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March 13, 2017

David Szymanski
New York State Department of Environmental Conservation
Division of Environmental Remediation
270 Michigan Ave.
Buffalo, New York 14203-2915

Re: Final Engineer Report, Former Dowell Facility, Depew, New York

Dear Mr. Szymanski,

Please find enclosed one electronic copy of the above-referenced document. If you have any questions or comments, please call me at (281) 285-4747. I can also be reached by e-mail at cocianni-v@slb.com.

Sincerely,

V. COCIANNI

Virgilio Cocianni
Remediation Manager

Enclosures

c: Matt Focucci/New York State Department of Health
Jim Strunk/The Dow Chemical Company
Cathy Barnett/CH2M HILL Engineers, Inc.

Final Engineer Report
Former Dowell Depew Facility, Depew, New York

Prepared for

New York State Department of
Environmental Conservation

On Behalf of

Schlumberger Technology Corporation and
The Dow Chemical Company

March 2017

Prepared by

CH2M HILL Engineers, Inc.

Engineer Certification

“I Key Rosebrook *certify that I am currently a NYS registered professional engineer I had primary direct responsibility for the implementation of the subject construction program, and I certify that the Remedial Work Plan was implemented and that all construction activities were completed in substantial conformance with the DER-approved Remedial Work Plan.”*

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Acronyms and Abbreviations

°C	degrees Celsius
AS	air sparging
bgs	below ground surface
CH2M	CH2M HILL Engineers, Inc.
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCA	1,2-dichloroethane
1,2-DCE	1,2-dichloroethene
cis-1,2-DCE	cis-1,2-dichloroethene
Dow	The Dow Chemical Company
DPT	direct-push technology
ERD	enhanced reductive dechlorination
ERH	electrical resistance heating
ESD	Emergency Shutdown Device
ET-DSP	electro thermal dynamic stripping process
FER	final engineer report
GAC	granular activated carbon
HSA	hollow-stem auger
ISCO	in situ chemical oxidation
ISTT	in situ thermal treatment
kW-Hr	kilowatt-hours
Mc^2	McMillan-McGee Corporation
MPE	multi-phase extraction
NYSDEC	New York State Department of Environmental Conservation
NYSEG	New York State Electric and Gas
PDS	power distribution system
PID	photoionization detector
POTW	publicly owned treatment works
PVC	polyvinyl chloride
PW	Parratt-Wolff Inc.
RA	remedial action
RAO	remedial action objective
RAWP	remedial action work plan
RD	remedial design
SCG	applicable standards, criteria, and guidelines
site	Former Dowell Depew Facility
STC	Schlumberger Technology Corporation
SVE	soil vapor extraction
1,1,1-TCA	1,1,1-trichloroethane
TCH	thermal conductive heating
TMS	temperature monitoring sensor
TTZ	target treatment zone
USEPA	U.S. Environmental Protection Agency
VCP	Voluntary Cleanup Program
VOC	volatile organic compound
WCS	water circulation system

SECTION 1

Introduction

This final engineer report (FER) was prepared for Schlumberger Technology Corporation (STC) and The Dow Chemical Company (Dow) as part of the New York State Department of Environmental Conservation (NYSDEC) Voluntary Cleanup Program (VCP) for the Former Dowell Depew Facility (site) located in Depew, New York. This FER presents the remedial action objective (RAO) and documents the design, construction, operation, and decommissioning of the in situ thermal treatment (ISTT) remediation system that operated at the site in accordance with the NYSDEC-approved remedial action work plan (RAWP) (CH2M HILL Engineers, Inc. [CH2M] 2015a). ISTT remedial action (RA) activities were performed between September 2015 and December 2016 in accordance with the NYSDEC-approved RAWP, except where noted herein.

The FER was prepared in accordance with the NYSDEC Program Policy document—Division of Environmental Remediation-10/Technical Guidance for Site Investigation and Remediation (NYSDEC 2010) and the site management plan (URS Corporation 2011) for the periodic submittal of data, information, recommendations, and certifications to the NYSDEC.

1.1 Purpose of the Final Engineer Report

The purpose of the FER is to provide a comprehensive summary of the RAO, site description/history, previous investigations and RAs, along with a detailed description of the ISTT RA activities completed at the site. This FER will serve as the final RA completion report for the ISTT remedy.

1.2 Project Objectives

RAOs are medium-specific goals that the RA is expected to meet to protect human health and the environment and to comply with the applicable or relevant and appropriate requirements. RAOs guide the formulation and evaluation of remedial alternatives. The following RAO was established based on the nature and extent of contamination, the resources that are currently and potentially threatened, and the potential for human and environmental exposure:

- Reduce volatile organic compound (VOC) concentrations in onsite groundwater to below applicable standards, criteria, and guideline (SCG) values to enable the removal of the institutional controls that prohibit groundwater use without treatment and require long-term monitoring from the property deed.

1.3 Organization of the Final Engineer Report

The report is organized as follows:

- Section 1—Introduction
- Section 2—Background
- Section 3—Remedial Action Selection and Design
- Section 4—ISTT Construction and Operation
- Section 5—Post-Remedy Sampling and Site Recommendations
- Section 6—References
- Appendix A—Mc^2 Remedial Design Report
- Appendix B—NYSDEC VCP Fact Sheet
- Appendix C—ISTT Implementation Photographic Log
- Appendix D—Well Abandonment Forms

- Appendix E—ISTT System Component Well Completion Diagrams
- Appendix F—Mc^2 Final Report
- Appendix G—Site Permits
- Appendix H—Analytical Laboratory Reports and Data Quality Evaluation
- Appendix I—Waste Management

SECTION 2

Background

Section 2 presents the site description, operational history of the facility, previous site investigations and RAs, geology and hydrogeology, and the nature and extent of groundwater contamination. The nature and extent of soil contamination is not included in this FER. Previous RA activities have remediated residual soil contamination to the restricted commercial use.

2.1 Site Description

The site is east of Buffalo, New York, at 3311 Walden Avenue in the Village of Depew (Figure 2-1). The site is in a mixed residential and industrial/commercial area. Properties surrounding the site include Walden Avenue to the north, a CSX railroad yard to the south, a lumber yard and supply store (84 Lumber) to the east, and a mattress manufacturer (Buffalo Batt and Felt) to the west. Figure 2-2 provides a site map of facility features prior to the ISTT RA. A residential neighborhood and a former recycling facility (EnviroSense Corp.) are adjacent to the site on the north side of Walden Avenue.

The approximately 1.8-acre site is relatively flat with a gentle downward slope to the north-northwest toward Walden Avenue. Maximum relief across the site (that is, from south to north) is about 4 feet, and surface water flows from south to north across the site. The property is currently vacant, and the ground surface consists primarily of gravel and grass with small- to medium-sized trees on portions of the site. A 6-foot-high chain-linked fence with a locked entrance gate along Walden Avenue surrounds the site.

2.2 Operational History

Former activities at the site included servicing industrial facilities and limited oilfield-related projects. Various industrial cleaning and oilfield-related chemicals were stored onsite and transferred into tank trucks for use at different job sites (URS Corporation 2004). A former railroad siding, which has been removed, traversed the site from east to west. Former onsite building structures included the following: a two-story office building, a chemical storage building, a one-story office/maintenance shop, an acid plant, a bulk cement plant, cement silos, an 8,000-gallon diesel aboveground storage tank, a 1,000-gallon gasoline underground storage tank with dispenser, a mud separator, an oil/water separator, and a hydrochloric acid aboveground storage tank (Figure 2-2). In the late 1980s, operations at the site were discontinued, and the facility was permanently closed. Building structures were razed during the 2003 to 2004 RA, and the site has been inactive since (URS Corporation 2011).

2.3 Previous Site Investigations and Remedial Actions

Site investigations and RAs were performed after site operations were discontinued. A chronology of the previous site investigations and RAs is presented in Table 2-1.

2.4 Geology and Hydrogeology

2.4.1 Geology

Surface soils encountered during the previous RAs at the site consisted of a fill layer composed of poorly sorted sands, silts, clay, gravel, and cinders that are approximately 0 to 4 feet thick. Underlying the fill layer is a regional glacial till deposit approximately 25 feet thick. The till is composed of unsorted clay, silt, fine sand, and fine to coarse gravel that exhibits low permeability. Subtle lithologic variations in the glacial till with depth indicate that two subunits, which have previously been identified in historical reports as the upper and lower units, are present within the till. The upper till is composed of unsorted silty clays and clayey silts that are light brown to brown in color, moist to wet, stiff to very stiff, slight to moderately plastic, and contain little to trace fine-grained sands and subangular to sub rounded glacial erratics (that is, pebbles and cobbles). The upper till transitions to the lower till at a depth of approximately 18 to 20 feet below ground surface (bgs). Similar to the upper till, the lower till is also composed of unsorted silty clays and clayey silts; however, unlike the upper till, the lower till is dark brown to dark grey in color, damp, stiff, slightly plastic, and contains a higher percentage of embedded subangular to subrounded glacial erratics with depth. Underlying the till is the Marcellus and Skaneateles Shale formations (Geraghty & Miller 1990). These rock formations are present throughout the southern half of the Erie-Niagara Basin and locally contain thin interbedded limestones. The Shale formations typically produce small quantities of groundwater ranging from 10 to 15 gallons per minute. The overlying glacial till deposit is an insignificant source of groundwater for the area.

2.4.2 Hydrogeology

Previous site investigation reports identified two independent groundwater units (defined as the upper and lower till units). The upper till unit is unconfined groundwater present in the fill material and upper till, and the lower till unit is confined groundwater in the lower till and upper bedrock. Flow in the upper, unconfined unit is generally to the north-northwest, whereas flow in the deeper, confined lower till/bedrock unit is to the west-northwest. Additionally, in situ hydraulic conductivity testing was performed on selected monitoring wells during previous site investigations to ascertain the hydraulic properties of the upper and lower till units. The slug test data presented a range of hydraulic conductivities that are representative of the clayey till unit, which overlies the bedrock across the site. The average hydraulic conductivity of the glacial till deposit at the time of the investigation was approximately 1.18×10^{-5} centimeters per second (URS Corporation 2003).

Groundwater elevation measurements taken prior to the construction and operation of the ISTT remediation system are presented in Table 2-2. Figure 2-3 presents the potentiometric surfaces for the upper and lower till units as measured in September 2015. The general groundwater flow direction for both lithologic units in relation to the VOC-impacted site monitoring wells (that is, MW-06S and MW-06D) is to the west, which is consistent with past measurements and flow directions (URS Corporation 2013; CH2M 2014 and 2015b).

2.5 Nature and Extent of Groundwater Contamination

Following the completion of the May 2004 RA, a long-term groundwater monitoring program was implemented to monitor VOC-impacted groundwater. Groundwater samples were collected from site monitoring wells quarterly from July 2004 to December 2009 and from September 2011 to July 2013. In June 2009, six injection wells were installed to implement in situ chemical oxidation (ISCO) to reduce VOC concentrations in site monitoring wells MW-06S and MW-06D. Approximately 375 gallons of hydrogen peroxide and sodium persulfate were injected between August and November 2009 (URS Corporation 2010). Analysis of groundwater samples collected from MW-06S and MW-06D between September 2011 and July 2013 indicated that the injection program had minimal impact on VOC concentrations in either site monitoring well. After the completion of the July 2013 sampling event, the long-term groundwater-monitoring program was modified. The sampling frequency was reduced from quarterly to annual sampling, and the monitoring well network was reduced to MW-06S, MW-06D, RW-01, MW-07S, and MW-07D.

Table 2-3 and Figure 2-4 present the analytes detected in groundwater during the June 2014 annual monitoring event. Ten VOCs were detected, and eight VOCs exceeded SCG values at one or more groundwater or recovery well. The eight VOCs exceeding SCG values are 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), total 1,2-dichloroethene (1,2-DCE), chloroethane, cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride (Figure 2-4).

The annual monitoring data indicated that remaining groundwater contamination exceeding SCG values onsite is still limited to the area around monitoring wells MW-06S and MW-06D (CH2M 2014); however, the lateral extent of onsite VOC-impacted groundwater had not been adequately defined to design a remedy for the site. In January and April 2015, CH2M conducted a target treatment zone (TTZ) investigation to define the lateral extent of onsite VOC-impacted groundwater so that a remedy could be selected and designed to address the residual onsite groundwater contamination. The results of TTZ investigation were previously presented in the RAWP (CH2M 2015a) and are included in this Final Engineer Report as Table 2-4 and Figures 2-5 and 2-6. The following key observations and conclusions were made based on the geotechnical and analytical results of the media samples collected during the TTZ investigation:

- Twenty-five VOCs were detected in one or more temporary monitoring well locations, and 14 of those VOCs exceeded their SCG value.
- The 14 VOCs that exceeded their SCG values were 1,1,1-TCA, 1,1-DCA, 1,1-DCE, 1,2-DCA, total 1,2-DCE, acetone, benzene, chloroethane, cis-1,2-DCE, ethylbenzene, tetrachloroethene, trichloroethene, vinyl chloride, and total xylenes.
- The highest VOC concentrations were generally detected in groundwater samples collected from temporary wells (TW-01S, TW-03S, and TW-04D) closest to monitoring wells MW-06S, MW-06D, and RW-01.
- As shown in Figures 2-5 and 2-6, the TTZ was identified based on groundwater results from the TTZ investigation. Based on the extent of SCG exceedances and the RAO, the TTZ was approximately 3,400 square feet and extended from ground surface to the top of bedrock, which is 30 feet deep on average.
- As presented in Table 2-4, the contaminant mass in the TTZ was calculated/estimated to be 9 pounds based on the average 1,1-DCA, chloroethane, and 1,1,1-TCA concentrations in TTZ groundwater. The estimate also accounted for mass sorbed to the soil assuming equilibrium conditions. Using the maximum concentrations of the same constituents, the maximum contaminant mass in the TTZ was estimated to be 56 pounds. The contaminant mass was calculated so that remediation vendors could select the appropriate media treatment approach given the possible remedial technologies that were under consideration.

Results of the September 2015 annual monitoring event are discussed in Section 4.1.2.

SECTION 3

Remedial Action Selection and Design

3.1 Remedial Action Selection

Given the RAO and the nature and extent of site contaminants, the following remediation technologies were considered for the TTZ RA:

- Excavation
- ISTT
- Soil mixing using ISCO
- Air sparging with soil vapor extraction (SVE)
- Enhanced reductive dechlorination (ERD) or ISCO by hydraulic fracturing

Soil mixing with ISCO, air sparging/SVE, and hydraulic fracturing (with either ISCO or ERD) were rejected because each technology provided only moderate treatment confidence given the geologic and hydrogeologic site conditions (for example, challenges in distributing and mixing reagents in the tight aquifer matrix) and/or would be expected to take multiple years to reach treatment goals.

Both excavation and ISTT were considered to provide high treatment confidence. Ultimately, ISTT was selected for the site because excavation would have a much higher level of community disruption, increase liability from transporting contaminated material, and pose more potential hazards during implementation.

3.2 Description of the Selected Remedial Technology and Selection of the ISTT Vendor

Thermal technologies involve the input of energy to the subsurface to raise the temperature and achieve contaminant removal by a combination of factors, including increasing the contaminant vapor pressure (to cause volatilization) and increasing the microbial metabolic rate (to enhance biodegradation). The most common methods for subsurface heating include technologies based on electrical resistance heating (ERH) or thermal conductive heating (TCH) principals, the latter of which is sometimes referred to as in situ thermal desorption. Regardless of the heat delivery method, the propagation of heat is the driving force for contaminant removal from groundwater and soil. Heat transfer in the subsurface can occur by convection, conduction, and/or radiation. Convection and conduction processes dominate subsurface heat transfer; therefore, technologies incorporating these two mechanisms are the most commonly applied for thermal remediation.

The application of heat significantly accelerates the mobilization and removal of residual VOCs from the subsurface. Heating the subsurface to temperatures around the boiling point of water can lead to significant changes in the thermodynamic conditions in the subsurface and can mobilize many organic contaminants to enhance subsurface removal processes.

Both ERH and TCH were considered viable options for the site remediation. In July 2015, a bid walk was conducted by CH2M, and select thermal venders in attendance were given the opportunity to bid on the upcoming ISTT RA using either ERH or TCH. In August 2015, after completing an evaluation of the thermal vendor proposals, the ISTT RA fieldwork was awarded to McMillan-McGee Corporation (Mc^2), a Canadian-based thermal remediation vendor that specializes in using Electro Thermal Dynamic Stripping Process (ET-DSP), which is its version of ERH.

3.3 ISTT Remedial Design

In September 2015, CH2M and Mc^2 personnel mobilized to the site to collect predesign soil samples so that Mc^2 could conduct electrical resistivity testing to support the ISTT remedial design (RD). Parratt-Wolff Inc. (PW) advanced two soil borings within the TTZ using a direct-push technology (DPT) drill rig. Each soil boring was advanced to approximately 24 feet bgs, and soil samples were collected from discrete sample intervals using a DPT sample core barrel lined with a 2-inch-diameter acetate liner. Upon retrieval, the sample liners were cut open, capped, and duct-taped (to retain soil moisture content), placed in a sample cooler, and shipped to Mc^2's laboratory for electrical resistivity testing. The resistivity testing data were used to calculate the general power requirements of the ET-DSP. Specifically, the Static Resistivity Test was conducted to estimate the electrical resistivity of the test material at ambient temperature while the Dynamic Resistivity Test was conducted to estimate the electrical resistivity of the test material as the temperature increases towards a maximum.

The resistivity testing data were then used to conduct an electro-thermal simulation study. The objective of the simulation study was to develop a subsurface numerical model of the site using ERH in conjunction with a multi-phase extraction (MPE) treatment system. The results of the numerical model were used as the basis for the ISTT system design elements and operating strategy for the ISTT remediation system at the site. A copy of the RD report prepared by Mc^2 is provided in Appendix A.

SECTION 4

ISTT Construction, Operation, and Decommissioning

Section 4 documents the ISTT construction, operation, and decommissioning activities performed during the ISTT remedy. ISTT RA activities were conducted from September 2015 to December 2016 in general accordance with the RD and RAWP (CH2M 2015a). Some modifications to the RD and RAWP implemented based on the site conditions encountered during installation of ISTT system components and operation of the ISTT remediation system. The various phases of work and modifications to the RD and RAWP are discussed in the following subsections.

4.1 Preconstruction Activities

4.1.1 Notifications

At the request and in consultation with NYSDEC, CH2M assisted NYSDEC in the construction and distribution of a NYSDEC VCP fact sheet for the site. The purpose of the fact sheet was to advise the adjacent property owners and local community of the upcoming RA activities scheduled to be conducted at the site and to provide the local community with NYSDEC contact information should questions arise during implementation of the remedy. A copy of the NYSDEC VCP fact sheet prepared by NYSDEC and CH2M is provided as Appendix B.

4.1.2 Pre-remedy Groundwater Sampling

Pre-remedy groundwater samples were collected on September 11, 2015, from the existing site monitoring wells (that is, MW-06S, MW-06D, MW-07S, MW-07D, RW-01, and RW-02) to establish a baseline for evaluating the remedy's effectiveness. Table 2-3 presents the analytes detected in groundwater during the June 2014 annual monitoring event, and Table 4-1 presents the analytes detected in groundwater during the September 2015 baseline event. Differences in groundwater VOC concentrations between the June and September 2015 sampling events may be attributed to seasonal fluctuations. VOC contaminant mass detected in the pre-remedy groundwater samples will be discussed later in this report.

4.1.3 Site Survey

Prior to the commencement of ISTT RA activities, Thew Associates, a New York State-licensed surveyor, staked each ISTT wellfield feature prior to the installation of ISTT components. Stakes were placed in accordance with the ISTT wellfield diagram included in the RD report (Appendix A). A photograph of the survey stakes is provided in Appendix C.

4.1.4 Site Preparation and Mobilization

CH2M and Mc^2 personnel mobilized to the site and began site setup in early October 2015. Temporary storage containers and facilities were established to facilitate various construction activities. ISTT system components were delivered to the site as work proceeded through the various phases of construction. Photographs of the delivery of ISTT system components are provided in Appendix C.

4.1.5 Well Abandonment and Perimeter Fence Post Replacement

Prior to ISTT construction activities, some existing site features were removed and/or modified to facilitate the installation of the ISTT system components. Modification to existing site features included the abandonment of existing site monitoring (MW-06S, MW-06D, and RW-01) and injection (IW-01S, IW-02S, IW-03S, IW-04D, IW-05D, and IW-06D) wells within the TTZ and the replacement of metal chain-linked fence posts with wooden posts. Photographs of the abandonment of wells within the TTZ are provided in Appendix C.

The existing polyvinyl chloride (PVC) site monitoring and injections wells within the TTZ required abandonment because they would melt during ISTT implementation. Wells were properly plugged and abandoned by PW, a New York State-licensed well driller, in accordance with NYSDEC regulations. Abandoned wells are presented in Figure 4-1, and the well abandonment form for each abandoned monitoring well is included in Appendix D.

The replacement of the metal chain-linked fence posts with wooden posts was a safety and ISTT system performance requirement that was completed to prevent the metal posts from interfering with the electrical currents being introduced into ground during ISTT system operation and protect the site workers and the community.

4.2 Phase I—ISTT Underground System Construction

4.2.1 Vertical Wells

Under Mc^2 and CH2M oversight, PW completed drilling activities in October 2015. Drilling activities consisted of installing electrodes, MPE wells, and temperature monitoring sensor (TMS) wells. Two hollow-stem auger (HSA) drill rigs were used to install the vertical ISTT system components at the site.

4.2.1.1 Borehole Advancement and Completion

Per the RD, soil borings were advanced down to the top of bedrock, which ranged from 26.5 to 31 feet bgs. Though generally in accordance with the RD, minor variations to the position of some ISTT system component boreholes were required due to the presence of existing subsurface features like buried building footers. CH2M and Mc^2 field personnel consulted with the Mc^2 RD team to confirm that the proposed modifications would not significantly alter the overall design and performance of the system.

Electrode, MPE, and TMS well construction details are provided in Sections 4.2.1.2 through 4.2.1.4. Photographs of the construction and installation of the electrodes, MPE wells, and TMSs are provided in Appendix C. Figure 4-2 presents the constructed locations of the ISTT wellfield components.

4.2.1.2 Electrodes

Each of the 8-inch-diameter electrodes were constructed by Mc^2 in Calgary and then shipped to the site. Mc^2 personnel connected electrical lead wires and water circulation lines to each electrode prior to installation into its borehole. Electrodes were double-stacked in each borehole and placed on 18.5-feet centers in a triangular pattern to optimize heating of the TTZ and minimize the formation of cold zones (Figure 4-2).

Installed electrodes were either 5 or 10 feet long. Typically, 10-foot electrodes were installed in each of the 22 electrode boreholes as the bottom “deep” electrode, and then another 10-foot or 5-foot electrode was installed as the top “shallow” electrode. The actual depth of each “deep” and “shallow” electrode was a function of the bedrock depth and the established design criteria.

Annular space between the electrode and the borehole wall was backfilled with 20/40 silica sand from the bottom of the borehole to approximately 1 to 2 feet bgs (exact depth varied for each electrode borehole). Each borehole was then backfilled with one bag of “fine” 10/20 silica sand to approximately 1 foot bgs, and Portland Cement grout to the surface. Electrode lead wires and water circulation lines were left exposed at the surface for connection to the ISTT aboveground system components.

Each electrode was assigned an identification number that was noted on the completion diagram as it went into the boring. Electrode well completion diagrams are provided as Appendix E.

4.2.1.3 Multi-Phase Extraction Wells

The spacing of the 4-inch-diameter MPE wells was based on the 22-foot capture radius specified in the RD (see Figure 4-2). Like the electrodes, the depth of the 15 MPE wells depended on the actual bedrock surface in the TTZ. When possible, a carbon steel sump was welded to the bottom of each stainless-steel well screen so that suspended materials could collect in the sumps during ISTT system operation and minimize clogging of the well screens. MPE well screens were installed from the bottom of each borehole to approximately 2.5 feet bgs (exact depth varied for each MPE well). A solid section of carbon steel casing was threaded onto each MPE well screen to complete the MPE well above the ground surface (approximately 2.5 feet above ground surface).

Annular space between the borehole and the well screen was filled with “fine” 10/20 silica sand to approximately 1 foot bgs. Portland Cement grout was placed above the sand pack to backfill the borehole to ground surface.

Each MPE well was assigned an identification number that was noted on the well completion diagram during construction. MPE well completion diagrams are provided as Appendix E.

4.2.1.4 Temperature Monitoring Sensor

The locations of the 2-inch-diameter TMS wells are shown in Figure 4-2. The TMS wells were installed to collect temperature data during ISTT system operation. Like the electrodes and MPE wells, the depth of the seven TMS wells depended on the actual bedrock surface in the TTZ. TMS wells consisted of 2-inch threaded black carbon steel pipe that was grouted in place to ground surface. Once constructed, a 10-sensor string of Digital Temperature Acquisition Module (digiTAM) temperature sensors was installed in each TMS well location.

Each TMS well was assigned an identification number that was noted on the well completion diagram during construction. TMS well completion diagrams are provided as Appendix E.

4.2.2 Horizontal Soil Vapor Extraction Wells

Four trenches were dug in select locations within the TTZ in accordance with the RD (Figure 4-2). In general, the four trenches were 1 to 2 feet deep and varied based upon the presence of existing subsurface features like former building footers. Within each trench, Mc^2 constructed a horizontal SVE well. Each SVE well consisted of a 2-inch-diameter, 25-foot-long fiberglass screen that was connected to a central riser pipe. Once constructed, each SVE well was placed within each trench and enclosed in 10/20 silica sand prior to the installation of the vapor cap discussed in Section 4.2.3.

4.2.3 Electrode Electrical Testing and Vapor Cap Installation

After drilling activities were complete, but prior to the installation of a concrete vapor cap, Mc^2 re-tested each electrode to verify that the electrical leads were properly connected and functional. Once each electrode lead was confirmed to be in proper working order in late October 2015, Elastizell Systems, Inc. installed a concrete vapor cap with an R-value of approximately R6 over the entire TTZ (Figure 4-2). Per the RD, the vapor cap extended beyond the footprint of the TTZ along the western, southern, and eastern edges to prevent fugitive emissions from escaping the subsurface and entering into the atmosphere, minimize energy losses during system operation, prevent air from being drawn into the

fluid extraction system, and promote the positive drainage of rainwater away from the TTZ.
The northern edge of the vapor cap was restricted by the property boundary and could not be extended.

4.3 Phase II—ISTT Aboveground System Construction

Mc^2, MK Environmental (a subcontractor to Mc^2), and New York State Electric and Gas (NYSEG) constructed and installed ISTT aboveground system components from November 2015 through January 2016.

Prior to the delivery and installation of ISTT aboveground system components, a 60-foot by 80-foot area, immediately east of the ISTT wellfield, was prepared for construction activities. Preparation work included the delivery, placement, and compaction of crushed gravel to serve as the base foundation on which the ISTT aboveground system components were later constructed.

ISTT aboveground system components were delivered to the site via flatbed trucks, offloaded, and placed at their designated locations using a truck-mounted crane. Construction and placement of ISTT aboveground system components were performed in accordance with the health and safety plan included in the RAWP (CH2M 2015a). Photographs of the delivery and the placement of ISTT aboveground system components are provided in Appendix C. Figure 4-3 presents the ISTT aboveground system components.

4.3.1 ET-DPS System

A new high-voltage (664 kilovolt-ampere) electrical feed was installed onsite by NYSEG to supply electricity to the ET-DSP system. Prior to installation, the plans and specifications for the electrical services were provided by Mc^2 to NYSEG for review and approval.

Installation of the ET-DSP system components consisted of the placement of a main electrical panel, a power distribution panel, two power distribution system (PDS) units, and two water circulation system (WCS) units. Installed electric cables connected power to ET-DPS system components. In accordance with the RD, the electrical current went from the offsite power lines to the onsite transformers, to the main power panel, to the power distribution panel, to the PDS and WCS units, and then to the underground electrodes (Figure 4-3).

Electrodes in rows E-A, E-B, and half of row E-C, as shown in Figure 4-2, were connected to PDS and WCS units A as shown in Figure 4-3, and electrodes in rows E-D, E-E, and half of row E-C were connected to PDS and WCS units B. Each PDS and WCS unit controlled electrical power and water circulation to 22 electrodes and were equipped with time-distributed control capabilities so that they could be controlled remotely over the internet via an onsite server and offsite server controlled by Mc^2. Each PDS unit contained multiple Emergency Shutdown Devices (ESDs) to ensure worker safety during system operation and maintenance.

Additional ET-DSP system component details are provided in Appendixes A and F.

4.3.2 Multi-Phase Extraction Treatment System

MK Environmental provided and installed the MPE treatment system components. This included the placement of a liquid and vapor knockout tank, a groundwater treatment unit, process water transfer tanks, a temporary groundwater storage tank, a vapor chiller unit, and a vapor treatment unit.

A high-density polyethylene conveyance piping manifold was then constructed above the ISTT wellfield. PVC lines were installed on the MPE and SVE wellheads and the conveyance piping manifold to connect the wellfield components to the aboveground MPE treatment system components. In accordance with the RD, system components were constructed so that extracted liquids and vapors flowed from the MPE and SVE wells through the conveyance piping to the knockout tank where liquids and vapors were separated and conveyed to their respective treatment system units for treatment and discharge.

Additional MPE treatment system component details are provided in Appendixes A and F.

4.4 Phase III—Operation of the ISTT System

4.4.1 Permits

Upon receiving NYSDEC-approval of the RAWP, CH2M and Mc^2 consulted with multiple local and state regulatory and municipal agencies to obtain the necessary permits to operate the ISTT remediation system as follows:

- On December 29, 2015, an underground injection control permit (for the reinjection of treated groundwater into the TTZ to keep the ISTT electrodes moist during operation) was received from the U.S. Environmental Protection Agency (USEPA) Region 2.
- On February 18, 2016, prior to operating the ISTT system, CH2M obtained a publicly owned treatment works (POTW) discharge permit (for the discharge of treated groundwater to a local offsite storm sewer manhole) from Erie County Sewer District No. 4.
- Approval was granted to begin using 45 percent glutaraldehyde microbiocide in the holding tank at the facility to treat biofouling as follows: May 24, 2016, from Erie County Sewer District No. 4; May 25, 2016, from NYSDEC; and July 8, 2016, from USEPA.

A copy of each approved permit is presented in Appendix G.

In consultation with NYSDEC and New York State Division of Air, CH2M determined that the discharge of treated VOC vapors from the vapor treatment unit portion of the treatment system qualified as a “trivial activity” as defined under Section 6 CRR-NY 201.3.3. As such, an air permit was not required and therefore not obtained. Documentation regarding the applicability of an air permit for operation of the MPE treatment system is included in Appendix G.

4.4.2 ISTT Acceptance Testing and System Initiation

ISTT acceptance testing was performed in December 2015 after ISTT system components were installed. In general, acceptance testing involved the following:

- Verification that the computer controller was communicating properly with system components.
- Verification that the ESDs were functional and properly communicating with both the onsite and offsite server controls.
- Measurement of the resistive load between electrodes to make sure that the loads were within design parameters.
- Balancing of the phase currents entering into the system, and confirming that induced surface potentials did not exceed 15 volts (threshold established by National Electric Code).

Initial startup (that is, commissioning) of the ET-DSP and testing of the MPE treatment system was performed in early February 2016 after NYSEG provided power to the site. ISTT commissioning involved testing various ISTT components to verify that each component operated safely and within the design parameters and establishing pneumatic and hydraulic control of the TTZ. The ET-DSP ISTT system startup began on February 22, 2016, after pneumatic and hydraulic control were established.

Mc^2 and MK environmental personnel stayed onsite for several days during initial start-up to make minor system adjustments and to train a local operator on system operations. A local operator (Ontario Specialty Contracting Inc.) was trained to monitor the system and make system adjustments as directed. Local operator duties included collecting manual flow readings and completing an operator checklist.

4.4.3 ET-DSP System Operation and Optimization

Subsurface heating of the TTZ was achieved by passing electric currents from the PDS units through the electrodes in the subsurface to generate heat. In addition to the introduction of electric currents, treated water from the WCS units was injected into each electrode at the design rate of 0.1 gallon per minute to prevent the electrodes from drying out and to promote uniform heating throughout the TTZ.

As the TTZ heated up, Mc^2 representatives remotely monitored system operation by logging into a website they designed to monitor the system. In some cases, the Mc^2 representatives were able to make changes to the system remotely without having to send an operator to the site. When adjustments could not be made remotely, Mc^2 representatives dispatched an onsite operator to make systematic adjustments to ISTT and MPE treatment system components.

Key optimization adjustments performed during initial heating included the following:

- Monitoring of power levels of electrodes and adjusting voltage tap settings on PDS unit transformers.
- Verifying that the hydraulic balance is maintained within the subsurface.
- Verifying that there were no leaks within the MPE treatment system conveyance lines and units.
- Adjusting blower speed to maintain target vapor recovery rates.
- Confirming that the electrode slurper tube assemblies (an essential component of the WCS units) were producing sufficient treated groundwater to keep the electrodes moist.

On average, temperatures within the TTZ rose approximately 1 to 2 degrees Celsius (°C) a day, and the average target temperature of 100°C was achieved at most TMS locations on May 12, 2016 (81 days into system operation). The average target temperature was maintained from May 12 to July 18, 2016. Temperature lags and fluctuations after July 18, 2016, were due to adjustments of the power delivery, desiccation of electrode wells, and down time for sampling, maintenance, and precipitation events. Figure 4-4 shows the average temperature within the TTZ during ISTT operations.

Subsurface heating operations lasted a total of 240 days, ending on October 19, 2016, 60 days longer than anticipated in the Remedial Design Report (Appendix A).

4.4.4 Treatment System Operations

Extracted vapors and liquids were conveyed from the MPE wells through the conveyance pipe to specialized treatment units where vapors and liquids were separated and treated as follows:

- **Vapor Treatment**. Vapors flowed into the liquid and vapor knockout tank where vapor then passed through a series of heat exchangers before entering into a second knockout tank to remove as much of the liquid stream as possible; the separated liquid stream was diverted to the liquid treatment process discussed below. Vapors were then cooled using a refrigerated glycol unit to a temperature suitable for carbon absorption. The cooled vapors then passed through a series of two 750-pound vapor-phase granular activated carbon (GAC) vessels to remove volatized VOCs before being vented into the atmosphere.
- **Liquid Treatment.** Liquids from the multi-phase streams were combined with extracted groundwater before being passed through an oil-water separator, which was used to remove nonaqueous phase liquid, if it had been present. The liquid was then pumped through a tray air stripper to remove dissolved VOCs before being pumped into a 21,000-gallon temporary holding tank. Before the treated water was reinjected into the electrodes or discharged to the offsite sanitary sewer manhole, it was pumped from the holding tanks through two bag filters, to remove

suspended solids, and finally pumped through a series of two 1,000-pound liquid-phase GAC vessels to remove volatilized VOCs.

Approximately 1.2 million gallons of treated groundwater was reinjected into the electrodes during ISTT system operation at an average injection rate of 3.5 gallons per minute. An additional 133,590 gallons was discharged to a local offsite sanitary sewer manhole in accordance with the POTW discharge permit.

4.4.5 ISTT System Monitoring

Several parameters were monitored to assess system performance and compliance. Key parameters included ground temperature, energy use, vapor quality, water quality, and in situ VOC concentrations through performance soil and groundwater sampling (Section 4.4.6). Temperature and energy use were used to assess the overall system progress, particularly as compared to the RD; the vapor, water, and soil results were used to estimate VOC mass removal from the site and to estimate the timeframe in which the system needed to operate to achieve the RAO. These are discussed in the following subsections.

4.4.5.1 Temperature Monitoring

Variability in the permeability of the TTZ resulted in greater vertical and lateral groundwater recharge in some areas of the TTZ, which in turn resulted in higher extraction rates, higher thermal energy input, and greater fluctuations in average temperatures with depth. Differences in the average temperature of the depth intervals monitored during ISTT operation are presented in Figure 4-5. The lower-than-anticipated average temperatures for the 674 to 680 feet above mean sea level interval (interval closest to the surface) was primarily attributed to the lateral infiltration of cool water from precipitation events infiltrating through the sidewalls of the TTZ.

Mc^2 remotely monitored the ISTT wellfield temperature and made daily adjustments to power and water inputs throughout the operation of the system. With the exception of the variability of the TTZ permeability, the monitored temperatures closely resemble the design temperature curves presented in the RD.

4.4.5.2 Energy Use

Energy input into the ISTT system is a function of soil resistivity, the spacing of electrodes, the effectiveness of the convective heat transfer (steam injection from the electrodes), and the rates of extraction. A total of 1,497,200 kilowatt-hours (kW-Hr) of energy was directed into the subsurface during the 240-day operation period. As presented in Figure 4-6, more energy was required overall to keep the shallow electrodes and the corresponding shallow TTZ depth intervals above the targeted average temperature than the deep electrodes and the corresponding deep TTZ depth intervals.

The actual total amount of energy used was greater than the design power consumption (1,281,100 kW-Hr) presented in the RD. The additional inputted energy was used to prevent heat loss from influx of cool groundwater from laterally entering into the TTZ along the eastern side of the TTZ and to extend system operations an additional 63 days beyond what was anticipated in the RD (extended ISTT system operations is discussed in Section 4.4.6).

4.4.5.3 Vapor Monitoring

Photoionization detector (PID) readings and flow measurements were collected by the onsite operator daily throughout heating operations to assess the performance of the MPE treatment system. Vapor monitoring was typically conducted biweekly from March to August 2016 on the influent vapor stream to assess VOC mass removal from the TTZ subsurface and on the effluent vapor stream to monitor the efficiency of the GAC removal and to determine when breakthrough occurred. Influent and effluent grab vapor samples were collected immediately before and after the vapor-phase GAC units using a PID and Tedlar bags for quick field analysis and SUMMA canisters for VOC laboratory analysis by USEPA Method TO-15.

The results from the influent and effluent samples are provided in Table 4-2 and are shown in Figures 4-7 and 4-8. Analytical laboratory reports and the data quality evaluation for the vapor monitoring samples are provided in Appendix H. As the TTZ subsurface temperature neared the design target temperature of 100°C, the influent vapor concentration peaked on May 6, 2016 (75 days into operation). After that point, the influent vapor concentrations gradually decreased by more than an order-of-magnitude as the design target temperature was maintained for the duration of the treatment period. Effluent VOC vapor concentrations were several orders-of-magnitude lower than influent concentrations throughout system operation. As a result, no vapor-phase GAC changeout was required.

Mc^2 used the laboratory data to calibrate PID and flow measurements and to estimate the contaminant mass removed from the wellfield (Appendix F). The total VOC mass removed in the vapor phase throughout system operation was calculated to be 65.9 pounds with and 6.8 pounds without acetone. Because acetone is a temporary byproduct of thermal remediation, the estimated VOC mass totals included in this report are provided both inclusive and exclusive of acetone.

4.4.5.4 Water Monitoring

Similar to vapor monitoring, water monitoring was conducted biweekly from March to August 2016. Influent water samples were collected to assess VOC mass removal from the TTZ subsurface. Effluent water samples were collected to verify that the treatment system was operating effectively and that the treated groundwater discharged to the local offsite sanitary sewer manhole was in compliance with the POTW discharge permit. Influent groundwater samples were collected immediately before the air stripper and effluent groundwater samples were collected for VOC analysis by Method 8260C after the liquid-phase GAC units using standard volatile organics analysis vials.

