given area may be combined.
3. To the extent practicable, separate solids from drilling muds, decontamination waters, and similar liquids. Place solids within separate containers.
4. Transfer all waste containers to a staging area. Access to this area will be controlled. Waste containers must be transferred to the staging area as soon as practicable after the generating activity is complete.
5. Pending transfer, all containers will be covered and secured when not immediately attended,
6. Label all containers with regard to contents, origin, and date of generation. Use indelible ink for all labeling.
7. Collect samples for waste characterization purposes, use boring/well sample analytical data for characterization.
8. For wastes determined to be hazardous in character, be aware on accumulation time limitations. Coordinate the disposal of these wastes with the Owner and NYSDEC.
9. Dispose of investigation-derived wastes as follows;
    - Soil, water, and other environmental media for which analysis does not detect organic constituents, and for which inorganic constituents are at levels consistent with background, may be spread on-site (pending NYSDEC approval) or otherwise treated as a non-waste material.
    - Soils, water, and other environmental media in which organic compounds are

detected or metals are present above background will be disposed as industrial waste or hazardous waste, as appropriate. Alternate disposition must be consistent with applicable State and Federal laws.

- Personal protective equipment, disposable bailers, and similar equipment may be disposed as municipal waste, unless waste characterization results mandate disposal as industrial wastes

10. If waste is determined to be listed hazardous waste, it must be handled as hazardous waste as described above, unless a contained-in determination is accepted by the NYSDEC.

9.0 Decontamination

Sampling methods and equipment have been chosen to minimize decontamination requirements and to prevent the possibility of cross-contamination. Decontamination of equipment will be performed between discrete sampling locations. Equipment used to collect samples between composite sample locations will not require decontamination between collection of samples.

Non-disposable equipment will be decontaminated between each sampling event. The sampler will be cleaned prior to each use, by one of the following procedures:

- Initially cleaned of all foreign matter;
- Sanitized with a steam cleaner;

OR

- Initially cleaned of all foreign matter;
- Scrubbed with brushes in alconox solution;
- Triple rinsed; and
- Allowed to air dry.

10.0 Sample Containers

The containers required for sampling activities are pre-washed and ordered directly from a laboratory, which has the containers prepared in accordance with USEPA bottle washing procedures. The following tables detail sample volumes, containers, preservation and holding time for typical analytes.

Table 11-1

Water Samples

Type of Analysis	Type and Size of Container	Number of Containers and Sample Volume (per sample)	Preservation	Maximum Holding Time
VOCs	40-ml glass vial with Teflon-backed septum	Two (2); fill completely, no air space	Cool to 4° C (ice in cooler), Hydrochloric acid to pH <2	7 days
Semivolatile Organic Compounds (SVOCs)	1,000-ml amber glass jar	One (1); fill completely	Cool to 4° C (ice in cooler)	7/40 days
Pesticides	1,000-ml amber glass jar	One (1); fill completely	Cool to 4° C (ice in cooler)	7/40 days
Polychlorinated biphenyls (PCBs)	1,000-ml amber glass jar	One (1); fill completely	Cool to 4° C (ice in cooler)	7/40 days
Metals	500-ml polyethylene	One (1); fill completely	Cool to 4° C (Nitric acid to pH <2	6 months

*Holding time is based on verified time of sample collection.

Note: *All sample bottles will be prepared in accordance with USEPA bottle washing procedures.*

TABLE 11-2
Soil Samples

Type of Analysis	Type and Size of Container	Number of Containers and Sample Volume (per sample)	Preservation	Maximum Holding Time
VOCs, SVOCs, PCBs, and Pesticides	8-oz, glass jar with Teflon-lined cap	One (1), fill as completely as possible	Cool to 4° C (ice in cooler)	7 days
VOCs by USEPA Method 5035 (if specified in work plan) Closed-system Purge and Trap Method	40-ml glass vial with Teflon-backed septum	Three (3), fill with 5 grams of soil using soil syringe	Cool to 4° C (ice in cooler). Two (2) with 10 mL DI water or 5 mL sodium bisulfate, one (1) with 5 mL methanol.	14 days
RCRA/TAL Metals, and cyanide	8-oz. glass jar with Teflon-lined cap	One (1); fill completely	Cool to 4° C (ice in cooler)	Must be extracted within 10 days; analyzed with 30 days

* Holding time is based on the times from verified time of sample collection.

Note: *All sample bottles will be prepared in accordance with USEPA bottle washing procedures.*

TABLE 11-3

List of Major Instruments for Sampling and Analysis

- MSA 360 0_2 /Explosimeter
- Hollige Series 963 Nephlometer (turbidity meter)
- EM-31 Geomics Electromagnetic Induction Device
- pH/Temperature/Conductivity Meter - Portable
- Hewlett Packard (HP) 1000 computer with RTE-6 operating system; and HP 9144 computer with RTE-4 operating system equipped with Aquarius software for control and data acquisition from gas chromatograph/mass spectrometer (GC/MS) systems; combined wiley and National Bureau of Standards (NBS) mass spectral library; and data archiving on magnetic tape
- Viriam 6000 and 37000 gas chromatrographs equipped with flame ionization, electron capture, photoionization and wall detectors as appropriate for various analyses,, and interfaced to Variam DS604 or D5634 data systems for processing data.
- Spectra-Physics Model SP 4100 and SP 4270 and Variam 4270 cam puting integrators
- Perkin Eimer (PE) 3000% and 3030% fully Automated Atomic Absorption Spectrophotometers (AAS) with Furnace Atomizer and background correction system
- PE Plasma II Inductively Coupled Argon Plasma (ICAP) Spectre meter with PE7500 laboratory computer
- Dionex 20001 ion chromatograph with conductivity detector for anion analysis, with integrating recorder

11.0 Sample Custody

This section describes standard operating procedures for sample identification and chain-of-custody to be utilized for all field activities. The purpose of these procedures is to ensure that the quality of the samples is maintained during their collection, transportation, and storage through analysis. All chain-of-custody requirements comply with standard operating procedures indicated in USEPA sample handling protocol.

Sample identification documents must be carefully prepared so that sample identification and chain-of-custody can be maintained and sample disposition controlled. Sample identification documents include:

- Field notebooks,
- Sample label,
- Custody seals, and
- Chain-of-custody records.

11.1 Chain-of-Custody

The primary objective of the chain-of-custody procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. A sample is in custody if it is:

- In someone's physical possession;
- In someone's view;
- Locked up; or
- Kept in a secured area that is restricted to authorized personnel.

11.2 Field Custody Procedures

- As few persons as possible should handle samples.
- Sample bottles will be obtained pre-cleaned from a source such as I-Chem. Coolers or boxes containing cleaned bottles should be sealed with a custody tape seal during transport to the field or while in storage prior to use.
- The sample collector is personally responsible for the care and custody of samples collected until they are transferred to another person or dispatched properly under chain-of-custody rules.
- The sample collector will record sample data in the notebook.
- The site manager will determine whether proper custody procedures were followed during the fieldwork and decide if additional samples are required.

11.3 Sample Tags

Sample tags attached to or affixed around the sample container must be used to properly identify all samples collected in the field. The sample tags are to be placed on the bottles so as not to obscure any QC lot numbers on the bottles; sample information must be printed in a legible manner using waterproof ink. Field identification must be sufficient to enable cross-reference with the logbook. For chain-of-custody purposes, all QC samples are subject to exactly the same custodial procedures and documentation as "real" samples.

11.4 Transfer of Custody and Shipment

- The coolers in which the samples are packed must be accompanied by a chain-of-custody record. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time on the chain-of-custody record. This record documents sample custody transfer
- Shipping containers must be sealed with custody seals for shipment to the laboratory. The method of shipment, name of courier, and other pertinent information are entered in the "Remarks" section of the chain-of-custody record and traffic reports.
- All shipments must be accompanied by the chain-of-custody record identifying their contents. The original record accompanies the shipment. The other copies are distributed appropriately to the site manager.
- If sent by mail, the package is registered with return receipt requested. If sent by common carrier, a bill of lading is used. Freight bills, Postal Service receipts, and bill of lading are retained as part of the permanent documentation.

11.5 Chain-of-Custody Record

The chain-of-custody record must be fully completed in duplicate, using black carbon paper where possible, by the field technician who has been designated by the project manager as responsible for sample shipment to the appropriate laboratory for analysis. In addition, if samples are known to require rapid turnaround in the laboratory because of project time constraints or analytical concerns (e.g., extraction time or sample retention period limitations, etc.), the person completing the chain-of-custody record should note these constraints in the "Remarks" section of the record.

11.6 Laboratory Custody Procedures

A designated sample custodian accepts custody of the shipped samples and verifies that the sample identification number matches that on the chain-of-custody record and traffic reports, if required. Pertinent information as to shipment, pickup, and courier is entered in the "Remarks" section.

11.7 Custody Seals

Custody seals are preprinted adhesive-backed seals with security slots designed to break if the seals are disturbed. Sample shipping containers (coolers, cardboard boxes, etc., as appropriate) are sealed in as many places as necessary to ensure security. Seals must be signed and dated before use. On receipt at the laboratory, the custodian must check (and certify, by completing the package receipt log and LABMIS entries) that seals on boxes and bottles are intact. Strapping tape should be placed over the seals to ensure that seals are not accidentally broken during shipment.

12.0 Laboratory Requirements and Deliverables

This section will describe laboratory requirement and procedures to be followed for laboratory analysis. Samples collected in New York State will be analyzed by a New York State Department of Health (NYSDOH) Environmental Laboratory Accreditation Program (ELAP)-certified laboratory. When required, analyses will be conducted in accordance with the most current NYSDEC Analytical Services Protocol (ASP). For example, ASP Category B reports will be completed by the laboratory for samples representing the final delineation of the Remedial Investigation, confirmation samples, samples to determine closure of a system, and correlation samples taken using field testing technologies analyzed by an ELAP-certified laboratory to determine correlation to field results. Data Usability Summary Reports will be completed by a third party for samples requiring ASP Category B format reports. Electronic data deliverables (EDDs) will also be generated by the laboratory in EQUIS format for samples requiring ASP Category B format reports.

13.0 Documentation

13.1 Sample Identification

All containers of samples collected from the project will be identified using the following format on a label or tag fixed to the sample container:

XX-ZZ-O/D-DDMMYYYY

XX: This set of initials indicates the Site from which the sample was collected.
ZZ: These initials identify the sample location. Actual sample locations will be recorded in the task log.
O/D: An "O" designates an original sample; "D" identifies it as a duplicate.
DDMMYYYY: This set of initials indicates the date the sample was collected

Each sample will be labeled, chemically preserved (if required) and sealed immediately after collection. To minimize handling of sample containers, labels will be filled out prior to sample collection when possible. The sample label will be filled out using waterproof ink and will be firmly affixed to the sample containers. The sample label will give the following information:

- Date and time of collection
- Sample identification
- Analysis required
- Project name/number
- Preservation

13.2 Daily Logs

Daily logs and data forms are necessary to provide sufficient data and observations to enable participants to reconstruct events that occurred during the project and to refresh the memory of the field personnel if called upon to give testimony during legal proceedings.

The site log is the responsibility of the site manager and will include a complete summary of the day's activity at the site.

The **Task Log** will include:

- Name of person making entry (signature).
- Names of team members on-site.
- Levels of personnel protection:
    - Level of protection originally used;
    - Changes in protection, if required; and
    - Reasons for changes.
-
- Documentation on samples taken, including:
    - Sampling location and depth station numbers;
    - Sampling date and time, sampling personnel;
    - Type of sample (grab, composite, etc.); and
    - Sample matrix.
- On-site measurement data.

- Field observations and remarks.
- Weather conditions, wind direction, etc.
- Unusual circumstances or difficulties.
- Initials of person recording the information.

14.0 Corrections to Documentation

14.1 Notebook

As with any data logbooks, no pages will be removed for any reason. If corrections are necessary, these must be made by drawing a single line through the original entry (so that the original entry can still be read) and writing the corrected entry alongside. The correction must be initialed and dated. Most corrected errors will require a footnote explaining the correction.

14.2 Sampling Forms

As previously stated, all sample identification tags, chain-of-custody records, and other forms must be written in waterproof ink. None of these documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on a document assigned to one individual, that individual may make corrections simply by crossing a line through the error and entering the corrected information. The incorrect information should not be obliterated. Any subsequent error discovered on a document should be corrected by the person who made the entry. All corrections must be initialed and dated.

14.3 Photographs

Photographs will be taken as directed by the site manager. Documentation of a photograph is crucial to its validity as a representation of an existing situation. The following information will be noted in the task log concerning photographs:

- Date, time, location photograph was taken;
- Photographer
- Description of photograph taken;

15.0 Sample Handling, Packaging, and Shipping

The transportation and handling of samples must be accomplished in a manner that not only protects the integrity of the sample, but also prevents any detrimental effects due to the possible hazardous nature of samples. Regulations for packaging, marking, labeling, and shipping hazardous materials are promulgated by the United States DOT in the Code of Federal Regulation, 49 CFR 171 through 177. All samples will be delivered to the laboratory and analyzed within the holding times specified by the analytical method for that particular analyte.

All chain-of-custody requirements must comply with standard operating procedures in the USEPA sample handling protocol.

15.1 Sample Packaging

Samples must be packaged carefully to avoid breakage or contamination and must be shipped to the laboratory at proper temperatures. The following sample packaging requirements will be followed:

- Sample bottle lids must never be mixed. All sample lids must stay with the original containers.
- The sample volume level can be marked by placing the top of the label at the appropriate sample height, or with a grease pencil. This procedure will help the laboratory to determine if any leakage occurred during shipment. The label should not cover any bottle preparation QC lot numbers.
- All sample bottles are placed in a plastic bag to minimize the potential for cross-contamination.
- Shipping coolers must be partially filled with packing materials and ice when required, to prevent the bottles from moving during shipment.
- The sample bottles must be placed in the cooler in such a way as to ensure that they do not touch one another. Ice will be added to the cooler to ensure that the samples reach the laboratory at temperatures no greater than 4°C.
- The environmental samples are to be placed in plastic bags. Ice is not to be used as a substitute for packing materials.
- Any remaining space in the cooler should be filled with inert packing material. Under no circumstances should material such as sawdust, sand, etc., be used.
- A duplicate custody record and traffic reports, if required must be placed in a plastic bag and taped to the bottom of the cooler lid. Custody seals are affixed to the sample cooler.

