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Middlesex FUSRAP Site - A Path to Site-Wide Closure – 13416

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ABSTRACT

The roadmap to obtaining closure of the Middlesex Sampling Plant FUSRAP site in Middlesex, New Jersey (NJ) has required a multi-faceted approach, following the CERCLA Process. Since 1998, the US ACE, ECC, and other contractors have completed much of the work required for regulatory acceptance of site closure with unrestricted use. To date, three buildings have been decontaminated, demolished, and disposed of. Two interim storage piles have been removed and disposed of, followed by the additional removal and disposal of over 87,000 tons of radiologically and chemically-impacted subsurface soils by the summer of 2008. The US ACE received a determination from the EPA for the soils Operable Unit, (OU)-1, in September 2010 that the remedial excavations were acceptable, and meet the criteria for unrestricted use as required by the 2004 Record of Decision (ROD) for OU-1. Following the completion of OU-1, the project delivery team performed additional field investigation of the final Operable Unit for Middlesex, OU-2, Groundwater. As of December 2012, the project delivery team has completed a Supplemental Remedial Investigation, which will be followed with a streamlined Feasibility Study, Proposed Plan, and ROD. Several years of historical groundwater data was available from previous investigations and the FUSRAP Environmental Surveillance Program. Historical data indicated sporadic detections of Volatile Organic Compounds (VOCs), primarily trichloroethylene (TCE), carbon tetrachloride (CT), and methyl tert-butyl ether (MTBE), with no apparent trend or pattern indicating extent or source of the VOC impact. In 2008, the project delivery team initiated efforts to re-assess the Conceptual Site Model (CSM) for groundwater. The bedrock was re-evaluated as a leaky multi-unit aquifer, and a plan was developed for additional investigations for adequate bedrock characterization and delineation of groundwater contaminated primarily by CT, TCE, and tetrachloethene (PCE). The investigation was designed to accumulate multiple lines of evidence to determine the source and to delineate the extent of contamination, as required to complete the CERCLA Process and gain regulatory acceptance. Investigative techniques included in-well vertical flow tracing, borehole geophysics and packer testing of temporary test holes to characterize contamination in the bedrock fractures beneath the site, and to delineate likely source areas.

INTRODUCTION

The Middlesex Sampling Plant (MSP) site is a nine-acre property located in Middlesex, NJ, approximately 29 kilometers southwest of Newark, NJ (Figure 1). The site is currently bordered by an auto salvage yard to the west, a railroad cut to the north, and mixed residential/industrial properties on the east and south sites of MSP. The known history of the MSP dates back to 1910, and when construction of a plant for manufacturing asphalt paint was the first documented use of the MSP site. This plant included a brick warehouse, boiler house, garage, administration building, dye warehouse, and four smaller buildings. Later activities conducted by the Manhattan Engineering District (MED) involved radioactive ore sampling, assaying and processing. Figure 2 shows the history of the various site uses, and summarizes some of the environmental investigations and remedial actions completed to date.

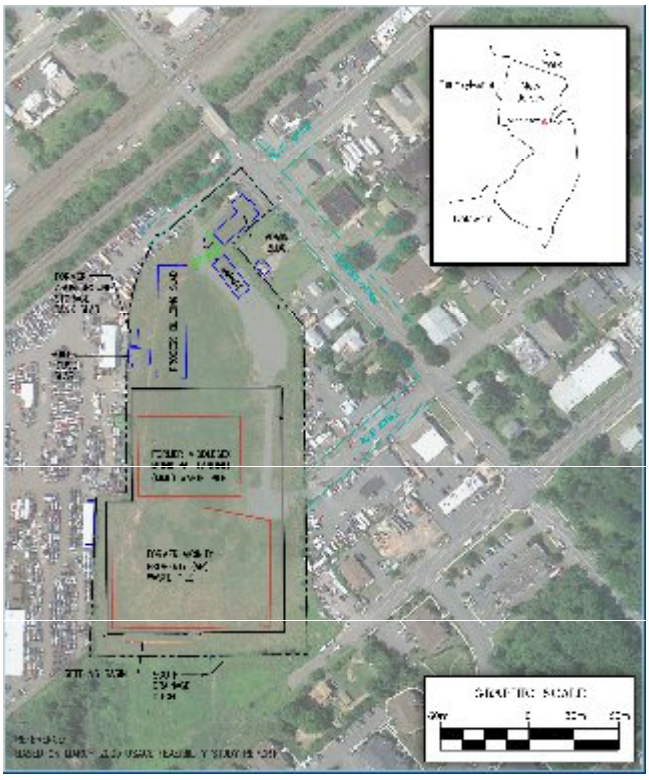

Figure 1. Middlesex Sampling Plant

Since 1998, the US ACE, has completed much of the work required for regulatory acceptance of site closure with unrestricted use. To date, three buildings have been decontaminated, demolished, and disposed of. Two interim storage piles have been removed and disposed of, followed by the additional excavation and disposal of over 87,000 tons of radiologically and chemically-impacted subsurface soils by the summer of 2008. The US ACE received a determination from the EPA for soils OU-1, in September 2010 the remedial actions were approved, and met the criteria for unrestricted use as required by the 2004 Record of Decision (ROD) for OU-1. Following the completion of OU-1, the project delivery team performed additional field investigation of the final Operable Unit for Middlesex, OU-2, Groundwater.