The results from the influent and effluent samples are provided in Table 4-3 and are shown in Figures 4-9 and 4-10. Analytical laboratory reports and the data quality evaluation for the water monitoring samples are provided in Appendix H. The influent liquid VOC concentrations peaked on April 8, 2016 (47 days into operation) and then gradually decreased to below laboratory detection limits as the system continued to operate. Effluent liquid VOC concentrations were either several orders-of-magnitude lower than influent concentrations or below laboratory detection limits throughout system operation. As a result, no liquid-phase GAC changeout was required.

Mc^2 used the laboratory data to estimate the contaminant mass removed from the wellfield (Appendix F). The total VOC mass removed in the liquid phase during system operation was estimated to be 5.2 pounds with and 0.2 pound without acetone.

4.4.5.5 Mass Removal Based on Influent Treatment System Sampling

The total estimated VOC mass removed based on treatment system measurements and analytical data is approximately 71 pounds (including acetone; Figure 4-11, Graph A) or 7.0 pounds (excluding acetone; Figure 4-11, Graph B).

As presented in Figure 4-11 (Graph A), contaminant mass removal (including acetone) gradually increased (between May and June) once average target temperatures were achieved within the TTZ subsurface. Contaminant mass removal peaked in mid-June before leveling off and plateauing in early August 2016. As presented in Figure 4-11, Graph B, when acetone is excluded from the cumulative mass removal, the mass removal gradually increases between April and August before leveling off.

4.4.6 ISTT System Performance Sampling

Soil and groundwater (when present) sampling within the TTZ was completed after 4, 7, and 9 months (June, August, and October 2016) of treatment to assess ISTT effectiveness and to help estimate when to shut down the system (by comparing results against SCG values). Soil and groundwater sample locations for 4, 7, and 9 months of operation are shown in Figures 4-12, 4-13, and 4-14, respectively.

4.4.6.1 Interim Sampling (June 2016)

Soil and groundwater samples were collected using a DPT drill rig at select locations within the ISTT wellfield to confirm soil temperature readings in the subsurface and to measure residual VOC concentrations. The following procedures were used to collect the samples:

- Soil cores were analyzed with a portable temperature gun as the soil cores were extracted from the subsurface.
- Soil cores within the stainless-steel sleeves were extracted from the DPT sample barrel, capped using tape and plastic caps, and cooled using ice to prevent volatilization.
- Soil core temperatures were periodically monitored to determine when soil cores reached ambient temperature (approximately 10 minutes) permissible for sample collection.
- After cooling, soil cores were screened with a PID. Soil samples were collected where VOCs were detected with the PID or from the middle of the 4-foot sample core using a TerraCore sampler kit. Samples were then hand-delivered to TestAmerica Laboratories, Inc., in Buffalo and analyzed for VOC analysis.
- Immediately after extracting the DPT soil core barrel, each borehole was checked to see if the borehole stayed open and whether sufficient groundwater was present to collect a groundwater grab sample. If groundwater was present, then tubing connected to a peristaltic pump was lowered down the borehole. Hot groundwater was pumped from the borehole into tubing that passed through an ice bucket bath to the appropriate sample bottleware. Samples were then hand-delivered to TestAmerica Laboratories, Inc., in Buffalo and analyzed for VOC analysis.

Soil and groundwater sample locations are presented in Figure 4-12. Sample locations SB-01, SB-02, and SB-04 were chosen based on their proximity to historical VOC groundwater detections. Sample location SB-03 was chosen because of its accessibility and proximity to the edge of the TTZ. Analytical results from the interim sampling event are provided in Table 4-4, and analytical laboratory reports and the data quality evaluation are provided in Appendix H. Multiple soil samples were collected from various sample depth intervals. Only one borehole stayed open (SB-03); therefore, only one groundwater grab sample was collected. The analytical results from both the interim soil sampling event and the bimonthly operation sample collection indicated that while the ISTT system had made significant reductions in VOC concentrations, mass removal had not reached asymptotic levels, and concentrations in both media continued to exceed remediation goals established in the RAWP. As a result, ISTT system operation continued.

4.4.6.2 Confirmation Sampling (August 2016)

An ISTT system performance confirmation sampling event was conducted in mid-August 2016 after diminished returns were observed in the influent biweekly liquid and vapor treatment monitoring samples. Performance confirmation samples were collected in the same manner as those collected during June 2016 Interim sampling event.

Soil and groundwater sample locations are presented in Figure 4-13. Sample locations were chosen by CH2M to confirm that the ISTT performance goals and the RAO were achieved across the TTZ. Two soil samples were collected from various sample depth intervals at each sample location. Groundwater grab samples were collected when water was present. Analytical results from the performance confirmation sampling event are provided in Table 4-5, and analytical laboratory reports and the data quality evaluation are provided in Appendix H. The analytical results indicated that the ISTT performance goals and RAO were achieved, except in the northeast corner of the TTZ.

Based on a review of the temperature data, the northeast corner of the TTZ was inconsistently heated, likely as a result of cool groundwater influx, and it was possible that temperature targets were not sustained throughout the entire operating period. As a result, an extended operations plan was developed (Section 4.4.6.3) to continue to target the northeast corner of the TTZ and closely monitor temperatures.

Because the goals had been achieved in the rest of the TTZ, electrodes in rows C, D, and E and extraction from wells in rows B, C, and D were suspended on August 30, 2016 (Figure 4-2).

4.4.6.3 Extended ISTT System Operations Sampling

Power to electrodes E-A-3, E-A-4, and E-B-4 and extraction from MPE wells in row A continued until October 2016. The objective was to use additional heating and extraction to achieve the ISTT performance goals and the RAO in the northeastern corner of the TTZ. To assess the effectiveness of the additional heating, temperature monitoring sensor TMS-D3 was placed in MPE well X-A-3 to confirm that temperatures in that portion of the site would mobilize/destroy the residual contaminant mass. Additionally, vapor and liquid samples were collected from MPE well X-A-3, twice weekly to evaluate the progress of the extended ISTT system operations.

Analytical results from the extended ISTT system operations are provided in Table 4-6, and analytical laboratory reports and the data quality evaluation are provided in Appendix H.

4.4.6.4 Confirmation Sampling (October 2016)

A second ISTT system performance confirmation sampling event was conducted on October 6, 2016, after temperatures conducive to removing residual VOCs were maintained and liquid and vapor monitoring samples taken from MPE well X-A-3 indicated mass recovery was asymptotic. Performance confirmation samples were collected in the same manner as those collected during the June and August 2016 sampling event.

Soil and groundwater sample locations are presented in Figure 4-14. Sample locations SB-10 and SB-11 were chosen because of their proximity to the August 2016 sampling location SB-03 and electrode E-A-4. Analytical results from the performance confirmation sampling event are provided in Table 4-7, and analytical laboratory reports and the data quality evaluation are provided in Appendix H.

4.4.7 Remedy Evaluation

Performance confirmation sampling performed in August and October 2016 (discussed in Section 4.4.6.2 and 4.4.6.4) indicate that the ISTT was successful in removing the bulk contaminant mass residing within the TTZ.

Confirmation soil sampling results indicate that the detected VOC concentrations within the TTZ are below the unrestricted-use soil SCG value for each sample location at each sample depth, with the exception of sample location SB-03 (collected in August 2016) at a sample depth of 14.5 feet bgs. The vinyl chloride concentration at SB-03 was just above the unrestricted-use soil SCG value (24.5 versus 20 micrograms per kilogram) and well below the vinyl chloride commercial soil SCG value of 13,000 micrograms per kilogram, which is the current restricted use of the site.

Extended ISTT system operations and the October confirmation groundwater sampling indicated that vinyl chloride and cis-1,2-DCE only slightly exceeded their respective groundwater SCG value and that these exceedances were restricted to a small portion of the TTZ. Coupled with the soil results and asymptotic mass recovery, it was no longer cost effective to continue ISTT operations. As a result, the heating of electrodes E-A-3, E-A-4, and E-B-4 and extraction from MPE wells in row A were suspended on October 19, 2016, ISTT operation ceased, and the system was readied for decommissioning. Vinyl chloride and cis-1,2-DCE groundwater concentrations are expected to attenuate and decrease to below groundwater SCG values as the TTZ cools down and the indigenous dechlorinating microorganisms are able to re-establish within the TTZ.

4.5 Phase IV—ISTT System Decommissioning

4.5.1 System Decommissioning

The ET-DSP system and MPE treatment system was decommissioned between October 20, 2016, and December 5, 2016, by CH2M, Mc^2, MK Environmental, and other lower-tier Mc^2 subcontractors. System decommissioning activities included the following tasks:

- Aboveground ISTT Infrastructure
  - Removal and disposal of water hoses and winter insulation.
  - Removal, decontamination, and disposal of MPE and SVE piping.
  - Disconnection and decontamination of extraction wellheads and instrumentation.
  - Removal, decontamination, and disposal of water circulation and MPE conveyance piping.
  - Disconnection and spooling of electrical cables, electrode wires, grounding wire, and communication cables associated with ET-DSP system components.
  - Removal, decontamination, and prepping of transfer pumps, TMSs, alarm sensors, and other reusable thermal treatment equipment for offsite transport.
  - Disconnection and decontamination of MPE treatment system components.
  - Loading of ET-DSP system components and MPE treatment units onto flatbed trucks for offsite transport.
  - Final discharge of water to the POTW offsite local sanitary sewer manhole.
  - Decontamination and removal of the treated groundwater temporary storage tank.
  - Removal of temporary electrical power drop (onsite transformers and connection leads).
- Belowground ISTT Infrastructure
  - Subsurface abandonment of electrodes. Abandonment of electrodes consisted of cutting and capping electrical leads and WCS hoses and grouting up surface depressions (if present).
  - Abandonment of MPE and TMS well locations. Abandonment of MPE and TMS well locations consisted of pulling well casing and tremie grouting down the boreholes until the grout reached the surface. Abandonment of SVE wells consisted of pumping grout down the central riser pipe until the grout reached the surface and then pulling the central riser pipe.
  - Conversion of MPE well locations X-A-1, X-A-3, and X-C-3 into post-remedy monitoring sample locations. Conversion included cutting out vapor cap pad and installing a lockable steel protective surface casing.
- Site Restoration
  - Removal and offsite disposal of the ISTT vapor cap.
  - Re-grading of the area formerly covered by the vapor cap.
  - Removal of the privacy mesh from the property fence.
  - Offsite disposal of general trash and debris.

4.5.2 Waste Management

To the maximum extent possible, system components (temperature sensors, vacuum and temperature gauges, fittings, and wellhead components, electrodes, and pumps) were salvaged, decontaminated, and shipped offsite for reuse by Mc^2 and MK Environmental. The following is a summary of the waste generated during ISTT system installation, operation, and decommissioning:

- Soil cuttings generated during the installation of the underground ISTT system components were placed in temporary rolloff containers. At the conclusion of drilling activities, waste characterization samples were collected from the rolloff containers to facilitate offsite disposal. Based on the analytical results of the waste characterization samples, the soil cuttings were classified as nonhazardous, and the waste was transported offsite and disposed of at a local landfill. The waste profile and signed manifests for the soil cutting rolloffs are provided in Appendix I.
- General trash, personal protective equipment, hoses, shipping materials, and other unusable waste generated during construction and installation of the ISTT system was considered nonhazardous. One rolloff container (approximately 2 tons) was shipped to and disposed of at a local municipal landfill.
- Decontamination water used during the decommissioning of the ISTT system components was pumped through the liquid-phase GAC before being discharged to the offsite local sanitary sewer manhole.
- During ISTT decommissioning, a waste characterization sample was taken of the sludge within the liquid and vapor knockout tank. The sludge accumulated inside the knockout tank during ISTT system operations. The waste characterization sample results indicated that the material was nonhazardous. The sludge was vacuumed out of the tank and taken offsite to a local processing plant for disposal. The waste profile and signed manifest for the sludge are provided in Appendix I.
- During ISTT decommissioning, a waste characterization sample was taken of the vapor-phase and liquid-phase GAC vessels. The waste characterization sample results indicated that the GAC was nonhazardous. The GAC was vacuumed out of each treatment vessel and taken offsite to a local processing plant for disposal or regeneration. The waste profile and signed manifest for the GAC are provided in Appendix I.
- The vapor cap was broken up into manageable pieces and stockpiled onsite for offsite disposal at a local municipal landfill. Approximately 12 dump-truck loads of broken concrete were disposed of offsite.
- General trash, PPE, hoses, shipping materials, and other unusable waste generated during the decommissioning of the ISTT system was considered nonhazardous. One rolloff container (approximately 2 tons) was shipped to and disposed of at a local municipal landfill.

SECTION 5

Post-Remedy Sampling and Site Recommendations

5.1 Post-Remedy Sampling Results

Post-remedy groundwater samples were collected from monitoring wells X-A-1, X-A-3, X-C-3, and RW-02 in December 2016 (45 days post-ISTT shutdown) and from monitoring wells X-C-3 and X-A-3 in February 2017 (105 days post-ISTT shutdown). Analytical results from the extended ISTT system operations are provided in Table 5-1, and analytical laboratory reports and the data quality evaluation are provided in Appendix H.

Post-remedy groundwater sample results confirm that vinyl chloride and cis-1,2-DCE are the only VOC analytes that still have detections above groundwater SCG values; however, vinyl chloride concentrations in groundwater collected from well X-A-3 decreased by nearly 30 percent between the December 2016 and February 2017 sampling event, indicating that further treatment is occurring. Additionally, the slight increase in cis-1,2-DCE at site monitoring well X-A-3, and vinyl chloride at site monitoring well X-C-3 are attributed to the continued degradation of the parent compound (that is, TCE). Water quality parameters collected during the February 2017 post-remedy sampling event are presented in Table 5-2. The results indicate that groundwater conditions are suitable for reductive dechlorination (that is, dissolved oxygen and oxidation reduction potential are low, and residual organic carbon [acetone] is present to sustain the reducing conditions) once the average TTZ temperature decreases to ideal temperatures that promote microbial activities throughout the entire TTZ (typically between 30 and 40°C).

5.2 Site Recommendations

Based on the success of the ISTT remedy, Dow and STC propose the following:

- Remove the groundwater monitoring and reporting requirement (that is, the periodic review report) from the site management plan and institutional controls/engineering controls form.
- Decommission and abandon the remaining site monitoring wells and piezometers.
- Prepare a final periodic review report submittal to NYSDEC documenting the achievement of the goals and decommissioning and abandonment of the remaining site monitoring wells and piezometers.

As the site owner, STC will continue to provide a signed copy of the institutional controls/engineering controls form to NYSDEC and/or other state agency as necessary, confirming adherence to the long-term institutional controls as required by the Declaration of Covenants and Restrictions.

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Tables

Table 2-1. Chronology of Site Investigations and Remedial Actions

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

Date	Work Performed
September 1989	Removal and offsite disposal of the 1,000-gallon UST and its associated dispenser, the 8,000-gallon AST, and contaminated soils.
May 1990	Site investigation performed to determine the presence or absence of chemical constituents in site soil and groundwater. Low-level VOC concentrations were detected in shallow groundwater.
January 1992	Physical/chemical evaluation of groundwater performed at former UST location. No contamination was detected in the groundwater sample.
September 1996 - March 1997	Monitoring well installation (MW-01, MW-02, MW-03, and MW-04) and groundwater sampling. VOC concentrations exceeded SCG values at MW-03, and lead exceeded the MCL at MW-02 and MW-04. The mud separator was decommissioned.
November 1997	Supplemental investigation was performed, soil samples were collected, and groundwater samples were collected from existing monitoring wells.
July 1998	Removal and offsite disposal of former acid plant concrete revetment, 500 tons of VOC-contaminated soil from around the acid plant, cement bulk plant debris, and other miscellaneous debris.
July 1998 - January 2000	Groundwater samples were collected four times during this period from MW-01 through MW-04 for VOCs.
February 26, 2001	The volunteers entered into a Voluntary Cleanup Agreement with NYSDEC.
July 2001	Site investigation was performed to collect soil, sediment, and groundwater samples. Hydraulic conductivity testing was performed. An asbestos survey and land survey of investigation locations was completed.
October 2003 - May 2004	Remedial activities, including asbestos abatement, building/structure demolition, monitoring well abandonment and installation, excavation and offsite disposal of approximately 4,610 tons of VOC-contaminated soil.
October 2005	Installation of monitoring well MW-07D.
April 2008	Offsite groundwater investigation completed.
June 2009	Installation and implementation of six injection wells upgradient of monitoring wells MW-06S and MW-06D. 377 gallons of hydrogen peroxide and sodium persulfate was injected between August and November 2009.
September 2010	Final remedial action report was prepared and submitted to NYSDEC.
May 2011	A site management plan was submitted to NYSDEC.
December 2011	NYSDEC issued a Certificate of Completion for the site remediation.
August 2013	First Periodic Review Report was submitted and presented a summary of the remedy performance during the period of December 7, 2011, through July 7, 2013.
August 2014	Second Periodic Review Report was submitted and presented a summary of the remedy performance during the period of July 7, 2013, through July 7, 2014.
January and April 2015	Groundwater Target Treatment Zone Investigation.
July 2015	Third Periodic Review Report was submitted and presented a summary of the remedy performance during the period of July 7, 2014, through July 7, 2015.
August 2015	Remedial Action Work Plan was prepared and submitted to NYSDEC. The work plan describes the construction, installation, and decomissioning details associated with the ISTT remedy.
August 2016	Fourth Periodic Review Report was submitted and presented a summary of the remedy performance during the period of July 7, 2015, through July 7, 2016.

Notes:

AST = above ground storage tank
ISTT = in situ thermal remediation
MCL = maximum contaminant level
NYSDEC = New York State Department of Environmental Conservation
SCG = applicable standards, criteria, and guidelines
UST = underground storage tank
VOC = volatile organic compound

Table 2-2. Groundwater Elevation Measurements

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

Well ID	Northing (feet)[a]	Easting (feet)[b]	Ground Surface Elevation (U.S. survey feet)[b]	Top of Casing Elevation (U.S. survey feet)[b]	Total Depth (ft btoc)	Depth to Top of Screen (ft bgs)	Depth to Bottom of Screen (ft bgs)	Total Depth Measured September 11, 2015 (ft btoc)	Depth to Water Measured September 11, 2015 (ft btoc)	Groundwater Elevation September 11, 2015 (ft amsl)
MW-01	1060918.910	1118926.532	680.66	680.38	29.72	20	30	28.83	14.00	666.38
MW-02	1061207.358	1119169.445	679.10	678.83	28.03	18.3	28.3	26.56	0.65	678.18
MW-04	1061182.237	1119049.105	678.14	677.71	27.57	18	28	27.70	1.70	676.01
MW-06S	1061160.411	1118936.396	677.54	677.13	20.09	10	20	19.88	2.10	675.03
MW-06D	1061162.079	1118940.064	677.45	677.16	30.21	20	30	29.70	2.16	675.00
MW-07S	1061150.146	1118858.431	677.17	676.66	19.49	9.5	19.5	19.00	4.60	672.06
MW-07D	1061142.027	1118861.752	677.43	676.83	29.90	20	30	30.22	5.46	671.37
RW-01	1061164.035	1118969.498	677.76	680.34	18.58	6	16	18.40	3.88	676.46
RW-02	1061102.659	1119042.870	678.66	681.16	18.50	6	16	18.05	4.65	676.51
PZ-01S	1061010.277	1118925.124	678.44	681.49	15.05	2	12	15.10	6.87	674.62
PZ-01D	1061004.001	1118926.203	678.86	681.88	27.52	22.5	24.5	27.07	7.15	674.73
PZ-02S	1060920.110	1118923.845	680.72	684.53	15.81	10	12	16.58	7.49	677.04
PZ-03S	1061038.815	1119046.902	680.09	683.08	14.99	10	12	15.03	4.95	678.13
PZ-03D	1061043.063	1119052.978	680.38	682.60	26.22	22	24	26.95	5.02	677.58
PZ-04S	1061069.999	1118915.093	678.23	681.23	15.00	10	12	15.12	7.02	674.21
PZ-04D	1061074.170	1118919.821	678.24	681.44	27.70	22.5	24.5	27.09	7.10	674.34
PZ-05S	1061114.176	1119128.343	679.56	682.19	14.63	10	12	15.00	5.25	676.94
PZ-05D	1061117.993	1119132.212	679.53	682.85	27.62	22.3	24.3	26.70	5.79	677.06
PZ-07S	1061161.630	1119094.894	679.01	681.93	15.42	10.5	12.5	14.80	5.54	676.39
PZ-07D	1061164.545	1119103.472	679.01	681.91	27.90	23	25	27.05	5.55	676.36
PZ-08S	1061181.135	1119044.411	678.25	681.90	15.45	9.8	11.8	15.02	6.13	675.77
PZ-09S	1061202.304	1119170.928	679.21	683.16	16.25	10.3	12.3	15.02	7.15	676.01

[a] North American Datum of 1983 (2011), New York State Plane Coordinate System (West Zone), United States survey feet.

[b] North American Vertical Datum of 1988, United States survey feet.

Notes:

ft amsl = feet above mean sea level

ft bgs = feet below ground surface

ft btoc = feet below top of casing

MW = monitoring well

PZ = piezometer

Table 2-3. Detected Analytes in Groundwater – June 2014

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

	Location	**MW-06D**	**MW-06S**	**MW-07D**	**MW-07S**	**RW-01**
	Sample ID	**MW-6D-061014**	**MW-6S-061014**	**MW-7D-061014**	**MW-7S-061014**	**RW-01-061014**
	Sample Date	**6/10/2014**	**6/10/2014**	**6/10/2014**	**6/10/2014**	**6/10/2014**
Analyte	**SCG Values**					
VOC (µg/L)						
1,1,1-Trichloroethane	5	**158 J**	**7.77**	0.82 U	0.82 U	0.82 U
1,1-Dichloroethane	5	**11,800**	**252**	0.38 U	0.38 U	**0.715 J**
1,1-Dichloroethene	5	**25.7**	**4.82**	0.29 U	0.29 U	0.29 U
1,2-Dichloroethane	0.6	**2.72**	0.21 U	0.21 U	0.21 U	0.21 U
1,2-Dichloroethene, Total	5*	**11.1**	**1.46 J**	0.81 U	0.81 U	**3.92**
Chloroethane	5	**568 J**	**13.9 J**	0.32 UJ	0.32 UJ	0.32 UJ
cis-1,2-Dichloroethene	5	**11.1**	**1.46**	0.81 U	0.81 U	**3.92**
Methyl tert-butyl ether	10	**0.687 J**	0.16 U	0.16 U	0.16 U	0.16 U
Trichloroethene	5	0.46 U	**0.503 J**	0.46 U	0.46 U	0.46 U
Vinyl Chloride	2	**4.77**	0.9 U	0.9 U	0.9 U	0.9 U

Notes:

SCG Values = Applicable standards, criteria, and guideline values. Division of Water Technical & Operational Guidance Series (TOGS) 1.1.1 New York State Ambient Water Quality Standards and Guidance Values and Ground Water Effluent Limitations

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

*Screening level for cis-1,2-Dichloroethene used for total 1,2-Dichloroethene.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the screening level.

µg/L = micrograms per liter

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample

U = The analyte was analyzed for but was not detected above the reported sample quantitation limit.

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

VOC = volatile organic compound

Table 2-4. Engineer Estimate of Contaminant Mass In Target Treatment Zone

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

A. Groundwater Concentration Data (see notes 1 through 3)

	Contaminant Concentration (µg/L)		
Well ID	**1,1-DCA**	**Chloroethane**	**1,1,1-TCA**
TW-03S	11,900	4,750	17.6
TW-05S	169	1	136
TW-11S	0.693	1	1
TW-01S	41.8	1	209
TW-13S	1	1	1
TW-06S	3.75	1	2.17
TW-12S	1,010	5.4	516
Average	1,875	680	126
Maximum	11,900	4,750	516

B. Site Data (see notes 4 and 5)

Parameter	Value	Unit	Comment
Top of Treatment Interval	3	ft bgs	Depth to groundwater within TTZ
Bottom of Treatment Interval	30	ft bgs	Based on TTZ Investigation (CH2M - July 2015)
Aquifer Porosity	0.25	--	Assumed value
Treatment Area	3,400	ft^2	Based on TTZ Investigation (CH2M - July 2015)
Soil Density	49.9	kg/ft^3	Assumed value of 110 lb per cubic foot
K_{oc} of 1,1-DCA	3.02E+01	L/kg	ATSDR, 2013
K_{oc} of Chloroethane	1.43E+02	L/kg	ATSDR, 1998
K_{oc} of 1,1,1-TCA	1.05E+02	L/kg	ATSDR, 2006
f_{oc}	0.0028	--	Average of TestAmerica 01/28/2015 site analytical data

C. Estimate of COC Mass (see note 6)

	Concentration		Mass		Mass		Total Mass (lb)
	in GW (µg/L)	**in Soil (µg/kg)**	**in GW (g)**	**in Soil (g)**	**in GW (lb)**	**in Soil (lb)**	
	1,1-DCA						
Average	1,875	159	1,218	730	3	2	4
Maximum	11,900	1,011	7,732	4,631	17	10	27
	Chloroethane						
Average	680	273	442	1,253	1	3	4
Maximum	4,750	1,911	3,086	8,753	7	19	26
	1,1,1-TCA						
Average	126	37	82	170	0	0	1
Maximum	516	152	335	696	1	2	2
	TOTAL						
Average	--	--	1,742	2,152	4	5	**9**
Maximum	--	--	11,154	14,080	25	31	**56**

Notes:

(1) Groundwater concentration data from January and April 2015 sampling events which were performed to delineate the TTZ.

(2) Calculations include the three predominant contaminants of concern: 1,1-DCA, chloroethane, and 1,1,1-TCA. Contribution to total mass from

(3) The laboratory reporting limit was used where the contaminant was not detected.

(4) The delineation of the TTZ is described in detail in the July 2015 Target Treatment Zone Investigation Technical Memorandum.

(5) K_{oc} values taken from the pertinent ToxGuides published by the Agency for Toxic Substances and Disease Registry.

(6) Equilibrium calculations to estimate mass in soil using groundwater data performed as follows:

X (conc. in soil) = $K_{oc} * f_{oc} * C$

-- = Not applicable

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

1,1,1-TCA = 1,1,1-trichloroethane

1,1-DCA = 1,1-dichloroethane

ATSDR = Agency for Toxic Substances and Disease Registry

C = concentration in groundwater

COC = contaminant of concern

f_{oc} = fraction of organic carbon

ft bgs = feet below ground surface

ft^2 = square feet

g = grams

kg/ft^3 = kilograms per cubic feet

K_{oc} = organic carbon water partition coefficient

L/kg = liters per kilogram

lb = pounds

Table 4-1. Detected Analytes in Groundwater – September 2015

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

	Location	**MW-06D**	**MW-06S**	**MW-07D**	**MW-07S**	**RW-01**	**RW-02**
	Sample ID	**MW-6D-091115**	**MW-6S-091115**	**MW-7D-091115**	**MW-7S-091115**	**RW-01-091115**	**RW-02-091115**
	Sample Date	**9/11/2015**	**9/11/2015**	**9/11/2015**	**9/11/2015**	**9/11/2015**	**9/11/2015**
Analyte	**SCG Values**						
VOC (µg/L)							
1,1,1-Trichloroethane	5	82.0 U**	**109**	0.82 U	0.82 U	0.82 U	0.82 U
1,1-Dichloroethane	5	**6310**	**848**	0.380 U	**0.462 J**	**0.833 J**	0.380 U
1,1-Dichloroethene	5	29.0 U**	**50.3**	0.290 U	0.290 U	0.290 U	0.290 U
1,2-Dichloroethene, Total	5*	81.0 U**	**9.10**	0.810 U	0.810 U	0.810 U	**6.72**
Chloroethane	5	**912**	**145**	0.320 U	0.320 U	0.320 U	0.320 U
cis-1,2-Dichloroethene	5	81.0 U**	**9.10**	0.810 U	0.810 U	0.810 U	**6.72**
Methylene Chloride	5	44.0 U**	**2.31 J**	0.440 U	0.440 U	0.440 U	0.440 U
Trichloroethene	5	46.0 U**	1.84 U	0.460 U	0.460 U	0.460 U	**1.62**
Vinyl Chloride	2	90.0 U**	3.60 U**	0.900 U	0.900 U	0.900 U	**3.93**

Notes:

SCG Values = Applicable standards, criteria, and guideline values. Division of Water Technical & Operational Guidance Series (TOGS) 1.1.1 New York State Ambient Water Quality Standards and Guidance Values and Ground Water Effluent Limitations

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**For MW-06S and MW-06D, the reporting limit of VOC compounds exceeded their respective SCG values due to the elevated 1,1-dichloroethane concentrations detected in these site monitoring wells; therefore, nondetect results of specific VOC compounds may not be indicative of actual concentrations of these specific VOCs at these locations.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the screening level.

µg/L = micrograms per liter

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

U = The analyte was analyzed for but was not detected above the reported sample quantitation limit.

VOC = volatile organic compound

Table 4-2. Monthly Influent and Effluent Vapor Results

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

	Sample ID	**Operational Days**	**1,1,1-Trichloroethane µg/m^3**	**1,1-Dichloroethane µg/m^3**	**1,1-Dichloroethene µg/m^3**	**1,2-Dichloroethane µg/m^3**	**1,2-Dichloroethene (Total) µg/m^3**	**cis-1,2-Dichloroethene µg/m^3**	**Acetone µg/m^3**	**Benzene µg/m^3**	**Chloroethane µg/m^3**	**Ethylbenzene µg/m^3**	**Tetrachloroethene µg/m^3**	**Trichloroethene µg/m^3**	**Vinyl Chloride µg/m^3**	**Total Xylenes µg/m^3**
Influent	AIR-INF-01-031016	18	**220**	**400**	**430**	2.1 U	**280**	**280**	**51 J**	**8**	**51**	**2.7 J**	**57**	**95**	**57**	**12.3 J**
	AIR-INF-02-032516	33	**160**	**620**	**970**	1.7 U	**320**	**290**	**30 J**	**9**	**27**	**2.0 J**	**110**	**120**	**51**	**8.6 J**
	AIR-INF-03-040816	47	**30 J**	**870**	**3,000**	13 U	**1,100**	**930**	170 U	**35 J**	18 U	12 U	**1,000**	**350**	**130**	**51 J**
	AIR-INF-01-042216	61	35 U	**1,700**	**5,500**	23 U	**1,700**	**1,700**	290 U	**54 J**	32 U	**22 J**	**4,500**	**830**	**320**	**110 J**
	AIR-INF-01-050616	75	10 U	**1,800**	**850**	6.7 U	**6,300**	**5,800**	**37,000 J**	**240**	**18 J**	**110**	**4,400**	**1,700**	**220**	**810**
	AIR-INF-01-052016	89	16 U	**120**	**100**	11 U	**790**	**720**	**51,000**	**60**	14 U	**26 J**	**820**	**240**	**52**	**160 J**
	AIR-INF-01-060316	103	**3.3 J**	**120**	**82**	1.7 U	**1,300**	**1,200**	**3,300**	**76**	2.2 U	**20**	**440**	**320**	**150**	**110**
	AIR-INF-01-061716	117	7.1 U	**120**	**68**	4.7 U	**1,200**	**1,100**	**620,000 J**	**84**	6.3 U	**28**	**270**	**360**	**81**	**170**
	AIR-INF-01-070116	131	2.8 U	**110**	**42**	1.8 U	**540**	**470**	**3,200**	**48**	2.5 U	**13**	**110**	**190**	**54**	**61**
	AIR-INF-01-071916	149	2.5 U	**73**	**34**	1.7 U	**480**	**430**	**2,400**	**44**	2.3 U	**22**	**140**	**190**	0.83 U	**110**
	AIR-INF-01-072916	159	3.0 U	**130**	**33**	2.0 U	**440**	**410**	**2,100**	**54**	**4.1 J**	**17**	**91**	**170**	**59**	**90**
	AIR-INF-02-081216	173	2.5 U	**120**	**24**	1.7 U	**480**	**440**	**1,900**	**45**	**3.0 J**	**12**	**81**	**180**	**55**	**63**
	AIR-INF-01-082616	187	3.3 U	**42**	**9.0 J**	2.2 U	**340**	**310**	**1,600**	**27**	2.9 U	**7.6 J**	**47**	**110**	**52**	**40**
Effluent	AIR-EFF-01-031016	18	1.6 U	1.1 U	0.40 U	2.1 U	1.2 U	1.2 U	**41 J**	0.93 U	1.6 U	0.87 U	2.0 U	1.6 U	**60**	1.1 U
	AIR-EFF-AS-01-031016	18	1.6 U	**1.6 J**	0.40 U	2.1 U	1.2 U	1.2 U	**170**	**2.0 J**	1.6 U	**6.5 J**	2.0 U	1.6 U	0.66 U	**29.5 J**
	AIR-EFF-02-032516	33	2.5 U	**1.4 J**	**2.4 J**	1.7 U	1.4 U	1.4 U	**33 J**	1.3 U	**24**	1.4 U	1.6 U	2.1 U	**28**	1.6 U
	AIR-EFF-AS-02-032516	33	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	20 U	1.3 U	2.2 U	1.4 U	**1.9 J**	2.1 U	0.82 U	1.6 U
	AIR-EFF-03-040816	47	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	20 U	1.3 U	**6.9 J**	1.4 U	1.6 U	2.1 U	**11**	1.6 U
	AIR-EFF-AS-03-040816	47	2.5 U	**2.3 J**	1.4 U	1.7 U	**7.9 J**	**8.1**	20 U	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	0.82 U	1.6 U
	AIR-EFF-01-042216	61	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	20 U	1.3 U	**35**	1.4 U	**4.9 J**	2.1 U	**400**	1.6 U
	AIR-EFF-AS-01-042216	61	**5.3 J**	**1.1 J**	**3.1 J**	1.7 U	1.4 U	1.4 U	**53 J**	1.3 U	2.2 U	1.4 U	**2.4 J**	2.1 U	0.82 U	1.6 U
	AIR-EFF-01-050616	75	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**140**	1.3 U	**4.0 J**	1.4 U	**3.9 J**	2.1 U	**170**	1.6 U
	AIR-EFF-AS-01-050616	75	7.6 U	**130**	**26**	5.0 U	**270**	**260**	**1,700**	**11 J**	6.8 U	4.4 U	**60**	**39**	**29**	**13 J**
	AIR-EFF-01-052016	89	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	20 U	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	**74**	1.6 U
	AIR-EFF-AS-01-052016	89	2.5 U	**74**	**6.9 J**	1.7 U	**230**	**220**	**6,400**	**15**	2.2 U	**3.2 J**	**25**	**26**	**7.9**	**20 J**
	AIR-EFF-01-060316	103	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**28 J**	1.3 U	**4.2 J**	1.4 U	1.6 U	2.1 U	**89**	1.6 U
	AIR-EFF-AS-01-060316	103	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**250**	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	0.82 U	1.6 U
	AIR-EFF-01-061716	117	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**25 J**	1.3 U	2.2 U	1.4 U	1.6 U	**16**	**60**	1.6 U
	AIR-EFF-AS-01-061716	117	2.5 U	1.0 U	**2.6 J**	1.7 U	1.4 U	1.4 U	**270**	1.3 U	2.2 U	1.4 U	1.6 U	**73**	0.82 U	1.6 U
	AIR-EFF-01-070116	131	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	20 U	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	**150**	**4.3 J**
	AIR-EFF-AS-01-070116	131	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**62 J**	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	0.82 U	1.6 U
	AIR-EFF-01-071916	149	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**59 J**	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	**77**	1.6 U
	AIR-EFF-AS-01-071916	149	**4.3 J**	**6.5 J**	1.4 U	1.7 U	**18**	**18**	**1,300**	**1.9 J**	2.3 U	1.4 U	1.6 U	**3.9 J**	**1.2 J**	1.6 U
	AIR-EFF-01-072916	159	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**21 J**	1.3 U	**2.6 J**	1.4 U	1.6 U	2.1 U	**30**	1.6 U
	AIR-EFF-AS-01-072916	159	2.5 U	**2.1 J**	1.4 U	1.7 U	**5.6 J**	**5.5 J**	**1,500**	**1.4 J**	2.2 U	1.4 U	1.6 U	2.1 U	0.82 U	1.6 U
	AIR-EFF-02-081216	173	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**22 J**	1.3 U	**4.0 J**	1.4 U	1.6 U	2.1 U	**55**	1.6 U
	AIR-EFF-AS-02-081216	173	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**28 J**	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	0.82 U	1.6 U
	AIR-EFF-01-082616	187	2.5 U	1.0 U	1.4 U	1.7 U	1.4 U	1.4 U	**32 J**	1.3 U	2.2 U	1.4 U	1.6 U	2.1 U	**19**	1.6 U
	AIR-EFF-AS-01-082616	187	2.5 U	**11**	1.4 U	1.7 U	**14 J**	**14**	**820**	**2.2 J**	2.2 U	1.4 U	1.6 U	**6.8 J**	**2.9 J**	1.6 U

Notes:

Bold indicates that the analyte was detected.

µg/m^3 = micrograms per cubic meter

J = The analyte was positively identified; the associated numerical value is the approximate concentration.

U = The analyte was analyzed for, but was not detected above the reported sample detection limit.

Table 4-3. Monthly Influent and Effluent Groundwater Results

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

	Sample ID	Operational Days	1,1,1-Trichloroethane µg/L	1,1-Dichloroethane µg/L	1,1-Dichloroethene µg/L	1,2-Dichloroethane µg/L	1,2-Dichloroethene (Total) µg/L	cis-1,2-Dichloroethene µg/L	Acetone µg/L	Benzene µg/L	Chloroethane µg/L	Ethylbenzene µg/L	Tetrachloroethene µg/L	Trichloroethene µg/L	Vinyl Chloride µg/L	Total Xylene µg/L
Influent	GW-INF-01-030416	12	4.10 UJ	**3.98 J**	1.45 UJ	1.05 UJ	**8.79 J**	**8.79 J**	**1,040 J**	2.05 UJ	1.60 UJ	3.70 UJ	1.80 UJ	2.30 UJ	4.50 UJ	3.30 UJ
	GW-INF-01-040816	47	1.64 U	**33.4**	**24.5**	0.420 U	**86.9**	**82.4**	**158**	**1.72 J**	0.640 U	1.48 U	**9.25**	**9.99**	**3.76**	1.32 U
	GW-INF-01-042216	61	8.20 U	**23.4**	**6.13 J**	2.10 U	**28.3**	**28.3**	**197**	4.10 U	3.20 U	7.40 U	**4.64 J**	**7.77 J**	9.00 U	6.60 U
	GW-INF-01-050616	75	3.28 UJ	**5.06 J**	1.16 UJ	0.840 UJ	**10.7 J**	**10.7 J**	**437 J**	1.64 UJ	1.28 UJ	2.96 UJ	**2.34 J**	**1.94 J**	3.60 UJ	2.64 UJ
	GW-INF-01-052016	89	8.20 U	3.80 U	2.90 U	2.10 U	**9.78 J**	**9.78 J**	**2,070**	4.10 U	3.20 U	7.40 U	3.60 U	4.60 U	9.00 U	6.60 U
	GW-INF-01-060316	103	8.20 U	3.80 U	2.90 U	2.10 U	8.10 U	8.10 U	**1,010 J**	4.10 U	3.20 U	7.40 U	3.60 U	4.60 U	9.00 U	6.60 U
	GW-INF-01-061716	117	3.28 U	1.52 U	1.16 U	0.840 U	3.24 U	3.24 U	**191**	1.64 U	1.28 U	2.96 U	1.44 U	1.84 U	3.60 U	2.64 U
	GW-INF-01-070116	131	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**128**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-INF-01-071516	145	0.820 U	0.380 U	0.290 U	0.210 U	**1.82 J**	**1.82**	**452**	0.410 U	0.320 U	0.740 U	0.360 U	**0.558 J**	0.900 U	0.660 U
	GW-INF-01-072916	159	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**136**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-INF-01-081216	173	8.20 U	3.80 U	2.90 U	2.10 U	8.10 U	8.10 U	**147**	4.10 U	3.20 U	7.40 U	3.60 U	4.60 U	9.00 U	6.60 U
	GW-INF-01-082616	187	3.28 U	1.52 U	1.16 U	0.840 U	3.24 U	3.24 U	**134**	1.64 U	1.28 U	2.96 U	1.44 U	1.84 U	3.60 U	2.64 U
Effluent	GW-EFF-01-030416	12	0.820 U	0.380 U	0.290 U	0.210 U	0.900 U	0.810 U	**3.83 J**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-040816	47	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**4.87 J**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-042216	61	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**13.2**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-050616	75	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**203**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-052016	89	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**17.3**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-060316	103	0.820 U	0.380 U	0.290 UJ	0.210 U	0.810 U	0.810 U	**13.9**	0.410 U	0.320 UJ	0.740 U	0.360 U	0.460 U	0.900 UJ	0.660 U
	GW-EFF-01-061716	117	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**35.2**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-070116	131	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**47.4**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-071516	145	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**44.6**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-072916	159	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**32.1**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-081216	173	0.820 U	0.380 U	0.290 U	0.210 U	0.810 U	0.810 U	**23.1**	0.410 U	0.320 U	0.740 U	0.360 U	0.460 U	0.900 U	0.660 U
	GW-EFF-01-082616	187	1.64 U	0.760 U	0.580 U	0.420 U	1.62 U	1.62 U	**42.5**	0.820 U	0.640 U	1.48 U	0.720 U	0.920 U	1.80 U	1.32 U

Notes:

Bold indicates that the analyte was detected.