15.2 Shipping Containers

Shipping containers are to be custody-sealed for shipment as appropriate. The container custody seal will consist of filament tape wrapped around the package and custody seals affixed in such a way that access to the container can be gained only by cutting the filament tape and breaking a seal.

Field personnel will make arrangements for transportation of samples to the lab. The lab must be notified as early in the week as possible regarding samples intended for Saturday delivery.

15.3 Marking and Labeling

- Chain of custody seals shall be placed on the container, signed, and dated prior to taping the container to ensure the chain of custody seals will not be destroyed during shipment.
- If samples are designated as medium or high hazard, they must be sealed in metal paint cans, placed in the cooler with vermiculite and labeled and placarded in accordance with DOT regulations.
- In addition, the coolers must also be labeled and placarded in accordance with DOT regulations if shipping medium and high hazard samples.

16.0 Calibration Procedures and Frequency

All instruments and equipment used during sampling and analysis will be operated, calibrated, and maintained according to the manufacturer's guidelines and recommendations as well as criteria set forth in the applicable analytical methodology references. Operation, calibration, and maintenance will be performed by personnel properly trained in these procedures. Section 11 lists the major instruments to be used for sampling and analysis. In addition, brief descriptions of calibration procedures for major field and laboratory instruments follow.

17.0 Field Instrumentation

17.1 Photovac/MiniRae Photoionization Detector (PID)

Standard operating procedures for the PID require that routine maintenance and calibration be performed every six months. The packages used for calibration are non-toxic analyzed gas mixtures available in pressurized containers.

17.2 Olympus Innov-X Delta X-Ray Fluorescence meter (XRF)

The Olympus XRF is calibrated before first use and every ten hours thereafter. The meter is calibrated by placing the end directly on the included metal disk and taking a reading. Readings require thirty seconds and readout provides a value and a range of accuracy. The meter should be set to read values in parts per million and to include chromium on the analyte list.

18.0 Internal Quality Control Checks

QC data are necessary to determine precision and accuracy and to demonstrate the absence of interferences and/or contamination of field equipment. Field-based QC will comprise at least 10% of each data set generated and will consist of standards, replicates, spikes, and blanks. Field duplicates and field blanks will be analyzed by the laboratory as samples and will not necessarily be identified to the laboratory as duplicates or blanks. For each matrix, field duplicates will be provided at a rate of one per 10 samples collected or one per shipment, whichever is greater. Field blanks which consist of trip, routine field, and rinsate blanks will be provided at a rate of one per 20 samples collected for each parameter group, or one per shipment, whichever is greater.

Calculations will be performed for recoveries and standard deviations along with review of retention times, response factors, chromatograms, calibration, tuning, and all other QC information generated. All QC data, including split samples, will be documented in the site logbook. QC records will be retained and results reported with sample data.

18.1 Blank Samples

Blank samples are analyzed in order to assess possible contamination from the field and/or laboratory so that corrective measures may be taken, if necessary. Field samples are discussed in the following subsection:

18.2 Field Blanks

Various types of blanks are used to check the cleanliness of field handling methods. The following types of blanks may be used: the trip blank, the routine field blank, and the field equipment blank. They are analyzed in the laboratory as samples, and their purpose is to assess the sampling and transport procedures as possible sources of sample contamination. Field staff may add blanks if field circumstances are such that they consider normal procedures are not sufficient to prevent or control sample contamination, or at the direction of the project manager. Rigorous documentation of all blanks in the site logbooks is mandatory.

- **Routine Field Blanks** or bottle blanks are blank samples prepared in the field to access ambient field conditions. They will be prepared by filling empty sample containers with deionized water and any necessary preservatives. They will be handled like a sample and shipped to the laboratory for analysis.
- **Trip Blanks** are similar to routine field blanks with the exception that they are **not** exposed to field conditions. Their analytical results give the overall level of contamination from everything except ambient field conditions. For the RI/FS, one trip blank will be collected with every batch of water samples for VOC analysis. Each trip blank will be prepared by filling a 40-ml vial with deionized water prior to the sampling trip, transported to the site, handled like a sample, and returned to the laboratory for analysis without being opened in the field.
- **Field Equipment Blanks** are blank samples (sometimes called transfer blanks or rinsate blanks) designed to demonstrate that sampling equipment has been properly prepared and cleaned before field use, and that cleaning procedures between samples are sufficient to minimize cross contamination. If a sampling team is familiar with a particular site, they may be able to predict which areas or samples are likely to have the highest concentration of contaminants. Unless other constraints apply, these samples should be taken last to avoid excessive contamination of sampling equipment.

18.3 Field Duplicates

Field duplicate samples consist of a set of two samples collected independently at a sampling location during a single sampling event. In some instances the field duplicate can be a blind duplicate, i.e., indistinguishable from other analytical samples so that personnel performing the analyses are not able to determine which samples are field duplicates. Field duplicates are designed to assess the consistency of the overall sampling and analytical system.

18.4 Quality Control Check Samples

Inorganic and organic control check samples are available from EPA free of charge and are used as a means of evaluating analytical techniques of the analyst. Control check samples are subjected to the entire sample procedure, including extraction, digestion, etc., as appropriate for the analytical method utilized.

APPENDIX 4

Backfill Amendment Information

REGENESIS

Project Information

RD Specialties
Webster, NY
Excavation
Prepared For:
Dan Noll (LaBella)

Target Treatment Zone (TTZ) Info	Unit	Value
Treatment Area	ft^2	360
Top Treat Depth	ft	5.0
Bot Treat Depth	ft	7.0
Vertical Treatment Interval	ft	2.0
Treatment Zone Volume	ft^3	720
Treatment Zone Volume	cy	27
Soil Type	---	silt
Porosity	cm^3/cm^3	0.40
Effective Porosity	cm^3/cm^3	0.15
Treatment Zone Pore Volume	gals	2,154
Treatment Zone Effective Pore Volume	gals	808
Fraction Organic Carbon (foc)	g/g	0.005
Soil Density	g/cm^3	1.5
Soil Density	lb/ft^3	94
Soil Weight	lbs	6.7E+04
Hydraulic Conductivity	ft/day	1.0
Hydraulic Conductivity	cm/sec	3.53E-04
Hydraulic Gradient	ft/ft	0.007
GW Velocity	ft/day	0.05
GW Velocity	ft/yr	17

Sources of 3-D Microemulsion Demand	Unit	Value
Dissolved Phase Mass	lbs	0
Sorbed Phase Contaminant Mass	lbs	0
Competing Electron Acceptor Mass	lbs	2
Stoichiometric 3DME Demand	**lbs**	**2**
TTZ Groundwater Mass Flux	L/day	7
CVOC Mass Flux through TTZ	lb/yr	0
CEA Mass Flux through TTZ	lb/yr	1
Total Mass Flux through TTZ	lb/yr	1
Total Mass Flux 3DME Demand	**lbs**	**2**

Application Dosing

3-D Microemulsion to be Applied	**lbs**	**400**
CRS to be Applied	**lbs**	**0**
BDI Plus to be Applied	**liters**	**0**
HRC Primer to be Applied	**lbs**	**120**

3-D Microemulsion®, BDI® Plus, CRS® Application Design Summary

Excavation		Field App. Instructions
Application Method	**Excavation**	
Spacing Within Rows (ft)	NA	
Spacing Between Rows (ft)	NA	
Application Points	**10**	
Areal Extent (square ft)	360	
Top Application Depth (ft bgs)	5	**Field Mixing Ratios**
Bottom Application Depth (ft bgs)	7	3DME Concentrate per Pt (lbs)
3DME to be Applied (lbs)	**400**	NA
3DME to be Applied (gals)	48	Mix Water per Pt (gals)
3DME Mix %	10%	NA
Volume Water (gals)	**431**	3DME Mix Volume per Pt (gals)
3DME Mix Volume (gals)	479	NA
CRS to be Applied (lbs)	**0**	CRS Volume per Pt (gals)
CRS Volume (gals)	0	NA
BDI Plus to be Applied (L)	**0**	BDI Volume per Pt (L)
BDI Mix Water Volume (gals)	0	NA
HRC Primer to be Applied (lbs)	**120**	HRC Primer per Pt (lbs)
HRC Primer Volume (gals)	13	NA
Total Application Volume (gals)	**492**	Volume per pt (gals)
Estimated Radius of Injection (ft)	3.9	NA
		Volume per vertical ft (gals)
		NA

Technical Notes/Discussion

Prepared By: ***Andy Lowy - Design Specialist***
Date: ***10/21/2016***

Assumptions/Qualifications

In generating this preliminary estimate, Regenesis relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site.

REGENESIS

Purchasing Information

RD Specialties	--	Excavation
3-D Microemulsion Required	**lbs**	**400**
CRS Required	**lbs**	**0**
BDI Plus Required	**liters**	**0**
HRC Primer Required	**lbs**	**120**
3-D Microemulsion Cost*	$	$1,460
CRS Cost	$	$0
BDI Plus Cost	$	$0
HRC Primer Cost	$	$366
Total Product Cost	**$**	**$1,826**
Estimated Tax and Freight %	%	15%
Estimated Tax and Freight Cost*	$	$274
Estimated Total Product Cost	**$**	**$2,100**

***Note that the combined tax and freight costs are preliminary estimates only. Please contact your local sales manager or Customer Service at 949-366-8000 to obtain a shipping quote. You will be asked to provide a ship-to address and estimated time of delivery.**

Currently Available Packaging Options

3DME Package Type***	# of packages	lbs required
400 lb poly drums	1	400
CRS Package Type* **	**# of packages**	**lbs required**
400-lb poly drums	0	0
BDI Plus Package Type* **	**# of packages**	**L required**
18-L kegs	0	0
HRC Primer Package Type* **	**# of packages**	**L required**
30-lb pails	4	120

****Available Package Types are subject to change.**

LABELLA
Associates, D.P.C.
Engineering
Architecture
Environmental
Planning

300 State Street, Suite 201 | Rochester, NY 14614 | p 585.454.6110 | f 585.454.3066 | www.labellapc.com

December 30, 2016

Ms. Nicole Kraft
Chief, GWCS
USEPA Region 2
290 Broadway, 20th Floor
New York, New York 10007

RE: **Inventory of Injection Wells Form**
Remedial Project
560 Salt Rd, Webster, New York
NYSDEC Inactive Hazardous Waste Site #C828062

Dear Ms. Kraft:

Please find the attached form 7520-16 to identify injection wells to be utilized at the property addressed as 560 Salt Road, Town of Webster, New York, hereinafter referred to as the "Site". This form identifies that 3-D Microemulsion and HRC Primer by Regenesis will be placed into the bottom of a remedial excavation in an area where hexavalent chromium impacts are located in soil and groundwater. These impacts were identified and have been delineated through the New York State Department of Environmental Conservation's (NYSDEC's) Inactive Hazardous Waste Disposal Site (IHWDS) Program Site #C828062. This work is being completed as part of a Corrective Measures Plan (CMP) currently under review by the NYSDEC.

In addition, one injection well will also be installed into the backfill of the excavation to allow for potential future applications of similar material in an effort to remediate impacts to the subsurface. This well would only be utilized in the event that then initial amendment placement does not adequately remedial residual impacts.

Please don't hesitate to contact me with any questions, comments or concerns regarding the attached form. Thank you for your help in this matter. I can be reached via email at dnoll@labellapc.com or at 585-295-6611.

Respectfully submitted,

LABELLA ASSOCIATES, D.P.C.

Daniel P. Noll, P.E.
Project Manager

cc: Peter Krasucki, RD Specialties

Todd Caffoe, NYSDEC

C:\Users\dnoll\Desktop\RD Spec\Cover letter to USEPA on UIC v2.docx

Type or print all information. See reverse for instructions.

OMB No. 2040-0042 Approval Expires 11/30/2014

INVENTORY OF INJECTION WELLS

EPA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF GROUND WATER AND DRINKING WATER

(This information is collected under the authority of the Safe Drinking Water Act)

1. DATE PREPARED *(Year, Month, Day)*
16-12-30

2. FACILITY ID NUMBER
NYS # 828062

PAPERWORK REDUCTION ACT NOTICE

The public reporting burden for this collection of information is estimated at about 0.5 hour per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, Director, Collection Strategies Division (2822), U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue, NW, Washington, DC 20460, and to the Office of Management and Budget, Paperwork Reduction Project, Washington, DC 20503.

3. TRANSACTION TYPE *(Please mark one of the following)*

☐ Deletion ☑ First Time Entry
☐ Entry Change ☐ Replacement

4. FACILITY NAME AND LOCATION

A. NAME *(last, first, and middle initial)*: RD Specialties

B. STREET ADDRESS/ROUTE NUMBER: 560 Salt Road

C. LATITUDE

DEG	MIN	SEC
43	14	10.18

D. LONGITUDE

DEG	MIN	SEC
77	23	58.21

E. TOWNSHIP/RANGE

TOWNSHIP	RANGE	SECT	1/4 SECT

F. CITY/TOWN: Webster

G. STATE: NY

H. ZIP CODE: 14580

I. NUMERIC COUNTY CODE: 055

J. INDIAN LAND *(mark "x")* ☐ Yes ☒ No

5. LEGAL CONTACT:

A. TYPE *(mark "x")* ☒ Owner ☐ Operator

B. NAME *(last, first, and middle initial)*: Peter Krasucki

C. PHONE *(area code and number)*: (585) 265-0220

D. ORGANIZATION: RD Specialities

E. STREET/P.O. BOX: 560 Salt Road

F. CITY/TOWN: Webster

G. STATE: NY

H. ZIP CODE: 14580

I. OWNERSHIP *(mark "x")*
☒ PRIVATE ☐ PUBLIC ☐ SPECIFY OTHER
☐ STATE ☐ FEDERAL

6. WELL INFORMATION:

A. CLASS AND TYPE		B. NUMBER OF WELLS		C. TOTAL NUMBER OF WELLS	D. WELL OPERATION STATUS				
		COMM	NON-COMM		UC	AC	TA	PA	AN
V	5	0	1	1	1				
				0					
				0					
				0					
				0					
				0					
				0					

COMMENTS *(Optional)*:

Well Type = 5X26
3-D Microemulsion and HRC primer by Regenesis to be placed into a remedial excavation and possibly injected in the future as well, for remediation at NYSDEC Inactive Hazardous Waste Site #C828062. This form includes planned initial injection in backfill and possible future injection through one wells installed in excavation at time of backfilling.