Thirteen overburden monitoring wells were installed to replace those removed during the soils remedial action, and 10 existing bedrock monitoring wells remained, most of which were located around the perimeter of the site. The overburden wells ranged in depth from 3 to 5 meters (m) below ground surface (BGS), and the bedrock wells ranged in depth from 15 m to 18 m BGS, with large open-hole intervals from the bottom of the 7 m surface isolation casings. Depth to bedrock on site ranges from 1 m BGS on the north side of the site to 3 m BGS at the south side.

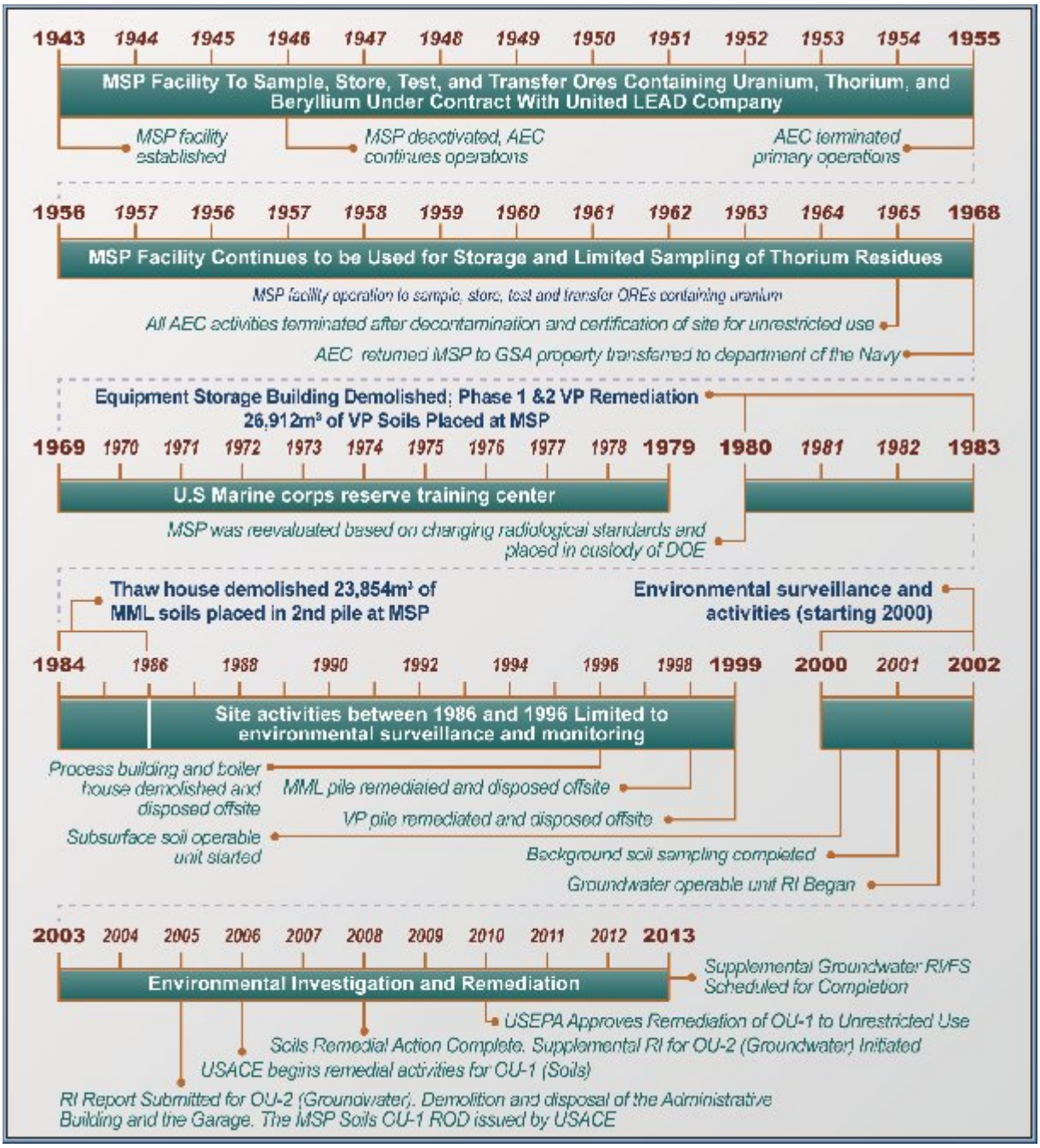

Figure 2. Middlesex Sampling Plant Timeline

The US ACE initiated a supplemental remedial investigation of groundwater in 2008, to monitor total uranium in the overburden aquifer after the source soil was removed. The groundwater investigation also included an evaluation of the extent of VOCs contamination known to exist in the bedrock aquifer. Historical data indicated sporadic detections of VOCs, primarily PCE, TCE, CT, and MTBE, with apparent distribution results suggesting an off-site source.

The groundwater investigation included various drilling and testing programs to adequately characterize the bedrock structure, including confirmation of strike and dip of the bedding planes, location of bedrock fractures and corresponding hydrogeologic flow patterns. From published data, it was known the regional bedrock dips at approximately 11 degrees north-northwest, and it was recognized the existing 10 bedrock wells, all installed at approximately the same depth, was not adequate to delineate zones of contamination. The testing programs included installation of deeper temporary test holes in the bedrock, hydraulic performance testing of the temporary test holes (TTHs), brine tracer testing to measure vertical gradients and flows, borehole geophysics, depth-discreet sampling, packer tests, and conversion of the TTHs to monitoring wells for future sampling in zones of interest.

