

SUPPLEMENTAL PRE-DESIGN INVESTIGATION

FIRE WATER RESERVOIR

EMERSON POWER TRANSMISSION FACILITY

ITHACA, NEW YORK

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Site No. 7-55-010

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1 Introduction

1.1 GENERAL

On behalf of Emerson Electric Co. and its subsidiary, Emerson Power Transmission Corp. (EPT), WSP Environment & Energy (WSP) conducted a series of supplemental pre-design investigations within and around the south and north tanks of the fire water reservoir at the EPT site in Ithaca, New York (Figure 1). The objective of the supplemental investigations was to gather additional data on groundwater quality immediately below and around the fire water reservoir and develop a more comprehensive understanding of potential migration pathways within bedrock underlying the area. This report details the scope and results of the supplemental pre-design investigations.

The supplemental pre-design investigations were conducted between October 2009 and April 2011 and were used to fill data gaps identified following the initial pre-design activities completed in June of 2009 and described in a report titled Supplemental Pre-Design Investigation, Fire Water Reservoir – South Tank, Emerson Power Transmission Facility, Ithaca, New York, dated August 26, 2009. The scope of the investigations included the following activities:

- removing the fire water reservoir interior liner
- installing horizontal sample ports into the perimeter walls of the reservoir
- cutting and removing sections of the concrete slab in the south tank and logging and sampling observed bedrock fractures
- installing and sampling three additional monitoring points in the south tank and five monitoring points in the north tank
- excavating test pits on the western side of the fire water reservoir to locate and evaluate an existing drain pipe connected to the south tank
- conducting supplemental surface and downhole geophysics and installing, logging, and sampling four additional bedrock monitoring wells near the fire water reservoir

This report has been prepared in accordance with an Administrative Order on Consent (Index #A7-0125-87-09) entered into by the New York State Department of Environmental Conservation (NYSDEC) and EPT on July 13, 1987.

Section 2.0 of this report provides a description of the firewater reservoir and an updated conceptual site model. Section 3.0 presents the scope of work completed within, below, and around the firewater reservoir and Section 4.0 presents a summary of these results. Sections 5.0 and 6.0 detail the scope and results of the supplemental geophysics and downhole logging completed to further evaluate groundwater migration pathways. Finally, Section 7.0 presents the conclusions of the pre-design investigations.

2 Fire Water Reservoir Description and Site Model

2.1 DESCRIPTION OF FIRE WATER RESEVOIR

As part of the facility closing and decommissioning, the firewater reservoir was taken out of service in October 2009. The reservoir consists of two interconnected tanks, designated the north tank and the south tank. The tanks have a total capacity of 200,000 gallons. Figure 2 is a schematic of the firewater reservoir and includes a plan view and cross sectional view of the reservoir. As shown in the schematic, each tank is approximately 33 feet long, 31 feet wide and 19 feet deep. The tanks are constructed of reinforced concrete and the base is approximately 7 feet into bedrock. Building 19, which was formerly above the reservoir, was demolished in late 2010. The concrete slab covering the top of the reservoir is supported by columns and is approximately 6 inches thick. The base of the reservoir varies in thickness from 2 to 6 inches and is constructed on competent bedrock and some minor amount of fill material. There is an opening between the tanks that allows water to flow into each tank and equilibrate. A 6- to 8-inch suction line extends along the east wall of the north tank and is connected to the facility's fire suppression pump located in the adjacent boiler house. With the closing of the facility, a portion of the fire suppression system has been converted to a dry system and the pump and suction line are no longer used as part of the facility's fire suppression system. A 4-inch drain line is located in each tank along the base of the western wall.

2.2 STRUCTURAL FRAMEWORK AND UPDATED CONCEPTUAL SITE MODEL

2.2.1 Joint Measurements and Trends

The orientation of bedrock joint sets was previously measured at seven bedrock outcrops across the site. Two primary joint sets were identified, one oriented north-northwest and another oriented east-northeast. The north-northwest trending joint set was more common and better expressed in the observed bedrock outcrops. A total of 22 measurements were made of the north-northwest trending joint set and 3 measurements of the east-northeast trending joint set. The average joint orientation of the 22 north-northwest trending joint set measurements was N18W/82E. The mean joint orientation of the 3 north-northeast trending joint set measurements was S72W/81N. These orientations are consistent with published regional trends, as well as previous measurements collected by Radian and WSP.

2.2.2 Geophysical Observations

As part of the Supplemental Pre-Design Investigations, additional surface geophysics and downhole logging and sampling of new wells were completed to develop a more comprehensive understanding of potential migration pathways within bedrock underlying the area and to build on the data collected from previous investigations. The geophysical logging confirms that two types of well-defined fractures are present beneath the firewater reservoir area. The first type is horizontal bedding plane fractures. The second type consists of three orientations of nearly vertical joint sets. The bedding plane fractures extend laterally a few inches or feet and intersect to create an interconnecting network of relatively planar, paper-thin, horizontal planes of effective porosity. The individual vertical joint sets extend tens of feet laterally and vertically to create an intersecting network of permeable vertical conduits that are bounded by blocks of bedrock.

In addition, the results of two additional exploratory borings installed near the firewater reservoir confirm the presence of bedding plane fractures at elevations of approximately 550 feet, 544 feet, and 515 feet above mean sea level (amsl). These three bedding planes have been identified as major migration pathways for affected groundwater beneath the firewater reservoir area.

2.2.3 Groundwater Flow

Groundwater flow within the overburden and underlying B-zone (highly fractured and jointed bedrock) generally mimics surface topography, which slopes to the northwest. Groundwater flow within the siltstone bedrock is significantly affected by the vertical and horizontal distribution of vertical joint sets and horizontal bedding plane fractures within the upper sections of bedrock.

Groundwater near the firewater reservoir area is present within the overburden and bedrock. Overburden groundwater is perched and is restricted to limited areas of the site where the discontinuous cover of soil is thickest. In areas where the soil cover is thin (i.e., steep slopes along South Cayuga Street), the overburden or upper portion of fractured bedrock is not saturated. Based on water level measurements collected during groundwater sampling, the overburden groundwater in the remediation area is in hydraulic communication with the underlying bedrock of the B-zone, and the two units appear to be acting as a single hydraulic unit. In addition, the results of previous aquifer testing conducted within the remediation area indicate that as a result of the highly fractured and jointed nature of the B-zone, the unit responds as porous media. In the less fractured and jointed deeper sections of bedrock (C-zone), the system responds as a fracture flow network with both primary and secondary porosity.

2.2.4 Updated Conceptual Site Model – Fire Water Reservoir Area

An updated conceptual site model (CSM; Figure 3) was developed for the firewater reservoir area based on the results of the supplemental pre-design investigations to illustrate the relationship between the constituents of concern, transport pathways, and the current remediation system.

