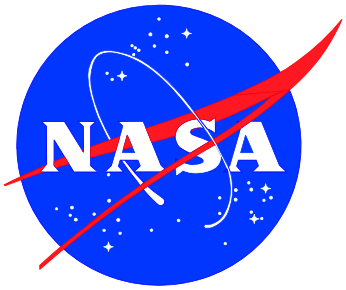
MOBILE LAUNCH PLATFORM/VEHICLE ASSEMBLY BUILDING AREA
(SWMU 056)
HOT SPOT 3 BIOREMEDIATION INTERIM MEASURES WORK PLAN
KENNEDY SPACE CENTER, FLORIDA

Prepared for:



National Aeronautics and Space Administration
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CERTIFICATION AND APPROVAL

I hereby certify that in my professional judgment this document entitled: *Mobile Launch Platform/Vehicle Assembly Area (SWMU 056) Hot Spot 3 Bioremediation Interim Measures Work Plan* generally satisfies the requirements set forth in Chapter 471, Florida Statues. I have completed and/or been in responsible charge of work completed by qualified professionals working directly under my supervision.

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ABBREVIATIONS AND ACRONYMS

10xNADC	ten times the Natural Attenuation Default Concentration
ADP	Advanced Data Package
CVOC	chlorinated volatile organic compound
cDCE	*cis*-1,2-dichloroethene
CCR	Construction Completion Report
cm^2	square centimeters
CMD	Corrective Measures Design
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
Dhc	*Dehalococcoides*
DNAPL	dense non-aqueous phase liquid
DPT	direct-push technology
DO	dissolved oxygen
EE	Engineering Evaluation
ESTCP	Environmental Security Technology Certification Program
ft BLS	feet below land surface
ft/yr	feet per year
FDEP	Florida Department of Environmental Protection
gpm	gallons per minute
gene copies/L	gene copies per liter
Geosyntec	Geosyntec Consultants
IM	interim measures
IMWP	Interim Measures Work Plan
KSC	Kennedy Space Center
KSCRT	KSC Remediation Team
L	liters
LTM	long term monitoring
µg/L	micrograms per liter
mg/L	milligrams per liter
MLP	Mobile Launch Platform
MLPV	Mobile Launch Platform/Vehicle Assembly Building
MNA	monitored natural attenuation
NASA	National Aeronautics and Space Administration
NADC	Natural Attenuation Default Concentration
ORP	oxidation reduction potential
psi	pounds per square inch
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation

ABBREVIATIONS AND ACRONYMS (continued)

ROI	radius of influence
SWMU	Solid Waste Management Unit
SZ	source zone
tDCE	*trans*-1,2-dichloroethene
TCE	trichloroethene
UIC	Underground Injection Control
TOC	total organic carbon
VAB	Vehicle Assembly Building
VABRA	VAB Reassessment Area
VC	vinyl chloride
vcrA	vinyl chloride reductase gene

SECTION I

INTRODUCTION

1.1 OVERVIEW

This document presents the design details for an Interim Measures (IM) Work Plan (IMWP) for implementation in Hot Spot 3 at the Mobile Launch Platform/Vehicle Assembly Building (MLPV) Area, located at the John F. Kennedy Space Center (KSC), Florida. The MLPV Area has been designated Solid Waste Management Unit Number 056 (SWMU No. 056) under KSC's Resource Conservation and Recovery Act (RCRA) Corrective Action program. This report was prepared by Geosyntec Consultants (Geosyntec) for the National Aeronautics and Space Administration (NASA) under contract number NNK12CA13B/NNK13CA23T and project control number ENV 1642. The Advanced Data Package (ADP) presentation covering the elements of this IMWP received KSC Remediation Team (KSCRT) approval at the April 2016 Team Meeting; the meeting minutes are included in Appendix A.

1.2 PURPOSE

This IMWP presents an approach and design for the remediation of chlorinated volatile organic compound (CVOC) groundwater impacts using bioremediation (biostimulation and bioaugmentation) in Hot Spot 3, which is defined by the area where CVOC (trichloroethene [TCE], *cis*-1,2-dichloroethene [cDCE], and vinyl chloride [VC]) concentrations are greater than 10 times their respective Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration (NADC) [10xNADC] near the western Mobile Launch Platform (MLP) structure. The IM treatment area is the Hot Spot 3 area, which is approximately 0.07 acres and extends from approximately 6 to 22 and 41 to 55 feet below land surface (ft BLS). Within Hot Spot 3, a source zone (SZ; area with TCE concentrations greater than 1% solubility [11,000 micrograms per liter (µg/L)]) was delineated and is approximately 0.02 acres and extends from approximately 6 to 16 and 41 to 50 ft BLS.

1.3 INTERIM MEASURES OBJECTIVE

The IMWP's objective for MLPV Hot Spot 3 is to provide treatment of CVOC groundwater impacts above their respective 10xNADC to reduce CVOC concentrations within the treatment area to concentrations that enable a transition to monitored natural attenuation (MNA).

1.4 INTERIM MEASURES WORK PLAN ORGANIZATION

The remainder of this MLPV IMWP is organized as follows:

Section II: *Site Conditions* – This section provides a brief description of the site setting and summarizes the existing groundwater impacts.

Section III: *Bioremediation Design* – This section provides specific details of the bioremediation injection activities.

Section IV: *Performance Monitoring* – This section provides specifics of the groundwater monitoring activities that will be performed as part of the IM.

Section V: *Interim Measures Reporting* – This section provides a brief description of the documentation and reporting activities to be completed to support the IMWP.

Section VI: *Implementation Timeline, Exit Strategy, and Costing* – This section provides specific details about the exit strategy for the IM, cost for implementation of the IM and the estimated timeline for implementing the IM.

Section VII: *Environmental Impact Analysis* – This section provides a summary of the environmental impact analysis conducted using SiteWise™.

Section VIII: *References* – This section provides the references for the citations in this report.

SECTION II

SITE CONDITIONS

2.1 OVERVIEW

The following subsections provide a brief description and history of the MLPV Area with a focus on the results pertinent to the IM. A detailed description of site history, operations, investigations and analytical results are contained in the following documents: RCRA Facility Investigation (RFI) Report, Revision 2 [NASA 2000], RFI Addendum Report [NASA 2003], Corrective Measures Study (CMS) Report [NASA 2004a], Corrective Measures Design (CMD) Report [NASA 2004b], Vehicle Assembly Building (VAB) Reassessment Area (VABRA) 2015 Environmental Conditions Assessment Report [NASA 2015a], 2015 Corrective Measures Implementation (CMI) and IM Annual Report [NASA 2015b], and 2016 CMI Progress Report [NASA 2016].

2.2 LOCATION AND DESCRIPTION

The MLPV Area is located within KSC on the east-central Atlantic Coast of Florida on Merritt Island in Brevard County (Figure 2-1). The MLPV Area is located within Sections 7, 8, 17, and 18 of Township 22 South, Range 37 East, as shown on the Orsino, Florida Quadrangle map (United States Geological Survey [USGS] 1976; Figure 2-2).

The MLPV facilities were originally built to support the Apollo/Saturn-V vehicle assembly and were later modified (1975) to support Space Transportation System shuttle missions. The Mobile Launch Platform area was used to repair post launch corrosion and/or blast damage on the launch platforms prior to reuse. The VAB was used to stack and prepare the space vehicles prior to launch.

2.3 BACKGROUND

During investigation activities in the MLPV Area, four areas have been identified as “Hot Spots” (Figure 2-3). A brief summary of the Hot Spots is provided below and more detailed information can be found in the 2016 CMI Progress Report [NASA 2016].

- Former Hot Spot 1
    - An area with TCE concentrations greater than 1,000 µg/L identified during the RFI [NASA 2000, NASA 2003] and was associated with an anecdotal TCE spill (approximately 4,000 gallons) that occurred in 1966.

  - Enhanced bioremediation was implemented per the CMD [NASA 2004b] and the area has been transitioned into the VAB Area long term monitoring (LTM) program.

- Hot Spot 2
  - An area with TCE concentrations greater than 300 µg/L and cDCE concentrations greater than 7,000 µg/L identified during supplemental assessment that occurred after the corrective action objective was achieved in Hot Spot 1 [NASA 2016].
  - Air sparging was implemented [NASA 2011a, NASA 2013] and is ongoing and the results were documented in the 2015 Annual CMI and IM Report [NASA 2015b].
- Hot Spot 3
  - An area with CVOC concentrations greater than 10xNADC identified during the VAB reassessment activities [NASA 2015a] that is the focus of this IMWP.
  - Located partially under and south of the western MLP structure (MLP footers extend into the treatment area) and adjacent to the crawler tracks.
  - A remedial alternative evaluation was performed for Hot Spot 3 and presented to the KSCRT in a Step 2 Engineering Evaluation (EE) ADP [NASA 2016] at the January 2016 KSCRT meeting; and KSCRT reached consensus to complete an IMWP for implementing bioremediation within the Hot Spot 3 10xNADC boundary (decision item 1601-D14).
- Hot Spot 4
  - An area where light non-aqueous phase liquid was identified during the VAB reassessment activities [NASA 2015a].
  - Implementation of a remedial alternative is on hold until MLP structure is removed; a non-aqueous passive phase liquid collection skimmer has been installed and interim groundwater monitoring is being implemented annually.

2.4 LITHOLOGY

A generalized lithologic cross section from the area where Hot Spot 3 is located is presented on Figure 2-4 and a brief summary is provided below:

- ground surface to approximately 12 ft BLS: sand;
- approximately 12 to 20 and 24 to 25 ft BLS: silty sand;
- approximately 20 to 24 and 25 to 27 ft BLS: shell hash (crushed shell fragments);

- approximately 27 to 47 ft BLS: sand to silty sand;
- approximately 47 to 61 ft BLS: interbedded clayey sand/sandy clay;
- approximately 61 to 66 ft BLS: silty sand; and
- approximately 66 to 75 ft BLS: sandy clay.

Geotechnical testing was performed to evaluate the permeability of the interbedded clayey sand/sandy clay present from approximately 47 to 61 ft BLS [NASA 2016]. The geotechnical testing results indicated that from 43 to 44 ft BLS, 46 to 47 ft BLS, 50 to 51 ft BLS, and 60 to 61 ft BLS the intrinsic permeability was approximately 10^{-9} square centimeters (cm^2) and from 54 to 55 ft BLS the intrinsic permeability was approximately 10^{-11} cm^2. Based on the generalized lithology and the geotechnical results, it is anticipated that a low permeability layer exists from approximately 52 to 60 ft BLS.

2.5 HYDROGEOLOGY

Groundwater zones for the MLPV Area have been generally defined as follows: (i) shallow groundwater less than 15 ft BLS; (ii) intermediate groundwater from approximately 15 to 40 ft BLS; and (iii) deep groundwater greater than 40 ft BLS. Groundwater elevations are collected as part of the VAB Area wide LTM program and the most recent groundwater elevation data (November 2014) are provided as Figures 2-5, 2-6, and 2-7, which were presented in the VAB Area 2014 Annual Groundwater Monitoring Results Report [NASA 2015c].

In general, in each zone, a radial groundwater flow pattern exists away from the VAB, and in the Hot Spot 3 Area, groundwater flow is generally to the northeast. Across the MLPV Area, groundwater is generally present from approximately 3 to 6 ft BLS. The groundwater flow velocity is estimated to be approximately 20 feet per year (ft/yr) in the area of Hot Spot 3 [NASA 2016] and approximately 71 ft/yr from the former source area towards the biosparge barrier [NASA 2015b].

2.6 GROUNDWATER CVOC DISTRIBUTION

The CVOC plumes associated with Hot Spot 3 are presented on Figure 2-8 and cross sections are presented on Figures 2-9 and 2-10. The focus of the IMWP is the 10xNADC area; therefore, the discussion of the CVOC distribution will focus on those areas. The 10xNADC and SZ areas were defined using the VABRA direct-push technology (DPT) groundwater sampling results and select DPT groundwater sampling results (locations with at least one sample with CVOC concentrations greater than the NADC) are presented on Figure 2-11. The SZ impacts encompass approximately 0.02 acres and extend from 6 to 16 ft BLS and 41 to 50 ft BLS, with the exception of the area around DPT1285 where TCE impacts greater than 11,000 µg/L were

measured to 55 ft BLS. The 10xNADC impacts encompass approximately 0.07 acres and extend from 6 to 22 ft BLS and 41 to 55 ft BLS.

As part of the Step 1 EE [NASA 2016], mass estimates were calculated for TCE, cDCE, *trans*-1,2-dichloroethene (tDCE), and VC within the 10xNADC area. It is estimated that within the 10xNADC area there is approximately 120 pounds of total CVOC mass present. Calculations are included in Appendix B.

2.7 GEOCHEMICAL EVALUATION

To aid in the evaluation of implementation of bioremediation, geochemical parameters were collected from monitoring well MW0001 (20 to 30 ft BLS). Monitoring well MW0001 was selected because it is the monitoring well installed within Hot Spot 3 that is closest to the treatment interval. Field geochemical results from the most recent sampling events for monitoring well MW0001 are presented in Table 2-1. A summary of the dissolved oxygen (DO), oxidation-reduction potential (ORP), and pH are provided below:

- DO: 0.14 to 0.57 milligrams per liter (mg/L);
- ORP: negative 183 to negative 275 millivolts; and
- pH: 7.3 to 7.5 standard units.

The DO and ORP results are generally indicative of an anaerobic (DO is measured as less than 0.5 mg/L [Wiedemeier 2006]), reducing (ORP is measured as negative) environment, and the pH results suggest a neutral pH. The DO, ORP, and pH results suggest an environment that is conducive to reductive dechlorination.

Groundwater sampling was performed to evaluate geochemical conditions within Hot Spot 3 and to provide information on the native dechlorinating microbial populations. Groundwater samples were collected from monitoring well MW0001 (20 to 30 ft BLS) on 3 September 2015 and analyzed for methane, ethene, ethane, sulfate, sulfide, total organic carbon (TOC), *Dehalococcoides (Dhc)*, and vinyl chloride reductase gene (*vcrA*). Groundwater sampling results are summarized below.

- Sulfide was detected at a concentration of 11 mg/L, which is below the concentration when sulfide inhibition to *Dhc* begins (34 to 170 mg/L).
- Sulfate was detected at a concentration of 31 mg/L, which is below the concentration range (approximately 100 to 500 mg/L) necessary to produce inhibitory sulfide concentrations (if sulfate is reduced to sulfide).
- TOC was detected at a concentration of 71 mg/L.

- *Dhc* organisms are present at a concentration of approximately 10^5 gene copies per liter of groundwater (gene copies/L) and *vcrA* is present at a concentration of approximately 10^5 gene copies/L.
- Ethane and ethene were not detected, and methane was detected at 1,000 µg/L.

The groundwater sampling results suggest that the sulfide concentrations are low enough that they will not inhibit reductive dechlorination by *Dhc* and that the sulfate concentrations are not high enough to produce a sulfide concentration that would be inhibitory to *Dhc*. The lack of ethene or ethane suggest that compete reductive dechlorination is limited, which is likely due to the low CVOC concentrations (in 20 to 30 ft BLS interval), lack of electron donor, and/or low *Dhc* and *vcrA* concentrations. Since the *Dhc* and *vcrA* concentrations are less than 10^6 gene copies/L and ethene was not detected, bioremediation will be implemented using biostimulation and bioaugmentation.

Table 2-1. Field Geochemical Parameters
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Location	Sample Date	Screen Interval (ft BLS)	Temperature (°C)	pH (S.U.)	Conductivity (mS/cm)	Turbidity (NTU)	Salinity (%)	Oxidation-Reduction Potential (mV)	Dissolved Oxygen (mg/L)	Total Dissolved Solids (g/L)	Color
MW0001	02/05/2014	20 to 30	24.6	7.5	0.72	16.7	0.35	-183	0.14*	0.47	clear
	09/03/2015		25.7	7.3	0.79	2.35	0.39	-275	0.57	0.51	clear

Notes:

1. All locations have prefix "VABRA-".
2. * indicates probe failed continuous calibration verification (CCV).
3. % indicates percent.
4. °C indicates degrees Celsius.
5. ft BLS indicates feet below land surface.
6. g/L indicates grams per liter.
7. mg/L indicates milligrams per liter.
8. mS/cm indicates milliSiemens per centimeter.
9. mV indicates millivolts.
10. NTU indicates Nephelometric Turbidity Unit.
11. pH indicates hydrogen ion concentration.
12. S.U. indicates standard units.

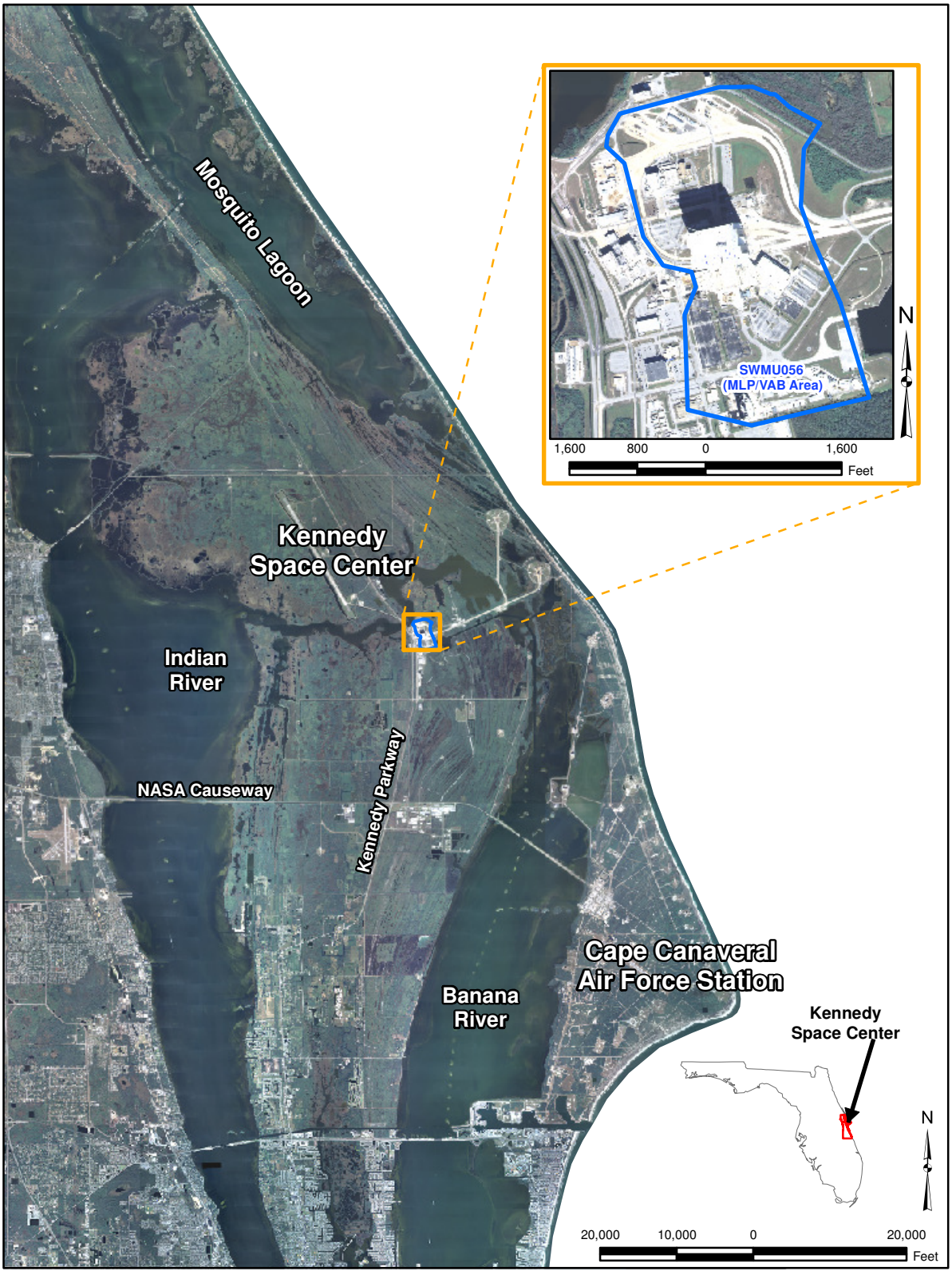

Figure 2-1
MLPV Location Map

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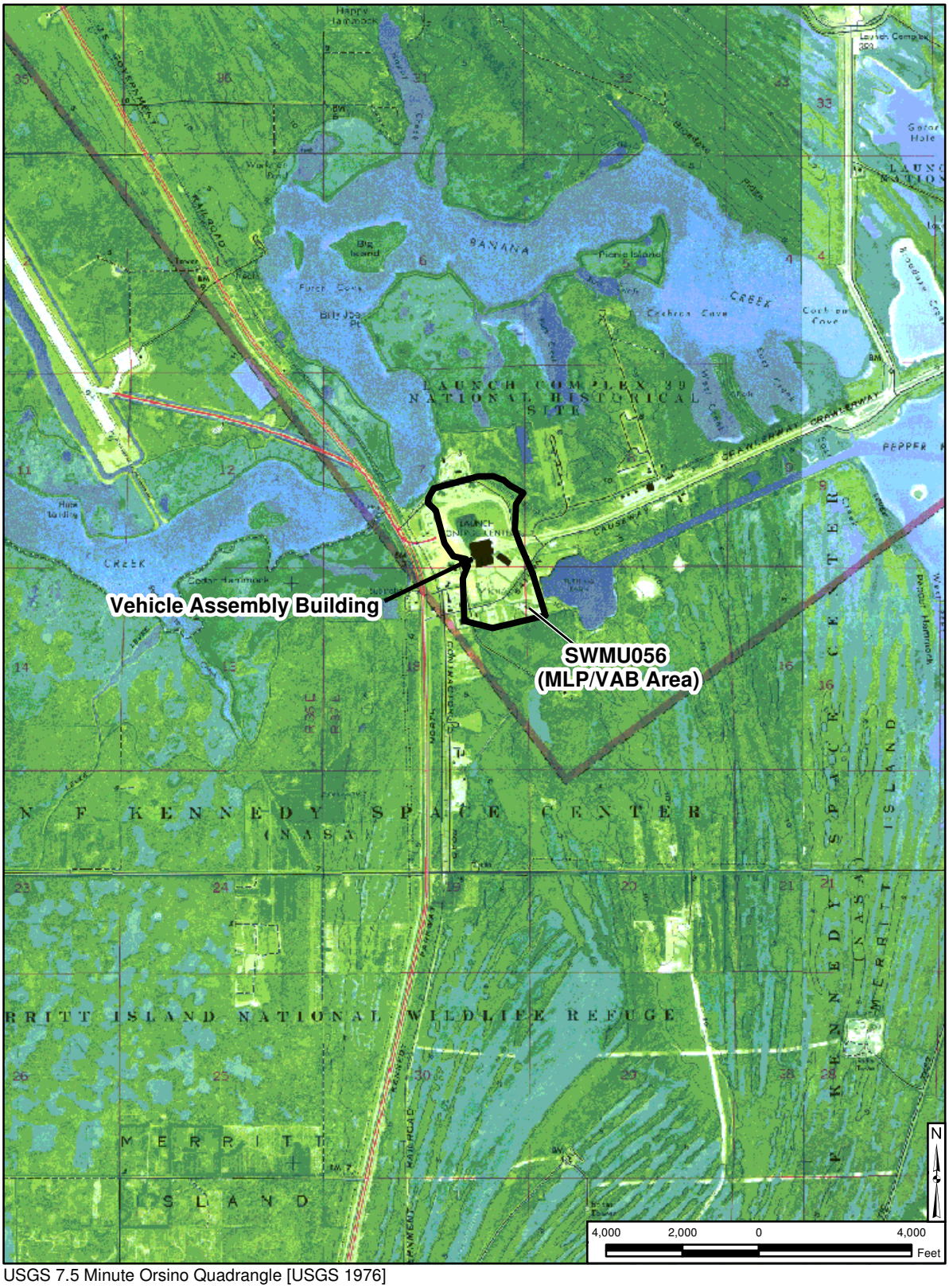

USGS 7.5 Minute Orsino Quadrangle [USGS 1976]

Figure 2-2
USGS Topographic Quadrangle Map

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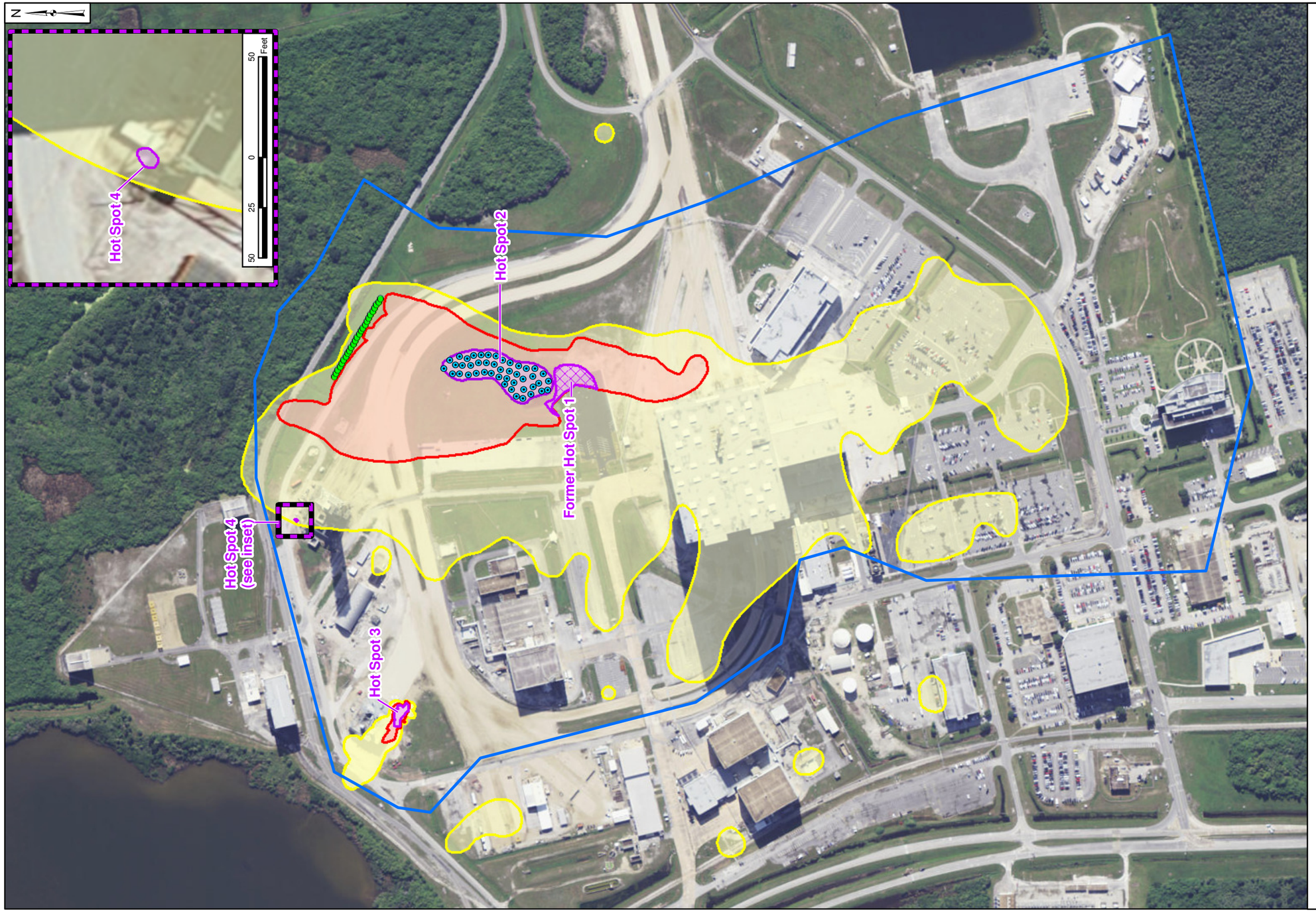

Figure 2-3
MLPV Area Hot Spots

Legend
- Low Concentration Plume
  Approximate Area = 65 acres
- High Concentration Plume
  Approximate Area = 13 acres
- SWMU056 (MLP Park Sites/VAB Area)
- Air Sparge Well Location
- Biosparge Well Location
- Hot Spot Area
- Hot Spot 2 Total Area = 1.17 acres
- Hot Spot 3 Total Area = 0.07 acres
- Hot Spot 4 Total Area = 0.002 acres
- Former Hot Spot 1 Total Area = 0.33 acres

400 200 0 400 Feet

Note:
1. 2013 World Imagery 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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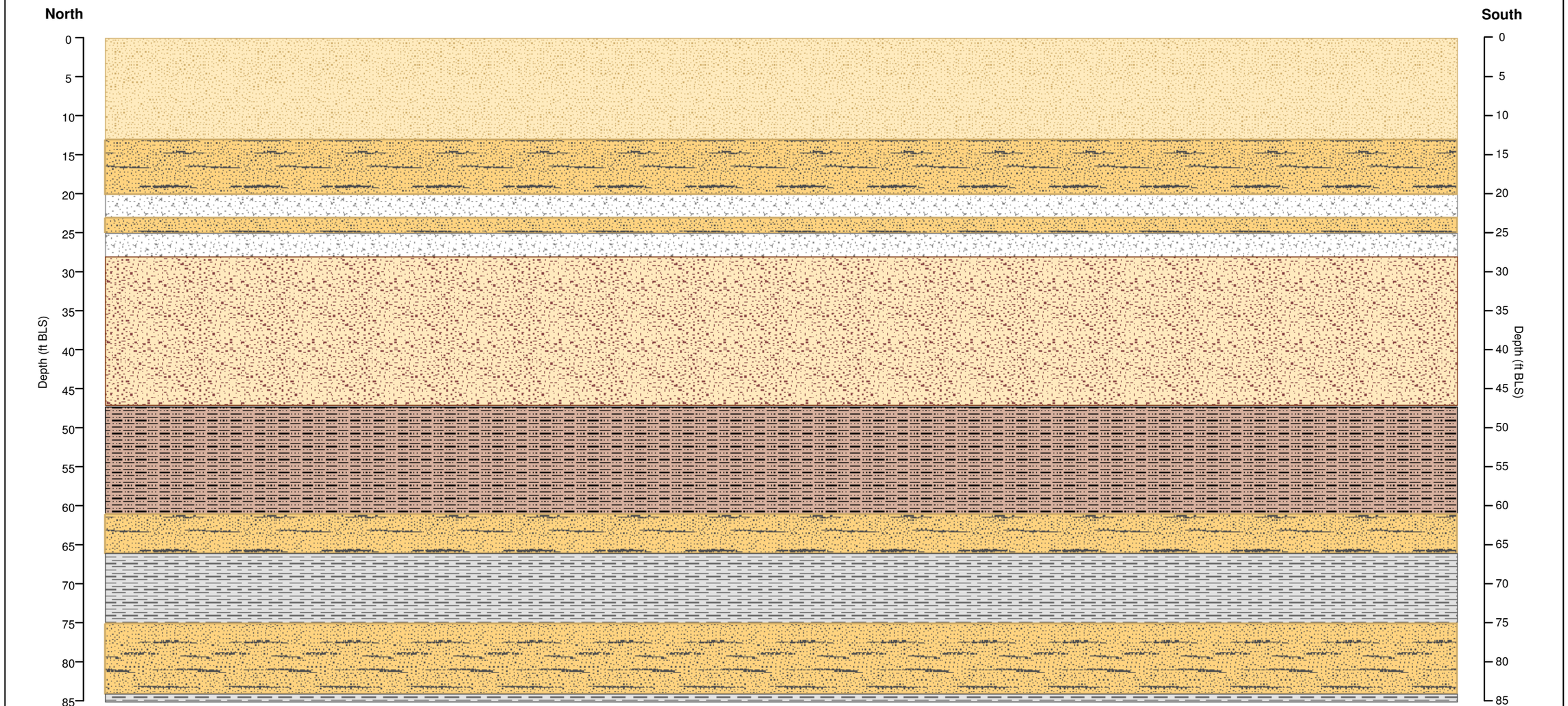

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Figure 2-4
Generalized Lithologic Cross Section
2-15/2-16

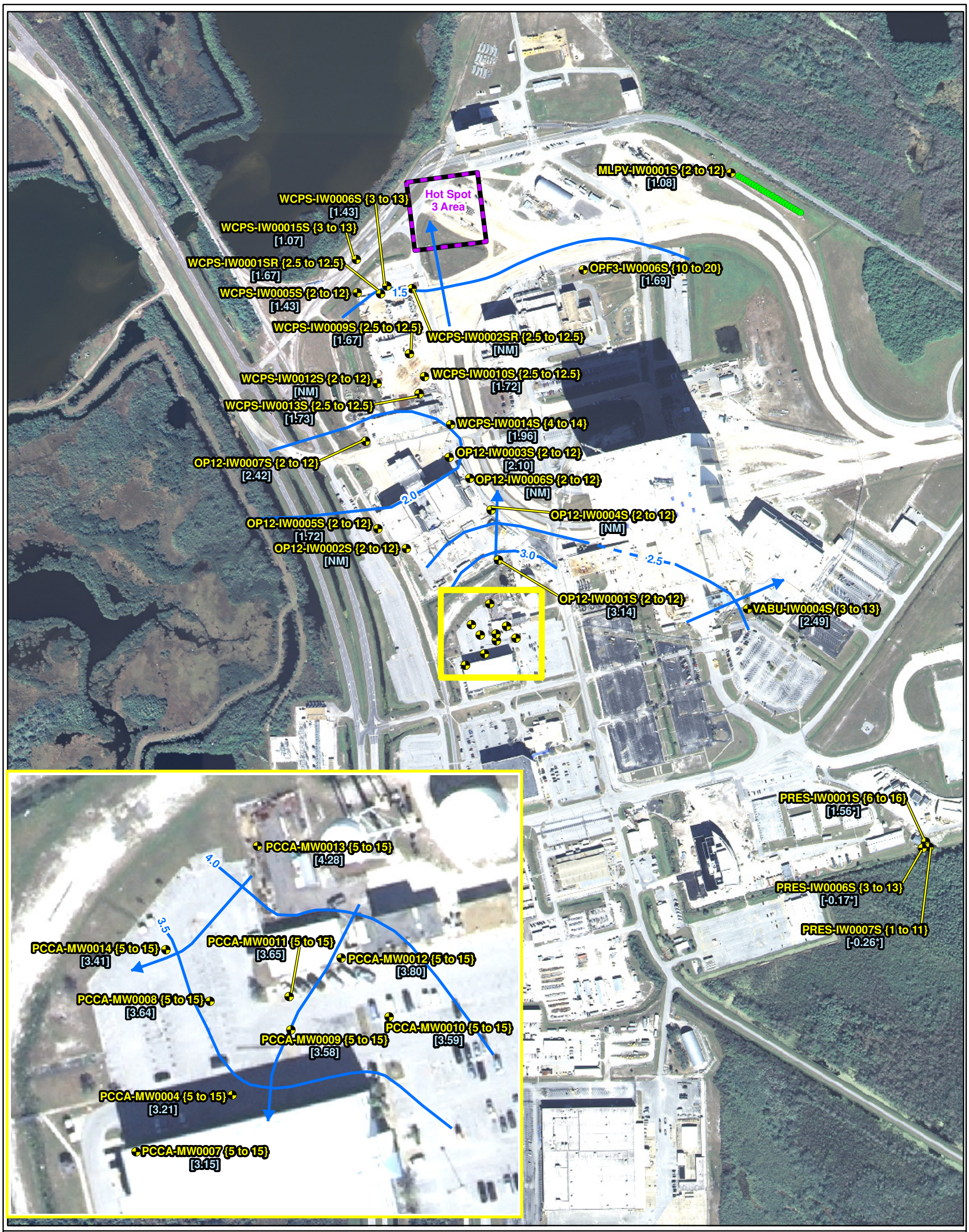

Figure 2-5
VAB Area Shallow Zone Potentiometric Surface Map – November 2014

Legend

- Shallow Monitoring Well Location {screen interval} and [groundwater elevation]
- Biosparge Well Location
- Inferred Equipotential Line
- Equipotential Line
- Generalized Groundwater Flow Direction

Notes:
1. Screen interval is presented in feet, below land surface (ft, BLS).
2. Groundwater elevation is presented in ft, NAVD88.
3. * indicates elevation was not used for contouring.
4. NM indicates not measured.