µg/L = micrograms per liter

J = The analyte was positively identified; the associated numerical value is the approximate concentration.

U = The analyte was analyzed for, but was not detected above the reported sample detection limit.

UJ = The analyte was analyzed for, but was not detected above the reported sample detection limit (estimated).

Table 4-4. ISTT System Performance Sampling Results – June 2016

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

Location ID:				**Location ID:**	**SB-03**	**SB-01**	**SB-01**	**SB-01**	**SB-02**	**SB-02**	**SB-02**
Sample Date:				**Sample Date:**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**
Media:				**Media:**	**Groundwater**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Sample Depth:				**Sample Depth:**	**0 - 18 ft**	**16 - 20 ft**	**20 - 24 ft**	**24 - 28 ft**	**4 - 8 ft**	**12 - 16 ft**	**20 - 24 ft**
Sample ID:				**Sample ID:**	**SB03-GW0018-060116**	**SB01-SL1620-060116**	**SB01-SL2024-060116**	**SB01-SL2428-060116**	**SB02-SL0408-060116**	**SB02-SL1216-060116**	**SB02-SL2024-060116**
Result Units:				**Result Units:**	**µg/L**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**
Analyte	**Groundwater SCG Values**	**Units**	**Soil Unrestricted Use SCG Values**	**Units**							
1,1,1-Trichloroethane	1	µg/L	680	µg/kg	16.4 U	0.237 U	0.233 U	0.245 U	0.291 U	0.305 U	0.245 U
1,1-Dichloroethane	5	µg/L	270	µg/kg	7.60 U	**3.27**	0.391 U	**2.69 J**	0.489 U	0.513 U	0.411 U
1,1-Dichloroethene	5	µg/L	330	µg/kg	5.80 U	**10.2**	0.392 U	**1.69 J**	0.491 U	0.515 U	0.413 U
1,2-Dichloroethane	0.6	µg/L	20	µg/kg	4.20 U	0.164 U	0.161 U	0.169 U	0.201 U	0.211 U	0.169 U
1,2-Dichloroethene (Total)	5*	µg/L	250	µg/kg	16.2 U	1.71 U	1.68 U	1.77 U	2.10 U	2.20 U	1.77 U
Acetone**	50	µg/L	500	µg/kg	**74.1 J**	29.3 U	33.4 U	30.8 U	47.0 U	**68.6**	32.2 U
Benzene	1	µg/L	60	µg/kg	8.20 U	0.160 U	0.157 U	0.165 U	0.196 U	0.206 U	0.165 U
Chloroethane	5	µg/L	700	µg/kg	6.40 U	0.736 U	0.724 U	0.762 U	0.906 U	0.950 U	0.762 U
cis-1,2-Dichloroethene	5	µg/L	250	µg/kg	16.2 U	**0.468 J**	0.410 U	0.431 U	0.513 U	0.538 U	0.431 U
Ethylbenzene	5	µg/L	1,000	µg/kg	14.8 U	0.225 U	0.221 U	0.232 U	0.277 U	0.290 U	0.233 U
Tetrachloroethene	5	µg/L	1,300	µg/kg	7.20 U	0.437 U	0.430 U	0.452 U	0.538 U	0.564 U	0.452 U
Trichloroethene	5	µg/L	470	µg/kg	9.20 U	0.717 U	0.705 U	0.741 U	0.882 U	0.925 U	0.742 U
Vinyl Chloride	2	µg/L	20	µg/kg	18.0 U	**16.8**	**0.745 J**	0.411 U	0.489 U	0.513 U	0.411 U
Xylenes, Total	5	µg/L	260	µg/kg	13.2 U	0.547 U	0.538 U	0.566 U	0.674 U	0.706 U	0.566 U

Notes:

SCG Values = Applicable standards,

Ambient Water Quality Standards and

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level.

Brown shading indicates that the result exceeded the soil screening level; however, there were no soil exceedances during the June 2016 sampling event.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

ft = feet

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the

U = The analyte was analyzed for but was not detected above the reported sample

SCG = applicable standards, criteria, and

Table 4-4. ISTT System Performance Sampling Results – June 2016

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

Location ID:				**Location ID:**	**SB-03**	**SB-03**	**SB-03**	**SB-03**	**SB-04**	**SB-04**	**SB-04**
Sample Date:				**Sample Date:**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**	**6/1/2016**
Media:				**Media:**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Sample Depth:				**Sample Depth:**	**12 - 16 ft**	**16 - 20 ft**	**20 - 24 ft**	**24 - 28 ft**	**16 - 20 ft**	**20 - 24 ft**	**24 - 28 ft**
Sample ID:				**Sample ID:**	**SB03-SL1216-060116**	**SB03-SL1620-060116**	**SB03-SL2024-060116**	**SB03-SL2428-060116**	**SB04-SL1620-060116**	**SB04-SL2024-060116**	**SB04-SL2428-060116**
Result Units:				**Result Units:**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**
Analyte	**Groundwater SCG Values**	**Units**	**Soil Unrestricted Use SCG Values**	**Units**							
1,1,1-Trichloroethane	1	µg/L	680	µg/kg	0.266 U	0.243 U	0.254 U	0.251 U	0.253 U	0.246 U	0.259 U
1,1-Dichloroethane	5	µg/L	270	µg/kg	0.446 U	0.409 U	0.426 U	0.422 U	**6.86**	**9.54**	**20.6**
1,1-Dichloroethene	5	µg/L	330	µg/kg	0.448 U	0.410 U	0.428 U	0.423 U	0.426 U	0.415 U	0.437 U
1,2-Dichloroethane	0.6	µg/L	20	µg/kg	0.184 U	0.168 U	0.175 U	0.174 U	0.175 U	0.170 U	0.179 U
1,2-Dichloroethene (Total)	5*	µg/L	250	µg/kg	1.92 U	1.76 U	1.83 U	1.81 U	1.82 U	1.78 U	1.87 U
Acetone**	50	µg/L	500	µg/kg	**369**	28.7 U	25.7 U	33.5 U	2.93 U	14.8 U	12.1 U
Benzene	1	µg/L	60	µg/kg	**0.350 J**	0.164 U	0.171 U	0.169 U	0.171 U	0.166 U	0.175 U
Chloroethane	5	µg/L	700	µg/kg	0.827 U	0.758 U	0.790 U	0.781 U	0.787 U	0.766 U	0.807 U
cis-1,2-Dichloroethene	5	µg/L	250	µg/kg	**0.900 J**	0.429 U	0.447 U	0.442 U	**0.977 J**	0.434 U	0.457 U
Ethylbenzene	5	µg/L	1,000	µg/kg	0.253 U	0.231 U	0.241 U	0.239 U	0.240 U	0.234 U	0.246 U
Tetrachloroethene	5	µg/L	1,300	µg/kg	**135**	0.450 U	0.469 U	0.464 U	0.467 U	0.455 U	0.479 U
Trichloroethene	5	µg/L	470	µg/kg	**9.43**	0.737 U	0.769 U	0.760 U	0.766 U	0.746 U	0.785 U
Vinyl Chloride	2	µg/L	20	µg/kg	**1.53 J**	0.409 U	0.426 U	0.422 U	**1.11 J**	**2.21 J**	**3.76**
Xylenes, Total	5	µg/L	260	µg/kg	**0.669 J**	0.563 U	0.587 U	0.581 U	0.585 U	0.569 U	0.600 U

Notes:

SCG Values = Applicable standards,

Ambient Water Quality Standards and

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level.

Brown shading indicates that the result exceeded the soil screening level; however, there were no soil exceedances during the June 2016 sampling event.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

ft = feet

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the

U = The analyte was analyzed for but was not detected above the reported sample

SCG = applicable standards, criteria, and

Table 4-5. ISTT System Performance Sampling Results – August 2016

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

Location ID:					**SB-01**	**SB-02**	**SB-03**	**SB-03**	**SB-04**	**SB-05**	**SB-01**
Sample Date:					**8/19/2016**	**8/18/2016**	**8/19/2016**	**8/17/2016**	**8/19/2016**	**8/19/2016**	**8/17/2016**
Media:					**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Soil**
Sample Depth:					**23 ft**	**18.7 ft**	**13 ft**	**26.5 ft**	**17.75 ft**	**23.75 ft**	**15 ft**
Sample ID:					**SB01-GW23-081916**	**SB02-GW18.70-081816**	**SB03-GW13-081916**	**SB-03-GW26.5-081716**	**SB04-GW17.75-081916**	**SB05-GW23.75-081916**	**SB01-SL15-081716**
Result Units:					**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/kg**
Analyte	**Groundwater SCG Values**	**Units**	**Soil Unrestricted Use SCG Values**	**Units**							
1,1,1-Trichloroethane	1	µg/L	680	µg/kg	0.820 U	0.820 U	3.28 U	0.820 UJ	3.28 U	0.820 U	0.230 U
1,1-Dichloroethane	5	µg/L	270	µg/kg	0.380 U	0.380 U	**26.4**	**76.7 J**	1.52 U	0.380 U	**0.901 J**
1,1-Dichloroethene	5	µg/L	330	µg/kg	0.290 U	0.290 U	1.16 U	**26.8 J**	1.16 U	0.290 U	**0.565 J**
1,2-Dichloroethane	0.6	µg/L	20	µg/kg	0.210 U	0.210 U	0.840 U	0.210 U	0.840 U	0.210 U	0.159 U
1,2-Dichloroethene (Total)	5*	µg/L	250	µg/kg	0.810 U	**1.58 J**	**5.74 J**	**15.2**	3.24 U	0.810 U	1.66 U
Acetone**	50	µg/L	500	µg/kg	**344**	**163**	**55.2**	**217 J**	**55.9**	**530 J**	44.6 U
Benzene	1	µg/L	60	µg/kg	**0.455 J**	**0.573 J**	1.64 U	**0.872 J**	1.64 U	**0.558 J**	**0.203 J**
Chloroethane	5	µg/L	700	µg/kg	0.320 U	0.320 U	1.28 U	0.320 UJ	1.28 U	0.320 U	0.716 U
cis-1,2-Dichloroethene	5	µg/L	250	µg/kg	0.810 U	**1.58**	**5.74**	**15.2 J**	3.24 U	0.810 U	**0.434 J**
Ethylbenzene	5	µg/L	1,000	µg/kg	0.740 U	0.740 U	2.96 U	0.740 U	2.96 U	0.740 U	0.218 U
Tetrachloroethene	5	µg/L	1,300	µg/kg	0.360 U	0.360 U	1.44 U	0.360 UJ	1.44 U	0.360 U	0.425 U
Trichloroethene	5	µg/L	470	µg/kg	0.460 U	0.460 U	**4.59**	**5.89 J**	1.84 U	0.460 U	0.697 U
Vinyl Chloride	2	µg/L	20	µg/kg	0.900 U	0.900 U	**3.62 J**	**7.96 J**	3.60 U	0.900 U	**2.36 J**
Xylenes, Total	5	µg/L	260	µg/kg	0.660 U	0.660 U	2.64 U	**0.973 J**	2.64 U	**3.98**	0.532 U

Notes:

SCG Values = Applicable standards,

Ambient Water Quality Standards and

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level.

Brown shading indicates that the result exceeded the soil screening level.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

ft = feet

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the

U = The analyte was analyzed for but was not detected above the reported sample

UJ = The analyte was not detected above the reported sample quantitation limit.

SCG = standards, criteria, and guidelines

Table 4-5. ISTT System Performance Sampling Results – August 2016

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

Location ID:			**SB-01**	**SB-02**	**SB-02**	**SB-03**	**SB-03**	**SB-04**	**SB-04**	**SB-05**	**SB-05**
Sample Date:			**8/17/2016**	**8/17/2016**	**8/17/2016**	**8/17/2016**	**8/17/2016**	**8/17/2016**	**8/17/2016**	**8/18/2016**	**8/18/2016**
Media:			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Sample Depth:			**24.5 ft**	**12 ft**	**20 ft**	**14.5 ft**	**25 ft**	**12 ft**	**17.8 ft**	**15 ft**	**25 ft**
Sample ID:			**SB01-SL24.5-081716**	**SB02-SL12-081716**	**SB02-SL20-081716**	**SB03-SL14.5-081716**	**SB03-SL25-081716**	**SB04-SL12-081716**	**SB04-SL17.8-081716**	**SB05-SL15-081816**	**SB05-SL25-081816**
Result Units:			**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**
Analyte	**Groundwater SCG Values**	**Units**									
1,1,1-Trichloroethane	1	µg/L	0.251 U	0.283 U	0.260 U	0.286 U	0.295 U	0.376 U	0.250 U	0.300 UJ	0.255 U
1,1-Dichloroethane	5	µg/L	0.422 U	0.476 U	0.437 U	**10.5**	**0.771 J**	0.631 U	0.421 U	0.504 UJ	0.428 U
1,1-Dichloroethene	5	µg/L	0.423 U	0.478 U	0.438 U	**13.0**	0.497 U	0.633 U	0.422 U	0.506 UJ	0.430 U
1,2-Dichloroethane	0.6	µg/L	0.174 U	0.196 U	0.180 U	0.198 U	0.204 U	0.260 U	0.173 U	0.207 UJ	0.176 U
1,2-Dichloroethene (Total)	5*	µg/L	1.81 U	2.04 U	1.87 U	**11.1**	2.13 U	2.71 U	1.81 U	2.17 UJ	1.84 U
Acetone**	50	µg/L	25.0 U	**80.0**	46.0 U	**89.0**	31.7 U	46.5 U	**80.8**	**172 J**	**69.9**
Benzene	1	µg/L	0.169 U	**0.272 J**	0.175 U	**0.455 J**	0.199 U	**0.697 J**	0.169 U	0.202 UJ	**0.623 J**
Chloroethane	5	µg/L	0.782 U	0.882 U	0.809 U	0.891 U	0.918 U	1.17 U	0.779 U	0.934 UJ	0.793 U
cis-1,2-Dichloroethene	5	µg/L	0.443 U	0.499 U	0.458 U	**10.6**	0.520 U	0.662 U	0.441 U	0.529 UJ	0.449 U
Ethylbenzene	5	µg/L	0.239 U	0.269 U	0.247 U	0.272 U	0.280 U	0.357 U	0.238 U	0.285 UJ	0.242 U
Tetrachloroethene	5	µg/L	0.464 U	0.524 U	0.480 U	0.529 U	0.545 U	0.694 U	0.463 U	0.555 UJ	0.471 U
Trichloroethene	5	µg/L	0.761 U	0.858 U	0.787 U	**1.58 J**	0.894 U	1.14 U	0.759 U	0.909 UJ	0.772 U
Vinyl Chloride	2	µg/L	0.422 U	0.476 U	0.437 U	**25.4**	**0.982 J**	0.631 U	0.421 U	0.504 UJ	0.428 U
Xylenes, Total	5	µg/L	0.581 U	0.655 U	0.601 U	0.662 U	0.683 U	0.869 U	0.579 U	0.694 UJ	0.590 U

Notes:

SCG Values = Applicable standards,
Ambient Water Quality Standards and
- Table 1 and Table 5 - Class GA; June 1998; modified January 1999;
modified April 2000; modified June 2004

Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level.

Brown shading indicates that the result exceeded the soil screening level.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

ft = feet

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the

U = The analyte was analyzed for but was not detected above the reported sample

UJ = The analyte was not detected above the reported sample quantitation limit.

SCG = standards, criteria, and guidelines

Table 4-5. ISTT System Performance Sampling Results – August 2016

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

Location ID:			**SB-06**	**SB-06**	**SB-07**	**SB-07**	**SB-08**	**SB-08**	**SB-09**	**SB-09**
Sample Date:			**8/18/2016**	**8/19/2016**	**8/18/2016**	**8/18/2016**	**8/18/2016**	**8/18/2016**	**8/19/2016**	**8/19/2016**
Media:			**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**	**Soil**
Sample Depth:			**15 ft**	**25 ft**	**15 ft**	**25 ft**	**12 ft**	**20 ft**	**12 ft**	**25 ft**
Sample ID:			**SB06-SL15-081816**	**SB06-SL25-081916**	**SB07-SL15-081816**	**SB07-SL25-081816**	**SB08-SL12-081816**	**SB08-SL20-081816**	**SB09-SL12-081916**	**SB09-SL25-081916**
Result Units:			**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**	**µg/kg**
Analyte	**Groundwater SCG Values**	**Units**								
1,1,1-Trichloroethane	1	µg/L	0.324 U	0.238 U	0.313 U	0.264 U	0.308 U	0.232 U	0.312 U	0.248 U
1,1-Dichloroethane	5	µg/L	0.544 U	0.400 U	0.526 U	0.443 U	0.518 U	0.390 U	0.524 U	0.417 U
1,1-Dichloroethene	5	µg/L	0.546 U	0.401 U	0.527 U	0.445 U	0.519 U	0.391 U	0.525 U	0.418 U
1,2-Dichloroethane	0.6	µg/L	0.224 U	0.164 U	0.216 U	0.182 U	0.213 U	0.161 U	0.216 U	0.172 U
1,2-Dichloroethene (Total)	5*	µg/L	2.34 U	1.72 U	2.26 U	1.90 U	2.22 U	1.68 U	2.25 U	1.79 U
Acetone**	50	µg/L	**136**	**57.8**	**21.9**	**49.7**	29.4 U	**8.52 J**	**78.0**	**19.7**
Benzene	1	µg/L	0.218 U	**0.368 J**	0.211 U	**0.213 J**	0.208 U	0.157 U	0.210 U	0.167 U
Chloroethane	5	µg/L	1.01 U	0.740 U	0.974 U	0.821 U	0.959 U	0.723 U	0.970 U	0.772 U
cis-1,2-Dichloroethene	5	µg/L	0.571 U	0.419 U	0.552 U	0.465 U	0.543 U	0.409 U	0.549 U	0.437 U
Ethylbenzene	5	µg/L	0.308 U	0.226 U	0.297 U	0.251 U	0.293 U	0.221 U	0.296 U	0.236 U
Tetrachloroethene	5	µg/L	0.598 U	0.439 U	0.578 U	0.488 U	0.570 U	0.429 U	0.576 U	0.459 U
Trichloroethene	5	µg/L	0.981 U	0.720 U	0.948 U	0.800 U	0.934 U	0.703 U	0.944 U	0.752 U
Vinyl Chloride	2	µg/L	0.544 U	0.400 U	0.526 U	0.443 U	0.518 U	0.390 U	0.524 U	0.417 U
Xylenes, Total	5	µg/L	0.749 U	0.550 U	0.724 U	0.611 U	0.713 U	0.537 U	0.721 U	0.574 U

Notes:

SCG Values = Applicable standards,
Ambient Water Quality Standards and
- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level.

Brown shading indicates that the result exceeded the soil screening level.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

ft = feet

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the

U = The analyte was analyzed for but was not detected above the reported sample

UJ = The analyte was not detected above the reported sample quantitation limit.

SCG = standards, criteria, and guidelines

Table 4-6. Extended ISTT System Treatment Results

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

		Location ID:	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**
		Sample Date:	**9/7/2016**	**9/9/2016**	**9/14/2016**	**9/16/2016**	**9/20/2016**	**9/23/2016**	**9/27/2016**	**9/30/2016**	**10/3/2016**
		Media:	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**
		Sample ID:	**X-A3-WELL-01-090716**	**X-A3-WELL-01 090916**	**X-A3-WELL-01-091416**	**X-A3-WELL-01-091616**	**X-A3-WELL-01-092016**	**X-A3-WELL-01-092316**	**X-A3-WELL-01-092716**	**X-A3-WELL-9-093016**	**X-A3-WELL-01-100316**
		Result Units:	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Analyte	**Groundwater SCG Values**	**Units**									
1,1,1-Trichloroethane	1	µg/L	3.28 U	3.28 U	1.64 U	1.64 U	1.64 U	1.64 UJ	3.28 UJ	1.64 U	3.28 U
1,1-Dichloroethane	5	µg/L	1.52 U	**2.76 J**	**4.37**	**4.07**	**3.65**	**4.64 J**	**4.92 J**	**4.88**	**5.08**
1,1-Dichloroethene	5	µg/L	1.16 U	1.16 U	0.580 U	0.580 U	0.580 U	0.580 UJ	1.16 UJ	0.580 U	1.16 UJ
1,2-Dichloroethane	0.6	µg/L	0.840 U	0.840 U	0.420 U	0.420 U	0.420 U	0.420 UJ	0.840 UJ	0.420 U	0.840 U
1,2-Dichloroethene (Total)	5*	µg/L	3.24 U	3.24 U	**2.47 J**	**2.75 J**	**3.85 J**	**3.54 J**	**3.55 J**	**3.64 J**	**3.42 J**
Acetone**	50	µg/L	**62.6**	**375**	**175 J**	**133 J**	**95.5**	**40.9 J**	**44.7 J**	**83.8 J**	**48.2**
Benzene	1	µg/L	1.64 U	1.64 U	0.820 U	0.820 U	0.820 U	0.820 UJ	1.64 UJ	0.820 U	1.64 U
Chloroethane	5	µg/L	1.28 U	1.28 U	0.640 U	0.640 U	0.640 U	0.640 UJ	1.28 UJ	0.640 U	1.28 U
cis-1,2-Dichloroethene	5	µg/L	3.24 U	3.24 U	**2.47**	**2.75**	**3.85**	**3.54 J**	**3.55 J**	**3.64**	**3.42 J**
Ethylbenzene	5	µg/L	2.96 U	2.96 U	1.48 U	1.48 U	1.48 U	1.48 UJ	2.96 UJ	1.48 U	2.96 U
Tetrachloroethene	5	µg/L	1.44 U	1.44 U	0.720 U	0.720 U	0.720 U	0.720 UJ	1.44 UJ	0.720 U	1.44 U
Trichloroethene	5	µg/L	1.84 U	1.84 U	**0.958 J**	**1.67 J**	**1.89 J**	**1.72 J**	**2.26 J**	**2.20**	**2.54 J**
Vinyl Chloride	2	µg/L	3.60 U	3.60 U	**2.80**	**1.90 J**	**5.58**	**4.34 J**	3.60 UJ	**3.95**	**4.61**
Xylenes, Total	5	µg/L	2.64 U	2.64 U	1.32 U	1.32 U	1.32 U	1.32 UJ	2.64 UJ	1.32 U	2.64 U

Notes:

SCG Values = Applicable standards, criteria, and guideline values. Division of Water Technical & Operational Guidance Series (TOGS) 1.1.1 New York State Ambient Water Quality Standards and Guidance Values and Ground Water Effluent Limitations

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level

µg/L = micrograms per liter

µg/m^3 = micrograms per cubic meter

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

U = The analyte was analyzed for but was not detected above the reported sample quantitation limit.

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

SCG = applicable standards, criteria, and guidelines

Table 4-6. Extended ISTT System Treatment Results

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

		Location ID:	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**	**X-A3**
		Sample Date:	**9/12/2016**	**9/16/2016**	**9/20/2016**	**9/23/2016**	**9/27/2016**	**9/30/2016**	**10/5/2016**	**10/7/2016**
		Media:	**Soil Gas**	**Soil Gas**	**Soil Gas**	**Soil Gas**	**Soil Gas**	**Soil Gas**	**Soil Gas**	**Soil Gas**
		Sample ID:	**AIR-X-A3-WELL-01-091216**	**AIR-X-A3-WELL-01-091616**	**AIR-X-A3-WELL-01-092016**	**AIR-X-A3-WELL-01-092316**	**AIR-X-A3-WELL-01-092716**	**AIR-X-A3-WELL-01-093016**	**AIR-X-A3-WELL-01-100516**	**AIR-X-A3-01-100716**
		Result Units:	**μg/m^3**	**μg/m^3**	**μg/m^3**	**μg/m^3**	**μg/m^3**	**μg/m^3**	**μg/m^3**	**μg/m^3**
Analyte	**Groundwater SCG Values**	**Units**								
1,1,1-Trichloroethane	1	μg/L	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	2.5 U	**3.1 J**	2.5 U
1,1-Dichloroethane	5	μg/L	**13**	1.0 U	**200**	**13**	**24**	**15**	**97**	**41**
1,1-Dichloroethene	5	μg/L	**3.0 J**	1.4 U	**17**	1.4 U	**5.1 J**	**2.0 J**	**16**	**5.0 J**
1,2-Dichloroethane	0.6	μg/L	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U
1,2-Dichloroethene (Total)	5*	μg/L	**8.7 J**	1.4 U	**160**	**10 J**	**16**	**9.1 J**	**96**	**64**
Acetone**	50	μg/L	**240**	**71 J**	**920**	**110 J**	**78 J**	**87 J**	**4000**	**6600**
Benzene	1	μg/L	**4.6 J**	1.3 U	**17**	**2.0 J**	**2.9 J**	**1.8 J**	**60**	**28**
Chloroethane	5	μg/L	2.2 U	2.2 U	**14**	2.2 U	2.2 U	2.2 U	**4.0 J**	2.2 U
cis-1,2-Dichloroethene	5	μg/L	**8.6**	1.4 U	**150**	**10**	**14**	**9.3**	**83**	**55**
Ethylbenzene	5	μg/L	**3.1 J**	1.4 U	**11**	1.4 U	**2.7 J**	**1.8 J**	**26**	**14**
Tetrachloroethene	5	μg/L	1.6 U	1.6 U	**3.6 J**	1.6 U	**1100**	1.6 U	**36**	**35**
Trichloroethene	5	μg/L	**16**	2.1 U	**130**	**10 J**	**30**	**16**	**110**	**73**
Vinyl Chloride	2	μg/L	**6.8**	0.82 U	**330**	**17**	**38**	**17**	**90**	**37**
Xylenes, Total	5	μg/L	**11 J**	1.6 U	**20 J**	1.6 U	**4.3 J**	**3.3 J**	**120**	**64**

Notes:

SCG Values = Applicable standards, criteria, and guideline values. Division of Water Technical & Operational Guidance Series (TOGS) 1.1.1 New York State Ambient Water Quality Standards and Guidance Values and Ground Water Effluent Limitations

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level

μg/L = micrograms per liter

μg/m^3 = micrograms per cubic meter

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

U = The analyte was analyzed for but was not detected above the reported sample quantitation limit.

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

SCG = applicable standards, criteria, and guidelines

Table 4-7. ISTT System Performance Sampling Results – October 2016

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

				Location ID:	**X-A3**	**SB-10**	**SB-11**
				Sample Date:	**10/6/2016**	**10/6/2016**	**10/6/2016**
				Media:	**Groundwater**	**Soil**	**Soil**
				Sample Depth:	**--**	**14.5 ft**	**14.5 ft**
				Sample ID:	**XA3-GW01-100616**	**SB10-SL14.5-100616**	**SB11-SL14.5-100616**
				Result Units:	**µg/L**	**µg/kg**	**µg/kg**
Analyte	**Groundwater SCG Values**	**Units**	**Soil Unrestricted Use SCG Values**	**Units**			
1,1,1-Trichloroethane	1	µg/L	680	µg/kg	1.64 U	0.277 U	0.292 U
1,1-Dichloroethane	5	µg/L	270	µg/kg	**3.85**	**8.88**	**4.61**
1,1-Dichloroethene	5	µg/L	330	µg/kg	0.580 UJ	**24.8**	**102**
1,2-Dichloroethane	0.6	µg/L	20	µg/kg	0.420 U	0.192 U	0.202 U
1,2-Dichloroethene (Total)	5*	µg/L	250	µg/kg	**2.48 J**	**9.92**	**17.4**
Acetone**	50	µg/L	500	µg/kg	**177 J**	42.7 U	76.9 U
Benzene	1	µg/L	60	µg/kg	0.820 U	**0.432 J**	**0.608 J**
Chloroethane	5	µg/L	700	µg/kg	0.640 U	0.863 U	0.910 U
cis-1,2-Dichloroethene	5	µg/L	250	µg/kg	**2.48**	**9.12**	**15.6**
Ethylbenzene	5	µg/L	1,000	µg/kg	1.48 U	0.264 U	0.278 U
Tetrachloroethene	5	µg/L	1,300	µg/kg	0.720 U	0.513 U	**0.627 J**
Trichloroethene	5	µg/L	470	µg/kg	**1.57 J**	**4.66**	**11.6**
Vinyl Chloride	2	µg/L	20	µg/kg	**5.10**	**15.8**	**15.4**
Xylenes, Total	5	µg/L	260	µg/kg	1.32 U	0.642 U	0.677 U

Notes:

SCG Values = Applicable standards,

Ambient Water Quality Standards and

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

Performance Standards in Soil are the

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level.

Brown shading indicates that the result exceeded the soil screening level; however, there were no soil exceedances during the June 2016 sampling event.

-- = information not available

µg/L = micrograms per liter

µg/kg = micrograms per kilogram

ft = feet

ISTT = in situ thermal treatment

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

U = The analyte was analyzed for but was not detected above the reported sample quantitation limit.

SCG = standards, criteria, and guidelines

Table 5-1. Post-Remedy Sampling Results

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

		Location ID:	**RW-02**	**X-A-1**	**X-C-3**		**X-A-3**	
		Sample Date:	**12/3/2016**	**12/3/2016**	**12/3/2016**	**2/1/2017**	**12/3/2016**	**2/1/2017**
		Media:	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**
		Sample Depth (ft btoc):	**13**	**27**	**27**	**27**	**27**	**27**
		Sample ID:	**RW-02-120316**	**X-A-1-120316**	**X-C-3-120316**	**X-C-3-01-020117**	**X-A-3-120316**	**X-A-3-01-020117**
		Result Units:	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Analyte	**Groundwater SCG Values**	**Units**						
1,1,1-Trichloroethane	1	µg/L	0.820 U	0.820 U	0.820 U	0.820 U	0.820 U	0.820 U
1,1-Dichloroethane	5	µg/L	0.380 U	0.380 U	0.380 U	**0.756 J**	**3.76**	**2.74**
1,1-Dichloroethene	5	µg/L	0.290 U	0.290 U	0.290 U	0.290 U	0.290 U	0.290 U
1,2-Dichloroethane	0.6	µg/L	0.210 U	0.210 U	0.210 U	0.210 U	0.210 U	0.210 U
1,2-Dichloroethene (Total)	5*	µg/L	0.810 U	**2.34**	**1.30 J**	**1.87 J**	**5.09**	**5.51**
Acetone**	50	µg/L	3.00 U	**67.1**	**4.46 J**	**3.90 J**	3.00 U	3.00 U
Benzene	1	µg/L	0.410 U	0.410 U	0.410 U	0.410 U	0.410 U	0.410 U
Chloroethane	5	µg/L	0.320 U	0.320 U	0.320 U	0.320 U	0.320 U	0.320 U
cis-1,2-Dichloroethene	5	µg/L	0.810 U	**2.34**	**1.30**	**1.87**	**5.09**	**5.51**
Ethylbenzene	5	µg/L	0.740 U	0.740 U	0.740 U	0.740 U	0.740 U	0.740 U
Tetrachloroethene	5	µg/L	0.360 U	0.360 U	0.360 U	0.360 U	0.360 U	0.360 U
Trichloroethene	5	µg/L	0.460 U	0.460 U	0.460 U	0.460 U	**1.41**	**0.845 J**
Vinyl Chloride	2	µg/L	0.900 U	0.900 U	**2.35 J**	**4.83**	**24.5 J**	**17.5**
Xylenes, Total	5	µg/L	0.660 U	0.660 U	0.660 U	0.660 U	0.660 U	0.660 U

Notes:

SCG Values = Applicable standards, criteria, and guideline values. Division of Water Technical & Operational Guidance Series (TOGS) 1.1.1 New York State Ambient Water Quality Standards and Guidance Values and Ground Water Effluent Limitations

- Table 1 and Table 5 - Class GA; June 1998; modified January 1999; modified April 2000; modified June 2004

*Screening level for cis-1,2-dichloroethene used for total 1,2-dichloroethene.

**Acetone generation is a temporary byproduct of thermal treatment and exceedances of the acetone SCG were not a driver for continued operation of the ISTT system.

Bold indicates that the analyte was detected.

Grey shading indicates that the result exceeded the groundwater screening level.

ft btoc = feet below top of casing

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.

µg/L = micrograms per liter

U = The analyte was analyzed for but was not detected above the reported sample quantitation limit.

Table 5-2. Post-Remedy Groundwater Quality

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

	Location ID:	**X-A-1**	**X-A-1**	**X-C-3**	**X-C-3**
	Sample Date:	**2/1/2017**	**2/1/2017**	**2/1/2017**	**2/1/2017**
	Media:	**Groundwater**	**Groundwater**	**Groundwater**	**Groundwater**
	Sample Depth (ft btoc):	**27**	**10**	**28**	**14**
Water Quality Parameter	**Units**				
Temperature	°C	42.62	26.69	46.11	35.79
Conductivity	mS/cm^c	0.854	0.190	0.950	0.928
Conductivity	ms/cm	1.138	0.844	1.332	1.119
Dissolved Oxygen	%	2.9	0.0	4.8	9.9
Dissolved Oxygen	mg/L	0.17	0.00	0.29	0.70
pH	SU	6.96	7.03	7.69	7.88
ORP	mV	-192.5	-164.3	-79.1	-122.5

Notes:

1. Parameters measured using a YSI water quality meter on February 1, 2017
2. Sample depths are approximate

% = percent

°C = degrees Celsius

ft btoc = feet below top of casing

mg/L = milligrams per liter

ms/cm = milliSiemens per centimeter

mS/cm^c = milliSiemens per centimeter (corrected)

mV = millivolts

ORP = oxidation reduction potential

SU = standard units

Figures

Image Source: ESRI - Microsoft 2011

FIGURE 2-1

Site Location Map

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

\\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIGX_X_LOCATION_MAP.MXD MWACH 1/16/2017 12:21:55 PM

Notes:
1. HCL = hydrochloric acid
2. UST = underground storage tank
3. Location of former buildings, tanks, concrete, and other former site features is approximate.

FIGURE 2-2
Site Map
Final Engineer Report
Former Dowell Depew Facility, Depew, New York

Image Source: ESRI - Microsoft 2011

Notes:
1. Groundwater elevations are presented in feet above mean sea level.
2. Groundwater levels were gauged on September 11, 2015.
3. Groundwater contour lines are dashed where inferred.
4. Site monitoring wells were resurveyed in April 2015. This figure uses updated site monitoring well and piezometer horizontal coordinates and vertical elevations.
5. Location of former buildings, tanks, concrete, and features is approximate.