Based on results of the testing program and re-evaluation of the CSM for groundwater, 19 additional bedrock monitoring wells were installed at and around the site, at various depths and locations to adequately characterize the bedrock aquifer and update the CSM. Through several iterations of investigation, each phase of testing provided new information that was used to re-assess and adjust the CSM.

From 2008 through 2012, thirteen quarterly rounds of groundwater sampling, analysis and reporting were completed. Concentrations in the overburden aquifer have been consistently below the federal maximum contaminant level (MCL) for total uranium. VOC analyses from bedrock wells have identified the presence of CT, PCE, TCE, and 1,1-dichloroethene (1,1 DCE) at concentrations above the New Jersey Department of Environmental Protection's (NJDEP) groundwater cleanup criteria.

In addition, the project delivery team conducted a comprehensive well search to evaluate the potential for human exposure to the contaminated groundwater via private supply wells. NJDEP records were reviewed to evaluate potential impacts from nearby properties of known contamination in this historically industrial area. The process resulted in the discovery of VOC contamination in a private water supply well at an adjacent residence. A Point of Entry Treatment (POET) system was installed immediately, and the well was taken offline shortly after when the residence was provided with public water supply. A later portion of the investigation detected CT in an on-site groundwater sample collected from TTH-30 (13,000 ug/L). The sample was collected from a monitoring well at the center of the site, clearly suggesting a nearby source, presumably on site. Figure 3 shows a Site Map with the relevant site features and monitoring wells.

Portions of the bedrock plume have been delineated, however, to ensure a defensible case for plume delineation, additional investigations is ongoing through winter 2012-2013. Remaining work includes drilling and testing to accurately determine the location of the source of CT impact to groundwater and the downgradient delineation of the plume. Once these investigations are

complete, the groundwater OU-2 will be able to proceed with completing the CERCLA documents allowing for regulatory acceptance and implementation of the ROD.