N

500 250 0 500 Feet

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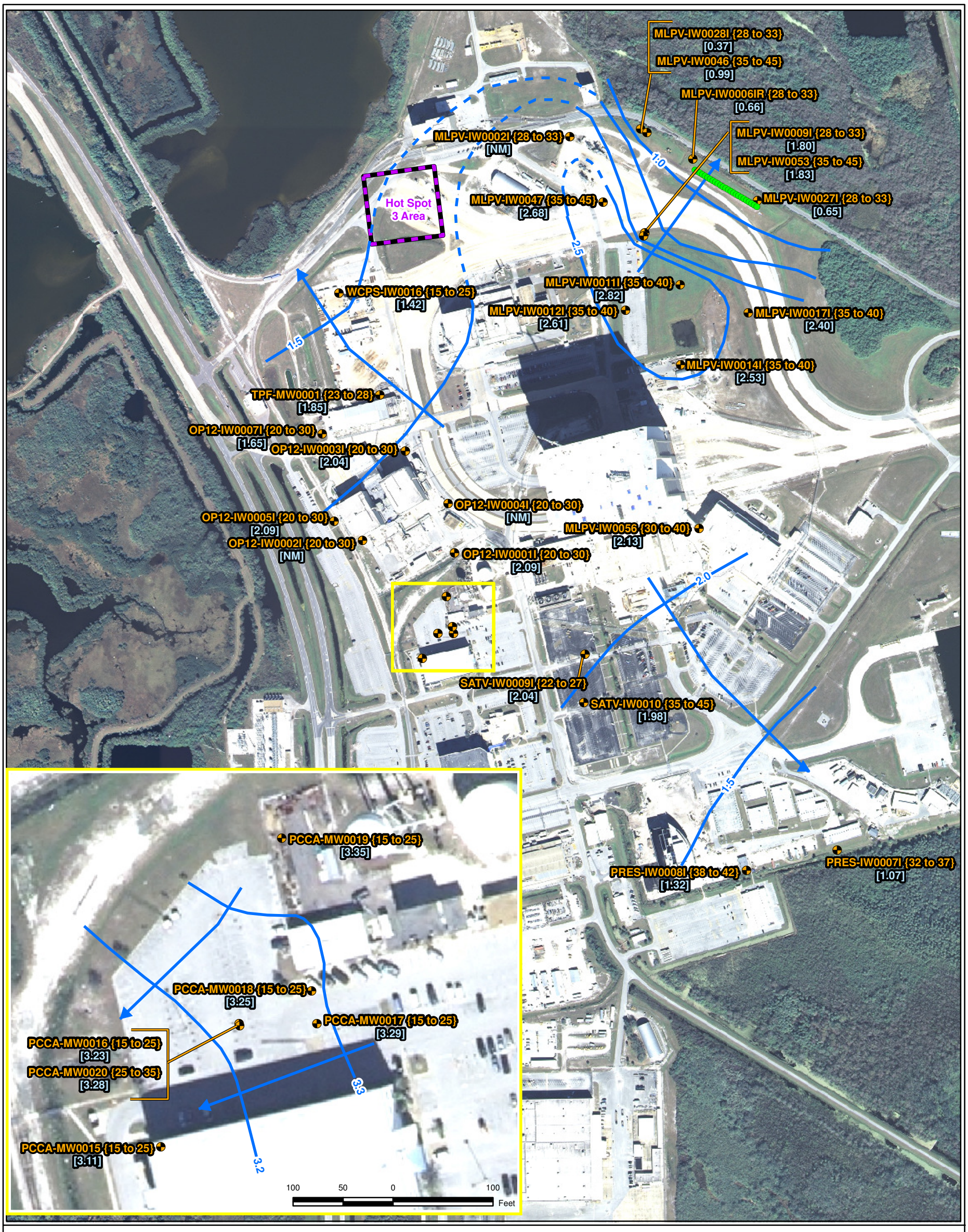

Figure 2-6
VAB Area Intermediate Zone Potentiometric Surface Map - November 2014

Legend

- Intermediate Monitoring Well Location {screen interval} and [groundwater elevation]
- Biosparge Well Location
- Inferred Equipotential Line
- Equipotential Line
- Generalized Groundwater Flow Direction

N

500 250 0 500
Feet

Notes:
1. Screen interval is presented in feet, below land surface (ft, BLS).
2. Groundwater elevation is presented in ft, NAVD88.
3. NM indicates not measured.

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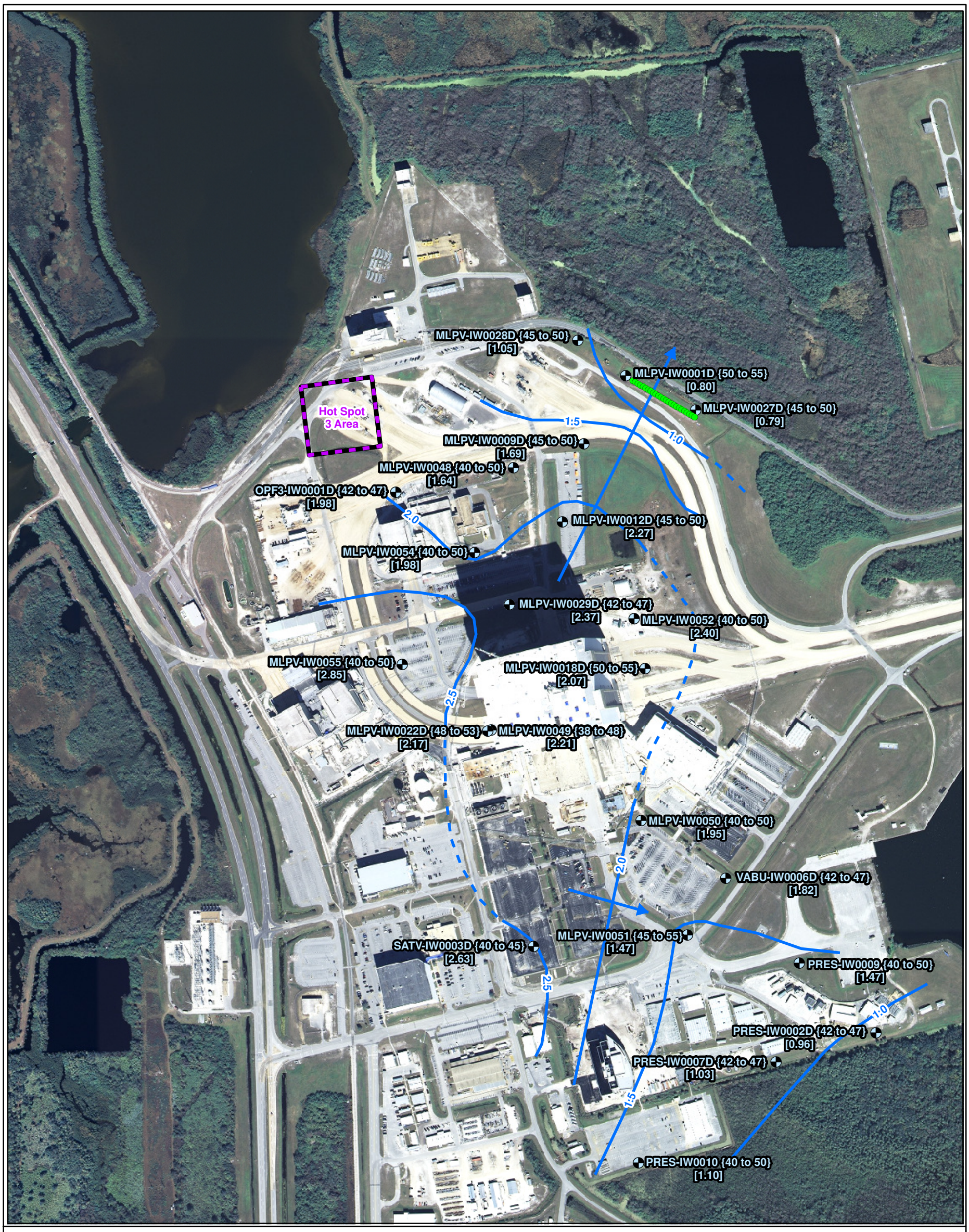

Figure 2-7
VAB Area Deep Zone Potentiometric Surface Map - November 2014

Legend

- Deep Monitoring Well Location {screen interval} and [groundwater elevation]
- Biosparge Well Location
- Inferred Equipotential Line
- Equipotential Line
- Generalized Groundwater Flow Direction

N

500 250 0 500 Feet

Notes:
1. Screen interval is presented in feet, below land surface (ft, BLS).
2. Groundwater elevation is presented in ft, NAVD88.

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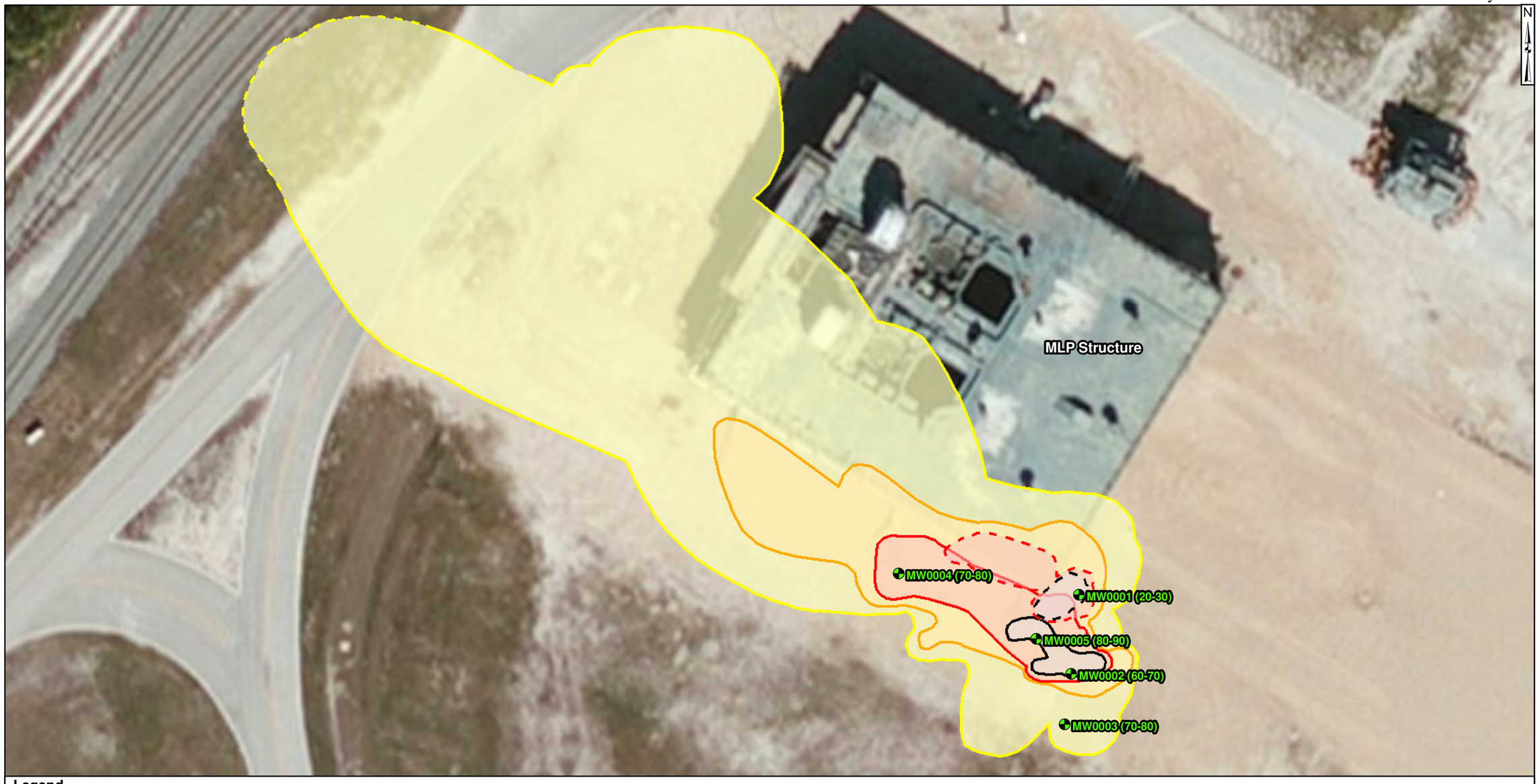


Legend

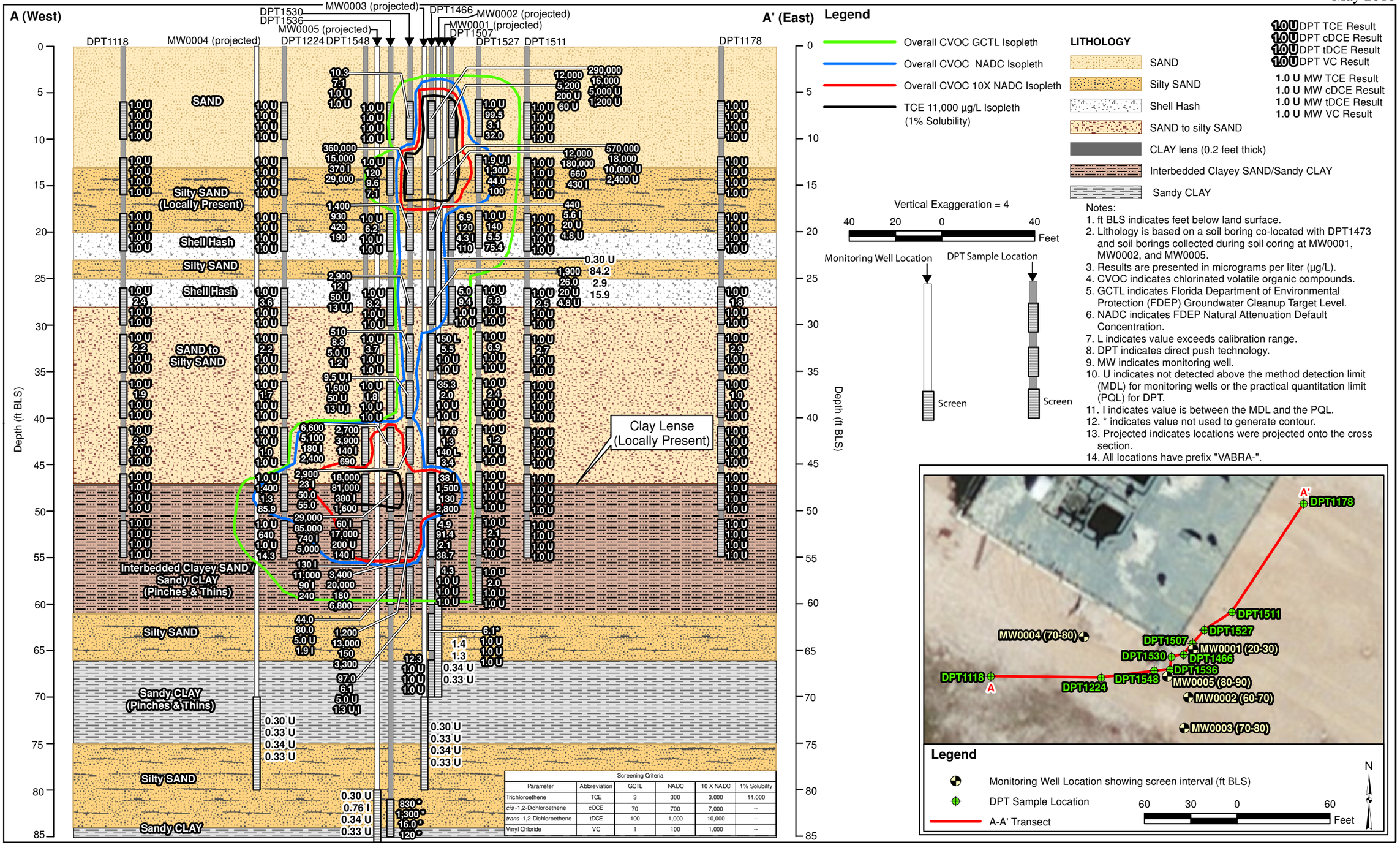
- Monitoring Well Location (showing screen interval, ft BLS)
- Overall TCE 1% Solubility Contour (dashed contours are 6 to 16 ft BLS interval and solid contours are 41 to 50 ft BLS interval) [Area = 0.02 Acres]
- Overall CVOC 10 x NADC Contour (dashed contours are 6 to 22 ft BLS interval and solid contours are 41 to 55 ft BLS interval) (Area = 0.07 Acres)
- Overall CVOC NADC Contour (6 to 55 ft BLS) [Area = 0.17 Acres]
- Overall CVOC GCTL Contour (6 to 60 ft BLS) [Area = 1.06 Acres]
- Inferred CVOC GCTL Contour

Notes:
1. ft BLS indicates feet below land surface.
2. CVOC indicates chlorinated volatile organic compounds.
3. NADC indicates Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration.
4. TCE indicates trichloroethene.
5. Contours based on direct push technology (DPT) groundwater sampling results.
6. Prefix for monitoring well locations is "VABRA-".
7. 2013 World Imagery Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community.

40 20 0 40 Feet

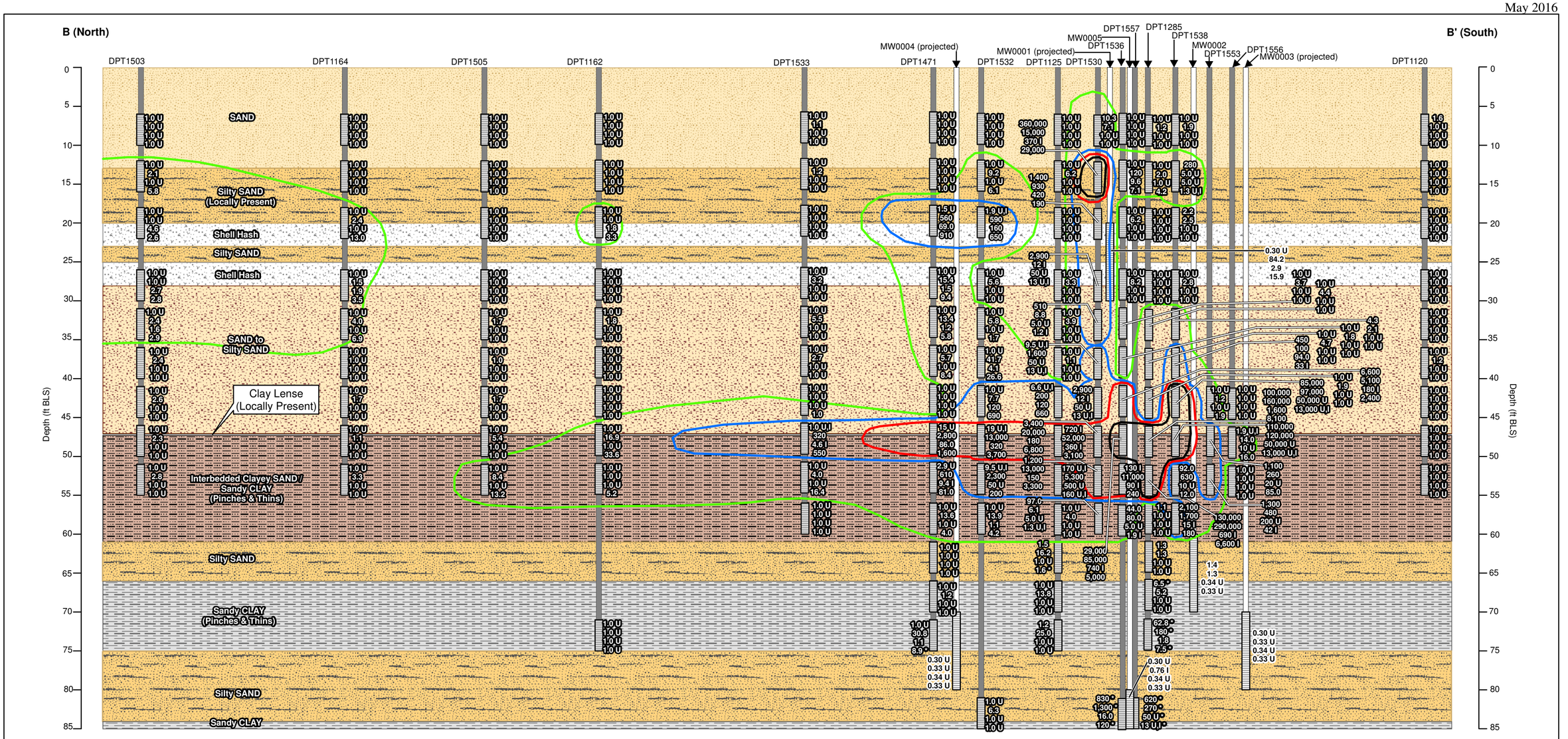
Path: (Titusville-01\Data\)P:\0GIS\FR2102_VAB_Reassessment\MXDs\MLPV_IMWP_MAR2016\CVOC_6to22_and41to60_HS3.mxd 29 March 2016 JRB

Figure 2-8
MLPV Area Hot Spot 3 CVOC Groundwater Plumes
2-23/2-24



Path: (Titusville-01\Data\)P:\0GIS\FR2102_VAB_Reassessment\MXDs\STEP1_ADP\Gen_CrossSection_AA_Overall_Isopleths_well_data.mxd 29 March 2016 MAH

Figure 2-9
Hot Spot 3 Cross Section A to A' CVOC Distribution



Legend

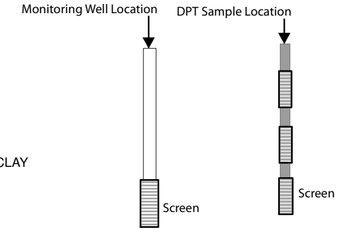
- Overall GCTL Isopleth
- Overall NADC Isopleth
- Overall 10X NADC Isopleth
- TCE 11,000 µg/L Isopleth (1% Solubility)

LITHOLOGY

- SAND
- Silty SAND
- Shell Hash
- SAND to silty SAND
- CLAY lens (0.2 feet thick)
- Interbedded clayey SAND / sandy CLAY
- Sandy CLAY

1.0 U DPT TCE Result
1.0 U DPT cDCE Result
1.0 U DPT tDCE Result
1.0 U DPT VC Result

1.0 U MW TCE Result
1.0 U MW cDCE Result
1.0 U MW tDCE Result
1.0 U MW VC Result

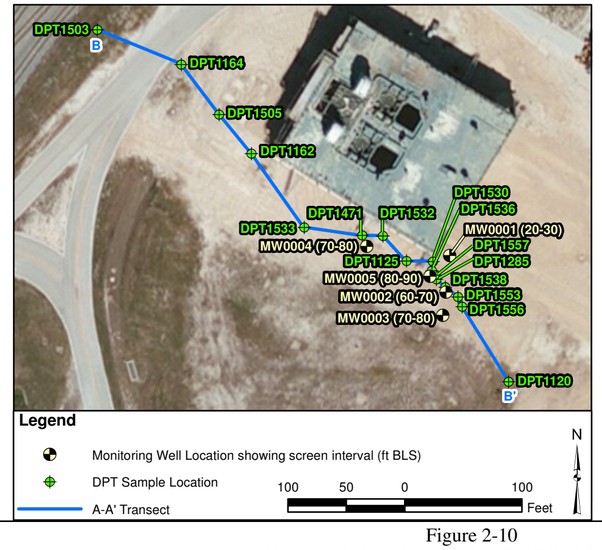


Screening Criteria					
Parameter	Abbreviation	GCTL	NADC	10 X NADC	1% Solubility
Trichloroethene	TCE	3	300	3,000	11,000
cis -1,2-Dichloroethene	cDCE	70	700	7,000	--
trans -1,2-Dichloroethene	tDCE	100	1,000	10,000	--
Vinyl Chloride	VC	1	100	1,000	--

Vertical Exaggeration = 3

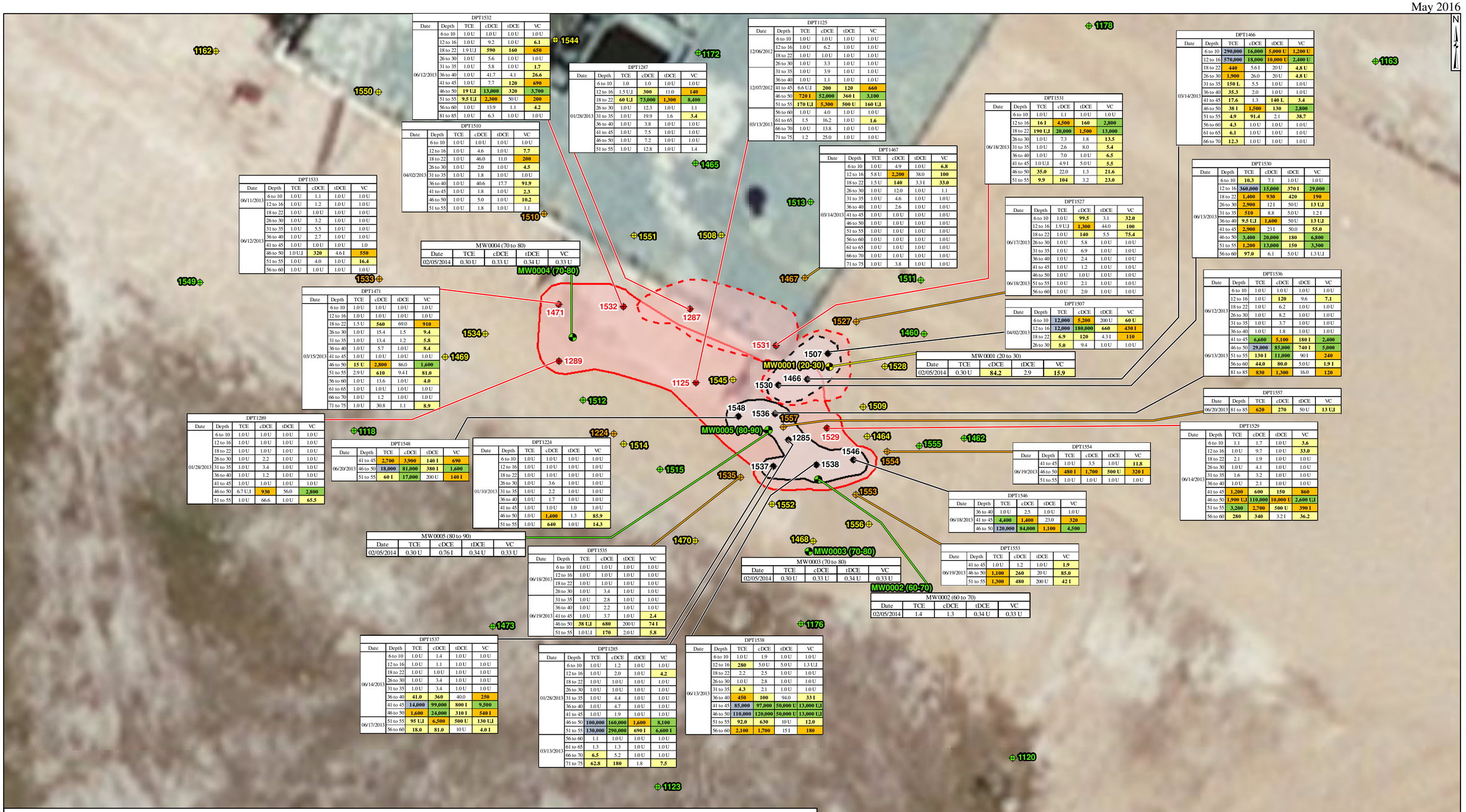
30 15 0 30 Feet

Notes:
1. ft BLS indicates feet below land surface.
2. Lithology is based on a soil boring co-located with DPT1473 and soil borings collected during soil coring at MW0001, MW0002, and MW0005.
3. Results are presented in micrograms per liter (µg/L).
4. CVOC indicates chlorinated volatile organic compounds.
5. GCTL indicates Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level.
6. NADC indicates FDEP Natural Attenuation Default Concentration.
7. DPT indicates direct push technology.
8. MW indicates monitoring well.
9. U indicates not detected above the method detection limit (MDL) for monitoring wells or the practical quantitation limit (PQL) for DPT.
10. I indicates value is between the MDL and the PQL.
11. * indicates value not used to generate contour.
12. Projected indicates locations were projected onto the cross section.
13. All locations have prefix "VABRA-".