KEY:

DEG = Degree
MIN = Minute
SEC = Second

SECT = Section
1/4 SECT = Quarter Section

COMM = Commercial
NON-COMM = Non-Commercial

AC = Active
UC = Under Construction
TA = Temporarily Abandoned
PA = Permanently Abandoned and Approved by State
AN = Permanently Abandoned and not Approved by State

SECTION 1. DATE PREPARED: Enter date in order of year, month, and day.

SECTION 2. FACILITY ID NUMBER: In the first two spaces, insert the appropriate U.S. Postal Service State Code. In the third space, insert one of the following one letter alphabetic identifiers:

D - DUNS Number,
G - GSA Number, or
S - State Facility Number.

In the remaining spaces, insert the appropriate nine digit DUNS, GSA, or State Facility Number. For example, A Federal facility (GSA - 123456789) located in Virginia would be entered as : VAG123456789.

SECTION 3. TRANSACTION TYPE: Place an "x" in the applicable box. See below for further instructions.

Deletion. Fill in the Facility ID Number.
First Time Entry. Fill in all the appropriate information.
Entry Change. Fill in the Facility ID Number and the information that has changed.
Replacement.

SECTION 4. FACILITY NAME AND LOCATION:

A. Name. Fill in the facility's official or legal name.
B. Street Address. Self Explanatory.
C. Latitude. Enter the facility's latitude (all latitudes assume North Except for American Samoa).
D. Longitude. Enter the facility's longitude (all longitudes assume West except Guam).
E. Township/Range. Fill in the complete township and range. The first 3 spaces are numerical and the fourth is a letter (N,S,E,W) specifying a compass direction. A township is North or South of the baseline, and a range is East or West of the principal meridian (e.g., 132N, 343W).
F. City/Town. Self Explanatory.
G. State. Insert the U.S. Postal Service State abbreviation.
H. Zip Code. Insert the five digit zip code plus any extension.

SECTION 4. FACILITY NAME & LOCATION (CONT'D.):

I. Numeric County Code. Insert the numeric county code from the Federal Information Processing Standards Publication (FIPS Pub 6-1) June 15, 1970, U.S. Department of Commerce, National Bureau of Standards. For Alaska, use the Census Division Code developed by the U.S. Census Bureau.
J. Indian Land. Mark an "x" in the appropriate box (Yes or No) to indicate if the facility is located on Indian land.

SECTION 5. LEGAL CONTACT:

A. Type. Mark an "x" in the appropriate box to indicate the type of legal contact (Owner or Operator). For wells operated by lease, the operator is the legal contact.
B. Name. Self Explanatory.
C. Phone. Self Explanatory.
D. Organization. If the legal contact is an individual, give the name of the business organization to expedite mail distribution.
E. Street/P.O. Box. Self Explanatory.
F. City/Town. Self Explanatory.
G. State. Insert the U.S. Postal Service State abbreviation.
H. Zip Code. Insert the five digit zip code plus any extension.
I. Ownership. Place an "x" in the appropriate box to indicate ownership status.

SECTION 6. WELL INFORMATION:

A. Class and Type. Fill in the Class and Type of injection wells located at the listed facility. Use the most pertinent code (specified below) to accurately describe each type of injection well. For example, 2R for a Class II Enhanced Recovery Well, or 3M for a Class III Solution Mining Well, etc.
B. Number of Commercial and Non-Commercial Wells. Enter the total number of commercial and non-commercial wells for each Class/Type, as applicable.
C. Total Number of Wells. Enter the total number of injection wells for each specified Class/Type.
D. Well Operation Status. Enter the number of wells for each Class/Type under each operation status (see key on other side).

CLASS I Industrial, Municipal, and Radioactive Waste Disposal Wells used to inject waste below the lowermost Underground Source of Drinking Water (USDW).

TYPE	**1I**	Non-Hazardous Industrial Disposal Well.
	1M	Non-Hazardous Municipal Disposal Well.
	1H	Hazardous Waste Disposal Well injecting below the lowermost USDW.
	1R	Radioactive Waste Disposal Well.
	1X	Other Class I Wells.

CLASS II Oil and Gas Production and Storage Related Injection Wells.

TYPE	**2A**	Annular Disposal Well.
	2D	Produced Fluid Disposal Well.
	2H	Hydrocarbon Storage Well.
	2R	Enhanced Recovery Well.
	2X	Other Class II Wells.

CLASS III Special Process Injection Wells.

TYPE	**3G**	*In Situ* Gasification Well
	3M	Solution Mining Well.

CLASS III (CONT'D.)

TYPE	**3S**	Sulfur Mining Well by Frasch Process.
	3T	Geothermal Well.
	3U	Uranium Mining Well.
	3X	Other Class III Wells.

CLASS IV Wells that inject hazardous waste into/above USDWs.

TYPE	**4H**	Hazardous Facility Injection Well.
	4R	Remediation Well at RCRA or CERCLA site.

CLASS V Any Underground Injection Well not included in Classes I through IV.

TYPE	**5A**	Industrial Well.
	5B	Beneficial Use Well.
	5C	Fluid Return Well.
	5D	Sewage Treatment Effluent Well.
	5E	Cesspools (non-domestic).
	5F	Septic Systems.
	5G	Experimental Technology Well.
	5H	Drainage Well.
	5I	Mine Backfill Well.
	5J	Waste Discharge Well.

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REGENESIS
Technology-Based Solutions for the Environment

SAFETY DATA SHEET

1. Identification

Product identifier	**Hydrogen Release Compound PRIMER (HRC PRIMER®)**
Other means of identification	None.
Recommended use	Remediation of soils and groundwater.
Recommended restrictions	None known.

Manufacturer/Importer/Supplier/Distributor information

Company Name	Regenesis
Address	1011 Calle Sombra San Clemente, CA 92673
Telephone	949-366-8000
E-mail	CustomerService@regenesis.com
Emergency phone number	CHEMTREC® at 1-800-424-9300 (International)

2. Hazard(s) identification

Physical hazards	Not classified.	
Health hazards	Skin corrosion/irritation	Category 2
	Serious eye damage/eye irritation	Category 1
OSHA defined hazards	Not classified.	

Label elements

Signal word	Danger
Hazard statement	Causes skin irritation. Causes serious eye damage.
Precautionary statement	
Prevention	Wash thoroughly after handling. Wear protective gloves. Wear eye/face protection.
Response	If on skin: Wash with plenty of water. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor. If skin irritation occurs: Get medical advice/attention. Take off contaminated clothing and wash before reuse.
Storage	Store away from incompatible materials.
Disposal	Dispose of waste and residues in accordance with local authority requirements.
Hazard(s) not otherwise classified (HNOC)	None known.

3. Composition/information on ingredients

Mixtures

Chemical name	CAS number	%
Lactic acid	50-21-5	90
Glycerol Tripolylactate	201167-72-8	6-7
Glycerin	56-81-5	3-4

Composition comments	All concentrations are in percent by weight unless otherwise indicated.

4. First-aid measures

Inhalation	Move to fresh air. Call a physician if symptoms develop or persist.

Skin contact	Remove contaminated clothing. Wash with plenty of soap and water. If skin irritation occurs: Get medical advice/attention. Wash contaminated clothing before reuse.
Eye contact	Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention immediately.
Ingestion	Rinse mouth. Never give anything by mouth to a victim who is unconscious or is having convulsions. Do not induce vomiting without advice from poison control center. Get medical attention if symptoms occur.
Most important symptoms/effects, acute and delayed	Severe eye irritation. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result. Skin irritation. May cause redness and pain.
Indication of immediate medical attention and special treatment needed	Provide general supportive measures and treat symptomatically. Keep victim under observation. Symptoms may be delayed.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water spray. Carbon dioxide (CO2). Dry chemical powder. Foam.
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed. Combustion products may include: carbon oxides, phosphorus compounds and metal oxides.
Special protective equipment and precautions for firefighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.
Fire fighting equipment/instructions	Move containers from fire area if you can do so without risk. Water spray should be used to cool containers.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Wear appropriate protective equipment and clothing during clean-up. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Large Spills: Stop the flow of material, if this is without risk. Use water spray to reduce vapors or divert vapor cloud drift. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling	Do not get this material in contact with eyes. Avoid contact with eyes, skin, and clothing. Provide adequate ventilation. Wear appropriate personal protective equipment. Observe good industrial hygiene practices.
Conditions for safe storage, including any incompatibilities	Store in original tightly closed container. Store in a cool, dry, well-ventilated place. Store away from incompatible materials (see Section 10 of the SDS). Recommended storage containers: plastic lined steel, plastic, glass, aluminum, stainless steel, or reinforced fiberglass.

8. Exposure controls/personal protection

Occupational exposure limits

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

Components	Type	Value	Form
Glycerin (CAS 56-81-5)	PEL	5 mg/m3	Respirable fraction.
		15 mg/m3	Total dust.

Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. Eye wash facilities and emergency shower must be available when handling this product.
Individual protection measures, such as personal protective equipment	
Eye/face protection	Wear approved, tight fitting indirect vented or non-vented safety goggles where splashing is probable. Face shield is recommended.
Skin protection	
Hand protection	Wear appropriate chemical resistant gloves. Rubber or vinyl-coated gloves are recommended.
Other	Wear appropriate chemical resistant clothing.
Respiratory protection	If engineering controls do not maintain airborne concentrations below recommended exposure limits (where applicable) or to an acceptable level (in countries where exposure limits have not been established), an approved respirator must be worn.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance	
Physical state	Liquid.
Form	Liquid.
Color	Yellow.
Odor	Odorless.
Odor threshold	Not available.
pH	2 (3% solution/water)
Melting point/freezing point	Not available.
Initial boiling point and boiling range	Not available.
Flash point	Not available.
Evaporation rate	Not available.
Flammability (solid, gas)	Not applicable.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	1.1 - 1.3
Solubility(ies)	
Solubility (water)	Soluble.
Solubility (other)	Acetone and DMSO.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	< 1000 cP

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.

Chemical stability	Undergoes hydrolysis in water to form lactic acid and glycerol.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.
Conditions to avoid	Avoid temperatures exceeding the flash point. Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents. Bases. Acids.
Hazardous decomposition products	Thermal decomposition or combustion may produce: carbon oxides, phosphorus compounds, metal oxides.

11. Toxicological information

Information on likely routes of exposure

Inhalation	May cause irritation to the respiratory system.
Skin contact	Causes skin irritation.
Eye contact	Causes serious eye damage.
Ingestion	Ingestion may cause irritation and malaise.
Symptoms related to the physical, chemical and toxicological characteristics	Severe eye irritation. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result. Skin irritation. May cause redness and pain.

Information on toxicological effects

Acute toxicity

Components	Species	Test Results
Glycerin (CAS 56-81-5)		
Acute		
Oral		
LD50	Rat	12600 mg/kg

Skin corrosion/irritation	Causes skin irritation.
Serious eye damage/eye irritation	Causes serious eye damage.
Respiratory or skin sensitization	
Respiratory sensitization	Not a respiratory sensitizer.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

Reproductive toxicity	This product is not expected to cause reproductive or developmental effects.
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not an aspiration hazard.

12. Ecological information

Ecotoxicity	The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.
Persistence and degradability	Material is readily degradable and undergoes hydrolysis in several hours.
Bioaccumulative potential	No data available.

Partition coefficient n-octanol / water (log Kow)

Glycerin (CAS 56-81-5)	-1.76
Lactic acid (CAS 50-21-5)	-0.72

Mobility in soil	No data available.
Other adverse effects	None known.

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Dispose of contents/container in accordance with local/regional/national/international regulations.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.
Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not established.

15. Regulatory information

US federal regulations	This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication Standard, 29 CFR 1910.1200. One or more components are not listed on TSCA.

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

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

CERCLA Hazardous Substance List (40 CFR 302.4)

Not listed.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

Hazard categories	Immediate Hazard - Yes Delayed Hazard - No Fire Hazard - No Pressure Hazard - No Reactivity Hazard - No

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous chemical	Yes

SARA 313 (TRI reporting)

Not regulated.

Other federal regulations

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

Not regulated.

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

Not regulated.

Safe Drinking Water Act (SDWA)	Not regulated.

US state regulations

US. Massachusetts RTK - Substance List

Glycerin (CAS 56-81-5)

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

Glycerin (CAS 56-81-5)

US. Pennsylvania Worker and Community Right-to-Know Law

Glycerin (CAS 56-81-5)

US. Rhode Island RTK

Not regulated.

US. California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins.

International Inventories

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

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

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

Issue date	10-April-2015
Revision date	-
Version #	01
Further information	HMIS® is a registered trade and service mark of the American Coatings Association (ACA).
HMIS® ratings	Health: 3 Flammability: 1 Physical hazard: 0
NFPA ratings	
Disclaimer	Regenesis cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use. The information in the sheet was written based on the best knowledge and experience currently available.

REGENESIS

Technology-Based Solutions for the Environment

SAFETY DATA SHEET

1. Identification

Product identifier	**3-D Microemulsion®**
Other means of identification	None.
Recommended use	Remediation of soils and groundwater.
Recommended restrictions	None known.

Manufacturer/Importer/Supplier/Distributor information

Company Name	Regenesis
Address	1011 Calle Sombra San Clemente, CA 92673
Telephone	949-366-8000
E-mail	CustomerService@regenesis.com
Emergency phone number	CHEMTREC® at 1-800-424-9300 (International)

2. Hazard(s) identification

Physical hazards	Not classified.	
Health hazards	Skin corrosion/irritation	Category 2
	Serious eye damage/eye irritation	Category 1
OSHA defined hazards	Not classified.	

Label elements

Signal word	Danger
Hazard statement	Causes skin irritation. Causes serious eye damage.
Precautionary statement	
Prevention	Wash thoroughly after handling. Wear protective gloves. Wear eye/face protection.
Response	If on skin: Wash with plenty of water. If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center/doctor. If skin irritation occurs: Get medical advice/attention. Take off contaminated clothing and wash before reuse.
Storage	Store away from incompatible materials.
Disposal	Dispose of waste and residues in accordance with local authority requirements.
Hazard(s) not otherwise classified (HNOC)	None known.