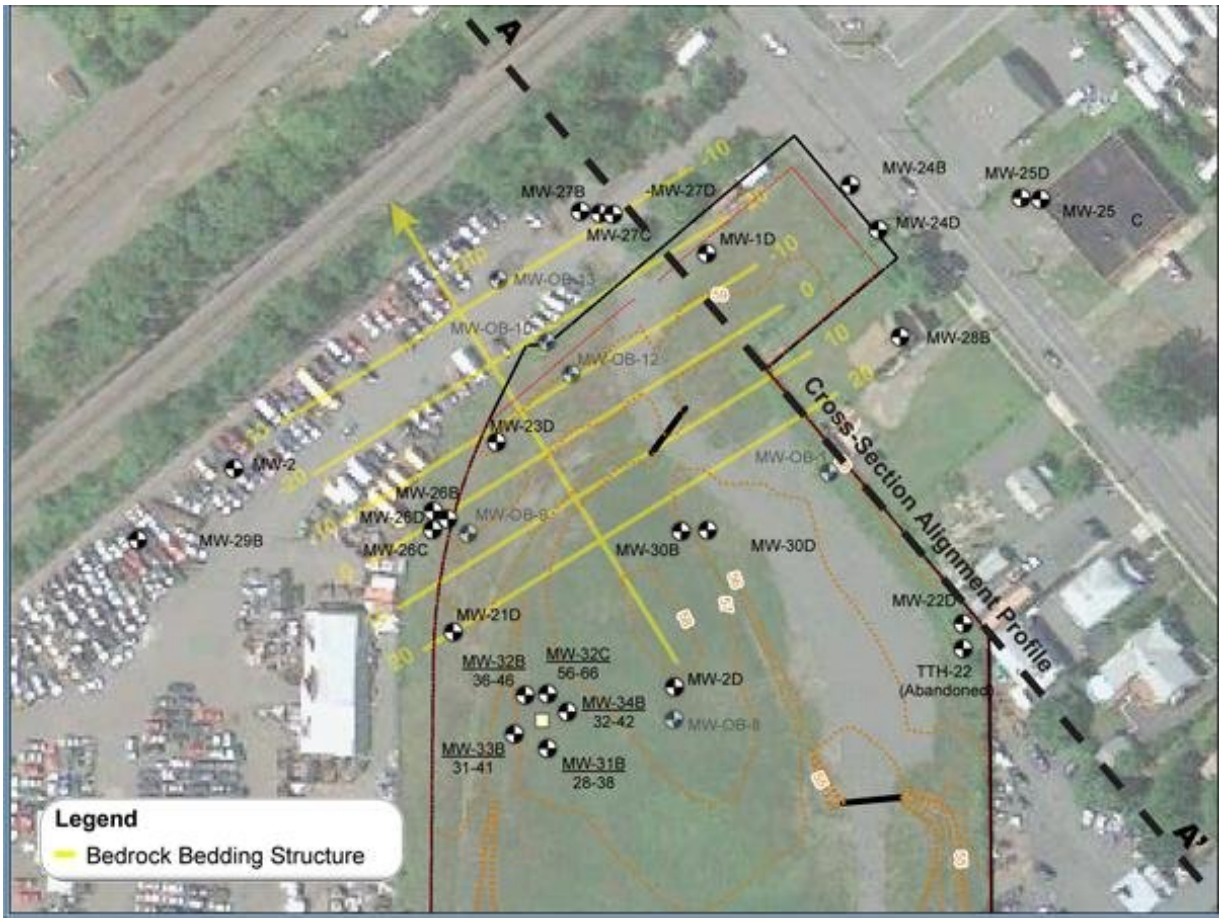

Figure 3. Site Map

GROUNDWATER INVESTIGATION THROUGH 2012

Purpose

In order to determine the nature and extent of the VOC contamination in the bedrock aquifer, a study was performed to identify and characterize the aquifer and aquitard units of the multi-unit bedrock beneath the MSP site. The goals of the study were to develop a site-specific model of groundwater flow and contaminant migration, relying on combining existing hydrogeologic data with results of diagnostic tests conducted in seven bedrock temporary test holes (subsequently converted to monitoring wells). Although the investigation is not yet complete, the source has been identified, and remaining fieldwork is scheduled to delineate the downgradient extent of the

plume. Once complete, the supplemental Remedial Investigation Report and Feasibility Study will be completed, facilitating advance of the project through the CERCLA Process.

Scope of Work Completed

Seven temporary test holes, TTH-22, -24, -25, -26,-27, -29, and -30 (shown on Figure 3 as converted monitoring wells MW-22…MW-30) were installed at on-site and offsite locations between September, 2010 and November, 2012. The test holes were completed as 15 cm diameter open holes, with approximately 7 m of steel surface casing, to an approximate total depth below grade ranging from 24 m in TTH-22 to 52 m in TTH-27. The greater completion depth of TH-27 was due to its downdip location relative to the other TTHs. TTH-25 was installed across Mountain Ave, as an upgradient location relative to the site based on anticipated westerly direction of groundwater flow in the bedrock. The cross-section shown in Figure 4 shows the bedding dip beneath the site, and other site features and investigative results that support the updated CSM. Geophysical borehole testing completed in the TTHs included fluid temperature, conductivity, acoustic televiewer, natural Gamma, caliper, spontaneous potential, and resistivity. These data were collected to further characterize the fractured bedrock and to identify distinct marker beds for borehole correlation. Flow tracing tests were performed in the seven TTHs to identify transmissive fractures and inflow/outflow zones within the boreholes; depth-discrete sampling was conducted as a rapid screening-level assessment of contamination; packer testing was conducted in selected zones of the test holes to measure vertical hydraulic head variations and to determine transmissivity values for the test zones as well as to obtain groundwater samples; and finally the test holes were converted to monitoring wells by installing ten-foot screens in the deep zones of each test hole, followed by the installation of paired monitoring wells in a shallower zone at locations adjacent to each deep test hole. The newly installed monitoring wells were sampled quarterly for VOCs through November 2012. By installing the TTHs and monitoring wells in several mobilization phases, the iterative data gained after each field activity was evaluated and used to update the CSM, and subsequently to design the next field effort for additional TTHs or MWs used to advance the delineation effort.