LEGEND

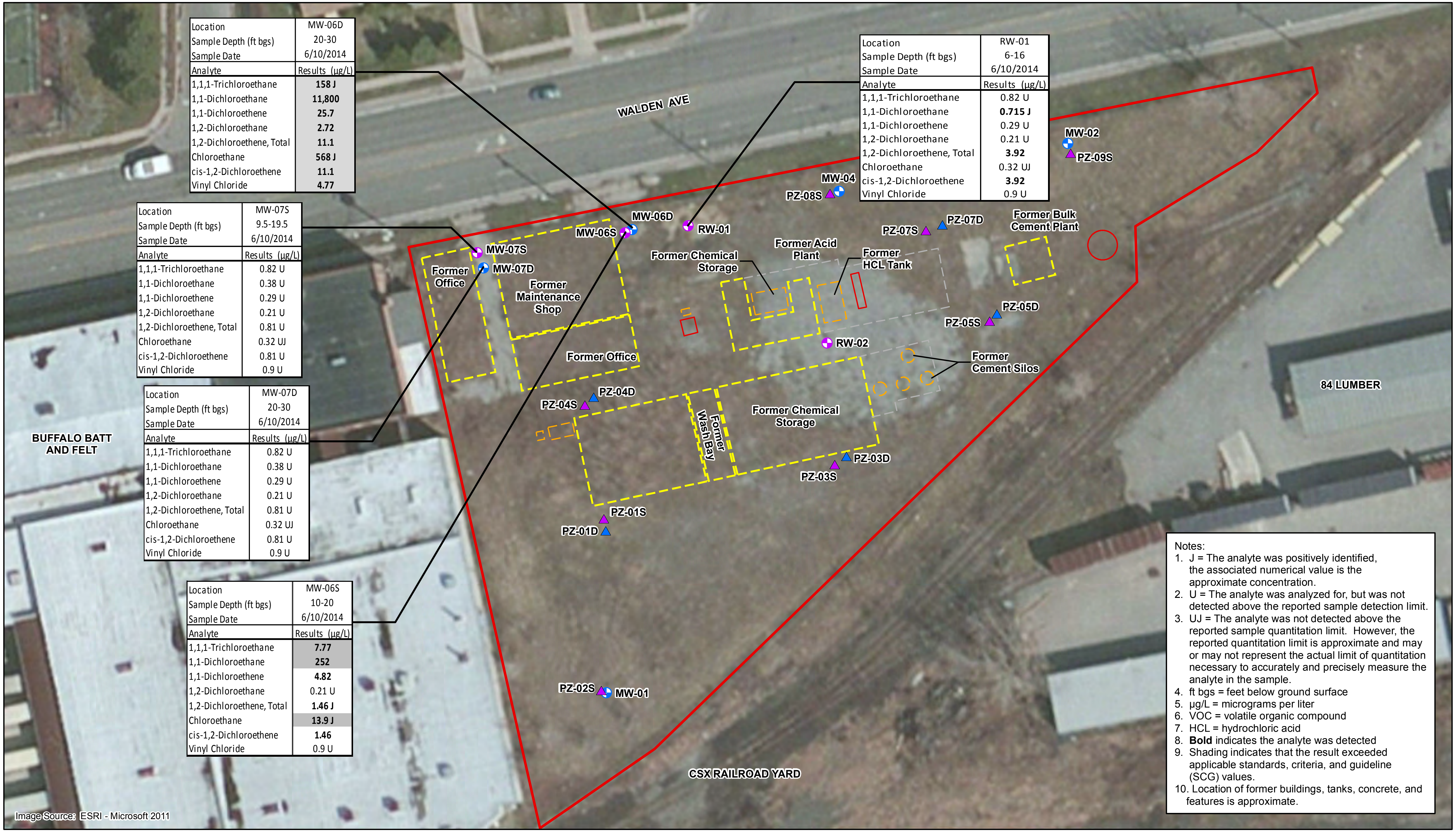
🟥 Site Boundary	◕ Monitoring Well / Recovery Well in Upper Till	— Groundwater Elevation Contour (Upper Till)	→ Groundwater Flow Direction (Upper Till)
⬚ Former Building Location	◕ Monitoring Well / Recovery Well in Lower Till	— Groundwater Elevation Contour (Lower Till)	→ Groundwater Flow Direction (Lower Till)
⬚ Former Feature Location	▲ Piezometer in Upper Till	672.82 Groundwater Elevation (Upper Till)	- - Former Concrete
☐ Former Tank	▲ Piezometer in Lower Till	672.05 Groundwater Elevation (Lower Till)	

0 25 50
Feet

N

FIGURE 2-3
Potentiometric Surface Map - September 2015
Final Engineer Report
Former Dowell Depew Facility, Depew, New York

ch2m:



Location	MW-06D
Sample Depth (ft bgs)	20-30
Sample Date	6/10/2014
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**158 J**
1,1-Dichloroethane	**11,800**
1,1-Dichloroethene	**25.7**
1,2-Dichloroethane	**2.72**
1,2-Dichloroethene, Total	**11.1**
Chloroethane	**568 J**
cis-1,2-Dichloroethene	**11.1**
Vinyl Chloride	**4.77**

Location	RW-01
Sample Depth (ft bgs)	6-16
Sample Date	6/10/2014
Analyte	Results (µg/L)
1,1,1-Trichloroethane	0.82 U
1,1-Dichloroethane	**0.715 J**
1,1-Dichloroethene	0.29 U
1,2-Dichloroethane	0.21 U
1,2-Dichloroethene, Total	**3.92**
Chloroethane	0.32 UJ
cis-1,2-Dichloroethene	**3.92**
Vinyl Chloride	0.9 U

Location	MW-07S
Sample Depth (ft bgs)	9.5-19.5
Sample Date	6/10/2014
Analyte	Results (µg/L)
1,1,1-Trichloroethane	0.82 U
1,1-Dichloroethane	0.38 U
1,1-Dichloroethene	0.29 U
1,2-Dichloroethane	0.21 U
1,2-Dichloroethene, Total	0.81 U
Chloroethane	0.32 UJ
cis-1,2-Dichloroethene	0.81 U
Vinyl Chloride	0.9 U

Location	MW-07D
Sample Depth (ft bgs)	20-30
Sample Date	6/10/2014
Analyte	Results (µg/L)
1,1,1-Trichloroethane	0.82 U
1,1-Dichloroethane	0.38 U
1,1-Dichloroethene	0.29 U
1,2-Dichloroethane	0.21 U
1,2-Dichloroethene, Total	0.81 U
Chloroethane	0.32 UJ
cis-1,2-Dichloroethene	0.81 U
Vinyl Chloride	0.9 U

Location	MW-06S
Sample Depth (ft bgs)	10-20
Sample Date	6/10/2014
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**7.77**
1,1-Dichloroethane	**252**
1,1-Dichloroethene	**4.82**
1,2-Dichloroethane	0.21 U
1,2-Dichloroethene, Total	**1.46 J**
Chloroethane	**13.9 J**
cis-1,2-Dichloroethene	**1.46**
Vinyl Chloride	0.9 U

Image Source: ESRI - Microsoft 2011

Notes:
1. J = The analyte was positively identified, the associated numerical value is the approximate concentration.
2. U = The analyte was analyzed for, but was not detected above the reported sample detection limit.
3. UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
4. ft bgs = feet below ground surface
5. µg/L = micrograms per liter
6. VOC = volatile organic compound
7. HCL = hydrochloric acid
8. **Bold** indicates the analyte was detected
9. Shading indicates that the result exceeded applicable standards, criteria, and guideline (SCG) values.
10. Location of former buildings, tanks, concrete, and features is approximate.

LEGEND

🟥	Site Boundary	▭	Former Feature Location	●	Monitoring Well / Recovery Well in Upper Till
▭	Former Building Location	— —	Former Concrete	●	Monitoring Well / Recovery Well in Lower Till
▭	Former Tank			▲	Piezometer in Upper Till
				▲	Piezometer in Lower Till

N

0 25 50
Feet

FIGURE 2-4

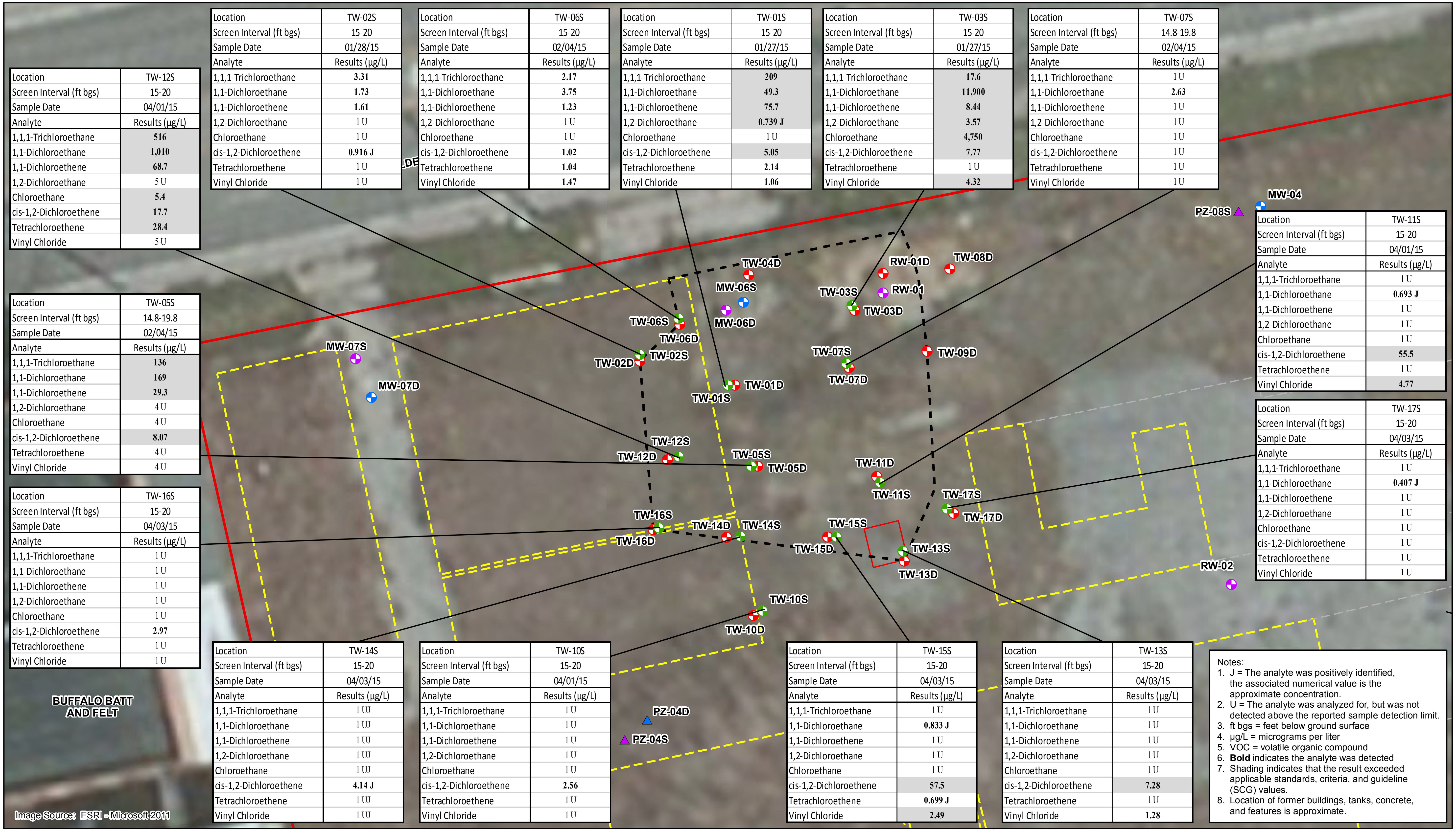
VOCs Exceeding SCG Values

Basis of Design for In Situ Thermal Treatment

Former Dowell Depew Facility, Depew, New York

ch2m.

RDD \\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIG2-4_VOC_EXCEEDANCES.MXD MWACH 2/21/2017 7:54:59 AM



Location	TW-02S
Screen Interval (ft bgs)	15-20
Sample Date	01/28/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**3.31**
1,1-Dichloroethane	**1.73**
1,1-Dichloroethene	**1.61**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**0.916 J**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-06S
Screen Interval (ft bgs)	15-20
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**2.17**
1,1-Dichloroethane	**3.75**
1,1-Dichloroethene	**1.23**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**1.02**
Tetrachloroethene	**1.04**
Vinyl Chloride	**1.47**

Location	TW-01S
Screen Interval (ft bgs)	15-20
Sample Date	01/27/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**209**
1,1-Dichloroethane	**49.3**
1,1-Dichloroethene	**75.7**
1,2-Dichloroethane	**0.739 J**
Chloroethane	1 U
cis-1,2-Dichloroethene	**5.05**
Tetrachloroethene	**2.14**
Vinyl Chloride	**1.06**

Location	TW-03S
Screen Interval (ft bgs)	15-20
Sample Date	01/27/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**17.6**
1,1-Dichloroethane	**11,900**
1,1-Dichloroethene	**8.44**
1,2-Dichloroethane	**3.57**
Chloroethane	**4,750**
cis-1,2-Dichloroethene	**7.77**
Tetrachloroethene	1 U
Vinyl Chloride	**4.32**

Location	TW-07S
Screen Interval (ft bgs)	14.8-19.8
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**2.63**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	1 U
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-12S
Screen Interval (ft bgs)	15-20
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**516**
1,1-Dichloroethane	**1,010**
1,1-Dichloroethene	**68.7**
1,2-Dichloroethane	5 U
Chloroethane	**5.4**
cis-1,2-Dichloroethene	**17.7**
Tetrachloroethene	**28.4**
Vinyl Chloride	5 U

Location	TW-05S
Screen Interval (ft bgs)	14.8-19.8
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**136**
1,1-Dichloroethane	**169**
1,1-Dichloroethene	**29.3**
1,2-Dichloroethane	4 U
Chloroethane	4 U
cis-1,2-Dichloroethene	**8.07**
Tetrachloroethene	4 U
Vinyl Chloride	4 U

Location	TW-16S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**2.97**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-11S
Screen Interval (ft bgs)	15-20
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.693 J**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**55.5**
Tetrachloroethene	1 U
Vinyl Chloride	**4.77**

Location	TW-17S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.407 J**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	1 U
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-14S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 UJ
1,1-Dichloroethane	1 UJ
1,1-Dichloroethene	1 UJ
1,2-Dichloroethane	1 UJ
Chloroethane	1 UJ
cis-1,2-Dichloroethene	**4.14 J**
Tetrachloroethene	1 UJ
Vinyl Chloride	1 UJ

Location	TW-10S
Screen Interval (ft bgs)	15-20
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**2.56**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-15S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.833 J**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**57.5**
Tetrachloroethene	**0.699 J**
Vinyl Chloride	**2.49**

Location	TW-13S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**7.28**
Tetrachloroethene	1 U
Vinyl Chloride	**1.28**

Notes:
1. J = The analyte was positively identified, the associated numerical value is the approximate concentration.
2. U = The analyte was analyzed for, but was not detected above the reported sample detection limit.
3. ft bgs = feet below ground surface
4. µg/L = micrograms per liter
5. VOC = volatile organic compound
6. **Bold** indicates the analyte was detected
7. Shading indicates that the result exceeded applicable standards, criteria, and guideline (SCG) values.
8. Location of former buildings, tanks, concrete, and features is approximate.

LEGEND

🟥	Site Boundary	⬚	Target Treatment Zone	⊕	Temporary Well (Shallow)	⊕	Monitoring Well / Recovery Well in Upper Till
⬚	Former Building Location	– –	Former Concrete	⊕	Temporary Well (Deep)	⊕	Monitoring Well / Recovery Well in Lower Till
☐	Former Tank					▲	Piezometer in Upper Till
						▲	Piezometer in Lower Till

N

0 10 20

Feet

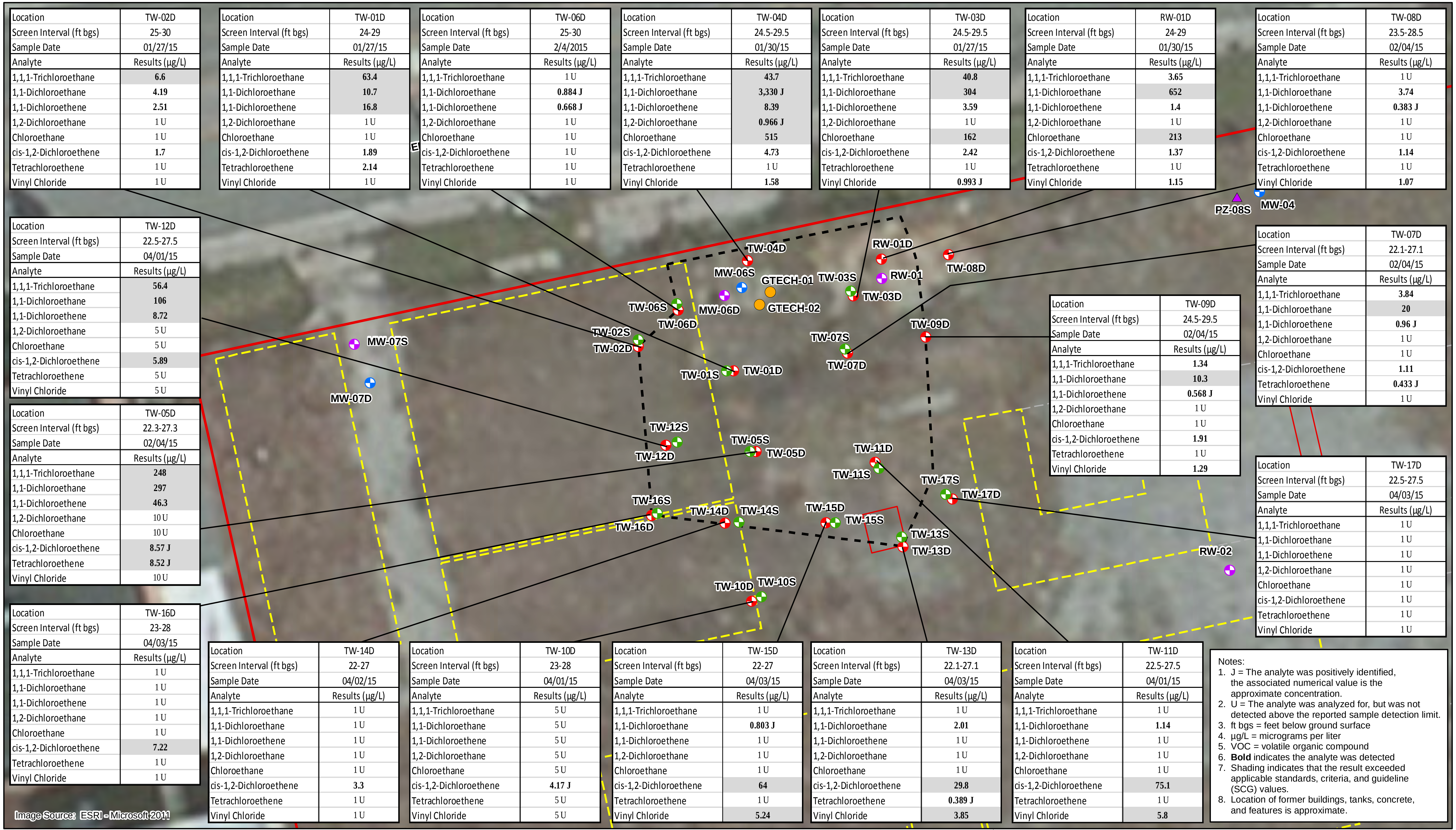
FIGURE 2-5

VOCs Exceeding SCG Values (Shallow) - January and April 2015

Target Treatment Zone Investigation Technical Memorandum

Former Dowell Depew Facility, Depew, New York

\\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIG_2-05_VOC_EXCEEDANCES_SHALLOW.MXD MWACH 2/21/2017 8:30:36 AM



Location	TW-02D
Screen Interval (ft bgs)	25-30
Sample Date	01/27/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**6.6**
1,1-Dichloroethane	**4.19**
1,1-Dichloroethene	**2.51**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**1.7**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-01D
Screen Interval (ft bgs)	24-29
Sample Date	01/27/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**63.4**
1,1-Dichloroethane	**10.7**
1,1-Dichloroethene	**16.8**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**1.89**
Tetrachloroethene	**2.14**
Vinyl Chloride	1 U

Location	TW-06D
Screen Interval (ft bgs)	25-30
Sample Date	2/4/2015
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.884 J**
1,1-Dichloroethene	**0.668 J**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	1 U
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-04D
Screen Interval (ft bgs)	24.5-29.5
Sample Date	01/30/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**43.7**
1,1-Dichloroethane	**3,330 J**
1,1-Dichloroethene	**8.39**
1,2-Dichloroethane	**0.966 J**
Chloroethane	**515**
cis-1,2-Dichloroethene	**4.73**
Tetrachloroethene	1 U
Vinyl Chloride	**1.58**

Location	TW-03D
Screen Interval (ft bgs)	24.5-29.5
Sample Date	01/27/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**40.8**
1,1-Dichloroethane	**304**
1,1-Dichloroethene	**3.59**
1,2-Dichloroethane	1 U
Chloroethane	**162**
cis-1,2-Dichloroethene	**2.42**
Tetrachloroethene	1 U
Vinyl Chloride	**0.993 J**

Location	RW-01D
Screen Interval (ft bgs)	24-29
Sample Date	01/30/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**3.65**
1,1-Dichloroethane	**652**
1,1-Dichloroethene	**1.4**
1,2-Dichloroethane	1 U
Chloroethane	**213**
cis-1,2-Dichloroethene	**1.37**
Tetrachloroethene	1 U
Vinyl Chloride	**1.15**

Location	TW-08D
Screen Interval (ft bgs)	23.5-28.5
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**3.74**
1,1-Dichloroethene	**0.383 J**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**1.14**
Tetrachloroethene	1 U
Vinyl Chloride	**1.07**

Location	TW-12D
Screen Interval (ft bgs)	22.5-27.5
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**56.4**
1,1-Dichloroethane	**106**
1,1-Dichloroethene	**8.72**
1,2-Dichloroethane	5 U
Chloroethane	5 U
cis-1,2-Dichloroethene	**5.89**
Tetrachloroethene	5 U
Vinyl Chloride	5 U

Location	TW-05D
Screen Interval (ft bgs)	22.3-27.3
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**248**
1,1-Dichloroethane	**297**
1,1-Dichloroethene	**46.3**
1,2-Dichloroethane	10 U
Chloroethane	10 U
cis-1,2-Dichloroethene	**8.57 J**
Tetrachloroethene	**8.52 J**
Vinyl Chloride	10 U

Location	TW-16D
Screen Interval (ft bgs)	23-28
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**7.22**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-07D
Screen Interval (ft bgs)	22.1-27.1
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**3.84**
1,1-Dichloroethane	**20**
1,1-Dichloroethene	**0.96 J**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**1.11**
Tetrachloroethene	**0.433 J**
Vinyl Chloride	1 U

Location	TW-09D
Screen Interval (ft bgs)	24.5-29.5
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**1.34**
1,1-Dichloroethane	**10.3**
1,1-Dichloroethene	**0.568 J**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**1.91**
Tetrachloroethene	1 U
Vinyl Chloride	**1.29**

Location	TW-17D
Screen Interval (ft bgs)	22.5-27.5
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	1 U
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-14D
Screen Interval (ft bgs)	22-27
Sample Date	04/02/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**3.3**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-10D
Screen Interval (ft bgs)	23-28
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	5 U
1,1-Dichloroethane	5 U
1,1-Dichloroethene	5 U
1,2-Dichloroethane	5 U
Chloroethane	5 U
cis-1,2-Dichloroethene	**4.17 J**
Tetrachloroethene	5 U
Vinyl Chloride	5 U

Location	TW-15D
Screen Interval (ft bgs)	22-27
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.803 J**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**64**
Tetrachloroethene	1 U
Vinyl Chloride	**5.24**

Location	TW-13D
Screen Interval (ft bgs)	22.1-27.1
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**2.01**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**29.8**
Tetrachloroethene	**0.389 J**
Vinyl Chloride	**3.85**

Location	TW-11D
Screen Interval (ft bgs)	22.5-27.5
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**1.14**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**75.1**
Tetrachloroethene	1 U
Vinyl Chloride	**5.8**

Notes:
1. J = The analyte was positively identified, the associated numerical value is the approximate concentration.
2. U = The analyte was analyzed for, but was not detected above the reported sample detection limit.
3. ft bgs = feet below ground surface
4. µg/L = micrograms per liter
5. VOC = volatile organic compound
6. **Bold** indicates the analyte was detected
7. Shading indicates that the result exceeded applicable standards, criteria, and guideline (SCG) values.
8. Location of former buildings, tanks, concrete, and features is approximate.

Image Source: ESRI - Microsoft 2011

LEGEND

🟥 Site Boundary	▭ Target Treatment Zone	● Temporary Well (Shallow)	● Monitoring Well / Recovery Well in Upper Till
▭ Former Building Location	— — Former Concrete	● Temporary Well (Deep)	● Monitoring Well / Recovery Well in Lower Till
▭ Former Tank		● Geotechnical Boring	▲ Piezometer in Upper Till

N

0 10 20
Feet

FIGURE 2-6

VOCs Exceeding SCG Values (Deep) - January and April 2015

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

ch2m:

Image Source: ESRI - Microsoft 2011

Notes:
1. Location of former buildings, tanks, concrete, and features is approximate.
2. Wells located within the target treatment area were plugged and abandoned between October 5 and 7, 2015.

LEGEND

▭ Site Boundary
▭ Former Building Location
▭ Former Tank
▭ Target Treatment Zone
— — Former Concrete
● Injection Well
● Monitoring Well / Recovery Well in Upper Till
● Monitoring Well / Recovery Well in Lower Till
▲ Piezometer in Upper Till
▲ Piezometer in Lower Till

N

0 10 20
Feet

FIGURE 4-1

Wells Abandoned Prior to Construction Activities

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

ch2m.

\\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIG_4-01_WELLS_ABANDONED_PRIOR_TO_CONSTRUCTION_ACTIVITIES.MXD MWACH 2/10/2017 8:29:05 AM

Notes:
1. SVE = soil vapor extraction
2. MPE = multi-phase extraction
3. TMS = temperature monitoring sensor

LEGEND

🟥 Electrode
🟦 MPE Well
🟩 Temperature Monitoring Sensor
-●- SVE Well
▭ Target Treatment Zone
🟩 Vapor Cap
🟥 Site Boundary

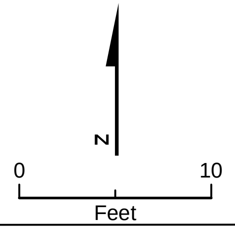


FIGURE 4-2

ISTT Wellfield

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

RDD \\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIG_4-02_ISTT_WELLFIELD.MXD MWACH 2/21/2017 8:27:39 AM

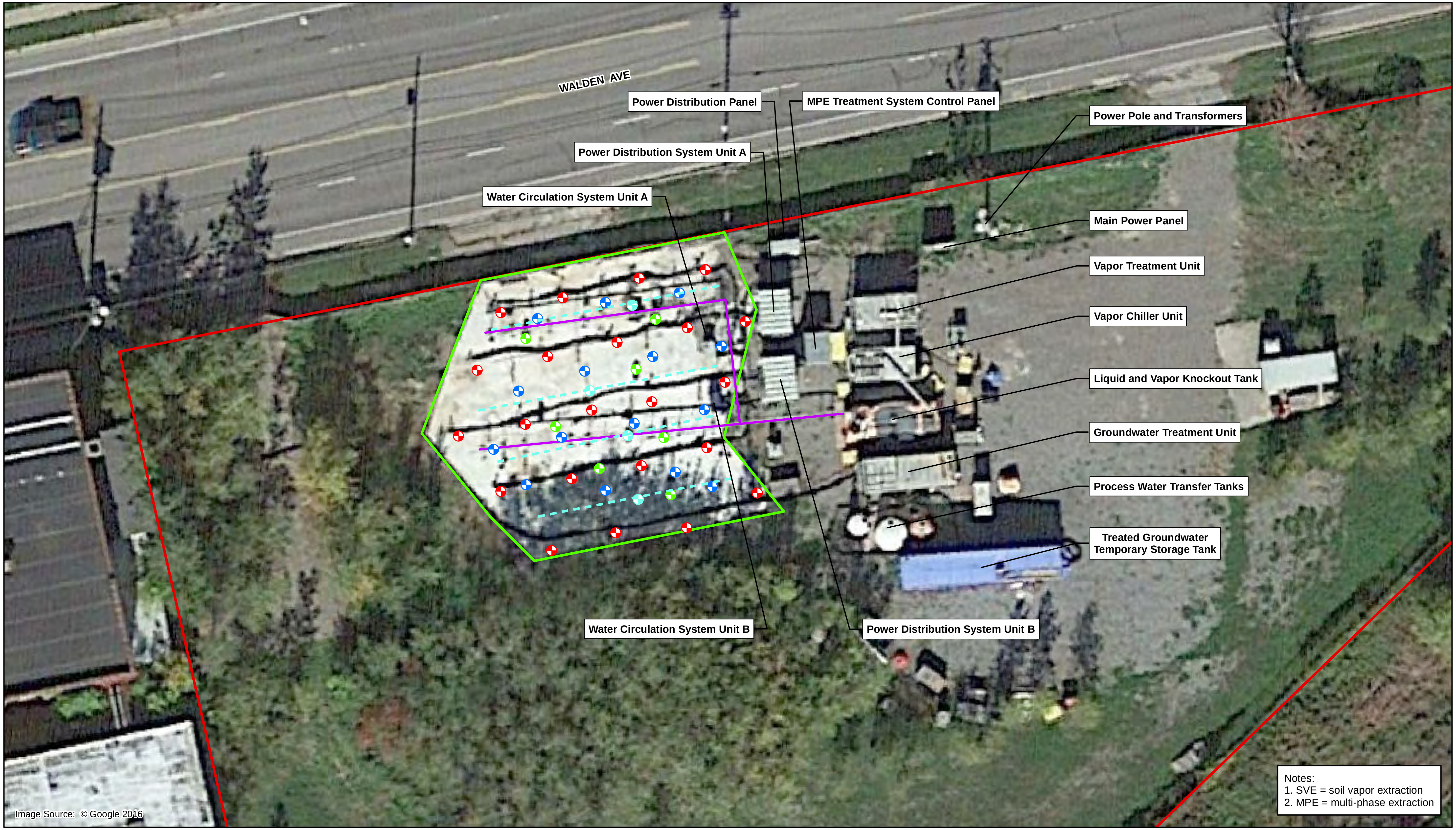


Image Source: © Google 2016

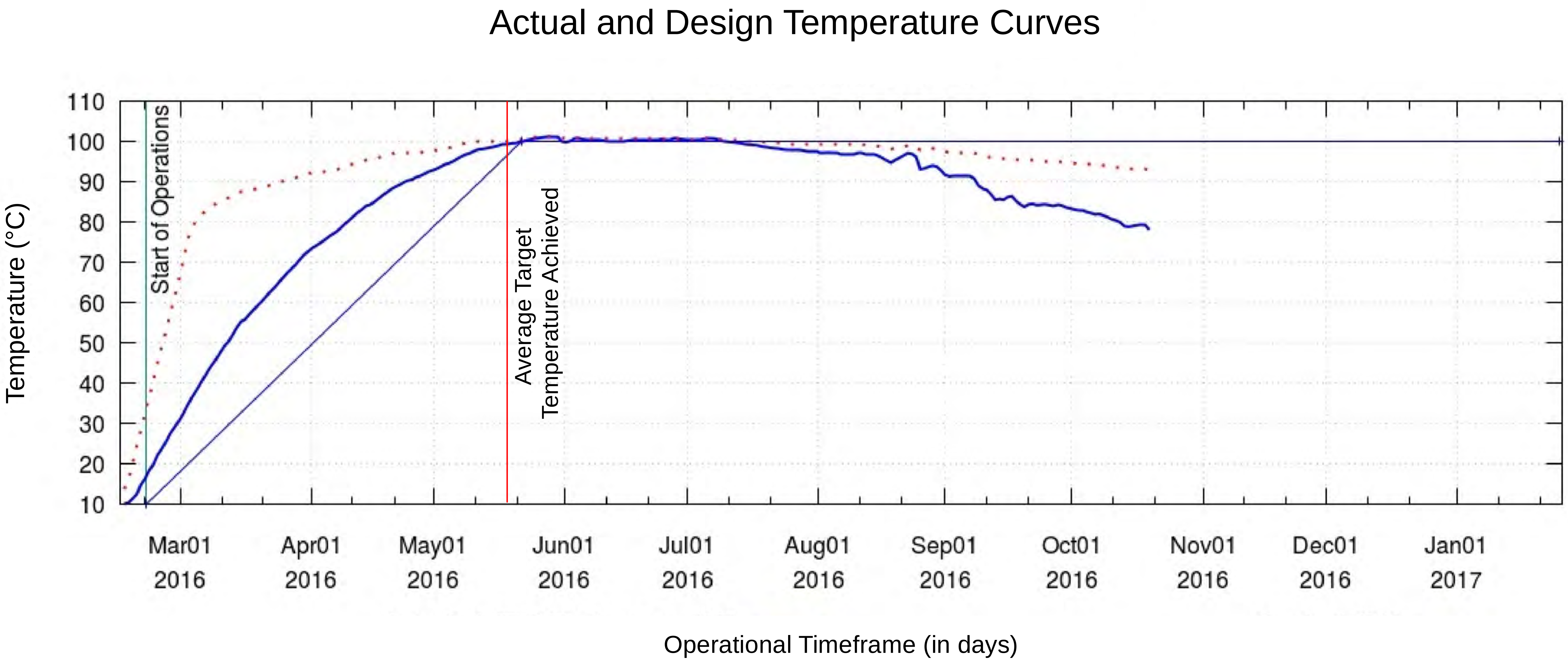
Notes:
1. SVE = soil vapor extraction
2. MPE = multi-phase extraction

LEGEND

🔴	Electrode
🔵	MPE Well
🟢	Temperature Monitoring Sensor
- ● -	SVE Well
—	Extracted Liquid and Vapor Conveyance Piping
🟥	Site Boundary
🟩	Vapor Cap

FIGURE 4-3
ISTT Map
Final Engineer Report
Former Dowell Depew Facility, Depew, New York

\\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIG_4-03_ISTT_MAP.MXD MWACH 2/21/2017 8:01:42 AM



Notes:

1. °C = degrees Celsius
2. Electrodes were powered up on February 17, 2016, during ISTT system commissioning. Official start of ISTT system operations began on February 22, 2016.

LEGEND

— Actual digiTAM^{TM} Average (°C) (average temperature immediately around temperature monitoring sensor locations)

• • • Calculated treatment zone average (°C) (average temperature immediately around electrodes)

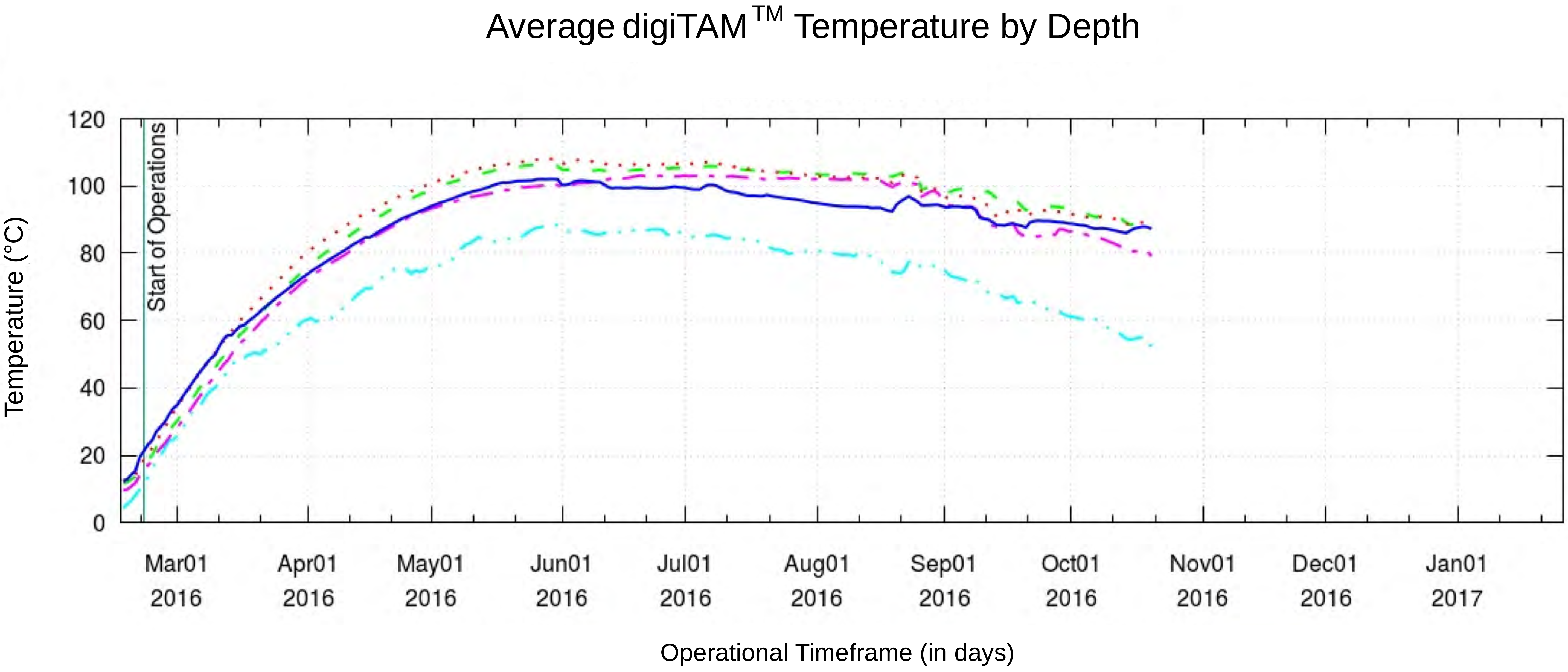
—+— Design* (°C) (average temperature across entire target treatment zone, assuming target temperature is reached after 90 days of operation)

FIGURE 4-4

ISTT Temperature Curves

Final Engineer Report

Former Dowell Depew Facility, Depew, New York



Notes:
1. °C = degrees Celsius
2. ft AMSL = feet above mean sea level
3. Electrodes were powered up on February 17, 2016, during ISTT system commissioning. Official start of ISTT system operations began on February 22, 2016.

LEGEND

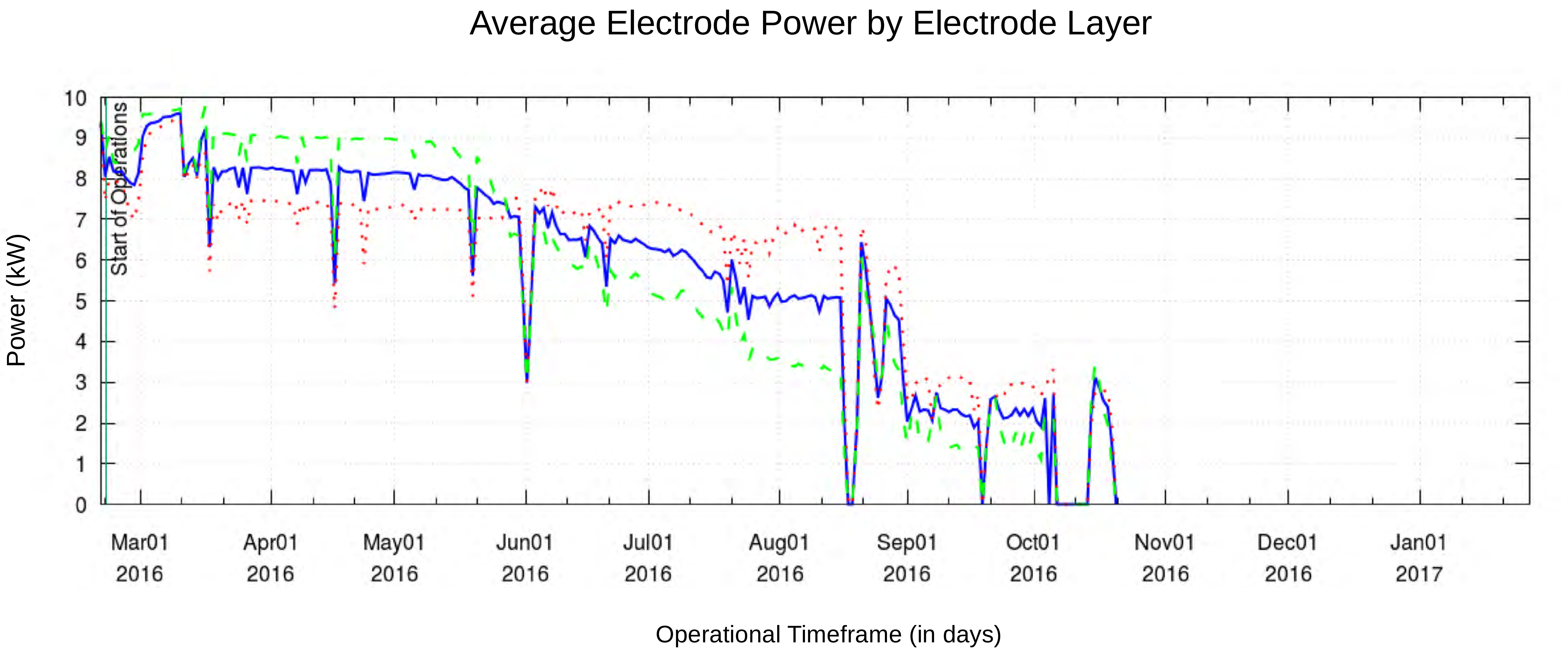
674-680 ft AMSL	656-662 ft AMSL
668-674 ft AMSL	650-656 ft AMSL
662-668 ft AMSL	

FIGURE 4-5

ISTT Average Depth Temperature Curves

Final Engineer Report

Former Dowell Depew Facility, Depew, New York



Notes:
1. kW = kilowatt
2. Electrodes were powered up on February 17, 2016, during ISTT system commissioning. Official start of ISTT system operations began on February 22, 2016.