The firewater reservoir is constructed of concrete and extends approximately 19 feet below ground surface (bgs). Unsaturated soil is present to a depth of approximately 12 feet, which is underlain by highly fractured bedrock to a depth of approximately 18 feet bgs. The base of the reservoir is constructed on competent bedrock. Groundwater is encountered at the soil bedrock contact at approximately 12 feet below bgs, which is approximately 7 feet above the base of the reservoir. The bedrock surrounding the reservoir is jointed and fractured siltstone.

As shown in Figure 3, the dissolved constituents migrated vertically downward via open joint sets that intersect three prominent bedding plane fractures. The main transport mechanisms for the releases are through the vertical joint sets and horizontal bedrock bedding planes. These migration pathways form an interconnected network for groundwater transport. The horizontal bedding planes (fractures) significantly decrease in frequency with depth. The vertical joint sets remain open and do not change with depth but appear to terminate at lithologic contacts.

A prominent horizontal bedding plane was identified at an elevation between 515 to 518 feet amsl (base of C-zone) beneath the firewater reservoir area. This nearly horizontal feature is encountered approximately 52 feet below the base of the reservoir (Figure 3).

Two additional prominent horizontal bedding planes have been identified at an elevation between 544 feet and 550 feet amsl (upper C-zone) beneath the firewater reservoir area. These horizontal features are encountered between 17 and 21 feet below the base of the reservoir and appear to discharge directly into the B-zone within the remediation area west of the firewater reservoir.

Figure 3 shows the migration pathways for affected groundwater downgradient of the fire water reservoir within the highly fractured B-zone and within the C-zone bedding plane fractures at 515 feet, 544 feet, and 550 feet amsl along generalized cross section line A-A'. Cross section A-A' generally shows the firewater reservoir and subsurface areas to the west.

As shown in the CSM block diagram on Figure 3, groundwater generally occurs within the upper portion of fractured bedrock (B-zone) and within bedding plane fractures encountered at 515 feet, 544 feet, and 550 feet amsl (C-zone). The bedding plane fractures and associated vertical joint sets are the primary migration pathways for affected groundwater. The Interim Remedial Measure (IRM) implemented in early



2009 was designed to intercept and remove mass from the B-zone and the three bedding plane fractures identified within the C-zone. The current placement and design of the extraction well network is appropriate to address the primary migration pathways for affected groundwater.



3 Fire Water Reservoir Scope of Work

This section describes the scope of work completed to further evaluate conditions immediately below and around the firewater reservoir. The work was implemented in phases, as depicted in Figure 4, between October 2009 and January 2010. Photographs taken during the fieldwork are provided in Appendix A and disposal certificates and waste manifests are provided in Appendix B.

3.1 RESERVOIR LINER REMOVAL

In October 2009, the firewater reservoir was permanently taken out of service as part of the closing and decommissioning of the EPT facility.

The reservoir liner was removed on October 20 and October 21, 2009 to evaluate conditions in each tank. The liner consisted of 40-millimeter thick EPDM rubber membrane glued to a 40-millimeter thick felt backing. The liner was fastened to the outer reservoir walls via metal cleats and screws. Removal was completed using utility knives and electric shears. Personnel conducting this work were confined space entry trained and the required confined space entry permits were in-place during all work completed within the tanks.

Following removal of the liner, groundwater was observed entering the reservoir at three locations, one within the south tank and two within the north tank. Samples of water were collected at each location and submitted to a laboratory for analysis of volatile organic compounds (VOCs) using U.S. Environmental Protection Agency (EPA) Method 8260B. The samples were designated as SouthTank102209, NorthTank102109, and NorthTank102209 (Table 1). Following sample collection, a quickset hydraulic cement was used to seal the leaks in the concrete.


All liner materials removed from the reservoir, personal protection equipment, and containment zone plastic were contained in a 20-yard hazardous waste roll-off staged east of the reservoir area for later disposal. On November 3, 2009, a waste characterization sample was collected and analyzed for VOCs using EPA Method 8260B (Rolloff110309 – Table 2). The roll-off container was transported from the site on November 24, 2009 by Hazmat Environmental Group Inc. The hazardous waste manifest and certification of disposal is included in Appendix B.

All water that entered the reservoir during the liner removal was pumped directly to a 21,000-gallon frac tank staged near the groundwater treatment building. A total of 8,443 gallons of water from the frac tank was subsequently treated in the IRM groundwater treatment system.

3.2 HORIZONTAL POINT INSTALLATION AND SAMPLING

A series of horizontal points were drilled through the walls of the reservoir in order to assess groundwater quality outside the reservoir. Four horizontal sample points (HP-1, HP-2, HP-3, and HP-4) were installed in the south tank on November 2, 2009 and November 3, 2009 and two (HP-5 and HP-6), were installed in the north tank on November 5, 2009 (Figure 4). A pneumatic hammer drill equipped with a 6-foot long, 1.375-inch drill bit was used to install each sample point. The height of the sample points ranged from 14 inches (HP-1) to 34 inches (HP-3) above the base of the reservoir. Each sample point was fitted with a sample port constructed of a 0.75-inch outer diameter galvanized steel pipe and ball valve (i.e., spigot). Hydraulic cement was used to patch and repair the wall around each sample point. Grab water samples were collected at HP-2, HP-3, and HP-6 directly from the spigot and analyzed for VOCs using EPA Method 8260B. No water collected in horizontal points HP-1, HP-4, and HP-5, thus aqueous samples could not be collected.

Prior to the installation of the sample port at HP-1, a decontaminated steel rod was inserted into the point to obtain a sample of the tightly packed fill material located behind the south wall of the south tank. The



sample was designated HP-1 SED (Table 2), collected in a 4-ounce glass jar, and analyzed for VOCs using EPA Method 8260B.

3.3 MONITORING POINT INSTALLATION AND SAMPLING

On November 3, 2009 and November 5, 2009, eight additional monitoring points were installed and sampled within the firewater reservoir (Figure 4). The monitoring points were designed to evaluate groundwater quality immediately beneath the base of the reservoir. At each sample location, the 6-inch concrete slab was drilled with an electric hammer drill equipped with a 0.50-inch outer diameter drill bit. A plumb-bob was lowered through the 0.50-inch hole to locate the vertical match point on the base of the reservoir. The concrete was then marked on top of the reservoir to indicate where a core would be drilled if casings were to be installed to the top of the reservoir, as MP-1 through MP-5 were previously constructed in June 2009.

A coring machine equipped with a 6.25-inch inside diameter coring bit was used to core a hole through the concrete base, which ranged from 3.5 to 6 inches thick. The monitoring points were designated MP-6 through MP-8 in the south tank and MP-9 through MP-13 in the north tank as shown in Figure 4.

Casing materials (4-inch steel) were lowered into the reservoir and installed in the 6-inch open core locations and sealed with the link-seal and quick-set grout. The bottom of each casing was notched prior to installation to allow groundwater to flow into the monitoring points. The monitoring points were completed with approximately 5 feet of casing rising above the base of the reservoir and fitted with watertight lockable caps. Information on the construction of each monitoring point was recorded in a field notebook and a representative photograph of the final construction is included in Appendix A. A schematic of the monitoring construction is shown as a detail in Figure 4.