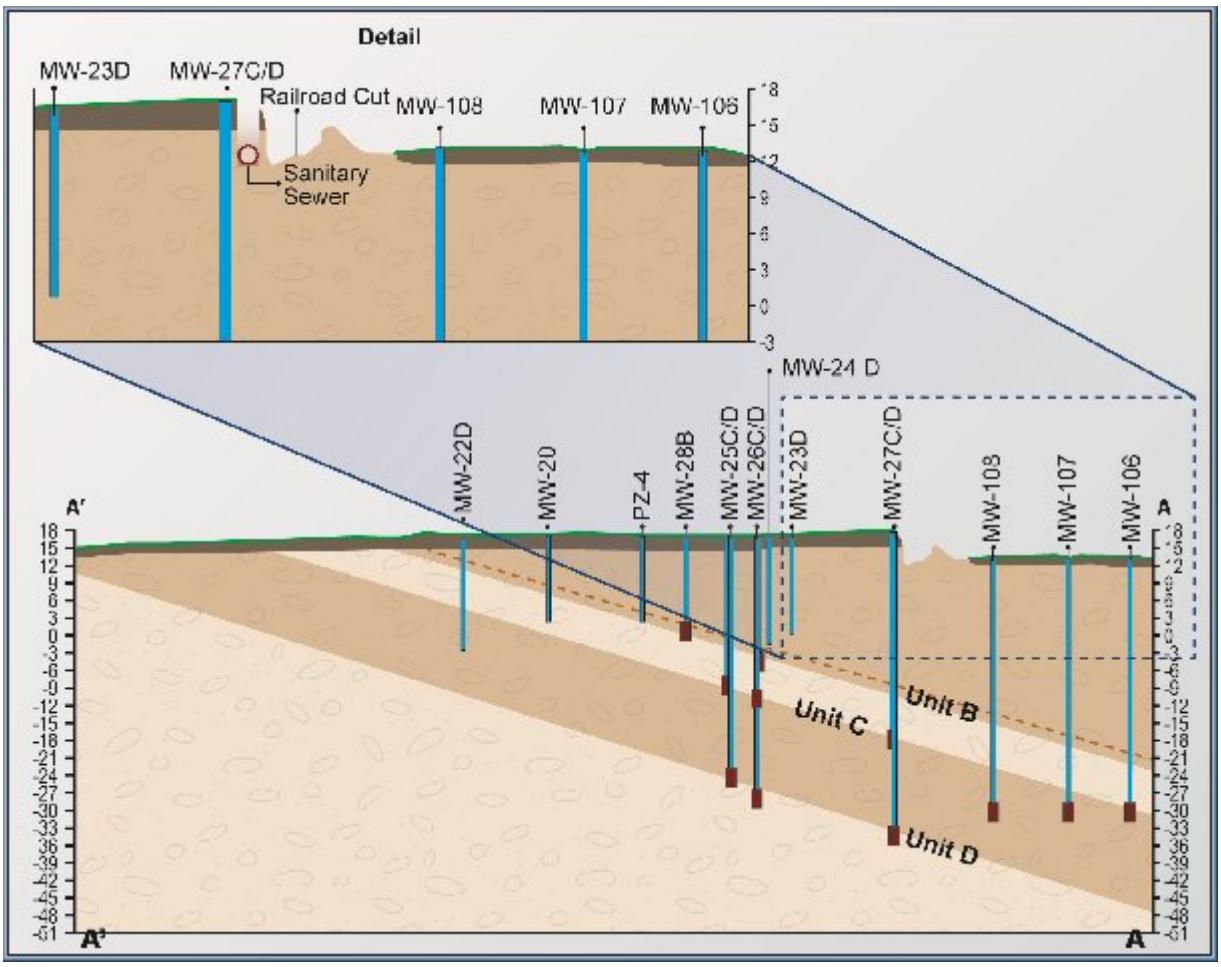

Figure 4. Bedding Dip Beneath the Site

Flow Tracing Test and Results

Brine tracer testing was performed on the TTHs prior to conversion to monitoring wells. The brine tracer tests are designed to determine vertical flow velocity (up or down) and to locate zones of relative increased transmissivity. The test is performed by introducing a small slug of saline water to the water column in the well, then profiling the movement of the brine slug vs. time as it travels up or down the water column in the TTH. When plotted, the data creates a signature plot such as the one shown in Figure 5 for TTH-27, from which vertical velocity is calculated, and fractures can be mapped.