LEGEND

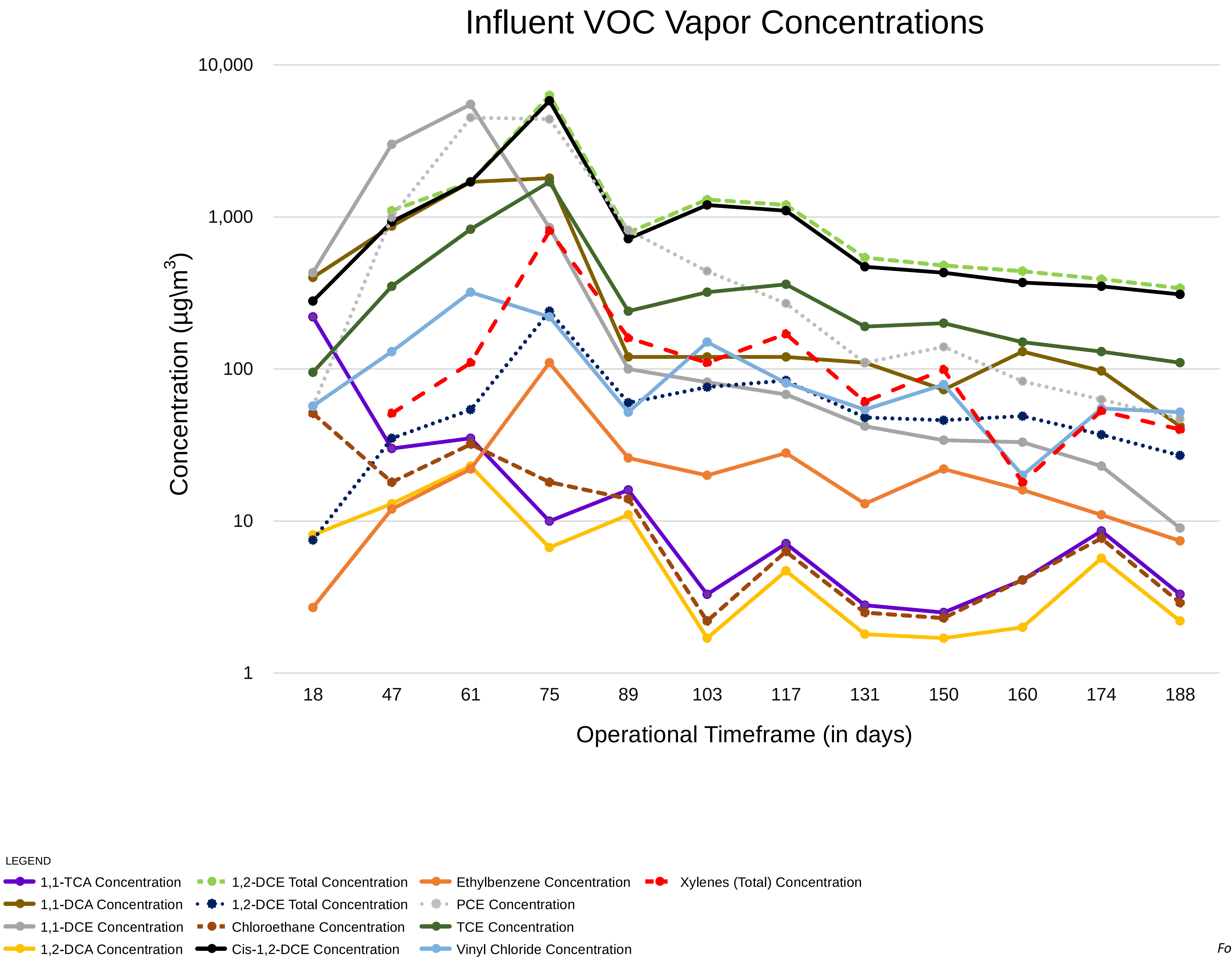
—	Shallow and Deep Combined
• • •	Shallow
– –	Deep

FIGURE 4-6

Power Use by Electrode Layer (Depth)

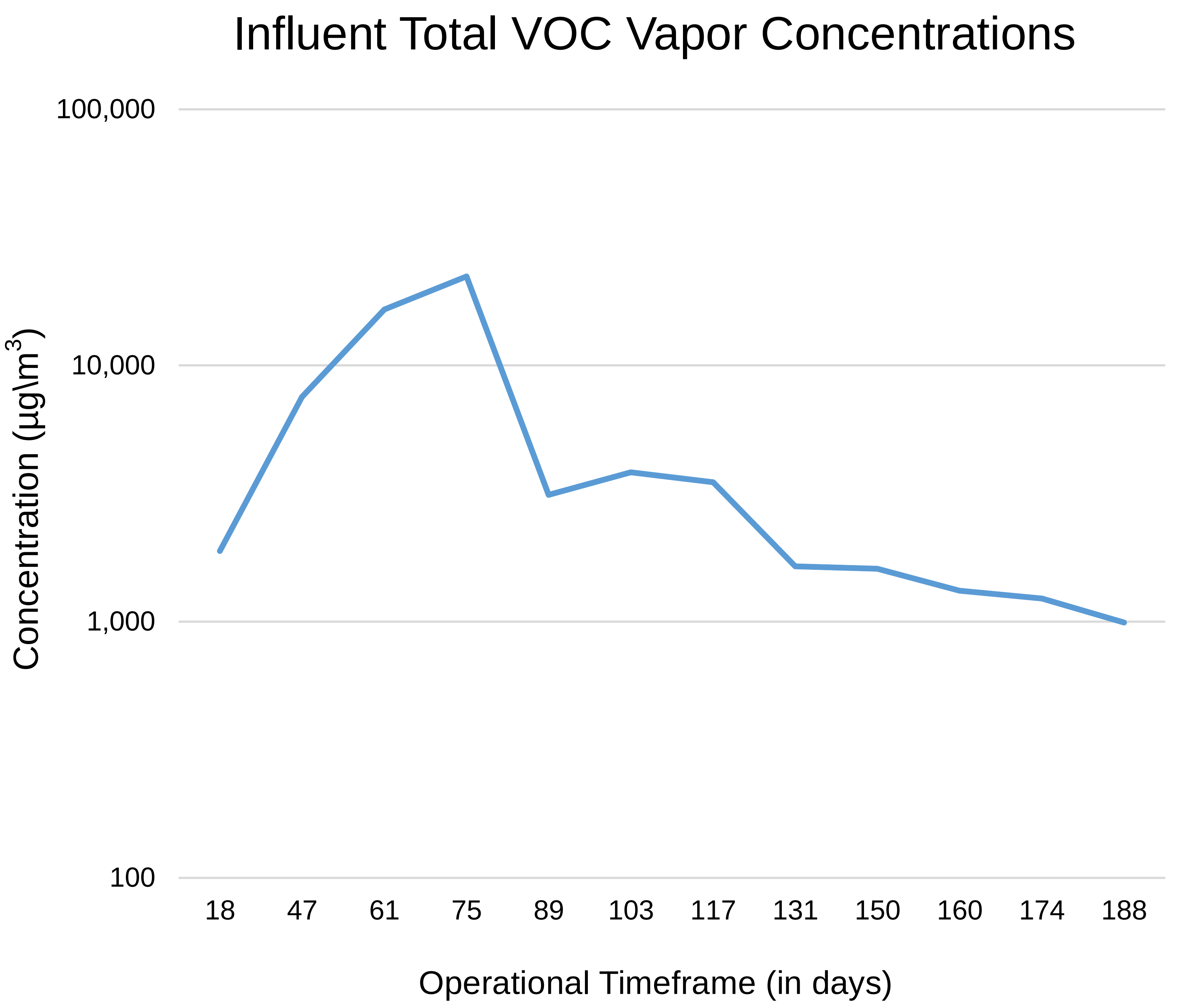
Final Engineer Report

Former Dowell Depew Facility, Depew, New York



Notes:
1. µg\m³ = micrograms per cubic meter
2. 1,1,1-TCA = 1,1,1-trichloroethane
3. 1,1-DCA = 1,1-dichloroethane
4. 1,1-DCE = 1,1-dichloroethene
5. 1,2-DCA = 1,2-dichloroethane
6. 1,2-DCE Total = 1,2-dichloroethene total
7. cis-1,2-DCE = cis-1,2-dichloroethene
8. PCE = tetrachloroethene
9. TCE = trichloroethene
10. VOC = volatile organic compounds
11. Influent VOC vapor concentration time graph excludes acetone concentrations.
12. Chemical concentrations are plotted on a logarithmic scale.

FIGURE 4-7
Influent VOC Vapor Concentrations
Final Engineer Report
Former Dowell Depew Facility, Depew, New York



Notes:
1. µg\m³ = micrograms per cubic meter
2. VOC = volatile organic compound
3. Influent total VOC vapor concentration time graph excludes acetone concentrations.
4. Chemical concentrations are plotted on a logarithmic scale.

LEGEND

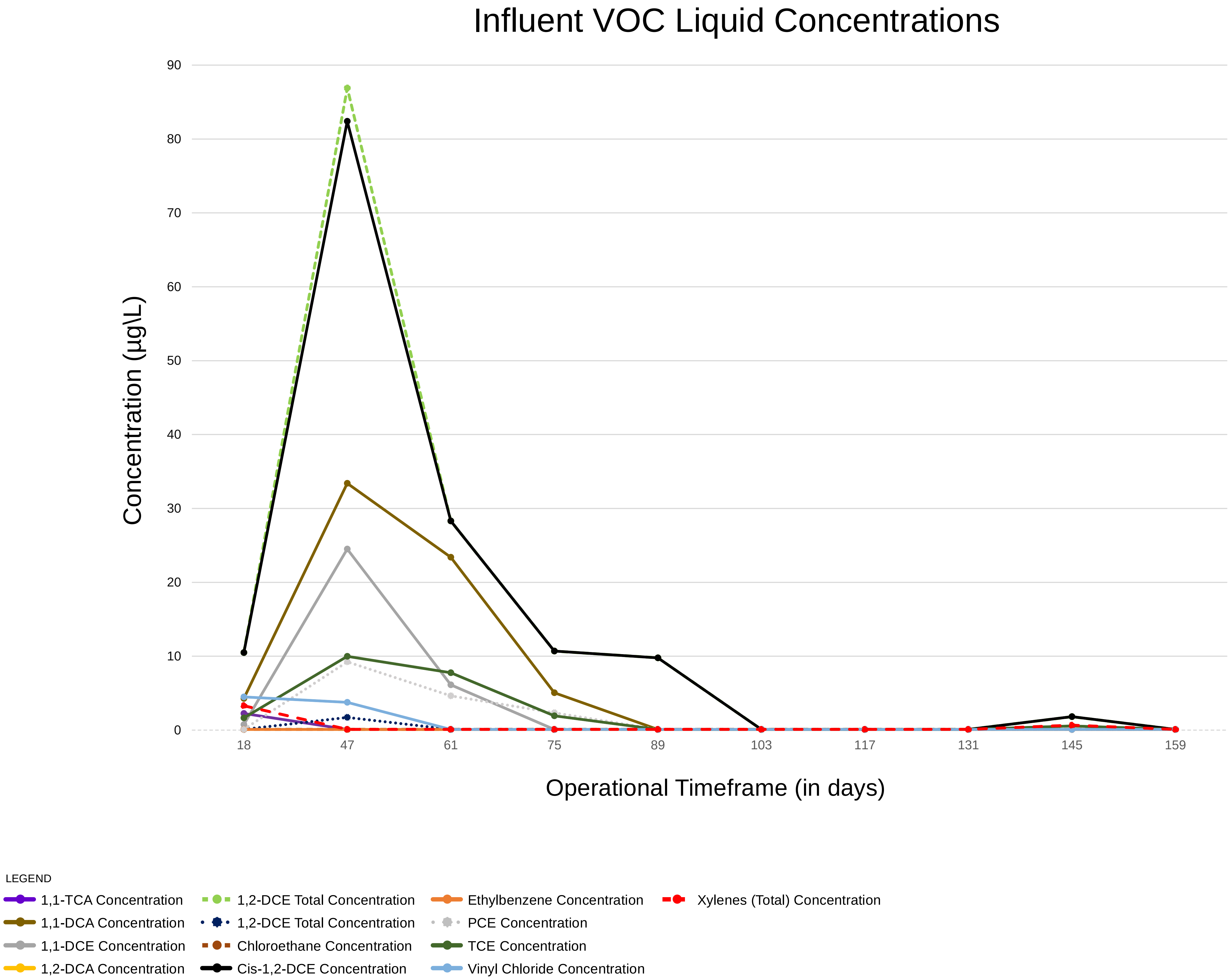
— Total VOCs

FIGURE 4-8

Influent Total VOC Vapor Concentrations

Final Engineer Report

Former Dowell Depew Facility, Depew, New York



Notes:
1. µg\L = micrograms per liter
2. 1,1,1-TCA = 1,1,1-trichloroethane
3. 1,1-DCA = 1,1-dichloroethane
4. 1,1-DCE = 1,1-dichloroethene
5. 1,2-DCA = 1,2-dichloroethane
6. 1,2-DCE Total = 1,2-dichloroethene total
7. cis-1,2-DCE = cis-1,2-dichloroethene
8. PCE = tetrachloroethene
9. TCE = trichloroethene
10. VOC = volatile organic compounds
11. Influent VOC vapor concentration time graph excludes acetone concentrations.

FIGURE 4-9

Influent VOC Liquid Concentrations

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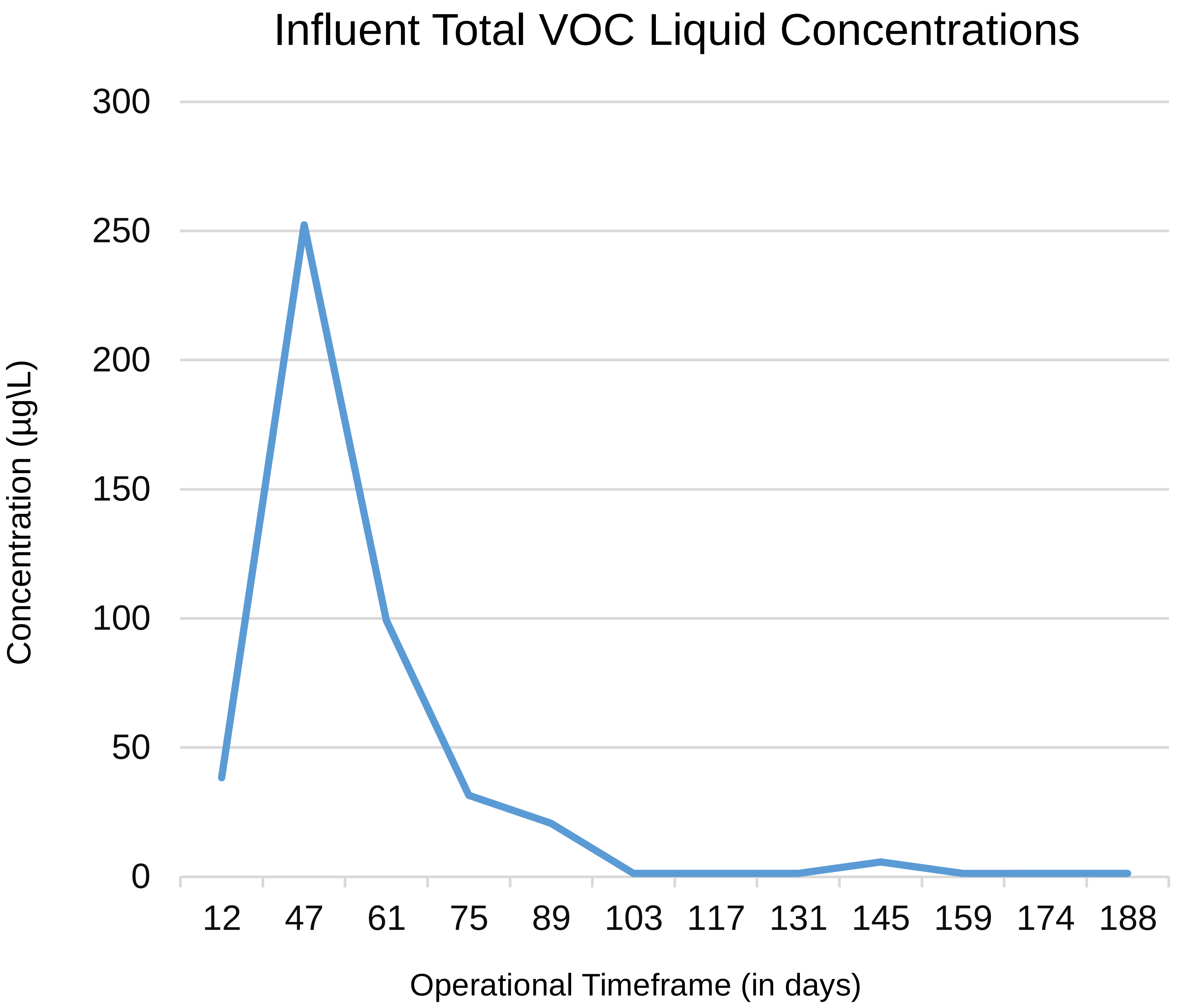
Former Dowell Depew Facility, Depew, New York

ch2m:

RDD \\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIG_4-9_INFLUENT_VOC_LIQUID_CONCENTRATIONS.MXD MWACH 2/6/2017 10:41:23 AM



Notes:
1. µg\L = micrograms per liter
2. VOC = volatile organic compound
3. Influent total VOC vapor concentration time graph excludes acetone concentrations.

LEGEND

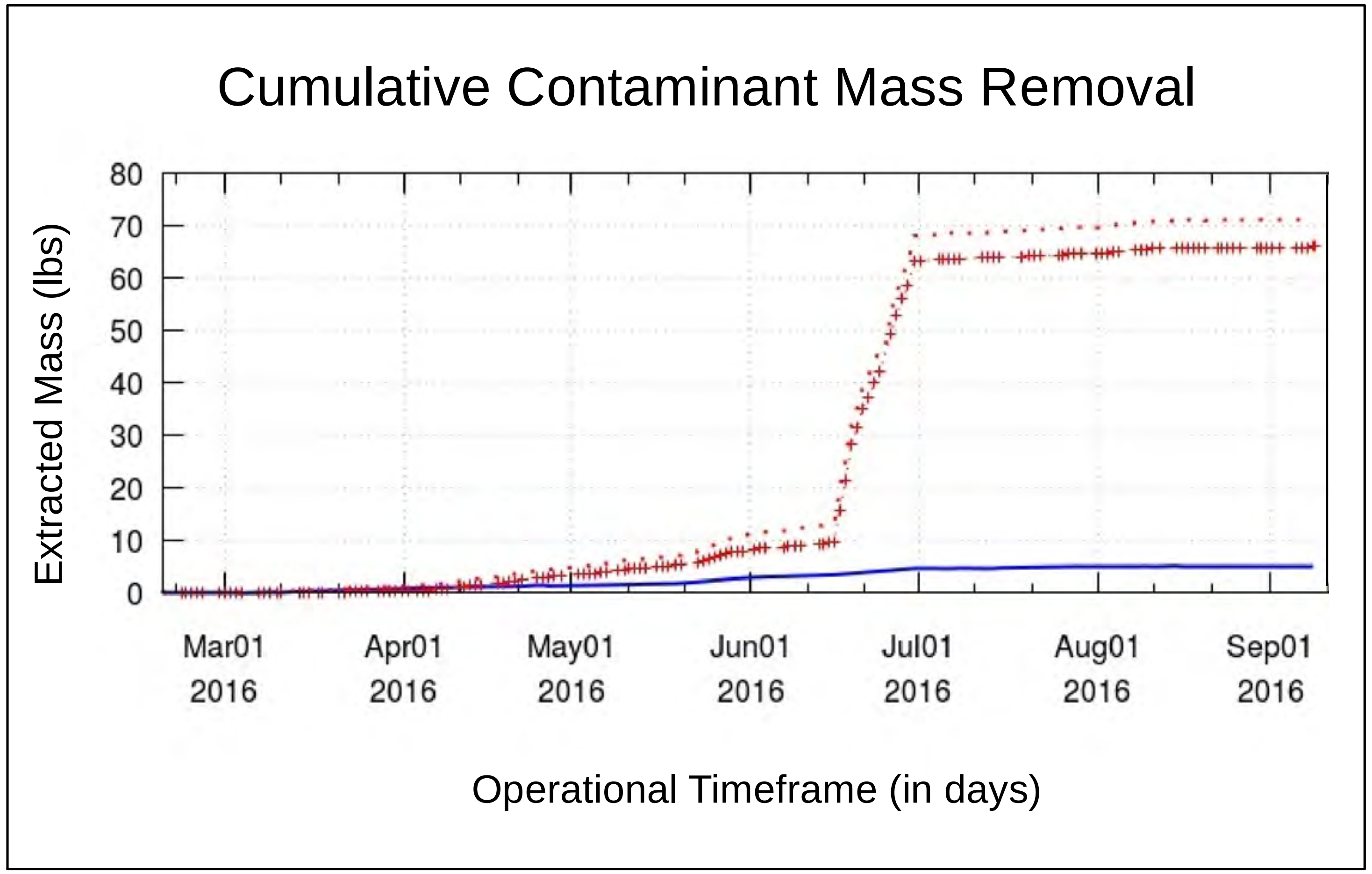
— Total VOCs

FIGURE 4-10

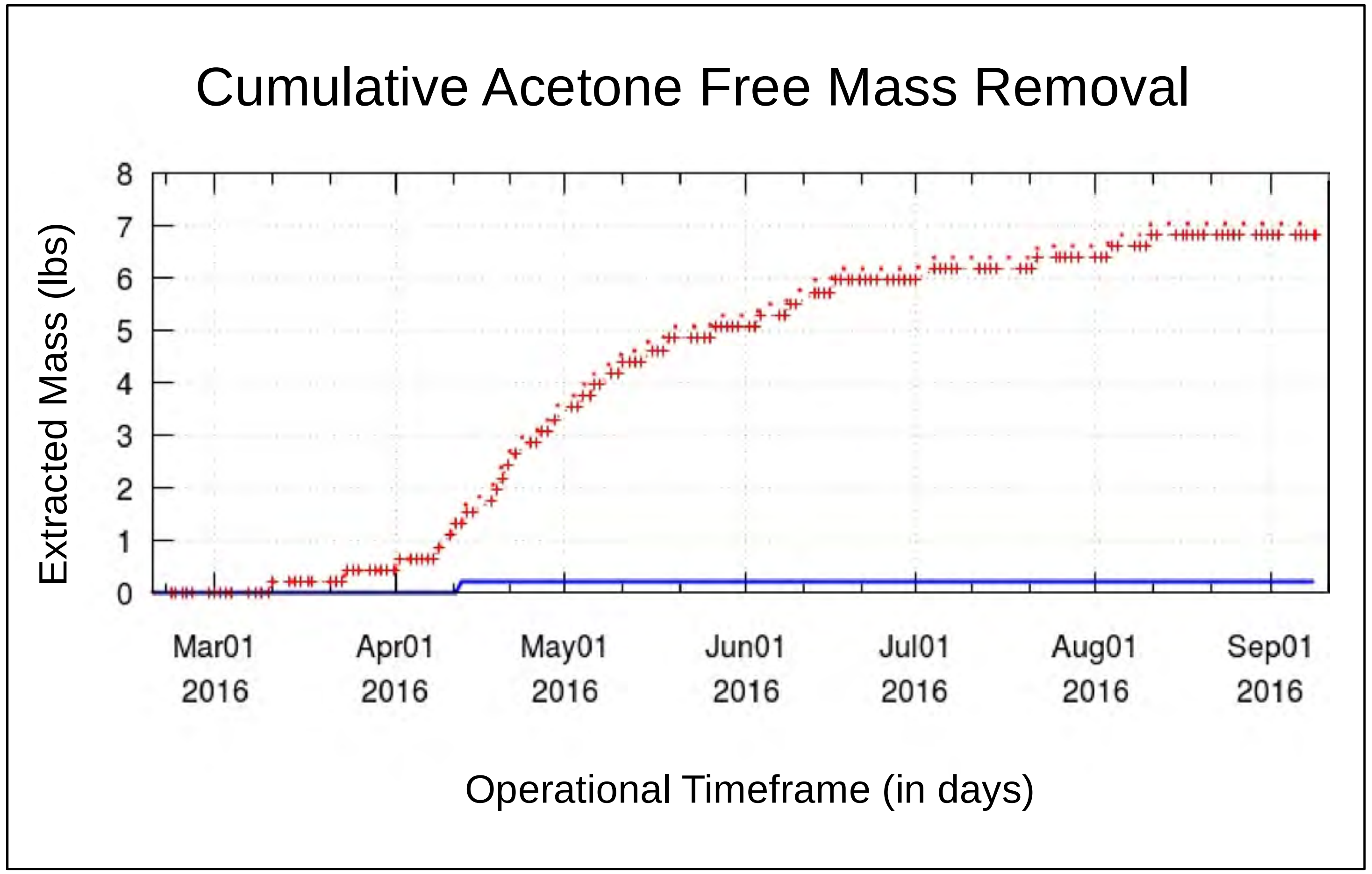
Influent Total VOC Liquid Concentrations

Final Engineer Report

Former Dowell Depew Facility, Depew, New York



Graph A.



Graph B.

Notes:
1. lbs = pounds
2. Electrodes were powered up on February 17, 2016 during ISTT system commissioning. Official start of ISTT system operations began on February 22, 2016.

LEGEND - *Graph A*

— Contaminant Mass Removed in Liquid Phase (5.2 lbs)

-+- Contaminant Mass Removed in Vapor Phase (65.9 lbs)

• • • Total Contaminant Mass Removed (71.1 lbs)

LEGEND - *Graph B*

— Acetone Free Contaminant Mass Removed in Liquid Phase (0.2 lbs)

-+- Acetone Free Contaminant Mass Removed in Vapor Phase (6.8 lbs)

• • • Acetone Free Contaminant Mass Removed (7.0 lbs)

FIGURE 4-11
Cumulative Contaminant Mass Removal
Final Engineer Report
Former Dowell Depew Facility, Depew, New York

RDD \\BROOKSIDE\GIS_SHARE\ENBG\00_PROJ\D\DOWELL\DOWELL_DEPEW_480860\MAPFILES\2017\FINALENGINEERREPORT\FIG_4-11_CUMULATIVE_CONTAMINATION_MASS_REMOVAL.MXD MWACH 2/6/2017 2:28:49 PM

Notes:
1. SVE = soil vapor extraction
2. MPE = multi-phase extraction
3. TMS = temperature monitoring sensor
4. SB-01 through SB-04 were sampled as part of the interim performance sampling event in June 2016.

LEGEND

- ● Electrode
- ● MPE Well
- ● Temperature Monitoring Sensor
- ● SVE Well
- ● Soil Boring Performance Sampling Location (June 2016)
- 🟩 Vapor Cap
- 🟥 Site Boundary

FIGURE 4-12

Interim Performance Sampling (June 2016)

Final Engineer Report

Former Dowell Depew Facility, Depew, New York

ch2m:

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Notes:
1. SVE = soil vapor extraction
2. MPE = multi-phase extraction
3. TMS = temperature monitoring sensor
4. SB-01 through SB-09 were sampled as part of the performance sampling event in August 2016.

LEGEND

● Electrode
● MPE Well
● Temperature Monitoring Sensor
-●- SVE Well
● Soil Boring Performance Sampling Location (August 2016)
🟩 Vapor Cap
🟥 Site Boundary

FIGURE 4-13
Confirmation Performance Sampling (August 2016)
Final Engineer Report
Former Dowell Depew Facility, Depew, New York

ch2m:

Notes:
1. SVE = soil vapor extraction
2. MPE = multi-phase extraction
3. TMS = temperature monitoring sensor
4. SB-10 and SB-11 were sampled as part of the performance sampling event in October 2016.

LEGEND

● Electrode
● MPE Well
● Temperature Monitoring Sensor
-●- SVE Well
● Soil Boring Performance Sampling Location (October 2016)
🟩 Vapor Cap
🟥 Site Boundary

N
0 10
Feet

FIGURE 4-14
Confirmation Performance Sampling (October 2016)
Final Engineer Report
Former Dowell Depew Facility, Depew, New York

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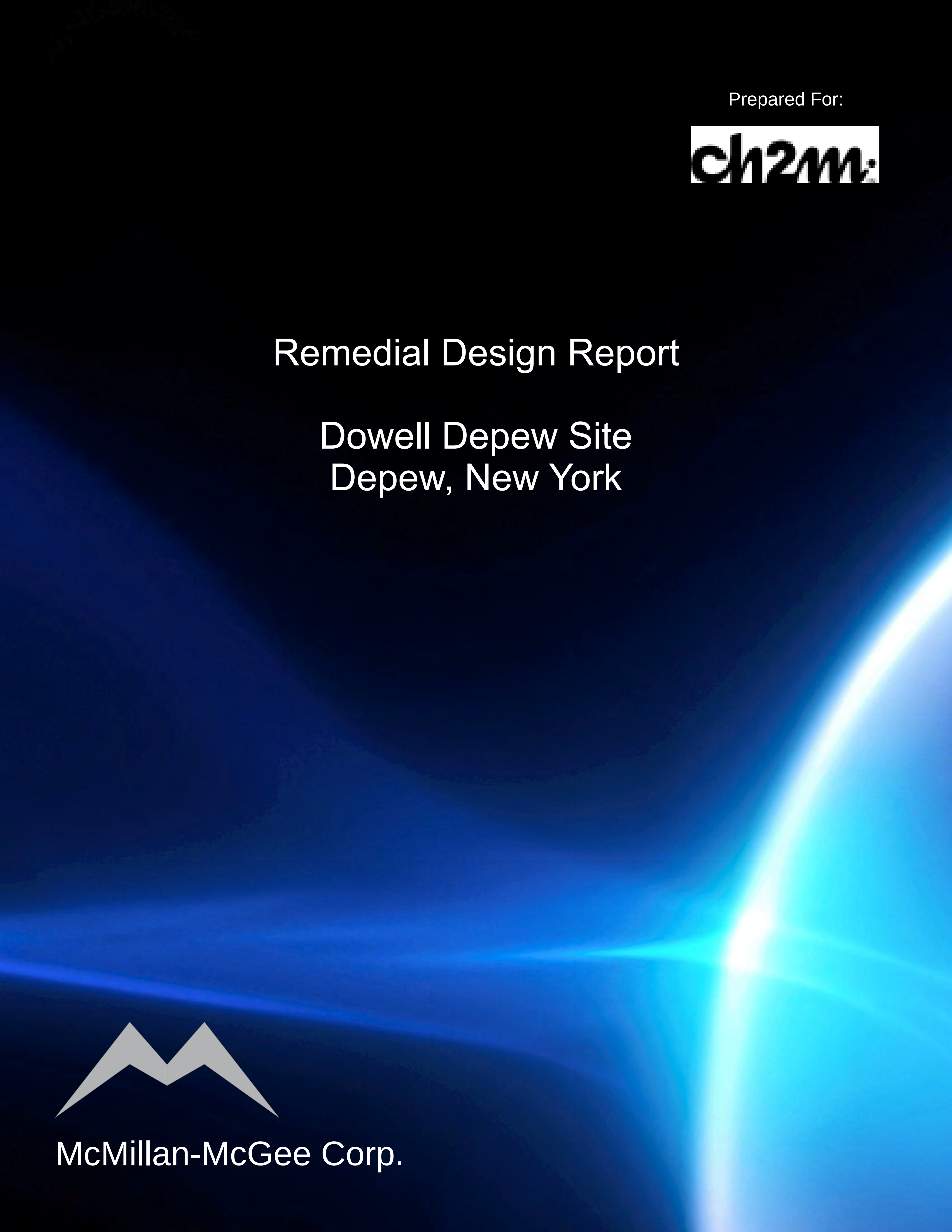
Appendix A
Mc^2 Remedial Design Report



Prepared For:

ch2m:

Remedial Design Report

Dowell Depew Site
Depew, New York

McMillan-McGee Corp.

Remedial Design Report
Dowell Depew Site
Depew, New York

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February 24, 2016

Electromagnetic Systems & Services for the Energy & Environmental Industries

Engineering Certification

This document, Remedial Design Report for the Former Dowell Facility, has been prepared under the supervision and control of the undersigned Alberta licensed Professional Engineer. The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted protocols and procedures. If conditions are discovered that differ from those described, the undersigned engineer should be notified to evaluate the effects of any additional information on the assessment and recommendations in this document. This document was prepared to provide information for the Former Dowell Facility project in Depew, New York, and should not be construed to apply to any other site.

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Reviewed and approved by:

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Through the engineering business of McMillan-McGee Corporation, APEGA Permit to Practice P09178

Executive Summary

McMillan-McGee Corporation (Mc²) has prepared this *Remedial Design Report* to describe the details of the Electro Thermal Dynamic Stripping Process (ET-DSP™) application that will be implemented for in-situ thermal treatment (ISTT) at the Former Dowell Facility, located at 3311-3313 Walden Avenue in the Village of Depew, New York, United States of America. The treatment volume delineated for ET-DSP™ application has an approximate areal extent of 3,661 square feet (ft^2) and extends from 0 to 30 feet (ft.) below ground surface (BGS), for a total estimated treatment volume of 4,068 cubic yards (yd^3). The primary goals of the thermal treatment application are to reduce volatile organic compound (VOC) concentrations in groundwater to below applicable regulatory criteria and remove VOC mass within the source zone.

During remedial activities, 44 ET-DSP™ electrodes in 22 borings will heat the treatment volume approximately to the target temperature of 212 degrees Fahrenheit (°F). The cumulative energy input to the electrodes is expected to be approximately 1,281 megawatts hours (MWHr) and site-wide water injection to the electrodes is estimated to be at a rate of 4.4 gallons per minute (GPM). Operations will run for approximately 180 days.

Vaporized VOCs and steam generated by elevated subsurface temperatures will be captured with 15 vertical multiphase extraction (MPE) and 4 horizontal vapor extraction (HVE) wells installed throughout the treatment volume. The total vapor flow is estimated at 139 standard cubic feet per minute (SCFM) under an estimated applied a vacuum of 12 inches mercury (in. Hg). The estimated liquid extraction rate from the treatment volume is 4.5 GPM. Extracted fluids will be processed in an aboveground treatment system. Processed water will be re-injected, and any residual water will be discharged.

Performance monitoring during the ET-DSP™ application will include the deployment of 70 digital temperature acquisition module (digiTAM™) sensors in 7 locations, as well as measurements of fluid flow and electrical power throughout the application. All data will be available on a secure webpage for remote monitoring. Cumulative mass removal in the extracted fluids will be monitored, and after shutdown, confirmation groundwater sampling will be performed to ensure that performance goals are achieved.

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Acronyms

BGS	Below Ground Surface
CH2M	CH2M Hill, Incorporated
COC	Constituent of Concern
C/W	Complete with
digiTAM™	Digital Temperature Acquisition Module
DCA	Dichloroethane
DNAPL	Dense Non-Aqueous Phase Liquid
ET-DSP™	Electro Thermal Dynamic Stripping Process
°	Degrees of angle
°F	Degrees Fahrenheit
FEP	Fluorinated ethylene propylene
ft.	Feet
ft.^{2}	Square feet
GAC	Granular Activated Carbon
GPM	Gallons Per Minute
HVE	Horizontal Vapor Extraction
Hz	Hertz
in. Hg	Inches of Mercury
IPS	Interphase Synchronization
ISTT	In Situ Thermal Treatment
kbps	Kilobits per second
KCl	Potassium Chloride
kVA	Kilo-Volt-Ampere
kW	Kilo Watt
KWHr	Kilowatt-Hour
LAN	Local Area Network
lbs.	Pounds
LNAPL	Light Non-Aqueous Phase Liquid
Mc^2	McMillan-McGee Corporation
MPE	Multiphase Extraction
mL	Milliliter
MWHr	Megawatt-Hour
NAPL	Non-Aqueous Phase Liquid
NPT	National Pipe Thread
NYSDEC	New York State Department of Environmental Conservation
Ω·m	ohm-meter
O&M	Operations and Maintenance
OD	Outer Diameter
PDP	Power Distribution Panel

PDS	Power Delivery System
PEX	Polyethylene With Cross-Links
PFD	Process Flow Diagram
P&ID	Piping and Instrumentation Diagram
PID	Photo Ionization Detector
PSI	Pounds Per Square Inch
PTFE	Polytetrafluoroethene
PVC	Polyvinyl chloride
R	Square feet • Degrees Fahrenheit • Hour / British Thermal Unit
SCFM	Standard Cubic Feet Per Minute
SRGT	Silicone Rubber Glass Fiber Tube
SVE	Soil Vapor Extraction
TCA	Trichloroethane
TDC/IPS	Time-Distributed Control / Interphase Synchronization
TDCM	Time-Distributed Control Mechanism
URS	URS Corporation
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
TDCM	Time-Distributed Control Mechanism
V	Volt
VOC	Volatile Organic Compound
WCS	Water Circulation System
yd^3	Cubic Yards

1. Introduction

Mc² has prepared this design report to describe the activities proposed for in-situ thermal treatment using ET-DSP™ at the former Dowell Facility, located at 3311-3313 Walden Avenue in the Village of Depew, New York. The activities defined in this report will be performed under contract by Mc², for CH2M Hill (CH2M).

1.1. Site Description and Location

The facility resides within a mixed residential and industrial/commercial area. The entire site is zoned industrial/commercial. Surrounding uses include a railroad line to the south, a manufacturing facility to the west, and a commercial lumberyard to the east. The closest residential structures are to the north across Walden Avenue. The property has previously included buildings such as office space, storage, and equipment repair garages that supported operations relating to the development and maintenance of natural gas and oil wells. Various industrial cleaning and oil-field chemicals were stored on-site and transferred into tank trucks for use at job sites (New York State Department of Environmental Conservation (NYSDEC), 2016).

Current VOCs detected in ground water at the site are likely a result of historical activities, which included servicing industrial facilities and limited oilfield-related projects. Dowell discontinued facility operations in the late 1980s and the facility was permanently closed.

1.2. Site Geology and Hydrology

Three distinct unconsolidated stratigraphic units have been identified in the test boring log (URS Corporation (URS), 2011) with supporting data provided by CH2M (2015): (i) the higher permeability and poorly sorted silt sand, fine to coarse gravel fill and cinders unit, which extends from ground surface to 4 ft. BGS, (ii) the clayey silt unit with a trace of fine gravel, which extends from the bottom of the upper fill unit to 10 ft. BGS, and (iii) the silty clay unit, with 5% fine to coarse sand, which extends from 10 to 20.5 ft. BGS, where the test boring log ended. Clay content increases with depth beginning at 4 ft. BGS. Between 4 ft. and 30 ft. BGS, the layer has been described as a thick layer of glacial till. The Marcellus Shale and/or Skaneateles Shale were anticipated to be encountered at 30 ft. BGS, but the drilling program (October 5 – October 20, 2015) encountered these bedrock shales at depths as shallow as 26.5 ft. BGS.

Site hydraulic conductivity was determined using falling- and rising-head tests in wells with screened intervals of 15-17 ft. BGS and 22-24 ft. BGS, with resulting values reported as 2.44×10^{-6} and 1.15×10^{-8} inches per second, respectively (CH2M, 2015). The hydraulic gradients for these zones are 0.057 ft./ft. and 0.04 ft./ft., and their porosity is 0.38 and 0.22, respectively (CH2M, 2015).

The depth to the groundwater was reported as 3 ft. BGS based on previous investigations (CH2M, 2015); however, during the drilling program groundwater was encountered at depths ranging from 1-3 ft. BGS.

1.3. Contaminant Concentrations, Remedial Goals, and Distribution

The historical maximum levels of Constituents of Concern (COC) detected in site groundwater and the remedial objectives for clean up are displayed in **Table 1** (CH2M, 2015)**.**

Table 1: Groundwater Concentrations and Remedial Objectives

Contaminant of Concern	Performance Standard in Soil		Maximum Historical Detection in Groundwater		
	Value	Units	Value	Units	Well ID
1,1,1-Trichloroethane	68	µg/kg	516	µg/L	TW-12S
1,1-Dichloroethane	27	µg/kg	11900	µg/L	TW-03S
1,1-Dichloroethene	33	µg/kg	75.7	µg/L	TW-01S
1,2-Dichloroethane	2	µg/kg	3.57	µg/L	TW-03S
1,2-Dichloroethene (Total)	25	µg/kg	77.1	µg/L	TW-11D
Acetone	5	µg/kg	2560	µg/L	TW-04D
Benzene	6	µg/kg	1.62	µg/L	TW-04D
Chloroethane	70	µg/kg	4750	µg/L	TW-03S
cis-1,2-Dichloroethene	25	µg/kg	75.1	µg/L	TW-11D
Ethylbenzene	100	µg/kg	31.5	µg/L	TW-04D
Tetrachloroethene	130	µg/kg	28.4	µg/L	TW-12S
Trichloroethene	47	µg/kg	7.7	µg/L	TW-15S
Vinyl Chloride	2	µg/kg	5.8	µg/L	TW-11D
Xylenes, Total	26	µg/kg	179	µg/L	TW-04D

The treatment volume has an approximate areal extent of 3,661 ft^2 and extends vertically from 0 to approximately 30 ft. BGS, for a total estimated treatment volume of 4,068 yd^3. The anticipated area of thermal influence for the proposed electrode network is approximately 4,900 ft^2 and extends from 0 to 30 ft. BGS, for a total estimated heated volume of about 5444 yd^3.