3. Composition/information on ingredients

Mixtures

Chemical name	CAS number	%
HRC-PED	823190-10-9	48-53
Fatty Acids (neutralized)	61790-12-3 or 112-80-1	30-35
Glycerol Tripolylactate	201167-72-8	<10

Composition comments	All concentrations are in percent by weight unless otherwise indicated.

4. First-aid measures

Inhalation	Move to fresh air. Call a physician if symptoms develop or persist.
Skin contact	Remove contaminated clothing. Wash with plenty of soap and water. If skin irritation occurs: Get medical advice/attention. Wash contaminated clothing before reuse.
Eye contact	Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention immediately.
Ingestion	Rinse mouth. Never give anything by mouth to a victim who is unconscious or is having convulsions. Do not induce vomiting without advice from poison control center. Get medical attention if symptoms occur.
Most important symptoms/effects, acute and delayed	Severe eye irritation. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result. Skin irritation. May cause redness and pain.
Indication of immediate medical attention and special treatment needed	Provide general supportive measures and treat symptomatically. Keep victim under observation. Symptoms may be delayed.
General information	Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media	Water spray. Carbon dioxide (CO2). Dry chemical powder. Foam.
Unsuitable extinguishing media	Do not use water jet as an extinguisher, as this will spread the fire.
Specific hazards arising from the chemical	During fire, gases hazardous to health may be formed. Combustion products may include: carbon oxides, phosphorus compounds and metal oxides.
Special protective equipment and precautions for firefighters	Self-contained breathing apparatus and full protective clothing must be worn in case of fire.
Fire fighting equipment/instructions	Move containers from fire area if you can do so without risk. Water spray should be used to cool containers.
Specific methods	Use standard firefighting procedures and consider the hazards of other involved materials.
General fire hazards	No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures	Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Surfaces may become slippery after spillage. Wear appropriate protective equipment and clothing during clean-up. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.
Methods and materials for containment and cleaning up	Spilled product may create a slipping hazard. The product is immiscible with water and will spread on the water surface. Large Spills: Stop the flow of material, if this is without risk. Use water spray to reduce vapors or divert vapor cloud drift. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Flush area clean with lots of water. Be aware of potential for surfaces to become slippery. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.
Environmental precautions	Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling	Do not get this material in contact with eyes. Avoid contact with eyes, skin, and clothing. Provide adequate ventilation. Wear appropriate personal protective equipment. Observe good industrial hygiene practices.
Conditions for safe storage, including any incompatibilities	Store in original tightly closed container. Store in a cool, dry, well-ventilated place. Store away from incompatible materials (see Section 10 of the SDS). Recommended storage containers: plastic lined steel, plastic, glass, aluminum, stainless steel, or reinforced fiberglass.

8. Exposure controls/personal protection

Occupational exposure limits	No exposure limits noted for ingredient(s).
Biological limit values	No biological exposure limits noted for the ingredient(s).
Appropriate engineering controls	Good general ventilation (typically 10 air changes per hour) should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. Eye wash facilities and emergency shower must be available when handling this product.

Individual protection measures, such as personal protective equipment

Eye/face protection	Wear approved, tight fitting indirect vented or non-vented safety goggles where splashing is probable. Face shield is recommended.
Skin protection	
Hand protection	Wear appropriate chemical resistant gloves. Rubber or vinyl-coated gloves are recommended.
Other	Wear appropriate chemical resistant clothing.
Respiratory protection	If engineering controls do not maintain airborne concentrations below recommended exposure limits (where applicable) or to an acceptable level (in countries where exposure limits have not been established), an approved respirator must be worn.
Thermal hazards	Wear appropriate thermal protective clothing, when necessary.
General hygiene considerations	Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

Appearance	
Physical state	Liquid.
Form	Semi-solid.
Color	Amber.
Odor	Odorless.
Odor threshold	Not available.
pH	Not available.
Melting point/freezing point	Not available.
Initial boiling point and boiling range	Not available.
Flash point	> 200.0 °F (> 93.3 °C) Closed Cup
Evaporation rate	Not available.
Flammability (solid, gas)	Not available.
Upper/lower flammability or explosive limits	
Flammability limit - lower (%)	Not available.
Flammability limit - upper (%)	Not available.
Explosive limit - lower (%)	Not available.
Explosive limit - upper (%)	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Relative density	0.9 - 1.1
Solubility(ies)	
Solubility (water)	Insoluble.
Solubility (other)	Slightly soluble in acetone.
Partition coefficient (n-octanol/water)	Not available.
Auto-ignition temperature	Not available.
Decomposition temperature	Not available.
Viscosity	Not available.

10. Stability and reactivity

Reactivity	The product is stable and non-reactive under normal conditions of use, storage and transport.
Chemical stability	Undergoes hydrolysis in water to form lactic acid, glycerol and fatty acids.
Possibility of hazardous reactions	No dangerous reaction known under conditions of normal use.
Conditions to avoid	Avoid temperatures exceeding the flash point. Contact with incompatible materials.
Incompatible materials	Strong oxidizing agents. Bases. Acids.
Hazardous decomposition products	Thermal decomposition or combustion may produce: carbon oxides, phosphorus compounds, metal oxides.

11. Toxicological information

Information on likely routes of exposure

Inhalation	May cause irritation to the respiratory system.
Skin contact	Causes skin irritation.
Eye contact	Causes serious eye damage.
Ingestion	Ingestion may cause irritation and malaise.
Symptoms related to the physical, chemical and toxicological characteristics	Severe eye irritation. Symptoms may include stinging, tearing, redness, swelling, and blurred vision. Permanent eye damage including blindness could result. Skin irritation. May cause redness and pain.

Information on toxicological effects

Acute toxicity	Not available.
Skin corrosion/irritation	Causes skin irritation.
Serious eye damage/eye irritation	Causes serious eye damage.

Respiratory or skin sensitization

Respiratory sensitization	Not a respiratory sensitizer.
Skin sensitization	This product is not expected to cause skin sensitization.
Germ cell mutagenicity	No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.
Carcinogenicity	This product is not considered to be a carcinogen by IARC, ACGIH, NTP, or OSHA.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)

Not listed.

Reproductive toxicity	This product is not expected to cause reproductive or developmental effects.
Specific target organ toxicity - single exposure	Not classified.
Specific target organ toxicity - repeated exposure	Not classified.
Aspiration hazard	Not an aspiration hazard.

12. Ecological information

Ecotoxicity	The product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.
Persistence and degradability	Material is readily degradable and undergoes hydrolysis in several hours.
Bioaccumulative potential	No data available.
Mobility in soil	The product is immiscible in water.
Other adverse effects	None known.

13. Disposal considerations

Disposal instructions	Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Dispose of contents/container in accordance with local/regional/national/international regulations.
Local disposal regulations	Dispose in accordance with all applicable regulations.
Hazardous waste code	The waste code should be assigned in discussion between the user, the producer and the waste disposal company.

Waste from residues / unused products	Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions).
Contaminated packaging	Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code	Not established.

15. Regulatory information

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Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	No
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

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

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

Issue date	22-April-2015
Revision date	-
Version #	01
Further information	HMIS® is a registered trade and service mark of the American Coatings Association (ACA).
HMIS® ratings	Health: 3 Flammability: 1 Physical hazard: 0
NFPA ratings	
Disclaimer	Regenesis cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use. The information in the sheet was written based on the best knowledge and experience currently available.

Biochemical Treatment of Hydraulically Complex Hexavalent Chromium and Chlorinated Volatile Organic Plumes

Richard J. Desrosiers

I. Richard Schaffner

Gordon T. Brookman

Groundwater contaminated with hexavalent chromium (Cr^{+6}) and chlorinated volatile organic compounds (cVOCs) presents unique in situ *remedial challenges in an oxygen-rich environment. On one hand, chemical oxidation would be effective in treating the cVOCs; however, it would not be appropriate to treat Cr^{+6}. Biological treatment may be appropriate to treat the Cr^{+6}; however, the cVOC degradation pathway within these mixed plumes is currently following an abiotic pathway with little to no daughter-product production. Thus, a blended approach was needed to treat both constituents* in situ *in an effort to avoid a long-term, costly pump-and-treat solution. This article evaluates an* in situ *biogeochemical stabilization/reduction strategy by injecting an inorganic carbon-based remedial additive into the geologic and hydrogeologic environment to decrease concentrations within the commingled Cr^{+6} and cVOC plume. The concept involves creating favorable redox reducing conditions to shift the groundwater geochemical equilibrium from the more toxic Cr^{+6} to the less toxic trivalent chromium (Cr^{+3}), with the final outcome being a conversion to chrome oxide that molecularly fixes to the soil grains. In addition, reducing conditions developed for chromium reduction should result in an increase in the available natural formation iron that should further enhance the natural abiotic reduction of cVOCs. © 2013 Wiley Periodicals, Inc.*

INTRODUCTION

A New England industrial facility utilized metal finishing process lines for decades involving the use of sulfuric, nitric, and chromic acid baths with an alkaline etch/clean line and deionized aqueous rinses. The process wastewater was transferred to holding tanks, where it was subsequently treated with sodium metabisulfate to control the oxidation-reduction potential (ORP) along with lime and/or sulfuric acid to control the pH prior to a permitted discharge to surface water or a sanitary sewer since the 1950s. Over time, these historical untreated wastewaters (either from the facility's acid baths or from the external holding tanks) were released to the subsurface. A solvent degreaser was present adjacent to the metal finishing process lines that released tetrachloroethene (PCE) and trichloroethene (TCE) to the subsurface.

Releases from the process line and degreaser migrated vertically downward along a hydraulic divide bifurcating the plume into a high hexavalent chromium (Cr^{+6}) and low to moderate chlorinated volatile organic compound (cVOC) plume and high cVOC and low

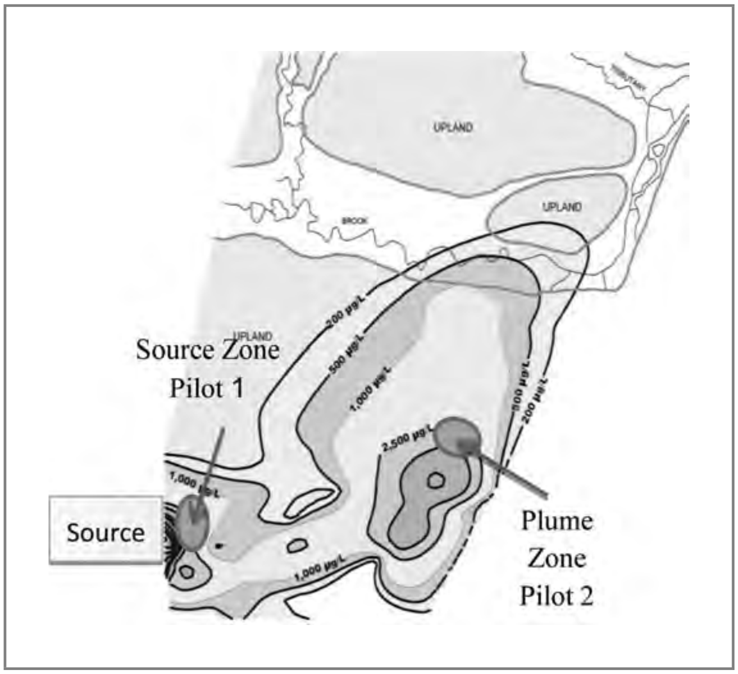

Exhibit 1. Site layout, contaminant plumes, and pilot study locations

to moderate Cr^{+6} plume. This article focuses on the commingled high Cr^{+6} and low to moderate cVOC plume. This plume is approximately 3,000 linear feet in length and flows beneath a major brook, discharging to an adjacent tributary (Exhibit 1).

The initial remedial approach considered by the project team involved a traditional pump-and-treat option to extract contaminated groundwater. The treatment train would have involved initial cVOC treatment prior to treating the Cr^{+6} within the facility wastewater treatment plant. This approach would have required increasing the size of the existing wastewater treatment facility, adding support staff to manage the treatment, and incurring an increase in discharge fees and electrical costs, with no certainty in the duration of treatment. An alternative remedial solution was to evaluate if an *in situ* biogeochemical treatment alternative would provide the level of Cr^{+6}, Cr^{+3}, and cVOC treatment needed to remove significant mass followed by a monitored natural attenuation program to meet remedial action cleanup criteria. Two pilots were designed (including a series of supporting microcosm studies) prior to implementing full-scale remediation. These pilots evaluated various additives over a five-year period.

In addition to additive selection, significant geologic, geochemical, and hydrologic challenges needed to be better understood prior to developing a final remedial work plan. These challenges include the presence of redox reduction inhibitors from the releases that contain nitrate from the nitric acid, sulfate from the sulfuric acid, elevated ORP (Eh) from the strong oxidized acids, and elevated pH from the physical mineralization and chemical interactions of the silt-clay geologic units that appear to buffer groundwater pH. The Eh/pH conditions in the plume have allowed the more toxic Cr^{+6} to remain in equilibrium rather than the more stable, less toxic Cr^{+3}, and have resulted in the migration of Cr^{+6} thousands of feet beyond the area of release. To assess subtle changes in

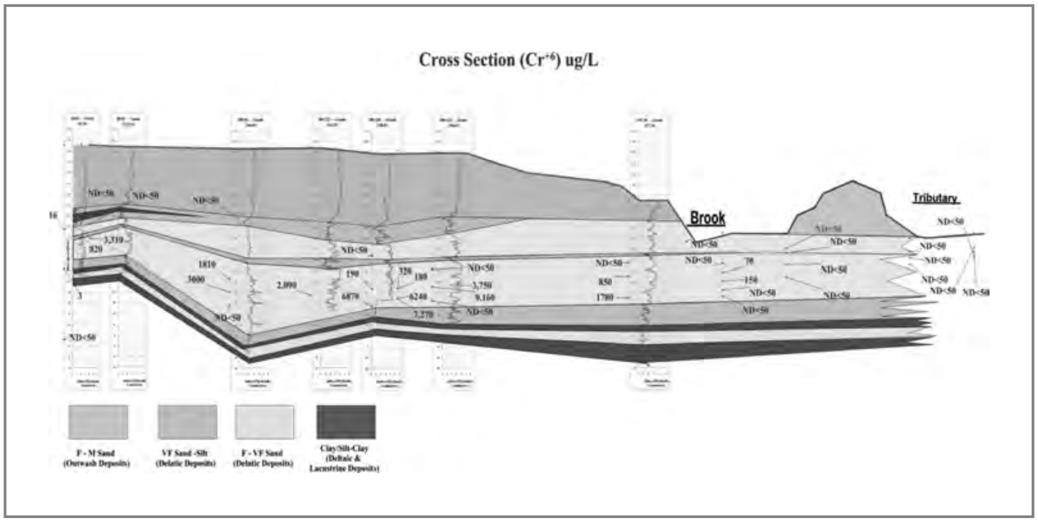

Exhibit 2. Geologic cross section

both local geology and geochemistry, a Triad investigative approach along with high-resolution site characterization was used.

GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

The glacial deposits directly below the release zone are composed of a more permeable fine to medium sand underlain by a silt unit interbedded with discontinuous thin clay units (Exhibit 2). The silt-clay unit acts like a leaky-confining unit, retarding the vertical migration of contaminants into an underlying deltaic unit, which is vertically bounded by a lower lacustrine clay unit that acts as a confining unit. The deltaic unit consists of a series of fine sand, silt, and clay stringers.

Since the source is located along a hydraulic divide, there are strong vertical downward gradients that drive the Cr^{+6} and cVOCs deeper into distinct thin deltaic units, which are then transported horizontally. These conditions created an upper (generally less concentrated) and lower (more concentrated) contaminant zone. At the lower lacustrine deposit, the vertical flow component is either upward or there is little vertical flow. Thus, the greatest cVOC concentrations within the groundwater system are present at the convergence of the downward and upward flow components.

Soil data indicate an adsorbed component of Cr^{+6} above the upper silt-clay unit and within the soil matrix of the deltaic unit where elevated concentrations in groundwater have been reported. It is likely that the adsorbed component is back diffusing from the silt and silt-clay units into the higher permeable fine to very fine sand units. A remedy to either prevent or treat releases from back diffusion should be implemented because the adsorbed contaminant will act as a continuous secondary source slowly releasing contaminants into the underlying more permeable deltaic units that would migrate to the discharge zone.

A Triad and high-resolution site characterization approach was undertaken to better understand the subtle glacial depositional changes and vertical hydraulic flow components. These techniques included Waterloo^{APS} Profilers, membrane interface probes (MIPs), borehole geophysics, collecting discrete groundwater grab samples based upon profiling data, collecting closely spaced cVOC and Cr^{+6} field screening data, installing traditional monitoring wells in discrete contaminant zones to evaluate transient seasonal changes, and completing soil borings using a RotoSonic™ rig to provide continuous soil profiles. These high-resolution techniques were more effective in delineating subtle changes in lithology and groundwater geochemistry at this site than conventional split spoon and GeoProbe™ sampling over short sampling intervals given limited soil recovery rates. In addition, these techniques provided a broader understanding of contaminant fate-and-transport mechanisms within the thin geologic units.

In most cases, the greatest concentrations of contaminants were detected at depths corresponding to an inflection point on the hydraulic head profile and typically occurred in zones of higher permeable units directly above low-permeability units.

Near the source of the release (recharge zone), the vertical downward hydraulic gradient was greater than the horizontal gradient; however, as contaminants migrate deeper into the deltaic deposits, the horizontal gradients become greater than the vertical gradients. Profiling techniques permitted the measurements of vertical groundwater hydraulic head every five feet (to assess upward and downward flow potential). These head measurements were graphed along with generalized stratigraphy based upon observed profiling to select discrete groundwater sampling intervals within the vertical profile. In most cases, the greatest concentrations of contaminants were detected at depths corresponding to an inflection point on the hydraulic head profile and typically occurred in zones of higher permeable units directly above low-permeability units.

The vertical flow components cause cVOCs and Cr^{+6} to migrate deeper in the groundwater system. In general, source-zone concentrations were reported to depths of 55 feet below grade; whereas 1,000 feet downgradient of the release, the contamination was reported at depths of 70 to 85 feet below grade (see Exhibit 2). Within the discharge transition zone, approximately 2,000 linear feet from the source, the plume vertically migrates upward and becomes shallower. At the wetlands discharge zone, the contaminants migrate upward through organic wetland mucks prior to surface water discharge.

Geologically, at the discharge transition zone, the upper silt-clay unit was incised by a glacial stream leaving the deltaic (fine to very-fine sand, silt, and silt-clay) units as the upper unconfined hydrostratigraphic unit hydraulically connected to the surface discharge zone. These changes in geologic conditions appear to influence plume geochemistry. At the point where the formation is incised, surficial seeps were observed along the steep slopes adjacent to the brook. It is within this transition zone where the deeper plume migrates beneath and beyond the brook. Eventually, the plume discharges to an adjacent tributary of this regional brook.

At the discharge zone to surface water, the contaminants vertically migrate through extensive organic deposits reducing Cr^{+6} and cVOC concentrations prior to plume discharge. Thus, within the transition zone there are lines of evidence of natural attenuation processes to support the conversion of the Cr^{+6} to Cr^{+3} due to more favorable Eh/pH equilibrium conditions enhanced by the organic muck. In addition, degradation of residual cVOCs likely via reductive dechlorination was observed through these natural attenuation processes, further reducing cVOC concentrations prior to discharge into the brook.

One of the goals of the remedial strategy is to evaluate remedial techniques (biogeochemical reduction) that include shifts in Eh/pH equilibrium condition (Cr^{+6} reduction) and biotic reducing conditions for cVOCs.

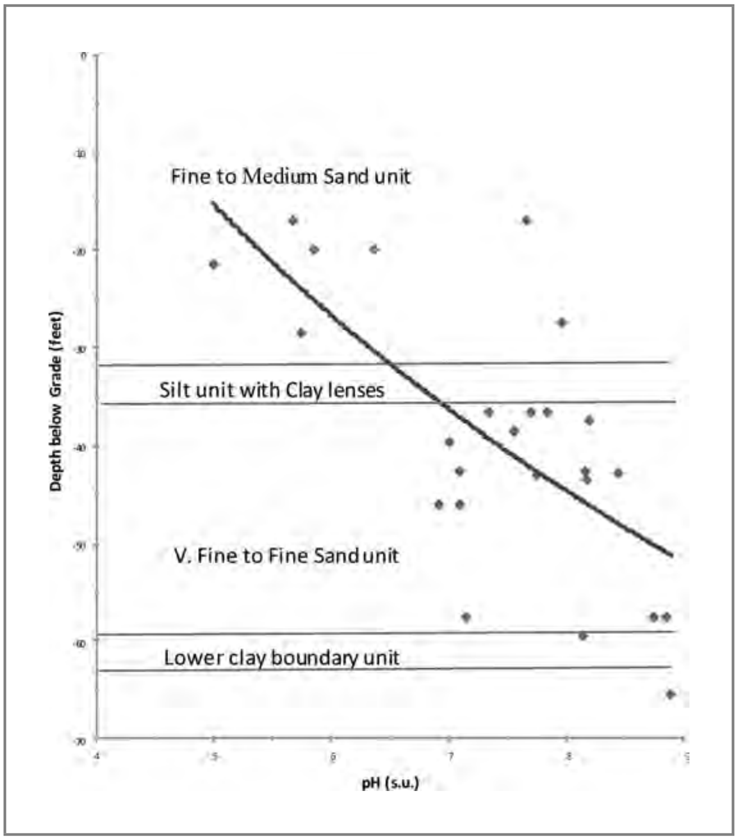

Exhibit 3. pH changes with depth below source areas

LOCAL GEOCHEMICAL CONDITIONS

The chemical interactions between the chemicals released in the source zone and the geologic units through which the chemicals migrate result in complex geochemical conditions that influence equilibrium stability of Cr^{+6} and cVOC degradation pathways. These geochemical conditions control contaminant migration and will significantly influence the design of a cost-effective *in situ* remedial alternative.

The fate of Cr^{+6} in groundwater is influenced by a number of anthropogenic and natural transformation factors including: (1) the elevated concentrations of nitrate and sulfate from the nitric and sulfuric acids; (2) the elevated alkalinity contributed from alkaline etch/clean lines; (3) the oxidized nature of the released acids resulting in elevated ORP; (4) the elevated dissolved oxygen (DO) concentrations at the recharge boundary; and (5) the influence of the clay units in buffering the acidic release. Of these factors, the two most influential in controlling Cr^{+6} reductions are elevated ORP and pH values influencing Eh/pH stability. ORP and pH values in the groundwater appear to be related to the oxidized condition of the released wastewater and the buffering capacity of the clay unit. Exhibit 3 depicts a plot of pH versus depth below grade. Vertical groundwater samples collected from monitoring wells in the vicinity of the source area indicate acidic conditions above the silt-clay unit and alkaline conditions below the unit within the deltaic unit in which the plume migrates. Soil data collected above the silt-clay unit (below the

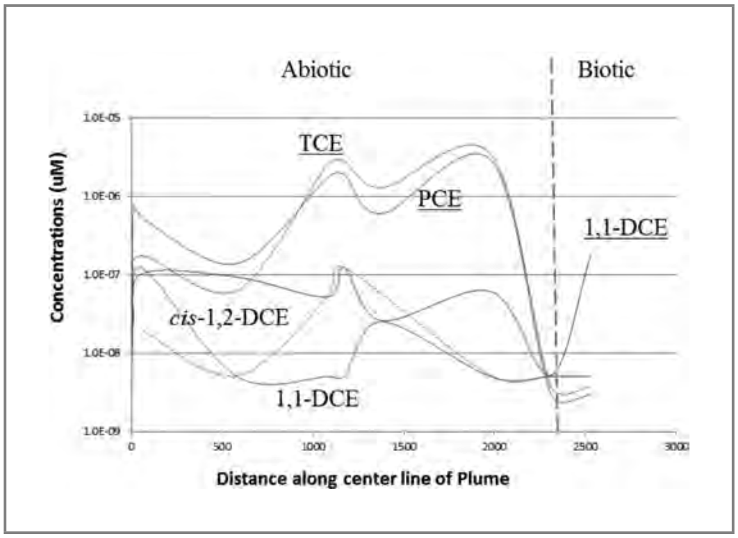

Exhibit 4. cVOC concentrations along plume center line

source) indicate that the dominant chromium state is the less toxic Cr^{+3}, whereas below the silt-clay unit, chromium is present as the more toxic Cr^{+6}. In addition, due to the oxidation conditions of the releases, there is an increase in ORP within the groundwater. The buffering effect of the clay silt-clay unit along with noncontinuous silt-clay stringers within the deltaic unit increased pH at least 4 standard units (s.u.) within the Cr^{+6} plume. These persistent ORP and pH conditions permit Cr^{+6} to be stable for long distances due to geochemical equilibrium conditions within the groundwater system. In addition, due to the presence of the strong downward vertical flow component, the elevated contaminant (Cr^{+6}/cVOC) concentrations are present in the more permeable thin-sand deltaic zones just above the lower-boundary clay.

To assess the natural cVOC degradation pathways, groundwater analytical data along the center line of the plume were plotted for the primary parent and daughter compounds of PCE and TCE (Exhibit 4). Data indicate lower concentrations in the source zone than downgradient within the core of the plume. As the plume migrates, the data suggest abiotic degradation is the preferred pathway along the length of the plume from the source to the transition zone, with biotic degradation occurring under reducing conditions in the transition zone/discharge zone (Exhibit 4). The degradation pathway of the cVOCs should follow an abiotic and/or biotic pathway (Brown et al., 2007). The data suggest that the parent compounds of PCE and TCE go through limited degradation toward daughter products. This suggests that the degradation pathway may follow abiotic beta elimination over biotic degradation. The abiotic degradation pathway dominates cVOC degradation from the source zone to the geologic transition zone 2,000 feet downgradient. At the transition zone, degradation changes to the biotic degradation pathway, owing to the organic muck servicing as an electron donor, where daughter products are present in greater concentrations than parent products.

These data provide lines of evidence to develop a remedial strategy that mimics the natural plume degradation processes. The pilot studies are intended to evaluate if, by creating reducing conditions (injecting an organic carbon source), that chromium will shift toward the more stable, less toxic Cr^{+3} and to enhance the abiotic degradation of cVOC through the production of naturally occurring iron minerals in the formation. The study (especially in the source zone) identified the presence of low concentrations of iron in the groundwater; however, under reducing conditions there was a significant increase in iron concentrations owing to ferrogenic reduction. Leveraging the naturally occurring iron within the formation, by enhancing reducing conditions, could be used to abiotically degrade the cVOC simultaneously while reducing the Cr^{+6} within the plumes. These processes are further explored in two pilot studies discussed in the sections that follow. The data presented include a representative assessment of a deep monitoring well, located in the downgradient portion of the injection zone. A summary of all the data within and downgradient of the pilot is presented at the end of each pilot study.

SOURCE-ZONE (HRC/3DME) PILOT STUDY

As stated earlier, the goal of the source-zone pilot study was to evaluate whether cVOC and Cr^{+6} concentrations can be reduced by lowering the redox potential in the test zone through organic carbon injections. Prior to conducting the pilot study, various additives, including dextrose; Hydrogen Release Compound$_{\text{primer}}$/3-D Microemulsion (HRC/3DMe; Regenesis; San Clemente, California); black strap molasses, electron donor compound (EDC) by EcoCycle Corporation of Tokyo, Japan; and corn starch were evaluated to determine which product could deliver the highest concentration of biochemical oxygen demand (BOD), a surrogate measurement for reducing equivalency.

The results indicated that the highest BOD concentration was achieved using the additive blend HRC/3DMe (3,000 mg/L), followed by dextrose (1,550 mg/L), black strap molasses (1,050 mg/L), EDC (1,200 mg/L), and corn starch (445 mg/L). Based upon these results, HRC/3DMe was selected for the source-zone pilot study. HRC provides a short-term release of lactic acid and a source of hydrogen. This product promotes microbial activity and rapidly establishes reducing conditions. Regenesis Corporation indicated the product will promote these conditions over weeks. The 3DMe additive provides freely available lactic acid that is fermented rapidly. In addition, there are free fatty acids and polylactate esters that are metabolized at controlled rates and converted to hydrogen, providing an electron-donor source over a prolonged period of time. The vendor claims the polylactate esters provide hydrogen for 12 to 18 months whereas the fatty acid esters provide hydrogen for 18 to 48 months.