Path: (Titusville-01\Data\)P:\0GIS\FR2102_VAB_Reassessment\MXDs\STEP1_ADP\Gen_CrossSection_BB_Overall_Isopleths_well_data.mxd 29 March 2016MAH

Figure 2-10
Hot Spot 3 Cross Section B to B' CVOC Distribution
2-27/2-28



DPT1532

Date	Depth	TCE	cDCE	tDCE	VC
06/12/2013	6 to 10	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	1.0 U	9.2	1.0 U	**6.1**
	18 to 22	1.9 U,I	**590**	**160**	**650**
	26 to 30	1.0 U	5.6	1.0 U	1.0 U
	31 to 35	1.0 U	5.8	1.0 U	**1.7**
	36 to 40	1.0 U	41.7	4.1	**26.6**
	41 to 45	1.0 U	7.7	**120**	**690**
	46 to 50	**19 U,I**	**13,000**	**320**	**3,700**
	51 to 55	**9.5 U,I**	**2,300**	50 U	**200**
	56 to 60	1.0 U	13.9	1.1	**4.2**
	81 to 85	1.0 U	6.3	1.0 U	1.0 U

DPT1125

Date	Depth	TCE	cDCE	tDCE	VC
12/06/2012	6 to 10	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	1.0 U	6.2	1.0 U	1.0 U
	18 to 22	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	1.0 U	3.3	1.0 U	1.0 U
12/07/2012	31 to 35	1.0 U	3.9	1.0 U	1.0 U
	36 to 40	1.0 U	1.1	1.0 U	1.0 U
	41 to 45	6.6 U,I	**200**	**120**	**660**
	46 to 50	**720 I**	**52,000**	**360 I**	**3,100**
	51 to 55	**170 U,I**	**5,300**	**500 U**	**160 U,I**
03/13/2013	56 to 60	1.0 U	4.0	1.0 U	1.0 U
	61 to 65	1.5	16.2	1.0 U	**1.6**
	66 to 70	1.0 U	13.8	1.0 U	1.0 U
	71 to 75	1.2	25.0	1.0 U	1.0 U

DPT1287

Date	Depth	TCE	cDCE	tDCE	VC
01/28/2013	6 to 10	1.0	1.0	1.0 U	1.0 U
	12 to 16	1.5 U,I	**300**	11.0	**140**
	18 to 22	**60 U,I**	**73,000**	**1,300**	**8,400**
	26 to 30	1.0 U	12.3	1.0 U	1.1
	31 to 35	1.0 U	19.9	1.6	**3.4**
	36 to 40	1.0 U	3.8	1.0 U	1.0 U
	41 to 45	1.0 U	7.5	1.0 U	1.0 U
	46 to 50	1.0 U	7.2	1.0 U	1.0 U
	51 to 55	1.0 U	12.8	1.0 U	1.4

DPT1531

Date	Depth	TCE	cDCE	tDCE	VC
06/18/2013	6 to 10	1.0 U	1.1	1.0 U	1.0 U
	12 to 16	**16 I**	**4,500**	**160**	**2,800**
	18 to 22	**190 U,I**	**20,000**	**1,500**	**13,000**
	26 to 30	1.0 U	7.3	1.8	**13.5**
	31 to 35	1.0 U	2.6	8.0	**5.4**
	36 to 40	1.0 U	7.0	1.0 U	**6.5**
	41 to 45	1.0 U,I	4.9 I	5.0 U	**5.5**
	46 to 50	**35.0**	22.0	1.3	**21.6**
	51 to 55	**9.9**	**104**	3.2	**23.0**

DPT1466

Date	Depth	TCE	cDCE	tDCE	VC
03/14/2013	6 to 10	**290,000**	**16,000**	**5,000 U**	**1,200 U**
	12 to 16	**570,000**	**18,000**	**10,000 U**	**2,400 U**
	18 to 22	**440**	5.6 I	20 U	**4.8 U**
	26 to 30	**1,900**	26.0	20 U	**4.8 U**
	31 to 35	**150 L**	5.5	1.0 U	1.0 U
	36 to 40	**35.3**	2.0	1.0 U	1.0 U
	41 to 45	**17.6**	1.3	**140 L**	**3.4**
	46 to 50	**38 I**	**1,500**	**130**	**2,800**
	51 to 55	**4.9**	**91.4**	2.1	**38.7**
	56 to 60	**4.3**	1.0 U	1.0 U	1.0 U
	61 to 65	**6.1**	1.0 U	1.0 U	1.0 U
	66 to 70	**12.3**	1.0 U	1.0 U	1.0 U

DPT1467

Date	Depth	TCE	cDCE	tDCE	VC
03/14/2013	6 to 10	1.0 U	4.9	1.0 U	**6.8**
	12 to 16	5.8 U	**2,200**	38.0	**100**
	18 to 22	1.5 U	**140**	3.3 I	**33.0**
	26 to 30	1.0 U	12.0	1.0 U	1.1
	31 to 35	1.0 U	4.6	1.0 U	1.0 U
	36 to 40	1.0 U	2.6	1.0 U	1.0 U
	41 to 45	1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50	1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55	1.0 U	1.0 U	1.0 U	1.0 U
	56 to 60	1.0 U	1.0 U	1.0 U	1.0 U
	61 to 65	1.0 U	1.0 U	1.0 U	1.0 U
	66 to 70	1.0 U	1.0 U	1.0 U	1.0 U
	71 to 75	1.0 U	3.8	1.0 U	1.0 U

DPT1530

Date	Depth	TCE	cDCE	tDCE	VC
06/13/2013	6 to 10	**10.3**	7.1	1.0 U	1.0 U
	12 to 16	**360,000**	**15,000**	**370 I**	**29,000**
	18 to 22	**1,400**	**930**	**420**	**190**
	26 to 30	**2,900**	12 I	50 U	**13 U,I**
	31 to 35	**510**	8.8	5.0 U	1.2 I
	36 to 40	**9.5 U,I**	**1,600**	50 U	**13 U,I**
	41 to 45	**2,900**	23 I	50.0	**55.0**
	46 to 50	**3,400**	**20,000**	**180**	**6,800**
	51 to 55	**1,200**	**13,000**	**150**	**3,300**
	56 to 60	**97.0**	6.1	5.0 U	1.3 U,I

DPT1527

Date	Depth	TCE	cDCE	tDCE	VC
06/17/2013	6 to 10	1.0 U	**99.5**	3.1	**32.0**
	12 to 16	1.9 U,I	**1,300**	44.0	**100**
	18 to 22	1.0 U	**140**	5.5	**75.4**
	26 to 30	1.0 U	5.8	1.0 U	1.0 U
	31 to 35	1.0 U	6.9	1.0 U	1.0 U
	36 to 40	1.0 U	2.4	1.0 U	1.0 U
	41 to 45	1.0 U	1.2	1.0 U	1.0 U
06/18/2013	46 to 50	1.0 U	1.0 U	1.0 U	1.0 U
	51 to 55	1.0 U	2.1	1.0 U	1.0 U
	56 to 60	1.0 U	2.0	1.0 U	1.0 U

DPT1507

Date	Depth	TCE	cDCE	tDCE	VC
04/02/2013	6 to 10	**12,000**	**5,200**	200 U	**60 U**
	12 to 16	**12,000**	**180,000**	**660**	**430 I**
	18 to 22	**6.9**	**120**	4.3 I	**110**
	26 to 30	**5.0**	9.4	1.0 U	1.0 U

DPT1536

Date	Depth	TCE	cDCE	tDCE	VC
06/12/2013	6 to 10	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	1.0 U	**120**	9.6	**7.1**
	18 to 22	1.0 U	6.2	1.0 U	1.0 U
	26 to 30	1.0 U	8.2	1.0 U	1.0 U
	31 to 35	1.0 U	3.7	1.0 U	1.0 U
	36 to 40	1.0 U	1.8	1.0 U	1.0 U
06/13/2013	41 to 45	**6,600**	**5,100**	**180 I**	**2,400**
	46 to 50	**29,000**	**85,000**	**740 I**	**5,000**
	51 to 55	**130 I**	**11,000**	90 I	**240**
	56 to 60	**44.0**	**80.0**	5.0 U	**1.9 I**
	81 to 85	**830**	**1,300**	16.0	**120**

DPT1557

Date	Depth	TCE	cDCE	tDCE	VC
06/20/2013	81 to 85	**620**	**270**	50 U	**13 U,I**

DPT1533

Date	Depth	TCE	cDCE	tDCE	VC
06/11/2013	6 to 10	1.0 U	1.1	1.0 U	1.0 U
	12 to 16	1.0 U	1.2	1.0 U	1.0 U
06/12/2013	18 to 22	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	1.0 U	3.2	1.0 U	1.0 U
	31 to 35	1.0 U	5.5	1.0 U	1.0 U
	36 to 40	1.0 U	2.7	1.0 U	1.0 U
	41 to 45	1.0 U	1.0 U	1.0 U	1.0
	46 to 50	1.0 U,I	**320**	4.6 I	**550**
	51 to 55	1.0 U	4.0	1.0 U	**16.4**
	56 to 60	1.0 U	1.0 U	1.0 U	1.0 U

DPT1471

Date	Depth	TCE	cDCE	tDCE	VC
03/15/2013	6 to 10	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22	1.5 U	**560**	69.0	**910**
	26 to 30	1.0 U	15.4	1.5	**9.4**
	31 to 35	1.0 U	13.4	1.2	**5.8**
	36 to 40	1.0 U	5.7	1.0 U	**8.4**
	41 to 45	1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50	**15 U**	**2,800**	86.0	**1,600**
	51 to 55	2.9 U	**610**	9.4 I	**81.0**
	56 to 60	1.0 U	13.6	1.0 U	**4.0**
	61 to 65	1.0 U	1.0 U	1.0 U	1.0 U
	66 to 70	1.0 U	1.2	1.0 U	1.0 U
	71 to 75	1.0 U	30.8	1.1	**8.9**

DPT1289

Date	Depth	TCE	cDCE	tDCE	VC
01/28/2013	6 to 10	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	1.0 U	2.2	1.0 U	1.0 U
	31 to 35	1.0 U	3.4	1.0 U	1.0 U
	36 to 40	1.0 U	1.2	1.0 U	1.0 U
	41 to 45	1.0 U	1.0 U	1.0 U	1.0 U
	46 to 50	6.7 U,I	**930**	56.0	**2,800**
	51 to 55	1.0 U	66.6	1.0 U	**65.5**

DPT1548

Date	Depth	TCE	cDCE	tDCE	VC
06/20/2013	41 to 45	**2,700**	**3,900**	**140 I**	**690**
	46 to 50	**18,000**	**81,000**	**380 I**	**1,600**
	51 to 55	**60 I**	**17,000**	200 U	**140 I**

DPT1224

Date	Depth	TCE	cDCE	tDCE	VC
01/10/2013	6 to 10	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	1.0 U	3.6	1.0 U	1.0 U
	31 to 35	1.0 U	2.2	1.0 U	1.0 U
	36 to 40	1.0 U	1.7	1.0 U	1.0 U
	41 to 45	1.0 U	1.0 U	1.0	1.0 U
	46 to 50	1.0 U	**1,400**	1.3	**85.9**
	51 to 55	1.0 U	**640**	1.0 U	**14.3**

DPT1554

Date	Depth	TCE	cDCE	tDCE	VC
06/19/2013	41 to 45	1.0 U	3.5	1.0 U	**11.8**
	46 to 50	**480 I**	**1,700**	**500 U**	**320 I**
	51 to 55	1.0 U	1.0 U	1.0 U	1.0 U

DPT1529

Date	Depth	TCE	cDCE	tDCE	VC
06/14/2013	6 to 10	1.1	1.7	1.0 U	**3.6**
	12 to 16	1.0 U	9.7	1.0 U	**33.0**
	18 to 22	2.1	1.9	1.0 U	1.0 U
	26 to 30	1.0 U	4.1	1.0 U	1.0 U
	31 to 35	1.6	3.2	1.0 U	1.0 U
	36 to 40	1.0 U	2.1	1.0 U	1.0 U
	41 to 45	**1,200**	**600**	**150**	**860**
	46 to 50	**1,900 U,I**	**110,000**	**10,000 U**	**2,600 U,I**
	51 to 55	**3,200**	**2,700**	**500 U**	**390 I**
	56 to 60	**280**	**340**	3.2 I	**36.2**

DPT1546

Date	Depth	TCE	cDCE	tDCE	VC
06/18/2013	36 to 40	1.0 U	2.5	1.0 U	1.0 U
	41 to 45	**4,400**	**1,400**	23.0	**320**
	46 to 50	**120,000**	**84,000**	**1,100**	**4,500**

DPT1553

Date	Depth	TCE	cDCE	tDCE	VC
06/19/2013	41 to 45	1.0 U	1.2	1.0 U	**1.9**
	46 to 50	**1,100**	**260**	20 U	**85.0**
	51 to 55	**1,300**	**480**	200 U	**42 I**

DPT1535

Date	Depth	TCE	cDCE	tDCE	VC
06/18/2013	6 to 10	1.0 U	1.0 U	1.0 U	1.0 U
	12 to 16	1.0 U	1.0 U	1.0 U	1.0 U
	18 to 22	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	1.0 U	3.4	1.0 U	1.0 U
06/19/2013	31 to 35	1.0 U	2.8	1.0 U	1.0 U
	36 to 40	1.0 U	2.2	1.0 U	1.0 U
	41 to 45	1.0 U	3.7	1.0 U	**2.4**
	46 to 50	**38 U,I**	**680**	200 U	**74 I**
	51 to 55	1.0 U,I	**170**	2.0 U	**5.8**

DPT1537

Date	Depth	TCE	cDCE	tDCE	VC
06/14/2013	6 to 10	1.0 U	1.4	1.0 U	1.0 U
	12 to 16	1.0 U	1.1	1.0 U	1.0 U
	18 to 22	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	1.0 U	3.4	1.0 U	1.0 U
	31 to 35	1.0 U	3.4	1.0 U	1.0 U
	36 to 40	**41.0**	**360**	40.0	**250**
	41 to 45	**14,000**	**99,000**	**800 I**	**9,500**
	46 to 50	**1,600**	**24,000**	**310 I**	**540 I**
06/17/2013	51 to 55	**95 U,I**	**6,500**	**500 U**	**130 U,I**
	56 to 60	**18.0**	**81.0**	10 U	**4.0 I**

DPT1285

Date	Depth	TCE	cDCE	tDCE	VC
01/28/2013	6 to 10	1.0 U	1.2	1.0 U	1.0 U
	12 to 16	1.0 U	2.0	1.0 U	**4.2**
	18 to 22	1.0 U	1.0 U	1.0 U	1.0 U
	26 to 30	1.0 U	1.0 U	1.0 U	1.0 U
	31 to 35	1.0 U	4.4	1.0 U	1.0 U
	36 to 40	1.0 U	4.7	1.0 U	1.0 U
	41 to 45	1.0 U	1.9	1.0 U	1.0 U
	46 to 50	**100,000**	**160,000**	**1,600**	**8,100**
	51 to 55	**130,000**	**290,000**	**690 I**	**6,600 I**
03/13/2013	56 to 60	1.1	1.0 U	1.0 U	1.0 U
	61 to 65	1.3	1.3	1.0 U	1.0 U
	66 to 70	**6.5**	5.2	1.0 U	1.0 U
	71 to 75	**62.8**	**180**	1.8	**7.5**

DPT1538

Date	Depth	TCE	cDCE	tDCE	VC
06/13/2013	6 to 10	1.0 U	1.9	1.0 U	1.0 U
	12 to 16	**280**	5.0 U	5.0 U	1.3 U,I
	18 to 22	2.2	2.5	1.0 U	1.0 U
	26 to 30	1.0 U	2.8	1.0 U	1.0 U
	31 to 35	**4.3**	2.1	1.0 U	1.0 U
	36 to 40	**450**	**100**	94.0	**33 I**
	41 to 45	**85,000**	**97,000**	**50,000 U**	**13,000 U,I**
	46 to 50	**110,000**	**120,000**	**50,000 U**	**13,000 U,I**
	51 to 55	**92.0**	**630**	10 U	**12.0**
	56 to 60	**2,100**	**1,700**	15 I	**180**

MW0001 (20 to 30)

Date	TCE	cDCE	tDCE	VC
02/05/2014	0.30 U	**84.2**	2.9	**15.9**

MW0002 (60 to 70)

Date	TCE	cDCE	tDCE	VC
02/05/2014	1.4	1.3	0.34 U	0.33 U

MW0003 (70 to 80)

Date	TCE	cDCE	tDCE	VC
02/05/2014	0.30 U	0.33 U	0.34 U	0.33 U

MW0004 (70 to 80)

Date	TCE	cDCE	tDCE	VC
02/05/2014	0.30 U	0.33 U	0.34 U	0.33 U

MW0005 (80 to 90)

Date	TCE	cDCE	tDCE	VC
02/05/2014	0.30 U	0.76 I	0.34 U	0.33 U

Legend

- Monitoring Well Location with at Least One CVOC Result Greater than GCTLs (screen interval (ft BLS))
- Monitoring Well Location with CVOC Result Less than GCTLs (screen interval (ft BLS))
- DPT Sampling Location withTCE Result Greater than 1% Solubility
- DPT Sampling Location with at Least One CVOC Result Greater than 10 x NADCs
- DPT Sampling Location with at Least One CVOC Result Greater than NADCs
- DPT Sampling Location with at Least One CVOC Result Greater than GCTLs
- DPT Sampling Location with CVOC Result Less than GCTLs

Overall TCE 1% Solubility Contour (dashed contours are 6 to 16 ft BLS interval and solid contours are 41 to 50 ft BLS interval)

Overall CVOC 10 x NADC Contour (dashed contours are 6 to 22 ft BLS interval and solid contours are 41 to 55 ft BLS interval)

Screening Criteria

Parameter	Abbreviation	GCTL	NADC
Trichloroethene	TCE	3	300
cis-1,2-Dichloroethene	cDCE	70	700
trans-1,2-Dichloroethene	tDCE	100	1,000
Vinyl Chloride	VC	1	100

20 10 0 20 Feet

Notes:
1. Depth is presented in feet below land surface (ft BLS).
2. Results are presented in micrograms per liter (µg/L).
3. Direct push technology (DPT) analytical results presented only for locations with at least one constituent exceeding Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration (NADC).
4. For DPT locations, U indicates not detected above the practical quantitation limit (PQL). For monitoring well locations, U indicates not detected above the method detection limit (MDL).
5. I indicates value is between the MDL and the PQL.
6. L indicates value exceeds calibration range.
7. CVOC indicates chlorinated volatile organic compounds.
8. Contours based on DPT groundwater sampling results.
9. Bold and yellow highlighted value indicates concentration greater than FDEP Groundwater Cleanup Target Level (GCTL).
10. Bold and orange highlighted value indicates concentration greater than FDEP NADC.
11. Bold and green highlighted value indicates concentration greater than 10 times the FDEP NADC.
12. Bold and blue highlighted value indicates concentration greater than the 1% solubility of trichloroethene (TCE).
13. Prefix for all DPT locations is "VABRA-".
14. 2011 Aerial Source: World_Imagery (Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community).

Path: (Titusville-01\Data\)P:\0GIS\FR2102_VAB_Reassessment\MXDs\MLPV_IMWP_MAR2016\HS3_Spider_with10XNADCplumes_17X22.mxd 29 March 2016 JRB

Figure 2-11
CVOC DPT Groundwater Sampling Results for Locations with Concentrations Greater than the FDEP NADC

SECTION III

BIOREMEDIATION DESIGN

3.1 TECHNOLOGY DESCRIPTION

In anaerobic-reducing environments, biologically mediated reductive dechlorination of TCE involves the sequential replacement of chlorine atoms on the alkene molecule by hydrogen atoms. The chlorinated ethenes serve as electron acceptors in these dechlorination reactions; simple organic carbon compounds (e.g., sugars, alcohols, fatty acids, etc.) and hydrogen serve as electron donors. The sequential dechlorination of TCE proceeds via cDCE and VC to ethene. There are several organisms capable of the dechlorination of TCE to cDCE, but only one genus, *Dhc*, is known to achieve complete dechlorination to ethene.

Bioremediation consists of either biostimulation (addition of electron donor), bioaugmentation (addition of microbes), or a combination of the two. Biostimulation involves injecting electron donor (e.g., ethanol, lactate, vegetable oil, etc.) into the saturated zone. Bioaugmentation consists of injecting microbial cultures (e.g. KB-1®) to provide necessary organisms to achieve complete reductive dechlorination. When conditions in a given treatment zone are optimized (i.e., neutral pH, *Dhc* and dissolved hydrogen present, and inhibitory factors absent), biotic dechlorination of CVOCs typically occurs within weeks to months.

Bioremediation implementation at MLPV Hot Spot 3 will consist of biostimulation and bioaugmentation using DPT injection of the electron donor and dechlorination culture.

3.2 AMENDMENT SELECTION

SRS®-SD from Terra Systems, Inc. was selected as the electron donor. SRS®-SD is a slow release, small droplet, neutral pH emulsified vegetable oil that is composed of the following:

- 60% food grade soybean oil (slow release electron donor);
- 4 to 7% potassium lactate (fast release electron donor);
- 5 to 15% emulsifiers (proprietary) and nutrients (yeast extract, nitrogen and phosphorous to support microbial growth);
- < 1% (minimum of 250 µg/L) vitamin B12 (important micronutrient for *Dhc*);
- 6 to 8 grams per liter of sodium bicarbonate (to aid in pH buffering); and
- balance of water.

Manufacturer's information is included in Appendix C and a copy of the FDEP product approval letter along with the completed Underground Injection Control (UIC) Memo is included in Appendix D.

3.3 INJECTION DETAILS

The proposed bioremediation treatment area is defined as the 10xNADC area (including the SZ), as depicted on Figure 2-11. The following sections discuss the amendment dosing requirements, injection locations, and the injection design parameters.

3.3.1 INJECTION LOCATION AND DEPTH. The SRS®-SD amendment will be injected into the subsurface by a DPT injection subcontractor (worked scoped assumed the use of Vironex, Inc.; the injection contractor can be modified during the IM Implementation Work Plan). The injection locations are presented on Figure 3-1 and are based on an expected radius of influence (ROI) of 8 feet (further details provided in Section 3.3.4). The coordinates of the injection locations are provided in Table 3-1. The proposed injection intervals were selected based on the data collected during the VABRA activities (Figure 2-11) and were extended 2 feet above and below the depth interval within the 10xNADC area where CVOC concentrations exceeded 10xNADC concentrations (to be conservative). The proposed injection intervals for each injection location and the UIC required Zone of Discharge are presented on Figure 3-1, and the proposed treatment interval is presented on the cross sections provided as Figure 3-2 and Figure 3-3. A brief summary of the rationale for the injection intervals is provided in Table 3-2.

Prior to completion of the IM Implementation Work Plan, a Ground Penetrating Radar (GPR) survey will be performed in the treatment area to evaluate the location of underground obstructions (MLP footers) that may interfere with the injection locations presented on Figure 3-1. The information obtained from the GPR survey will be utilized in the IM Implementation Work Plan to adjust the proposed injection locations.

3.3.2 AMENDMENT DOSING. The volume of SRS®-SD to be injected was calculated based on discussions with Terra Systems, Inc. and the following assumptions:

- a uniform porosity of 0.3;
- a desired 8-foot ROI;
- electron donor (the oil portion of the SRS®-SD) occupying a minimum of 0.7% of the pore space in the SZ and a minimum of 0.2% of the pore space in the 10xNADC ring (defined as the area between the SZ contour and the 10xNADC contour);
- minimizing the volume of chase water necessary to obtain the desired ROIs; and
- the SRS®-SD solution being 60% electron donor (soybean oil).

The dosing calculations are provided in Appendix E. Implementation of bioremediation of the 10xNADC area includes the injection of a total of 33 drums of electron donor into 25 injection locations in both the SZ and the 10xNADC ring. Within the SZ, bioremediation would include the injection of approximately 29 drums (52.5 gallons per drum) of electron donor into 13 injection locations. Note that 2 of the 13 injection locations have two treatment intervals (injection locations INJ17 and INJ18 on Figure 3-1). The volume of SRS®-SD was calculated assuming that the oil portion of the SRS®-SD would fill approximately 0.7% of the pore volume, which is a conservative estimate based on the possibility of dense non-aqueous phase liquid (DNAPL) being present. Within the 10xNADC ring, the implementation of bioremediation would include the injection of approximately 4 drums (52.5 gallons per drum) of SRS®-SD into 12 injection locations. Note that 2 of the 12 injection locations have two treatment intervals (injection locations INJ15 and INJ16 on Figure 3-1). The volume of the SRS®-SD was calculated assuming it would fill approximately 0.2% of the 10xNADC ring pore volume. The percentage of the pore volume to be filled in the 10xNADC ring was reduced from the dosing used in the SZ, since the concentrations in this area are less than what are observed in the SZ. The dosing for the SZ (0.7% of the pore volume) and for the 10xNADC area (0.2% of the pore volume) were selected based on past experience at similar sites.

Additionally, the Environmental Security Technology Certification Program (ESTCP) Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents was utilized to estimate the amount of electron donor required. The ESTCP tool recommended filling between 0.05% and 0.06% of the pore volume in the 10xNADC ring and 0.15% to 0.34% of the pore volume in the SZ. Therefore, Geosyntec is comfortable with the conservative dosing of 0.2% in the 10xNADC ring and 0.7% in the SZ. The ESTCP tool calculations are included in Appendix E.

3.3.3 INJECTION DESIGN. The injection activities were designed using two different injection methods: low pressure injection from approximately 4 to 52 ft BLS and high pressure injection in the low permeability interval from approximately 52 to 57 ft BLS. The goal of the low pressure injection is to completely distribute the electron donor throughout the treatment area (within the permeable interval), and the goal of the low pressure injection is to create fractures where the electron donor can be distributed (within the low permeability interval).

As discussed previously, a DPT injection subcontractor will be contracted to carry out the injection activities. The DPT injection subcontractor will mobilize to the MLPV Hot Spot 3 with the appropriate equipment to complete the subsurface injections, which is anticipated to include the following:

- two Geoprobe® DPT rigs;
- one injection platform with mixing tanks;

- low pressure centrifugal pump for upper high permeability zone and a positive displacement high pressure pump for low permeability zone;
- an injection manifold with a maximum of eight injection set-ups (four per DPT rig) that each include a 2-foot injection tool for the high permeability zone (4 to 52 ft BLS);
- an injection manifold with one injection set-up that includes a jetting injection tool for injecting into the low permeability zone (52 to 57 ft BLS); and
- a flow meter, flow controller, and pressure gauge for each manifold outlet.

The high pressure injection activities will include the injection of the SRS®-SD solution at one location at a time, with an injection rate of approximately 20 gallons per minute (gpm) with pressures of 150 to 250 pounds per square inch (psi) [typical for this type of formation provided by Vironex, Inc.]. The injections will be performed using a jet injection tool and will occur from the bottom up. The jet injection tool targets a discrete zone and will fracture the low permeability zone to inject the SRS®-SD solution into the low permeability interval. The jet injection nozzle promotes a high exit velocity and will create an approximate 1-inch fracture zone every 2 ft (3 intervals total from 52 to 57 ft BLS). Since there are no existing monitoring wells screened in the high pressure injection interval, no existing monitoring wells will need to be abandoned prior to injection activities.

The low pressure injection activities will include injection of the SRS®-SD solution at up to 8 locations (simultaneously) with an injection rate between 2 to 7 gpm with a pressure of 20 to 50 psi (based on injection activities at Launch Complex 34). The injections will be performed using a 2-foot injection tool and will occur from the bottom up. The existing monitoring well that is screened in the low pressure injection interval (MW0001) will not to be abandoned prior to implementation injection of activities (no anticipated daylighting/preferential pathway issues based on injection activities performed at Launch Complex 34 using the same technique).

The injection locations that have both high pressure and low pressure injection (INJ08 through INJ14 and INJ17 and INJ18) will be completed using two borings (one directly adjacent to the other). First, the high pressure injection will occur in one boring, and then the low pressure injection will occur in the adjacent boring. The sequencing of the injection locations will be detailed in the IM Implementation Work Plan.

During injection activities, information regarding the injection start time, finish time, volume injected, flow rate, and injection pressure will be recorded for each injection interval.

3.3.4 RADIUS OF INFLUENCE. In order to achieve the desired 8-foot ROI, the SRS®-SD solution will be diluted with potable water from an on-site fire hydrant (Section 3.3.5). The calculations are included in Appendix E.

The dilution ratio for the low pressure injection locations is 1:80 SRS®-SD to water ratio by volume in the SZ and 1:270 SRS®-SD to water ratio by volume in the 10xNADC ring (calculations included in Appendix E). It is anticipated that approximately 50 gallons of chase water will be used following the injection of the diluted SRS®-SD solution (to clear the SRS®-SD solution from the injection lines and DPT rods).

The dilution ratio for the high pressure injection locations (52 to 57 ft BLS) is 1:10 SRS®-SD to water ratio by volume to fill approximately 10 to 20% of the pore volume with the diluted SRS®-SD solution based on an 8-foot ROI (note the dosing of the SRS®-SD is the same for the low and high permeability injection interval, just the volume of dilution water is reduced to account for the difficulty in accessing the pore space during injection activities (low permeability equals high resistance to flow).

Approximately 161,000 gallons of diluted SRS®-SD solution will be injected over different treatment intervals at injection locations according to Figure 3-1, and approximately 10,500 gallons of chase water (50 gallons per injection interval) will be injected following the SRS®-SD solution (Appendix E). In total, approximately 171,000 gallons of fluid (SRS®-SD solution and chase water) will be injected across the treatment area at the MLPV Hot Spot 3.

3.3.5 WATER SOURCE. Water for the dilution and chase water will be obtained from an on-site fire hydrant (there are two options within 250 feet of the treatment area), and stored in holding tanks provided by the DPT injection subcontractor. Before the hydrant water is injected, chlorine will be removed with a dechlorinator (Beckett Chlorine and Chloramine Remover, or equivalent) per product specifications. In addition, if required (DO greater than 1 mg/L), the hydrant water will be made anaerobic prior to injections. To create anaerobic water an oxygen scavenger (sodium sulfite, or equivalent) will be added to the water. It is estimated (Appendix E) that a total of 0.24 grams sodium sulfite per gallon will be utilized based on an assumption that the potable water will have a DO concentration of approximately 8 mg/L. The DO concentration in the potable water will be verified in the field and the amount of sodium sulfite will be adjusted accordingly.

3.3.6 BIOAUGMENTATION. Bioaugmentation will be implemented at the MLPV Hot Spot 3 during the injection of the SRS®-SD solution. Approximately 57 liters (L) of dechlorination culture (KB-1® or equivalent) will be added to the subsurface. The volume of KB-1 was calculated by assuming that 0.5 L of dechlorination culture will be injected into every other 2-foot injection interval at each of the 25 injection locations (calculations included in Appendix E). Per SiREM's recommendations, the smallest volume of dechlorination culture that can be accurately injected is approximately 0.5 L. The bioaugmentation culture will be injected either during SRS®-SD injections or following those injections, and the injection of SRS®-SD solution and KB-1® will be followed by the injection of approximately 50 gallons of anaerobic

chase water or by additional SRS®-SD solution per injection interval to clear the hoses and DPT rods. Additional details of the injection methods, conditions, tooling, and when bioaugmentation culture injection will occur will be provided in the IM Implementation Work Plan. The bioaugmentation information has been included in the UIC information (Appendix D).

3.3.7 INJECTION COMPLETION AND TIMEFRAME. After completion of the injection at each location, the injection boreholes will be abandoned using tremmie grouting methods. The estimated time for completion is approximately 18 days.

