EXHIBIT O

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2013 ANNUAL PROGRESS REPORT

NATURAL RESTORATION STUDY LAKEHURST AREA I/J (SITE OW006)

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ARAR	Applicable or Relevant and Appropriate Requirement
BNP	Bi-Metallic Nano-Scale Particle
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
c-DCE (or c-1,2-DCE)	cis-1,2-Dichloroethene
CA	Chloroethane
COM	Center of mass
cVOC(s)	Chlorinated Volatile Organic Compound(s)
DCA (or 1,1-DCA)	1,1-Dichloroethane
DCE (or 1,1-DCE)	1,1-Dichloroethene
DO	Dissolved Oxygen
et al	and others
JB-MDL	Joint Base – McGuire Dix Lakehurst
MAROS	Monitoring and Remediation Optimization System
mg/l	milligrams per liter
MNA	Monitored Natural Attenuation
mV	Millivolt
NAES	Naval Air Engineering Station
NJDEP	New Jersey Department of Environmental Protection
ORP	Oxidation Reduction Potential
PID	Photoionization Detector
PCE	Tetrachloroethene
ROD	Record of Decision
TCE	Trichloroethene
TOC	Total Organic Carbon
USEPA	United States Environmental Protection Agency
VAL	VAL Associates Laboratory (Cherry Hill, New Jersey)
VC	Vinyl Chloride
VOC(s):	Volatile Organic Compound(s)
µg/l	micrograms per liter
µS/cm	Microsiemens per centimeter
°C	Degrees Celsius
%	Percent

This report summarizes the results of two groundwater sampling events conducted during 2013 at Lakehurst Area I/J (Site OW006) of the Joint Base – McGuire Dix Lakehurst (JB-MDL), formerly known as Areas I and J of the Naval Air Engineering Station (NAES) in Lakehurst, New Jersey (Site). The Site location is shown on Figure 1. The groundwater monitoring was performed as part of the ongoing Groundwater Natural Restoration Program at Area I/J. A Site Plan is presented as Figure 2. Sampling events were performed in May 2013 and November 2013.

1.1 BACKGROUND

Investigations performed between 1985 and 1992 at Area I/J revealed that groundwater was contaminated by chlorinated volatile organic compounds (cVOCs) resulting from past site operations (Dames & Moore, 1992). The cVOCs include tetrachloroethene (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (c-DCE), vinyl chloride (VC), 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE) and other cVOCs. The groundwater cVOC plume extended approximately 1 mile beyond the southeast Site boundary. Additional studies, including groundwater fate and transport modeling and a wetlands study, indicated that implementation of a proposed groundwater pump and treat system would drain approximately 87 acres of wetlands within the Pinelands region. The studies also suggested that the effect of pumping would be insignificant compared to the mass loss of contaminants resulting from natural restoration (Dames & Moore, 1993).

Based on these findings, JB-MDL entered into an agreement with the United States Environmental Protection Agency (USEPA), the New Jersey Department of Environmental Protection (NJDEP), and the Pinelands Commission to perform a study to verify the existence and evaluate the effectiveness of the natural restoration processes in degrading the cVOC plume. This study was initiated in 1995 and, following a 3-year demonstration (Tetra Tech, 1999), the Record of Decision (ROD) was revised to name Natural Restoration as the preferred remedial strategy. The activities and results of the Natural Restoration program have been documented in subsequent progress reports (URS, 2001 through URS, 2011).

In its letter dated February 5, 2003, USEPA requested that samples for Monitored Natural Attenuation (MNA) parameters be collected during one sampling event annually. The MNA parameters include chloride, nitrate, nitrite, sulfate, total iron. dissolved iron, carbon dioxide, alkalinity, total organic carbon, dissolved oxygen and oxidation-reduction potential (ORP). Since 2004, these parameters were collected during the second semi-anual sampling event each year from selected transect wells. These parameters are used to demonstrate whether Natural Restoration is active within the cVOC plume (USEPA, 1998) and whether these processes will ultimately reduce the cVOC levels to the Applicable or Relevant and Appropriate Requirements (ARARs).

1.2 NATURAL RESTORATION PROCESSES

A detailed description of natural restoration processes has been presented in previous Progress Reports (Brown & Root, 1997, Tetra Tech 1999, URS 2001, 2003, 2004, 2005, 2007, 2008, 2010, 2011, 2012a, 2012b, 2014a). A brief summary is provided herein.

Attenuation of cVOCs in groundwater can occur through numerous processes. These processes can be physical, chemical, or biological. Physical processes include dispersion, dilution, retardation, and volatilization. These physical processes can reduce contaminant concentrations in groundwater, but do not transform or destroy the compounds. Destruction of cVOCs occurs through chemical and biological degradation. There are two types of abiotic chemical reactions that are significant for chlorinated aliphatics: hydrolysis and elimination (Vogel, et al., 1987; McCarty, 1994). In hydrolysis, an OH- ion replaces the halogen (in cVOCs, the halogen is the chloride ion). Elimination reactions involving elimination of the halogen from a halogenated alkane and formation of C=C double bond.

Chlorinated VOCs are biodegraded under both aerobic and anaerobic conditions. Reductive dehalogenation is one such anaerobic process marked by the step-wise removal of chlorine by anaerobic bacteria. For example, PCE is reduced to TCE, then to c-DCE, VC, and finally ethene (Freedman & Gossett, 1989; Major, et al., 1991; de Bruin, et al., 1992). The reductive dehalogenation of cVOCs takes place in reduced environments created by the biological oxidation of electron donors (carbon sources) in the presence of electron acceptors (oxygen, nitrate, iron, sulfate, or carbon dioxide) present in the aquifer. Dehalogenating bacteria couple the oxidation of electron donors such as acetone, methanol, various organic acids, benzene, toluene, ethylbenzene and xylene (BTEX) or other organic matter with the reduction of chlorinated compounds to gain energy.

1.3 OBJECTIVES

The objective of the Natural Restoration Study is to document the existence and effectiveness of natural attenuation processes in remediating the cVOC plume at Area I/J. Multiple lines of evidence are used to support Natural Restoration (USEPA, 1998). The first line of evidence requires that contaminant loss or transformation in the field be documented. This was accomplished by analyzing for cVOC parent compounds, transformation intermediates and end products in the groundwater through periodic monitoring of the contaminant plume throughout the Natural Attenuation Study, which was initiated in 1995. The data gathered was used to monitor changes in the contaminant concentrations within the plume over time and space. These data are presented in the following reports: Brown & Root, 1997; TetraTech NUS, 1999; URS, 2001 through 2014.

The second line of evidence requires that the distribution of electron donors and acceptors and/or alteration of groundwater chemistry be supportive of intrinsic biodegradation processes. This was accomplished by analyzing for electron donors, electron acceptors, and end products in the groundwater in a round of specialized groundwater sampling performed in June of 1996 (Brown & Root Environmental, 1997). This initial round of sampling was supplemented by measurement of a more limited subset of natural attenuation field parameters during semi-annual monitoring of the contaminant plume. Of particular interest was the delineation and stability of aerobic and anaerobic zones within the contaminant plume. This will dictate the types of biological degradation observed within those zones.