The remedial objectives at the site are to reduce COC concentrations in groundwater to the above levels specified by CH2M Hill. The secondary remedial objectives at the site are to:

1. Prevent the mobilization of COCs to areas outside of the limits that define the treatment volume;
2. Maintain hydraulic and pneumatic control throughout thermal remediation;

3. Achieve the design target temperature of approximately 212°F; and,
4. Treat and dispose of vapors, groundwater, and COCs that are recovered by the extraction system.

1.4. Project Schedule

A proposed project schedule describing the timeline of the main project milestones was presented by Mc^2. A brief outline of the proposed project component durations is illustrated in **Table 2**.

Table 2: Approximate Duration of Project Components

Components	Approximate Duration
Drilling & Furnishing & Installation of Underground Components	10 weeks
Above Ground Remediation Component Installation	9 weeks
Acceptance Testing	1 weeks
System Operation	27 weeks
Performance Verification and Surface/Subsurface restoration	5 weeks
Demobilization	7 weeks

1.5. Project Organization

The thermal remediation team consists of CH2M Hill, Mc², and MK Environmental. The role and contact information of each team member is outlined in **Table 3.**

Table 3: Project Organization

Organization	Role	Contact Name(s)	Contact Information
CH2M Hill	Engineering consultant; oversight and verification	Jason Burkard	Jayson.burkard@ch2m.com +1 (314) 335-3046 +1 (314) 477-7284
McMillan-McGee Corp. (Mc²)	ET-DSP™ contractor; in-situ thermal treatment	David Rountree	drountree@mcmillan-mcgee.com +1 (403) 569-5116 +1 (403) 921-0848
		Wayne Robella	wrobella@mcmillan-mcgee.com +1 (403) 569-5106 +1 (403) 461-1669
		Nicholas Dumaresq	ndumaresq@mcmillan-mcgee.com +1 (403) 569-5113 +1 (403) 869-7645
MK Environmental	Soil vapor and groundwater treatment	Ed Tung	etung@mkenv.com +1 (630) 848-0585 +1 (630) 920-1104

2. Treatment Technology

A full-scale ET-DSP™ and MPE application will be implemented for thermal treatment at the site. This application is based on the results of the *Thermal Model*, undertaken by Mc^2 for the Dowell facility which can be found in **Appendix A**. VOC vapors produced in the subsurface at elevated temperatures will be captured with MPE wells and collected in an aboveground treatment system. ET-DSP™ is a patented electro-thermal technology (United States patent number 6,596,142; Canadian patent number 2,341,937) where the power input to individual electrodes is controlled and water recirculation is used to enhance convective heat transfer. These processes have the potential to create a more uniform temperature distribution earlier into an application than other ISTT technologies (McGee and Donaldson, 2009).

2.1 ET-DSP™ Heat Transfer Mechanisms

Field applications of ET-DSP™ use power delivery system (PDS) units to direct low frequency (60 Hertz (Hz)) three-phase electrical power to a network of subsurface electrodes. Adjacent electrodes are 120° out of phase such that gradients in electric potential are induced, which causes current conduction and resistive heat dissipation throughout the treatment volume. The power dissipated by electrical resistance heating is proportional to the inverse of the distance squared from each electrode (McGee and Donaldson, 2009). Water injection during ET-DSP™ compensates for this non-uniform power distribution by increasing convective heat transfer within the treatment volume, which propagates heat further from the electrodes into the subsurface. Conductive heat transfer also occurs as a result of the temperature gradients induced during heating. The transient temperature distribution during ET-DSP™ is dictated by the conservation of energy, which can include conduction, convection, electro-thermal, phase change and heat accumulation mechanisms (McGee and Vermeulen, 2007).

2.2 ET-DSP™ Mass Removal Mechanisms

At elevated temperatures, vaporization, volatilization, dissolution and desorption are enhanced such that conditions are more favorable for the extraction of VOC mass from the subsurface (e.g., United States Army Corp of Engineers (USACE), 2009; Triplett Kingston et al., 2014). These mechanisms are described by the temperature dependence of the vapor pressures, Henry's law constants, solubilities and soil-water partition coefficients for the fluids in question, respectively. In addition, liquid viscosity, interfacial tension, and density decrease at elevated temperatures, which can make non-aqueous phase liquids (NAPLs) more mobile for extraction.

Vaporization (i.e., boiling of immiscible VOCs and groundwater) and volatilization (i.e., partitioning of VOCs from the dissolved phase to the gas phase) are the most dominant mass removal mechanisms during ET-DSP™. As such, extraction wells must be designed for effective gas capture, with appropriate locations, screened intervals and applied vacuums, in order for performance to be successful. The accurate development of a detailed geological and hydrogeological site conceptual model informs this design.

2.3 ET-DSP™ Subsurface Vapor Generation

The placement and operation of ET-DSP™ electrodes and extraction wells are designed such that sufficient temperatures will be achieved to vaporize COCs in the source zone. Vaporization occurs when the total gas pressure, given as the sum of the partial vapor and dissolved gas pressures, exceeds the sum of the ambient atmospheric, hydrostatic and capillary pressures. Consequently, boiling points increase with depth below the water table and vary with lithology.

When NAPL is present, gas production first occurs at the co-boiling (i.e., steam distillation, heteroazeotrope) temperature, since vapor pressures are additive at immiscible fluid interfaces (e.g., Dalton’s Law). Fractional distillation theory governs the composition of the vapor phase. Co-boiling continues until all of the NAPL vaporizes, and capture of the resulting vapors can represent a significant amount of the total VOC mass extracted. For multicomponent NAPL mixtures, the more volatile components vaporize preferentially, and both the composition of the NAPL and the co-boiling temperature change over time (e.g., Raoult’s Law). Gas bubbles are generated at NAPL-water interfaces during co-boiling and propagate upwards as buoyancy forces overcome capillary trapping forces. Subsurface heterogeneities influence the path of co-boiled vapor bubbles towards extraction wells below the water table.

Continued temperature increase to the groundwater boiling point during ET-DSP™ operation generates a significant amount of steam throughout the subsurface, which facilitates the transport of any remaining VOC vapors towards extraction wells. In addition, steam generation allows for increased volatilization and dynamic stripping of dissolved constituents, which can be an important mechanism to reduce VOC concentrations in the source zone.

Gas transport during ET-DSP™ is influenced by pressure gradients due to the vacuum applied at subsurface extraction wells. A proper vapor cap provides a no-flow boundary condition at the top of the treatment zone, which assists vapor flow through the vadose zone towards extraction wells. In lower permeability media, steam formation also has the potential to create a secondary porosity for Taylor bubble flow (McGee et al., 2004) as an additional transport mechanism for VOC mass towards extraction wells.

In the final stages of operation, pressure cycling can be performed as a strategy to create new gas pathways and remove mass in regions where vapors might be trapped. This technique involves varying individual electrode power inputs and applied vacuums such that regions of the subsurface are pressurized and depressurized.

Subsurface temperatures are monitored in real time during an ET-DSP™ application in order to identify the vapor generation response (i.e., changes in the rate of temperature increase, indicating regions of sensible or latent heat), as well as to inform the operation of the electrodes and water circulation system (WCS) units.

2.4 ET-DSP™ Conceptual Design

The conceptual design shown in **Figure 1** illustrates the main processes that are involved in an ET-DSP™ application.

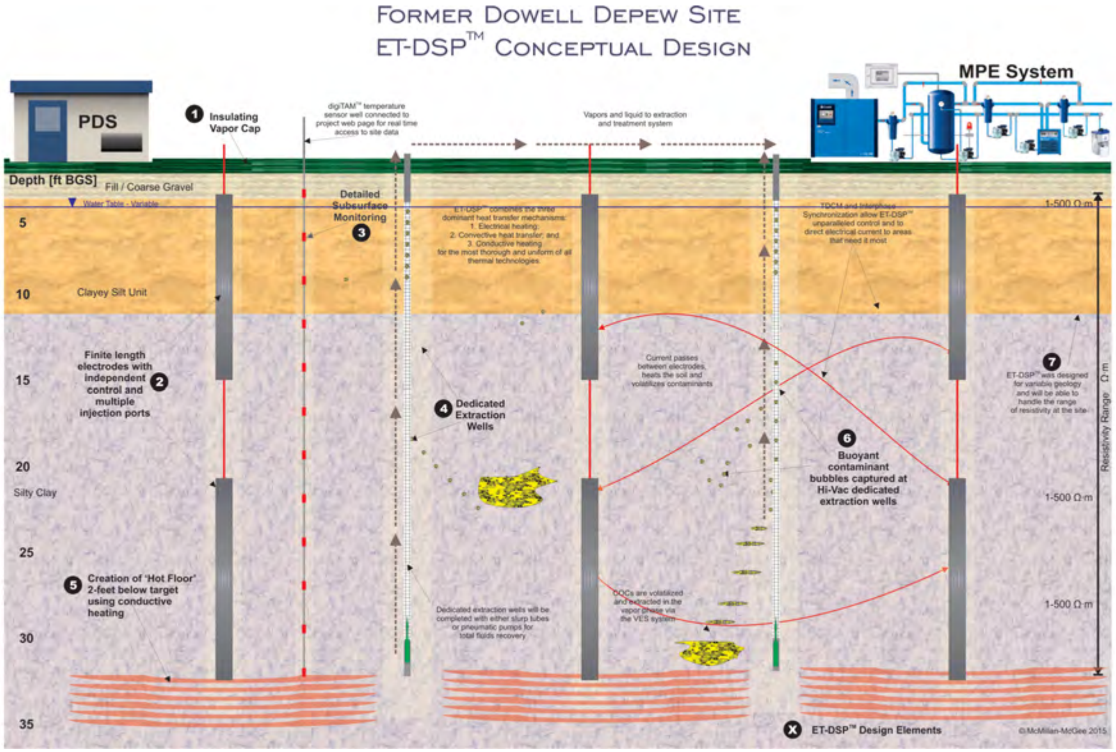

Figure 1: Schematic of Technical Approach Using ET-DSP™ (not to scale)

Element 1: The treatment area is covered with a vapor cap that consists of concrete, asphalt, insulation, geomembrane and/or cellular concrete surfaces. The vapor cap is critical for maximizing vapor capture and minimizing heat loss in the vadose zone. It also limits infiltration and short-circuiting during vapor extraction.

Element 2: Finite length electrodes with independent control are double stacked vertically in holes to conduct electric current throughout the vertical extent of the treatment volume. The applied electric field accelerates charge carriers in the pore water, which results in the kinetic energy transfer that causes resistive heat dissipation. The use of stacked electrodes can improve performance associated with the preferential flow of current through more conductive lithologies.

An important element of ET-DSP™ involves the injection of water at the ends of the electrodes, which enhances convective heat transfer, mitigates the electrode dipole effect, and maintains liquid contact at the electrode surface to avoid decreased power input associated with resistive conditions during gas production. Injected water that vaporizes also facilitates the dynamic stripping process. The benefit of this design is a more uniform, hot temperature distribution throughout the treatment volume, resulting in thorough contaminant mobilization and capture at the MPE wells

Element 3: Continuous remote data monitoring of temperature using digiTAM™ sensors will allow operators to respond in real time to transient subsurface conditions. The data will be available on a dedicated project web page.

Element 4: Dedicated multiphase extraction wells are used to capture fluids for aboveground treatment and discharge. Compressed air assisted vacuum-lift groundwater recovery tubes are operated at sufficient extraction rates to maintain inward gradients for hydraulic control, as water is injected to the electrodes and vaporized liquids displace groundwater, and also function as a mechanism to capture dissolved VOCs.

Element 5: Conductive heating will heat soil and/or rock to the approximate target temperature up to 2-3 feet below the bottom of the electrodes, creating a hot floor effect. This will prevent downward migration of contaminants, as any immiscible mixtures of COCs and water will be vaporized, creating a buoyant gas, which will migrate upwards to the vadose zone (see Element 6).

Element 6: VOC vapors and steam are created at elevated temperatures in the treatment volume. Sufficient local and macroscopic connection of vapor pockets thus created causes bubble and/or channel flow upwards towards the vadose zone and towards extraction wells for capture. Continuous operation of the extraction wells at sufficient vacuums will capture vaporized VOCs, soil gas, and steam for pneumatic control.

Element 7: The electric field and current path between electrodes can be controlled using Interphase Synchronization (IPS) and the electric power input to the electrodes can be varied by operators using the

Time-Distributed Control Mechanism (TDCM). These tools can help promote the development of a more uniform temperature distribution during ET-DSP™ operations, especially when spatial differences in electrical, thermal and hydraulic properties are encountered within a heterogeneous treatment volume.

3 Remedial Approach

The delineated treatment volume at the site will be targeted with a combination of ET-DSP™ and MPE. The design is based on fundamental physical and thermodynamic principles, lessons learned from previous projects, the site conceptual model, the resistivity of soils from the site, sampled at varying depths, and analyzed in the Mc^2 thermal laboratory, the ET-DSP™ numerical simulation, and the remedial objectives outlined in **Section 1.3**.

3.1 Design Support

Test borehole data, historic site use information, and groundwater concentration and flow rate data were presented by CH2M, based on previous drilling investigations, monitoring well installations, and hydraulic tests. A brief overview of these site characteristics was presented in **Sections 1.1, 1.2,** and **1.3**. A numerical simulation of the ET-DSP™ application, using a three dimensional finite difference multiphase heat transfer model, was performed by Mc^2 with site-specific parameters to inform the design of the ET-DSP™ system.

An important parameter that governs the electrical resistance heating component of the ET-DSP™ heat transfer process is the electrical resistivity of the soil. Seventeen soil samples from the site, collected at various depth intervals within the proposed treatment volume, were evaluated using static (i.e., constant temperature) and dynamic (i.e., variable temperature) resistivity tests in the Mc^2 thermal laboratory. These resistivity test results were in turn used to determine the general power requirements during ET-DSP™ operations and the temperature dependence of the soil resistivity, respectively. The *Resistivity Report* can be found in **Appendix B**. The average static resistivity of the samples ranged from 16.4 to 82.0 ohm-meters ($\Omega \cdot m$)**.** Results from the dynamic resistivity test indicated a decrease in resistivity by a factor of approximately 2.02 as temperatures increased from ambient to near-boiling conditions**.** Note that the soil samples were saturated with approximately 62 milliliters (mL) of site groundwater for the dynamic test.

3.2 Remedial Components

The design elements for the thermal remediation of the site are presented in **Table 4**. Key features are summarized as follows:

1. Twenty-two (22) electrode wells with two (2) ET-DSP™ electrodes per well, for a total of forty-four (44) ET-DSP™ electrodes;
2. Fifteen (15) vertical MPE wells, screened from 2 ft. BGS (above the groundwater table) to 31 ft. BGS.

3. Four (4) shallow horizontal vapor extraction wells, each with a 25 ft. screen interval installed at 1 to 3 ft. BGS.
4. Seven (7) sensor wells for data acquisition and monitoring. Each of the wells will have eleven (10) digiTAM™ sensors embedded at 3 ft. intervals, for a total network of seventy (70) temperature measurement devices.

Actual system components were adjusted during the installation to match the following field conditions: groundwater was encountered at depths ranging from approximately 1 to 3 ft. BGS and the underlying shale formation was encountered at depths ranging from 26.5 to 29 ft. BGS during the drilling program. **Section 3.4** provides a detailed description of how the design was adapted to accommodate field conditions.

The MPE wells will be used to extract vapor, liquid and dissolved phase VOCs. The use of separate, shallow horizontal vapor extraction wells is expected to allow application of greater pneumatic control in the vadose zone for VOC capture. Extracted fluids will be directed towards an aboveground treatment system, which is specifically designed for the COCs, emissions requirements, and flow rates anticipated for thermal treatment at the site. The treatment system equipment will include a phase separator, air stripper, vacuum blower, air compressor, and a cooling tower, as well as vapor-liquid separators, holding tanks, bag filters, carbon vessels, pumps, air filters, and heat exchangers.

3.3 Technical Design Summary

A synopsis of the technical ET-DSP™ design is presented in **Table 4.**

Table 4: Project Technical Design

Item	Units	Comments
Site Characteristics		
Treatment Area [ft^2]	3,661	Approximate; scaled from a figure provided
Heated Volume [yd^3]	5,444	Thermal influence x depth interval
Deep Extent of Treatment [ft. BGS]	30	As per drilling reports
Shallow Extent of Treatment [ft. BGS]	0	Treatment assumed close to surface
Depth to Groundwater [ft. BGS]	1-3	As per field reports
Contaminants of Concern	VOCs	Primarily 1,1-DCA, chloroethane, 1,1,1-TCA; refer to **Table 1** for detailed concentration information
Mass Estimate [lbs.]	100	Preliminary mass estimate
Remedial Goals [µg/L]	Variable	Refer to **Table 1** for COCs and performance goals
Soil Resistivity (ohm·m)	16.4-82.0	As per Mc^2's Resistivity Report
Remedial Approach		
ET-DSP™ Electrode Locations	22	8" OD, 2/boring, ET-DSP™ HT design, 10' long, (unless this length was restricted by encountered shale)
Power Delivery Systems [kVA]	2 x 1,330	Web power control, 480V primary, multi-tap sec.
digiTAM™ Temp. Sensors	70	7 strings, 10 temperature sensors at 3' intervals
Electrode Spacing [ft.]	18.5	Based on expected resistivity, electrode layout, and performance goals
Bottom of Electrodes [ft. BGS]	26.5-31	As per drilling reports
Top of Electrode [ft. BGS]	~4	Conductive heat transfer above
Target Temperature [°F]	~212	Avg. in treatment zone, steam stripping of COCs
Vapor/Liquid Extraction Wells	15+4	4" SS304 cont. wire wrap well screen, 0.006" slot size, C/W slurper tubes, 4 horizontal wells set at approximately 1-3 foot BGS
Vapor Recovery Air Flow [scfm]	139	9.28 SCFM per extraction well
Vapor Treatment Method	VGAC	Dependent on mass & abatement requirements
Liquid Treatment Method	AS/LGAC	Air stripper, granular activated carbon
Vapor Cap [ft^2]	6,480	Cellular concrete type, approximately R6
Summary Information		
Cumulative Power Input [MW·Hr]	~1,281	Cumulative estimate based on 315 kWHr/yd^3
Electrical Power Input [kW]	~297	Avg. for project duration ~ 6.74 kW per electrode
Water Demand [GPM]	0	~0.1 GPM/electrode, Re-circulation design
Time to Target Temp. [days]	~60	Approximately
Project Duration [days]	180	Base case for expected conditions

3.4 Subsurface Design

3.4.1 Target Zones

The areal extent targeted for heating corresponds to the horizontal placement of the ET-DSP™ electrodes shown in the well field layout details (**WFL-01, Appendix C**), which encompasses the treatment area suggested by CH2M Hill**.** The depth interval targeted for heating corresponds to the vertical placement of the ET-DSP™ electrodes shown in the well construction details (**WCD-01, Appendix C**), which ranges from a shallow extent (depending on location) of 3 to 5 ft. BGS to a deep extent (depending on location) of 26.5 to 31 ft. BGS. Substantial heat transfer is expected to extend approximately 3 to 5 ft. above and below the ends of each electrode.

3.4.2 Electrodes

A total of 44 electrodes were installed in 22 boreholes with electrodes installed to variable depths (averaging approximately 28 ft. BGS), depending on where the underlying shale was encountered. The electrodes are configured as shown in the well field layout (**WFL-01, Appendix C**) and constructed as shown in the electrode well construction details (**WCD-01, Appendix C**). Design criteria and installation details for each electrode well are displayed in **Appendix D**. The electrodes spacing varied, but was on average 18.5 ft. apart in a repeating triangular pattern.

Calculated power densities presented in the *Thermal Model* report indicate that the average power during ET-DSP™ operations will be approximately 297 kilowatts (kW) (6.74 kW per electrode). Peak electrode power is expected to be 499 kW (11.35 kW per electrode). The electrode power levels will be optimized during operations according to the rate of temperature increase observed in the subsurface. Once the target temperature is achieved in an area, the electrodes can be placed into a maintenance mode, during which the power is reduced while the achieved temperature is maintained.

3.4.3 Extraction Wells

A total of 15 vertical MPE wells, complete with compressed air-assisted vacuum-lift groundwater recovery (i.e. slurper) tubes, and 4 horizontal shallow soil vapor extraction (SVE) wells, were installed throughout the treatment volume. The extraction wells are located as shown in the well field layout details (**WFL-01, Appendix C**)**.** The vertical MPE wells were designed as shown in the well construction details (**WCD-01, Appendix C**), but field conditions permitted installation of sumps in only one well. The remainder of the vertical MPE wells were capped on the bottom with no sump. All wells are screened from 3.0 ft. BGS to a depth that corresponds with encountered shale rock (27-29.7 ft. BGS). The horizontal SVE wells were installed below the vapor cap, with a total screened length of 25 ft. at depths of 1-3 ft. BGS. These are constructed as shown in drawing **TD-01** (**Appendix C**). Design criteria and installation details for each MPE extraction well are displayed in **Appendix D**.

The total design vapor recovery airflow is 139 SCFM from the well field. The MPE wells are designed for vapor capture, to be operated at 12 in. Hg, and are anticipated to have a maximum radius of capture greater than 15.5 ft., in order to ensure complete vacuum influence over the entire treatment volume. At boiling temperatures, steam generation is anticipated to increase the secondary permeability of the formation, leading to increased vapor flow.

3.4.4 Sensor Wells

Sensor wells will be used to monitor subsurface temperature and groundwater levels within and around the treatment volume. DigiTAM™ temperature sensors will be installed in the seven sensor wells. The sensor wells are configured as shown in the well field layout drawing **WFL-01** (**Appendix C**) and constructed as shown in the well construction drawing **WCD-01** (**Appendix C**)**.** Temperature contour plots generated from the digiTAM™ data can be used to assess the relative magnitude of the various subsurface heat transfer processes, which in turn can inform operators of potential adjustments to the WCS, TDCM settings, or other ET-DSP™ components.

DigiTAMs™ are integrated with the Mc² onsite local area network (LAN) and will be monitored as part of the overall data acquisition strategy for the thermal project.

3.5 Above Ground Design

3.5.1 Extraction System

Compressed air assisted vacuum-lift groundwater recovery (i.e. slurper) tubes will be used for the extraction of groundwater. The liquid extraction rate for the ET-DSP™ component of the system is expected to be 4.51 GPM, providing an extraction/injection ratio of 1.025. Recovered groundwater flow from the vacuum-lift tubes will depend on and be regulated by the intake depth below the water table, the compressed air supply rate, the compressed air supply frequency, and the compressed air supply pressure. Extraction rates at individual MPE wells will vary over the course of thermal treatment, in particular as phase change and pneumatic fracturing in lower permeability media occurs.

The extraction system will use a high capacity, high vacuum pump (blower) to provide the driving force for vapor extraction and groundwater/soil vapor conveyance through the piping network to the treatment system. This blower will be capable of providing both high-flow, low vacuum, and low-flow, high vacuum conditions using suitable flow control valves. The vapor recovery line for the vapor extraction piping will connect to the primary liquid/vapor knockout tanks and heat exchangers to capture entrained liquids and condensate before being moved to the vapor treatment side of the treatment system.

3.5.2 Treatment System

The treatment system is designed to process two flow streams: (1) vapors and entrained liquids; and, (2) groundwater. The process flow diagram (PFD) is presented in **M-1** (**Appendix E**), and the piping and instrumentation (P&ID) diagrams are presented in **M-2** through **M-6** (**Appendix E**). The presented treatment system may change if required to meet operational requirements.

A high-capacity, high-vacuum blower will be used to extract volatilized vapors and steam from the MPE wells. The extracted vapors will be piped back to the treatment system via a common header and will first pass through a liquid-vapor knockout tank to separate any silt and liquid (i.e. condensate) from the vapor stream. The vapors will then pass through heat exchangers to reduce temperature and a second liquid-vapor separator to extract additional condensate formed due to cooling in the heat exchangers. Following liquid removal, vapors will be drawn through the vacuum blower, undergoing a temperature rise in the process, and will therefore pass through a final heat exchanger to reduce the vapor temperature to an acceptable level for efficient COC adsorption using a sacrificial granular activated carbon (GAC) system.

Extracted groundwater from the MPE wells along with condensate collected in the knockout tanks will be pumped into a liquid phase separator vessel. Accumulated light non-aqueous phase liquid (LNAPL) and/or dense non-aqueous phase liquid (DNAPL) will be periodically gravity-drained into storage tanks for offsite disposal.

Water from the phase separator will be pumped to an air stripper and then passed through a liquid GAC system. The treated water will be pumped into an equalization tank, from which the water will then be re-used as injection water for the site or stored onsite in a 21,000 gallon holding tank for shipment offsite. The air stripper vapor stream will be discharged to the atmosphere.

3.5.3 VOC Releases and Removal Efficiency

It is estimated that 90% to 95% of the mass removed from the subsurface will be in the vapor stream and will be treated using the regenerative carbon unit. Removal efficiency from the vapor stream is expected to be greater than 95%.

The groundwater flow and vapor condensate streams will be treated with an oil/water separator and an air stripper. The air stripper will remove most of the dissolved contamination; and a secondary treatment with liquid granular activated carbon system will also be employed to achieve municipal discharge criteria. The removal efficiency for this process is expected to be greater than 95%. The percentage of mass that will be removed as dissolved contamination is expected to be less than 10% of the total mass.

All tanks containing VOCs or untreated water will be held under vacuum to control fugitive emissions. A line from the knockout tank will be connected to all treatment tanks through a vacuum regulator and vacuum relief valve, to prevent any VOC vapors from escaping. All tanks will also have individual vacuum relief valves as a safety precaution. Additionally, all valves, flanges, and pipe joints shall be monitored periodically via use of a handheld Photo Ionization Detector (PID) during routine inspections to monitor for fugitive VOC emissions.

3.5.4 Injection System

Water will be injected at each electrode to enhance convective heat transfer within the treatment volume, mitigate the dipole effect, and maintain liquid contact at each electrode surface in order to avoid breaking the electrical circuit. Each electrode will be equipped with both top and bottom water injection lines, which will deliver water from the WCS units to the subsurface through laser-cut injection slots. The shallow electrode in each borehole will be equipped with a water return line – which has a spring check valve to prevent back flow – to prevent overpressure conditions as needed. The average total injection rate for all electrode locations will be 4.4 GPM (average of 0.1 GPM per electrode), and is expected to be variable during operations.

In the event of resistive conditions in the subsurface, a potassium chloride (KCl) solution may be injected via the WCS units. This will increase the electrical conductivity of the subsurface (in accordance with Archie’s Law), which in turn increases the power density of electrical resistance heating dissipated in the subsurface (e.g., McGee and Vermeulen, 2007). If injected, KCl concentrations must be below drinking water standards and/or state permissible levels. Based on the electrical profiling results, it is not anticipated that KCl injection will be required.

3.5.5 Utility Requirements

3.5.5.1 Electrical

Results from the numerical simulation suggest that the cumulative energy input to the electrodes will be approximately 1,281 MWHr. The power requirement will be satisfied by one three-phase 1,500 kVA (Kilo-Volt-Ampere) service located on the north side of the treatment area. A utility-supplied transformer with a 480/277 Volt (V) Wye secondary will provide the service from a new 3-phase power pole located at least 25 ft. from the nearest electrode. Note that all earth-grounded electrical equipment, including the transformer and power distribution panel (PDP), are to be located at least 25 ft. from the nearest electrode. A detailed description of the electrical requirements is presented in the single line electrical drawing **ESL-01** (**Appendix C**).

3.5.5.2 Water

The treated extracted water is expected to satisfy requirements of the WCS units and ET-DSP™ electrodes, but if not, demand will be met by municipal city water, which is provided by a neighboring property. An average water usage rate of 4.4 GPM for the electrodes is anticipated over the 180 days of operations, resulting in a total water requirement of 1.14 million gallons of water. Total water extracted over the period is expected to be 1.17 million gallons of water, assuming an extraction/injection ratio of 1.025, resulting in a total volume to be discharged offsite of less than 29,000 gallons of water. These estimates do not include blow down water or other incidentals (wet test, startup and decontamination), and will be modified and controlled during operations based on subsurface behavior. Potable water will also be used for make-up water to the electrodes and for treatment system wet testing during startup. An onsite potable water supply line has been tapped and metered from a neighbor on the west side of the property, and a backflow preventer will be installed within the treatment building. This water supply will supplement the WCS feed lines.

3.5.6 Telecommunications

The telecommunications system that will be used includes a LAN at the site for real-time data communications. A high-speed Internet connection for offsite data transfer and remote control of the system by Mc² will be installed. A minimum 300 kilobits per second (kbps) download and upload speeds are required. Onsite personnel will require mobile phones to communicate with Mc² project staff.

3.6 Controls & System Monitoring

Monitoring of the treatment system is accomplished through automated and manual system checks. The treatment system will be equipped with liquid level sensors to activate pumps and trigger alarms in the event of high and low liquid level conditions. The discharge holding tank will have a high-high level sensor to shut down the system to prevent an overflow of the tank. The oil/water separator will also have a high-high level sensor that will shut down the system to prevent an overflow. The knockout tanks will have high-high, high, low, and low-low level switches to control and protect the transfer pumps and prevent an overflow of the oil/water separator.

In the event of a treatment system shutdown, operations personnel will be alerted via automated call-out, email, or text message to their cell phones.

3.7 Sampling and analysis

Vapor samples will be collected at the blower outlet, between each vapor GAC unit, and the treatment system outlet, and screened using a PID. In addition, vapor samples will be collected at specific locations along the treatment train at periodic intervals for analysis by United States Environmental Protection Agency (USEPA) Method TO-15. The PID measurements will be calibrated to the analytical vapor measurements and both data sets will be used for the quantification of mass removal, carbon bed mass loading, and mass discharge to atmosphere.

Liquid samples will be collected at the inlet of the air stripper and between each liquid GAC unit and analyzed by USEPA Method 8260. These samples will be taken at periodic intervals. Effluent concentrations will be used for the quantification of mass removal, carbon bed mass loading, mass discharge to the atmosphere, and mass transfer offsite.

The sampling procedures and safety precautions will be outlined in the Operations and Maintenance (O&M) Plan. CH2M Hill will perform confirmation sampling of the treatment area at the end of operations. Additional sampling will be required if operations are extended.

A number of other process and well field parameters will be monitored during system operations. A summary of the data collected and the frequency of that collection is presented in **Table 5**. Note that Mc² and the ET-DSP™ operator will agree upon a reasonable schedule to collect the manual readings as the project progresses.

Table 5: Monitoring Summary

Parameter	Media	Location	Method	Frequency
Pressure	Extracted vapor	MPE wells	Vacuum gauge (manual)	3 x weekly
Pressure	Soil	Sensor wells	Vacuum gauge (manual)	Biweekly
Temperature	Soil	Sensor wells	DigiTAM™ (automatic)	Hourly (averaged daily)
Temperature	Extracted vapor	MPE wells	Temperature gauge (manual)	3 x weekly
Flow	Extracted vapor	Vapor treatment system	Averaging pitot tube (manual)	3 x weekly
Volume	Treatment system water	Groundwater pumping from wells	Flow totalizer (manual)	3 x weekly
Volume	Injection water	Electrode injection water (potable)	Flow totalizer (manual)	3 x weekly
Volume	Injection water (by electrode)	Electrode injection water	WCS (automatic)	Hourly
Volume	Treated water	Treated water discharge	Flow totalizer (manual)	3 x weekly
Power	Soil	Electrodes	PDS (automatic)	Hourly

4 Construction Activities

Field construction will include the installation and/or performance of:

- ET-DSP™ electrodes;
- Vertical MPE wells;
- Horizontal SVE wells;
- DigiTAM™ sensor wells;
- Treatment system piping and hoses;
- Electrode lead wire, hose, and communication cable;
- Treatment system equipment;
- Power connections to the PDS and WCS equipment;
- Power connections to the ET-DSP™ and treatment equipment;
- System acceptance testing; and,
- Wet testing the treatment system prior to startup.

Mc² and MK Environmental construction personnel will oversee these subcontracted construction activities and provide both construction oversight and construction management services.

4.1 Staging Equipment & Supplies

All equipment and supplies used during the construction of the treatment system will be staged in a secure manner. The PDS and treatment systems will be located within a secured area. The lifting details for the ET-DSP™ equipment can be found in the Mc² Lifting Plan (**Appendix F**).

The approximate layout of the treatment system, PDS units, and WCS units are presented in the well field layout details (**WFL-01**, **Appendix C**). The most efficient placement of the PDS and WCS units, such that hose and wire runs are minimized, will be confirmed during equipment off-loading. Mc² equipment cut sheets are presented in **Appendix G**.

4.2 Subsurface Construction

4.2.1 Drilling Program

Vertical holes were drilled using the auger drilling method. This method was chosen because an auger drilling contractor (Paratt-Wolff) already had access to the site and knowledge of site lithology. Horizontal SVE wells were trenched and backfilled. The drilling program is detailed in **Table 6**. All drilling and construction waste was appropriately containerized for onsite storage in roll-off bins prior to offsite disposal.

Table 6: Drilling Program Details

Item	Quantity	Average Depth (Length) (ft.)	Boring Diameter (in)	Total Depth (ft.)	Approximate Drilling Waste (ft^3)	Notes
Electrode Boreholes	22	28	16	616	860	To accommodate 8” electrode
Vertical MPE Boreholes	15	28	10	420	229	To accommodate 1.5" carbon steel casing
Horizontal SVE Trench	4	25	1.5’ x 2’ trench	100	300	To accommodate 2" fiberglass screened pipe
digiTAM™ Boreholes	7	28	4	196	17	To accommodate 1” carbon steel riser pipe
Total	48	N/A	N/A	1,332	1,406	

4.2.2 Underground Utilities

The site has a natural gas line, estimated to be 8-inch diameter, running along Walden Avenue. The treatment area also contains SVE pipes constructed of polyvinyl chloride (PVC) that have been abandoned according to the New York State Department of Environmental Conservation’s Groundwater Monitoring Well Decommissioning Policy (NYSDEC, 2009).

4.2.3 Electrode Wells

Electrode boreholes are 16 inches in diameter and were drilled using the auger method. Two (2) ET-DSP™ electrodes weighing approximately 100 pounds (lbs.) each were installed in each borehole at 22 locations. While the design calls for electrodes 10 ft. long by 8 inches in diameter and the bottom of the deeper electrode to be installed at approximately 30 ft. BGS, the shale rock underlying the treatment volume was encountered at shallower depths in the field, limiting the installation depths. The design was amended with shorter electrodes, preserving the spacing between electrodes. Design criteria and installation details for each electrode well, including electrode length, are displayed in **Appendix D**. The boring depth was originally to extend to 31.5 ft. BGS, but was completed at shallower depths as noted above. Sand was used to backfill the annulus of each electrode. The backfill between the electrodes consisted of sand (10/20 silica sand or equivalent) up to the top boring plug, itself consisting of a fine sand seal (40/60 silica sand or equivalent) and neat cement grout able to withstand elevated temperatures, finished to ground surface (high temperature Portland Type I/II or equivalent). Additional electrode construction details are presented in drawing **WCD-01** (**Appendix C**).

The electrodes were manufactured with silicone rubber-fiberglass braid-fluorinated ethylene propylene (FEP) tube jacket cable. All electrode cables have been run on the surface from the PDS units to the electrode borehole locations under the piping network. The electrodes were each equipped with a top and bottom water injection hose. These hoses are connected at the surface through tee fittings to a 3/8-inch general-purpose water conveyance hose.

4.2.4 Vertical Extraction Wells

The vertical MPE well boreholes are 10 inches in diameter and were drilled using auger methods. These wells consist of 4-inch diameter, continuous wire wrap, 0.010-inch slotted 304 stainless steel screen. The screened interval varied from well to well. While the top of the screen was consistent at 3 ft. BGS, the bottom of the screen ranged from 27 to 29.7 ft. in depth. Similar to the electrode drilling, shale bedrock was encountered below this depth. In order to correct for shallow depths, screen lengths were adjusted in the field. Design criteria and installation details for each extraction well, including screen interval, are displayed in **Appendix D.** A silica sand filter pack (40/60 or equivalent) was installed in the annular space around the well screen. The boring was finished to ground surface with approximately 2 ft. of neat cement grout above a 0.5 ft. fine sand seal (40/60 silica sand or equivalent). A 1 ft. sump was to be installed below the screen of each extraction well to prevent sediment from being drawn into the treatment system, and where depth allowed, this was accomplished; otherwise a carbon steel cap was placed at the end of the screen. The top of the carbon steel riser pipe was completed with a 4-inch male National Pipe Thread (NPT) connection. Each extraction well was fitted with a wellhead, which in turn was connected to a pipe network for conveyance to the treatment system. Vertical MPE well designs are detailed in drawing **WCD-01** (**Appendix C**).

Each MPE well will each be equipped with a 1 inch outside diameter (OD) crossed-link polyethylene (PEX) downhole compressed air-assisted vacuum groundwater recovery tubes (i.e., slurper tubes). The compressed air line will be a ¼ inch OD polytetrafluoroethene (PTFE) tube internal to the PEX tube. A main vacuum blower will apply vacuum to the wellhead in the aboveground treatment system. Each wellhead will be equipped with a temperature gauge, a vacuum gauge, and a sample port/bleeder valve. Detailed wellhead and slurper tube design drawings are presented in drawing **WHD-01** (**Appendix C**).

4.2.5 Shallow Horizontal SVE Wells

The shallow horizontal SVE wells are 2 inches in diameter and trenched to approximately 1-3 ft. BGS. These wells will consist of 2-inch diameter fiberglass cut with a 0.010 inch slotted screen. The screened interval is 25 ft. long, at a depth of 1-3 ft. BGS. A 6-inch sand filter pack (10/20 or equivalent) was installed in the trench space around and above the well screen. The trenching was completed with 6 inches of vapor cap material to prevent short-circuiting during operation. The top of the fiberglass riser pipe will be complete with a 2-inch male NPT fitting, which in turn will connect to a wellhead. A main vacuum blower will apply vacuum to the wellhead in the aboveground treatment system. Each wellhead will be equipped with a temperature gauge, a vacuum gauge, and a sample port/bleeder valve. Shallow SVE well designs are detailed in drawings **TD-01** and **WHD-01** (**Appendix C**).

4.2.6 Sensor Wells

Installation of digiTAM™ sensors was performed in conjunction with the installation of the electrodes and extraction wells. The temperature sensor (digiTAM™ string) is a 0.5-inch diameter PTFE tube with digital sensors embedded at 3 ft. depth intervals, housed in a watertight 1-inch copper drop tube. The wells consist of a 1.5-inch carbon steel casing and end cap, which houses the digiTAM™ strings. Neat cement grout was used to fill the annular space around the sensor well carbon steel casing. Sensor well construction drawings are presented in drawing **WCD-01** (**Appendix C**). Sensor wellhead details are presented in drawing **WHD-01** (**Appendix C**).