Table 3-1. Injection Location Coordinates Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Injection Location	Easting	Northing
INJ01	233821.644	471604.692
INJ02	233824.479	471604.883
INJ03	233827.631	471604.502
INJ04	233821.719	471601.078
INJ05	233825.062	471601.269
INJ06	233828.849	471600.380
INJ07	233832.116	471598.861
INJ08	233834.887	471596.512
INJ09	233836.844	471594.167
INJ10	233840.314	471594.802
INJ11	233843.656	471595.247
INJ12	233839.627	471591.379
INJ13	233842.906	471591.125
INJ14	233846.121	471591.696
INJ15	233831.620	471602.348
INJ16	233834.962	471601.142
INJ17	233838.166	471598.480
INJ18	233841.616	471598.691
INJ19	233830.413	471605.131
INJ20	233833.883	471605.385
INJ21	233837.300	471604.629
INJ22	233838.432	471601.459
INJ23	233841.087	471603.486
INJ24	233843.783	471601.396
INJ25	233844.724	471599.052

Note:

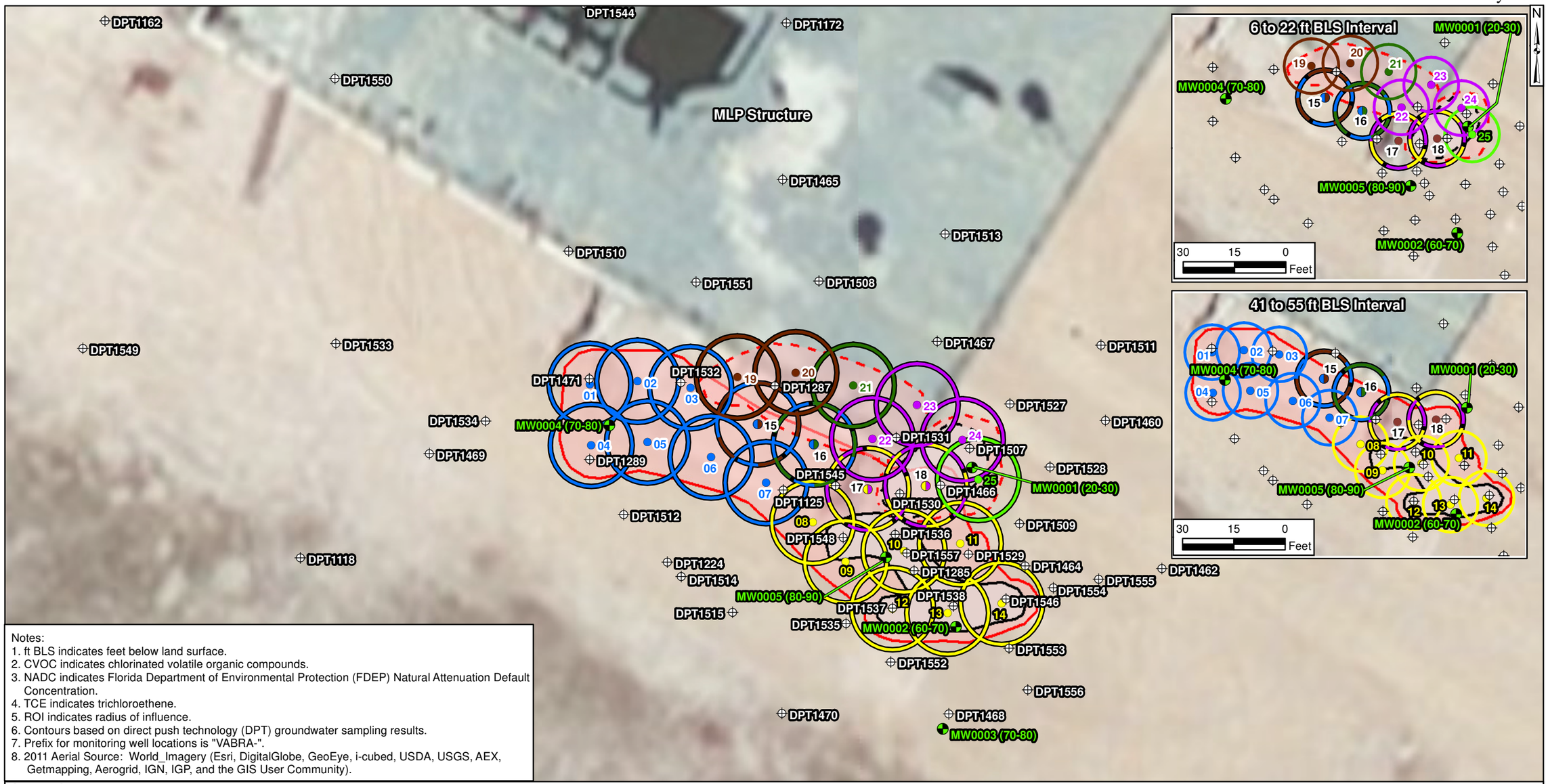
1. Coordinates are in US State Plane North American Datum of 1983, Florida East, Meters.

Table 3-2. Injection Rationale Table
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Injection Location	Injection Interval (ft BLS)	Rationale for Injection Interval			Rationale for Extension of Injection Interval
		DPT Location that Injection Interval is Based Upon	Interval with CVOCs > 10xNADC (ft BLS)	Interval with TCE > 1% solubility (ft BLS)	
Deep Injection Locations/Impacts Greater than 30 ft BLS					
INJ01	44 to 52	DPT1471	46 to 50	NA	Extended 2 feet above and below impacted interval.
INJ02	44 to 52	DPT1471	46 to 50	NA	
		DPT1532	46 to 50	NA	
INJ03	44 to 52	DPT1532	46 to 50	NA	
INJ04	44 to 52	DPT1289	46 to 50	NA	
INJ05	44 to 52	DPT1289	46 to 50	NA	
INJ06	44 to 52	DPT1125	46 to 50	NA	
		DPT1289	46 to 50	NA	
INJ07	44 to 52	DPT1125	46 to 50	NA	
INJ08	39 to 57	DPT1548	46 to 55	46 to 50	ROI extends into deep SZ; therefore, injection interval extended from 39 to 57 ft BLS (injection interval the same for all locations to be conservative). Extended 2 feet above and below the shallowest and deepest impacts identified.
		DPT1125	46 to 55	NA	
INJ09	39 to 57	DPT1548	46 to 55	46 to 50	
INJ10	39 to 57	DPT1285	46 to 55	46 to 55	
		DPT1536	41 to 55	46 to 50	
INJ11	39 to 57	DPT1529	46 to 55	NA	
INJ12	39 to 57	DPT1537	41 to 50	41 to 45	
INJ13	39 to 57	DPT1538	41 to 50	41 to 50	
INJ14	39 to 57	DPT1546	41 to 50	46 to 50	
INJ15	44 to 52	DPT1125	46 to 50	NA	Extended 2 feet above and below impacted interval.
		DPT1532	46 to 50	NA	
INJ16	44 to 52	DPT1125	46 to 50	NA	
INJ17	39 to 57	DPT1530	46 to 55	NA	ROI extends into deep SZ; therefore, injection interval extended from 39 to 57 ft BLS to be conservative. Extended 2 feet above and below the shallowest and deepest impacts identified.
		DPT1536	41 to 55	46 to 50	
		DPT1548	46 to 55	46 to 50	
INJ18	39 to 57	DPT1466	46 to 50	NA	
		DPT1536	41 to 55	46 to 50	
		DPT1530	46 to 55	NA	
Shallow Injection Locations/Impacts Less than 30 ft BLS					
INJ15	16 to 26	DPT1287	18 to 22	NA	Extended 2 feet above shallowest impact identified. No sample collected from 22 to 26 ft BLS; therefore, injection interval extended to 26 ft BLS (26 ft BLS start of next interval with CVOC concentrations less than 10xNADC).
INJ16	10 to 26	DPT1287	18 to 22	NA	
		DPT1531	12 to 22	NA	
INJ17	4 to 26	DPT1530	12 to 16	12 to 16	ROI extends into shallow SZ; therefore, injection interval extended to 4 ft BLS to be conservative. No sample collected from 22 to 26 ft BLS; therefore, injection interval extended to 26 ft BLS (26 ft BLS start of next interval with CVOC concentrations less than 10xNADC).
		DPT1531	12 to 22	NA	
INJ18	4 to 26	DPT1466	6 to 16	6 to 16	Extended 2 feet above shallowest impact identified. No sample collected from 22 to 26 ft BLS; therefore, injection interval extended to 26 ft BLS (26 ft BLS start of next interval with CVOC concentrations less than 10xNADC).
		DPT1530	12 to 16	12 to 16	
		DPT1531	12 to 22	NA	
INJ19	16 to 26	DPT1287	18 to 22	NA	
INJ20	16 to 26	DPT1287	18 to 22	NA	
INJ21	10 to 26	DPT1287	18 to 22	NA	
		DPT1531	12 to 22	NA	
INJ22	4 to 26	DPT1531	12 to 22	NA	ROI extends into shallow SZ; therefore, injection interval extended to 4 ft BLS to be conservative. No sample collected from 22 to 26 ft BLS; therefore, injection interval extended to 26 ft BLS (26 ft BLS start of next interval with CVOC concentrations less than 10xNADC).
INJ23	4 to 26	DPT1531	12 to 22	NA	
INJ24	4 to 26	DPT1507	6 to 16	6 to 16	Extended 2 feet above shallowest impact identified. No sample collected from 22 to 26 ft BLS; therefore, injection interval extended to 26 ft BLS (26 ft BLS start of next interval with CVOC concentrations less than 10xNADC).
		DPT1531	12 to 22	NA	
INJ25	4 to 18	DPT1466	6 to 16	6 to 16	Extended 2 feet above and below impacted interval.
		DPT1507	6 to 16	6 to 16	

Notes:

1. ft BLS indicates feet below land surface.
2. DPT indicates direct-push technology.
3. CVOCs indicates chlorinated volatile organic compounds.
4. 10xNADC indicates ten times the Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration (NADC).
5. TCE indicates trichloroethene.
6. NA indicates not applicable.
7. ROI indicates radius of influence.
8. SZ indicates source zone.



Notes:
1. ft BLS indicates feet below land surface.
2. CVOC indicates chlorinated volatile organic compounds.
3. NADC indicates Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration.
4. TCE indicates trichloroethene.
5. ROI indicates radius of influence.
6. Contours based on direct push technology (DPT) groundwater sampling results.
7. Prefix for monitoring well locations is "VABRA-".
8. 2011 Aerial Source: World_Imagery (Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community).

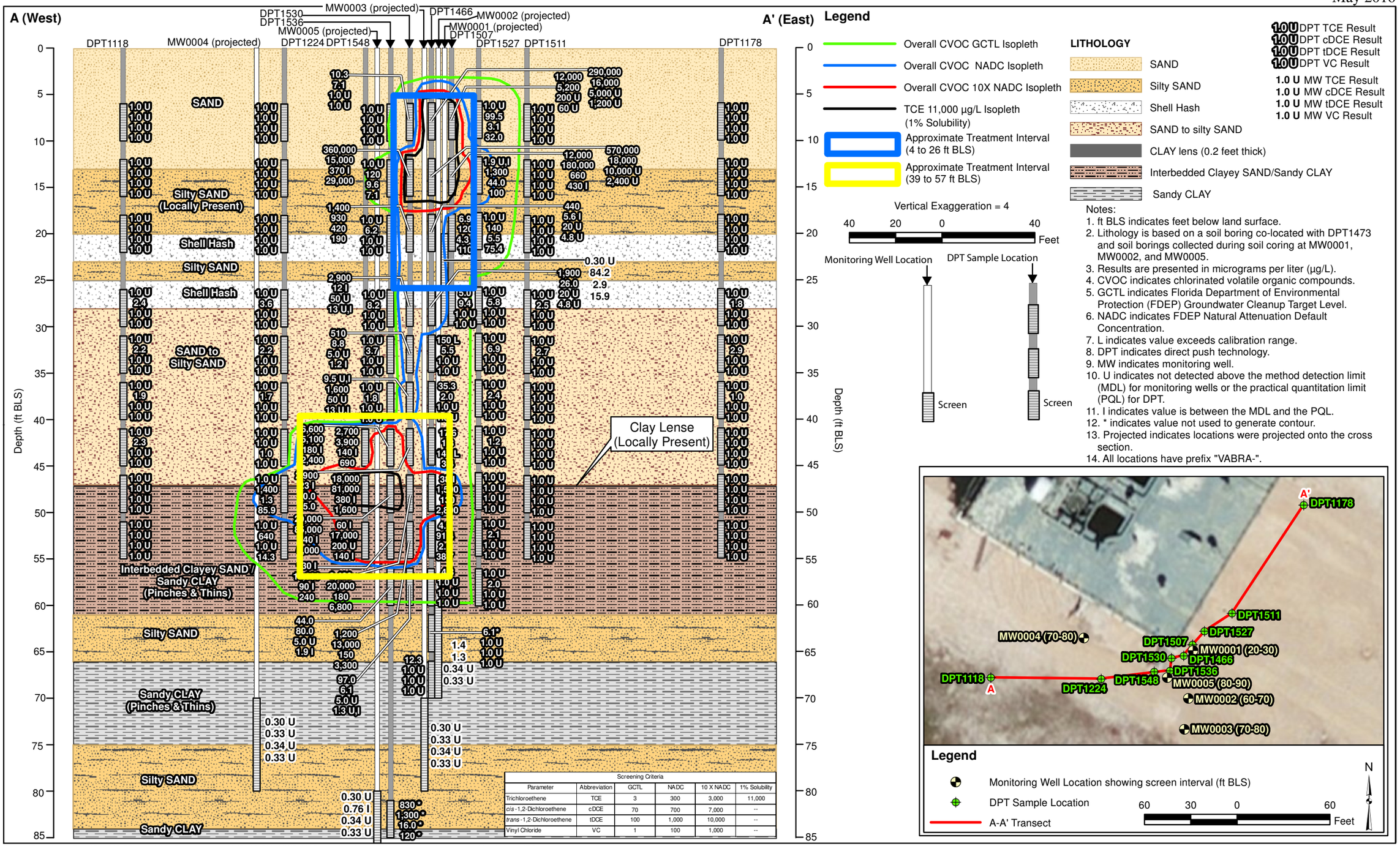
Legend

- DPT Sampling Location
- Monitoring Well Location
- Overall TCE 1% Solubility Contour (dashed contours are 6 to 16 ft BLS interval and solid contours are 41 to 50 ft BLS interval)
- Overall CVOC 10 x NADC Contour (dashed contours are 6 to 22 ft BLS interval and solid contours are 41 to 55 ft BLS interval)
- Injection Location with Estimated 8 ft ROI for 4 to 18 ft BLS (Total = 1)
- Injection Location with Estimated 8 ft ROI for 4 to 26 ft BLS (Total = 3)
- Injection Location with Estimated 8 ft ROI for 39 to 57 ft BLS (Total = 7)
  Low pressure injection from 39 to 52 ft BLS
  High pressure injection from 52 to 57 ft BLS
- Injection Location with Estimated 8 ft ROI for 4 to 26 and 39 to 57 ft BLS (Total = 2)
  Low pressure injection from 4 to 26 and 39 to 52 ft BLS
  High pressure injection from 52 to 57 ft BLS
- Injection Location with Estimated 8 ft ROI for 10 to 26 ft BLS (Total = 1)
- Injection Location with Estimated 8 ft ROI for 16 to 26 ft BLS (Total = 2)
- Injection Location with Estimated 8 ft ROI for 44 to 52 ft BLS (Total = 7)
- Injection Location with Estimated 8 ft ROI for 10 to 26 and 44 to 52 ft BLS (Total = 1)
- Injection Location with Estimated 8 ft ROI for 16 to 26 and 44 to 52 ft BLS (Total = 1)

20 10 0 20 Feet

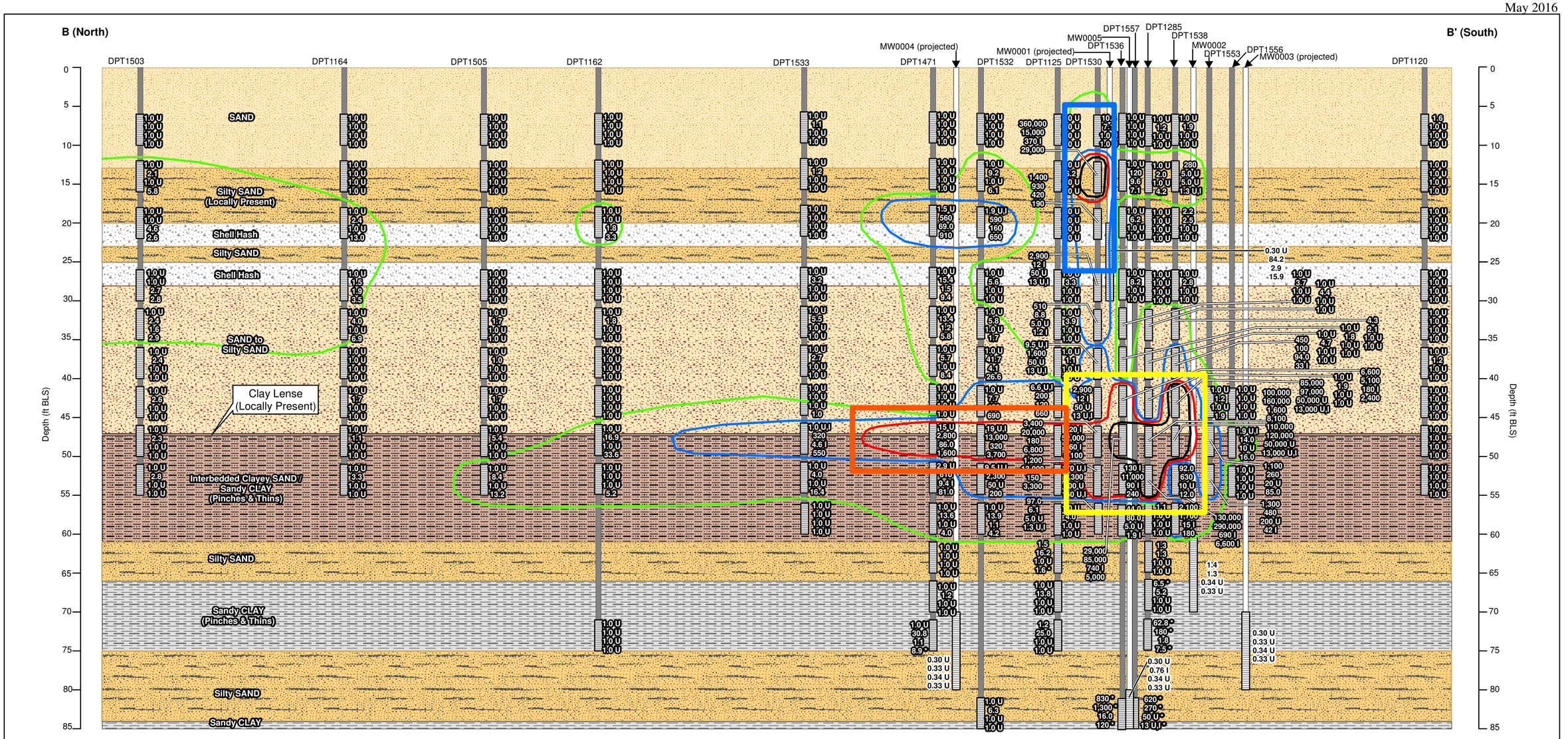
Path: (Titusville-01\Data\)P:\0GIS\FR2102_VAB_Reassessment\MXDs\MLPV_IMWP_MAR2016\Bioremediation_OverallCVOC_10xNADCwithDPT_F_MAR2016.mxd 29 March 2016 MAH

Figure 3-1
Proposed Injection Layout for Implementation of Bioremediation in the 10xNADC Area



Path: (Titusville-01\Data\)P:\0GIS\FR2102_VAB_Reassessment\MXDs\MLPV_IMWP_MAR2016\INJ_Interval_CrossSection_AA.mxd 29 March 2016 JRB

Figure 3-2
Proposed Injection Intervals for Bioremediation:
Cross Section A-A'



Legend

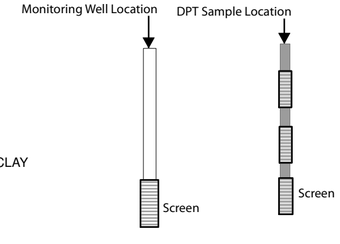
- Overall GCTL Isopleth
- Overall NADC Isopleth
- Overall 10X NADC Isopleth
- TCE 11,000 µg/L Isopleth (1% Solubility)
- Approximate Treatment Interval (4 to 26 ft BLS)
- Approximate Treatment Interval (39 to 57 ft BLS)
- Approximate Treatment Interval (44 to 52 ft BLS)

LITHOLOGY

- SAND
- Silty SAND
- Shell Hash
- SAND to silty SAND
- CLAY lens (0.2 feet thick)
- Interbedded clayey SAND / sandy CLAY
- Sandy CLAY

1.0 U DPT TCE Result
1.0 U DPT cDCE Result
1.0 U DPT tDCE Result
1.0 U DPT VC Result

1.0 U MW TCE Result
1.0 U MW cDCE Result
1.0 U MW tDCE Result
1.0 U MW VC Result



Screening Criteria					
Parameter	Abbreviation	GCTL	NADC	10 X NADC	1% Solubility
Trichloroethene	TCE	3	300	3,000	11,000
cis -1,2-Dichloroethene	cDCE	70	700	7,000	--
trans -1,2-Dichloroethene	tDCE	100	1,000	10,000	--
Vinyl Chloride	VC	1	100	1,000	--

Vertical Exaggeration = 3

30 15 0 30 Feet

Notes:
1. ft BLS indicates feet below land surface.
2. Lithology is based on a soil boring co-located with DPT1473 and soil borings collected during soil coring at MW0001, MW0002, and MW0005.
3. Results are presented in micrograms per liter (µg/L).
4. CVOC indicates chlorinated volatile organic compounds.
5. GCTL indicates Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Level.
6. NADC indicates FDEP Natural Attenuation Default Concentration.
7. DPT indicates direct push technology.
8. MW indicates monitoring well.
9. U indicates not detected above the method detection limit (MDL) for monitoring wells or the practical quantitation limit (PQL) for DPT.
10. I indicates value is between the MDL and the PQL.
11. * indicates value not used to generate contour.
12. Projected indicates locations were projected onto the cross section.
13. All locations have prefix "VABRA-".

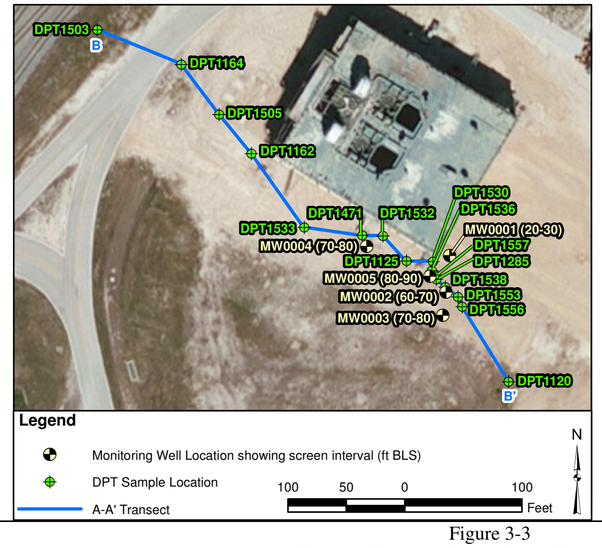


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Figure 3-3
Proposed Injection Intervals for Bioremediation:
Cross Section B-B'

SECTION IV

PERFORMANCE MONITORING

This section provides details on the baseline and performance monitoring that will occur in association with the bioremediation implementation.

4.1 BASELINE GROUNDWATER SAMPLING

4.1.1 BASELINE DPT GROUNDWATER SAMPLING. Prior to initiation of the injection activities, a baseline DPT groundwater sampling event will be performed to refine the CVOC distribution. The DPT groundwater sampling may be used to refine the performance monitoring well screen intervals and the injection intervals if necessary. Any modifications to the injection intervals or performance monitoring well screen intervals will be documented in the IM Implementation Work Plan (Section 5.1). Additionally, select baseline DPT groundwater sampling locations will be performed adjacent to the proposed monitoring well locations to aid in correlating data from the baseline DPT groundwater sampling and the first monitoring well sampling event. Lastly, baseline DPT groundwater samples will be collected from 56 to 60 ft BLS at DPT1538 to confirm the presence of CVOCs at concentrations greater than 10xNADC, and the results will be utilized to evaluate if that interval will be included in the treatment area.

4.1.2 PRE-INJECTION BASELINE MONITORING WELL SAMPLING. Prior to the injection activities, monitoring well MW0001 will be sampled and the samples will be analyzed for UIC parameters per the FDEP SRS® Products Acceptance Letter (Appendix D), which includes total dissolved solids, total recoverable hydrocarbons, and sodium. Since performance monitoring wells cannot be installed prior to the injection activities (due to the use of high pressure injection techniques), the results of the UIC sampling from monitoring well MW0001 will be used as the baseline UIC sampling results. It is anticipated that these results will be included in the IM Implementation Work Plan.

4.2 GROUNDWATER MONITORING WELL INSTALLATION AND LOCATION

To aid in the evaluation of the bioremediation performance, nine proposed monitoring wells (MWA through MWI) will be installed via DPT (Figure 4-1) after the injection activities are completed. The locations and screen intervals for the monitoring wells were selected based upon the following (data presented on Figure 2-11):

- MWA (5 to 15 ft BLS) – TCE concentrations greater than 1% solubility from 6 to 16 ft BLS at DPT1507 and selected for UIC monitoring within injection area;
- MWB (12 to 17 ft BLS) – TCE concentrations greater than 1% solubility from 12 to 16 ft BLS at DPT1530;

- MWC (40 to 50 ft BLS) – TCE concentrations greater than 1% solubility from 41 to 50 ft BLS at DPT1538;
- MWD (45 to 55 ft BLS) – TCE concentrations greater than 1% solubility from 46 to 55 ft BLS at DPT1285 and selected for UIC monitoring within injection area;
- MWE (45 to 50 ft BLS) – TCE concentration greater than 1% solubility from 46 to 50 ft BLS at DPT1548;
- MWF (18 to 23 ft BLS) – CVOC concentrations greater than 10xNADC from 18 to 22 ft BLS at DPT1287;
- MWG (45 to 50 ft BLS) – CVOC concentrations greater than 10xNADC from 46 to 50 ft BLS at DPT1532;
- MWH (45 to 55 BLS) – location selected for downgradient UIC monitoring (CVOC concentrations greater than NADC from 46 to 50 ft BLS at DPT1533); and
- MWI (45 to 55 ft BLS) – location selected for upgradient UIC monitoring.

A minimum number of monitoring wells were proposed to effectively evaluate the performance of bioremediation and monitor CVOC concentrations across a majority of the treatment area and interval. The depths of the monitoring well screen intervals (10 feet in length or less) were selected to focus on the impacted intervals.

The monitoring wells shall be 0.75-inch diameter Schedule 40 polyvinyl chloride and shall be constructed as presented on Figure 4-2. The monitoring wells shall be developed using a peristaltic pump until they are visibly free of particulate matter.

4.3 POST-INJECTION GROUNDWATER MONITORING PLAN

All groundwater samples will be collected in general accordance with the FDEP Standard Operating Procedures [FDEP 2014] and the KSC Sampling and Analysis Plan [NASA 2011b]. A summary of the proposed sampling plan is provided in Table 4-1 and the monitoring well locations are presented on Figure 4-1. In addition to the proposed monitoring wells, existing monitoring well MW0002 is proposed to be included in the sampling plan to monitor below the treatment interval to evaluate migration of the CVOC impacts due to the injection activities. Additionally, groundwater samples are proposed to be collected from proposed monitoring wells MWH and MWI and analyzed for CVOCs to evaluate if bioremediation is influencing impacts outside the treatment area. The proposed groundwater monitoring plan is to monitor the performance of the bioremediation IM. It is anticipated that an Interim Groundwater Monitoring Plan will be developed to monitor the CVOC concentrations in groundwater greater than the GCTL but less than the 10xNADC (Figure 2-8).

During all sampling events, both groundwater level measurements and field parameters will be collected from each performance and UIC monitoring well. The field parameters measured during sampling will include the following: DO, ORP, pH, conductivity, salinity, total dissolved solids, temperature, and turbidity.

4.3.1 POST-INJECTION BASELINE MONITORING WELL SAMPLING. The baseline sampling event will occur immediately after injection activities are complete since monitoring wells cannot be installed prior to injection due to high pressure injection in the low permeability zone. During the baseline sampling event, groundwater samples will be collected from ten monitoring wells. Samples collected from the performance and UIC monitoring wells will be laboratory analyzed for the parameters listed in Table 4-1.

4.3.2 POST-INJECTION PERFORMANCE AND UIC MONITORING. Post-injection performance and UIC monitoring will occur as outlined in Table 4-1. A rationale for the proposed analysis parameters provided in Table 4-1 is provided below:

- CVOCs, ethene, and ethane will be monitored to evaluate progress of biologically mediated reductive dechlorination;
- methane will be monitored to evaluate the redox conditions of the aquifer (methane is produced by methanogens, which are organisms that thrive under similar conditions to *Dhc*);
- sulfate and sulfide will be monitored to evaluate the possibility of inhibition to *Dhc* by sulfide and to evaluate changes in concentration as sulfate reduction occurs (anticipate analysis for one year and then will discontinue, if concentrations are less than inhibitory levels);
- TOC will be monitored to evaluate distribution and concentration of electron donor for dechlorinating organisms;
- *Dhc* and *vcrA* will be monitored to evaluate the concentration of dechlorinating organisms present; and
- UIC parameters will be monitored per the FDEP SRS® Products Acceptance Letter (Appendix D) and includes total dissolved solids, total recoverable hydrocarbons, and sodium.

In addition to the monitoring well sampling, it is anticipated that a supplemental DPT groundwater sampling event will occur during the post-injection monitoring period (1 to 2 years after injection) to provide a more robust understanding of CVOC concentrations within the SZ and 10xNADC area. Groundwater samples will be collected via DPT from locations at or adjacent to previous DPT sampling locations (Figure 2-11) and/or along the centerline of the plume.

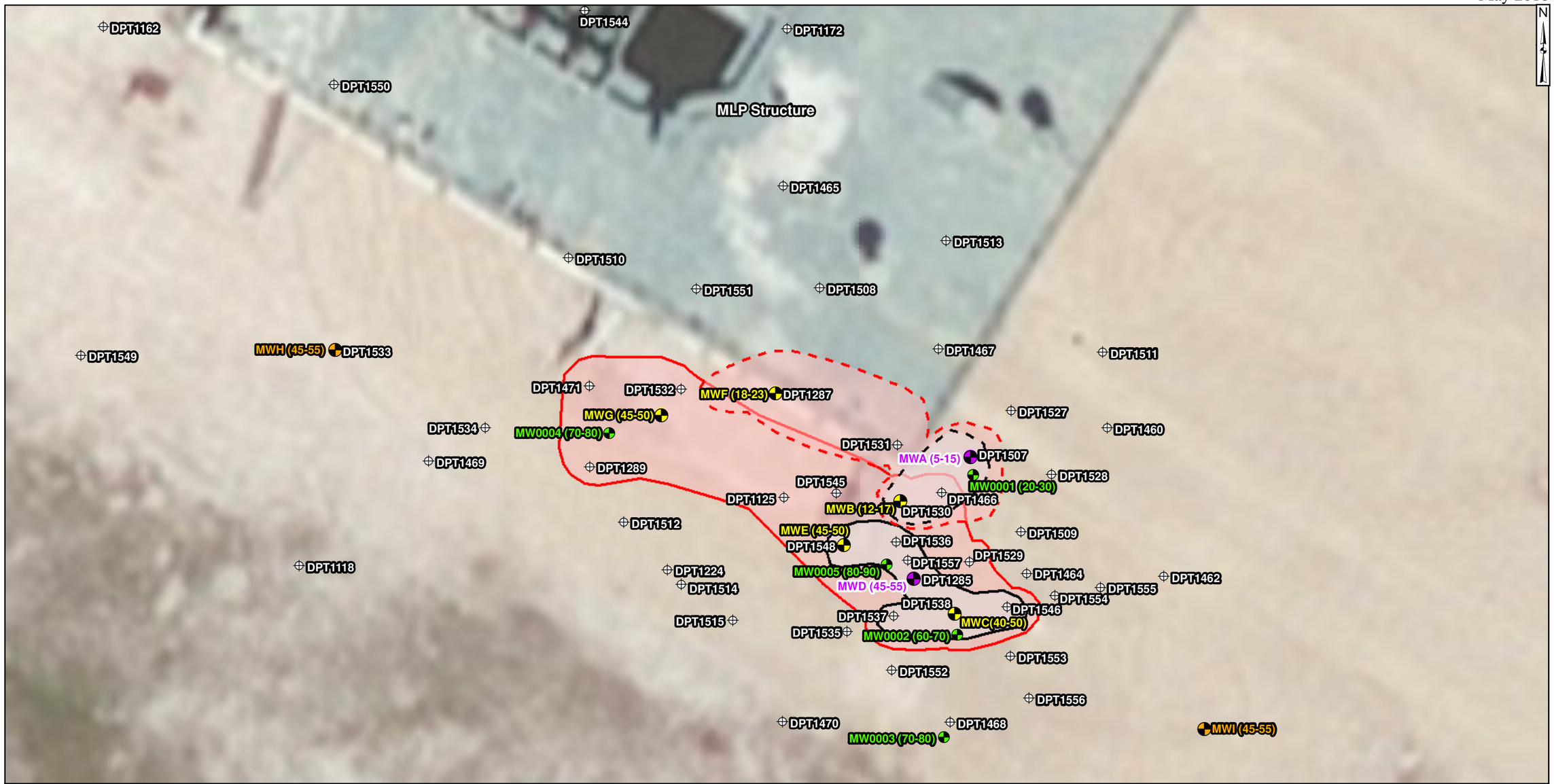
The supplemental DPT groundwater sampling and the performance monitoring data will be utilized to evaluate if an additional injection event is required and to aid in the design of the additional injection event and/or expansion of the treatment area.