The widespread presence of daughter products and the groundwater geochemical data supported the occurrence of natural attenuation. These first and second lines of evidence were combined to derive input for the RT3D fate and transport modeling in the May 1999 Final Report (Tetra Tech, 1999) and subsequent model updates prepared following the completion of sampling in 2003 and 20088 (URS, 2004 and URS, 2010). The third line of evidence requires direct microbiological evidence that indigenous bacteria are capable of mediating the contaminant transformations observed. As is often the case, the first and second lines provided sufficient evidence of the occurrence of natural attenuation that detailed microbial data from the third line was not pursued.

2.1 GROUNDWATER MONITORING

The groundwater monitoring program is intended to obtain additional groundwater quality data to supplement the data obtained previously in the Natural Restoration study to: (1) monitor the cVOC concentrations, if any, in wells along the line of compliance; (2) monitor the migration of the cVOC plume over time; (3) track the attenuation of cVOC concentrations over time; (4) delineate, if required, the horizontal and vertical extent of the cVOC plume; (5) identify and evaluate trends in groundwater quality data that may be indicative of cVOC degradation; and (6) evaluate the effectiveness of remedial measures. As in previous years, groundwater sampling included two sampling events conducted during May and November 2013.

The monitoring program in place for several years consisted of sampling 55 monitoring wells on a semi-annual basis. This number was reduced to 54 wells following the damage to well NJ in 2012. In the Five-Year Review for JB MDL-Lakehurst (Black & Veatch, January 2012), recommendations were made to alter the existing monitoring program. Based on Monitoring and Remediation Optimization System (MAROS) analysis of sampling data it was deemed that wells GT, IN, IT, JM, JR, LA, LE, LI, LK, LW, LY, MC, MI, MK, NC and NN should be sampled on an annual basis only. In addition, wells DI, DL, DQ, IW, JI, JL, KY, LH, LP, LX, MG, MJ, NK and NL were recommended for annual sampling because no VOCs have been detected in these wells above ARARs since 2006. This recommendation was also included in the 2012 Annual Progress Report for Area I/J. Both USEPA and NJDEP concurred with this recommendation. Therefore, in May 2013, 25 wells were sampled for VOCs. These wells were: DG, GJ, IQ, IS, JJ, JS, JT, JW, LC, LD, LF, LG, LJ, LM, LO, LS, LU, LZ, MA, ME, MH, NB, NI and NM. In November 2013, samples were collected from 54 wells.

Sampling during previous investigations revealed that the cVOC contamination in Area I/J is primarily in the deep zone (55 to 70 feet below the ground surface). The monitoring network was adjusted accordingly. Currently five (5) shallow wells and 14 intermediate wells are in the semi-annual monitoring program, mostly on JB-MDL property near the base boundary. The monitoring program includes 35 deep wells both on the base and in the undeveloped off-base area. Five of these wells (NK, NL, NM and NN) are screened below the "deep" interval to provide additional vertical delineation. The sixth well NI, was intended to provide vertical delineation near well LK, but was not screened at the correct interval, so well NM was subsequently installed with the proper screened interval. These deeper wells were installed in 2003 and incorporated into the monitoring program at that time. During 2013, as in previous years, groundwater sampling was performed as discussed below.

2.1.1 Semi-Annual Sampling Events

2.1.1.1 Water Level Measurement

As described above, two sampling events were performed from May 15 to May 21, 2013 (May 2013) and from November 11 to 25, 2013 (November 2013). The May 2013 sampling event included sampling 25 monitoring wells located in Area I/J and in off-site areas, and was performed by URS. During this period, well ME was inaccessible because of flooded access roads. Well ME was sampled on June 11, 2013. The November 2013 round included 54 wells, as described above. When each well was opened, the headspace in the well casing was screened with a calibrated photoionization detector (PID). The depth to water was then measured from the surveyed top of the inner PVC casing. These measurements were used to calculate the elevation of the potentiomentric surface (groundwater table).

2.1.1.2 Groundwater Sampling Methodology

For both groundwater sampling rounds described herein, a low-flow purging and sampling technique was used. The wells were purged and sampled using an adjustable-rate submersible bladder pump placed at the midpoint of the well screen. Wells were pumped at 0.1 to 0.5 liters per minute. In-situ measurements of temperature, pH, specific conductance, dissolved oxygen and redox potential were made using a calibrated water quality meter with a flow-through cell. The meter was calibrated in accordance with NJDEP requirements. In-situ measurements were recorded every three to five minutes. When the in-situ readings had stabilized the wells were sampled through the pump discharge tubing.

2.1.1.3 Field Measurements

As described above, during each sampling event, groundwater level and physical parameter measurements (temperature, pH, specific conductance, dissolved oxygen, redox potential) were obtained from all wells sampled. Dissolved iron was also measured at each well using a colorimetric field test kit. A dedicated in-line 0.45 micron filter was attached to the pump discharge to remove solids. Filtered groundwater was collected in a vial, mixed with a reagent and analyzed with a photospectrometer to obtain the dissolved iron measurement. The groundwater level measurements were used to construct groundwater elevation contour maps and the physical parameter and dissolved iron measurements were used to construct isopleth maps of selected physical parameters.

2.1.1.4 Sample Analysis

During the sampling rounds described herein, samples were collected from 25 wells in May and from 54 wells in November for VOCs analysis. Duplicate samples were collected during both sampling events. Also, during each sampling event, trip blanks and field blanks were submitted for VOCs analysis. The groundwater sample analyses for both events were performed by TestAmerica Laboratory of Savannah, Georgia (NJDEP Certification # GA769, DoD ELAP Certification # 0399-01). The groundwater samples were analyzed for VOCs by USEPA Method 524.2.

During the November 2013 sampling event, MNA parameter samples were collected from 16 plume transect wells (IQ, IT, JM, JR, KY, LA, LC, LF, LH, LK, LU, LW, LY, MA, MC and MK). The MNA analyses included dissolved and total iron (USEPA Method E200.7), alkalinity (USEPA Method E310.1), carbon dioxide (USEPA Method 406 B), chloride, sulfate (USEPA Method E300.00), phosphate (USEPA Method (E365.2), sulfide (E376.2) and total organic carbon (USEPA Method 415.2) and dissolved gasses (methane, ethane, ethene) (Method RSK175). Typically, the MNA analysis also included nitrate and nitrite, but due to a miscommunication with the laboratory, these parameters were not analyzed for.

Data validation was conducted on all groundwater sampling laboratory data. Details of the validation and findings for the May and November 2013 samples were presented to JB MDL in technical reports (URS, October 11, 2013 and URS, February 17, 2014, respectively). For both sampling events, minor quality assurance / quality control (QA/QC) issues were identified, but the data was deemed to be 100% usable for its intended purpose.