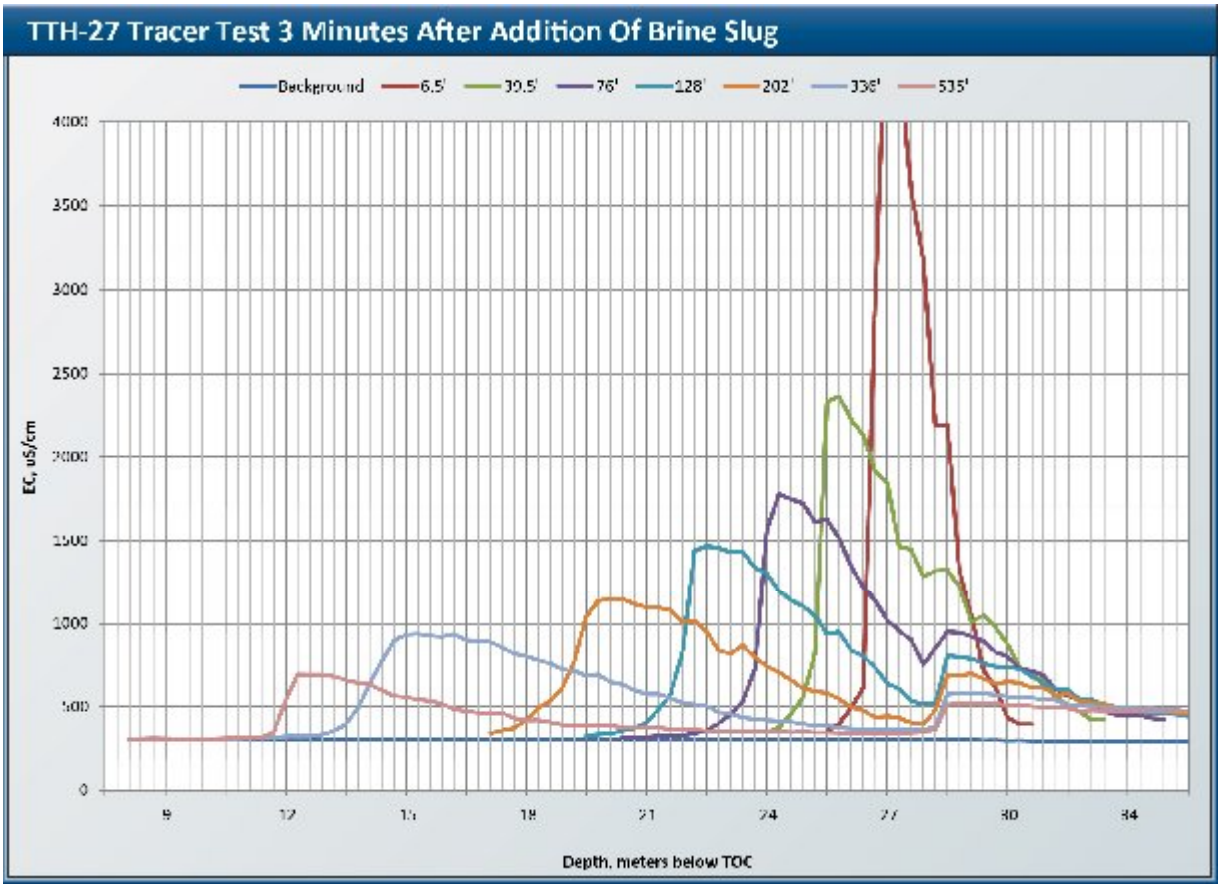

Figure 5. In-well Vertical Flow Velocity Profile

Depth-Discreet Sampling

The depth-discrete vertical flow sampling procedure permits a rapid screening-level assessment of concentrations of contaminants of concern in individual inflow fractures/zones identified through in-well flow tracing. Information on vertical contaminant distribution and the position of potential source(s) of the detected contamination can thus be obtained. As the ambient flow regime in TTH-25 featured only one inflow fracture zone near the top of the open hole and all other fracture zones were flow receiving (into the aquifer from TTH-25), the formula for calculating concentration was not applicable. It is apparent, that contaminant concentrations in the uppermost sample are several times lower than in the sample collected below Unit C. The latter sample showed the highest concentrations of 1,1 DCE (63 ppb) and TCE (18 ppb), indicating that the contaminated groundwater resides in the lower portions of the hole. Carbon tetrachloride is a principal contaminant detected in depth-discrete samples collected from TTH-26. The fracture at 28 m (Unit C) showed the highest calculated concentration (74 ppb) of this compound. Significant concentrations of CT (21 ppb) were also inferred for a shallower fracture at 14 m. Carbon tetrachloride was also a principal contaminant in TTH-27, with its highest concentrations

of 182 ppb calculated for Unit B. Results of the depth-discreet sampling provided a screening-level assessment on the vertical distribution of VOC contamination in each of the TTHs. This data enabled the identification of the interval within the TTH that should be further evaluated by the permanent well screen interval subsequently installed within the TTH. The analytical results, coupled with the stratigraphic data gained from geophysical and brine testing was used to further develop the site conceptual model in terms of contaminant flow, transport, and source identification. An example of the synthesized stratigraphic, brine testing and depth-discreet results is shown on Figure 6.

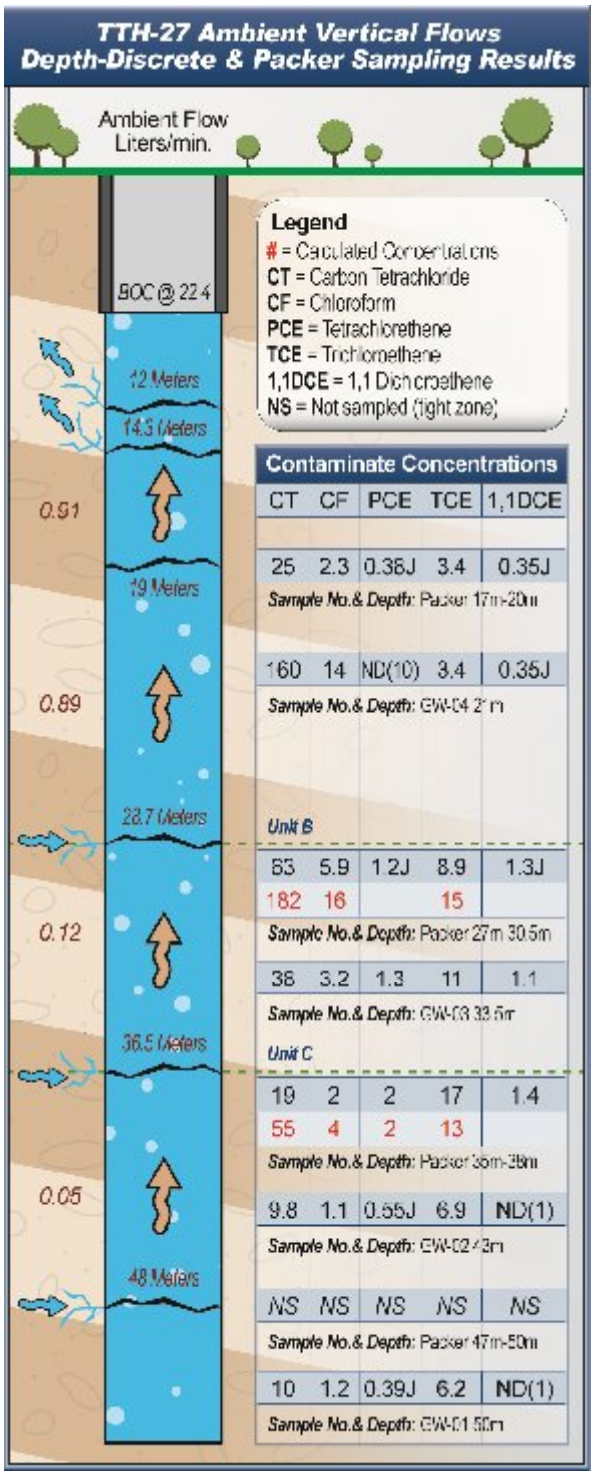

Figure 6. Vertical Flow, Depth-discreet and Packer Testing Sampling Results

Packer Testing

Packer tests were conducted in selected zones in three of the TTHs to 1) measure vertical hydraulic head differences between the tested zones and water levels of the open holes (head profiling), 2) determine transmissivity values for the test zones, and 3) obtain groundwater samples from the isolated test zones. The pattern of vertical head profile distribution in each of the test holes is consistent with that inferred from the vertical flow salt tracing (brine) tests. In TTH-25, the highest heads, indicative of inflow zones, were measured in the upper portion of the holes, and the lowest heads (indicative of exit/outflow zones) were measured in Zones I and III. The latter Zone corresponds to the outflow zone at the 27 m fracture, and the former to an ultimate exit zone near the bottom of the hole. In TTH-26, the lowest head was measured in Zone III, which straddled a principal water exit fracture

at 22m. In TTH-27, the highest head was measured in the lowest Zone I and decreased upward through Zone IV, consistent with an upward flow measured throughout an open-hole section of this hole.