Table 4-1. Proposed Monitoring Plan
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Sampling Location	Screen Interval (ft BLS)	Purpose of Well	Analysis								
			Performance Monitoring						UIC Monitoring		
			CVOCs using EPA Method 8260B	Methane, Ethene, and Ethane using EPA Method RSK-175	Sulfate using EPA Method 9056A	Sulfide using EPA Method 9034	TOC using SM 5310B	*Dehalococcoides* and *vcrA* (vinyl chloride reductase gene)	TDS using SM 2540C	Total Recoverable Hydrocarbons using FL-PRO	Sodium using EPA Method 200.7
Baseline Event - Post-Injection Activites											
MWA	5 to 15	Performance monitoring of shallow source zone/UIC Monitoring	X	X	X	X	X	X	X	X	X
MWB	12 to 17	Performance monitoring of shallow source zone	X	X	X	X	X	X			
MWC	40 to 50	Performance monitoring of deep source zone	X								
MWD	45 to 55	Performance monitoring of deep source zone/UIC Monitoring	X	X	X	X	X	X	X	X	X
MWE	45 to 50	Performance monitoring of deep source zone	X								
MWF	18 to 23	Performance monitoring of shallow CVOC 10xNADC	X	X			X	X			
MWG	45 to 50	Performance monitoring of deep CVOC 10xNADC	X	X			X	X			
MWH	45 to 55	UIC Monitoring	X						X	X	X
MWI	45 to 55	UIC Monitoring	X						X	X	X
MW0002	60 to 70	Performance monitoring below treatment area	X								
Semi-Annual Performance and Semi-Annual UIC Monitoring											
MWA	5 to 15	Performance monitoring of shallow source zone/UIC Monitoring	X	X	X	X	X	X	X	X	X
MWB	12 to 17	Performance monitoring of shallow source zone	X	X	X	X	X	X			
MWC	40 to 50	Performance monitoring of deep source zone	X								
MWD	45 to 55	Performance monitoring of deep source zone/UIC Monitoring	X	X	X	X	X	X	X	X	X
MWE	45 to 50	Performance monitoring of deep source zone	X								
MWF	18 to 23	Performance monitoring of shallow CVOC 10xNADC	X	X			X	X			
MWG	45 to 50	Performance monitoring of deep CVOC 10xNADC	X	X			X	X			
MWH	45 to 55	UIC Monitoring	X*						X	X	X
MWI	45 to 55	UIC Monitoring	X*						X	X	X
MW0002	60 to 70	Performance monitoring below treatment area	X*								

Notes:

1. ft BLS indicates feet below land surface.
2. CVOCs indicates chlorinated volatile organic compounds.
3. EPA indicates United States Environmental Protection Agency.
4. TOC indicates total organic carbon.
5. SM indicates standard method.
6. TDS indicates total dissolved solids.
7. UIC indicates underground injection control.
8. 10xNADC indicates ten times the Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration (NADC).
9. * indicates monitoring well will be sampled annually with analysis of samples for CVOCs (not semi-annually).
10. Baseline sampling will occur after injection activities are complete and performance monitoring wells are installed.



Legend

- DPT Sampling Location
- Existing Monitoring Well Location showing screen interval (ft BLS)
- Proposed Performance Monitoring Well Location showing screen interval (ft BLS)
- Proposed Performance and UIC Monitoring Well Location showing screen interval (ft BLS)
- Proposed UIC Monitoring Well Location showing screen interval (ft BLS)
- Overall TCE 1% Solubility Contour (dashed contours are 6 to 16 ft BLS interval and solid contours are 41 to 50 ft BLS interval)
- Overall CVOC 10 x NADC Contour (dashed contours are 6 to 22 ft BLS interval and solid contours are 41 to 55 ft BLS interval)

Notes:
1. ft BLS indicates feet below land surface.
2. CVOC indicates chlorinated volatile organic compounds.
3. NADC indicates Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration.
4. TCE indicates trichloroethene.
5. UIC indicates Underground Injection Control.
6. Contours based on direct push technology (DPT) groundwater sampling results.
7. Prefix for monitoring well locations is "VABRA-".
8. 2011 Aerial Source: World_Imagery (Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, and the GIS User Community).

20 10 0 20 Feet

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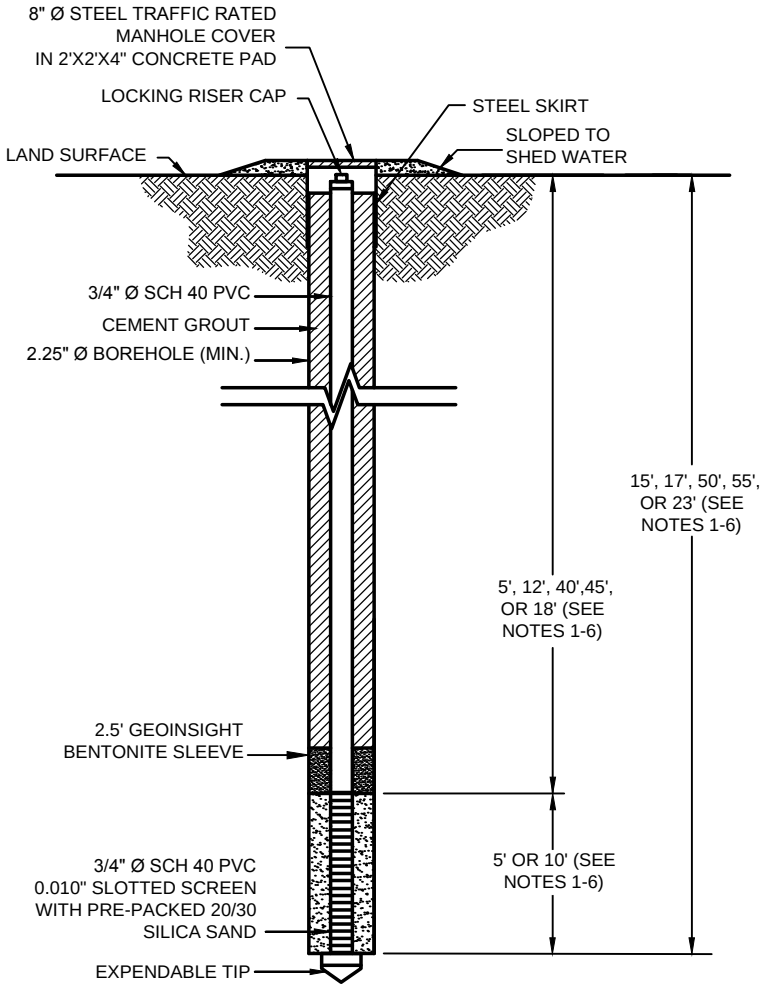
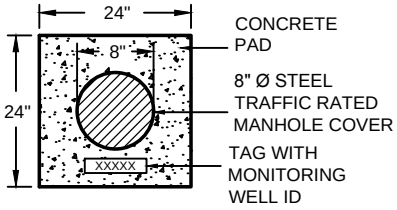
Figure 4-1
Proposed Monitoring Well Locations



PERFORMANCE MONITORING WELL
DETAIL
MWA THROUGH MWI
NOT TO SCALE



PERFORMANCE MONITORING WELL PLAN VIEW
MWA THROUGH MWI

NOT TO SCALE

NOTES:
1. PROPOSED MONITORING WELL MWA SCREEN INTERVAL IS 5 TO 15 FEET BELOW LAND SURFACE (FT BLS).
2. PROPOSED MONITORING WELL MWB SCREEN INTERVAL IS 12 TO 17 FT BLS.
3. PROPOSED MONITORING WELL MWC SCREEN INTERVAL IS 40 TO 50 FT BLS.
4. PROPOSED MONITORING WELL MWD, MWH, AND MWI SCREEN INTERVALS ARE 45 TO 55 FT BLS.
5. PROPOSED MONITORING WELLS MWE AND MWG SCREEN INTERVALS ARE 45 TO 50 FT BLS.
6. PROPOSED MONITORING WELL MWF SCREEN INTERVAL IS 18 TO 23 FT BLS.
7. PROPOSED MONITORING WELL IDs TO BE MODIFIED TO NUMERICAL VALUES AT TIME OF INSTALLATION.

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Figure 4-2
Proposed Monitoring Well Construction Details

SECTION V

INTERIM MEASURES REPORTING

5.1 INTERIM MEASURES IMPLEMENTATION WORK PLAN

After baseline DPT groundwater sampling, the IM Implementation Work Plan will be completed. This report will provide the design and coordination specifications to conduct the IM, as well as other items required by KSCRT EE Process, Revision 4 (August 2014). The IM Implementation Work Plan will be signed/sealed by the Florida licensed professional engineer in responsible charge of the project.

5.2 INTERIM MEASURES CONSTRUCTION COMPLETION REPORT

The IM Construction Completion Report (CCR) will document initial activities associated with implementation of bioremediation within the 10xNADC area in Hot Spot 3. It is anticipated that the CCR will include documentation of injection activities, monitoring well installation, baseline groundwater sampling results, and recommendations, as well as any other items required by KSCRT EE Process, Revision 4 (August 2014). The IM CCR will be signed/sealed by the Florida licensed professional engineer in responsible charge of the project. The CCR will be presented as an ADP to the KSCRT.

5.3 INTERIM MEASURES PERFORMANCE MONITORING DOCUMENTATION

Annual IM reports will be prepared to document MLPV Area activities and will be presented to the KSCRT in an ADP. The presentation will include the information required by the KSCRT EE Process, Revision 4 (August 2014). At a minimum, the reports will include:

- results of laboratory analyses of groundwater samples and interpretation of the data;
- recommendations and conclusions; and
- an exit strategy.

Annual reports will be signed/sealed by the Florida licensed professional engineer in responsible charge of the project.

SECTION VI

IMPLEMENTATION TIMELINE, EXIT STRATEGY, AND COSTING

6.1 IMPLEMENTATION TIMELINE

The approximate timeline for implementation of bioremediation in the 10xNADC area from completion of the Health and Safety Plan to the CCR is provided below. This timeline assumes no issues or conflicts in scheduling with the facility.

- 45 working days site preparation, site plan submittal and approval, utility locate, and pre-injection DPT sampling;
- 18 working days for SRS®-SD injection associated activities;
- 3 working days for monitoring well installation and development;
- 16 working days for baseline groundwater sampling, obtaining data from the lab and analyzing data; and
- 60 days (depending on KSCRT meeting schedule) for preparation of CCR and presentation of the CCR ADP to the KSCRT.

6.2 EXIT STRATEGY AND REMEDIATION TIMEFRAME

The IMWP's objective for MLPV Hot Spot 3 is to provide treatment of CVOC groundwater impacts above 10xNADC to reduce CVOC concentrations within the treatment area to concentrations that enable a transition to MNA. The performance monitoring data will be evaluated and based on the results, an additional injection can be performed to enhance bioremediation of CVOCs, the treatment area can be expanded to treat a larger area of CVOC impacts, or the area can be transitioned into a monitoring program.

The estimated time to reach NADCs for TCE, cDCE, and VC is between three and five years (calculations provided in Appendix F). The remediation timeframe was calculated assuming a first order decay, using the dechlorination rates for CVOCs from the implementation of biostimulation in the former source area at MLPV (calculated using two years of data, which accounted for daughter product creation and subsequent degradation), and the average concentration of TCE, cDCE, and VC within the 10xNADC ring and the SZ. Dechlorination rates were estimated from concentration reductions of CVOCs observed (from 2006 to 2008 during biostimulation activities) in samples collected from two source area wells at MLPV (SAMW0002 and SAMW0003) which are located within MLP/VAB source area.

6.3 INTERIM MEASURES COSTING

The capital cost and first year sampling and reporting costs for implementation of bioremediation in the 10xNADC are provided in Table 6-1. The estimated capital cost for the injection activities and initial baseline sampling is approximately $320,000 and the estimated annual cost for sampling and reporting is $50,000 per year. The DPT groundwater sampling event and second injection event (if warranted) are estimated to cost $40,000 and $120,000, respectively.

The total costs for the implementation and one year of sampling and reporting is estimated to be $370,000. The total cost for the implementation, the DPT groundwater sampling event, the second injection event (if required), and three to five years of monitoring is estimated to be $630,000 to $730,000.

Table 6-1. Hot Spot 3 Bioremediation Costing
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Item	Description	Quantity	Unit	Unit Cost	Total Cost	Estimate Basis
Capital Costs						
Site Preparation						
Site Preparation and Mobilization	Miscellaneous site preparation	1	EA	$3,000	$3,000	Engineering Estimate
Detailed GPR Survey	Ground penetrating radar (GPR) survey of site	1	DAY	$1,200	$1,200	Engineering Estimate
GPR Survey Oversight	Oversight of GPR survey	1	DAY	$1,600	$1,600	Engineering Estimate
Baseline DPT Groundwater Sampling	5 days of DPT sampling for CVOCs (DPT operator, mobile lab, oversight, and data evaluation)	5	DAY	$7,920	$39,600	EDS (1/2016); Columbia Technologies (2/2016); Engineering Estimate
				Subtotal	$45,400	
Emulsified Oil Injection						
Mobilization/Demobilization		2	EA	$1,320	$2,640	Vironex (3/2016)
Injection Services	SRS®-SD (0.7% pore space in the Source Zone and 0.2% pore space in the 10xNADC ring) and KB-1® injection; assumes low pressure injection from 6 to 52 ft BLS (injection at 8 locations simultaneously [4 gpm per location] for 7.2 hours per day) and high pressure injection from 52 to 57 ft BLS (2 days); includes decon between each location	15	DAY	$5,797	$86,955	Vironex (3/2016)
Tool Decon Between Locations		1	EA	$4,950	$4,950	Vironex (3/2016)
Setup and Breakdown	Includes time for setup and breakdown and injection services	2	DAY	$2,365	$4,730	Vironex (3/2016)
Per Diem	Per diem for injection services subcontractor	17	DAY	$495	$8,415	Vironex (3/2016)
HASP/Spill Plan/Injection Reporting		1	EA	$2,750	$2,750	Vironex (3/2016)
Tremie Grout Injection Locations	Based on the number of injection locations and their corresponding total injection depth, approximately 1,623 ft will need to be tremie grouted	1,623	FT	$0.83	$1,339	Vironex (3/2016)
Substrate Handling	Equipment and personnel to manage SRS®-SD during injection	1	EA	$4,169	$4,169	Vironex (3/2016)
Emulsified Vegetable Oil	Purchase 33 drums of SRS®-SD (1 injection event); the price includes packaging, standard freight, and Florida sales tax	33	DR	$840	$27,704	Terra Systems (2/2016)
Fork Lift Rental	Rental for unloading the drums of SRS®-SD from the truck and staging on site	1	DAY	$1,306	$1,306	FECC (5/2014)
KB-1® Culture	Purchase 57 L of KB-1® culture (1 injection event); the price includes packaging and Florida sales tax	57	L	$262	$14,954	SiREM (2/2016)
KB-1® Culture Shipping Charges	Outbound and return shipping charges for KB-1® culture vessels; the price includes Florida sales tax	1	EA	$2,204	$2,204	SiREM (2/2016)
Remediation Management/Oversight	Oversight and management of injection implementation (14 injection days, plus one day for oversight of emulsified vegetable oil delivery, one day for set up, and one day for break down)	18	DAY	$1,600	$28,800	Engineering Estimate
				Subtotal	$190,916	
Post-Emulsified Oil Injection						
Monitoring Well Installation - DPT	Installation and surveying of 9 monitoring wells using DPT following DPT data evaluation (includes installation, surveying and oversigh [estimate 3 days])	9	EA	$1,900	$17,100	EDS (11/2015) and Kugelmann (1/2016)
Baseline Groundwater Sampling	Collection and analysis of groundwater samples from 10 monitoring wells (9 newly installed and 1 existing) for VOCs; 5 monitoring wells for MEEs and TOC; 3 monitoring wells for sulfate and sulfide; 4 monitoring wells for TRPH, TDS, and sodium, 5 monitoring wells for *Dhc* and *vcrA* (estimate 2 days)	10	EA	$825	$8,250	Test America (5/2015); Sirem (5/2015); Engineering Estimate
				Subtotal	$25,350	
Engineering Design, Management, and Reporting Costs						
Project Engineering/Management Support	Project coordination, health and safety, meetings, telephone conferences, progress reports, administrative support, permits (2 hrs/day)	56	HR	$150	$8,400	Engineering Estimate
Implementation Work Plan	Implementation Work Plan per NASA Engineering Evaluation process	1	EA	$20,000	$20,000	Engineering Estimate
Construction Completion Report (CCR)	Summary of project implementation	1	EA	$15,000	$15,000	Engineering Estimate
ADP prep/presentation	ADP preparation and presentation of CCR	1	EA	$8,000	$8,000	Engineering Estimate
				Subtotal	$51,400	
				Total Capital Cost	**$320,000**	
Post-Implementation Annual Costs						
Annual Costs						
Semi-annual Performance and UIC Sampling	Collection and analysis of groundwater samples from 10 monitoring wells (9 newly installed and 1 existing) for VOCs; 5 monitoring wells for MEEs and TOC; 3 monitoring wells for sulfate and sulfide; 4 monitoring wells for TRPH, TDS, and sodium, 5 monitoring wells for *Dhc* and *vcrA*	19	EA	$825	$15,675	Test America (5/2015); Sirem (5/2015); Engineering Estimate
Reporting (Annual Report)/Data Evaluation	Document results of implementation (Annual Interim Measures Report/Step 4	1	EA	$25,000	$25,000	Engineering Estimate
ADP prep/presentation	ADP preparation and presentation of results of implementation (Annual Interim Measures Report/Step 4	1	EA	$8,000	$8,000	Engineering Estimate
				Subtotal	$48,675	
				Total Post-Implementation Cost	**$50,000**	
Post-Implementation Evaluation Costs						
DPT Groundwater Sampling Costs						
DPT Groundwater Sampling	5 days of DPT sampling for CVOCs (DPT operator, mobile lab, oversight, and data evaluation)	5	DAY	$7,920	$39,600	EDS (1/2016); Columbia Technologies (2/2016); Engineering Estimate
				Subtotal	$39,600	
				Total Post-Implementation Evaluation Cost	**$40,000**	

Table 6-1. Hot Spot 3 Bioremediation Costing
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Item	Description	Quantity	Unit	Unit Cost	Total Cost	Estimate Basis
Additional Injection Event						
Costs for additional injection event, if required						
Mobilization/Demobilization		2	EA	$1,320	$2,640	Vironex (3/2016)
Injection Services	SRS®-SD (0.7% pore space in the Source Zone and 0.2% pore space in the 10xNADC ring) and KB-1® injection; assumes low pressure injection from 6 to 52 ft BLS (injection at 8 locations simultaneously [4 gpm per location] for 7.2 hours per day) and high pressure injection from 52 to 57 ft BLS (2 days); includes decon between each location	8	DAY	$5,797	$46,376	Vironex (3/2016)
Tool Decon Between Locations		1	EA	$4,950	$4,950	Vironex (3/2016)
Setup and Breakdown	Includes time for setup and breakdown and injection services	2	DAY	$2,365	$4,730	Vironex (3/2016)
Per Diem	Per diem for injection services subcontractor	10	DAY	$495	$4,950	Vironex (3/2016)
HASP/Spill Plan/Injection Reporting		1	EA	$2,750	$2,750	Vironex (3/2016)
Tremie Grout Injection Locations	Based on the number of injection locations and their corresponding total injection depth, approximately 1,350 ft will need to be tremie grouted	1,350	FT	$0.83	$1,114	Vironex (3/2016)
Substrate Handling	Equipment and personnel to manage SRS®-SD during injection	1	EA	$4,169	$4,169	Vironex (3/2016)
Emulsified Vegetable Oil	Purchase 16 drums of SRS®-SD (1 injection event) - 50% original dosing (15 drums) in the Source Zone and 25% of original dosing (1 drum); the price includes packaging, standard freight, and Florida sales tax	16	DR	$840	$13,432	Terra Systems (2/2016)
Fork Lift Rental	Rental for unloading the drums of SRS®-SD from the truck and staging on site	1	DAY	$1,306	$1,306	FECC (5/2014)
KB-1® Culture	Purchase 25 L of KB-1® culture (1 injection event); the price includes packaging and Florida sales tax	25	L	$262	$6,559	SiREM (2/2016)
KB-1® Culture Shipping Charges	Outbound and return shipping charges for KB-1® culture vessels; the price includes Florida sales tax	1	EA	$1,353	$1,353	SiREM (2/2016)
Remediation Management/Oversight	Oversight and management of injection implementation (8 injection days, plus one day for oversight of emulsified vegetable oil delivery, one day for set up, and one day for break down)	11	DAY	$1,600	$17,600	Engineering Estimate
				Subtotal	$111,928	
				Total Second Injection Event Cost	**$120,000**	
				Total Remediation Cost (Capital, Second Injection Event, three years of O&M&M)	**$630,000**	
				Total Remediation Cost (Capital, Second Injection Event, five years of O&M&M)	**$730,000**	

SECTION VII

ENVIRONMENTAL IMPACT ANALYSIS

An environmental impact analysis of the bioremediation implementation was conducted using SiteWise™, a life-cycle environmental footprint assessment tool developed by the United States Navy, United States Army Corps of Engineers, and Battelle. The environmental footprint assessment included the remedial investigation (baseline DPT groundwater sampling), implementation (remedial action construction), remedial operation (post-implementation DPT groundwater sampling), and long term monitoring portions of the bioremediation implementation.

The SiteWise tool utilizes project specific inputs including: (i) production of the materials required for the activity (consumables); (ii) transportation – personnel; (iii) transportation – material and equipment; (iv) on-site activities including equipment operation (equipment use and miscellaneous); and (v) management of the waste produced. Using these inputs the SiteWise™ tool provides quantitative results for the following metrics: greenhouse gas emission, energy use, air emissions of criteria pollutants, water consumption and worker safety.

The project specific inputs utilized for the analysis by SiteWise™ included the following:

Remedial Investigation

- utility locate; and
- pre-injection DPT groundwater sampling with analysis of samples by a mobile laboratory.

Remedial Action Construction

- one injection event of 171,000 gallons of SRS®-SD solution and KB-1® and a second injection event of 70,500 gallons of SRS®-SD solution and KB-1®;
- installation of nine monitoring wells; and
- baseline sampling event.

Remedial Action Operations

- post-implementation DPT groundwater sampling with analysis of samples by a mobile laboratory.

Long Term Monitoring

- three years of semi-annual sampling.

The results from the SiteWise™ analysis for these activities is presented in Appendix G and summarized in Table 7-1.

The driver for the metrics was the equipment use and miscellaneous input, with the exception of the following metrics during the remedial action construction phase: greenhouse gas emissions, total energy used, and total SO_x emissions. The equipment use and miscellaneous input includes injection activities (operation of equipment and water for dilution), DPT groundwater sampling, and laboratory analysis. The main driver in the equipment use and miscellaneous input was the water used during injection to dilute the SRS®-SD. The driver during the remedial action construction for the greenhouse gas emissions, total energy used, and total SO_x emissions was the consumables due to the production of the SRS®-SD and the installation of monitoring wells.

In order to reduce the footprint of the bioremediation implementation, the following best management practices could be utilized:

- optimizing sampling plans (quantity and frequency);
- reducing the amount of equipment idling;
- optimizing site activities to reduce travel requirements; and
- using a laboratory with a sustainability program in place.

Table 7-1. Summary of SiteWise™ Outputs
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Metric	Units	Total
Greenhouse Gas Emissions	metric ton CO_2	50
Total Energy Used	MMBTU	1,200
Water Consumption	gallons	240,000
Total NO_x Emissions	metric ton	0.21
Total SO_x Emissions	metric ton	0.12
Total PM_{10} Emissions	metric ton	0.026

Notes:

1. CO_2 indicates carbon dioxide.
2. MMBTU indicates one million British Thermal Units.
3. NOx indicates nitrogen oxides.
4. SOx indicates sulfur oxides.
5. PM_{10} indicates particulate matter with a diameter of 10 micrometers or less.

SECTION VIII

REFERENCES

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APPENDIX A

APPLICABLE MEETING MINUTES

post active remediation monitoring (PARM) plan, transition site to LTM, or utilize available mobile air sparge unit to continue IM.

Results: Decision item 1604-D

1604-M05	Anne Chrest/ NASA	Engineering Evaluation (EE) Review Process **Discussion**: For the EE review process, please provide response to comments to your NASA RPM 1 week prior to meeting. The final response to comments should be sent to the team 2 days before meeting. All pilot test work plans should have formal technical review. All work plans should include a costing sheet as done in EE Step 3.
1604-M06	Whitney Morrison/ Geosyntec	MLPV Hot Spot 3 Bioremediation IMWP (SWMU 056) **Goal**: Obtain team consensus on Hot Spot 3 Bioremediation IMWP. **Discussion**: Hot Spot 3 is located partially under and south of the western Mobile Launch Platform (MLP) structure, around the MLP footers, and adjacent to the crawler tracks. From approximately 47 to 61 feet (ft) below land surface (BLS) the lithology is clayey sand with sandy clay and shell fragments. The Hot Spot 3 Outstanding Florida Waters (OFW) impacted area is being added to the Engineering Evaluation (EE) process and additional supplemental assessment activities will be performed. It is anticipated that a Step 1 and 2 EE will be presented for that area, and for this reason it is not addressed as part of this Interim Measures (IM) Work Plan (IMWP). The IM objective for active remediation is to reduce chlorinated volatile organic compound (CVOC) concentrations within the treatment area to concentrations that enable a transition to monitored natural attenuation (MNA). The horizontal treatment area includes the Source Zone (SZ) and the ten times the Natural Attenuation Default Concentration (10xNADC) area with a design radius of influence (ROI) of 8-ft. The vertical treatment area is 2 ft above and below the area where CVOCs are greater than 10xNADCs, which is generally from 4 to 26 ft BLS and 39 to 57 ft BLS. Baseline direct-push technology (DPT) groundwater sampling will be conducted. DPT injection of 33 drums of SRS®-SD diluted with potable water from an on-site fire hydrant will be performed by the DPT injection

subcontractor (approximately 160,000 gallons of SRS®-SD solution). The injection was designed so that SRS®-SD (oil) will occupy 0.7% of the pore space in the SZ and 0.2% of the pore space in the 10xNADC ring. Bioaugmentation using 57 liters of KB-1® will be performed. The injection activities will be performed using two different injection methods: low pressure injection from approximately 4 to 52 ft BLS and high pressure injection in the low permeability interval from approximately 52 to 57 ft BLS. Approximately 50 gallons of chase water per injection interval will be injected following the SRS®-SD solution. Nine performance monitoring wells will be installed and baseline sampling will be conducted after injection activities. Semi-annual performance and Underground Injection Control (UIC) monitoring will be conducted. Supplemental DPT sampling is anticipated to occur one to two years after the injection. This sampling will provide a more robust understanding of CVOC concentrations as well as aid in the design of an additional injection, if required.

Recommendation was made to consider monitoring total alkalinity and/or bicarbonate alkalinity to monitor buffering capacity (could also possibly be used as a tracer). Buffering issues were not encountered during the previous Mobile Launch Platform/Vehicle Assembly Building (MLPV) bioremediation implementation and are not expected to occur during this implementation. Regardless, the SRS®-SD formulation proposed to be used during the bioremediation implementation (provided in the IMWP Section 3.2) includes sodium bicarbonate to provide additional buffering capacity to reduce the pH reduction that can occur as the substrate is fermented and reductive dechlorination occurs. Due to major issues with buffering observed at FDSA the suggestion to monitor the buffering capacity will be reconsidered.

Team consensus reached on the Hot Spot 3 Bioremediation IMWP.

Results: Decision item 1604-D09

1604-M07	Emily Lawson/ Geosyntec	<u>Wilson Corners (SWMU 0001)</u> **Goal**: Present the 2015 annual long term monitoring (LTM) and proposed 2016 LTM plan.

APPENDIX B

MASS CALCULATIONS
(FURNISHED ON CD)

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client:	NASA	**Project:**	MLPV Hot Spot 3 Bioremediation IM Work Plan	**Project/Proposal #:**	FR0579C	**Task #:**	23

TITLE OF COMPUTATIONS **MASS CALCULATIONS**

COMPUTATIONS BY:	Signature		3/21/2016 DATE
	Printed Name and Title	Whitney Morrison, E.I. Senior Staff Engineer	
ASSUMPTIONS AND PROCEDURES			
CHECKED BY: (Peer Reviewer)	Signature		3/21/2016 DATE
	Printed Name and Title	Rebecca C. Daprato, Ph.D., P.E. Senior Engineer	
COMPUTATIONS CHECKED BY:	Signature		3/21/2016 DATE
	Printed Name and Title	Jim Langenbach, P.E., BSCE Principal Engineer	
COMPUTATIONS BACKCHECKED BY: (Originator)	Signature		3/21/2016 DATE
	Printed Name and Title	Whitney Morrison, E.I. Senior Staff Engineer	
APPROVED BY: (PM or Designate)	Signature		3/21/2016 DATE
	Printed Name and Title	Rebecca C. Daprato, Ph.D., P.E. Senior Engineer	

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

Appendix B. 10xNADC Area Mass Calculations
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Depth Interval	Average Concentration (µg/L)				GIS Area	Thickness	Volume Area * Thickness	Dissolved Mass Pore Volume * Average Concentration * (10^{-6} g/µg) * (0.0022 lb/g) (lbs)				Equilibrium Soil Concentration Average Concentration * Koc * foc * (10^{-3} mg/µg) (mg/kg)				Sorbed Mass Soil Concentration * Volume * (100 lb/ft^3) * (10^{-6} kg/mg) (lbs)				Total Mass Sorbed Mass + Dissolved Mass
(ft BLS)	TCE	cDCE	tDCE	VC	(acres)	(ft)	(ft^3)	TCE	cDCE	tDCE	VC	TCE	cDCE	tDCE	VC	TCE	cDCE	tDCE	VC	(lbs)
10xNADC Ring Mass Calculations																				
6 to 22	24	16,300	--	4,057	0.0173	16	12,084	0.005	3.1	--	0.8	0.004	0.8	--	0.1	0.005	1.0	--	0.1	5.0
23 to 40	--	--	--	--	--	17	--	--	--	--	--	--	--	--	--	--	--	--	--	0
41 to 60	543	8,673	25,000	1,099	0.0423	19	35,021	0.3	4.7	0.2	0.6	0.9	4.0	22.1	0.3	3.2	13.8	0.8	1.0	24.7
Source Zone Mass Calculations																				
6 to 22	138,429	26,140	--	3,507	0.0054	16	3,784	8.2	1.5	--	0.2	25.2	1.3	--	0.1	9.5	0.5	--	0.04	20.0
23 to 40	--	--	--	--	--	17	--	--	--	--	--	--	--	--	--	--	--	--	--	0
41 to 60	29,704	51,781	--	2,519	0.0093	19	7,696	3.6	6.2	--	0.3	49.2	23.6	--	0.7	37.8	18.2	--	0.5	66.6
					Total Dissolved Mass:			**30 lbs**				**Total Sorbed Mass:**				**87 lbs**				
																			Total 10xNADC Area Mass:	**117 lbs**

Notes:

1. 10xNADC indicates ten times the Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration (NADC).
2. TCE indicates trichloroethene.
3. cDCE indicates *cis*-1,2-dichloroethene.
4. tDCE indicates *trans*-1,2-dichloroethene.
5. VC indicates vinyl chloride.
6. µg/L indicates micrograms per liter.
7. ft BLS indicates feet below land surface.
8. ft indicates feet.
9. ft^3 indicates cubic feet.
10. lbs indicates pounds.
11. g indicates grams.
12. µg indicates micrograms
13. mg indicates milligrams.
14. mg/kg indicates milligrams per kilogram.
15. Average groundwater concentrations calculated from direct push technology (DPT) groundwater sampling results.
16. Porosity assumed to be 0.25.
17. Soil density assumed to be 100 lb/ft^3 .
18. f_{oc} assumed to be 0.0011 (6 to 22 ft BLS) for SAND with silt and shell and 0.01 (41 to 60 ft BLS) for interbedded clayey SAND/sandy CLAY, which were based upon data from Wilson Corners.
19. K_{oc} data calculated from Sawyer, McCarty and Parking, 5th Edition (2002): TCE = 165.7 L/kg, cDCE = 45.6 L/kg, tDCE = 77.5 L/kg, and VC = 26.3 L/kg.
20. The tDCE mass is based on the 50,000 U (non-detect) value.
21. Total mass is rounded to nearest whole number.
22. -- indicates that the compound was not present above applicable screening criteria in the depth interval presented.