The source-zone pilot was located adjacent to and just downgradient of the process line and degreaser releases. Cr^{+6} concentrations within the pilot ranged from 0.41 to 2.53 mg/L in the upper portion of the deltaic unit to 2.32 to 3.91 mg/L in the lower portion. However, immediately upgradient of the pilot-study area, concentrations were reported as high as 38.2 mg/L within a sand stringer located within the silt-clay unit. The baseline TCE concentrations ranged from non-detect to 0.9 μg/L in the upper portion and 12 to 23 μg/L in the lower portion of the deltaic unit, whereas PCE concentrations ranged from 1.1 to 3.8 μg/L in the shallow and 42 to 87 μg/L in the deeper portion of the deltaic unit. The targeted injection zone was from 34 to 46 feet below grade. This interval was selected because of its location close to the source and potential mass flux that would migrate through the injection zone. One of the proposed remedies involves designing biogeochemical barriers where contaminated groundwater will migrate across the barrier resulting in reduced concentrations within the plume on the downgradient side. This concept would require supplemental injections to maintain the reducing conditions, so an evaluation of the life expectancy of the remedial effect is important to the overall design and cost implications.

The additive was injected through open GeoProbe^{TM} rods from the bottom to the top of the injection zone. The rods were driven to approximately 46 feet below grade using a knockout plug. Once at depth, 50 gallons of a proprietary mixture of HRC/3DMe and makeup water was injected in one-foot intervals. Once the 50 gallons were injected, the rods were pulled back one foot and the process repeated over the entire 12-foot treatment zone for a total of approximately 600 gallons per injection point. The injection rate was metered at 2 to 4 gallons per minute over an approximate 250-minute duration per point. The down-hole injection pressures were observed to range from 40 to 60 pounds per square inch (psi). Based upon design parameters, the injection volume represented approximately 3 to 7 percent by volume of the groundwater system's injection treatment zone, assuming a porosity of 25 percent. A total of six injection points were completed around three cluster performance wells. In general, the injections were located approximately 17 feet from a performance monitoring well, except one upgradient point, which was 12 feet from a well. The closer point was designed to evaluate the effects from injecting the additive closer to the performance well. In addition, three injection points surrounded the up- and downgradient performance wells, whereas only two injection points were used around the side of the third lateral performance wells.

The performance and adjacent monitoring wells were monitored during the injection to evaluate real-time changes in hydraulic head, specific conductance, temperature, salinity, pH, and ORP in an effort to evaluate the effective injection distribution zone within the groundwater system.

Six performance monitoring wells were installed at three locations within the proposed injection zone to supplement other adjacent monitoring wells. Three wells were installed within the upper portion of the contaminant zone, and three wells were installed within the lower deltaic unit, where the greatest concentrations were reported. The wells were constructed using 2-inch diameter, 5-foot long, 10-slot well screens with a sand pack extending 2 feet above the well screen. The remaining annulus was grouted to grade. These injection-zone performance wells (upgradient, lateral, and downgradient within the injection zone) along with adjacent existing monitoring wells were monitored for changes in short- and long-term groundwater quality. In addition, these wells were used to monitor field parameters during the injection to evaluate additive distribution and propagation patterns. The wells were developed prior to sampling baseline conditions and were redeveloped after the injection, due to silt accumulations.

The performance and adjacent monitoring wells were monitored during the injection to evaluate real-time changes in hydraulic head, specific conductance, temperature, salinity, pH, and ORP in an effort to evaluate the effective injection distribution zone within the groundwater system. Real-time field data identified changes in the geochemistry of groundwater in the performance wells within 200 to 230 minutes of initiating the injection. The presence of the additive in these wells suggests an effective initial injection radius of at least 17 feet. The results of the source-zone pilot have demonstrated that the HRC/3DMe additive blend was successful at reducing Cr^{+6} to Cr^{+3}, likely to chrome oxide (Cr^2O^3). Several lines of evidence show that the additive is still effective five years after the injection and continues to maintain a reducing environment despite significantly contaminated upgradient conditions.

The source-zone discussion is based upon data collected from (1) a downgradient well cluster (shallow and deep) within the injection zone and (2) a well located approximately 200 feet downgradient of the injection zone. Data collected from the other four

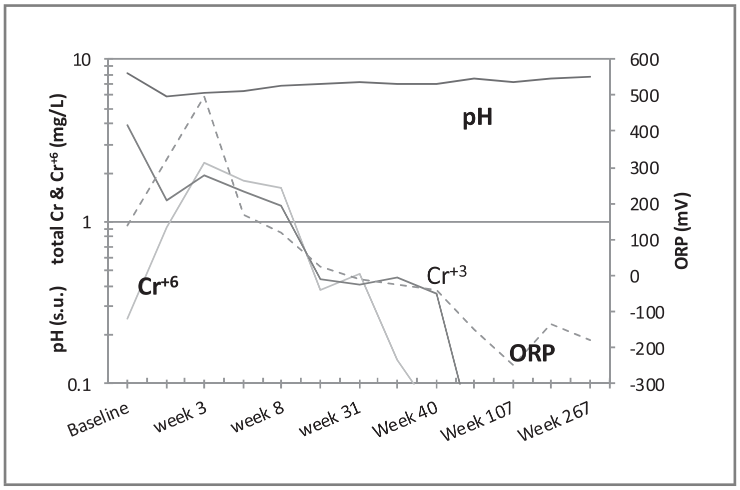

Exhibit 5. Changes in source zone geochemical parameters

monitoring wells in the injection zone (upgradient and lateral locations) are summarized at the end of this section.

Two primary geochemical factors that influence the equilibrium stability of chromium are pH and ORP (Exhibit 5). The deep injection zone pH baseline was reported at 8.3 s.u., whereas the ORP baseline was reported at 139.1 millivolts (mV). Chromium under these ORP/pH equilibrium conditions would favor the more toxic Cr^{+6}. The pH and ORP values of the HRC/3DMe were 2.2 s.u. and 434 mV. The study identified that initial groundwater pH decreased to 6.2 s.u. in week 3, apparently influenced by the pH of the additive. The values of pH fluctuated during the study and were reported at 7.7 s.u. or a decrease of 0.6 s.u. in pH, in week 267. The ORP initially increased from 139.1 mV to 499.5 mV in week 3 due to the high ORP of the additive, before then beginning to decrease. ORP values continued to decrease to its lowest value –249.2 mV in week 107 and then increased to –133.6 mV by week 267. The data reported during and at the end of the 267-week study suggest that chrome oxide would be the more stable form of chromium.

The highest initial total chromium concentration (Cr^{+3} and Cr^{+6}) was 3.91 mg/L in the deep deltaic zone. At week 3, Cr^{+6} was 2.32 mg/L, while total chromium was reported at 1.94 mg/L (difference in total chromium and Cr^{+6} is due to analytical method variability). This trend of Cr^{+6} being greater than total chromium continued until week 25, when total chromium (0.434 mg/L) was greater than Cr^{+6} (0.38 mg/L). At week 40, concentrations of Cr^{+6} were less than the detection limit of 0.01 mg/L and have remained below the detection limit through week 267 within the deep downgradient well of the injection zone. Total chromium has continued to decrease in concentration to 0.038 mg/L in week 267. Values of total chromium and Cr^{+6} were below the criteria specified in the remedial action plan.

The initial deep deltaic zone cVOC concentrations in the source zone (Exhibit 6) were less than the concentrations in the downgradient portion of the plume. The goal of these pilots was to demonstrate that *in situ* treatment of Cr^{+6} and cVOCs (Exhibit 6) could be achieved by injecting an organic carbon-based additive to create chemically reducing conditions. The baseline PCE concentration in groundwater was 42 μg/L and

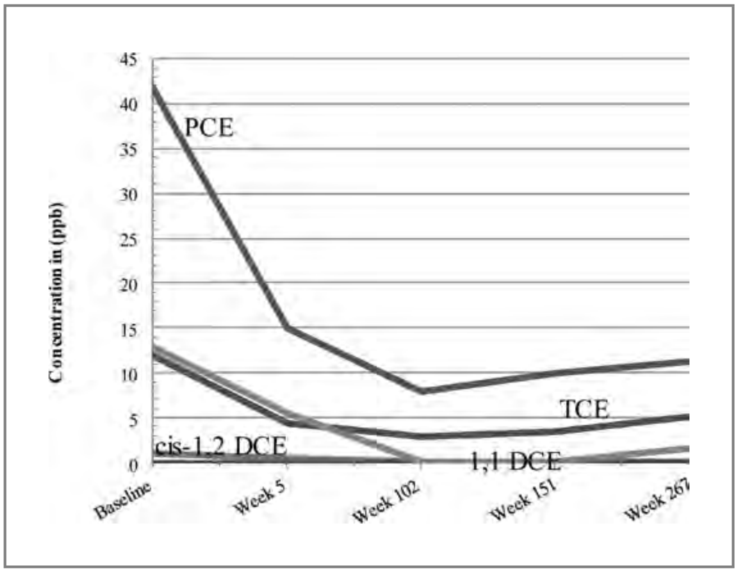

Exhibit 6. Deep deltaic cVOC source zone concentrations over time

was subsequently reduced to 7.9 μg/L (an 81 percent decrease) at week 102 then increased to 10 and 11.3 μg/L in weeks 151 and 267. Baseline TCE was 12 μg/L, subsequently reduced to 2.8 μg/L (a 77 percent decrease) at week 102, and increased to 3.5 and 5.0 μg/L in weeks 151 and 267. Baseline 1,1,1-trichloroethane (TCA) was 9.3 μg/L and was subsequently reported below the analytical detection limit of 0.5 μg/L (a 95 percent decrease) at weeks 102 through 267. Baseline *cis*-1,2-dichloroethene (*cis*-1,2-DCE) was 1.0 μg/L and was subsequently reported below the analytical detection limit of 0.5 μg/L at week 5 through 267. The lack of an increase in *cis*-1,2-DCE would further suggest that the cVOCs follow an abiotic degradation pathway due to the absence of a known daughter product. The slight increase in PCE and TCE concentrations at weeks 102 through 267 also corresponds with a net decrease in iron concentrations. This may suggest that cVOC concentrations are related to the presence of dissolved (available iron) iron due to the chemically reducing conditions. The upgradient concentrations of PCE, TCE, TCA, and *cis*-1,2-DCE were 48, 24, 74, and 84 percent, respectively lower at week 267. Thus, the percentage change in the pilot is likely skewed high based upon the influent groundwater entering the pilot-study area; however, the difference between the influent- and injection-zone results indicates a reduction in cVOCs.

Under terminal electron acceptor utilization during organic carbon metabolism, methanogenesis is the final stage. The 267-week study supports that chemically reducing conditions were present in the downgradient portion of the injection zone (Exhibit 7). The greatest concentrations of cVOCs and Cr^{+6} in the deep deltaic zone were reported within the lower portion of the injection zone. The following changes within the lower zone were observed: (1) a 95 percent decrease in DO concentration (3.2 to 0.2 mg/L) was reported at week 107, and the DO rebounded to 1.3 mg/L, or 60 percent less than the baseline at week 267; (2) dissolved iron concentrations increased 40 times in week 40 (0.036 to 1.41 mg/L), and decreased to 0.115 mg/L, or 220 percent greater than baseline at week 267; (3) a 72-times decrease in nitrate concentration (3.62 to 0.05 mg/L) was reported in week 5, and increased to 2.41 mg/L, or 35 percent less than baseline at week

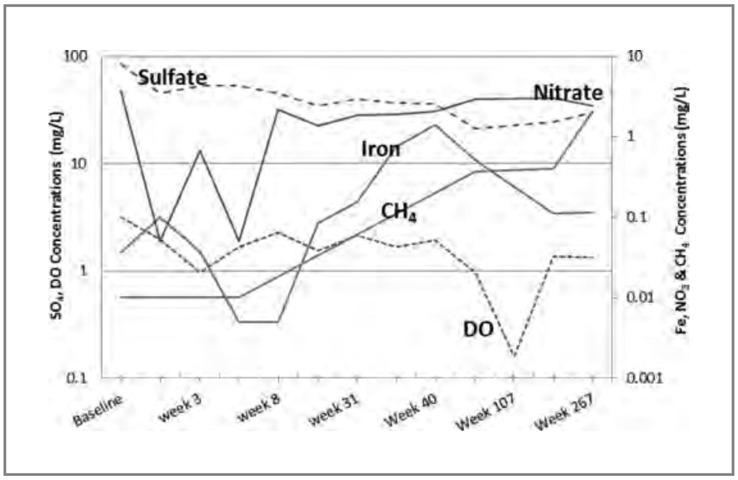

Exhibit 7. Inorganic and methane data over time in downgradient position of injection zone

267; (4) a 75 percent decrease in sulfate concentration was reported in week 102 (84.4 to 21.1 mg/L), and increased to 29.8 mg/L or 65 percent less than baseline in week 267; (5) methane was not detected until week 102 when the methane concentration was reported at 0.37 mg/L and increased to 2.05 mg/L by week 267. These data suggest that methanogenesis was initiated between weeks 40 and 102 and has continued through week 267 in the deeper injection zone (lower portion of the deltaic unit).

The primary parameter used to select the injection additive for the pilot study during the initial screening was BOD. The baseline deep groundwater concentrations reported in the pilot for total organic carbon (TOC) and BOD were less than the analytical reporting limit of 1.0 mg/L (Exhibit 8). The TOC concentration increased to 220 mg/L at the end of week 3, 80 mg/L at week 5, 21.7 mg/L at week 8, 38 mg/L at week 25, and subsequently to 6.0 mg/L in week 267. BOD increased to 46 mg/L in week 3 and 5, decreased to 3 mg/L in week 7, increased to 34 mg/L in week 8, and subsequently decreased to 7 mg/L in week 267. The decrease in week 7 may have been due to the decrease in short-term lactic acid (HRC), whereas the increase in week 25 could be attributed to the increase in free fatty acids and fatty acid esters associated with the 3DMe.