Groundwater grab samples were collected from the monitoring points on November 3 and November 5, 2009 (Table 3). The monitoring points were purged a minimum of three casing volumes or until dry before collecting the samples. Groundwater samples were collected using dedicated disposable Teflon bailers. Bailers were lowered slowly into the monitoring points to avoid agitating the water. VOC samples were collected in three pre-cleaned 40-ml vials and shipped under chain of custody to the laboratory for analysis VOCs using EPA Method 8260.

During the installation of the monitoring points, a petroleum sheen was visible on the water entering the east side of the south tank. This water was segregated into a second 21,000 gallon frac tank, located parallel to the first frac tank, due to the inability of the IRM system to treat petroleum product. On November 10, 2009, a 5,000 gallon capacity vacuum truck removed 3,488 gallons of water and trace amounts of petroleum product from the frac tank. The water was shipped under manifest to Michigan Disposal Waste for treatment and disposal. A copy of the hazardous waste manifest is presented Appendix B.

3.4 EXISTING DRAIN PIPE EVALUATION

During the removal of the reservoir liner, two 4-inch cast iron pipes were identified along the base of the western wall in both the north and south tanks of the reservoir. A dark brown to black colored sediment was observed inside the south tank pipe and was sampled for VOCs using Method 8260B (South P-1; Figure 4 and Table 2).

A plumbing company was contracted to video tape the pipes using a fiber optic camera. On November 5 and 6, 2009 both pipes were investigated and viewed using the fiber optic camera. The pipes were determined to be plugged/sealed 6.5 feet and 7 feet from the tank opening, respectively. A valve appeared to be sealing off the north tank pipe and a concrete plug was observed in the south tank pipe. The pipes leading up to the valve were intact and appeared to have no bends or turns. Onsite



reconnaissance on the hillside west of the reservoir discovered a vertical stand pipe attached to the south tank piping. The top of the stand pipe was approximately 6 feet below the top of the reservoir and plugged with concrete approximately 11 feet below the top of casing. No evidence (i.e., a valve or stand pipe) was found at ground level west of the north tank.

3.5 FLOOR CUT INVESTIGATION

3.5.1 Initial Floor Cut Investigation

To assess conditions below the base of the concrete slab, two diagonal (NE to SW) sections of the floor (Trench-1 and Trench-2) were cut along the base of the south tank (Figure 4) on November 4, 2009. The floor cuts, which are referred to as trenches, were saw-cut with a 14-inch electric saw to a width of 6-inches. Trench-1 was cut to a length of approximately 240 inches and Trench-2 was cut to a length of approximately 177 inches. The trenches were oriented based on the predominant direction (N18°W) of vertical joint sets identified in the area, such that the length of the trenches would perpendicularly intersect northwest trending vertical bedrock fractures.

Once the concrete floor was cut and the concrete removed, a shop vac was used to remove debris and clean the top of the bedrock surface for visual logging. The exposed bedrock surface was then inspected, photographed, and logged. All observable fractures and joints were noted and the trend of the fracture recorded in the field log book. Trend measurements were made using a Brunton compass adjusted for magnetic declination of Ithaca, New York at the time of the investigation (12° 12' W).

Trench-1 contained a single joint that trends N16W and a parallel joint set that trends N18W. Groundwater was observed discharging from the parallel joint set and a grab sample (T-1), was collected from the joint set and analyzed for VOCs using EPA Method 8260B (Table 4). Figure 4 shows the location at which grab samples of groundwater were collected and the bedrock fracture trends.

Trench-2 was intersected by three single joints (N15W, N2W, and N40W) and one parallel joint set (N17W), as shown in Figure 4. A sample (T-2) was collected near the parallel joint set towards the center of the trench cut and analyzed for VOCs using EPA Method 8260B (Table 4). A light-phase petroleum product sheen was observed seeping into the center of the trench cut near the location of sample (T-2). Photographs of trench cuts and observed petroleum product are provided in Appendix A.


Following logging and sampling, both floor trenches were sealed using a quick-set grout and hydraulic cement. A layer of grout was installed first, directly on top of the underlying bedrock. After allowing the grout to set up, hydraulic cement was installed above the grout to create a tight seal with the existing concrete.

The saw-cut concrete and debris was removed from the reservoir at the end of the investigation and was contained in a 20-yard hazardous waste roll-off with the materials generated during the reservoir liner removal. Personal protective equipment and containment zone plastic were also added to the roll-off. The roll-off was picked up on November 24, 2009 by Hazmat Environmental Group Inc. The hazardous waste manifest and certification of disposal can be found in Appendix B.

3.5.2 Follow-Up Floor Cut Investigation

Approximately 21,000 gallons of water, primarily surface water run-off, accumulated in the south tank during the period between November 2009 and January 2010. An electric submersible pump was used to extract water from the south tank to a frac tank located north of the groundwater treatment building for temporary storage. The water was managed in the IRM groundwater treatment system between January 25 and January 29, 2010.

On January 26, 2010, three additional trenches (Trench-3, Trench-4, and Trench-5) were installed within the south tank to further assess the parallel joint set identified within Trench-2. The additional trenches



were installed at locations to the northwest and southeast of Trench-2 as shown in Figure 4. Sections of Trench-2 were also re-opened and re-sampled. The floor cuts were installed in a similar manner as Trenches 1 and 2.

Trench-3 contained a single joint that trends N17W and appeared to intersect Trench-2. Groundwater was observed seeping into the floor cut near the joint and a sample (T-3), was collected and analyzed for VOCs using EPA Method 8260B (Table 4).

Trench-4 also contained a NW trending joint (N18W) that appeared to intersect T-2. A sample (T-4) was collected near the joint and analyzed for VOCs using EPA Method 8260B (Table 4).

Trench-5 contained a single joint that trends N34W. Groundwater was observed seeping into the trench and a sample (T-5) was collected from the joint and analyzed for VOCs using EPA Method 8260B (table 4). The joint observed in Trench-5 does appear to intersect the other trench cuts.

Following sampling and logging, the four trenches were sealed in a similar manner as Trenches 1 and 2. A layer of grout was installed first, directly on top of the underlying bedrock. After allowing the grout to set up, hydraulic cement was installed above the grout to create a tight seal with the existing concrete.


Saw-cut concrete generated during the additional floor trench investigation was removed from the reservoir and contained in 55-gallon Department of Transportation (DOT) authorized drums. Personal protective equipment was added to a satellite accumulation drum located inside the EPT facility. A total of two concrete debris drums were generated. The hazardous waste manifests and waste disposal certificates are included in Appendix B for the drum shipment completed on February 16, 2010.

The water generated during the follow up trench work was contained in 55-gallon DOT authorized drums stationed directly above the reservoir. The water was drummed due to the light petroleum product sheen observed during the installation of the horizontal and monitoring point locations. The hazardous waste manifests and waste disposal certificates are included in Appendix B for the drum shipment completed on February 16, 2010.