APPENDIX C

SRS®-SD PRODUCT INFORMATION (FURNISHED ON CD)

Terra Systems, Inc.
SRS®-SD Small Droplet Emulsified Vegetable Oil (EVO) Substrate for Maximum Radius of Influence
United States Patent# RE40,448

The anaerobic bioremediation process uses native or introduced microorganisms to degrade chlorinated solvents such as tetrachloroethene (PCE) and trichloroethene (TCE) to innocuous end products including ethene and ethane. An organic substrate must be added to the groundwater to generate reducing conditions and provide the necessary carbon and hydrogen to support biodegradation of the chlorinated solvents. The organic substrate can be a slow release substrate like Terra Systems' small droplet SRS®-SD emulsified vegetable oil substrate. SRS®-SD is designed to release bio-available hydrogen over a period of 3 to 5 years thus enhancing the long-term anaerobic biodegradation of the chlorinated solvents. SRS®-SD optimizes the naturally occurring biodegradation system by supplying the rate limiting factor (in this case hydrogen) in the degradation of VOC's, certain pesticides/herbicides, perchlorate, and immobilization of certain metals (Cr, As, and some radionucleides).

SRS®-SD **Substrate Specifications**

Terra Systems, Inc.'s manufacturing facility is configured to allow us to provide our customers with custom blended substrate packages without a cost premium. The SRS®-SD package contains the following components:

Ingredient	Percent	Description
Food grade soy bean oil	40 - 60%	Terra Systems operates its own state-of-the-art manufacturing facility for SRS®-$B_{uffered}$ production and can custom blend substrate packages as site conditions require.
Emulsifiers and proprietary nutrient package containing nitrogen and phosphorus	5 – 15%	Organic and inorganic nutrients support growth of the anaerobic microbial population.
Vitamin B_{12}	<1%	He et al. 2007 demonstrated that vitamin B_{12} is an important micronutrient to enhance dechlorination activity. They found that 25 ppb of Vitamin B_{12} gave the maximum stimulation of dechlorination.
Potassium Lactate	4 - 7%	Soluble substrate to rapidly generate anaerobic conditions
Water	20-50%	

KEY BENEFITS OF SRS®-SD **Emulsified Vegetable Oil (EVO) Substrate Include:**

- SRS®-SD promotes biodegradation of PCE and TCE to non-toxic end products
- SRS®-SD's mean droplet size of 0.6 micron is ideal for maximum radius of influence in the formation
- SRS®-SD's low viscosity of <50 centipoise injected improves radius of influence
- SRS®-SD's slow release formula eliminates the need for continuous substrate additions
- SRS®-SD contains only non-toxic food grade materials, which results in green, sustainable remediation
- SRS®-SD can be used as a PRB to cuts off plume migration
- SRS®-SD is effective in treating source zones
- The in situ application of. SRS®-SD minimizes site disruptions
- Using SRS®-SD reduces treatment time from decades to months and years

As a result of its low viscosity, small droplet size and longevity, SRS®-SD is an ideal substrate for injection using direct-push technology. The low viscosity allows a greater volume of SRS®-SD to be applied in a shorter period of time and increases the substrate delivery radius per point. This results in fewer direct push delivery points and overall shorter delivery time requirements per site. Terra Systems, Inc. has applied this technology at military bases, dry cleaners and manufacturing sites throughout the USA and in Brazil, Taiwan and Japan.

For more information contact: **Michael Free**
Terra Systems, Inc. 1035 Philadelphia Pike Suite E, Wilmington, DE 19809
(office) 302-798-9553 or (cell 484-889-2214
e-mail: mfree@terrasystems.net
On the Web@ http:/www.terrasystems.net/

60% SMALL DROPLET SLOW RELEASE EMULSIFIED VEGETABLE OIL SUBSTRATE (SRS®-SD_{PL}) SAFETY DATA SHEET

1. Product Identification

Synonyms:	60% Small Droplet Slow Release Substrate (SRS®-SD_{PL}) Emulsified Vegetable Oil (EVO)
Recommended Use:	Treatment of groundwater contaminated with chlorinated solvents and other anaerobically degradable compounds.
Supplier:	Terra Systems, Inc. 130 Hickman Road, Suite 1 Claymont, Delaware 19703 Telephone (302) 798-9553 Fax (302) 798-9554 www.terrasystems.net

2. Hazards Identification

Emergency Overview	
Caution:	May cause eye irritation.
Health Rating:	1 - Slight
Flammability Rating:	1 - Slight
Reactivity Rating:	1 - Slight
Contact Rating:	1 - Slight
Protective Equipment:	Goggles; Proper Gloves
Storage Color Code:	Green (General Storage)
Potential Health Effects	
Inhalation:	Not expected to be a health hazard. If heated, may produce vapors or mists that irritate the mucous membranes and cause irritation, dizziness, and nausea. Remove to fresh air.
Ingestion:	Not expected to be a health hazard via ingestion. Large doses may produce abdominal spasms, diarrhea.
Skin Contact:	No adverse effects expected. May cause irritation or sensitization in sensitive individuals.
Eye Contact:	May cause mild irritation, possible reddening.
Chronic Exposure:	No information found.
Aggravation of Pre-existing Conditions:	No information found.

3. Composition/Information on Ingredients

Ingredient	Synonyms	CAS #	Percent	Hazardous
Soy bean oil	Soya oil	8001-22-7	60%	No
Emulsifiers and proprietary nutrient package containing nitrogen, phosphorus and vitamin B_{12}		Mixture	5 – 15%	No
Potassium lactate	L-Lactic acid potassium salt	996-31-6	<5%	Yes
Water		7732-18-5	20 - 30%	No

The emulsifiers and nutrient package mixture is a trade secret and consists of ingredients of unknown acute toxicity.

4. First Aid Measures

Inhalation: Not expected to require first aid measures. Remove to fresh air. Get medical attention for any breathing difficulty.

Ingestion: If large amounts were swallowed, give water to drink and get medical advice.

Skin Contact: Not expected to require first aid measures. Wash exposed area with soap and water. Get medical advice if irritation develops.

Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

5. Fire Fighting Measures

Fire: Flash point: >200 C (>392 F). Not considered to be a fire hazard. Isolate from heat and open flame.

Explosion: Not considered to be an explosion hazard. Closed containers may explode if exposed to extreme heat.

Fire Extinguishing Media: Dry chemical, foam, or carbon dioxide. Water spray may be ineffective on fire, but can protect fire-fighters and cool closed containers. Use fog nozzles if water is used.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full face piece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Clean-up personnel may require protective clothing. Absorb in sand, paper towels, “Oil Dry”, or other inert material. Scoop up and containerize for disposal. Flush trace residues to sewer with soap and water. Containerized waste may be sent to an approved waste disposal facility.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Containers of this material are not hazardous when empty since they do vapors or harmful substances; observe all warnings and precautions listed for the product. Do not store above 49 C (120 F). Keep container tightly closed and upright when not in use to prevent leakage.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:	None established.
Ventilation System:	Not expected to require any special ventilation.
Personal Respirators (NIOSH Approved):	Not expected to require personal respirator usage.
Skin Protection:	Wear protective gloves and clean body-covering clothing.
Eye Protection:	Use chemical safety goggles and/or a full face shield where splashing is possible. Provide readily accessible eye wash stations and safety showers.
Slips, Trips, and Falls:	Material is slippery when spilled. Clean up with sand, paper towels, “Oil Dry”, or other inert material.

9. Physical and Chemical Properties

Appearance:	White liquid.
Odor:	Vegetable oil.
Solubility:	Miscible in water.
Specific Gravity (water=1):	0.95-0.98. 8.09 pounds per gallon.
pH:	6-7 (40% aqueous solution)
% Volatiles by volume @ 21C (70F):	Negligible.
Boiling Point:	≥ 100C (≥ 212F)
Melting Point:	No information found.
Flash Point (F):	No information found.
Autoignition Temperature:	No information found.
Decomposition Temperature:	No information found.
Vapor Density (Air=1):	No information found.
Vapor Pressure (mm Hg):	< 1.0 @ 20C (68F).
Evaporation Rate (BuAc=1):	No information found.
Viscosity @23 C (73 F):	213 centipoises (1.2 centipoises diluted 1:10)
Partition Coefficient (octanol/water):	No information found.

10. Stability and Reactivity

Stability:	Stable under ordinary conditions of use and storage.
Reactivity:	Not reactive under ordinary conditions.
Hazardous Decomposition	

Products:	Carbon dioxide and carbon monoxide may form when heated to decomposition.
Hazardous Polymerization:	Will not occur.
Incompatibilities:	Strong oxidizers, acids.
Conditions to Avoid:	Incompatibles. Isolate from heat and open flame.

11. Toxicological Information

Soybean Oil:	No information found on toxicology. It is not a carcinogen listed by IARC, NTP, NIOSH, OSHA, or ACGIH.
Emulsifier/Nutrient Mixture:	No information found on toxicology. It is not a carcinogen listed by IARC, NTP, NIOSH, OSHA, or ACGIH.
Potassium Lactate:	Oral rat LD50: data not available. This compound is not listed as a carcinogen by IARC, NRP, NIOSH, OSHA, or ACGIM.
SRS-SD:	The toxicity of the mixture has not been measured.

12. Ecological Information

Environmental Fate:	No information found.
Environmental Toxicity:	No information found.
Degradability:	This product is completely biodegradable under both aerobic and anaerobic conditions.
Soil Mobility:	This compound will move with groundwater until the adsorbed onto the soil. Degradation products may be mobile.
Bioaccumulation Potential:	No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

OSHA STATUS: This product is not hazardous under the criteria of the Federal OSHA hazard Communication Standard 29 CFR 1910.1200. However, thermal processing and decomposition fumes from this product may be hazardous as noted in Section 10.

TSCA STATUS: No component of this product is listed on the TSCA inventory.

CERCLA (Comprehensive Response Compensation, and Liability Act): Not reportable.

SARA TITLE III (Superfund Amendments and Reauthorization Act)
Section 312 Extremely Hazardous Substances: None
Section 311/312 Hazard Categories: Non-hazardous Under Section 311/312
Section 313 Toxic Chemicals: None

RCRA STATUS: If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal, whether a material containing the product or derived from the product should be classified as a hazardous waste. (40 CFR 261.20-24)

CALIFORNIA PROPOSITION 65: The following statement is made in order to comply with the California safe Drinking Water and Toxic Enforcement Act of 1986. The product contains no chemicals known to the State of California to cause cancer.

16. Other Information

NFPA Ratings:	Health: **1** Flammability: **1** Reactivity: **1**
Date Prepared:	January 17, 2014
Revision Information:	SDS Section(s) changed since last revision of document include: None.
Disclaimer:	Terra Systems, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. TERRA SYSTEMS, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, TERRA SYSTEMS, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.
Prepared by:	Terra Systems, Inc.
Phone Number:	(302) 798-9553 (U.S.A.)

APPENDIX D

UIC MEMORANDUM
(FURNISHED ON CD)

Florida Department of

Memorandum — Environmental Protection

TO: Cathy McCarty, P.G.
Florida Department of Environmental Protection
Bureau of Water Facilities Regulation
Underground Injection Control Section - MS 3530
2600 Blair Stone Road, Tallahassee, FL 32399-2400

FROM: _____ (Note 1.)

_____

_____

DATE: _____

SUBJ: **Proposed Injection Well(s) for In Situ Aquifer Remediation at a Remedial Action Site**

Pursuant to paragraph 62-528.630(2)(c), F.A.C., inventory information is hereby provided regarding the proposed construction of temporary injection well(s) for the purpose of in situ aquifer remediation at a contaminated site.

Facility name:	Mobile Launch Platform/Vehicle Assembly Building (MLPV) Area
Facility address:	Launcher Road
City/County:	Kennedy Space Center, Brevard County, FL
Latitude/Longitude:	N28°35'22.60"/W80°39'15.89"
FDEP Facility Number:	N/A
Facility owner's name:	National Aeronautics and Space Administration
Facility owner's address:	Mail Code SI-E2
	Building K6-1547 (Logistics Facility)
	Kennedy Space Center, Florida 32899-0001
Well contractor's name:	Geosyntec Consultants (remediation contractor) (Note 2.)
Well contractor's address:	6770 S Washington Ave, Suite 3
	Titusville, FL 32780
	No injection wells to be utilized

Facility name: MLPV Area
FDEP facility no.: N/A

AFFECTED AQUIFER

Name of aquifer: Surficial aquifer
Depth to groundwater (feet): ~ 3 to 6 feet (ft) below land surface (BLS)
Aquifer thickness (feet): ~ 45 to 50 ft
Areal extent of contamination (square feet): The treatment area is the area with chlorinated volatile organic compound (CVOC) concentrations greater than 10 times their respective Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration (NADC) [10xNADC], which is approximately 0.07 acres (3,050 ft^2) and extends from approximately 6 to 22 and 41 to 55 ft BLS.

INJECTION WELLS

A site map showing the location and spacing of injection wells, the areal extent of the groundwater contamination plume, and associated monitoring wells is attached. The injection well(s) features are summarized below, and/or a schematic of the injection well(s) is attached.

Direct-push or HSA/Mud rotary *(circle the appropriate well type)*
Diameter of well(s) (i.e., riser pipe & screen) (inches): ____
Total depth of well(s) (feet): _____
Screened interval: _____
Grouted interval: _____
Casing diameter, if applicable (inches): _____
Cased depth, if applicable: _____ to _____ feet below land surface
Casing material, if applicable: _____

PROJECT DESCRIPTION

The in situ, injection-type aquifer remediation product/process remediates contaminants by:
(check those that apply)

- ■ bioremediation,
- ☐ chemical oxidation, or
- ☐ other (describe) _____

Brief description of the project:

The project involves injection of electron donor (SRS®-SD) diluted 1:80 in the area with TCE concentrations greater than 11,000 µg/L (Source Zone [SZ]) above 52 ft BLS, 1:10 in the SZ in the low permeability zone (52 to 57 ft BLS), and 1:270 in the area with CVOC concentrations greater than 10xNADC but outside the SZ into the subsurface via DPT injection points to promote microbial growth for the reduction of CVOCs. Also, includes the injection of KB-1® microbial culture followed by anaerobic chase water. The injection interval varies per location, but is generally from 4 to 26 and 39 to 57 ft BLS. No injection wells will be utilized.

Summary of major design considerations and features of the project:

Number of injection wells: 25 DPT injection locations
Injection volume per well (gallons): Injection volume varies per injection point. The minimum injection volume is 388 gallons (26 gallons of SRS®-SD diluted in 237 gallons of water plus 125 gallons of chase water) and the maximum injection volume is 9,815

gallons (116 gallons of SRS®-SD diluted in 9,149 gallons of water plus 550 gallons of chase water). Chase water ranges from 125 to 550 gallons per location. The volume of KB-1® varies by location, but 1 to 3 L of KB-1® followed by a range of 125 to 550 gallons of anaerobic chase water per location (~50 gallons per injection interval), if necessary.

Single or multiple injection events: Two events – same total volume each event

Injection volume total (all wells, all events): The total injection volume will be approximately 171,062 gallons (1,733 gallons of SRS®-SD diluted in approximately 158,829 gallons of water plus approximately 10,500 gallons of chase water) and 57 L of KB-1®.

FLUID TO BE INJECTED

Composition of injected fluid:
(ingredient, wt. %) (Note 3.): SRS®-SD is an emulsified vegetable oil (soybean) that contains 60% soybean oil, at least 4% potassium lactate, 5 to 15% emulsifiers and nutrient package, 6-8 g/L of sodium bicarbonate, and a balance of water. The SRS®-SD will be diluted with water at a 1:80 ratio in the SZ above 52 ft BLS, 1:10 ratio in the SZ in the low permeability zone (52 to 57 ft BLS), and at a 1:270 ratio in the area with CVOC concentrations greater than 10xNADC outside the SZ with water from an on-site fire hydrant. Sodium sulfite is an oxygen scavenger that will be added to the fire hydrant water (0.24 grams per gallon) to create anaerobic water prior to injection.

TEMPORARY INJECTION ZONE OF DISCHARGE (ZOD)

(check those that apply)

☐ No ZOD needed. The fluid to be injected meets the primary and secondary groundwater standards of Chapter 62-550, F.A.C., and the minimum groundwater criteria of Chapters 62-520 and 62-777, F.A.C.

■ ZOD permission by rule 62-520.310(8)(c), F.A.C., for reagent chemical species and/or parameter(s) in the fluid to be injected (or re-injected) that exceed secondary groundwater standards. ZOD permission by this rule also applies to chemical species in the fluid to be injected that exceed primary groundwater standards or minimum groundwater criteria, provided those species are prime constituents of the reagents used to remediate site contaminants. The list of chemical species and parameters for which the approved Remedial Action Plan identifies zone size, duration and groundwater monitoring are as follows:
Sodium, total dissolved solids, and total recoverable petroleum hydrocarbons

☐ ZOD permission by rule 62-520.310(8)(c), F.A.C., for the following contaminants of concern that exceed their groundwater standards in the fluid to be re-injected as part of a closed-loop re-injection system for which the approved Remedial Action Plan identifies zone size, duration and groundwater monitoring:

☐ ZOD permission by variance because fluid to be injected contains the following impurities that are not prime constituents of the reagents used to remediate the site's

Facility name: MLPV Area
FDEP facility no.: N/A

contaminants, and the concentration of those impurities in the fluid to be injected are in excess of their primary groundwater standards:

_____
_____
_____

☐ A variance needs to be granted before the remediation can be conducted.

☐ A variance has already been granted for the impurities listed above:

Date variance granted: _____ Zone size (feet):_____ Duration (time):_____

♦◆♦

☐ If ZOD permission by rule 62-520.310(8)(c), F.A.C., or by variance is checked above, then a figure that delineates the ZOD is attached, or ■ the ZOD is described as follows:
The ZOD is defined as the area with a 20 ft buffer around the treatment area.

CLEANUP CRITERIA AND ENFORCEABLE APPROVAL ORDER

In situ injection-type aquifer remediation of the contaminants of concern at this site is intended to meet the groundwater cleanup target levels established for them in accordance with applicable and appropriate chapters of the Florida Administrative Code and cited in the approved Remedial Action Plan. Additionally, all other groundwater standards will be met at the time of project completion for any residuals associated with the ingredients of the injected remediation products, and any by-products or intermediates produced as a result of the chemical or biochemical transformation of those ingredients or the contaminants of concern during their use. Applicable primary and secondary drinking water standards are set forth in Chapter 62-550, F.A.C., and additional groundwater quality criteria are set forth in Chapters 62-520 and 62-777, F.A.C.

The remediation plan estimates that site remediation will take 36 to 60 months. We will notify you if there are any modifications to the remediation strategy which will affect the injection well design or the chemical composition and volume of the injected remediation product(s).

The proposed remediation plan was approved on _____ by an enforceable approval order. A copy is attached. The remediation system installation is expected to commence within 60 days. Please call me at _____ if you require additional information.

##########

Note 1. This notification memorandum is primarily for use by state technical reviewers, but remediation contractors may fill in all blanks except those labeled “FROM” and “DATE” on page 1, and the “approval date”, and “telephone number” blanks in the last paragraph on page 4. Those blanks are filled only by the regulator. In the case that the memorandum form is partially completed by the remediation contractor, the FDEP technical reviewer must verify that the information provided by the contractor is accurate and complete. Local programs are not authorized to approve underground injections into aquifers. Reason: Per agreement with EPA, the FDEP cannot delegate this authority. Local programs, after reviewing a Remedial Action Plan or an injection proposal document, should follow the instructions in the March 16, 2000, memorandum to arrange for Department headquarters’ execution of an approval order, and then complete this memorandum.

Note 2. If an injection well installation contractor has not yet been selected, then indicate the name and address of the project’s general remediation contractor/consultant.

Note 3. Complete chemical analysis of the fluid to be injected is required by Chapter 62-528, F.A.C. Some remediation products and processes may have already submitted this information at the time of application for acceptance by the Innovative Technology Acceptance Program. For those situations, when completing the Fluid To Be Injected section of this memorandum, it will suffice to indicate: (1) an Innovative Technology Acceptance letter has been issued; (2) the date of the acceptance letter; (3) the acceptance letter contains the chemical analysis, or a voucher for the confidential disclosure of the injected fluid's chemical composition if it is a proprietary formulation; and (4) the fluid will be injected at concentrations that are less than or equal to those cited in the acceptance letter. For products and processes that do not hold an Innovative Technology Acceptance letter, but for which the site-specific Remedial Action Plan provides a complete description of the chemical composition of the fluid to be injected, it will be necessary to enter this information into the Fluid To Be Injected section of this memorandum.

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

BOB MARTINEZ CENTER
2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32399-2400

RICK SCOTT
GOVERNOR

HERSCHEL T. VINYARD JR.
SECRETARY

September 26, 2013

Via Electronic Mail
Michael Lee [mlee@terrasystems.net]

Michael D. Lee, Ph.D.
Vice President Research and Development
Terra Systems, Inc.
130 Hickman Road, Suite 1
Claymont, DE 19703

Re: **SRS® Products**

Dear Dr. Lee:

The Waste Cleanup Program (WCP) hereby accepts the use of SRS® remediation products for the purpose of in-situ anaerobic bioremediation of chlorinated hydrocarbons and other suitable contaminants in groundwater and soil. The products included in this acceptance letter are SRS®-SD, SRS®-FR, SRS®-B, SRS®-M, SRS®-Z and SRS®-C. The primary ingredient of these formulations is emulsified vegetable oil. The use of any of these products must be detailed in a site-specific remedial action plan. Enclosure 1 contains regulatory information.

The WCP does not provide endorsement of specific or brand name remediation products or processes, but it does recognize the need to determine their acceptability in the context of environmental regulations, safety and the protection of public health. For that reason, the WCP issues an "acceptance" letter, not an approval. In no way shall an acceptance be construed as a certification of performance. Additionally, vendors, upon receipt of an acceptance, must market their product or process on its own merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace.

Remedial action plans that propose the use of an accepted product or process should include a copy of the acceptance letter in the plan's appendix, and reference it in the text of the document. It is not a requirement that a particular remediation product or process have an official acceptance letter in order for it to be proposed in a site-specific remedial action plan. The plan, however, must contain sufficient information about the product or process to show that it meets all applicable rules and regulations.

The WCP reserves the right to revoke its acceptance of a product or process if it has been falsely represented. Additionally, WCP acceptance of any product or process does not imply it has been deemed applicable for all cleanup situations, or that it is preferred over other treatment or cleanup techniques in any particular case. A site-specific evaluation of applicability and cost-

effectiveness must be considered for any product or process, whether conventional or innovative, and adequate site-specific design details must be provided in a remedial action plan submitted for Department review and approval. If you have any questions, please contact us at the numbers below.

Sincerely,

X

Gary Millington

Gary Millington, P.E.
Division of Waste Management
Office of District and Business Support
gary.millington@dep.state.fl.us
(850) 245-7502

enc: (1) Regulatory Information

c: Mubeen Darji, P.E. – WCP/Tallahassee
Rob Cowdery, P.E. – PRP/Tallahassee

ENCLOSURE 1

REGULATORY INFORMATION

a. Regulations: Chapters of the Florida Administrative Code (F.A.C.) that may be applicable, either in part or in their entirety, include but are not necessarily limited to Chapter 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C., for groundwater classes and standards, and groundwater permitting and monitoring requirements; Chapter 62-528, F.A.C., for Underground Injection Control (UIC), particularly Part V, for Class V, Group 4 aquifer remediation projects; Chapter 62-780, F.A.C., for cleanup criteria; and Chapter 62-777, F.A.C., for cleanup target levels.

   Users of SRS® products shall comply with all applicable regulations. This includes meeting applicable cleanup target levels for residual concentrations of reagent ingredients and any byproducts of concern produced by chemical and biological reactions induced by those ingredients during the timeframe of the cleanup project. For the ingredients of concern that are present in excess of cleanup target levels, the timeframe is that which is permitted for a temporary injection zone of discharge (ZOD) as described below.

b. UIC and ZOD permits: Per Rule 62-528.630(2)(c), F.A.C., Class V injection-type aquifer remediation wells are exempt from the permitting requirements of Rule 62-528.635, F.A.C., when authorized by a Department-approved remedial action plan or other enforceable mechanism, provided the requirements of the rules governing the remediation project, as well as the construction, operation, and monitoring requirements of Chapter 62-528, F.A.C., are met. Per Rule 62-528.630(2)(c), F.A.C., the issuance of an enforceable, site-specific remedial action plan approval order by the Department for injection-type aquifer remediation constitutes the granting of a Class V injection well construction/clearance permit. And per Rule 62-520.310(8)(c), F.A.C., if a temporary ZOD is necessary, and permissible by way of that rule, then the issuance of the site-specific remedial action plan approval order also constitutes the granting of permission for the temporary ZOD.

c. UIC notification: Remedial action plans proposing injection-type aquifer remediation shall include information pursuant to Rules 62-528.630(2)(c)1 through 6, F.A.C., for the inventory purposes of the UIC program. Reviewers of those plans, upon issuance of an enforceable remedial action plan approval order by the Department, must submit a completed copy of the UIC inventory notification form to the UIC program in Tallahassee.

d. General information about temporary ZODs: For groundwater remediation, the composition of an injected material must meet the primary and secondary drinking water standards set forth in Chapter 62-550, F.A.C., and the minimum groundwater criteria of Chapter 62-520, F.A.C., pursuant to UIC Rule 62-528.600(2)(d), F.A.C. Aquifer remediation products that do not meet these requirements must seek relief from water quality criteria by one of two mechanisms. Permission for a temporary ZOD may be obtained via Rule 62-520.310(8)(c), F.A.C. If a ZOD is not permissible by rule, it will be necessary to seek a variance from Department rules in accordance with Section 120.542, Florida Statutes.

Rule 62-520.310(8)(c), F.A.C., allows for a temporary ZOD for closed-loop re-injection systems, for the prime constituents of the reagents used to remediate site contaminants, and for groundwater secondary standards. In order to obtain permission for a temporary ZOD by rule, a site-specific remedial action plan must indicate: (a) the chemical ingredients of concern in the fluid to be injected that will be present in excess of groundwater standards; (b) the size of the ZOD that is needed; (c) the amount of time that the ZOD will be needed; and (d) a plan for monitoring the injected chemical ingredients of concern. The size of the temporary ZOD will usually be the injection well radius of influence when the treatment system is a single injection point. For a multiple point system, the ZOD can usually be expressed and illustrated as the total area of the cluster formed by all the injection points, located side-by-side with overlapping radii of influence.

e. Specific ZOD information for SRS® products: The SRS® products addressed by this acceptance letter include SRS®-SD, a small droplet formulation; SRS®-FR, a large droplet formulation used for fractured rock formations and barrier systems where retention in the formation is critical, SRS®-B, a formulation that contains a buffering agent, SRS®-M for remediation of metals, SRS®-Z, a zero-valent iron formulation, and SRS®-C, a customizable formulation. A site-specific remedial action plan shall specify the product(s) to be used, the volume and concentration at which the products will be injected, and the size and duration of the ZOD needed. All of the products addressed by this acceptance letter will have ZOD and monitoring requirements for sodium, total dissolved solids (TDS), and total recoverable petroleum hydrocarbons (TRPH). The vegetable oil is a source of TRPH. The SRS®-Z formulation will also require a ZOD for iron.

   Upon expiration of the time period granted for the ZOD, the concentration of each parameter must meet its respective groundwater standard or its natural-occurring background value at the specific cleanup site, whichever is less stringent.

g. Utilization of wells: If a remediation site happens to have an abundance of monitoring wells, then the WCP has no objection to the use of some wells for the application of injected products. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply reagents. This will avoid premature conclusion that the entire site meets cleanup goals. By making sure that designated tracking wells are not also used for treatment, there will be more assurance that the treatment process has permeated the entire site and that it did not remain localized to the area immediately surrounding each injection well.

h. Avoidance of migration: For injection-type, in-situ aquifer remediation projects, pursuant to Rule 62-528.630(3), F.A.C., injection of remediation products shall be performed in such a way, and at such a rate and volume, that no undesirable migration of either the ingredients of concern, site contaminants, or remediation byproducts results.

i. Abandonment of wells: Upon issuance of a Site Rehabilitation Completion Order, injection wells shall be abandoned pursuant to Section 62-528.645, F.A.C., and the Underground Injection Control Section of the Department shall be notified so that the treatment wells can be removed from the injection well inventory-tracking list.

130 Research Lane, Ste 2
Guelph ON N1G 5G3
(519) 822-2265

KB-1® Material Safety Data Sheet

Section 1: Material Identification

Trade Name: KB-1®
Chemical Family: bacterial mixture
Chemical name: No IUC name for mixture is known to exist
Manufacturer/Supplier: SiREM
130 Research Lane, Suite 2,
Guelph, Ontario,
Canada N1G 5G3

For Information call: 519-822-2265 / 1-866-251-1747 x236
Emergency Number: 519-822-2265
Description: Microbial inoculum (non-pathogenic, non-hazardous)
Trade Name: KB-1®
Product Use: Bioremediation of contaminated groundwater.
Date Prepared: 2 February 2005

Section 2: Composition, Information on Ingredients

KB-1® is a microbial culture grown in an aqueous dilute mineral salt solution media containing no hazardous ingredients.

The microbial composition of KB-1® (as determined by phylogenetic analysis) is listed in Table 1. Identification of organisms was obtained by matching 16S rRNA gene sequence of organisms in KB-1® to other known organisms. The characteristics of related organisms can be used to identify potential or likely characteristics of organisms in KB-1®.

Table 1. Genus' Identified in KB-1® Microbial Inoculum

Genus
Dehalococcoides sp.
Geobacter sp.
Methanomethlovorans sp.

Section 3: Hazards Identification:

A review of the available data does not indicate any known health effects related to normal use of this product.

Section 4: First Aid Measures:

Avoid direct contact with skin and eyes. In any case of any exposure which elicits a response, a physician should be consulted immediately.

Eye Contact: Flush eyes with water for at least 15 minutes, occasionally lift upper and lower eyelids, if undue irritation or redness occurs seek medical attention.

Skin Contact: Remove contaminated clothing and wash skin thoroughly with water and antibacterial soap. Seek medical attention if irritation develops or open wounds are present.

Ingestion: Do not induce vomiting, drink several cups of water, seek medical attention.

Inhalation: Remove to fresh air. If not breathing give artificial respiration. In case of labored breathing give oxygen. Call a physician.

Section 5 - Fire Fighting Measures:

Non-flammable
Flash Point: not applicable
Upper flammable limit: not applicable
Lower flammable limit: not applicable

Section 6 – Accidental Release Procedures

Spilled KB-1® should be soaked up with sorbant and saturated with a 10% bleach solution (prepared by making a one in ten dilution of diluted standard bleach [normally sold at a strength of 5.25% sodium hypochlorite] to disinfect affected surfaces. Sorbant should be double bagged and disposed of as indicated in section 12. After removal of sorbant, area should be washed with 10% bleach solution to disinfect. If liquid from the culture vessel is present on the fittings, non-designated tubing or exterior of the stainless steel pressure vessel liquid should be wiped off and the area washed with 10% bleach solution.