Shallow-zone baseline monitoring well TOC concentrations were reported at 1.2 mg/L, which increased to 120 mg/L at week 3, with a concentration of 3.37 mg/L in week 151. Baseline BOD values were reported less than the reporting limit of 1.0 mg/L and increased to 44 mg/L at week 3, and decreased to below the reporting limits in weeks 25 through 102 with an increase in week 151 with a concentration of 6 mg/L. The baseline pH value was 8.5 s.u., which was reduced to 6.7 s.u. in week 5 then increased to 7.3 s.u. in week 267. The baseline value of ORP was 107.2 mV and was reduced to –154.4 mV, –199.8 mV, and –101.3 mV, respectively, in weeks 102, 107, and 151 with an increase to 25.6 mV in week 267. The baseline Cr^{+6} concentration was reported below the reporting limit of 0.25 mg/L, increased to 0.41 mg/L at week 3, and decreased to below the reporting limit of 0.01 mg/L at week 151, and then increased to 0.28 mg/L at week 267. The baseline total chromium concentration was 0.41 mg/L and subsequently

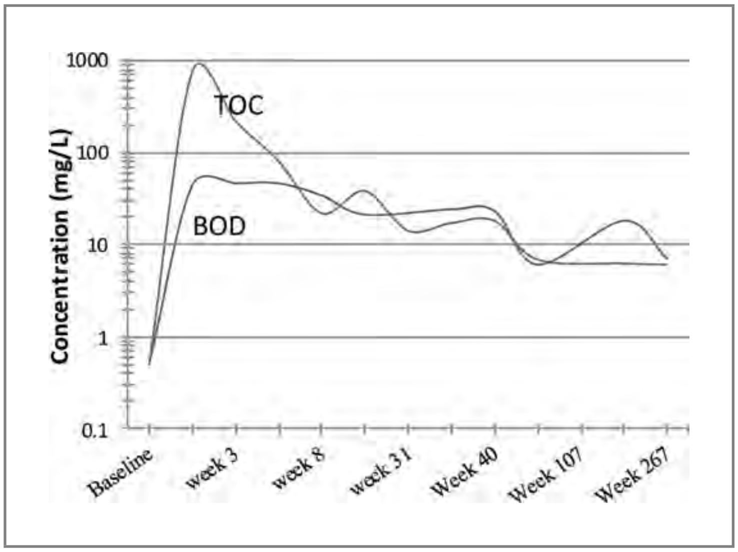

Exhibit 8. TOC and BOD concentrations in deep source zone over time

decreased to 0.04 mg/L at week 151. By week 151, both Cr^{+6} and total chromium concentrations were below the regulatory criteria.

The DO concentrations within the shallow injection-zone well were lower than the deeper injection zone; however, similar reductions were observed through week 151. Baseline DO concentrations decreased from 7.9 mg/L to 0.2 mg/L by week 102, and increased to 1.3 mg/L at week 151 and 3.7 mg/L at week 267. Baseline iron concentrations increased from 0.013 mg/L to 0.234 mg/L by week 151. Baseline nitrate concentrations decreased from 4.93 mg/L to below the reporting limit of 0.05 mg/L in week 5, and increased to 0.23 mg/L at week 151. Baseline sulfate concentrations increased during the study from 11.8 mg/L to 171 mg/L at week 267. Methane was not detected in the baseline sampling and was reported at 0.150 mg/L at week 267.

At a deep deltaic unit well, located approximately 200 feet downgradient of the HRC/3DMe injection zone, reductions in Cr^{+6} and cVOC concentrations can be contributed from contaminant reductions from the pilot-study area. Based upon the seepage velocity, the additive injected at the source zone should have migrated 250 to 375 feet over the 267-week study. The concentration of Cr^{+6} decreased from 860 to 357 μg/L (58 percent), and total chromium was reduced from 1,050 to 338 μg/L (68 percent). The concentration of PCE decreased from 23 to 11.7 μg/L (49 percent), TCE decreased from 8.3 to 3.6 μg/L (57 percent), TCA decreased from 9.4 to 2.3 μg/L (76 percent), and *cis*-1,2-DCE decreased below the reporting limits of 0.5 μg/L. However, pH increased from 7.5 to 8.1 s.u., and ORP increased from 48 to 148 mV.

A summary of the Cr^{+6} and cVOC results for those wells within and downgradient of the pilot-study area are presented in Exhibit 9. These data show that Cr^{+6} reductions ranged from 32 to 99 percent and that total chromium reductions ranged from 67 to 99 percent.

Exhibit 10 presents the changes in PCE, TCE, and *cis*-1,2-DCE. Reductions in PCE concentrations ranged from 0 to 94 percent, TCE concentrations increased (14 percent) at one of the six injection-zone monitoring wells and decreased up to 94 percent at the

Exhibit 9. Changes in source zone pre/post chromium concentrations

	Cr^{+6} (mg/L)			Total Cr (mg/L)		
Well ID	**Pre**	**Post**	**%**	**Pre**	**Post**	**%**
Shallow—upper central pilot	2.53	0.36	(86)	2.13	.39	(82)
Shallow—lateral of pilot	0.52	0.03	(94)	0.63	<0.01	(98)
Shallow—lower central pilot	0.41	0.28	(32)	0.41	0.04	(90)
Deep—upper central pilot	3.91	<0.01	(99)	3.06	0.03	(99)
Deep—lateral of pilot	3.78	0.11	(97)	2.99	0.14	(95)
Deep—lower central pilot	2.32	<0.01	(99)	3.91	0.03	(99)
200′ downgradient of pilot	1.09	0.36	(67)	1.05	0.34	(67)

< = non-detect.

( ) = negative reductions.

Exhibit 10. Changes in source zone pre/post chlorinated VOC concentrations

	PCE (μg/L)			TCE (μg/L)			*cis*-DCE (μg/L)		
Well ID	**Pre**	**Post**	**%**	**Pre**	**Post**	**%**	**Pre**	**Post**	**%**
Shallow—upper central pilot	2.8	2.4	(14)	0.7	0.8	14	<1.0	<0.25	ND
Shallow—lateral of pilot	3.8	<0.25	(94)	0.9	<0.25	(72)	<1.0	<0.25	ND
Shallow—lower central pilot	1.1	1.1	0%	<1.0	<0.25	ND	<1.0	<0.25	ND
Deep—upper central pilot	87	5.3	(94)	23	1.2	(94)	1.9	3	60
Deep—lateral of pilot	63	46	(27)	16	6.2	(61)	1.6	<0.25	(84)
Deep—lower central pilot	42	11.3	(73)	12	5	(58)	1	<0.25	(75)
200′ downgradient of pilot	33	11.7	(65)	12	3.6	(70)	<0.5	<0.5	ND

< = non-detect.

( ) = negative reductions.

other wells (see Exhibit 10), whereas, *cis*-1,2-DCE generally did not change except for an increase of 60 percent in one well and a decrease to 84 percent at another.

MICROCOSM STUDY

The HRC/3DMe initial field pilot study was successful; however, given the extent of the plume, it was decided to perform a more detailed evaluation of alternative additives to determine if a less expensive additive could provide a comparable level of success. To assess comparable organic carbon–based additives, a microcosm study (Spectrum Analytical, Inc., 2009) was conducted to evaluate a series of potential additives to determine which one should be injected into the second pilot-study area. An initial screening was performed to select the most promising two additives to conduct an expanded microcosm study. In the screening and microcosm studies, the additives were mixed with two representative groundwater samples from the plume. The groundwater samples consisted of low concentrations of cVOCs and Cr^{+6}(sample A) and high concentrations of cVOCs and Cr^{+6}(sample B).

The additives evaluated under the initial screening study included dextrose, fructose, sucrose, food-grade molasses (with condensed whey solution), whey, and a mixture of HRC/3DMe. These additives were mixed with 300 milliliters of groundwater from Sample A and Sample B at 50 percent of their solubility, whereas the HRC/3DMe was mixed based upon the proprietary mixture used during the first pilot study. Once mixed, the samples were allowed to sit overnight, and an aliquot was taken from each mixture and analyzed for BOD, TOC, DO, pH, ORP, conductivity, and temperature.

The HRC/3DMe initial field pilot study was successful; however, given the extent of the plume, it was decided to perform a more detailed evaluation of alternative additives to determine if a less expensive additive could provide a comparable level of success.

The results of the screening study suggested that the highest BOD and TOC values were reported for fructose and sucrose. Molasses reported the lowest pH values with the next highest BOD and TOC values. Because fructose and sucrose were similar, simple sugars and molasses was slightly more complex, fructose and molasses were selected for the full microcosm study. For comparison purposes, the HRC/3DMe reported lower values for BOD, TOC, and pH.

For the microcosm study, the additives were again mixed with site groundwater samples A and B. However, due to low groundwater heterotrophic plate counts (HPC), site sediment (50 g) was mixed with the sample to potentially increase the microbial population. The microcosm study was conducted over an eight-week period and sampled at weeks 2, 4, 6, and 8. A sample aliquot was extracted from each microcosm for chemical analysis, including total chromium, Cr^{+6}, iron, manganese, ferrous iron, nitrate, nitrite, sulfate, sulfite, DO, and HPC. In addition, the volume of gas production (assumed to largely be a combination of CO_2 and methane) from each microcosm was measured.

The analytical results from the microcosm were compared to the baseline groundwater concentrations for samples A and B to determine changes during the microcosm study. The goal was to evaluate which additive would produce sufficient redox reactions to reduce Cr^{+6}. This reductive process was expected to decrease DO concentrations, increase iron concentrations, decrease nitrate and sulfate concentrations, and increase gas production. The concentration of DO decreased to less than 1 mg/L for both additives in both groundwater samples. A greater increase in iron concentrations was reported with the molasses, likely because the molasses contained iron. Nitrate concentrations were reduced with fructose and increased with molasses. Sulfate concentrations increased in groundwater sample A and decreased in groundwater sample B for fructose and increased for both samples for molasses. The production of gas was greater and more prolonged with molasses than fructose. It is worth noting that the molasses additive yielded a higher sulfate concentration. Molasses had other favorable characteristics, including greater concentrations of manganese, lower pH, and lower ORP values. BOD values were higher in groundwater sample A with fructose but were comparable in both of the groundwater sample B microcosms.

Molasses consistently yielded the lowest ORP and pH values and the greatest increase in HPC. Considering the oxidized nature of the release and buffering capacity of the geologic units, the reduced pH and ORP conditions posed by the molasses were deemed positive. The molasses microcosm resulted in Cr^{+6} concentrations below the reporting limits and, therefore, the regulatory criteria for two of the four sampling periods. Molasses consistently yielded higher ferrous iron concentrations than fructose, a potential critical factor for abiotic degradation of cVOC. The molasses also consistently yielded the greatest total heterotrophic population density throughout the study. Fructose was more successful in decreasing nitrate concentrations and had mixed results in reducing sulfate concentrations (more successful within Sample B). Molasses consistently resulted in higher nitrate and sulfate concentrations likely due to their content in the molasses.

One issue with molasses was the elevated sulfate concentration, which was not present in the fructose. However, the benefits of having Cr^{+6} reported below the analytical reporting limit and regulatory criteria, along with lower pH and ORP values, the greater population density of bacteria, more consistent production of gas, and significant increase in iron concentrations, made molasses the additive of choice for the second pilot.

DOWNGRADIENT (MOLASSES) PILOT STUDY

To evaluate whether molasses could be as effective as HRC/3DMe, a second full-scale pilot study was implemented. Chemical data identified that the contaminants were located in a thin portion of the groundwater system approximately 62 to 72 feet below grade in the selected pilot-study area (Exhibit 1). The distribution of Cr^{+6} and cVOC was consistent with the source zone. Concentrations of Cr^{+6} were greater in the deeper well-screen than the shallow well-screen intervals (7.25 vs. 0.18 mg/L). The pilot was conducted over a 183-week period. The data presented include a representative assessment of the deep monitoring wells within the pilot-study area.

To assess performance in and downgradient of the injection zone, additional monitoring wells were installed. Given the approximately 10-foot thickness of the treatment zone, one paired-well cluster and one single-screened well were installed within the injection zone. An additional downgradient well was installed 40 to 70 feet from the injection points to evaluate additive propagation effects from the injection. A total of 46 gallons of molasses was injected per foot, at a rate of 6 gallons per minute, totaling 3,721 gallons of molasses within eight points. The increase in viscosity and depth of the molasses injection appears to have contributed to an increase in injection pressures (75 to 85 psi) over the 40 to 60 psi used in the source-zone pilot study. In addition, based on the field data collected (pH, ORP, temperature, and conductivity) during the injections, the distribution was not as uniform as the source-area injections. The field data collected at adjacent wells during the injection suggest a more elliptical north/south injection pattern. The direction of the distribution appears to be consistent with the depositional environment and heterogeneity of the formation materials.