3.6 TEST PITS

Between April 19 and April 23, 2010, a series of test pits were excavated on the western side of the fire water reservoir to locate and assess the drain pipe exiting the base of the south tank as described in Section 3.4. A test pit excavated on the west side of the stand pipe uncovered a brick valve box structure, approximately 2-cubic feet in dimension, at a depth of 11 feet bgs (Figure 5). The vertical stand pipe, identified during previous reconnaissance (see Section 3.4), entered the top of the brick structure and a horizontal 4-inch cast-iron pipe exited the west side of the structure. The vertical stand pipe was broken approximately 1-foot above the brick structure. A concrete plug was apparent inside the brick structure and inside the vertical stand pipe where the stand pipe was broken. Some soil staining was noted around the brick structure and soil samples were taken on the west (WStandPipe-8 and WStandPipe-11), northwest (NWStandPipe-11), northeast (NEStandPipe-11), southwest (SWStandPipe-11), and southeast (SEStandPipe-11) sides of the brick structure at 11 feet bgs (Table 5). Groundwater and a slight sheen of petroleum product began to seep into the test pit during the excavation. A sample of the seepage (WStandPipeAq-11 – Table 6) was collected and submitted to the laboratory for analysis of VOCs using Method EPA 8260B.

In order to trace the location of the cast iron pipe, the excavation was extended further west to determine where the cast-iron pipe terminated. Additional soil samples were collected 5 feet west of the stand pipe, 1 foot north of the trench (W5StandPipe-11; Table 5), and 7 feet west of the stand pipe (W7StandPipe-10). The 4-inch cast-iron pipe transitioned into a 4-inch clay pipe approximately 3 feet west of the stand pipe. The transition from cast-iron to clay was damaged during the excavation and a soil sample from around the clay pipe transition was collected (ClayPipe-11; Table 5). Using a fish-tape reel, the pipe was



determined to be plugged approximately 18 feet west (down the hillside) of the clay transition. A test pit was installed at the end of the fish tape to intercept the end of the pipe. A 4-inch cast iron pipe was found in the north end of the test pit, but the end of the pipe was not uncovered. Using the excavator bucket, the cast-iron pipe was pulled vertically and the end of the pipe was discovered.

The section of cast-iron pipe was approximately 6 feet long, which correlated to the pipe terminating approximately 2 feet from the drainage ditch. A sample (Table 5) was collected from inside the pipe that remained in the hillside, where the 6-foot section was broken off (CIPipeSludge-5). This section was subsequently sealed with concrete. A sample (S5CIPipe-3) was also collected 5 feet south of where the 6-foot section was broken off (Table 5). Three additional test pits were installed and sampled (Table 5) southeast (TestPit1-5), northeast (TestPit2-6), and south (TestPit3-4) of the existing piping and near Outfall 001. Soil at TestPit3-4 was visually impacted by petroleum and, thus was sampled and analyzed using New York State Department of Health (NYSDOH) Method 310.13 for petroleum fingerprinting (Table 6) and VOCs using EPA Method 8260B (Table 5). A test pit (WDitch-ST-5) installed northwest of the end of the cast-iron pipe filled with seepage water, and therefore, a soil sample could not be collected. A sample of the seepage water (WDitch-ST-5) was collected and analyzed for VOCs using Method EPA 8260B (Table 7).

Two test pits were installed west of the north tank, but no evidence of the pipe exiting the north tank was found. A soil sample was collected from each test pit and labeled WDitchSoil-NT-5 and TestPit4-8 (Table 5). The test pit west of the drainage ditch was allowed to accumulate seepage water, which was then sampled (WDitch-NT-5) and analyzed for VOCs using EPA Method 8260B (Table 7).

All soil excavated during the test pit activities was placed back into the ground at the end of the activities. The hillside was compacted with the excavator bucket and an erosion mat and hay bales were used to ensure erosion into Outfall 001 was minimized.

3.7 C-ZONE MONITORING WELL INSTALLATION AND SAMPLING (MW-12C AND MW-13C)


Two shallow C-zone monitoring wells were installed to the east of the fire water reservoir to further evaluate groundwater quality (Figure 4). Monitoring well MW-12C was installed approximately 20 feet east of the south tank and monitoring well MW-13C was installed approximately 20 feet south east of the south tank. The monitoring wells were installed on April 27, 2010 and construction details are included in Appendix C.

3.7.1 Monitoring Well Installation and Development

Wells MW-12C and MW-13C were installed using hollow-stem auger, air rotary, and rock coring methods. Parratt-Wolff, Inc., of East Syracuse, New York, a driller licensed in the state of New York in accordance with § 15-1525 of the New York Environmental Conservation Law, provided the drilling services. Each boring was drilled through the overburden using 6.25-inch inside-diameter (ID) hollow-stem augers. Continuous soil samples were collected from the ground surface to refusal at bedrock using 2-foot-long, split-spoon samplers. The soils recovered from the split spoons were screened for organic vapors in the field using a photoionization detector (PID). Sample descriptions and PID readings were recorded in a field notebook.

Each borehole was advanced through the hollow stem auger rods into competent bedrock using nominal 6-inch air rotary methods. A 4-inch steel surface casing was then installed in the borehole to a depth of 12.5 feet bgs. The annular space was backfilled with a bentonite-cement slurry grout mixture (tremie piped from the bottom to the top as the hollow stem augers were removed) and allowed to set for at least 18 hours.

The boreholes were advanced to the terminal depth (30 feet bgs) using HX rock coring methods. Each section of rock core recovered from the borings was logged (e.g., lithology, structure, weathering, and



fracture characterization, which were recorded in a field notebook. The total recovery, modified recovery, and Rock Quality Designation (RQD) were also calculated for each coring run.

The monitoring wells were constructed of 2-inch-ID threaded, flush jointed, Schedule 40 PVC blank casing attached to screens with 0.010-inch horizontal slots. Both monitoring wells were constructed with a 5-foot screen length and screened interval from 24 to 29 feet bgs.

A clean sand filter pack was placed from the bottom of the well borehole to approximately 2 feet above the top of the screen. The remaining annular space was backfilled with hydrated bentonite chips from the top of the sand filter pack to 1-foot bgs. Each monitoring well was completed with a flush-mount protective steel well cover, and the PVC casing for each well was fitted with a watertight expandable plug and padlock. Well construction information was recorded in a field notebook, and boring logs and as-built well construction diagrams were prepared for each monitoring well after completion of the field activities (Appendix C). The monitoring wells were completed and installed by Parratt-Wolff, Inc. of East Syracuse, New York.

Following installation, the monitoring wells were developed by pumping groundwater using a submersible pump to remove sediments, ensure effective communication between the open borehole and fractures in the surrounding formation, and prepare the wells for groundwater sampling. Development continued until the discharge was relatively free of suspended sediments or until the wells were purged dry two to three times. Water generated during well development activities was collected in drums and managed in the same manner as other investigation-derived waste. All development activities were conducted with clean equipment to prevent potential cross-contamination between well locations.