Section 7 - Handling and Storage

KB-1® is shipped in stainless steel pressure vessels and connected to injection lines and inert gas is used to pressurize the vessel to displace the contents. KB-1® should be handled with care to avoid any spillage. Vessels are shipped with 1 pound per square inch (psi) pressure; valves should not be opened until connections to appropriate lines for subsurface injection are in place.

Storage Requirements: Avoid exposing stainless steel pressure vessels to undue temperature extremes (i.e., temperatures less than 0°C or greater than 30°C may result in harm to the microbial cultures and damage to the vessels). All valves should be in the closed position when the vessel is not pressurized or not in use to prevent the escape of gases and to maintain anaerobic conditions in the vessel. Avoid exposure of the culture to air as the presence of oxygen will kill dechlorinating microorganisms.

Section 8 - Exposure Controls/Personal Protection

Personal protective equipment:

Skin: Protective gloves (latex, vinyl or nitrile) should be worn.
Eye Protection: Wear appropriate protective eyeglasses or goggles when opening pressure vessels, valves, or when pressurizing vessels to inject contents into the subsurface.
Respiratory: No respiratory protection is required.
Engineering Controls: Good general room ventilation is expected to be adequate.

Section 9: Physical and Chemical Properties:

Physical State: liquid
Odour: skunky odour
Appearance: dark grey, slightly turbid liquid under anaerobic conditions, pink if exposed to air (oxygen).
Specific gravity: not determined
Vapor pressure: not applicable
Vapor density: not applicable
Evaporation rate: not determined
Boiling point: ~100° C
Freezing point/melting point: ~ 0°C

pH: 6.5-7.5
Solubility: fully soluble in water

Section 10 – Stability and Reactivity Data

Stable and non-reactive.
Maintain under anaerobic conditions to preserve product integrity.
Materials to avoid: none known

Section 11 - Toxicological Information

Potential for Pathogenicity:

KB-1® has tested negative (i.e., the organisms are not present) for a variety of pathogenic organisms listed in Table 2. While there is no evidence that virulent pathogenic organisms are present in KB-1®, there is potential that certain organisms in KB-1® may have the potential to act as opportunistic (mild) pathogens, particularly in individuals with open wounds and/or compromised immune systems. For this reason standard hygienic procedures such as hand washing after use should be observed.

Table 2, Results of Human Pathogen Screening of KB-1® Dechlorinator

Organism	**Disease(s) Caused**	***Test result***
Salmonella sp.	Typhoid fever, gastroenteritis	Not Detected
Listeria monocytogenes	Listerioses	Not Detected
Vibrio sp.,	Cholera, gastroenteritis	Not Detected
Campylobacter sp.,	Bacterial diarrhea	Not Detected
Clostridia sp.,	Food poisoning, Botulism, tetanus, gas gangrene	Not Detected
Bacillus anthracis	Anthrax	Not Detected
Pseudomonas aeruginosa	Wound infection	Not Detected
Yersinia sp.,	Bubonic Plague, intestinal infection	Not Detected
Yeast and Mold	Candidiasis, Yeast infection etc.	Not Detected
Fecal coliforms	Indicator organisms for many human pathogens diarrhea, urinary tract infections	Not Detected
Enterococci	Various opportunistic infections	Not Detected

Section 12. Disposal Considerations

Material must be disinfected or sterilized prior to disposal. Consult local regulations prior to disposal.

Section 13 – Transport Information

Non-hazardous, non-pathogenic microbial inoculum – Biosafety Risk Group 1.

Chemicals, Not Otherwise Indexed (NOI), Non-hazardous

Not subject to TDG or DOT guidelines.

Disclaimer:

The information provided on this MSDS sheet is based on current data and represents our opinion based on the current standard of practice as to the proper use and handling of this product under normal, reasonably foreseeable conditions.

Last revised: 2 August 2011

APPENDIX E

SUBSTRATE DOSING, INJECTION, AND ROI CALCULATIONS (FURNISHED ON CD)

Appendix E1. Electron Donor Dosing and Injection Volume Calculations
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Treatment Interval (ft BLS)	Number of Injection Locations	Injection Method	Porosity	Injection Location Area (8 ft ROI) $\pi*(ROI)^2$ (ft^2)	Injection Interval (feet)	Number of 2-foot Injection Intervals Per Injection Location	Volume of Injection Area Area * Injection Interval * Number of Injection Locations (ft^3)	Pore Volume of Injection Area Volume * Porosity * 7.48 gal/ft^3 (gal)	Volume of SRS®-SD Based on Filling 0.7% (Source Zone) or 0.2% (10xNADC) Pore Volume Pore Volume * 0.007 (Source Zone) or 0.002 (10xNADC) (gal)	Drums of SRS®-SD (52.5 gal per drum; 60% EVO) Volume SRS®-SD / 52.5 gal / 0.6 (drum)	Dilution	Volume of SRS®-SD Solution Based on Total Number of Drums Drums of SRS®-SD * 52.5 gal/drum * Dilution (gal)	Volume of SRS®-SD Solution Volume SRS®-SD * Dilution	Volume of Chase Water (50 gal per Injection Interval) Number of 2-foot Injection Intervals * 50 gal * Number of Injection Locations (gal)	Total Injection Volume (SRS®-SD Solution and Chase Water) SRS®-SD Solution + Chase Water (gal)	Volume of SRS®-SD Solution per Location Volume SRS®-SD Solution / Number of Injection Locations (gal)	Volume SRS®-SD Solution per Injection Interval Volume of SRS®-SD Solution per Location / Number of 2-foot Injection Intervals (gal)
Source Zone Calculations																	
4 to 18	1	Low Pressure	0.3	201	14	7	2,815	6,317	44	1.4	80		5,896	350	6,246	5,896	842
4 to 26	3	Low Pressure	0.3	201	22	11	13,270	29,780	208	6.6	80		27,795	1,650	29,445	9,265	842
4 to 26	2	Low Pressure	0.3	201	22	11	8,847	19,853	139	4.4	80		18,530	1,100	19,630	9,265	842
39 to 52		Low Pressure	0.3	201	13	7	5,228	11,732	82	2.6	80	**103,862**	10,949	650	11,599	5,475	842
52 to 57		High Pressure	0.3	201	5	3	2,011	4,512	32	1.0	10		526	250	776	263	105
39 to 52	7	Low Pressure	0.3	201	13	7	18,297	41,060	287	9.1	80		38,323	2,275	40,598	5,475	842
52 to 57		High Pressure	0.3	201	5	3	7,037	15,792	111	3.5	10		1,842	875	2,717	263	105
Total (Source Zone)	**13**	---	---	---	---	---	**57,504**	**129,047**	**903**	**29**	---		**103,862**	**7,150**	**111,012**	---	---
10xNADC Ring Calculations																	
10 to 26	1	Low Pressure	0.3	201	16	8	3,217	7,219	14	0.46	270		6,770	400	7,170	6,770	846
16 to 26	2	Low Pressure	0.3	201	10	5	4,021	9,024	18	0.57	270		8,463	500	8,963	4,231	846
44 to 52	7	Low Pressure	0.3	201	8	4	11,259	25,268	51	1.60	270		23,696	1,400	25,096	3,385	846
16 to 26 and	1	Low Pressure	0.3	201	10	5	2,011	4,512	9	0.29	270	**56,700**	4,231	250	4,481	4,231	846
44 to 52			0.3	201	8	4	1,608	3,610	7	0.23	270		3,385	200	3,585	3,385	846
10 to 26 and	1	Low Pressure	0.3	201	16	8	3,217	7,219	14	0.46	270		6,770	400	7,170	6,770	846
44 to 52			0.3	201	8	4	1,608	3,610	7	0.23	270		3,385	200	3,585	3,385	846
Total (10xNADC Ring)	**12**	---	---	---	---	---	**26,942**	**60,463**	**121**	**4**	---		**56,700**	**3,350**	**60,050**	---	---
OVERALL TOTAL	**25**	---	---	---	---	---	**84,446**	**189,510**	**1,024**	**33**	---	**160,562**	**160,562**	**10,500**	**171,062**	---	---

Notes:

1. CVOCs indicates chlorinated volatile organic compounds.
2. ft BLS indicates feet below land surface.
3. ROI indicates radius of influence.
4. ft^2 indicates square feet.
5. ft^3 indicates cubic feet.
6. gal indicates gallons.
7. π indicates 3.14159265359.
8. % indicates percent.
9. 10xNADC indicates ten times the Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentration (NADC).
10. EVO indicates emulsified vegetable oil.
11. Dilution factor selected for low pressure injection locations to create an 8-foot ROI by filling 100% of the pore volume and for high pressure injection locations by filling 10 to 20% of the pore volume (based on an 8-foot ROI).

Appendix E2. Electron Donor Dosing Calculations using the ESTCP Tool

Substrate Estimating Tool (Version 1.2)

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 4 to 26 ft BLS (SZ)

RETURN TO COVER PAGE

NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	25	1-10,000	feet	Figure 2-8
Length (Parallel to predominant groundwater flow)	16	1-1,000	feet	Figure 2-8
Saturated Thickness	22	1-100	feet	4 to 26 ft BLS
Treatment Zone Cross Sectional Area	550	--	ft^2	
Treatment Zone Volume	8,800	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	19,752	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	19,752	--	gallons	
Design Period of Performance	5.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	3.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	30%	.05-50	percent	Appendix B - engineering estimate
Effective Porosity	30%	.05-50	percent	
Average Aquifer Hydraulic Conductivity	16.3	.01-1000	ft/day	Step 2 EE (30 to 50 ft BLS)
Average Hydraulic Gradient	0.0008	0.0001-0.1	ft/ft	Step 2 EE (30 to 50 ft BLS)
Average Groundwater Seepage Velocity through the Treatment Zone	0.04	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	15.9	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	19,586	--	gallons/year	
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3	Appendix B - engineering estimate
Soil Fraction Organic Carbon (foc)	0.11%	0.01-10	percent	foc 0.0011 for SAND with silt and shell (Wilson Corners)
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	0.6	0.01 to 10	mg/L	MW0001
Nitrate	5.00	0.1 to- 20	mg/L	Engineering estimate
Sulfate	31	10 to 5,000	mg/L	MW0001
Carbon Dioxide (estimated as the amount of Methane produced)	1.0	0.1 to 20	mg/L	Engineering estimate
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	5	0.1 to 20	mg/L	Engineering estimate
Iron (III) (estimated as the amount of Fe (II) produced)	10	0.1 to 20	mg/L	Engineering estimate
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	138.400	--	mg/L	Appendix B - SZ average concentration
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	26.100	--	mg/L	Appendix B - SZ average concentration
Vinyl Chloride (VC)	3.500	--	mg/L	Appendix B - SZ average concentration
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	-229	-400 to +500	mV	Average from MW0001
Temperature	25	5.0 to 30	ºC	Average from MW0001
pH	7.4	4.0 to 10.0	su	Average from MW0001
Alkalinity	300	10 to 1,000	mg/L	Engineering estimate
Total Dissolved Solids (TDS, or salinity)	490	10 to 1,000	mg/L	Average from MW0001
Specific Conductivity	755	100 to 10,000	µs/cm	Average from MW0001
Chloride	10	10 to 10,000	mg/L	Engineering estimate
Sulfide - Pre injection	11.0	0.1 to 100	mg/L	MW0001
Sulfide - Post injection	0.0	0.1 to 100	mg/L	Engineering estimate
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	Engineering estimate
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	Engineering estimate
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	Engineering estimate

NOTES:

Geochemistry values are the average of the values presented in Table 2-1. The electron acceptor values are the average concentrations for the shallow source zone from Appendix B.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 4 to 26 ft BLS (SZ)

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	25	feet	8	meters
Length (parallel to groundwater flow)	16	feet	4.9	meters
Saturated Thickness	22	feet	6.7	meters
Design Period of Performance	5	years	5	years

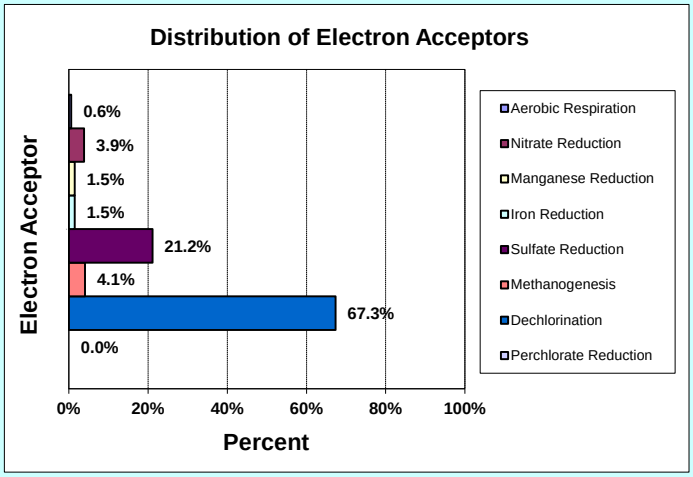
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.3	percent	0.3	percent
Effective Porosity	0.3	percent	0.3	percent
Average Aquifer Hydraulic Conductivity	16.3	ft/day	5.8E-03	cm/sec
Average Hydraulic Gradient	0.0008	ft/ft	0.0008	m/m
Average Groundwater Seepage Velocity	0.04	ft/day	1.3E+00	cm/day
Average Groundwater Seepage Velocity	16	ft/yr	4.8	m/yr
Effective Treatment Zone Pore Volume	19,752	gallons	74,769	liters
Groundwater Flux (per year)	19,586	gallons/year	74,140	liters/year
Total Groundwater Volume Treated (over entire design period)	117,684	gallons total	445,469	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	0.6%	0.074
Nitrate Reduction	3.9%	0.466
Sulfate Reduction	21.2%	2.556
Manganese Reduction	1.5%	0.180
Iron Reduction	1.5%	0.177
Methanogenesis	4.1%	0.493
Dechlorination	67.3%	8.138
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**12.08**

Hydrogen demand in pounds/gallon:	1.03E-04
Hydrogen demand in grams per liter:	1.23E-02



4. Substrate Equivalents: Design Factor = 3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	1,680	153	825	as lactic acid
2. Molasses Product	1,282	107	783	as sucrose
3. Fructose Product	1,013	90	825	as fructose
4. Ethanol Product	518	75	422	as ethanol
5. Sweet Dry Whey (lactose)	799	sold by pound	569	as lactose
6. HRC®	614	sold by pound	500	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	315	40	321	as soybean oil
8. Emulsified Vegetable Oil	525	67	321	as soybean oil

Notes:

1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 10 to 26 ft BLS (10xNADC)

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	30	1-10,000	feet	Figure 2-8 (subtracted out SZ)
Length (Parallel to predominant groundwater flow)	45	1-1,000	feet	Figure 2-8 (subtracted out SZ)
Saturated Thickness	16	1-100	feet	10 to 26 ft BLS
Treatment Zone Cross Sectional Area	480	--	ft^2	
Treatment Zone Volume	21,600	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	48,483	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	48,483	--	gallons	
Design Period of Performance	5.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	3.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	30%	.05-50	percent	Appendix B - engineering estimate
Effective Porosity	30%	.05-50	percent	
Average Aquifer Hydraulic Conductivity	16.3	.01-1000	ft/day	Step 2 EE (30 to 50 ft BLS)
Average Hydraulic Gradient	0.0008	0.0001-0.1	ft/ft	Step 2 EE (30 to 50 ft BLS)
Average Groundwater Seepage Velocity through the Treatment Zone	0.04	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	15.9	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	17,093	--	gallons/year	
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3	Appendix B - engineering estimate
Soil Fraction Organic Carbon (foc)	0.11%	0.01-10	percent	foc 0.0011 for SAND with silt and shell (Wilson Corners)
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	0.6	0.01 to 10	mg/L	MW0001
Nitrate	5.00	0.1 to- 20	mg/L	Engineering estimate
Sulfate	31	10 to 5,000	mg/L	MW0001
Carbon Dioxide (estimated as the amount of Methane produced)	1.0	0.1 to 20	mg/L	Engineering estimate
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	5	0.1 to 20	mg/L	Engineering estimate
Iron (III) (estimated as the amount of Fe (II) produced)	10	0.1 to 20	mg/L	Engineering estimate
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	0.024	--	mg/L	Appendix B - 10xNADC average concentration
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	16.300	--	mg/L	Appendix B - 10xNADC average concentration
Vinyl Chloride (VC)	4.100	--	mg/L	Appendix B - 10xNADC average concentration
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	-229	-400 to +500	mV	Average from MW0001
Temperature	25	5.0 to 30	ºC	Average from MW0001
pH	7.4	4.0 to 10.0	su	Average from MW0001
Alkalinity	300	10 to 1,000	mg/L	Engineering estimate
Total Dissolved Solids (TDS, or salinity)	490	10 to 1,000	mg/L	Average from MW0001
Specific Conductivity	755	100 to 10,000	µs/cm	Average from MW0001
Chloride	10	10 to 10,000	mg/L	Engineering estimate
Sulfide - Pre injection	11.0	0.1 to 100	mg/L	MW0001
Sulfide - Post injection	0.0	0.1 to 100	mg/L	Engineering estimate
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	Engineering estimate
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	Engineering estimate
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	Engineering estimate

NOTES:

Geochemistry values are the average of the values presented in Table 2-1. The electron acceptor values are the average concentrations for the shallow 10xNADC ring from Appendix B.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 10 to 26 ft BLS (10xNADC)

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	30	feet	9	meters
Length (parallel to groundwater flow)	45	feet	13.7	meters
Saturated Thickness	16	feet	4.9	meters
Design Period of Performance	5	years	5	years

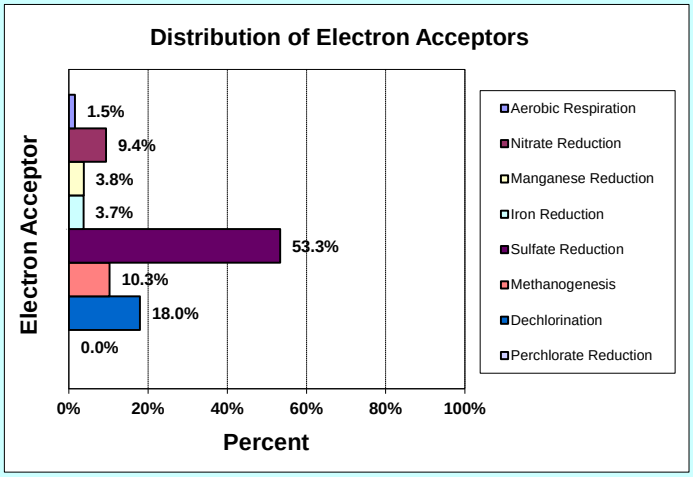
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.3	percent	0.3	percent
Effective Porosity	0.3	percent	0.3	percent
Average Aquifer Hydraulic Conductivity	16.3	ft/day	5.8E-03	cm/sec
Average Hydraulic Gradient	0.0008	ft/ft	0.0008	m/m
Average Groundwater Seepage Velocity	0.04	ft/day	1.3E+00	cm/day
Average Groundwater Seepage Velocity	16	ft/yr	4.8	m/yr
Effective Treatment Zone Pore Volume	48,483	gallons	183,524	liters
Groundwater Flux (per year)	17,093	gallons/year	64,704	liters/year
Total Groundwater Volume Treated (over entire design period)	133,951	gallons total	507,044	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	1.5%	0.084
Nitrate Reduction	9.4%	0.512
Sulfate Reduction	53.3%	2.909
Manganese Reduction	3.8%	0.205
Iron Reduction	3.7%	0.202
Methanogenesis	10.3%	0.562
Dechlorination	18.0%	0.980
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**5.45**

Hydrogen demand in pounds/gallon:	4.07E-05
Hydrogen demand in grams per liter:	4.88E-03



4. Substrate Equivalents: Design Factor = 3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	759	69	327	as lactic acid
2. Molasses Product	579	48	311	as sucrose
3. Fructose Product	457	41	327	as fructose
4. Ethanol Product	234	34	167	as ethanol
5. Sweet Dry Whey (lactose)	361	sold by pound	226	as lactose
6. HRC®	277	sold by pound	198	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	142	18	127	as soybean oil
8. Emulsified Vegetable Oil	237	30	127	as soybean oil

Notes:

1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 39 to 57 ft BLS (SZ)

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	20	1-10,000	feet	Figure 2-8
Length (Parallel to predominant groundwater flow)	45	1-1,000	feet	Figure 2-8
Saturated Thickness	18	1-100	feet	39 to 57 ft BLS
Treatment Zone Cross Sectional Area	360	--	ft^2	
Treatment Zone Volume	16,200	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	36,363	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	36,363	--	gallons	
Design Period of Performance	5.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	3.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	30%	.05-50	percent	Appendix B - engineering estimate
Effective Porosity	30%	.05-50	percent	
Average Aquifer Hydraulic Conductivity	16.3	.01-1000	ft/day	Step 2 EE (30 to 50 ft BLS)
Average Hydraulic Gradient	0.0008	0.0001-0.1	ft/ft	Step 2 EE (30 to 50 ft BLS)
Average Groundwater Seepage Velocity through the Treatment Zone	0.04	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	15.9	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	12,820	--	gallons/year	
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3	Appendix B - engineering estimate
Soil Fraction Organic Carbon (foc)	1.00%	0.01-10	percent	foc 0.01 for interbedded clayey/SAND/sandy CLAY from WC
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	0.6	0.01 to 10	mg/L	MW0001
Nitrate	5.00	0.1 to- 20	mg/L	Engineering estimate
Sulfate	31	10 to 5,000	mg/L	MW0001
Carbon Dioxide (estimated as the amount of Methane produced)	1.0	0.1 to 20	mg/L	Engineering estimate
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	5	0.1 to 20	mg/L	Engineering estimate
Iron (III) (estimated as the amount of Fe (II) produced)	10	0.1 to 20	mg/L	Engineering estimate
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	29.700	--	mg/L	Appendix B - SZ average concentration
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	51.800	--	mg/L	Appendix B - SZ average concentration
Vinyl Chloride (VC)	2.500	--	mg/L	Appendix B - SZ average concentration
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	-229	-400 to +500	mV	Average from MW0001
Temperature	25	5.0 to 30	ºC	Average from MW0001
pH	7.4	4.0 to 10.0	su	Average from MW0001
Alkalinity	300	10 to 1,000	mg/L	Engineering estimate
Total Dissolved Solids (TDS, or salinity)	490	10 to 1,000	mg/L	Average from MW0001
Specific Conductivity	755	100 to 10,000	µs/cm	Average from MW0001
Chloride	10	10 to 10,000	mg/L	Engineering estimate
Sulfide - Pre injection	11.0	0.1 to 100	mg/L	MW0001
Sulfide - Post injection	0.0	0.1 to 100	mg/L	Engineering estimate
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	Engineering estimate
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	Engineering estimate
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	Engineering estimate

NOTES:

Geochemistry values are the average of the values presented in Table 2-1. The electron acceptor values are the average concentrations for the deep source zone from Appendix B.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 39 to 57 ft BLS (SZ)

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1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	20	feet	6	meters
Length (parallel to groundwater flow)	45	feet	13.7	meters
Saturated Thickness	18	feet	5.5	meters
Design Period of Performance	5	years	5	years

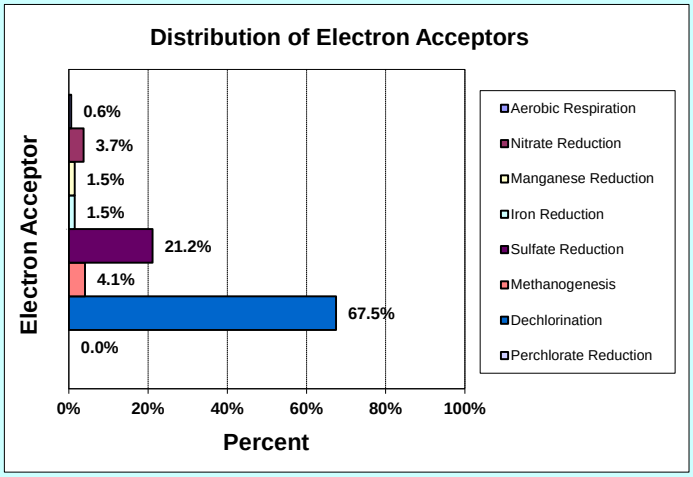
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.3	percent	0.3	percent
Effective Porosity	0.3	percent	0.3	percent
Average Aquifer Hydraulic Conductivity	16.3	ft/day	5.8E-03	cm/sec
Average Hydraulic Gradient	0.0008	ft/ft	0.0008	m/m
Average Groundwater Seepage Velocity	0.04	ft/day	1.3E+00	cm/day
Average Groundwater Seepage Velocity	16	ft/yr	4.8	m/yr
Effective Treatment Zone Pore Volume	36,363	gallons	137,643	liters
Groundwater Flux (per year)	12,820	gallons/year	48,528	liters/year
Total Groundwater Volume Treated (over entire design period)	100,463	gallons total	380,283	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	0.6%	0.063
Nitrate Reduction	3.7%	0.384
Sulfate Reduction	21.2%	2.182
Manganese Reduction	1.5%	0.154
Iron Reduction	1.5%	0.151
Methanogenesis	4.1%	0.421
Dechlorination	67.5%	6.958
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**10.31**

Hydrogen demand in pounds/gallon:	1.03E-04
Hydrogen demand in grams per liter:	1.23E-02



4. Substrate Equivalents: Design Factor = 3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	1,434	130	825	as lactic acid
2. Molasses Product	1,095	91	783	as sucrose
3. Fructose Product	864	77	825	as fructose
4. Ethanol Product	442	64	422	as ethanol
5. Sweet Dry Whey (lactose)	682	sold by pound	569	as lactose
6. HRC®	524	sold by pound	500	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	269	34	321	as soybean oil
8. Emulsified Vegetable Oil	448	57	321	as soybean oil

Notes:

1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Table S.1 Input for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 44 to 52 ft BLS (10xNADC)

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NOTE: Unshaded boxes are user input.

1. Treatment Zone Physical Dimensions	Values	Range	Units	User Notes
Width (Perpendicular to predominant groundwater flow direction)	15	1-10,000	feet	Figure 2-8 (subtracted out SZ)
Length (Parallel to predominant groundwater flow)	65	1-1,000	feet	Figure 2-8 (subtracted out SZ)
Saturated Thickness	8	1-100	feet	44 to 52 ft BLS
Treatment Zone Cross Sectional Area	120	--	ft^2	
Treatment Zone Volume	7,800	--	ft^3	
Treatment Zone Total Pore Volume (total volume x total porosity)	17,508	--	gallons	
Treatment Zone Effective Pore Volume (total volume x effective porosity)	17,508	--	gallons	
Design Period of Performance	5.0	.5 to 5	year	
Design Factor (times the electron acceptor hydrogen demand)	3.0	2 to 20	unitless	
2. Treatment Zone Hydrogeologic Properties				
Total Porosity	30%	.05-50	percent	Appendix B - engineering estimate
Effective Porosity	30%	.05-50	percent	
Average Aquifer Hydraulic Conductivity	16.3	.01-1000	ft/day	Step 2 EE (30 to 50 ft BLS)
Average Hydraulic Gradient	0.0008	0.0001-0.1	ft/ft	Step 2 EE (30 to 50 ft BLS)
Average Groundwater Seepage Velocity through the Treatment Zone	0.04	--	ft/day	
Average Groundwater Seepage Velocity through the Treatment Zone	15.9	--	ft/yr	
Average Groundwater Discharge through the Treatment Zone	4,273	--	gallons/year	
Soil Bulk Density	1.6	1.4-2.0	gm/cm^3	Appendix B - engineering estimate
Soil Fraction Organic Carbon (foc)	1.00%	0.01-10	percent	foc 0.01 for interbedded clayey/SAND/sandy CLAY from WC
3. Native Electron Acceptors				
A. Aqueous-Phase Native Electron Acceptors				
Oxygen	0.6	0.01 to 10	mg/L	MW0001
Nitrate	5.00	0.1 to- 20	mg/L	Engineering estimate
Sulfate	31	10 to 5,000	mg/L	MW0001
Carbon Dioxide (estimated as the amount of Methane produced)	1.0	0.1 to 20	mg/L	Engineering estimate
B. Solid-Phase Native Electron Acceptors				
Manganese (IV) (estimated as the amount of Mn (II) produced)	5	0.1 to 20	mg/L	Engineering estimate
Iron (III) (estimated as the amount of Fe (II) produced)	10	0.1 to 20	mg/L	Engineering estimate
4. Contaminant Electron Acceptors				
Tetrachloroethene (PCE)	0.000	--	mg/L	
Trichloroethene (TCE)	0.543	--	mg/L	Appendix B - 10xNADC average concentration
Dichloroethene (cis-DCE, trans-DCE, and 1,1-DCE)	8.700	--	mg/L	Appendix B - 10xNADC average concentration
Vinyl Chloride (VC)	1.100	--	mg/L	Appendix B - 10xNADC average concentration
Carbon Tetrachloride (CT)	0.000	--	mg/L	
Trichloromethane (or chloroform) (CF)	0.000	--	mg/L	
Dichloromethane (or methylene chloride) (MC)	0.000	--	mg/L	
Chloromethane	0.000	--	mg/L	
Tetrachloroethane (1,1,1,2-PCA and 1,1,2,2-PCA)	0.000	--	mg/L	
Trichloroethane (1,1,1-TCA and 1,1,2-TCA)	0.000	--	mg/L	
Dichloroethane (1,1-DCA and 1,2-DCA)	0.000	--	mg/L	
Chloroethane	0.000	--	mg/L	
Perchlorate	0.000	--	mg/L	
5. Aquifer Geochemistry (Optional Screening Parameters)				
A. Aqueous Geochemistry				
Oxidation-Reduction Potential (ORP)	-229	-400 to +500	mV	Average from MW0001
Temperature	25	5.0 to 30	ºC	Average from MW0001
pH	7.4	4.0 to 10.0	su	Average from MW0001
Alkalinity	300	10 to 1,000	mg/L	Engineering estimate
Total Dissolved Solids (TDS, or salinity)	490	10 to 1,000	mg/L	Average from MW0001
Specific Conductivity	755	100 to 10,000	µs/cm	Average from MW0001
Chloride	10	10 to 10,000	mg/L	Engineering estimate
Sulfide - Pre injection	11.0	0.1 to 100	mg/L	MW0001
Sulfide - Post injection	0.0	0.1 to 100	mg/L	Engineering estimate
B. Aquifer Matrix				
Total Iron	10000	200 to 20,000	mg/kg	Engineering estimate
Cation Exchange Capacity	NA	1.0 to 10	meq/100 g	Engineering estimate
Neutralization Potential	10.0%	1.0 to 100	Percent as $CaCO_3$	Engineering estimate

NOTES:

Geochemistry values are the average of the values presented in Table 2-1. The electron acceptor values are the average concentrations for the deep 10xNADC ring from Appendix B.