3.1 GROUNDWATER ELEVATIONS AND FLOW DIRECTIONS

Groundwater level measurements were entered into the project database, which also contains the surveyed reference elevations for each monitoring well in Area I/J. These values were used to calculate the elevation of the groundwater potentiometric surface or water table. The depth to water and groundwater elevations for the May 2013 and the November 2013 sampling events are presented in Tables 1 and 2, respectively. For each sampling event, the groundwater elevations were plotted on a site map and the potentiometric surface was contoured. The potentiometric surface contour maps for the May 2013 and the November 2013 sampling events are presented as Figures 3 and 4, respectively. In general, the potentiometric surface and estimated flow directions are similar to those from previous sampling events. The hydraulic gradient across the study area during both 2013 sampling events was approximately 0.0027 ft/ft. Groundwater elevations at well clusters showed little variation between the wells screened at different depths. This suggests that there is little vertical gradient and that groundwater flow is predominantly horizontal. As previously observed, groundwater flow is primarily to the east-southeast over most of the Site, toward Blacks Branch. South of Blacks Branch, however, flow appears to be to the northeast, again toward Blacks Branch. This suggests that Blacks Branch is a groundwater receptor.

3.2 LABORATORY ANALYSES

3.2.1 Volatile Organic Compounds

The VOC analytical results for the May 2013 and the November 2013 sampling rounds are presented in Tables 3 and 4, respectively.

3.2.1.1 Horizontal Distribution

Positive detections of VOCs for these events are shown on Figures 5 and 6, respectively. The distribution of total VOCs in deep wells for the May 2013 and the November 2013 sampling rounds are presented in Figures 7 and 8, respectively. The contours presented on these maps represent the distribution of VOCs in the deep zone only. As stated previously, the majority of positive detections are typically in the deep zone.

The only positive detections of contaminants of concern in shallow wells during both 2013 sampling rounds were PCE in well DL in November 2013 (1.3 µg/l) and VC in well GJ in May (1.3 µg/l) and November (0.91 µg/l). Both of these wells are located in the upgradient portion of the Northern Plume. In November 2013, p-isopropyltoluene (200 µg/l) and toluene (2.5 µg/l) were detected in well DG and sec-butylbenzene (0.48 µg/l) was detected in well DQ. These compounds are not among the typical Area I/J contaminants of concern. With the exception of a 9.4 µg/l detection of p-isopropyltoluene in well DG in November 2011, these compounds had not been detected in these wells previously.

During 2013, the only detection of chlorinated ethenes in intermediate wells were in the Northern Plume. In source area well LF, PCE was detected at 0.33 µg/l in May 2013. TCE (2.3 µg/l and 1.5 µg/l) and cis-1,2-DCE (2.1 µg/l and 0.72 µg/l) were detected in LF during both rounds. In sidegradient well LO, TCE was detected at 0.70 µg/l and 0.73 µg/l. TCE was detected in intermediate well IS near Blacks Branch at 0.41 µg/l in November 2013, below the ARAR of 1.0 µg/l. TCE was not detected in well IS in May 2013. Chloroform was detected in intermediate wells IS, JI, JL, JS and LZ during at least one 2013 sampling event, but all of these detections were below the ARAR of 1.0 µg/l.

The distribution of total VOCs in deep wells for the two 2013 sampling rounds depicted on Figures 7 and 8 appears to have changed significantly between rounds, but much of this is due to the fact that several downgradient wells near Blacks Branch and North Ruckles Branch were not sampled in May 2013. Also, several VOCs that are not typical contaminants of concern at Area I/J, including acetate and toluene were detected in downgradient wells IQ, JJ, and JW in 2013.

The distribution of PCE in deep wells for the two rounds is presented on Figures 9 and 10, respectively. PCE was not detected in any deep well in the Southern Plume during either 2013 sampling event. The distribution of PCE in Northern Plume deep wells was notably similar between the two rounds. In May 2013, PCE was detected above the ARAR of 1 µg/l in wells NI (12 µg/l), LM (5.9 µg/l) and MA (3.70 µg/l). PCE was also detected below the ARAR in wells NM (0.77 µg/l) and MA (0.4 µg/l). Several wells in which PCE is typically detected below the ARAR (LK, LY, MK and IT) were not sampled in May.

In November 2013, PCE was again detected above the ARAR in wells LM (9.1 µg/l), NI (19 µg/l) and MA (5.9 µg/l). PCE was detected below the ARAR in wells NM (0.83 µg/l), LY (0.45 µg/l) and IT (0.34 µg/l). PCE was not detected in any well south of Blacks Branch during either sampling event in 2013.

The distribution of TCE in deep wells for the two rounds described herein is presented on Figures 11 and 12. The extent of the TCE plume is typically greater than that of the PCE plume. In May 2013, TCE was detected at 21 µg/l in source area well NI and at 52 µg/l in sidegradient well LM. In November, similar concentrations of 26 µg/l and 56 µg/l were detected in wells NI and LM, respectively. In May, TCE was detected above the ARAR in mid-plume wells MA (29 µg/l) and MC (1.6 µg/l). In November TCE was detected above the ARAR in wells LE (1.4 µg/l), LG (2.2 µg/l), LY (8.2 µg/l), MA (42 µg/l) and IT (1.3 µg/l). As shown on Figure 12, the TCE plume in November extends to well IT, north of Blacks Branch. Wells IT, MK and MI were not sampled in May.

In the Southern Plume, TCE was not detected in any of the 6 deep wells sampled in May 2013. In November, the only TCE detections in the Southern Plume were 0.49 µg/l in well IN, 0.59 µg/l in well LA and 0.50 µg/l in well LC, all below the ARAR of 1 µg/l. TCE was not detected in any well south of Blacks Branch or North Ruckles Branch in 2013.

The c-DCE plume resembles the Total VOCs plume, as c-DCE is the most prevalent contaminant at Area I/J. The distribution of c-DCE in deep wells for the May and November 2013 sampling rounds is presented on Figures 13 and 14, respectively. Similar to TCE, the concentrations of c-DCE are very similar between the two 2013 sampling rounds. Most differences in the plume shape between the two rounds are due to the difference in the wells sampled in each round. In the Northern Plume, the highest c-DCE in May and November 2013 were in wells NI (50 µg/l and 63 µg/l), MA (34 µg/l and 44 µg/l) and LM (23 µg/l and 25 µg/l). The c-DCE plume extended to wells MC (1.1 µg/l) in May, but only to well MA (44 µg/l) in November. In previous years, the c-DCE plume typically extended to wells IT, MK and MI. Exceedences of the ARAR of 2.0 µg/l were detected in wells NI, LM, LY and MA during at least one 2013 round. C-DCE was also detected in intermediate well LF at 2.1 µg/l in May 2013. C-DCE was not detected in any wells near Blacks Branch in 2013.