3.7.2 Groundwater Sampling

On May 25, 2010, groundwater samples were collected from MW-12C and MW-13C. Prior to sampling, the wells were purged of three well volumes, or until the boreholes went dry and the purge water was processed through the groundwater extraction system immediately. The pH, specific conductance, temperature, turbidity, and dissolved oxygen were monitored during the purging process with a water quality meter to ensure that representative groundwater quality samples were collected. The wells were purged with dedicated air-displacement pumps operated by a QED Well Wizard pump controller and sampled using dedicated Teflon bailers. The wells were allowed to recharge for a period of no more than 2 hours, or until water was present in the borehole, before samples were collected. The groundwater samples were analyzed for VOCs by EPA Method 8260B.



4 Fire Water Reservoir Sampling Results

This section details the results the supplemental investigation conducted around and below the fire water reservoir. The results of samples collected from each phase of investigation are presented in Figures 6 and 7. The results are listed in Tables 1 through Table 7. Analytical laboratory data packages are included in Appendix D.

4.1 RESERVOIR LINER REMOVAL - SEEPAGE WATER RESULTS

Three samples (SouthTank102209, NorthTank102109, and NorthTank102209) were collected to evaluate the quality of water seeping into the tanks following removal of the liner. The results show that only trace levels of VOCs were detected in each sample. The sample results are presented in Table 1.

4.2 HORIZONTAL POINT AND DRAIN LINE SEDIMENT RESULTS

Samples of the sediment collected from HP-1 (HP-1-SED) and within the existing drain line in the south tank (South P-1) contained low levels of two chlorinated solvents trichloroethane (TCE) and *cis*-1,2-dichloroethene (*cis*-1,2-dichlorethene [DCE]; Table 2). The highest concentration of TCE and *cis*-1,2-DCE was detected in the sample South P-1 at 240 micrograms per kilogram ($\mu\text{g}/\text{kg}$) and 87 $\mu\text{g}/\text{kg}$, respectively. Total VOCs at HP-1-SED and South P-1 contained 155 $\mu\text{g}/\text{kg}$ and 769 $\mu\text{g}/\text{kg}$, respectively.

4.3 MONITORING POINT AND HORIZONTAL POINT GROUNDWATER SAMPLE RESULTS

Results for the groundwater samples collected from the eight new monitoring points and the three horizontal points that contained water are shown in Figure 6 and summarized in Table 3. TCE, *cis*-1,2-DCE, and vinyl chloride were the primary VOCs detected. TCE concentrations ranged from 15 micrograms per liter ($\mu\text{g}/\text{l}$; MP-10) to 5,300 $\mu\text{g}/\text{l}$ (MP-8) and *cis*-1,2-DCE ranged from 71 $\mu\text{g}/\text{l}$ (MP-10) to 2,600 $\mu\text{g}/\text{l}$ (MP-8). Vinyl chloride concentrations ranged from 60 $\mu\text{g}/\text{l}$ in MP-10 to 290 $\mu\text{g}/\text{l}$ in MP-7. Samples collected from the horizontal points had lower concentrations than detected in the monitoring points. In the horizontal points, TCE ranged from 11 $\mu\text{g}/\text{l}$ (HP-6) to 30 $\mu\text{g}/\text{l}$ (HP-3), *cis*-1,2-DCE ranged from 18 $\mu\text{g}/\text{l}$ (HP-2) to 35 $\mu\text{g}/\text{l}$ (HP-6), and vinyl chloride ranged from 3.3 $\mu\text{g}/\text{l}$ (HP-2) to 7.1 $\mu\text{g}/\text{l}$ (HP-6).

4.4 FLOOR CUT INVESTIGATION RESULTS

The results for groundwater samples collected from the floor trenches (Figure 6) and identified joint sets within the trenches contained predominantly TCE, *cis*-1,2-DCE, and vinyl chloride (Table 4). The highest concentrations of VOCs were detected in the initial groundwater samples collected from Trench -2. TCE was detected at 19,000 $\mu\text{g}/\text{l}$, *cis*-1,2-DCE at 1,300 $\mu\text{g}/\text{l}$, and vinyl chloride at 370 $\mu\text{g}/\text{l}$ in this sample. Follow up samples collected from Trench-2 (samples T-2A and T-2B) contained significantly lower levels of VOCs when compared to the initial trench sample. Total VOC levels were reported at 4,556 $\mu\text{g}/\text{l}$ for sample T-2A and 6,174 $\mu\text{g}/\text{l}$ for sample T-2B (Table 4).

Groundwater samples collected from the three additional floor trench cuts also contained predominantly TCE, *cis*-1,2-DCE, and vinyl chloride at levels generally consistent with concentrations detected in the surrounding monitoring point locations. TCE levels ranged from 164 $\mu\text{g}/\text{l}$ (T-5) to 804 $\mu\text{g}/\text{l}$ (T-4) and levels of *cis*-1,2-DCE ranged from 82 $\mu\text{g}/\text{l}$ (T-3) to 2,080 $\mu\text{g}/\text{l}$ (T-5). Vinyl chloride concentrations ranged from 38 $\mu\text{g}/\text{l}$ (T-3 duplicate) and 270 $\mu\text{g}/\text{l}$ (T-5).

4.5 TEST PIT SAMPLE RESULTS

4.5.1 Soil Sample Results

Soil samples collected from the test pits west of the reservoir (Figures 7 and 8) contained trace levels of VOCs, with total VOCs ranging from non-detect to 195 µg/kg (CIPipeSludge-5; Table 5). CIPipeSludge-5 had the highest detection of cis-1,2-DCE (101 µg/kg) and the only detection of TCE (94 µg/kg). The sample from TestPit3-4 was also analyzed for petroleum fingerprinting using the NYSDOH Method 310.13. The sample was found to contain primarily Lube Oil (3,180,000 µg/kg) and partially Diesel Fuel #2 (330,000 µg/kg; Table 6).

4.5.2 Groundwater Sample Results

The three water samples WDitch-ST-5, WStandPipeAq-11, and WDitch-NT-5 collected from the test pits contained 233 µg/l, 211 µg/l, and 2 µg/l of total VOCs, respectively (Table 7). The highest concentration of cis-1,2-DCE was found in WStandPipeAq-11 (116 µg/l) and the highest detection of TCE was found in WDitchST-5 (107 µg/l). Groundwater results are shown in Figure 7 and Figure 8.

4.6 C-ZONE MONITORING WELL RESULTS (MW-12C AND MW-13C)

4.6.1 Groundwater

The results of groundwater samples collected from monitoring wells MW-12C and MW-13C indicate that groundwater quality in the shallow fractured bedrock between 24 feet and 29 feet bgs east of the reservoir has been only moderately impacted compared to downgradient wells closer to the reservoir (Figure 6). TCE and cis-1,2-DCE were the predominant VOCs detected at these locations. The sample collected from MW-12C contained TCE at 1.0 µg/l and cis-1,2-DCE at 3.0 µg/l. The groundwater sample collected from MW-13C contained TCE at a concentration of 339 µg/l and cis-1,2-DCE at a concentration of 41.8 µg/l. Groundwater sample results are summarized in Table 8.