The data for the deep portion of the injection zone indicated a baseline pH of 8.7 s.u. and a baseline ORP of 12.6 mV (Exhibit 8). The pH decreased to 4.2 s.u. in week 14, and increased to 4.8 and 7.1 in weeks 66 and 183, respectively (Exhibit 11). The pH of the injected molasses was 4.1 s.u. ORP values decreased to –32.6 mV in week 4, increased to 55.9 mV in week 22, and decreased to –180 mV and –112.3 mV in weeks 66 and 183, respectively. The negative ORP values reported in week 66 through 183 also corresponded with reductions of sulfate concentrations and production of methane. These reducing conditions resulted in a rapid decrease in Cr^{+6} concentrations from the baseline of 7.27 mg/L to below reporting limits of 0.5 mg/L at weeks 4 through 66 and 0.058 mg/L at week 183. The baseline concentration of total chromium was 5.92 mg/L

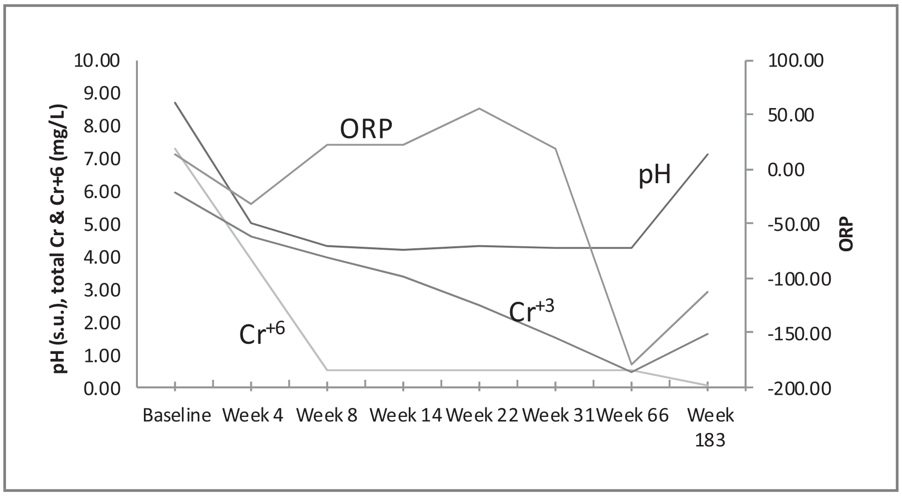

Exhibit 11. Changes in downgradient geochemical parameters

(difference between Cr^{+6} and total chromium is due to analytical method variability), which was reduced to 0.464 mg/L at week 66, and increased to 1.62 mg/L at week 183. The data indicated that while the hexavalent chromium was reduced below regulatory criteria, total chromium was not. The redox reduction of chromium appears to have converted the Cr^{+6} to Cr^{+3} but was insufficient to fully reduce the soluble Cr^{+3} as a precipitate onto the soil matrix. This condition could be related to the presence of sulfate in the molasses acting as an electron acceptor and/or that additional molasses was required to achieve Cr^{+3} precipitates. In addition, the duration of negative ORP values with the molasses-based pilot study were less (152 weeks) than were reported with the HRC/3DMe-based pilot study (236 weeks).

Groundwater samples were collected for cVOCs during baseline and at week 183. These data identified no significant changes in PCE concentrations (320 to 291 μg/L) and a slight increase in TCE concentrations (370 to 445 μg/L). TCA was reduced from 12 to 0.6 μg/L, and *cis*-1,2-DCE had a slight change from 12 to 8 μg/L. These data suggest that even though iron concentrations were more elevated with the molasses than the HRC/3DMe, the reduction in cVOCs was not as great. The changes in cVOC concentrations also correlated well with the changes in PCE, TCE, TCA, and *cis*-1,2-DCE reported in the upgradient groundwater entering the pilot study zone. Thus, while Cr^{+6} was reduced in the pilot study, cVOC concentrations did not appear to have significantly changed.

The deep well-screen data (Exhibit 12) identified: (1) a 99 percent reduction in DO through week 66 (1.6 to 0.01 mg/L), which rebounded to 0.2 mg/L in week 183; (2) baseline total iron increased from 0.52 mg/L to 165 mg/L in week 14, and decreased to 23.5 and 0.34 mg/L in weeks 66 and 183, respectively (one contributing factor for the increase in iron could be that the molasses injected had an iron concentration of 200 mg/L); (3) nitrate was reduced from 2.61 mg/L to below the reporting limit of 0.05 mg/L in week 8 through 31, and increased to 0.53 and 1.72 mg/L in week 66 and 183, respectively; (4) sulfate increased from 380 to 4,840 mg/L in week 4, and decreased

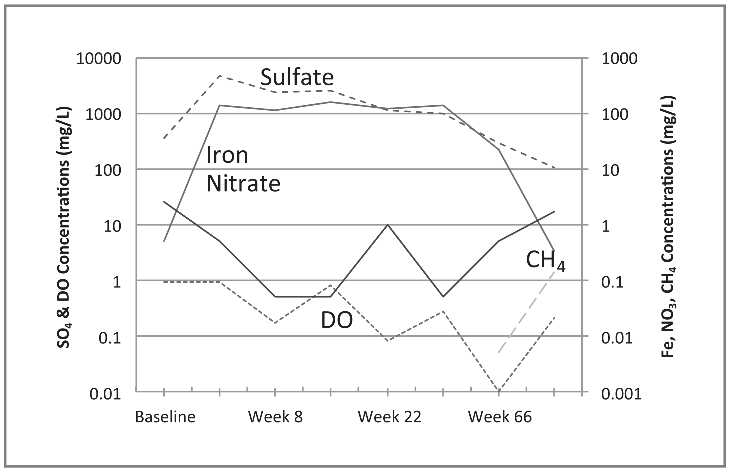

Exhibit 12. Inorganic and methane concentrations over time in deep well screen samples

to 304 mg/L in week 66 and 112 mg/L in week 183 (the increase in sulfate was also likely a result of the sulfur content of the molasses); and (5) methane was not analyzed until week 66 with a reported concentration below the reporting limit of 0.01 mg/L and was detected at 0.14 mg/L in week 183. The presence of methane at week 183 would suggest that sulfate was reduced below baseline conditions during week 66, with a 71 percent reduction from baseline in week 183. Thus, once sulfate-reducing conditions were achieved, methanogenesis began.

The reported TOC and BOD values in the deeper zone were greater in the molasses pilot study than the source-zone pilot study. The TOC baseline value was less than the reporting limit of 1.0 mg/L and increased to 26,000 mg/L in week 8 and reduced to 6,980, 4.99, and 13 mg/L in weeks 31, 66, and 183, respectively. The BOD baseline concentration was less than the reporting limit of 1.0 mg/L and increased to 90,900 mg/L in week 8 and reduced to 2,400, 620, and 28 mg/L in weeks 31, 66, and 183, respectively. The pilot study concentrations of BOD were greater than the microcosm study. These data suggest that a sufficient organic carbon source was injected to create reducing conditions.

In general, the DO concentrations within the deep injection zone were greater than reported within the shallow injection zone. Baseline DO concentrations were reduced from 8.9 mg/L to 1.6 mg/L in week 2, and increased to 5.3 mg/L (week 4), 9.4 mg/L (week 8), and a final 7.8 mg/L at week 183. Baseline iron concentrations increased from 0.009 mg/L to 0.038 mg/L in week 8, and decreased to below reporting limits (0.01 or 0.05 mg/L) in weeks 22 through 183. The baseline nitrate concentration was 0.94 mg/L, and varied between 0.44 mg/L (week 183) and 1.25 mg/L (week 4). The baseline sulfate concentration was 26.4 mg/L and varied between 17.1 mg/L (week 183) and 38.2 mg/L (week 4). Methane was not detected above detection limits during post-injection sampling.

Baseline TOC concentrations in the shallow zone were below the 1.0 mg/L reporting limit and varied between 4.5 mg/L (week 8) and below reporting limits through week 31 and then increased to 460 mg/L at week 66 and below reporting limits at week 183.

Exhibit 13. Changes in downgradient pre/post chromium concentrations

	Cr^{+6} (mg/L)			Total Cr (mg/L)		
Well ID	**Pre**	**Post**	**%**	**Pre**	**Post**	**%**
Shallow—Center of pilot	0.18	< 0.01	(94)	0.152	< 0.01	(93)
Shallow—Lateral extent	0.42	0.82	95	0.374	0.84	125
Deep—Center of pilot	7.27	0.06	(99)	5.92	1.62	(9)
70′ downgradient of pilot	1.52	0.56	(63)	1.83	0.60	(52)

< = non-detect.

( ) = negative reductions.

Baseline BOD values were reported less than the reporting limit and remained below that limit except for week 14 (4 mg/L). The baseline pH value was 9.1 s.u. and varied between 7.5 s.u. (week 66) to 9.2 s.u. (week 22). The baseline ORP value was 69.8 mV; the ORP then increased to 98.3 mV and 79.8 mV (weeks 2 to 8) then varied with a low of –40.6 mV at week 183. The baseline Cr^{+6} concentration was not detected above the reporting limit of 0.18 mg/L and increased to 0.38 mg/L at week 4, and decreased to below the reporting limit of 0.01 mg/L between week 14 and 183, except for week 31, with a concentration of 0.29 mg/L. The baseline total chromium concentration was 0.15 mg/L, increased to 0.26 mg/L in week 4, and then was below reporting limits of 0.01 mg/L in weeks 14 through 183, except week 31 (0.26 mg/L).

While shallow well-screen chromium concentrations were below regulatory criteria, the redox parameters were not consistent with the deeper well-screen results. These findings likely represent that the additive concentration reaching the upper well screen was less than for the lower well screen. This distribution of injected molasses was likely influenced by the heterogeneity of the deltaic unit and may indicate a lower permeable zone in the upper contaminant zone than the lower contaminant zone. This is consistent with the Cr^{+6} concentrations reported in the deep zone (7.27 mg/L) versus concentrations reported in the upper Cr^{+6} zone (below the reporting limit of 0.18 mg/L). Additionally, the molasses viscosity was greater than the HRC/3DMe, which likely influenced additive distribution.

At the downgradient monitoring well located 40 to 70 feet from the injection points, chemically reducing conditions were also observed. Based on the seepage velocity, treated groundwater in the treatment zone would have migrated approximately 175 to 265 feet. The downgradient Cr^{+6} concentration was reduced from 1.52 mg/L to 0.56 mg/L (63 percent) and the total chromium concentration was reduced from 1.83 to 0.61 mg/L (67 percent). The pH decreased from 8.8 to 8.0 s.u., and ORP was reduced from 102.9 to –51.5 mV. The data also indicate reductions in cVOC concentrations. PCE concentration decreased from 88 to 42.2 μg/L (52 percent) and TCE from 150 to 68 μg/L (55 percent). TCA and *cis*-1,2-DCE concentrations were below the reporting limit pre- and post-injection (3.5 years). The reduction in cVOC observed in the downgradient well suggests that cVOC reduction occurred in the injection zone. However, since no cVOC samples were analyzed during the pilot, the reductions in the

Exhibit 14. Plume-zone results: PCE, TCE, and *cis*-DCE

	PCE (μg/L)			TCE (μg/L)			*cis*-DCE (μg/L)		
Well ID	**Pre**	**Post**	**%**	**Pre**	**Post**	**%**	**Pre**	**Post**	**%**
Shallow—Center of pilot	17	<5.0	(70)	17	<5.0	(70)	<0.5	<5.0	ND
Shallow—Lateral extent	14	49.1	250	21	71.6	240	<0.5	0.8	ND
Deep—Center of pilot	320	291	(9)	370	445	20	<12	8	ND
70′ downgradient of pilot	88	42.2	(52)	150	68	(54)	<2.5	0.6	ND

< = non-detect.

( ) = negative reductions.

downgradient well were likely from the reduced conditions in the pilot. The cVOC concentrations reported in the injection zone at the end of the pilot likely reflected upgradient contamination migrating into the pilot zone. Thus, the amount of additive injected after 187 weeks was not sufficient to maintain the reducing conditions to treat cVOC influx. The reductions observed in the downgradient well are similar to reductions reported in the first pilot study.

A summary of the chromium data for the wells in and downgradient of the pilot-study area are presented in Exhibit 13. These data show that Cr^{+6} reductions ranged from 32 to 99 percent and that total chromium reductions ranged from 67 to 99 percent.

Exhibit 14 presents the changes in PCE, TCE, and *cis*-1,2-DCE concentrations. Reductions in PCE concentration ranged up to 94 percent, and TCE concentration increased at one location and was reduced up to 94 percent at another, whereas, the *cis*-1,2-DCE concentration generally did not change except for an increase of 60 percent at one well and a decrease of 84 percent at another well.

CONCLUSIONS

The introduction of an organic carbon source into the commingled plume effectively reduced the more toxic Cr^{+6} to the less toxic, more stable Cr^{+3}, along with a reduction in cVOC concentrations. In the HRC/3DMe pilot study, both Cr^{+6} and total chromium concentrations decreased below the analytical method detection limits and regulatory criteria; however, at the downgradient molasses pilot study, only the Cr^{+6} was reduced below analytical method detection limits and regulatory criteria. The reduction in cVOCs ranged from 25 to 95 percent in the HRC/3DMe pilot study, and variable reductions were observed in the downgradient molasses pilot study. Data downgradient beyond the HRC/3DMe pilot identified a 65 to 70 percent reduction in Cr^{+6} and total chromium concentrations and a 65 to 70 percent reduction in cVOC concentrations, whereas, downgradient of the molasses pilot, there was a 60 to 65 percent reduction in Cr^{+6} and total chromium and a 50 to 55 percent reduction in cVOC concentrations.

Several formation and additive issues were identified that will need to be resolved before developing a final remedial design. The oxidizing effect of the release resulted in elevated ORP levels and increased pH with depth. Both molasses and HRC/3DMe were effective in reducing Cr^{+6} concentrations; however, the HRC/3DMe appeared to be somewhat more effective in reducing the Cr^{+3} to a precipitate that can be rendered immobile in the formation. This may be due to the extended period of reducing conditions observed with this product over molasses. The molasses injection resulted in higher TOC and BOD values both initially and at 187 weeks. The greatest values of TOC and BOD likely contributed to quicker reduction in chromium concentrations. The cVOCs were more effectively reduced, with the HRC/3DMe potentially related to an increase in dissolved iron from the formation. The molasses injection produced higher iron concentrations (perhaps due to the iron in the molasses); however, no significant changes in cVOC were observed. This may be due to the type of iron (potentially elemental iron) present in the molasses. Greater iron increases were reported during the first pilot with reduced cVOC concentrations. At the end of each pilot, iron concentrations were less than background values in the molasses pilot, and approximately one order of magnitude above background levels in the HRC/3DMe pilot. These data suggest that reducing conditions were effective in shifting Cr^{+6} to Cr^{+3} and decreasing cVOC concentrations, provided that reducing conditions are maintained for an extended period of time and that chemically reduced iron remains elevated for a longer period of time. Site data suggest that the preferred cVOC degradation pathway within the pilot-study areas was abiotic. However, after the introduction of an organic carbon additive, there were limited increases in daughter products, suggesting some biotic degradation.

The next steps involve further delineation of the thin transmissive units to design an effective injection treatment program. In addition, studies will be completed to evaluate the presence of fatty acids and iron and sulfate reducers. Another study will evaluate the effects of adding an iron amendment to enhance cVOC reduction. The long-term goal is to create the geochemical conditions conducive for transforming Cr^{+6} and cVOCs.

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