The sum of the calculated transmissivity values for all test zones of the three test holes ranges from 0.97 m^2/d for TTH-25, 1.15 m^2/d for TTH-26 to 2.89 m2/d for TTH-27. For comparison, a single major aquifer unit in the Passaic formation typically exhibits a transmissivity value greater than 12.4 m^2/d. Thus, the low transmissivity values measured for the entire open-hole sections of the test holes indicate that no major aquifer unit is penetrated by any of these test holes, so that the entire section can be considered as a regional aquitard.

The measured transmissivity values are associated with specific zones that are parts of the minor bedrock hydrostratigraphic units designated as Units B, C, and D. The packer testing results show that the thick bedrock section between the two lowest Units, D and C, is a tight aquitard. Results of the packer testing transmissivity evaluation determined that by relative measure to major (water bearing) aquifer units within the Passaic Formation, the units encountered in the three TTHs are significantly less transmissive. The water bearing units encountered in these three TTHs, however, can still be mapped and used as useful input for the site conceptual model in terms of defining the nature and extent of VOC contamination in the bedrock aquifer unit(s), and describing the contaminant flow, transport pathways, and source identification.

Analytical results from the packer samples are generally similar to the depth-discrete sampling results. The highest concentration of TCE (85 ppb) was detected at the lowermost Zone I in background/upgradient test hole TTH-25. This zone is part of bedrock aquifer Unit D. The highest concentrations of PCE (30 ppb) and 1,1 DCE (140 ppb) were detected in Zone III (bedrock aquifer Unit C) of the same upgradient test hole TTH-25. The highest concentrations of CT (84 ppb) and its presumed breakdown product, CF (7.1 ppb), were detected in Zone II (aquifer Unit B) of downgradient test hole TTH-26.

Synthesized Data

The following examples demonstrate conclusions made from combining the vertical flow tracing, depth-discreet and packer testing data from the first three tests. Figure 6 shows the graphical depiction example from TTH-27.

In test hole TTH-25, transmissive fractures were located at 12m, 27m, 42m, and 46 m below ground surface. The fracture at 46 m was designated as bedrock aquifer Zone D, and the fracture at 27 m was designated as bedrock aquifer Zone B. The synthesis of wellbore hydraulics of TTH-25 compiled from the salt tracing (brine) test results documents a downward, discharging pattern of ambient vertical flows. This pattern is indicative of decreasing hydraulic head with the depth of this test hole.

In test hole TTH-26, transmissive fractures were located at 14m, 22m, 47m, and 38 m below ground surface. The fracture at 22 m was designated as Zone B (correlates with Zone B in TTH-25). The fracture at 47 m was designated as Zone C. The borehole was stagnant below 44 m. As revealed by the salt tracing results, the hydraulics of cross-flows in TTH-26 is atypical as it featured two exit zones at different depths (at 22 m and at 38 m).

In test hole TTH-27, the ambient hydraulics featured a consistent upward flow, with the largest inflow from a fracture at 29 m (correlates with Zone B from the other two test holes), and the flow exited through to subvertical fractures at 14 m and 12 m. This test hole was not deep enough to penetrate Zone D).

Groundwater Sampling Results

Over the course of 13 rounds of sampling between 2008 and 2012, several chlorinated volatile organics exceed their respective governing standards for maximum contaminants concentrations, including CT with the greatest concentration of 8,000 ug/L detected in MW-30B; TCE with the greatest concentration of 230 ug/L also detected in MW-30B; 1,1-dichloroethene (1,1-DCE) with the greatest concentration of 120 ug/L detected in MW-25C; PCE with the greatest concentration of 25 ug/L also detected in MW-25C. It is noted that the analytical results obtained for the monitoring wells in clusters MW-25, MW-26, and MW-27 are similar to analytical results from the packer testing of respective aquifer units in test holes TTH-25, TTH-26, and TTH-27.

CONCLUSIONS

All transmissive fractures identified are bedding plane partings. They dip at 10.4˚ to the north-west, and have hydraulic characteristics of minor transmissive fractures within a very low-transmissivity bedrock sequence. The more distinct bedding fractures have been identified with letters B, C, and D, with D being the deepest zone. High-angle transmissive fractures were only mapped near the top of bedrock in TTH-27 where they provided upward flow pathways to the railroad cut. In general, high-angle fractures (joints) provide for vertical leakage in a multi-unit bedrock with prevailing bedding-parallel groundwater flow. Results of the testing described above, combined with an evaluation of the distribution of VOCs in the bedrock aquifer, the vertical and horizontal extent of VOC contamination in the bedrock aquifer is delineated. By understanding the groundwater flow and contaminant transport mechanisms as a function of fracture flow and bedding plane flow, the horizontal extent can be defined in terms consistent with the CSM and specifically, within the dipping beds of the multi-unit bedrock aquifer beneath the MSP site.