The Cat5 communication cable for each digiTAM™ unit was connected to the sensor string through a junction box and brought back to a remote box located in the well field. Up to 36 digiTAM™ units can be connected to each remote box.

4.2.7 Piping Systems

Aboveground extraction system piping will be installed and connected to the extraction wellheads. Separate pipe and hose networks for (i) extracted fluids, (ii) compressed air, (iii) WCS water, and (iv) electrode over-pressurization fluid returns will be installed throughout the well field and connected the treatment system components. Each of these pipe networks will be thermally and electrically isolated during operations.

The main multiphase extraction vapor/liquid header into the treatment system will be constructed of steel pipe, and will split into smaller laterals that are connected to the wellheads. Extraction pipes will be sloped at an approximate 1° angle towards the treatment system in order to facilitate the gravity drainage of recovered groundwater. The extraction header piping will rest on wooden supports for electrical isolation, and electrical cables and hoses will run underneath and along side these supports. Various hoses will also run on these supports to supply compressed air to the slurper tubes, supply water to the WCS units, and allow electrode injection water to return to the treatment system in the event of over-pressurization. The placement of the piping network is shown in **Drawing WFL-01** (**Appendix C**).

The MPE wellheads will each have three lateral connections to the treatment area headers: (i) a 2 inch OD high temperature vacuum hose for the vapor stream, (ii) a 1 inch OD PEX tube for the recovered groundwater stream and (iii) a ¼ inch OD PFTE tube for the compressed air stream internal to the 1 inch PEX tube. Each connection point will have a ball valve to adjust the liquid, vapor and compressed air flow rates. All manifolds on the lateral piping will be complete with cam and groove fittings to facilitate maintenance and breakdown of the piping network. Refer to **Drawing WHD-01** (**Appendix C**) for extraction system connection details.

4.3 Above Ground Construction

4.3.1 Aboveground Utilities

Overhead electrical and telephone lines run along the North West edge of the site, parallel to Walden Avenue, on utility poles. During drilling, care was taken to remain at least 10 ft. from any overhead lines, or as otherwise specified by the local jurisdiction.

4.3.2 Vapor Cap

A vapor cap insulates against heat loss through the ground surface, isolates aboveground components from electric potentials induced in the subsurface, prevents fugitive vapor emissions, reduces atmospheric air from being drawn into the extraction wells and limits heat loss associated with groundwater recharge in the vadose zone. This feature is necessary in order to create and maintain high temperatures in the vadose zone and prevent condensation of vaporized VOCs.

The vapor cap for the Site consists of an insulating, cellular concrete with an approximate minimum thickness of 6 inches. This corresponds to an approximate insulating value of R-6.

4.3.3 Power Supply

A detailed description of all power supply connections, cable runs, and specifications can be found in the electrical single line diagram (**ESL-01**, **Appendix C**). Mc² will coordinate with a local, licensed electrical contractor to perform the appropriate electrical connections upstream of the ET-DSP™ electrodes.

4.3.4 ET-DSP™ Neutral Connections

All extraction wells will be fitted with electrical lugs on the bottom flange plate of the wellhead where a 1/0 bonding wire will be attached. Bonding wires from up to eight extraction wells will be connected together in a daisy chain using split bolts and a single wire will be brought back to the PDS unit to connect to the ET-DSP™ neutral. The groups of extraction wells that will be connected together will coincide with the groups electrodes that are connected to each PDS unit, such that specific areas can be isolated while other areas continue to operate.

Aboveground structures such as PDP, treatment system, and PDS units will be grounded using grounding wire. This network will be connected to the utility ground and will be brought back to the transformer where the utility is connected. The WCS is bonded to the associated PDS unit using a 2/0 grounding wire. All equipment in or near the well field will be placed on wood or concrete blocks or otherwise isolated. The ET-DSP™ neutral is separate from the utility ground. This creates an independent return path for the input energy back to the energy source as a means to control power delivery.

4.3.5 Treatment System

The liquid treatment system equipment will be skid-mounted with secondary containment in the skid. This secondary containment will have a high level sensor in the holding tank to shut down the system if a leak is detected. Additionally, all transfer hoses with unprocessed liquids will be double contained (primary with sleeve).

Once the treatment system is staged at its designated location, a short section of pipe will be installed from the end of the extraction system header to the primary liquid/vapor separator. The treatment system equipment will arrive with the controls described earlier pre-installed. After completing all piping connections, the liquid treatment system will be pressure tested at 60 pounds per square inch (PSI) for 30 minutes. Additionally, a wet test of the treatment system will be completed prior to startup to ensure proper operation of all treatment system equipment and controls.

5 Operational Strategy

5.1 Operations and Maintenance Plan

The operational schedule for the anticipated stages of initial heating, maintaining target temperatures, pressure cycling and cool down is described in the O&M Plan. The O&M Plan also contains details regarding startup procedures, operations and maintenance procedures, and specific health and safety precautions.

5.2 Hydraulic and Pneumatic Control

Controlling potential migration and/or redistribution of COCs will be achieved by maintaining a sufficient vacuum and hydraulic control within the treatment volume. Hydraulic and pneumatic control will be established through the extraction of subsurface fluids at sufficient rates, and monitored throughout the ET-DSP™ application with vacuum pressure gauges and flow totalizers. A ratio of extracted liquids to injected water must be greater than unity in order to maintain hydraulic control.

Groundwater table elevations can be measured at the extraction wells using a water level tape, while the electrodes are turned off, in order to ensure that inward hydraulic gradients are maintained throughout the treatment volume.

5.3 Health & Safety

Safety is of paramount concern during all phases of this remediation project. Mc^2 will prepare a comprehensive Health & Safety Addendum. This plan includes provisions for the strict adherence of safety standards and controls during drilling, construction, and operations. This will ensure that the potential for exposure of personnel to hazards and unsafe conditions is minimized.

Appropriate signage will be placed throughout the site and on the perimeter fence. High voltage zones, hot surfaces and process tanks will be appropriately labeled and placarded.

6 Performance Monitoring

Performance monitoring will include extraction and treatment system parameters, ET-DSP™ parameters, pressure and temperature.

6.1 Subsurface Monitoring

Continuous monitoring of site operations will be conducted to ensure that hydraulic and vapor capture are maintained, over-pressurization is prevented, and operational temperatures are achieved and maintained. Vapor pressure gradients will be determined by manually measuring the vadose zone pressure at extraction wells periodically.

Temperature monitoring will be achieved with 70 digiTAM™ temperature sensors deployed in 7 sensor wells. This high density of temperature data will be logged in a database and used to visualize subsurface conditions in thermal contour maps (e.g., **Figure 2**). Since the vadose zone will act as a saturated steam system under operating conditions, pressure in this zone will be a function of temperature (and vice-versa). This concept allows for interpretation of subsurface temperature data to provide supplementary subsurface pressure data.

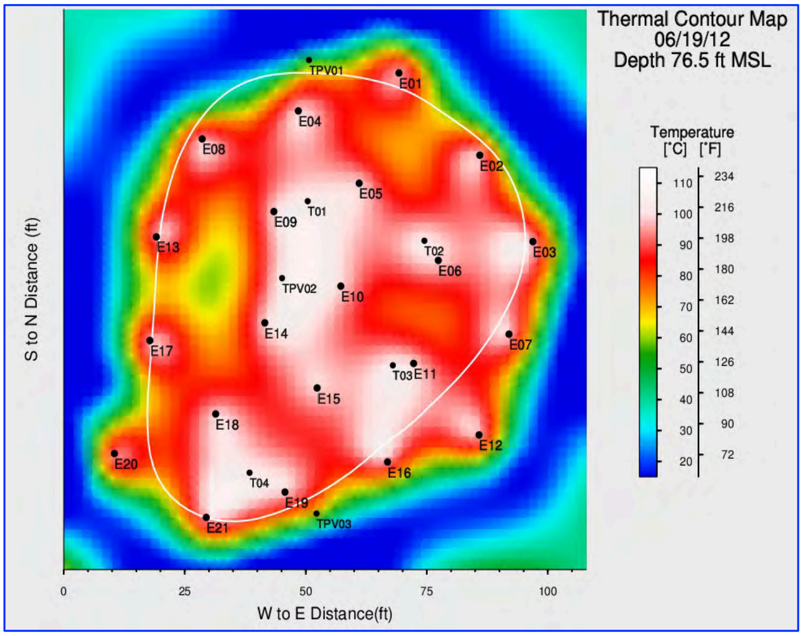

Figure 2: Sample Subsurface Temperature Distribution Map

6.2 Treatment System Monitoring

Onsite personnel will monitor the remediation system during operations. Site monitoring activities will be conducted at a reasonable frequency agreed upon by Mc² and the ET-DSP™ operator. Further details are described in the O&M Plan. Upon completion of each site monitoring round, the information will be compiled into an ongoing project database available from the project website. Contaminant mass removed from soil, volume of liquid removed, system runtime, and subsurface vapor flow rates will be calculated manually using analytical results, PID, and flow measurements taken at periodic intervals.

6.3 Temperature and Vacuum Monitoring

Subsurface temperatures and vacuum levels in the treatment volume will be monitored using the digiTAM™ and extraction wells, respectively. Vacuum data will be measured manually at each vapor extraction point and recorded on the project website.

6.4 Groundwater and Soil Sampling

Once asymptotic conditions are reached at the end of thermal treatment operations, conformational post-treatment soil and/or groundwater sampling will be performed by CH2M to assess COC concentration and mass reduction.

6.5 Data Collection and Management

Mc²'s electronic data collection and management system will transmit data from addressed digital sensors located throughout the well field and treatment area via a communication protocol to an onsite server. The onsite server's database will function as the first storage location for the collected data and will also act as the conduit for real-time sensor data transfer to a central server located offsite for redundant storage. All data will be transferred between the onsite and central offsite servers over a secure Internet connection. The central server will be used to provide immediate access to relevant data, which in turn can used to calculate and render models of the thermal process and process real-time data for visual presentation. The database may be remotely accessed via the Internet.

6.5.1 ET-DSP™ Control Systems

The entire ET-DSP™ control system, including the WCS, will be connected to a LAN that, in turn, is accessible over the Internet and monitored via the project webpage. This will provide remote access and control for Mc² operators who may be offsite during operations.

ET-DSP™ also utilizes TDC/IPS to control the power to individual electrodes via proprietary computer controllers within the PDS units. This method controls the sine wave of the three-phase power to the millisecond such that each phase can be individually manipulated, and can alter the phases of power applied to individual electrodes to re-orient the flow of electric current between electrodes. For example, should it become apparent that certain electrodes are in electrically resistive zones, the power to the electrodes in these areas can be increased with the TDC/IPS to encourage the development of a more uniform heating pattern. Additionally, the power delivery system includes an assortment of voltage tap settings to further control the heating process.

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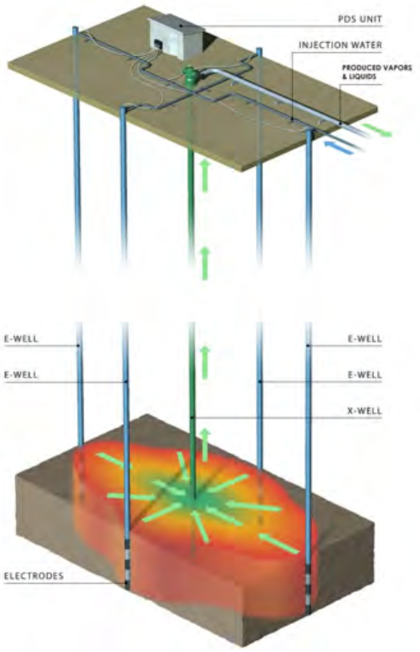
Appendix A – Thermal Model

Thermal Model

Electro-Thermal
Model and Design

Former Dowell Depew Facility

McMILLAN-McGEE CORP
CREATORS OF ET-DSP



Submitted to
CH2M Hill

Depew, New York
December 20, 2015

Electro-thermal Simulation Study

APEGA Permit No. P09178

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This document contains information and data that is confidential and has been made available to CH2M Hill, to whom it is addressed strictly on the understanding that its contents will not be disclosed or discussed with any third parties except for the individual's own professional advisers.

Disclaimer

In preparing this report, we have relied upon information provided by you, the Client, and your representatives. This information has been accepted as represented without independent verification. We have relied upon these representations as to the completeness and accuracy of the data provided and that no material changes have occurred or is expected to occur, from that which was projected in this report, between the date the information has been provided and the date of this report, and that no new information has come to light that may result in a material change to the findings contained herein this report.

Contents

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List of Tables

Nomenclature

Symbol	Description
BGS	Below Ground Surface
COCs	Contaminant of Concern
CVOC	Chlorinated Volatile Organic Compound
DCE	1,1-Dichloroethene
*digi*PAM™	Digital Pressure Acquisition Module
*digi*TAM™	Digital Temperature Acquisition Module
DNAPL	Dense Non-Aqueous-Phase Liquid
ET-DSP™	Electro-Thermal Dynamic Stripping Process
Mc2	McMillan-McGee Corp.
MPE	Multiphase Extraction
NAPL	Non-Aqueous-Phase Liquid
PDS	Power Delivery System
SVE	Soil Vapor Extraction
TCE	Trichloroethene
UCL	Upper Confidence Limit
VC	Vinyl Chloride
VOC	Volatile Organic Compound

Symbol	Description
Used in Equations	
λ_c	Thermal Conductivity of the chemical [W/m/°C]

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Symbol	Description
λ_w	Thermal Conductivity of the Water [W/m/°C]
λ_r	Thermal Conductivity of the Rock [W/m/°C]
λ_{ob}	Thermal Conductivity of the Overburden [W/m/°C]
λ_{ub}	Thermal Conductivity of the Under-burden [W/m/°C]
ρ	Electrical Resistivity [Ωm]
σ_w	Electrical Conductivity of the Water [S/m]
A_{gw}	Area Perpendicular to Ground Water Flow [m^2]
h_e	Electrode Length [m]
K	Hydraulic Conductivity [ft/day]
L_e	Electrode Length [m]
P_i	Initial Pressure [kPa]
R_e	Electrode Resistance
S_c	Chemical Saturation [-]
S_g	Gas Saturation [-]
S_w	Water Saturation [-]
T_i	Initial Temperature [°C]
v_{gw}	Ground Water Flow Velocity [m/day]
a	Cementation Factor in Archie's Law [-]
a_i	Fit Parameters in a Cubic Fit of the Temperature [-]
z_{BGS}	distance below ground surface [m]
	Radius of Capture Equation
F	vertical flow constant [-]
C_a	Capillary number [-]
c_1, c_2	Capillary number coefficient correlation constants [-]
d_1, d_2	Capillary number exponent correlation constants [-]
d	pore throat diameter [m]
$E\acute{o}$	Eötvös number for channels with a square cross section
g	acceleration due to gravity [$\mathrm{m/s}^2$]
H	Thickness of heated volume [m]
h	Characteristic height [m]
K	$k-$values [-]
k_h	Horizontal permeability [mD]
k_v	Vertical permeability [mD]
r_e	Radius of capture [m]
r_w	Radius of extraction well [m]
α	residual water fraction [-]
γ	surface tension of water [N/m]
μ_l	viscosity of water [Pas]

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Symbol	Description
ϕ	porosity [-]
ρ	density of water [kg/m^3]
τ	Tortuosity parameter [-]
v_v	Average vertical discharge velocity [m/s]
v_v	Horizontal velocity of the liquid [m/s]
v_b	Vertical velocity of the vapour [m/s]
$\pm$	plus or minus

Symbol	Description
	Units of Measure
α	attenuation factor
cm	centimetre
h	hour
in	inch
kg	kilo gram
yd^3	cubic yards
°C	Degrees Celsius
°F	Degrees Fahrenheit
ft	feet
gpm	gallons per minute
inHg	inches of mercury
kg/m^3	kilograms per cubic meter
lbs	pounds
mD	millidarcy
m	metre
m^3	cubic meter
mm	milli metre
mg/l	milligrams per liter
kW	kilowatts
mmHg	Millimeters of Mercury
%	percent
s	second
scfm	standard cubic feet per minute
µg/kg	micrograms per kilogram
µg/l	micrograms per Liter
µg/m^3	micrograms per cubic meter

table continued on next page

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Symbol	Description
g/m^3	grams per cubic meter
µV	microvolts
MW	megawatt
Ωm	Ohm meter

1

Summary

The objective of the simulation study is to develop a subsurface model of the Former Dowell Depew Facility in Depew, New York using an electro-thermal[1] process in conjunction with a multiphase extraction MPE system. The model will be used to determine the basis for the system design and operating strategy of the two systems, specifically, to address many of the design elements of a typical electro-thermal project as shown in Figure 1.1.

The results of this model estimate the pertinent design characteristics of an electro-thermal remediation project, such as:

1. Total energy input of 1,281 $\mathrm{MW \cdot h}$ or 412 $\mathrm{kWh/m^3}$ (315 $\mathrm{kWh/yd^3}$);
2. Total water extraction volume of 4,425,030 L (1,168,969 gallons);
3. Total water injection volume of 4,317,192 L (1,140,481 gallons);
4. Vapor extraction rate of 139 scfm ;
5. Time to reach target temperatures of 52 to 57 days;

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[1] Electro-thermal processes are also commercially referred to in the industry as Electrical Resistance Heating, (ERH) or the Electro-thermal Dynamic Stripping Process, ET-DSP™.

6. Peak temperatures are generally limited to the boiling temperature of water as a function of depth and pressure in the soil[2];
7. The anticipated contaminant mass recovery of 45 kg (100 lbs);
8. Electrode spacing of 5.639 m (18.50 ft); and,
9. A minimum extraction well spacing of 6.67 m (21.88 ft).

The site location is shown in Figure 1.2. The overall treatment area is approximately 340 m^2 and is shown in Figure 2.2. The vertical extent of the treatment volume may vary as defined by the chemical distribution or the top of an aquitard. The treatment area will be heated from about surface to an average depth of 9.45 m resulting in a treatment volume of approximately 3,109 m^3 (4,066 yd^3). The boundaries of the heated volume extend to the extremities of the treatment volume. The results of the simulation study are presently in chapter 3 and summarized in section 3.1.

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[2] Water in the presense of chemicals will boil at the azeotropic temperature of the mixture, which can be less than the boiling temeperature of water.

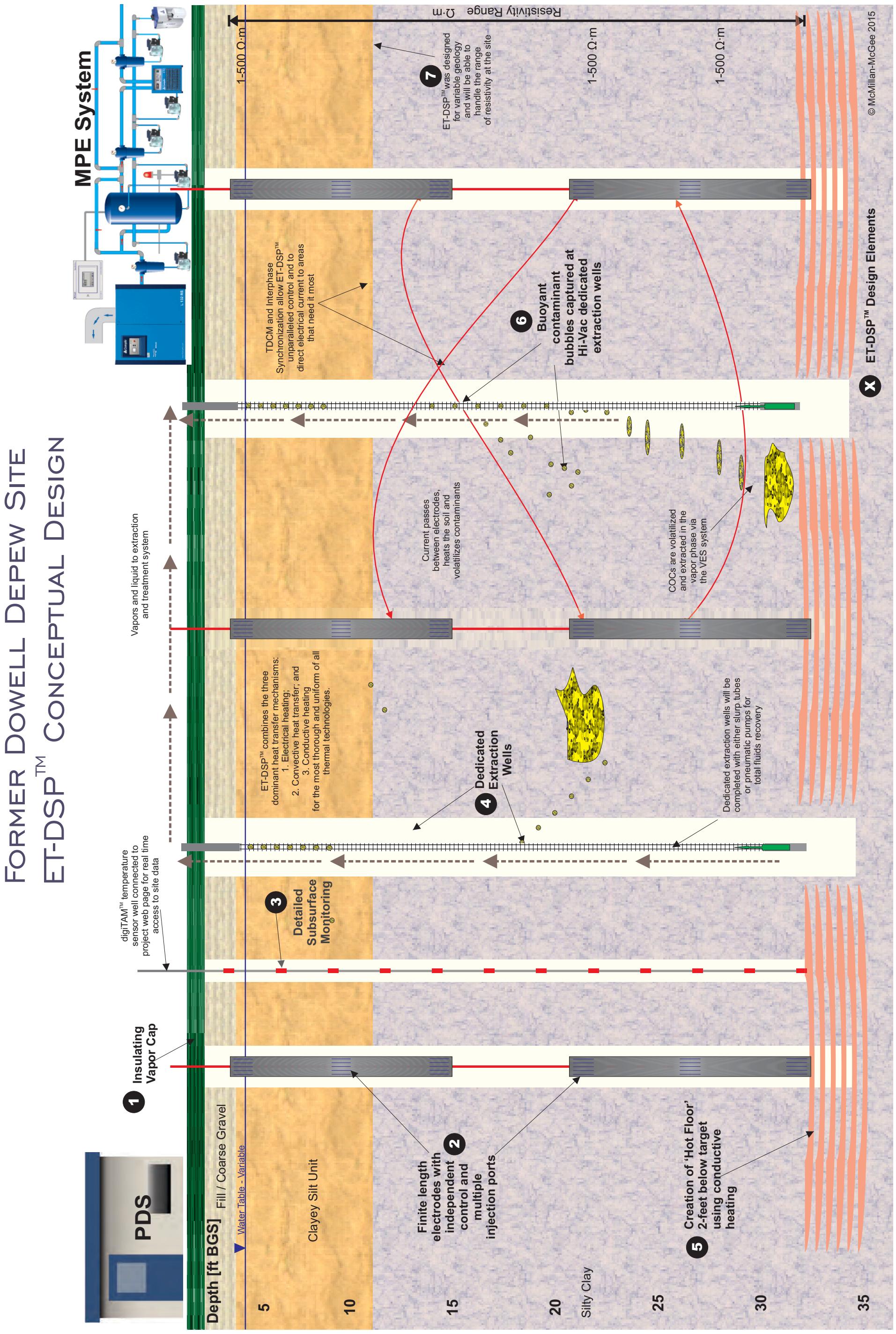

Figure 1.1.: Conceptual model of the remediation process.

Figure 1.2.: Areal view of the project site location.

The study resulted in a technical approach for this project with specific regard to the

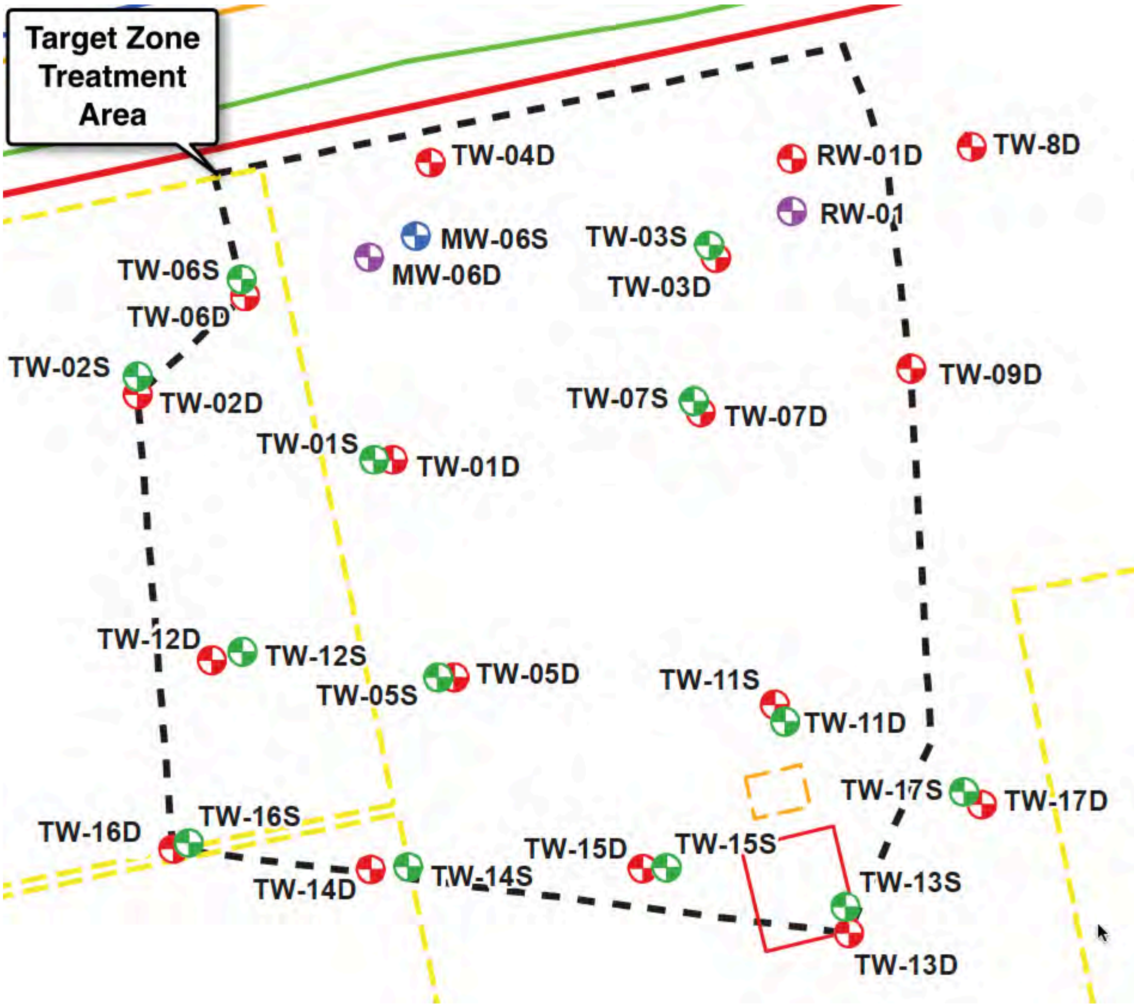

Figure 1.3.: Areal view of the Treatment Area.

following design issues:

Treatment Region Treatment is confined to the area defined by the distribution of chemicals in the subsurface. The heated volume extends from surface to an average depth of 9.45 m BGS. The total treatment area is 340 m^2 (3,661 ft^2) and the treatment volume is 3,109 m^3 (4,066 yd^3).

Vapor Cap The entire treatment area should be covered with an insulating material with a minimum insulating value of R-6 vapor[3] . The cap enhances the systems thermal efficiency by reducing the migration of cool vapor into the treatment area during heating. It is needed to facilitate heating of shallow soils and ensure

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[3] An insulating factor of was assumed in this study.

mobilized constituents of concern (COCs) are captured and extracted from the treatment area. The vapor cap extends 3 m outside of the thermal treatment area.

Electrodes The design simulation model calls for an electrode well configuration as summarized in Figure 1.4. The well configuration is a function the thickness. This design of electrode wells is needed to achieve target temperatures. All in all there are 22 electrode wells with two electrodes in each well. The horizontal spacing between electrodes varies slightly but on average is 5.639 m. The recommended drilling method for the electrode wellbores is Sonic. The average power per electrode is 6.74 kW over a project duration of 180 day, with an estimated peak electrode power of 11.35 kW. The average water injection rate into each electrode is 0.379 L/min. Should highly resistive soil be encountered electrolyte can be injected into the electrodes to increase power to design levels.

Extraction Well The simulation study resulted in 15 extraction wellbores extending through the treatment volume as shown in Figure 1.4. The extraction rate for each well is easily determined by taking the total project extraction rate (17.07 L/min) and dividing by the total number of wells with a result of 0.301 gal/min (1.138 L/min). Though the extraction wells may be of different lengths, it was assumed that the extraction per well is the same throughout the well field[4]. The estimated vapor extraction rate per well for achieving mass recovery is 9.28 scfm with a total vapor flow into the plant of 139 scfm . The maximum estimated vacuum needed to achieve the vapor flow rates is 12 inches Hg.

Sensors To monitor temperature and optimize electric power input, the appropriate number of temperature monitoring wells will be used.

Existing Infrastructure Remediation is to occur in an area of the site with existing infrastructure and in an area with a residential community.

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[4] It is a practical impossibility to monitor the extraction rate on a well by well basis with any degree of accuracy during thermal operations.

Electrical Properties Electrical properties of the soil are variable in the treatment volume as there are different soil conditions present. The resistivity profile for the site (and assumed for this numerical simulation study) is shown in Figure 1.5. Average static electrical resistivity of the soil was assumed to be 32.71 Ωm and ranges in value from 20 Ωm to 80 Ωm. The resistivity changes (approximately) by a factor of 2.37 through the operating temperature range as was measured by the dynamic resistivity tests at the McMillan-McGee thermal laboratory. The assumed temperature dependence on resistivity is shown in Figure 1.6. Data beyond 88.1 °C is extrapolated using methods developed by Chute and Vermeulen[3].

Water Table The depth to the water table is 0.30 m. For soil depths above the water table, moisture content is critical to maintaining electrical conductivity. For soil above the aquifer, treatability will depend on maintaining moisture content in the soil during electro-thermal heating. The electrical properties measured during the resistivity testing of vadose zone soil samples from the site, indicate that the vadose and saturated zone soil is conductive and suitable for electro-thermal heating processes. Saline injection through the electrodes is likely not needed for this site, but remains an option if necessary. It is also assumed that the ground water flow velocity is negligible within the treatment volume[5].

Simulation Study The optimization of the heating strategy and operations through detailed data monitoring are to minimize the overall energy consumption of the project while still achieving the clean up goals. The simulation study provides a conservative (aggressive heating) estimate of the energy.

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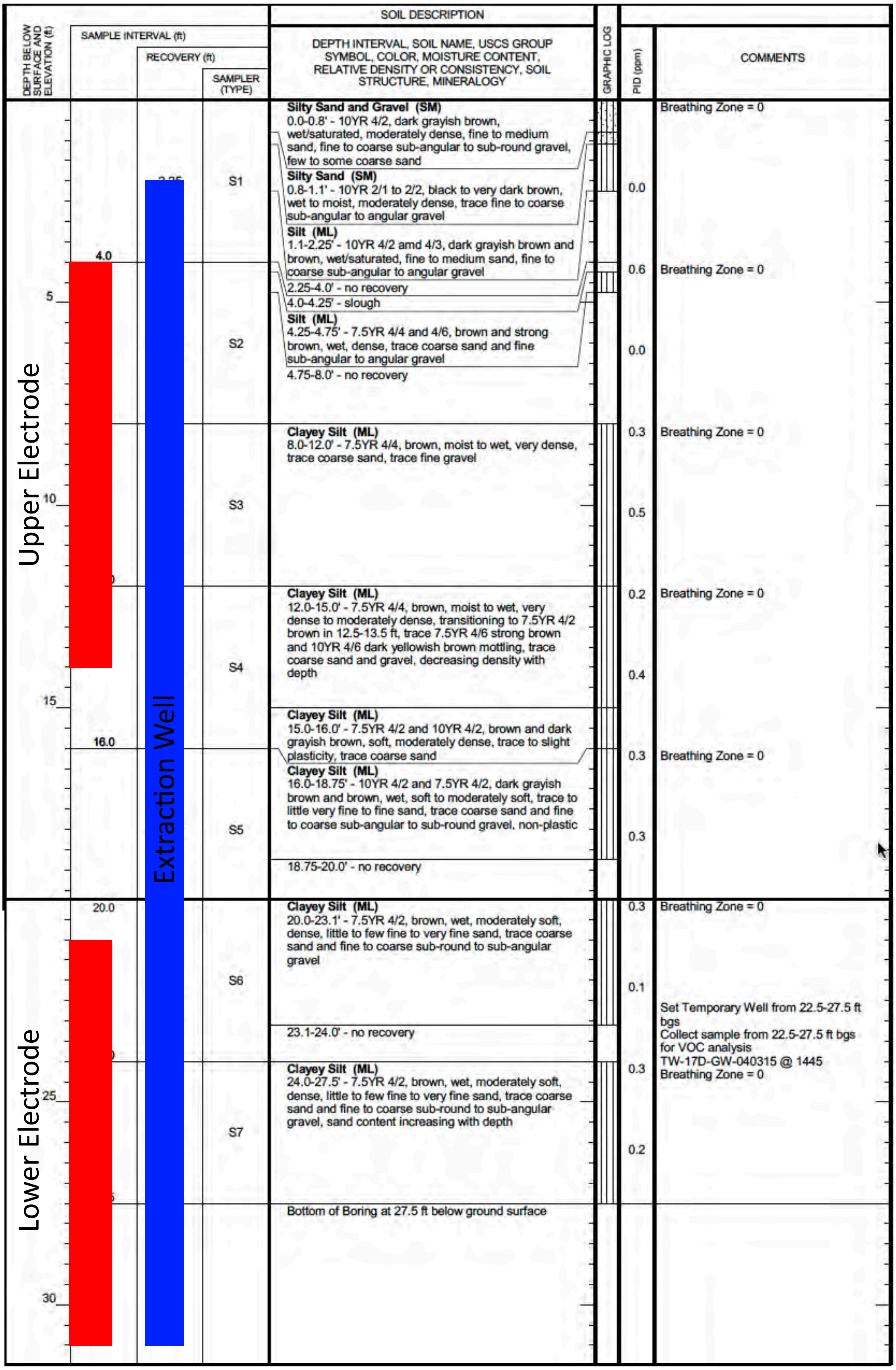
[5] Engineering controls maybe needed to mitigate groundwater flow in the surfical sand unit.



DEPTH BELOW SURFACE AND ELEVATION (ft)	SAMPLE INTERVAL (ft)	RECOVERY (ft)	SAMPLER (TYPE)	SOIL DESCRIPTION DEPTH INTERVAL, SOIL NAME, USCS GROUP SYMBOL, COLOR, MOISTURE CONTENT, RELATIVE DENSITY OR CONSISTENCY, SOIL STRUCTURE, MINERALOGY	GRAPHIC LOG	PID (ppm)	COMMENTS
			S1	**Silty Sand and Gravel (SM)** 0.0-0.8' - 10YR 4/2, dark grayish brown, wet/saturated, moderately dense, fine to medium sand, fine to coarse sub-angular to sub-round gravel, few to some coarse sand			Breathing Zone = 0
				Silty Sand (SM) 0.8-1.1' - 10YR 2/1 to 2/2, black to very dark brown, wet to moist, moderately dense, trace fine to coarse sub-angular to angular gravel		0.0	
	4.0			**Silt (ML)** 1.1-2.25' - 10YR 4/2 amd 4/3, dark grayish brown and brown, wet/saturated, fine to medium sand, fine to coarse sub-angular to angular gravel 2.25-4.0' - no recovery		0.6	Breathing Zone = 0
5			S2	4.0-4.25' - slough **Silt (ML)** 4.25-4.75' - 7.5YR 4/4 and 4/6, brown and strong brown, wet, dense, trace coarse sand and fine sub-angular to angular gravel 4.75-8.0' - no recovery		0.0	
10			S3	**Clayey Silt (ML)** 8.0-12.0' - 7.5YR 4/4, brown, moist to wet, very dense, trace coarse sand, trace fine gravel		0.3 0.5	Breathing Zone = 0
			S4	**Clayey Silt (ML)** 12.0-15.0' - 7.5YR 4/4, brown, moist to wet, very dense to moderately dense, transitioning to 7.5YR 4/2 brown in 12.5-13.5 ft, trace 7.5YR 4/6 strong brown and 10YR 4/6 dark yellowish brown mottling, trace coarse sand and gravel, decreasing density with depth		0.2 0.4	Breathing Zone = 0
15	16.0			**Clayey Silt (ML)** 15.0-16.0' - 7.5YR 4/2 and 10YR 4/2, brown and dark grayish brown, soft, moderately dense, trace to slight plasticity, trace coarse sand			
			S5	**Clayey Silt (ML)** 16.0-18.75' - 10YR 4/2 and 7.5YR 4/2, dark grayish brown and brown, wet, soft to moderately soft, trace to little very fine to fine sand, trace coarse sand and fine to coarse sub-angular to sub-round gravel, non-plastic 18.75-20.0' - no recovery		0.3 0.3	Breathing Zone = 0
	20.0		S6	**Clayey Silt (ML)** 20.0-23.1' - 7.5YR 4/2, brown, wet, moderately soft, dense, little to few fine to very fine sand, trace coarse sand and fine to coarse sub-round to sub-angular gravel 23.1-24.0' - no recovery		0.3 0.1	Breathing Zone = 0 Set Temporary Well from 22.5-27.5 ft bgs Collect sample from 22.5-27.5 ft bgs for VOC analysis TW-17D-GW-040315 @ 1445
25			S7	**Clayey Silt (ML)** 24.0-27.5' - 7.5YR 4/2, brown, wet, moderately soft, dense, little to few fine to very fine sand, trace coarse sand and fine to coarse sub-round to sub-angular gravel, sand content increasing with depth		0.3 0.2	Breathing Zone = 0
				Bottom of Boring at 27.5 ft below ground surface			
30							

Figure 1.4.: Electrode well design in the treatment volume.