In the Southern Plume, the only detection of c-DCE above the ARAR of 2 µg/l was in well LC (57 µg/l) in May and in wells LA (5.1 µg/l), LC (63 g/l), IN (5.3 µg/l), NB (12 µg/l) and NN (5.6 µg/l) in November. In May 2013, c-DCE was not detected downgradient of well LC. In November, c-DCE was detected in mid-plume wells JR (1.5 µg/l) and LW (2.0 µg/l) and downgradient well JM (0.59 µg/l). The highest c-DCE concentration in the Southern Plume was consistently in well LC. There were no detections of c-DCE beyond North Ruckles Branch in 2013.

The distribution of VC in deep wells for the two rounds described herein is presented on Figures 15 and 16. VC was detected in wells NI (4.0 µg/l) and MA (1.7 µg/l) in May 2013 and in wells NI (3.4 µg/l), LM (1.1 µg/l), LY (0.53 µg/l) and MA (2.5 µg/l) in November. VC was not detected in the Southern Plume or in any wells south of North Ruckles Branch or Blacks Branch in 2013.

3.2.1.2 Vertical Distribution

Since the addition of wells screened below the "deep" zone in the Northern Plume, it is possible to evaluate the vertical distribution of cVOCs in cross-section when all wells are sampled. The location of vertical cross-section line A-A' is shown on Figure 17. The distribution of PCE, TCE and c-DCE and total VOCs along cross-section A-A' is presented on Figure 18 for the May 2013 sampling and on Figure 19 for the November 2013 sampling round. These cross-sections show that for all of these compounds during both sampling rounds, the highest concentration in the source area is found in well NI. Well NI is located near well LK and its screen interval overlaps that of LK. Given the horizontal and vertical proximity to LK, the concentrations observed in NI have been notably higher. Well LK was not sampled in May 2013, but in November 2012, the respective total VOC concentrations in LK and NI were 1.51 µg/l and 114.84 µg/l. In well NM, screened below NI, the total VOC concentrations in May and November 2013 were 3.35 µg/l and 3.12 µg/l, respectively, so the impacts in well NI are delineated vertically.

In May 2013, source area wells sampled included intermediate well LJ, deep well NI and "deeper" well NM. No chlorinated ethenes were detected in well LJ. In NI, PCE, TCE and c-DCE concentrations were 12 µg/l, 21 µg/l and 50 µg/l, respectively, while the corresponding concentrations in NM were over an order of magnitude lower. The cross-section depicts how the VOC impacts in this area are concentrated in the interval 60 to 75 feet below grade. Because of the reduced sampling program in May, the source area is the only location along cross-section A-A' where multiple wells at different intervals were sampled.

In November 2013, more wells along A-A' were sampled but the vertical distribution is similar. Well NI is located near well LK and its screen interval overlaps that of LK. Given the horizontal and vertical proximity to LK, the concentrations observed in NI have been notably higher. No VOCs were detected in well LJ. Concentrations in LK are generally 2 orders of magnitude lower than in well NI. Concentrations in deeper well NM were again 1 to 2 orders of magnitude lower than well NI. The vertical interval with the highest impact is clearly defined at well NI. In November, no VOCs were detected in well MC, but VOCs were detected in downgradient deep well MK, and in intermediate/deep well couplet IS/IT. This suggests that the plume may be below the screen interval of well MC and rise slightly as it approaches the downgradient Blacks Branch. In downgradient couplet IS/IT, concentrations in deep well IT were slightly higher than in intermediate well IS.

The vertical distribution in the mid-plume area for 2013 is not known because intermediate well LZ is not sampled and the well screened below MA (well NJ) was damaged in 2012 and no deeper well is located near well MC. Boring logs for the deeper wells indicate a gray to brown clay layer encountered at 90 to 100 feet below grade. This clay unit was at least 50 feet thick at well NJ. This clay unit likely acts as a lower confining layer, preventing deeper vertical migration of the cVOCs plume. JB MDL intends to replace well NJ in the future.

3.2.1.3 Trends

Detailed evaluation of concentration trends in selected wells in Area I/J have been provided in previous progress reports. The trend graphs were updated with the May 2013 and November 2013 data and are presented in Appendix A. In most cases, as observed in the past, the cVOC trends do not indicate a typical reductive dechlorination sequence in which degradation of a parent compound is coupled with an increase in the daughter compound, which subsequently decays to its respective daughter product. Typically at Area I/J, the concentrations of the different cVOCs increase or decrease together within each well. The trends observed in these wells are discussed below.

In the Northern Plume source area, cVOCs concentrations in well LH have remained at fairly low and consistent levels since 2001, with no positive detections of cVOCs since 2006. Following a significant decrease from 1998 to 2001, TCE and c-DCE concentrations in well LF have fluctuated. TCE and c-DCE concentrations in LF were 7.4 µg/l and 4.5 µg/l in December 2011, and have decreased steadily since then to 1.5 µg/l and 0.72 µg/l, respectively in November 2013.

From the start of the Natural Restoration Program in 1996, through 2000, the highest cVOCs concentrations were detected in Well LK. Concentrations in well LK dropped dramatically from 2000 through 2001, and have remained low since 2001. Since 2009, LK has had only two detections greater than 5 µg/l (c-DCE at 6.8 µg/l in April 2011 and 5.2 µg/l in May 2012). In November 2013, no VOCs were detected above ARARs in LK. The decrease may be related to the Bi-Metallic Nano-Scale Particle (BNP) treatments. When it was installed in 2004, well NI had the highest total cVOCs concentrations in Area I/J. However, concentrations of PCE, TCE and c-DCE in well NI decreased approximately 65%, 72% and 82%, respectively, from 2004 through 2013.

Meanwhile, concentrations of TCE and c-DCE in well LM (east of LK) increased steadily from 2002 through 2008, before leveling off somewhat since 2009. TCE concentrations in LM were higher than those in well NI from 2009 through 2012. Since the start of the Natural Restoration Program in 1996, the TCE and c-DCE concentration in LM have both increased by a factor of 4.5. However, following decreases of 50% in LM since 2012, the highest concentrations in Area IJ were in well NI during both 2013 sampling rounds. In well LY, TCE and c-DCE increased from 2002 through 2004, and have decreased somewhat from 2005 through 2009. Even excluding the non-detect May 2010 results, these concentrations continued to show fluctuations, with an overall decreasing trend through November 2012. Typically in Area I/J, in-well concentrations of TCE and c-DCE increase and decrease in unison. However, in November 2013, the TCE concentration increased while the c-DCE concentration decreased.

In Northern Plume mid-plume well MA, concentrations of TCE and c-DCE increased steadily from 1996 through 2000. Since then, concentrations have fluctuated significantly. Since 2008, TCE concentrations have ranged from non-detect to 60 µg/l, with the c-DCE concentrations behaving in a similar manner. Concentrations of TCE and c-DCE in well MA increased from December 2011 through both 2013 rounds. In well MC, concentrations fluctuated within a fairly narrow range through 2006. Since then, concentrations of PCE and TCE tend to drop to non-detect about every three to four years, with increases in-between. This pattern may represent slugs of contaminants moving through the system.