4.7 SUMMARY OF FIRE WATER RESERVOIR INVESTIGATION

The base of the reservoir slab varies in thickness from 2 to 6 inches and is constructed directly on competent bedrock and some minor amount of fill material. Following liner removal, groundwater water was observed seeping into the reservoir; however, the results of samples collected from the horizontal point locations and seepage areas did not contain elevated levels of VOCs. No significant mass and no TCE product was identified immediately around the south or north tank. TCE, cis-1,2-DCE, and vinyl chloride were detected in water samples collected from the eight additional monitoring points; however, the concentrations detected were well below VOC levels detected in monitoring and extraction wells installed near and downgradient of the reservoir.



5 Geophysics and Exploratory Boring Scope of Work

5.1 SURFACE GEOPHYSICS AND CROSS HOLE TOMOGRAPHY

A geophysical survey was conducted south and east of the fire water reservoir to further evaluate potential groundwater migration pathways (Figure 8). The survey, which used electrical resistivity (ER) to remotely image the subsurface, was conducted by Mid-Atlantic Geosciences of Lancaster, Pennsylvania in September 2010.

Surface resistivity measurements were collected by introducing an electrical current in the ground using electrodes at the ground surface. The apparent resistivity of the subsurface was determined by measuring the voltage difference between the electrodes. The depth and volume of the subsurface zone represented by the measured apparent resistivity is a function of the geometry of the current and potential electrodes located at the surface. Electrodes were set at specific depths in the borehole to collect crosshole measurements between two boreholes and were used in conjunction with the surface electrodes (up-hole measurements).

Using an AGI Super Sting R8/IP resistivity meter and Swift automated electrode switching system, apparent resistivity readings were collected along two profiles located east and south of the fire water reservoir area (Figure 8). Along each profile, electrodes were spaced at the ground surface at 1-meter intervals. To collect electrical imaging data, a dipole-dipole array was used. The measured apparent resistivities were plotted as resistivity pseudo-sections depicting the apparent resistivity versus nominal survey depth for each profile in order to confirm data quality.


The apparent resistivity pseudo-sections were mathematically inverted using EarthImager 2D by Advanced Geosciences, Inc., to produce a color-coded cross sectional images or profiles for each transect line displaying the distribution of resistivities between the various subsurface materials. Each resistivity measurement was assigned a color from dark blue to red. Bedrock, a typically highly resistive material, generally yields resistivity measurements of 200 to 5,000-ohm meters, which plot as regions of light green, yellow, and red. Regions with resistivities below 200 ohm-meters generally plot as shades of green and light blue. Water-bearing zones, which have dramatically reduced resistivities due to the highly conductive nature of groundwater, typically yield regions of blue or dark blue within the more resistive areas. The focus of the geophysical interpretation was to identify and generally locate the highly conductive water bearing zones within the subsurface.

5.2 EXPLORATORY BORING AND LOGGING

Following the geophysical survey, two exploratory bedrock borings/monitoring wells (MW-14C and MW-15C) were installed and sampled in the area south and east of the fire water reservoir. The exploratory borings/monitoring wells were drilled to 45 feet bgs between March 14 and 18, 2011 at the locations shown in Figure 8. Exploratory boring MW-14C was installed approximately 4 feet south of the south tank. The area was previously inaccessible due to the location of an electrical substation, which was demolished in late 2010 along with Building 19.

5.2.1 Drilling Methods

The exploratory borings/monitoring wells were installed using hollow-stem auger, mud rotary, and rock coring methods. Parratt-Wolff, Inc., provided the drilling services. Each boring was drilled through the overburden using 6.25-inch ID hollow-stem augers. The soils recovered from the cuttings were screened for organic vapors in the field using a PID. Sample descriptions and PID readings were recorded in a field notebook.



Each borehole was advanced through the hollow stem auger rods into competent bedrock using nominal 6-inch air rotary methods. Rock cores were collected and logged from 15 to 25 feet bgs at each location using HX rock coring methods. The rock core depth interval was selected so that the depth corresponded to the base of the reservoir, which is at approximately 19 feet bgs. Each section of rock core recovered from the borings was logged (e.g. lithology, structure, weathering, and fracture characterization) and descriptions were recorded in a field notebook. The total recovery, modified recovery, and RQD were also calculated for each coring run. Following core collection and logging, a 4-inch steel surface casing was installed in the borehole. The annular space was backfilled with a bentonite-cement slurry grout mixture (tremie piped from the bottom to the top as the hollow stem augers were removed) and allowed to set for at least 18 hours. The length of the surface casing was 25 feet at each location. The boreholes were then advanced to the terminal depth of 45 feet bgs using nominal 4-inch mud rotary drilling methods.

The exploratory borings were completed as open boreholes with a stick-up protective steel outer well covering, and the inner surface casing was fitted with a watertight lockable cap. Well construction information was recorded in a field notebook, and boring logs and as-built well construction diagrams were prepared for each exploratory boring after completion of the field activities (Appendix C).

5.2.2 Rock Core Sampling Methods

WSP collected rock core grab samples from MW-14C and MW-15C, which were drilled adjacent to the fire water reservoir. The rock core samples were collected from intervals where elevated PID readings or visual observations indicated potential for impacts. At MW-14C a rock core sample was collected from 17.5-18 feet bgs, 19.5 to 20.0 feet bgs, and 20.0 to 20.5 feet bgs. At MW-15C a rock core sample was collected from 20.4 to 20.9 feet bgs. These depths correspond to the bottom of the fire water reservoir.

The selected interval was first placed in a plastic bag and crushed in the field using a rock hammer and mallet. Once the rock core grab sample was crushed, the lithic fragments were placed in a 4-oz. glass jar, labeled, and packed on ice for shipment to Test America Laboratory in Amherst, New York. The grab samples were analyzed for VOCs using EPA Method 8260B.


5.2.3 Borehole Development

The exploratory borings were developed by removing groundwater using a submersible pump to remove sediments, ensure effective communication between the open borehole and fractures in the surrounding formation, and prepare the boreholes for downhole geophysical logging. Development continued until the discharge was relatively free of suspended sediments or until the borehole had been purged dry two to three times. Water generated during well development activities was collected in drums and managed in the same manner as other investigation-derived waste. All development activities were conducted with clean equipment to prevent potential cross-contamination between boring locations.