Figure 7 shows the results of the November 2012 round of groundwater sampling. Based on the observed pattern of distribution of the CT concentrations detected in monitoring wells relative to bedrock hydrostratigraphy, groundwater flow direction, and historical sampling results, CT and its breakdown product CF were originally thought to be the only contaminants that likely originated from sources located on, or immediately adjacent to, the former MSP site.

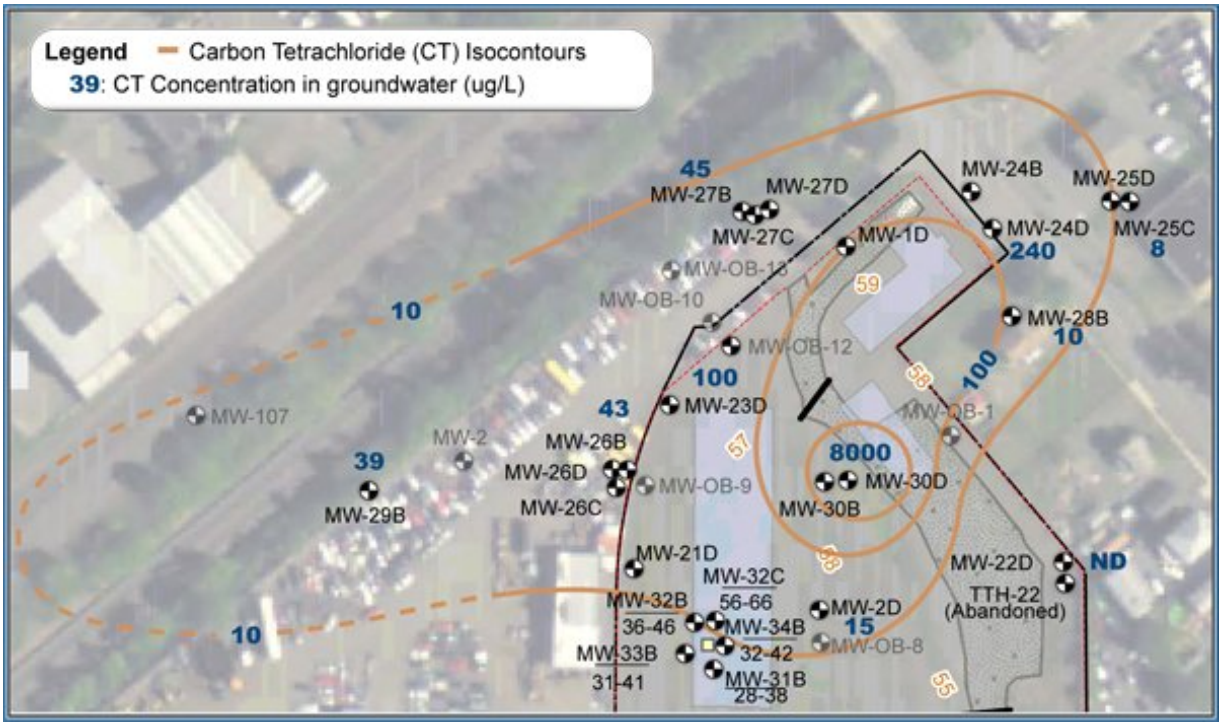

Figure 7. November 2012 Groundwater Sampling Results

Based on the preliminary findings of the study underway and supported by historical data, the TCE, 1,1-DCE and PCE contamination in groundwater most likely originated from both offsite and on-site sources. The highest concentrations of TCE were found at 230 ug/L in MW-30B, located at the center of the site, while the next highest concentration of TCE was detected in upgradient well MW-25D at 150 ug/L in monitoring Unit D, the deep aquifer unit. Given the west-northwesterly direction of groundwater flow in Unit D and a projected position of subcrop of this unit, the origin of TCE contamination at these two locations are from two separate sources; one from a source located east of Mountain Avenue and north of William Street, and the second near the center of the MSP site, in the vicinity of MW-30B.

The detection of low concentrations of TCE in some monitoring wells completed above Unit D downgradient of MW-25D and MW-30B can be explained by several dispersive mechanisms, including mixing induced by the adjacent property's domestic well pumping and the occurrence of an upward vertical gradient adjacent to the railroad cut (observed in TTH-25). The same mechanism would explain detections of PCE in monitoring wells completed above Unit C downgradient of MW-25C.

The distribution of CT concentrations shows a more complex pattern. Based on the analytical results from the sampling event in November 2012, the highest concentrations of CT were detected in well MW-30B (8,000 ug/L), and in MW-24D (240 ug/L), both wells completed in Unit B. The next highest CT concentration was detected in MW-26C (79 ug/L). This well is completed within aquifer Unit C and positioned hydraulically cross-gradient of MW-24D. Packer sampling results

for TTH-26 have shown that CT impacts at that location are not limited to Unit C but extend upward into Unit B. The original source of CT appears likely to have been located between the former process building and garage on the MSP property, and within the subcrop of Unit B.

Historically, CT was detected at 89 ppb in a former shallow piezometer URS-PZ-4 (URS, 2005) located approximately 34 m north-northeast of MW-2D. The domestic well on an adjacent property, located approximately 37 m south of MW-24D and straddling both Unit B and C, has likely played a significant role in spreading CT contaminated groundwater downward into Unit C and laterally toward MW-24D. An off-site source of CT (located across Mountain Avenue) is unlikely given the low concentrations of CT detected in Unit B (across Mountain Ave.), and in test zones above this unit, during packer sampling of the upgradient test hole, TTH-25.