In downgradient sentinel wells MI and MK, cVOCs concentrations remained at previously observed low levels, following concentration spikes in 2003. Both wells have been within their normal range since February 2004, while decreasing slowly over this period. Since 2009, no cVOCs have been detected above 1.3 µg/l in MI, or above 0.9 µg/l in MK. In MI, no VOCs were detected in November 2013, while only TCE was detected at 0.59 µg/l in MK. In well IT, TCE had remained below 2.3 µg/l from September 2000 to August 2011, but increased slightly to 2.8 µg/l in December 2011 and decreased to 2.4 µg/l and 0.59 µg/l in 2013. In well JJ on the south side of Blacks Branch, no cVOCs have been detected since August 2003.

In well LA in the source area of the Southern Plume, after increasing from 1997 through 2000, concentrations of c-DCE and 1,1-DCA continued an overall decreasing concentration trend observed since 2001 through 2013. In well LC, after increasing from 1996 through 2002, concentrations of c-DCE continued to fluctuate within the previously observed range in 2013. In mid-plume well LW, concentrations of c-DCE and 1,1-DCA continued to fluctuate within the range observed over the last several years. In well JR, 1,1-DCA and c-DCE decreased during both 2013 rounds after having increased from May 2010 through 2012. In Southern Plume sentinel well JM, concentrations remained similar to those observed since 2004. No cVOCs have been detected in JM at greater than 2 µg/l since 2009.

3.2.1.4 Plume Mass

The contaminant concentration trends described in Section 3.2.1.3 show that in many wells in Area I/J, the concentrations are decreasing. However, the strongest indication of natural restoration is an overall decrease in the mass of the VOC compounds in the plume(s). The computer program Environmental Visualization System (EVS) was utilized to calculate the total mass of VOCs in the Site OW006 plumes at regular intervals throughout the Natural Restoration Study. Plume masses for the Northern and Southern Plumes were calculated by assigning the VOC concentration for each well to the mid-point of the well screen. The 3-dimensional VOC distribution was estimated by krieging between these points. The water table was set as an upper boundary and a depth of 100 feet was established as a lower boundary, based on a clay layer encountered at approximately this depth in some deep borings. The accuracy of the plume mass calculations is limited by the data sets available. Throughout the Natural Restoration Study, the number and distribution of wells in the monitoring program has varied.

The mass of total VOCs was calculated for the first full sampling round during the years 1996 through 2012. The calculated plume masses are presented in Table 5, and, despite fluctuations, show a notable decrease in total VOC masses over the course of the study through 2013.

For the first several years of the study, the relationship between the number of wells sampled and the plume VOC mass should be noted. In 1997, the sampling event included 84 wells and the plume masses in the Northern and Southern Plumes were 53.2 pounds (lbs) and 70.2 lbs, respectively. In 1998, when only 44 wells were sampled, the respective masses were 232 lbs and 246 lbs. The additional wells sampled in 1997 include many intermediate and shallow wells that were later removed from the monitoring program because they were consistently free of VOC detections. In the 1997 plume mass estimates, the presence of the non-detects in these well, placed an upper vertical limit on the VOC plume. When these non-detect points were removed from the data set, the program extrapolated the deep well detections, leading to an increase in the plume mass. This is also evident in the elevation of the plume center of mass elevation. In 1997, the estimated centers of mass of both plumes were several feet lower than in most other years. This is also likely due to the presence of non-detects in the intermediate and shallow wells, placing emphasis on the deep wells, where most positive detections are found. For these reasons, it may be more useful to consider the estimates from 2005 through 2013, when the number of wells in the data set were most consistent. Even over this time period, the plume mass estimates for the Northern and Southern Plumes have decreased by 23% and 57%, respectively. The plume mass decrease supports the decreasing trends observed at individual wells shown in Appendix A.

As shown on Table 5, the estimated mass in the Northern Plume more than doubled from 53.9 lbs to 120 lbs from 2011 to 2012, followed by a decrease to 79.1 lbs in 2013. Comparison of the 2012 and 2013 data shows the likely reason for this is the positive detections in 2012 in wells LP, ME and MC, where no VOCs were detected in 2013. Even though the total VOC detections in these wells were fairly low (1.31 µg/l total VOCs in well LP; 6.90 µg/l in ME; and 8.87 µg/l in MC), the distance between wells, particularly ME, results in a significant increase in aerial extent and, therefore volume of the plume in 2012. The estimated extent of the plume was approximately 0.37 square miles (235 acres) larger in 2012 than in 2013, due primarily to these detections.

Conversely, in the Southern Plume, the estimated mass increased from 73 lbs in 2012 to 100.9 in 2013. The largest difference between the two data sets is noted in mid-plume well LW, where the total VOC concentration was 72.2 µg/l in 2013 compared to 6.60 µg/l in 2012. It should be noted that the 2013 data includes a detection of 65 µg/l of acetone in 2013. Acetone has not been detected in LW previously, and is not a typical contaminant of concern in Area I/J. Whereas the VOC mass difference in the Northern Plume was the result of fairly low concentrations spread over a large area, the change in the Southern Plume appears to be the result of an expansion of the highest concentrations in the source area to the mid-plume area.

For each event where the plume masses were estimated, EVS was also used to estimate the center of mass (COM) of the plumes. Tracking the COM of the plume can indicate whether the plume is shrinking, expanding, sinking or otherwise changing location. The COMs for the Northern and Southern Plumes for the years 1996 through 2013 are shown on Figure 20. For both plumes the COM migrated somewhat over the course of the study, while remaining in the same general area. The COM of the Northern Plume was generally located in an area about 500 feet north of well MA. The 2012 COM is located about 700 feet west of this area, likely as a result of the detections in wells LP and ME noted above that resulted in a significant expansion of the plume to the east. The November 2013 Northern Plume COM is located about 1,300 feet west of the 2012 COM. This shift is towards the plume source area and reflects not only the absence of positive detections in wells LP and ME, but also the non-detect in well MC, which usually has cVOC impacts. Decreasing downgradient concentrations will result in the COM "retreating" toward the source area where elevated concentrations remain.

The Southern Plume COM was generally located in an area about 500 feet northeast of well LC, the most impacted well in the Southern Plume. With few exceptions, the Southern

Plume COM has not shifted significantly over the course of the study. The 2013 COM is about 100 feet southeast of that from 2012. This downgradient shift may be the result of the increased total VOC concentration noted above in mid-plume well LW.

3.2.2 Monitored Natural Attenuation Parameters

The results of the Monitored Natural Attenuation (MNA) parameter samples collected from plume transect wells in November 2013 are presented in Table 6.