5.3 DOWN HOLE GEOPHYSICAL LOGGING AND GROUNDWATER SAMPLING

5.3.1 Downhole Logging

On March 21, 2011, Mid-Atlantic Geosciences completed downhole geophysical logging of exploratory borings MW-14C and MW-15C. Downhole logging was also conducted on existing well MW-5-40 which, is an open borehole monitoring well east of the reservoir, in August 2010 (Figure 8). The geophysical logs and report are included as Appendix E. The geophysical logging techniques were the same as those used during the site Remedial Investigation conducted in 2007 in the remediation area and included logging of fluid temperature, fluid conductivity, natural gamma radiation, borehole diameter and surface structure using a three-arm caliper, and optical/high resolution acoustic televiewer (OPTV/HRAT) imaging of the borehole walls.



The purpose of the geophysical logging was to identify potential open fracture zones where groundwater was entering or exiting the borehole. A fluid probe was used to measure changes in temperature and conductivity of the undisturbed water column in the boreholes. A three-arm caliper provided a mechanical measurement of the borehole wall diameter and was used to identify the location of fractures along the borehole wall. The natural gamma radiation logs were used to identify lithologic changes in the borehole and for stratigraphic correlation between boring locations.

Both the temperature/conductivity logs and caliper logs were verified by the OPTV/HRAT survey. The OPTV uses a downhole camera equipped with a hyperbolic mirror to examine the borehole walls. Unlike a standard downhole television camera, this device uses successive image scans (0.5 millimeter in length) to build a continuous optical record that is ultimately transferred to a paper log for analysis. In wells with low visibility (due to groundwater with a high particle load), the HRAT is substituted for the OPTV. The HRAT uses an acoustical signal to build a similar log of the borehole. Onboard magnetometers measure the orientation of the OPTV/HRAT during its descent allowing the strike and dip of fractures or bedding planes to be measured directly from the output log.

The OPTV/HRAT survey provided for direct visual examination of the potential fracture zones identified by the logs to determine the fracture abundance and their potential for transmitting groundwater. This information was used to select specific open or partially open fractures for collecting discrete interval groundwater samples.

5.3.2 Groundwater Sampling

On March 23 through March 25, 2011, groundwater samples were collected from newly installed monitoring wells MW-14C and MW-15C and existing well MW-5-40. Samples were collected using a bailer and standard purge and sample techniques. The samples were collected, labeled, packed on ice, and shipped to Pace Laboratory of Greensburg, Pennsylvania for VOC analysis using EPA Method 8260B.

The wells were purged of three water volumes, or until the boreholes went dry, and the purge water was processed through the groundwater extraction system immediately. The pH, specific conductance, temperature, turbidity, and dissolved oxygen were monitored during the purging process with a water quality meter to ensure that representative groundwater quality samples were collected. The wells were purged with dedicated air-displacement pumps run by a QED Well Wizard pump controller and sampled using dedicated Teflon bailers. The wells were allowed to recharge for a period of no more than 2 hours, or until water was present in the borehole, before samples were collected. The groundwater samples were analyzed for VOCs by EPA Method 8260B.

6 Geophysics and Exploratory Boring Results

6.1 SURFACE GEOPHYSICS FINDINGS AND OBSERVATIONS

As shown in Figure 9, the two inverted resistivity cross-sections are presented for transects CH01 and E12-SB-01. These represent a cross-hole tomography profile and an up-hole profile, respectively. The image for CH01 is a cross-hole resistivity tomography profile collected between wells EXB-01 and EXB-02. These two wells are located approximately 58 feet apart and were installed to a depth of approximately 80 feet bgs. Both wells were constructed with approximately 20 feet of steel casing set into bedrock with the remainder of the well left as an open bedrock hole. In order to ensure that the steel casing did not produce erroneous results, the upper electrodes in both wells were lowered to a depth of 30 feet bgs. Note that data collected between the ground surface and 30 feet bgs (hachured area in Figure 10) was not used.


In applying resistivity tomography at lithologically complex sites with numerous subsurface utilities, some erroneous data is collected during a survey. To counteract this, a number of computer algorithms were calculated and used to smooth the data. This process removes as little of the data as necessary to achieve a legible profile. During processing of survey CH01, 18 points out of the 477 points were smoothed (3.77% of the data). Survey E12-SB-01, however, required that 454 points out of 1,316 points be smoothed, i.e., 35.5% of the data. This transect had a high amount of background noise due to the numerous intersecting utilities, which appear clearly in the profile (Figure 10). The areas in question (represented with hatched lines) are reconstructed with an algorithm, and should not be considered a true representation of the underlying geology.

Results for Profile CH01 indicate three distinct conductive (low resistivity) anomalies (A, B, C, in Figure 10). Anomaly A is located at approximately 35 to 45 feet bgs and is approximately 25 feet wide. This conductive feature is consistent with perched groundwater observed in monitoring MW-5-40, which is located east of the south tank of the reservoir. Anomaly B ranges from approximately 50 – 75 feet bgs and is approximately 48 feet wide. This feature is consistent with the C-zone bedding plane fracture identified across the area. Anomaly C is a small isolated conductive anomaly at approximately 55 feet bgs and is about 10 feet wide. Anomalies A and B are indicative of water-bearing bedding plane fractures in bedrock.

Profile E12-SB-01 is a surface-to-borehole resistivity profile that was collected instead of a standard surface resistivity profile due to several subsurface utilities that cross and run parallel to the transect line. Due to the presence of a thick layer of concrete near EXB-02, the first surface electrode was placed approximately 45 feet away from the borehole. This is the reason for the hachured zone from 0 – 45 feet along the profile moving away from EXB-02 (Figure 10). Results from Profile E12-SB-01 indicate a very noisy shallow subsurface, due to the location of several utilities. The red resistive features in the shallow depths below the surface electrodes (from 75 to 190 feet along-profile) are likely attributed to dry resistive fractures in shallow bedrock. Anomalies D, E, F, and G are all conductive anomalies that are indicative of water-bearing fractures.

6.2 DOWNHOLE OBSERVATIONS

The reports for the downhole geophysical logging conducted in wells MW-14C, MW-15C, and MW-5-40 are included in Appendix E. On August 25, 2010, MW-5-40 was logged using an Optical Televiewer, 3-Arm Caliper, and a Robertson Geologging, LTD. Micrologger II and/or a Mount Sopris Matrix to collect fluid temperature, fluid conductivity, and natural gamma readings. At the time of the geophysical logging, the water level in MW-5-40 was 30 feet bgs. Two small high-angle features were identified above the water table at depths of 18.7 feet and 20.6 feet bgs. Within the water column at 38.5 feet bgs (549 feet



amsl), a sealed bedding plane fracture was identified. This directly correlates to a bedding plane fracture previously observed beneath the remediation area.

On March 21, 2011, exploratory borings MW-14C and MW-15C were also logged using an Optical Televiwer, 3-Arm Caliper, and a Robertson Geologging, LTD. Micrologger II and/or a Mount Sopris Matrix. At the time of the geophysical logging, the water level in MW-14C was 21.8 feet bgs. Few planar features were recognizable on the televiwer logs. Within the water column at 37.3 feet bgs (550 feet amsl), an open fracture was identified. An open fracture zone was also identified from 43.3 to 43.6 feet bgs (544 feet amsl).