Table S.5 Output for Substrate Requirements in Hydrogen Equivalents

Site Name: MLPV - 44 to 52 ft BLS (10xNADC)

RETURN TO COVER PAGE

1. Treatment Zone Physical Dimensions

	Values	Units	Values	Units
Width (perpendicular to groundwater flow)	15	feet	5	meters
Length (parallel to groundwater flow)	65	feet	19.8	meters
Saturated Thickness	8	feet	2.4	meters
Design Period of Performance	5	years	5	years

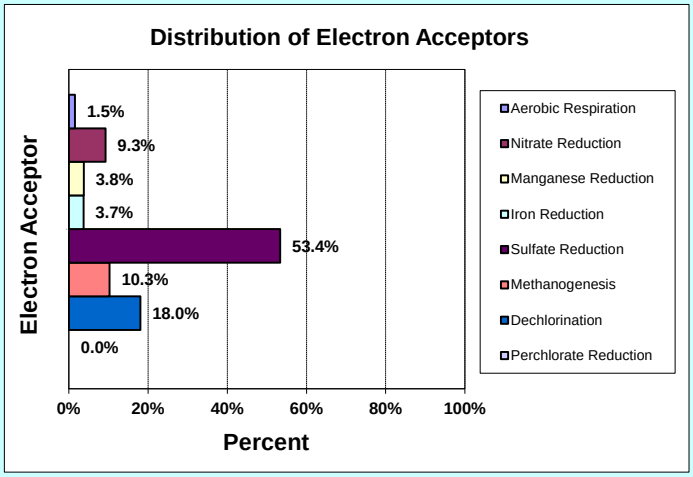
2. Treatment Zone Hydrogeologic Properties

	Values	Units	Values	Units
Total Porosity	0.3	percent	0.3	percent
Effective Porosity	0.3	percent	0.3	percent
Average Aquifer Hydraulic Conductivity	16.3	ft/day	5.8E-03	cm/sec
Average Hydraulic Gradient	0.0008	ft/ft	0.0008	m/m
Average Groundwater Seepage Velocity	0.04	ft/day	1.3E+00	cm/day
Average Groundwater Seepage Velocity	16	ft/yr	4.8	m/yr
Effective Treatment Zone Pore Volume	17,508	gallons	66,273	liters
Groundwater Flux (per year)	4,273	gallons/year	16,176	liters/year
Total Groundwater Volume Treated (over entire design period)	38,875	gallons total	147,153	liters total

3. Distribution of Electron Acceptor Demand

	Percent of Total	Hydrogen Demand (lb)
Aerobic Respiration	1.5%	0.025
Nitrate Reduction	9.3%	0.146
Sulfate Reduction	53.4%	0.844
Manganese Reduction	3.8%	0.060
Iron Reduction	3.7%	0.059
Methanogenesis	10.3%	0.163
Dechlorination	18.0%	0.285
Perchlorate Reduction	0.0%	0.000
Totals:	**100.00%**	**1.58**

Hydrogen demand in pounds/gallon:	4.07E-05
Hydrogen demand in grams per liter:	4.88E-03



4. Substrate Equivalents: Design Factor = 3.0

Product	Quantity (lb)	Quantity (gallons)	Effective Concentration (mg/L)	Effective concentration is for total volume of groundwater treated.
1. Sodium Lactate Product	220	20	327	as lactic acid
2. Molasses Product	168	14	310	as sucrose
3. Fructose Product	133	12	327	as fructose
4. Ethanol Product	68	10	167	as ethanol
5. Sweet Dry Whey (lactose)	105	sold by pound	226	as lactose
6. HRC®	80	sold by pound	198	as 40% lactic acid/40% glycerol
7. Linoleic Acid (Soybean Oil)	41	5	127	as soybean oil
8. Emulsified Vegetable Oil	69	9	127	as soybean oil

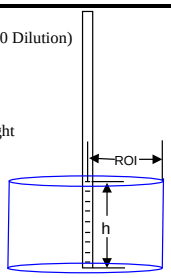
Notes:

1. Quantity assumes product is 60% sodium lactate by weight.
2. Quantity assumes product is 60% sucrose by weight and weighs 12 pounds per gallon.
3. Quantity assumes product is 80% fructose by weight and weighs 11.2 pounds per gallon.
4. Quantity assumes product is 80% ethanol by weight and weighs 6.9 pounds per gallon.
5. Quantity assumes product is 70% lactose by weight.
6. Quantity assumes HRC® is 40% lactic acid and 40% glycerol by weight.
7. Quantity of neat soybean oil, corn oil, or canola oil.
8. Quantity assumes commercial product is 60% soybean oil by weight.

Appendix E3. Radius of Influence (ROI) Calculations for Individual Injection Locations at MLPV
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

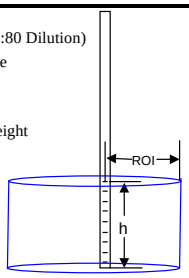
4 to 18 ft BLS (Source Zone)

V_{EVO}	5,896	gal	EVO Inj. Volume (1:80 Dilution)
V_{water}	350	gal	Chase Water Volume
V_{total}	6,246	gal	Total Inj. Volume
V_{total}	835.0	ft^3	Total Inj. Volume
h	14	ft	Injection Interval Height
π	3.14		
n	0.3		Effective Porosity
$ROI = \sqrt{V_{total}/\pi * n * h}$			
ROI	8.0	ft	



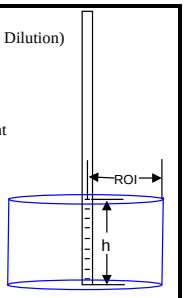
4 to 26 ft BLS (Source Zone)

V_{EVO}	9,265	gal	EVO Inj. Volume (1:80 Dilution)
V_{water}	550	gal	Chase Water Volume
V_{total}	9,815	gal	Total Inj. Volume
V_{total}	1,312	ft^3	Total Inj. Volume
h	22	ft	Injection Interval Height
π	3.14		
n	0.3		Effective Porosity
$ROI = \sqrt{V_{total}/\pi * n * h}$			
ROI	8.0	ft	



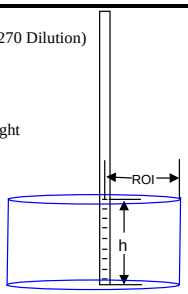
39 to 52 ft BLS (Source Zone)

V_{EVO}	5,475	gal	EVO Inj. Volume (1:80 Dilution)
V_{water}	325	gal	Chase Water Volume
V_{total}	5,800	gal	Total Inj. Volume
V_{total}	775.3	ft^3	Total Inj. Volume
h	13	ft	Injection Interval Height
π	3.14		
n	0.3		Effective Porosity
$ROI = \sqrt{V_{total}/\pi * n * h}$			
ROI	8.0	ft	



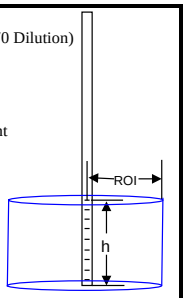
10 to 26 ft BLS (10xNADC Ring)

V_{EVO}	6,770	gal	EVO Inj. Volume (1:270 Dilution)
V_{water}	400	gal	Chase Water Volume
V_{total}	7,170	gal	Total Inj. Volume
V_{total}	958.5	ft^3	Total Inj. Volume
h	16	ft	Injection Interval Height
π	3.14		
n	0.3		Effective Porosity
$ROI = \sqrt{V_{total}/\pi * n * h}$			
ROI	8.0	ft	



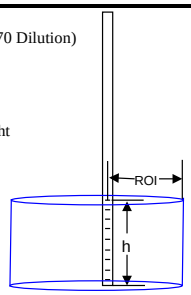
16 to 26 ft BLS (10xNADC Ring)

V_{EVO}	4,231	gal	EVO Inj. Volume (1:270 Dilution)
V_{water}	250	gal	Chase Water Volume
V_{total}	4,481	gal	Total Inj. Volume
V_{total}	599.1	ft^3	Total Inj. Volume
h	10	ft	Injection Interval Height
π	3.14		
n	0.3		Effective Porosity
$ROI = \sqrt{V_{total}/\pi * n * h}$			
ROI	8.0	ft	



44 to 52 ft BLS (10xNADC Ring)

V_{EVO}	3,385	gal	EVO Inj. Volume (1:270 Dilution)
V_{water}	200	gal	Chase Water Volume
V_{total}	3,585	gal	Total Inj. Volume
V_{total}	479.3	ft^3	Total Inj. Volume
h	8	ft	Injection Interval Height
π	3.14		
n	0.3		Effective Porosity
$ROI = \sqrt{V_{total}/\pi * n * h}$			
ROI	8.0	ft	



Notes:

1. Emulsified vegetable oil injection volume (EVO Inj Volume) from "Volume of SRS®-SD Solution per Location" in Appendix E1.
2. Chase water volume calculated by multiplying 50 gallons of chase water per the total number of per 2-foot injection intervals per injection location listed in Appendix E1.
3. Total Inj. Volume claculated by summing EVO Inj. Volume and Chase Water Volume.

Appendix E4. Sodium Sulfite Calculations
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

			Given O_2 Concentration (mg/L)	Target Sulfite Concentration (mg/L)	Minimum Mass Sulfite Required for Target Injectate Volume (g)	Minimum Mass Sulfite Required for Target Injectate Volume (TBS)
Molecular Weights	**g/mol**		1	8	5,100	129.5
sodium sulfite (Na2SO3)	126.04		2	16	10,201	259.1
oxygen (O2)	32		4	32	20,401	518.1
Reaction:			6	47	30,602	777.2
$2Na_2SO_3 + O_2 \rightarrow 2Na_2SO_4$			8	63	40,803	1036.2 potable water
density sodium sulfite:					0.24	grams per gallon
2.663	g/ml					
Requirement		**Target Injectate Volume:**			171,062	gallons
7.9	sulfite per O2				647,470	Liters

Appendix E5. KB-1® Dosing Volume Calculations
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Treatment Interval (ft BLS)	Number of Injection Locations	Injection Interval (feet)	Number of 2-foot Injection Intervals Per Injection Location	Number of Injection Intervals to Receive KB-1® Per Injection Location*	Volume of KB-1® Per Injection Location (liters)	Volume of KB-1® Per Treatment Interval (liters)
Source Zone Calculations						
4 to 18	1	14	7	4	2.0	2.0
4 to 26	3	22	11	6	3.0	9.0
4 to 26 and 39 to 57	2	22	11	6	3.0	6.0
		18	9	5	2.5	5.0
39 to 57	7	18	9	5	2.5	17.5
Total (Source Zone)	**13**	---	---	---	---	**39.5**
10xNADC Ring Calculations						
10 to 26	1	16	8	4	2.0	2.0
16 to 26	2	10	5	3	1.5	3.0
44 to 52	7	8	4	2	1.0	7.0
16 to 26 and 44 to 52	1	10	5	3	1.5	1.5
		8	4	2	1.0	1.0
10 to 26 and 44 to 52	1	16	8	4	2.0	2.0
		8	4	2	1.0	1.0
Total (10xNADC Ring)	**12**	---	---	---	---	**17.5**
OVERALL TOTAL	**25**	---	---	---	---	**57**

Notes:

1. * indicates that the number of injection intervals was calculated by dividing the number of 2-foot injection intervals per location by 2, and rounding up to the nearest whole number.
2. Design calls for 0.5 liters of KB-1® to be injected per injection interval receiving KB-1.
3. ft BLS indicates feet below land surface.

APPENDIX F

REMEDIATION TIMEFRAME CALCULATIONS (FURNISHED ON CD)

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client:	NASA	**Project:**	MLPV Hot Spot 3 Bioremediation IM Work Plan	**Project/Proposal #:**	FR0579C	**Task #:**	23

TITLE OF COMPUTATIONS **REMEDIATION TIMEFRAME CALCULATIONS**

COMPUTATIONS BY:
Signature
Printed Name and Title: Whitney Morrison, E.I., Senior Staff Engineer
3/21/2016 DATE

ASSUMPTIONS AND PROCEDURES

CHECKED BY: (Peer Reviewer)
Signature
Printed Name and Title: Rebecca C. Daprato, Ph.D., P.E., Senior Engineer
3/21/2016 DATE

COMPUTATIONS CHECKED BY:
Signature
Printed Name and Title: Jim Langenbach, P.E., BSCE, Principal Engineer
3/21/2016 DATE

COMPUTATIONS BACKCHECKED BY: (Originator)
Signature
Printed Name and Title: Whitney Morrison, E.I., Senior Staff Engineer
3/21/2016 DATE

APPROVED BY: (PM or Designate)
Signature
Printed Name and Title: Rebecca C. Daprato, Ph.D., P.E., Senior Engineer
3/21/2016 DATE

APPROVAL NOTES:

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

Appendix F. Remediation Timeframe Calculations
Mobile Launch Platform/Vehicle Assembly Building Area, SWMU 056

Constituent	Dechlorination Rate from MLP	Depth Interval	Average Concentration Within The Area Specified	FDEP NADC	Estimated Time to NADC
	r		C_0	C(t)	t
	(day^{-1})	ft BLS	(µg/L)	(µg/L)	(years)
10xNADC Ring Calculations					
Trichloroethene	7.25E-03	6 to 22	3,000	300	0.87
		41 to 60	3,000		0.87
cis -1,2-dichloroethene	2.97E-03	6 to 22	16,300	700	2.90
		41 to 60	8,673		2.32
Vinyl Chloride	2.23E-03	6 to 22	4,057	100	4.55
		41 to 60	1,099		2.94
Source Zone Calculations					
Trichloroethene	7.25E-03	6 to 22	138,429	300	2.32
		41 to 60	29,704		1.74
cis -1,2-dichloroethene	2.97E-03	6 to 22	26,140	700	3.34
		41 to 60	51,781		3.97
Vinyl Chloride	2.23E-03	6 to 22	3,507	100	4.37
		41 to 60	2,519		3.96

Notes:

1. Calculation assumes a first order decay using equation $C(t) = C_0 e^{-rt}$.
2. MLP indicates the Mobile Launch Platform Site; dechlorination rates from bioremediation of Hot Spot 1 former source area.
3. FDEP indicates Florida Department of Environmental Protection.
4. NADC indicates Natural Attenuation Default Concentration.
5. µg/L indicates micrograms per liter.
6. Average concentration is the average concentration provided in Appendix B.
7. Average concentration for trichloroethene assumed to be 3,000 µg/L in the 10xNADC Area because the calculated average concentration was less than the 10xNADC value.

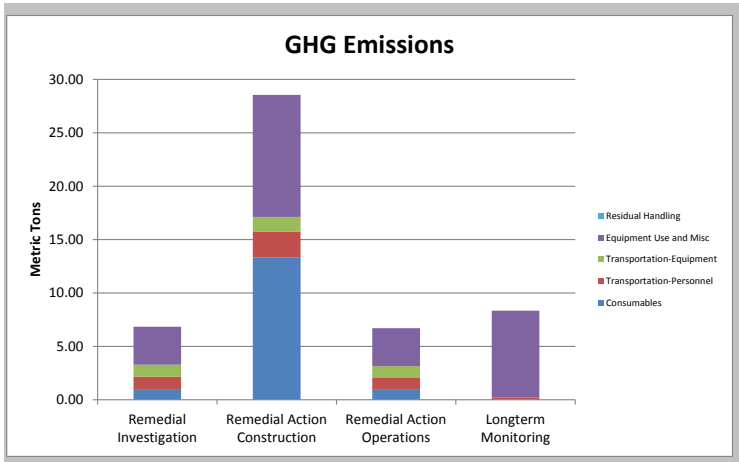
APPENDIX G

SITEWISE™ OUTPUT
(FURNISHED ON CD)

Sustainable Remediation - Environmental Footprint Summary
Bio 10xNADC

Phase	Activities	GHG Emissions	Total Energy Used	Water Consumption	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx Emissions	Total SOx Emissions	Total PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	MWH	metric ton	metric ton	metric ton	metric ton	metric ton	metric ton		
Remedial Investigation	Consumables	0.93	4.9E+00	NA	NA	NA	NA	NA	1.9E-03	3.7E-03	7.4E-04	NA	NA
	Transportation-Personnel	1.24	1.6E+01	NA	NA	NA	NA	NA	4.1E-04	8.9E-06	4.4E-05	1.3E-05	1.0E-03
	Transportation-Equipment	1.11	1.5E+01	NA	NA	NA	NA	NA	3.5E-04	6.2E-06	3.1E-05	4.2E-06	3.4E-04
	Equipment Use and Misc	3.56	5.0E+01	2.5E+02	0.0E+00	4.3E-03	4.4E-04	3.9E-04	1.9E-02	1.2E-02	1.7E-03	1.4E-05	4.1E-03
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	6.83	8.53E+01	2.50E+02	0.00E+00	4.30E-03	4.40E-04	3.87E-04	2.21E-02	1.55E-02	2.48E-03	3.10E-05	5.46E-03
Remedial Action Construction	Consumables	13.32	6.9E+02	NA	NA	NA	NA	NA	2.2E-02	4.3E-02	8.6E-03	NA	NA
	Transportation-Personnel	2.44	3.1E+01	NA	NA	NA	NA	NA	8.7E-04	1.9E-05	9.7E-05	5.6E-05	4.5E-03
	Transportation-Equipment	1.36	1.8E+01	NA	NA	NA	NA	NA	4.3E-04	7.6E-06	3.8E-05	5.8E-06	4.6E-04
	Equipment Use and Misc	11.42	1.3E+02	2.4E+05	0.0E+00	9.5E-02	1.1E-02	7.8E-03	1.1E-01	1.8E-02	9.1E-03	1.4E-04	3.7E-02
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	28.54	8.67E+02	2.39E+05	0.00E+00	9.53E-02	1.08E-02	7.76E-03	1.30E-01	6.16E-02	1.78E-02	2.04E-04	4.23E-02
Remedial Action Operations	Consumables	0.93	4.9E+00	NA	NA	NA	NA	NA	1.9E-03	3.7E-03	7.4E-04	NA	NA
	Transportation-Personnel	1.11	1.4E+01	NA	NA	NA	NA	NA	3.6E-04	7.2E-06	3.6E-05	1.1E-05	8.7E-04
	Transportation-Equipment	1.11	1.5E+01	NA	NA	NA	NA	NA	3.5E-04	6.2E-06	3.1E-05	4.2E-06	3.4E-04
	Equipment Use and Misc	3.56	5.0E+01	2.5E+02	0.0E+00	4.3E-03	4.4E-04	3.9E-04	1.9E-02	1.2E-02	1.7E-03	1.4E-05	4.0E-03
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	6.71	8.37E+01	2.50E+02	0.00E+00	4.30E-03	4.40E-04	3.87E-04	2.20E-02	1.55E-02	2.48E-03	2.92E-05	5.21E-03
Longterm Monitoring	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00	0.0E+00	0.0E+00	NA	NA
	Transportation-Personnel	0.20	2.5E+00	NA	NA	NA	NA	NA	8.2E-05	2.6E-06	1.2E-05	2.8E-06	2.3E-04
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	8.14	1.2E+02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E-02	2.9E-02	3.3E-03	6.5E-07	7.9E-04
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	8.34	1.19E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.91E-02	2.93E-02	3.27E-03	3.46E-06	1.02E-03
Total		**5.0E+01**	**1.2E+03**	**2.4E+05**	**0.0E+00**	**1.0E-01**	**1.2E-02**	**8.5E-03**	**2.1E-01**	**1.2E-01**	**2.6E-02**	**2.7E-04**	**5.4E-02**

Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent electricity from renewable sources	Total Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	
Remedial Investigation	0.0E+00	0.0E+00	0.0E+00	45,400	4.4E-02	0.0%	**$623,066**
Remedial Action Construction	0.0E+00	0.0E+00	0.0E+00	387,666	3.4E-01	0.0%	
Remedial Action Operations	0.0E+00	0.0E+00	0.0E+00	40,000	4.2E-02	0.0%	
Longterm Monitoring	0.0E+00	0.0E+00	0.0E+00	150,000	8.1E-03	0.0%	
Total	**0.0E+00**	**0.0E+00**	**0.0E+00**	**$623,066**	**4.3E-01**	**0.0%**	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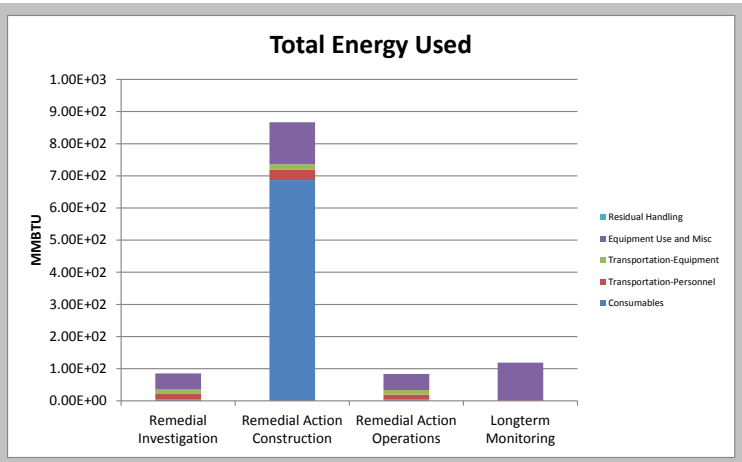
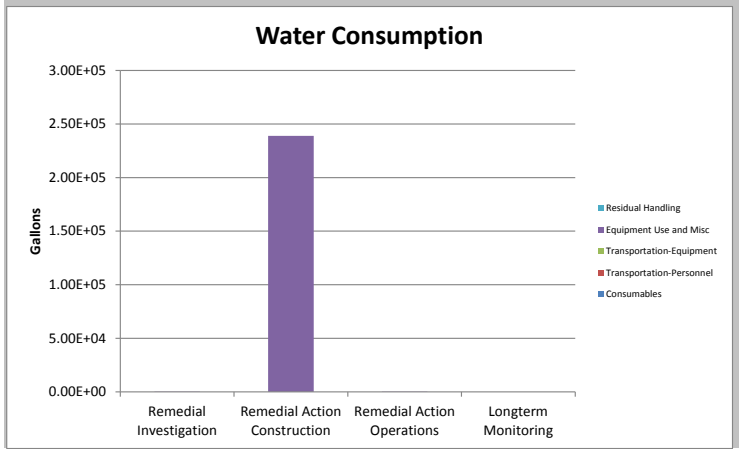
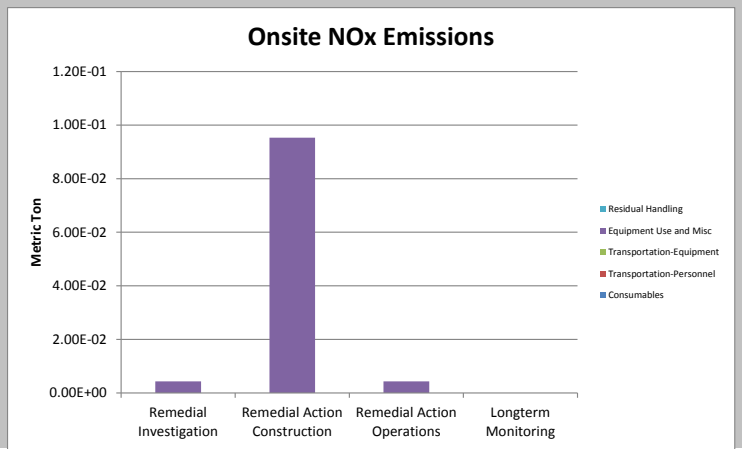
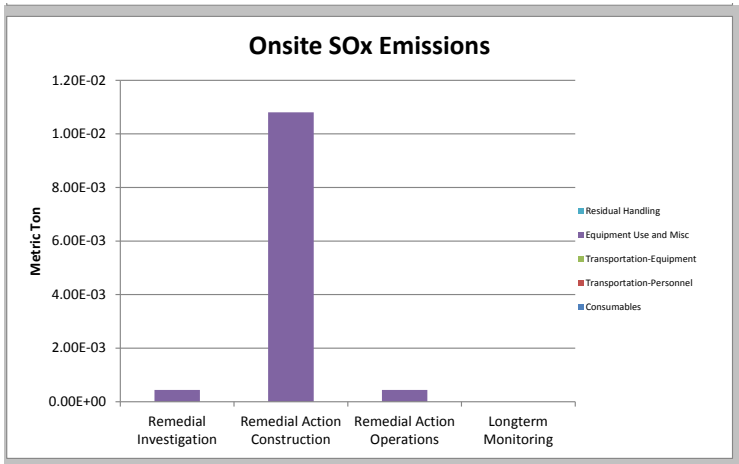
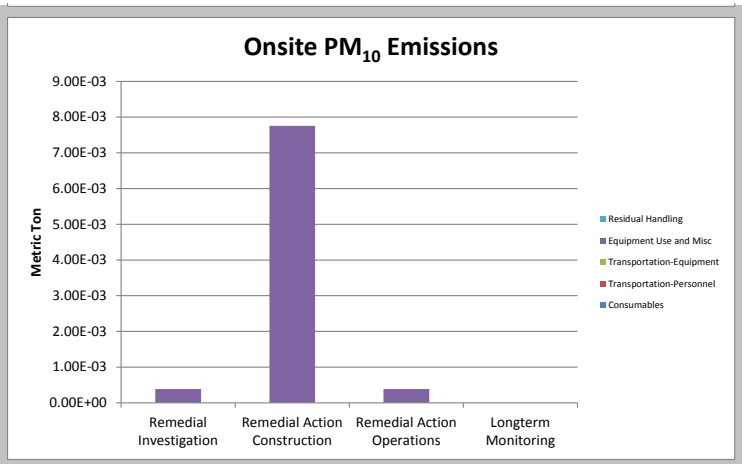
Metric Tons
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

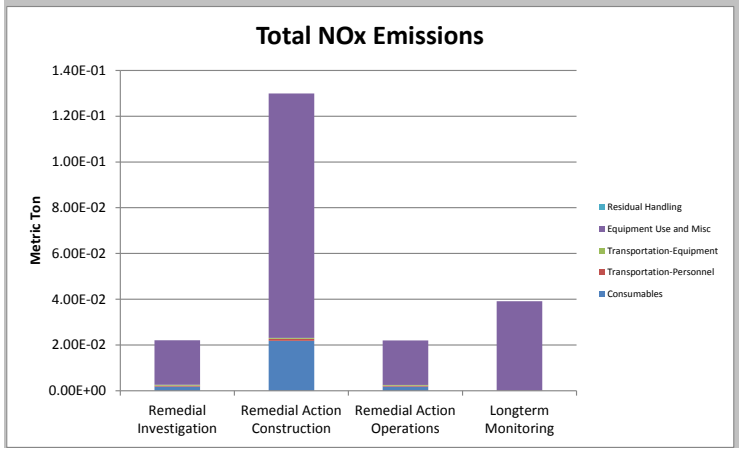

Total Energy Used
MMBTU
1.00E+03
9.00E+02
8.00E+02
7.00E+02
6.00E+02
5.00E+02
4.00E+02
3.00E+02
2.00E+02
1.00E+02
0.00E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

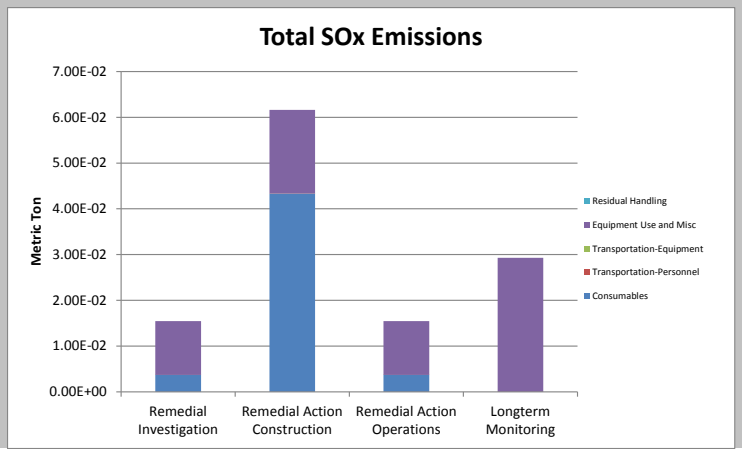

Water Consumption
Gallons
3.00E+05
2.50E+05
2.00E+05
1.50E+05
1.00E+05
5.00E+04
0.00E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

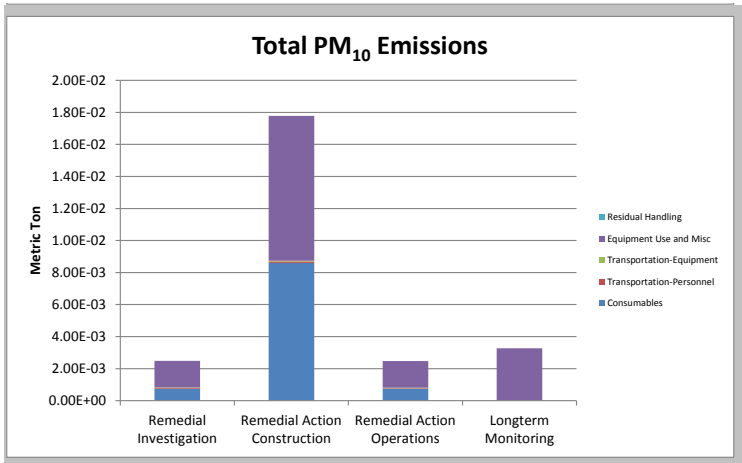

Onsite NOx Emissions
Metric Ton
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

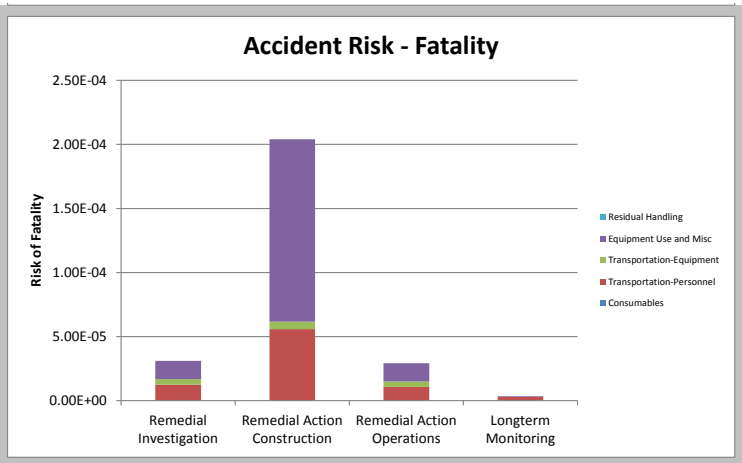

Onsite SOx Emissions
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
Metric Ton
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Onsite PM10 Emissions
9.00E-03
8.00E-03
7.00E-03
6.00E-03
5.00E-03
4.00E-03
3.00E-03
2.00E-03
1.00E-03
0.00E+00
Metric Ton
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Total NOx Emissions
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Metric Ton
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Total SOx Emissions
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
Metric Ton
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Total PM10 Emissions
Metric Ton
2.00E-02
1.80E-02
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Fatality
Risk of Fatality
2.50E-04
2.00E-04
1.50E-04
1.00E-04
5.00E-05
0.00E+00
Remedial Investigation
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Longterm Monitoring
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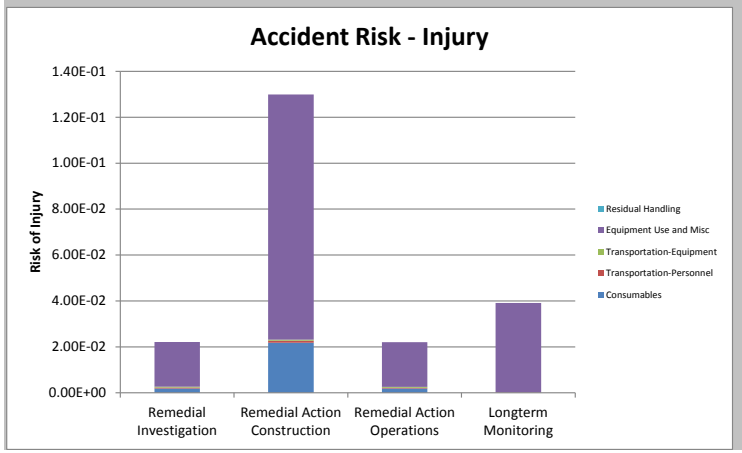
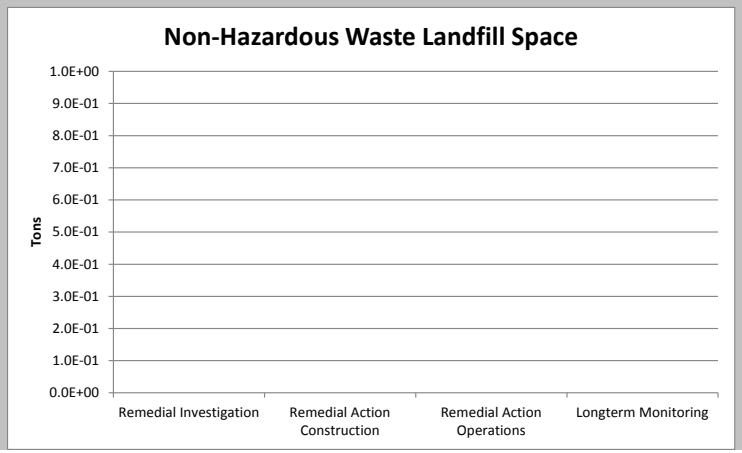
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Injury
Risk of Injury
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Non-Hazardous Waste Landfill Space
Tons
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Remedial Investigation
Remedial Action Construction
Remedial Action Operations
Longterm Monitoring