Chloride in groundwater can be evidence of natural attenuation of cVOCs, as with each step of the reductive dechlorination process; a chloride ion in the cVOCs is replaced by a hydrogen ion, releasing the chloride ion into solution. Therefore, elevated levels of chloride in groundwater can be indicative of active reductive dechlorination. The distribution of chloride in transect wells sampled during the November 2013 sampling event is shown on Figure 21. In the Northern Plume, chloride levels were elevated around the source area with the highest level of 89 mg/L in well LY, 23 mg/l in well LF and 20 mg/l in well LH. The chloride concentration in well LK was 9.7 mg/l. Elevated chloride concentrations were also detected in mid-plume wells MA (19 mg/l) and MC (12 mg/L). In the Southern Plume, no elevated chloride levels were detected. Concentrations ranged from 2.6 mg/l in well LU to 6.6 mg/l in downgradient well JM. The chloride concentrations in source area wells LA and LC were 4.0 mg/l and 3.2 mg/l, respectively, which are similar to background levels.

As described in Section 1.2, after oxygen is consumed as an electron acceptor and the environment becomes more reducing, nitrate, ferric iron, and sulfate are sequentially used as alternative electron acceptors. The distribution of dissolved iron is described in Section 3.2.3.3. As described in Section 2.1.1.4, nitrate and nitrite analyses were not performed. However, as described in previous Progress Reports, nitrite was typically not detected and the distribution of nitrate suggested that nitrate reduction was not a significant natural attenuation process.

The distribution of sulfate is shown on Figure 22 and is very similar to that observed in November 2012 and previous sampling events. In the Northern Plume, sulfate concentrations range from 0.63 mg/l in well MK to 19 mg/l in well LY. In the Southern Plume, concentrations ranged from 0.54 mg/l in well LC to 7.8 mg/l in well JR. As previously observed, sulfate concentrations are greatest in the Northern Plume source area, and decrease downgradient. In the Southern Plume, sulfate was detected in source area wells LA and LC at 2.6 mg/l and 0.54 mg/l, respectively, and in downgradient wells JR and LW at 7.8 mg/l to 5.3 mg/l. Overall, the sulfate levels are lower than those typically required for reductive dechlorination. Ideally, sulfate levels of 100 mg/l or higher are required to be considered a significant electron acceptor.

The distribution of total organic carbon (TOC) in wells sampled during the November 2013 sampling event is shown on Figure 23. TOC concentrations ranged from non-detect in several wells to 2.5 mg/l in well LY. Elevated TOC levels (>1 mg/l) were only detected in the Northern Plume upgradient wells LY and MA. TOC was not detected in any Southern Plume wells at the laboratory detection limit of 0.5 mg/l. Concentrations were greatest in the Northern Plume source area wells LF and LY. The TOC levels detected are significantly less than the 20 mg/l typically required to sustain biologically mediated reductive dechlorination processes.

The distribution of carbon dioxide (CO_2) in transect wells is presented on Figure 24. In the Northern Plume, CO_2 was detected in source area wells at concentrations ranging from 7.4 mg/l in well LF to 20 mg/l in well NI, and at 13 mg/l in mid-plume well MA. CO_2 was detected in all seven Southern Plume wells at concentrations ranging from 3.3 mg/l in well LU to 9.7 mg/l in well LW. The CO_2 concentrations in Southern Plume wells are similar to background levels and do not appear to be related to contaminant distribution. CO_2 concentrations were greatest in and immediately downgradient of the source area of the Northern Plume. These concentrations would suggest that reduction of carbon dioxide to methane (methanogenesis) could support the reductive dechlorination process in this area. This is supported by the limited presence of vinyl chloride in these wells. However, methane concentrations do not indicate significant methanogenesis. The distribution of methane concentrations in transect wells is presented on Figure 25. Despite slightly elevated methane levels in the Northern Plume source area (590 µg/l in NI), the results do not suggest significant methanogenesis. Methane was detected at 26 µg/l in mid-plume well MA. The highest methane concentration in the Southern Plume was 14 µg/l in well LC. All others were either non-detect or less than 10 µg/l. Dissolved oxygen and redox potential data (discussed in Sections 3.2.3.1 and 3.2.3.2, respectively) do not indicate conditions conducive to methanogenesis.

Ethane and ethene are the innocuous end products of the degradation of chlorinated ethanes and chlorinated ethenes, respectively. Neither ethane nor ethene were detected above laboratory detection limits in any of the transect wells in November 2013. This could suggest either that the degradation processes are stalled at chloroethane and vinyl chloride, or that the ethane and ethene, once produced, break down rapidly to carbon dioxide and water.

Alkalinity is an indication of carbon dioxide reactions with aquifer material and can be an indicator of biological activity. The distribution of alkalinity in transect wells is presented on Figure 26. The only alkalinity detections were in Northern Plume source area wells LF, LK, LY and NI at concentrations ranging from 5.9 mg/l to 28 mg/l. Alkalinity was not detected in any other transect wells in either plume. The presence of carbon dioxide and alkalinity in the same wells (LF, LK, LY and NI) suggests the possibility of cVOC reduction in these areas.

Phosphorous is a nutrient utilized by microbes during biodegradation. Figure 27 presents the distribution of phosphorous in transect wells in November 2013. In the Northern Plume, phosphorous was only detected in wells LH (0.018 mg/l) and NI (0.021 mg/l). Phosphorous was not detected in any other wells. In the Southern Plume, phosphorous levels ranged from

0.024 mg/l in well LC to 0.24 mg/l in well LW. This distribution does not appear related to cVOC distribution. While, the data suggests that phosphorous is not a significant nutrient, other indicators, such as TOC, suggest that biodegradation may be limited by other factors as well.

Transect well samples were analyzed for both dissolved iron and total iron. Dissolved iron is another indicator of the redox condition of an aquifer. Ferric iron (FeIII - solid) is reduced to ferrous iron (FeII - dissolved) after oxygen and nitrate supplies are exhausted as electron acceptors. The presence of dissolved iron indicates an environment that could be conducive to reductive dechlorination. Besides being an electron acceptor for biologically driven dehalogenation processes, iron plays a significant role in the abiotic transformation of cVOCs. It undergoes reduction and oxidation as it moves in and out of the reducing and oxidizing zones of the plume and facilitates abiotic degradation of cVOCs.

The distribution of dissolved iron in transect wells in November 2013 is shown on Figure 28, and is very similar to that from November 2012. The highest dissolved iron concentration was detected immediately downgradient of the Northern Plume source area in well LY (24 mg/l). Source area concentrations ranged from non-detect to 6.5 mg/l in well LH. Dissolved iron was detected at 7.4 mg/l in mid-plume well MA. In the Southern Plume, iron concentrations ranged from non-detect in three wells to 0.37 mg/l in well JR. Total iron measures both FeII and FeIII species. The distribution of total iron is shown on Figure 29. The highest total iron concentration is in well LY (26 mg/l).

In the Southern Plume, the highest total iron was in well JR (1.1 mg/l). In the Northern Plume, the total iron distribution was similar to that of dissolved iron. The highest total iron was detected in and near the source area, and generally decreases downgradient. However, in Southern Plume, the highest total iron was detected in downgradient wells LW and JR. A useful way to evaluate iron data is to plot the ratio of dissolved iron to total iron. This gives an indication of the portion of iron that is present in a reduced form. This ratio is plotted on Figure 30. The highest dissolved iron: total iron ratios in the Northern Plume are found in and near the source area in wells LF, LK, LY and NI where ratios indicate virtually all of the iron is dissolved. This would be expected since this is where the most reducing conditions are present. The calculated dissolved : total iron ratio in Southern Plume well LA was 1.17, which although technically not possible, indicates that all of the iron present is in the ferrous state. No other Southern Plume well had a ratio greater than 0.50.