At the time of the geophysical logging, the water level in MW-15C was 42.8 feet bgs. No planar features were observed in the downhole log. Above the recorded water column at 37.5 feet bgs (550 feet amsl), a bedding plane fracture was identified. Within the water column, a sealed second fracture was identified at 43.5 feet bgs.

As discussed in Section 2.0, an updated CSM has been prepared to show the distribution of the bedding plane fractures and to conceptualize the vertical and horizontal movement of groundwater in the fire water reservoir area. The CSM has been updated to incorporate the supplemental geophysical data and the bedding plane fractures observed at 550 feet and 544 feet amsl. These bedding plane fractures along with the bedding plane fracture previously identified at 515 feet amsl are considered the primary horizontal migration pathways for affected groundwater beneath the fire water reservoir area.


6.3 ROCK CORE SAMPLE RESULTS

Results of the rock core sampling indicate that dissolved VOCs are present within the rock matrix and micro fractures of the unsaturated bedrock below the reservoir's south tank (Table 9). However, no residual source material (TCE product) was found in the rock core grab samples collected from just below the elevation of the reservoir (boring MW-14C). In the boring installed immediately south of the south tank (MW-14C), TCE levels ranged from 4,310 $\mu\text{g}/\text{kg}$ to 8,450 $\mu\text{g}/\text{kg}$. The highest concentration of TCE was detected in the interval between 19.5 feet bgs and 20.0 feet bgs. Cis-1,2-DCE was detected at concentrations between 343 $\mu\text{g}/\text{kg}$ and 429 $\mu\text{g}/\text{kg}$ at depths between 17.5 feet and 20 feet bgs. Lower levels (<30 $\mu\text{g}/\text{kg}$) of methylene chloride, PCE, and trans-1,2-DCE were also detected in the samples. Low levels of VOCs were detected in the rock core samples collected east of the north tank in the borehole for well MW-15C. The concentration of TCE was 35.5 $\mu\text{g}/\text{kg}$ in the rock core sample collected from 20.4 feet bgs to 20.9 feet bgs and the concentration of cis-1,2-DCE was 185 $\mu\text{g}/\text{kg}$.

6.4 GROUNDWATER SAMPLING RESULTS

On March 23 through March 25, 2011, groundwater samples were collected from wells MW-14C and MW-15C and existing well MW-5-40. Existing well MW-5-40 was selected for additional sampling because the well is open from 17 to 40 feet bgs and intersects the bedding plane fracture encountered at approximately 550 feet amsl. This well does not intersect the lower bedding plane fracture observed at 544 feet amsl. Laboratory Reports are included in Appendices D. Groundwater sample results are summarized in Table 8.

The highest concentration of total VOCs (104,220 $\mu\text{g}/\text{l}$) was detected in well MW-14C, which is located within 5 feet of the south tank of the reservoir (Figure 6). TCE and its associated degradation products, cis-1,2-DCE and vinyl chloride, were the predominant compounds detected in the groundwater sample. TCE was detected at a concentration of 89,600 $\mu\text{g}/\text{l}$ and cis-1,2-DCE was detected at a concentration of 13,500 $\mu\text{g}/\text{l}$. Vinyl chloride was detected at a concentration 414 $\mu\text{g}/\text{l}$.



The sample collected from MW-15C contained a lower level of total VOCs (1,890 µg/l) compared to levels hydraulically downgradient of the fire water reservoir. TCE was detected at 1,290 µg/l, cis-1,2-DCE at 544 µg/l, and vinyl chloride at 14.6 µg/l.

The groundwater sample collected from well MW-5-40, located between wells MW-14C and MW-15C (Figure 6), had concentrations of TCE at 6,390 µg/l, cis-1,2-DCE at 18,000 µg/l, and vinyl chloride at 774 µg/l. The results of the sample collected from MW-5-40 are consistent with previous sampling results.

6.5 GEOPHYSICS AND GROUNDWATER SUMMARY

As discussed in Section 2.0 and shown in Figure 3, an updated CSM has been prepared to conceptualize the vertical and horizontal movement of groundwater flow in the fire water reservoir area. The CSM has been updated to incorporate the bedding plane fractures observed at 550 feet and 544 feet amsl. Based on the results of the supplemental downhole geophysics investigation and groundwater samples collected from monitoring wells MW-5-40, MW-14C, and MW-15C, the bedding plane fractures identified at 550 feet and 544 feet amsl are significant pathways for affected groundwater movement beneath the fire water reservoir area. Elevated VOC concentrations in groundwater are present within these two bedding plane fractures, which are between 17 and 21 feet below the base of the reservoir. These fractures, as well as the deeper bedding plane fracture previously identified at 515 feet amsl, are considered the primary migration pathways for affected groundwater at the site.



7 Conclusions

The results of the supplemental pre-design investigations show that there is not TCE product or dense non aqueous phase liquid (DNAPL) material immediately below or around the south or north tank of the fire water reservoir. The total concentrations of TCE, cis-1,2-DCE, and vinyl chloride detected in aqueous samples collected from the eight additional monitoring points and from rock core samples collected from elevations corresponding to depths below the reservoir were well below VOC levels detected in monitoring and extraction wells installed near and downgradient of the reservoir.

Soil and water samples collected from the existing drain pipe that exits the south tank did not contain elevated levels of VOCs, and no TCE product or significant VOC mass was encountered in any of the test pit samples collected in the vicinity of the drain pipe.

Results of the rock core sampling indicate that VOCs are present within the rock matrix and micro fractures present at depth below the south tank and surrounding area. However, no residual TCE product was detected in the rock core samples.

Results of the geophysical investigation and additional groundwater characterization show that elevated levels of VOCs are present within two bedding plane fractures between 17 feet and 21 feet below the base of the south tank of the reservoir. These fractures, as well as the deeper bedding plane fracture previously identified at 515 feet amsl, are likely the primary migration pathways for affected groundwater at the site. Based on a review of system performance data previously submitted to the NYSDEC and the elevation of the current extraction wells compared to the location of the subsurface mass, the IRM implemented in early 2009 is effective in intercepting and removing mass from the B-zone and the three bedding plane fractures identified within the C-zone. The shallow B-zone extraction wells intersect and contain affected groundwater present in the B-zone and the bedding plane fractures at 550 feet and 544 feet amsl. The C-zone extraction wells intersect and contain affected groundwater present in the bedding plane fractures encountered at 544 feet and 515 feet amsl.



Acronyms

μg/kg	micrograms per kilogram
μg/l	micrograms per liter
amsl	above mean sea level
bgs	below ground surface
CSM	conceptual site model
DCE	<i>cis</i> -1,2-dichloroethene
DNAPL	dense non aqueous phase liquid
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
EPT	Emerson Power Transmission
ER	electrical resistivity
ID	inside diameter
IRM	Interim Remedial Measure
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OPTV/HRAT	optical/high resolution acoustic televiewer
PID	photoionization detector
RQD	Rock Quality Designation
TCE	trichloroethene
VOC	volatile organic compounds