3.2.3 Field Measurements

The results of in-situ field measurements, made with an electronic meter with a flow-through cell or field test kits for the May 2013 and the November 2013 sampling events are presented in Tables 1 and 2, respectively.

3.2.3.1 Dissolved Oxygen

Dissolved oxygen (DO) is an indicator of natural attenuation as biological activity consumes dissolved oxygen and reductive dechlorination generally takes place only when dissolved oxygen is consumed and a reducing environment is created. Generally, DO levels less than 1.0 mg/l are indicative of the conditions where reductive dechlorination may occur. The distribution of DO in deep wells during the May 2013 and the November 2013 sampling rounds are presented in Figures 31 and 32, respectively.

The May 2013 DO measurements in Northern Plume source area wells NI and NM are less than 1 mg/l and suggest conditions where reductive dechlorination could occur. Elevated DO levels (>1 mg/l) were found in upgradient wells LG and LM, and in mid-plume wells MA and MC. DO levels less than 1 mg/l were also measured in downgradient wells ME and IQ. No measurements were made in downgradient wells MI, MK or IT. In the Southern Plume, no DO levels less than 1 mg/l were measured in May 2013. In the Southern Plume, no DO values > 1 mg/l was measured. DO values greater than 10 mg/l were measured in wells NB and LU, and may represent instrument error.

In November 2013, Northern Plume source area wells LK, NI, NM, LG, LI and LY all had DO values near or below 1 mg/l. DO was also measured below 1 mg/l in wells LM, LP, ME, IQ and IT along the northern periphery of the study area. The lowest DO measured was in downgradient well IQ (0.33 mg/l). Other mid-plume and downgradient wells ranged from 1 mg/l to 3 mg/l.

In the Southern Plume, DO measurements in the source area ranged from 1.3 mg/l in well LA to 6.30 mg/l in wells NC. The lowest value was in mid-plume well LW (0.44 mg/l) With the exception of the low DO values in the Northern Plume source area, the DO distribution does not appear to be related to contaminant distribution and does not suggest extensive anaerobic conditions.

3.2.3.2 Redox Potential

The distribution of redox potential (ORP) should mimic that of DO and subsequent electron acceptors, such as iron and sulfate. As DO is consumed, the ORP should drop to zero, or even become negative, as reducing conditions are produced. Further reduction of iron (FeIII) and sulfate will result in ORP of -150 millivolts (mV) to -250 mV. The distribution of ORP in deep wells during the May 2013 and the November 2013 sampling rounds are presented in Figures 33 and 34, respectively.

In May 2013, the lowest ORP measured was in well NM (-88 mV). Well NM is in the Northern Plume source area. It is screened below the most impacted well in the area (NI) which had an ORP of 211. The only other negative ORP was in well ME (-51 mV). ME is located along the northern periphery of the study area and is not impacted with cVOCs. Other ORP values in the

Northern Plume ranged from 100 mV in well IQ to 266 in well MC. Similarly, Southern Plume ORP values ranged from 229 mV in well LC to 283 mV in wells NB, LS and JW.

In November 2013, more wells were measured for ORP but the results were similar to those from May. In the Northern Plume, the lowest ORPs were in wells NM (-96) mV and ME (27 mV). Other Northern Plume ORPs ranged from 88 mV in well LK mV to 396 mV in well MI. In the Southern Plume, ORP ranged from 181 mV in well GT to 411 mV in well IW.

In general, the distribution of ORP values does not appear to be closely associated with contaminant distribution, where the lowest ORP values would be expected in the most impacted wells. Although the ORP in the Northern Plume source area was somewhat lower than other areas of the plume, the negative values typically associated with reductive dechlorination are not observed in the most impacted wells.

3.2.3.3 Dissolved Iron

In addition to the laboratory analyses of transect wells for dissolved iron in November 2012 (Section 3.2.2), dissolved iron (DI) was also measured in all wells sampled during both sampling rounds described herein in the field using colorimetric test kits. The distribution of DI as measured by field test kits for the May 2013 and the November 2013 sampling rounds are presented in Figures 35 and 36, respectively.

In May 2013, DI was measured at > 5.5 mg/l in Northern Plume source area deep well NM and mid-plume MA. Otherwise, no distribution related to the contaminant distribution is observed. Well NI, screened above NM, had a DI concentration of 2.96 mg/l. DI values between 1 mg/l and 3 mg/l were measured along the base boundary and northern boundary of the study area in wells LG, LM, ME and IQ. The only Northern Plume DI measurement less than 1 mg/l was in well MC (0.25 mg/l). In the Southern Plume, Source Area wells LC (0.10 mg/l) and NB (0.31 mg/l) had lower DI values than the side-gradient wells JT (>5.5 mg/l) and LS (3.98 mg/l)

In November 2013, the only DI value greater than 5 mg/l was in well LK (>5.5 mg/l) and MA (5.25 mg/l). The DI in other source area wells NI (1.11 mg/l), NM (3.62 mg/l) and LY (2.67 mg/l) were slightly higher than other areas of the plume. In the Southern Plume, no DI values greater than 1 mg/l were measured in November 2013.

Because dissolved iron was measured both in the field and in the laboratory, an evaluation of the correlation of the two sets of results was conducted. A graph of laboratory vs. field measurements of dissolved iron is presented as Figure 37. The graph includes only those wells in which DI was positively detected using both methods. In general, the correlation is poor, as the laboratory results generally exceed the corresponding field result by an average factor of 1.3. However, increasing field DI measurements generally correspond with increasing laboratory DI measurements, although it is not a direct correlation.

Based on the results of the two sampling rounds conducted in Area I/J (Site OW006) during May 2013 and November 2013, in conjunction with previous data, the following conclusions can be drawn regarding the natural restoration of groundwater cVOCs:

- The analysis of the data continues to support the previous findings of the Natural Attenuation Study for Areas I & J. Natural attenuation remains active in the cVOC plumes and continues to reduce the overall plume volume. The natural attenuation processes should continue to limit further migration of contaminants

- As observed previously, the groundwater cVOCs form two distinct plumes:

  - The Northern Plume originates near well LH and extends offsite to wells MI, MK and IT. Although no definitive source has been identified, the highest concentrations in the Northern Plume are detected in deep wells LM and NI. The Southern Plume originates near wells LA and LC and extends off-site to well JM. The highest cVOC concentrations in the Southern Plume are found in well LC.

- Attenuation of cVOCs by natural attenuation is supported by the following evidence:

  - Widespread distribution of cVOC dehalogenation products. As shown on Figures 12 and 13, the dehalogenation product cis-1,2-DCE is currently the most widespread cVOC is Area I/J.

  - The presence of anaerobic (or less aerobic) conditions near reported contaminant source areas, which are consistent with biologically-mediated reductive dehalogenation of cVOCs.

  - Some field parameter data (ORP, dissolved iron) indicate conditions conducive to, and/or created by anaerobic degradation of cVOCs may be present near the Northern Plume source area, although results are not definitive and vary somewhat between rounds. Similarly, some MNA parameters collected from plume transect wells near the Northern Plume source area provides evidence of reductive dechlorination. The distributions of chloride, CO_2, dissolved iron, alkalinity and methane production show patterns related to contaminant distribution and suggest natural attenuation of cVOCs. These parameters are less conclusive in the Southern Plume. The data suggests that reductive dechlorination may be most active near the Northern Plume source area, where organic material in the form of peat or lignite has been reported. Downgradient from the source area, other natural attenuation processes such as dilution may play a greater role in limiting plume migration.

- Overall, cVOC concentrations in most wells are stable or decreasing. Well LM had shown consistently increasing cVOC concentration trends from 2005 through 2011, but has decreased by almost 25% since then. The concentrations of TCE and c-DCE in well MA have fluctuated over the course of the study, but have increased steadily since a non-detect in 2011. Increasing trends were previously observed in wells LC and LF, but concentrations have recently leveled out or even begun to decrease, although most wells show some degree of fluctuation.

- From its installation in 2004, through 2009, the highest cVOC concentrations in the Northern Plume source area were detected in well NI, although no residual source material was identified near it during a 2012 investigation. However, since installation, concentrations in well NI have decreased about 78% through 2013. From May 2010 through November 2012, the highest cVOC concentrations in the Northern Plume have been detected in well LM. However, following recent decreases in well LM, well NI had the highest cVOC concentrations in the Northern Plume in 2013.

- Compliance wells JM, MI and MK, which showed concentration spikes in 2003, returned to pre-2003 concentrations in 2004 and remained there through November 2013.

- During 2013, VOCs were detected in sentinel wells JS, JT, LS, JW, JJ, ME and LP, but the VOCs detected included acetone, toluene and chloroform, which are not the cVOCs detected throughout most of Area I/J. Also, for the wells south of North Ruckles Branch and Blacks Branch, groundwater flow directions suggest these detections did not originate from Area I/J.

- Based on DO and redox measurements in May and November 2013, the redox zones are not as clearly defined as in the past. These measurements do not indicate strongly reducing conditions near the plume source areas, although other field measurements and MNA parameter results do indicate conditions conducive to reductive dechlorination in and around the source areas, particularly in the Northern Plume source area.

- DO, ORP and other geochemical parameters indicate that attenuation of c-DCE and VC at the downgradient extremes of both plumes is most likely due to dilution, and not reductive dechlorination.

- The results of the November 2013 MNA sampling, in conjunction with cVOC concentration trend, field measurements and previous data suggest that attenuation is occurring, although at a slow rate and may be limited by aquifer geochemistry. Trends in measured MNA parameters suggest that conditions supportive of reductive dechlorination may not be as prevalent as they were earlier in the Natural Restoration Program. Reductive dechlorination may be most prevalent in the source area where other organic material has been observed. Future MNA sampling rounds are necessary to confirm these conditions. It appears that the capacity of the anaerobic zones to further attenuate the daughter chlorinated solvents has decreased over the years, resulting in the migration of TCE, c-DCE and 1,1-DCA into the aerobic zones of the plumes where biochemical transformation is less likely and dilution may be a more important attenuation mechanism. Reduction of source area concentrations will be critical to the continued success of Natural Attenuation in Areas I & J.

- Estimates of the mass of VOCs in the Area I/J plumes shows that the VOC mass decreased in 2013, following an increase in 2012 in the Northern Plume. The 2013 decrease is due to decreased concentrations in mid-plume wells MA and MC, as well as non-detects in peripheral wells that had significant detections in 2013, significantly increasing the plume volume and mass. This also resulted in a westward shift in the Northern Plume center of mass. The mass of the Southern Plume increased by 38%, due primarily to a 65 µg/l detection of acetone in mid-plume well LW. The Southern Plume center of mass did not shift notably from 2012 to 2013. These estimates are useful tools in tracking the fate of the plumes, but the accuracy of the estimates is dependent on the data sets used in the calculations and can vary with the number and locations of wells sampled.

- Although the MNA parameters and geochemical data suggest that conditions at Area I/J are generally not conducive to reductive dechlorination, natural attenuation continues to occur, as evidenced by decreasing contaminant concentrations in most wells. Current conditions may represent a decrease in cVOC degradation rates, but physical processes (dilution) continue to limit the migration of the plumes. The cause of the changed conditions and degradation rates could be depletion of organic matter utilized in reductive dechlorination. It is possible that contaminant concentrations have decreased to a threshold below which the microbial population decreases or ceases activity. The changes in site conditions and degradation rates will be evaluated further in the Five-Year Summary Report, which will include an update of the flow and reactive transport model.

For the continuation of the Natural Restoration Program at JB MDL Area I/J (Site OW006), the following recommendations are made:

- Based on the results of this progress study, it is recommended that Natural Restoration (attenuation) remain as the preferred remedial alternative for the remediation of groundwater contamination at Area I/J (Site OW006).

- The monitoring program should continue as in 2013, with 25 wells sampled semi-annually and 29 wells sampled annually. In this program, 25 wells will be sampled in May of each year and 54 wells will be sampled in November of each year. After well NJ is replaced, it should be sampled annually. When collected, groundwater samples should be analyzed for VOCs and the MNA field parameters (temperature, pH, conductivity, DO, and ORP and dissolved iron) should be measured during each sampling event.

- In addition, during one semi-annual sampling event each year, samples should be collected from the transect wells and analyzed for the MNA parameters in accordance with USEPA Technical Protocol (USEPA, 1998). The Northern Plume transect wells include LH, LK, LY, MA, MC, MK, IT and IQ. Southern Plume transect wells include KY, LA, LC, LW, JR, LU, and JM. Well NI should be added to the list of transect wells as this well typically has the highest concentrations in the Northern Plume source area. The proposed groundwater monitoring program is presented in Table 7.

- Since 2012, cVOC concentrations in mid-plume well MA have increased steadily. cVOC concentrations in this well should be monitored closely over the next several sampling rounds.

- The next analytical flow and reactive transport model update will include the two 2013 sampling events summarized herein. This update should include a re-evaluation of the cVOC decay rates. If additional data support recent sampling results, it would suggest that cVOC decay rates have changed over time. The model should incorporate changing decay rates in the calibration and simulations. In conjunction with the reactive transport model, a graphical approach for estimating cleanup times provided in the USEPA publication *Calculations and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies (EPA/540/S-05/500)* will be used to verify model-derived decay rates. The Five-Year Summary Report should include possible explanations for changing decay rates and the impact on the projected cleanup time.

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