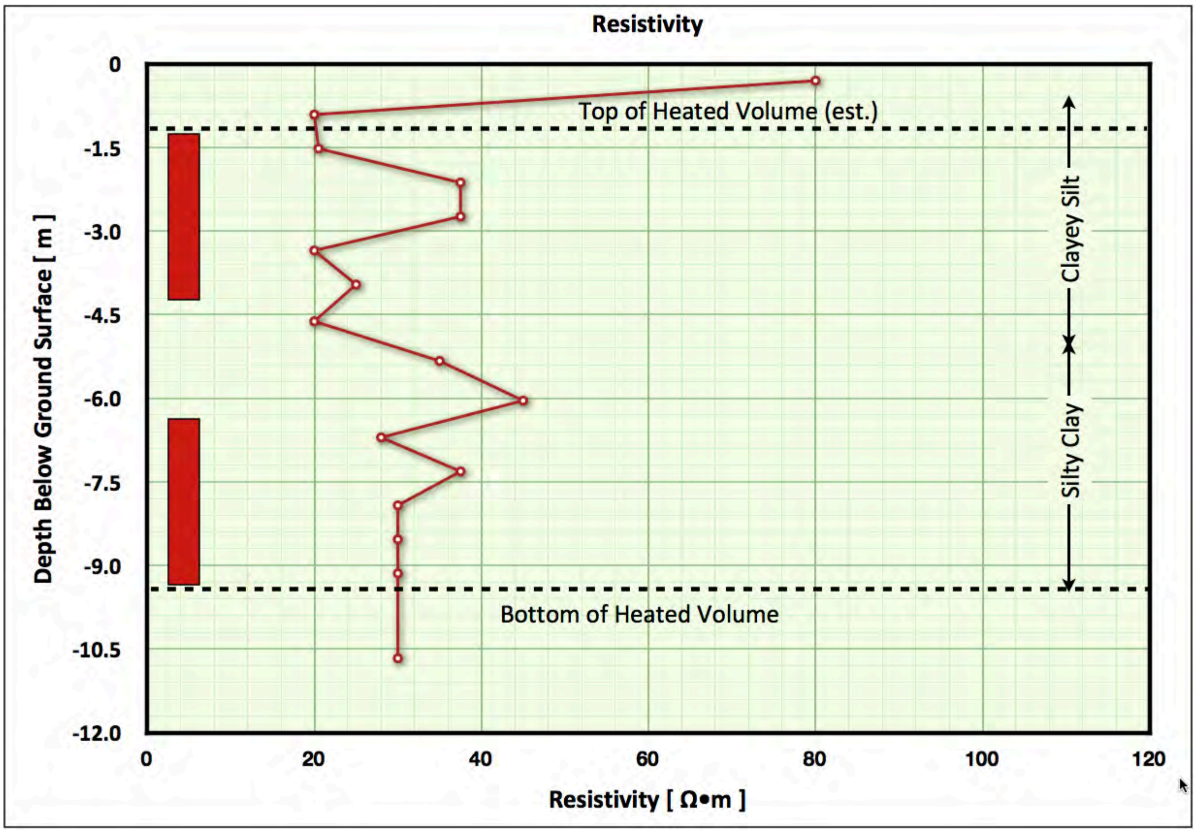
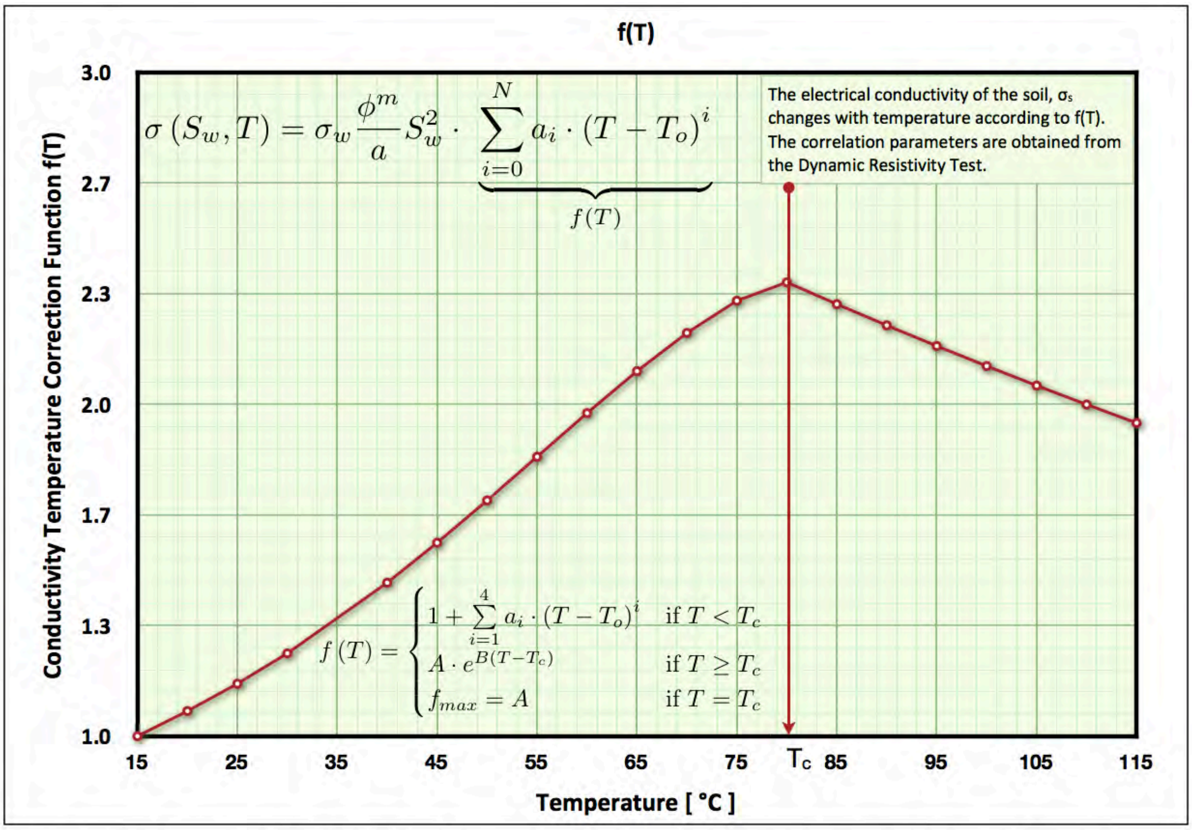


Figure 1.5.: Resistivity profile.



Resistivity Temperature Coefficients Below Tc

T_0	$a_{i=0}$	$a_{i=1}$	$a_{i=2}$	$a_{i=3}$	$a_{i=4}$
15.00	1.00	0.014603	0.000078251	0.00000477856	-0.00000006777

Resistivity Temperature Coefficients Above Tc

T_c	A	B
80.00	2.3673000	-0.0056352

Figure 1.6.: Temperature dependent resistivity mulitplier.

2

Simulation Study

The input data are obtained from CH2M Hill with electrical profiling data obtained from McMillan-McGee. Data not available from the client were obtained from the public domain. An aggressive heating approach was taken in the preparation of the data file.

Figure 2.2 shows the ET-DSP™ thermal treatment area. The scope of this simulation study is limited to only the ET-DSP™ process within the treatment area.

2.1. The Site

2.1.1. Background Information

This simulation study is for the remediation of the Depew site in Depew, New York 14043 USA.

Site Description

The Depew project is located at 3311 Walden Avenue in the Village of Depew, New York. In summary;

1. The site is in a mixed residential and industrial/commercial area. A neighborhood and a recycling facility are located adjacent to the site on the north side of Walden Avenue.

2. As shown on Figure 2.1, the entire site covers approximately 5260.91 □m (1.8 acres).

3. The property is currently vacant, and the ground surface consists primarily of gravel and grass with small- to medium-sized trees on portions of the site.

4. A 1.83 m (six foot) high chain-linked fence with a locked entrance gate along Walden Avenue provides security for the site.

5. The thermal treatment area is shown in Figure 2.2.

Activities at the site included servicing industrial facilities and limited oilfield-related projects. Various industrial cleaning and oilfield-related chemicals were stored onsite and transferred into tank trucks for use at different job sites. Figure 2.1, shows the former onsite building structures: (i) two-story office building, (ii) chemical storage building, (iii) one-story office/maintenance shop, (iv) an acid plant, (v) bulk cement plant, (vi) cement silos, (vii) 8,000-gallon diesel aboveground storage tank (AST), (viii) 1,000-gallon gasoline underground storage tank (UST) with dispenser, (ix) mud separator, (x) oil/water separator, and a (xi) hydrochloric acid above ground storage tank.

In the late 1980s, operations at the site were discontinued, and the facility was permanently closed. Building structures were demolished during the 2003 to 2004 remedial action (RA), and the site has since been inactive (URS 2011).

A summary of the site conditions are:

1. The chemicals of concern are listed with the primary constituents being (mainly VOC DNAPL's) The 14 VOCs listed in the statement of work are:

   a) 1,1,1-trichloroethane (1,1,1-TCA),

   b) 1,1-dichloroethane (1,1-DCA),

   c) 1,1-dichloroethene (1,1-DCE),

   d) 1,2-dichloroethane (1,2-DCA),

   e) total 1,2-dichloroethene (1,2-DCE),

   f) acetone,
   g) benzene,
   h) chloroethane,
   i) cis-1,2-dichloroethene (cis-1,2-DCE),
   j) ethylbenzene,
   k) tetrachloroethene (PCE),
   l) trichloroethene (TCE),
   m) vinyl chloride, and
   n) total xylene.

2. The deepest extent of the treatment volume is approximately 9.45 m (31.00 ft) BGS with the shallow extent at just below ground surface.

3. Groundwater flow velocities are not reported and are assumed to be negligible[1].

4. A review of the soil boring logs indicates that the lithology at the site is heterogeneous and complicated with inter-dispersed sand and gravel lenses. Generally, however, the top half of the treatment volume consists of clayey silt and the lower interval is a silty clay interval.

5. Generally, the site is clear of buried utilities. A GPR survey did detect an anomaly within the data that showed a response consistent with a former utility or other linear feature. Based on historical imagery this anomalous response is most likely a former roadway which was present in this area. No significant response was obtained within the survey area.

6. It is expected that monitoring and extraction wells not suitably constructed for exposure to high temperature will be decommissioned prior to the implementation of thermal treatment.

---

[1] If the ground water flow velocities are greater than 1 m/day then this can result in significant heat flux out of the treatment volume. Typically this will require engineering controls to confine flow velocities to manageable values to mitigate these losses.

7. Removing the volatile chemicals from the subsurface within the timeframe of 180 day is the desired outcome of remediation effort. This is anticipated to reduce the risk posed to human health and the environment by site contaminants.

8. A thermal vapor cap with a minimum R-value of 5.00 $\left[\frac{\mathrm{ft}^2\,{}^\circ F\,\mathrm{hr}}{\mathrm{BTU}}\right]$ was assumed to be installed over the treatment area and extending a minimum of 3 m outside of the treatment footprint.

9. A network of groundwater extraction and/or multiphase (vapor and groundwater) extraction wells will be installed and operated within the treatment area to ensure that hydraulic control can be maintained throughout operations.

Figure 2.1.: Treatment area for the Depew site showing the locations of historic infrastructure.

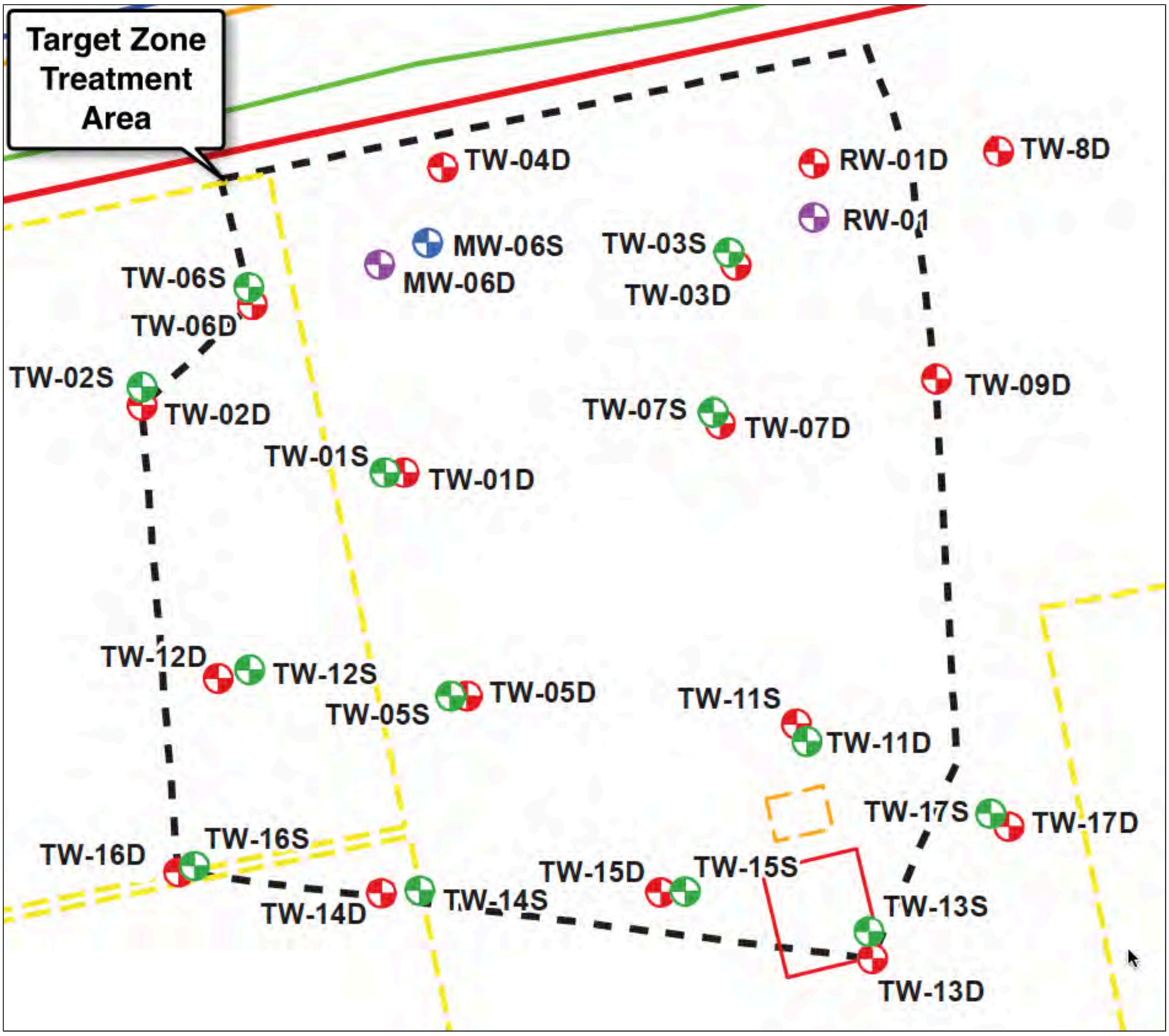


Figure 2.2.: Thermal treatment area for the Depew site.

2.1.2. Geology

The conceptual description of the stratigraphy and geology used in this study, was provided by CH2M Hill. The soil at the Depew site is characterized by a number of stratigraphic units which tend to be generally consistent across the site. These units consist of:

1. Heterogeneous surficial fill (mixture of clay, silty clay, sand, gravel, bricks, and other construction debris) is present from 0 to 4 feet below ground surface (bgs).
2. Glacial till (low permeability unsorted clays and silts) underlies the surficial fill material and is approximately 25 to 30 feet thick.
3. Glacial irregularities are present within the glacial till. The size and frequency of the glacial irregularities generally increase with depth.
4. The Marcellus and Skaneateles Shale Formations underlies the glacial till deposit and is encountered at a depth of 27 to 30 feet bgs.
5. Shallow groundwater consists of two independent groundwater units (defined as the upper and lower till units).
    a) The upper till is unconfined groundwater in the surficial fill and upper till.
    b) The lower till is confined groundwater in the lower till and upper bedrock.
6. The groundwater table for both groundwater units is encountered in the surficial fill and glacial till deposits at depths of approximately 1 to 4 feet bgs.
7. The groundwater flow direction for both groundwater units is primarily to the west and to the northwest, which is consistent with past measurements and flow directions.
8. The average hydraulic gradient as measured in June 2014 for the upper till is 0.057 feet per feet (ft/ft) and for the lower till is 0.04 ft/ft.
9. The upper till (less than 20 feet bgs) has a porosity of 0.38 and a hydraulic conductivity of $6.2 \cdot 10^{-5}$ (cm/s) and the lower till (greater than 20 feet bgs) has a porosity of 0.22 and a hydraulic conductivity $2.9 \cdot 10^{-8}$.

10. The estimated groundwater flow velocity for the upper till is approximately 10 feet per year (0.008 m/day) and for the lower till, the estimated flow velocity is less than 1 foot per year (0.0008 m/day).

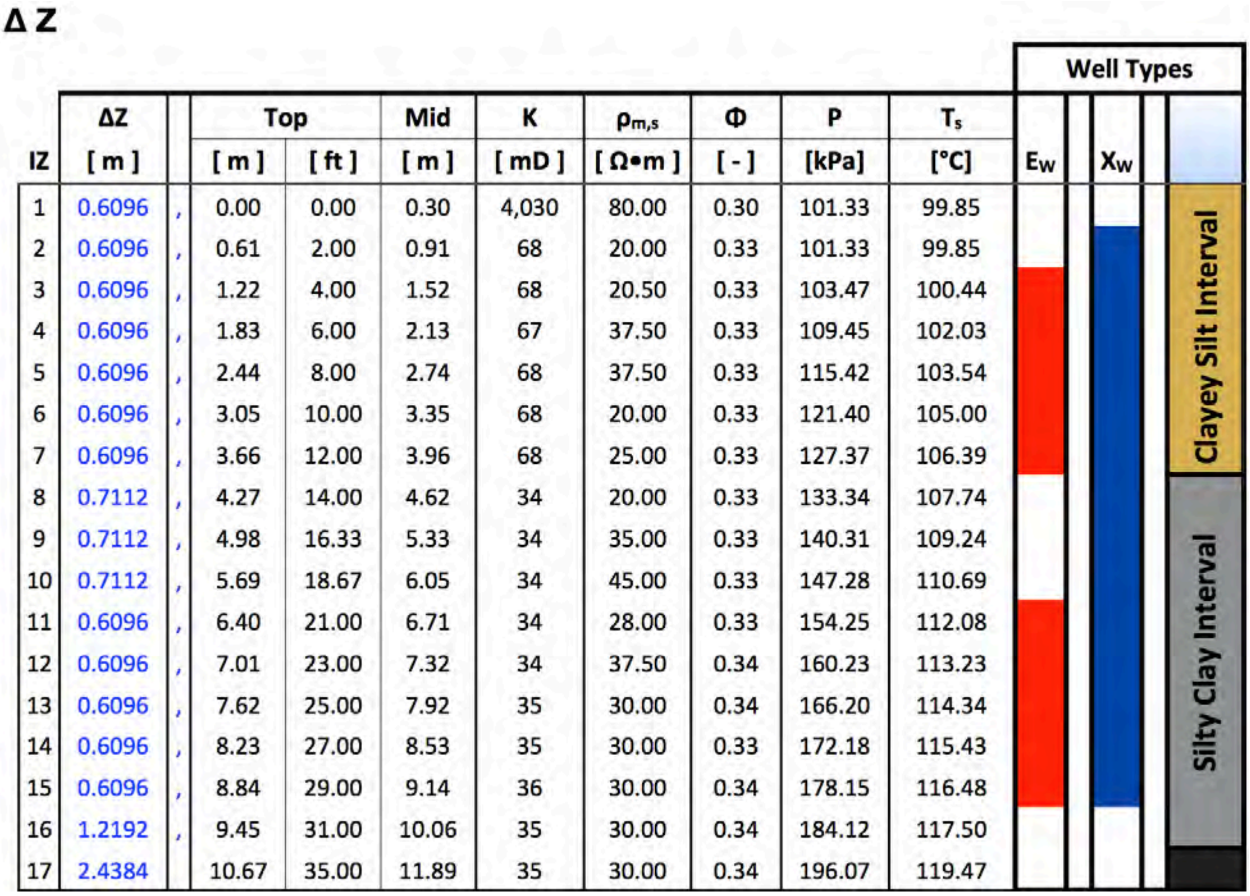
The geological and electrical properties are summarized in Figure 2.3. The geologic features as used in this study are:

1. The treatment volume consists of an upper clayey silt interval layer that is more more permeable than the deeper silty clay interval. The clay underlying the treatment volume is assumed to have a low electrical resistivity and a very low permeability, based on literature values.

2. The porosity throughout the treatment volume is assumed to have an average value of 33% and is the total porosity. This approach is used since water is assumed to occupy the entire pore volume at the onset of heating. Not accounting for interstitial water within the entire pore volume will underestimate the energy calculations.

3. The resistivity as measured in the McMillan-McGee thermal laboratory indicates a fairly uniform vertical resistivity profile.

4. The soils are assumed to have a uniform average bulk permeability with the upper interval being twice as hydraulic conductive as the lower interval. Heating will dramatically increase the permeability of soils, especially clays, and thus a higher value but representative value is used for the lower interval.



ΔZ

											Well Types		
	ΔZ		Top		Mid	K	$\rho_{m,s}$	Φ	P	T_s			
IZ	[m]		[m]	[ft]	[m]	[mD]	[Ω•m]	[-]	[kPa]	[°C]	E_W	X_W	
1	0.6096	,	0.00	0.00	0.30	4,030	80.00	0.30	101.33	99.85			Clayey Silt Interval
2	0.6096	,	0.61	2.00	0.91	68	20.00	0.33	101.33	99.85		🟦	
3	0.6096	,	1.22	4.00	1.52	68	20.50	0.33	103.47	100.44	🟥	🟦	
4	0.6096	,	1.83	6.00	2.13	67	37.50	0.33	109.45	102.03	🟥	🟦	
5	0.6096	,	2.44	8.00	2.74	68	37.50	0.33	115.42	103.54	🟥	🟦	
6	0.6096	,	3.05	10.00	3.35	68	20.00	0.33	121.40	105.00	🟥	🟦	
7	0.6096	,	3.66	12.00	3.96	68	25.00	0.33	127.37	106.39	🟥	🟦	
8	0.7112	,	4.27	14.00	4.62	34	20.00	0.33	133.34	107.74		🟦	Silty Clay Interval
9	0.7112	,	4.98	16.33	5.33	34	35.00	0.33	140.31	109.24		🟦	
10	0.7112	,	5.69	18.67	6.05	34	45.00	0.33	147.28	110.69		🟦	
11	0.6096	,	6.40	21.00	6.71	34	28.00	0.33	154.25	112.08	🟥	🟦	
12	0.6096	,	7.01	23.00	7.32	34	37.50	0.34	160.23	113.23	🟥	🟦	
13	0.6096	,	7.62	25.00	7.92	35	30.00	0.34	166.20	114.34	🟥	🟦	
14	0.6096	,	8.23	27.00	8.53	35	30.00	0.33	172.18	115.43	🟥	🟦	
15	0.6096	,	8.84	29.00	9.14	36	30.00	0.34	178.15	116.48	🟥	🟦	
16	1.2192	,	9.45	31.00	10.06	35	30.00	0.34	184.12	117.50			
17	2.4384	,	10.67	35.00	11.89	35	30.00	0.34	196.07	119.47			

Figure 2.3.: Summary of geological features used in this study.

2.2. Assumptions

2.2.1. General Assumptions

Some of the more general project assumptions captured in the simulation are:

1. The input energy estimates are for electrode operations only. Additional energy for the project is required to run the treatment plant and / or for contingency operations. From experience, the ancillary and contingent energy for a project of this size can be an additional 15%. Our best estimate of the ancillary energy is 173 $\mathrm{MW \cdot h}$ and can be used for estimating the energy budget.

2. The heated volume surrounds the treatment volume in all dimensions by design. The heated volume is larger than the treatment volume in order to ensure complete thermal treatment of the contaminants.

3. The water extracted may be treated and re-injected into the electrodes.

4. All areas of the treatment and heated volumes are open and available for drilling.

5. Horizontal wells designed to be incorporated into the remedial design are not modelled in this study. These wells will be located just below ground surface and above the water table. The liquids extracted from the horizontal wells needs to be incorporated into the calculation for maintaining hydraulic control.

6. Each extraction well is assumed to extract liquids and vapors at the same rates as all the other extraction wells. For effective and economic remediation, the extraction wells should be operated with this strategy. At steam temperatures, a significant component of the vapour will be steam. It is very important to maintain hydraulic control and not over extract liquids relative to liquid injection into the electrodes.

7. Water and current injection into the electrodes will vary for each electrode as determined by this simulation study. Boundary electrodes will operate with 1.14 times more current than interior electrodes to compensate for heat losses.

8. The chemical mass is *uniformly* distributed throughout the vertical interval.

9. To achieve the minimum temperature target early in the project, an aggressive ramp-up with increased peak power to each electrode is necessary.

10. The water saturation distribution, S_w, is assumed to be 100%. This is appropriate given water injection into the electrodes to maximize heat transfer. The chemical saturation is comparatively small.

2.2.2. Assumptions

1. Two distinct geological units are assumed, a higher permeability clayey silt interval above a lower permeability silty clay layer. A high permeability anthropogenic fill layer below the surface cap is assumed.

2. The soil electrical resistivity value used in the simulation is the average of resistivity values measured in soil samples collected from by CH2M Hill. It is assumed that power control to the electrodes dominates the energy input to the soil. Actual electrode currents will be controlled during the project to maintain the recommended power levels.

3. The electrode current is regulated to less than 120 A. The soil is relatively conductive and current regulation is necessary. Water injection rates into the upper and lower electrodes are operated in a balance so that the rates are the same.

4. The water extracted is treated and *is* re-injected back into the electrodes. A heat exchanger may be used to recover the energy in extracted water to pre-heat the electrode injection water. The model conservatively does *not* factor in such energy savings in the energy balance calculations, instead assuming a water injection temperature of 15 °C.

5. It is assumed that groundwater velocities and insignifcant and will have a negligible affect on heating. Therefore ground water flow velocities are assumed to be zero.

6. Hydraulic conductivity data were obtained from CH2M Hill and, if necessary, the public domain.

2.2.3. Resistivity

The indigenous resistivity data were obtained from CH2M Hill and measured by the McMillan-McGee thermal laboratory and are summarized in Figures 2.4 and 2.6. The resistivity data is provided in Figure 2.5. The measured data are provided for convenience in Appendix C and depicted in Figures C.1 to C.9.

Heating the soil using electricity operates by applying a voltage across installed electrodes to induce current in the soil itself. Therefore, the design of the ERH system for site treatability depends on knowing the electrical resistivity profile of the treatment volume.

Another key property of the soil in determining its electrothermal treatability is the electrical resistivity as a function of temperature. Generally, as water saturated soils are heated to boiling temperature, the electrical resistivity will decrease to one third of its initial value as shown in Figure 2.6.

Power controls for the electrical heating process must be capable of adjusting for the variations in electrical conductivity as a function of water saturation and temperature. A site specific temperature dependence was estimated as a linear multiplier of 2.37 for a 75 °C increase in temperature based on past experience and literature values. The conductivity of the interstitial water, σ_w, used in Equation 2.1 is estimated similarly.

The overall average resistivity data, $\hat{\rho}$, adjacent to each electrode, for example, 32.71 Ωm, can be used to estimate the electrode resistance, R_e using Equation 2.2. Equation 2.2 has been used extensively and accurately predicts the electrode resistance measured in the field.

$$\sigma_s\left(S_w, T\right) = \underbrace{\sigma_w \frac{\phi^m}{a} S_w^2}_{Salinity\,Effects} \cdot \underbrace{\sum_{i=0}^{N} a_i \cdot \left(T - T_o\right)^i}_{Temperature\,Effects} \tag{2.1}$$

$$R_e = \frac{1}{2\pi\sigma_s h_e}\left[\frac{r_w}{h_e} + \sinh^{-1}\left(\frac{h_e}{r_w}\right) - \sqrt{1 + \left(\frac{r_w}{h_e}\right)^2}\right] \tag{2.2}$$

Water is injected into the electrodes and/or electrode boreholes to ensure that ohmic contact is maintained between the electrode, the graphite back fill and the soil during electrical heating. As well, the injection of water greatly helps in the rate of heat transfer into the soil. The average temperature of the injection water is 15 °C (note that waste heat may recovered during project implementation, increasing this value).

The injection rate must be carefully managed and depends on the input power and the electrical properties of the soil. For the Depew project the value for the average injection rate is 0.379 L/min, (0.100 gal/min) per electrode.

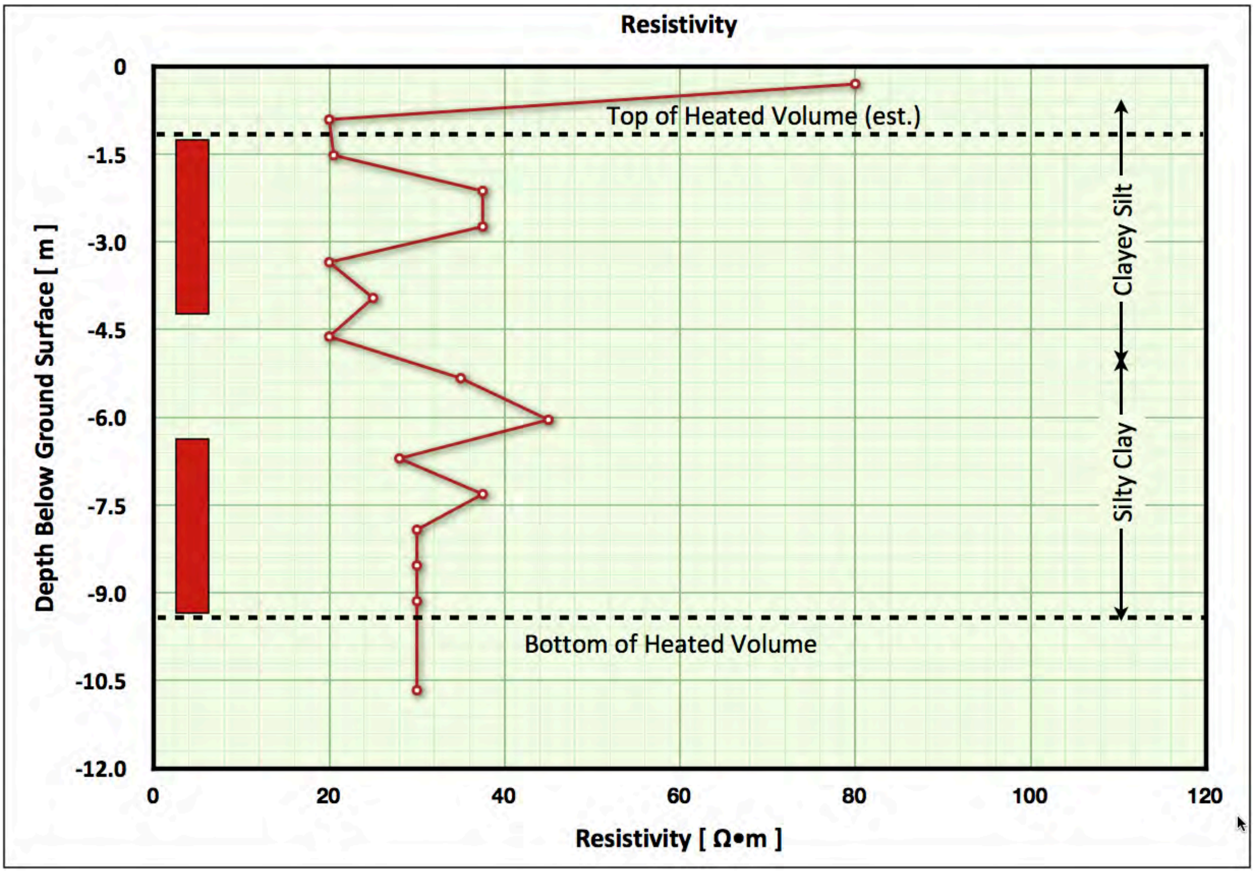
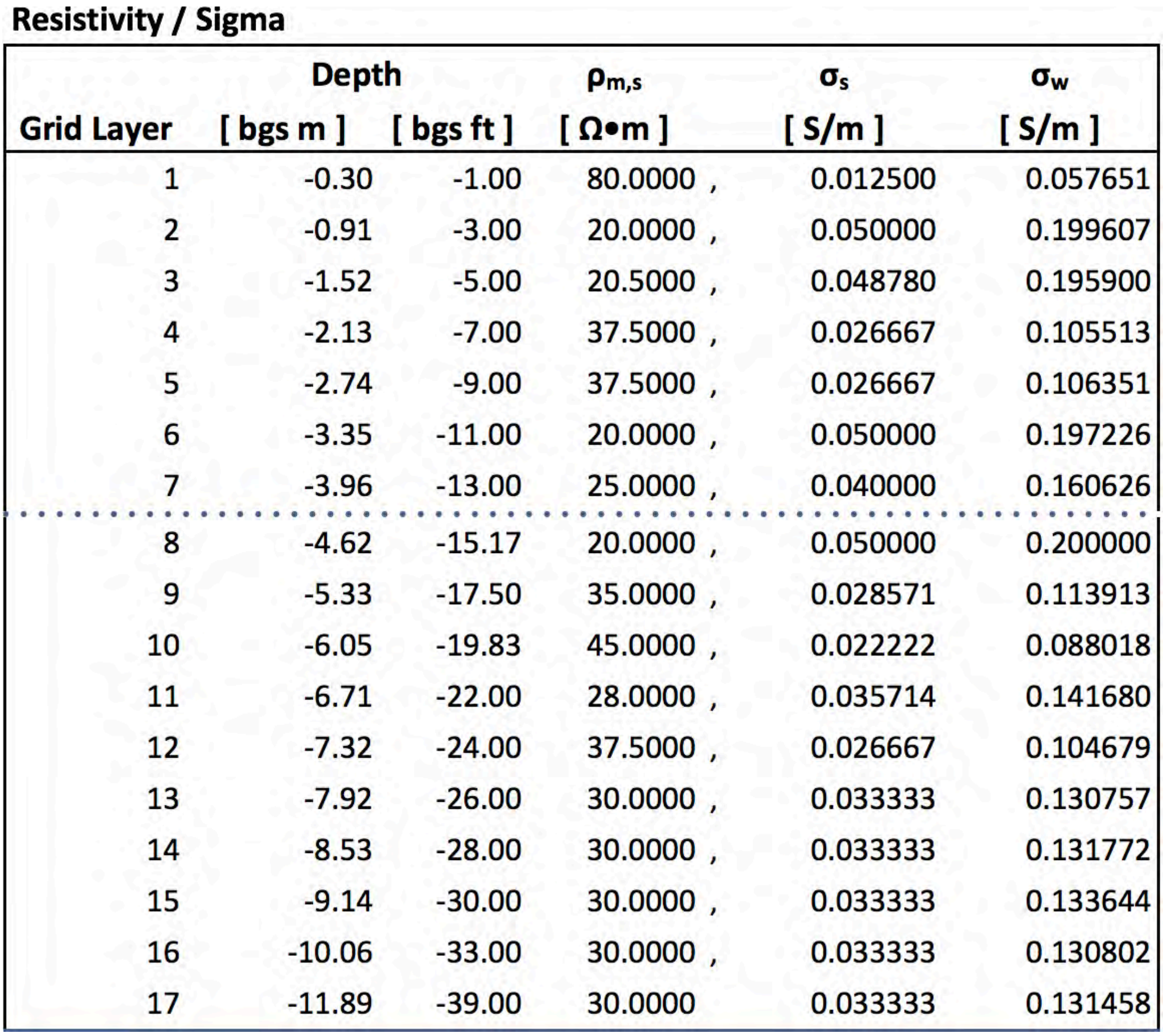


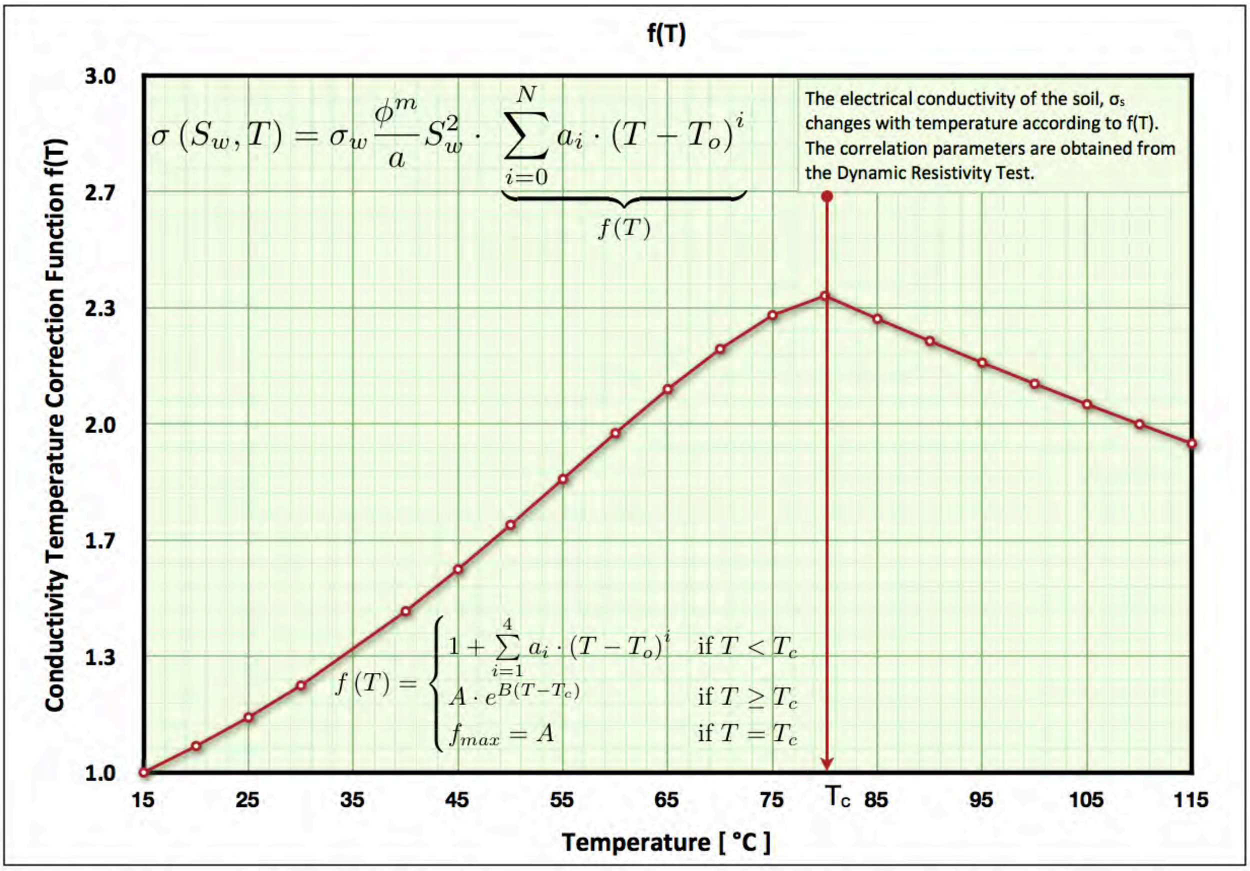
Figure 2.4.: Resistivity profile plot for the site.



Resistivity / Sigma

	Depth		$\rho_{m,s}$	σ_s	σ_w
Grid Layer	[bgs m]	[bgs ft]	[Ω•m]	[S/m]	[S/m]
1	-0.30	-1.00	80.0000 ,	0.012500	0.057651
2	-0.91	-3.00	20.0000 ,	0.050000	0.199607
3	-1.52	-5.00	20.5000 ,	0.048780	0.195900
4	-2.13	-7.00	37.5000 ,	0.026667	0.105513
5	-2.74	-9.00	37.5000 ,	0.026667	0.106351
6	-3.35	-11.00	20.0000 ,	0.050000	0.197226
7	-3.96	-13.00	25.0000 ,	0.040000	0.160626
8	-4.62	-15.17	20.0000 ,	0.050000	0.200000
9	-5.33	-17.50	35.0000 ,	0.028571	0.113913
10	-6.05	-19.83	45.0000 ,	0.022222	0.088018
11	-6.71	-22.00	28.0000 ,	0.035714	0.141680
12	-7.32	-24.00	37.5000 ,	0.026667	0.104679
13	-7.92	-26.00	30.0000 ,	0.033333	0.130757
14	-8.53	-28.00	30.0000 ,	0.033333	0.131772
15	-9.14	-30.00	30.0000 ,	0.033333	0.133644
16	-10.06	-33.00	30.0000 ,	0.033333	0.130802
17	-11.89	-39.00	30.0000	0.033333	0.131458

Figure 2.5.: Resistivity profile data for the site.



Resistivity Temperature Coefficients Below Tc

T_0	$a_{i=0}$	$a_{i=1}$	$a_{i=2}$	$a_{i=3}$	$a_{i=4}$
15.00	1.00	0.014603	0.000078251	0.00000477856	-0.00000006777

Resistivity Temperature Coefficients Above Tc

T_C	A	B
80.00	2.3673000	-0.0056352

Figure 2.6.: Dynamic resistivity as a function of temperature.

2.2.4. Hydraulic Conductivity

Hydraulic conductivity, (K) is a property of the soil or rock that is a measure of the ease with which a fluid (water in this case) can move through the pore space. It depends on the intrinsic permeability of the material and on the degree of saturation. For this study values of saturated hydraulic conductivity, which describes water movement through saturated media, are provided from CH2M Hill. The hydraulic conductivity in the upper interval unit is assumed to be 6.2^{-5} cm/ sec, while the value in the silty clay interval is 2.9×10^{-8} cm/ sec based on CH2M Hill geotechnical tests.

Typical values for the hydraulic conductivity (in cm/s) for different soil types are summarized in Table 2.1[5]. The permeability can vary over several orders of magnitude for a particular soil type. Darcy's law is used to convert the units of hydraulic conductivity to permeability units for input into the numerical simulation program (see details in Appendix D). For water, to convert from 1 cm/s to Darcys multiply by 1,034. For example, from Table 2.1 clean sand has a hydraulic conductivity to water of 10^{-4} cm/s, which is equivalent to 0.1034 D or 103.4 mD (input units for the numerical model). The resulting permeability estimates used in this study are in the range of typical values as shown in Table 2.1.

When very large or small permeabilities are input into the numerical model, simulation calculations can become problematic to compute. In order to improve the efficiency and stability of the numerical model and to provide conservative engineering design, the permeabilities were increased for the silty clay interval but still in the range of values typically used for the lithology type. This change in input values renders the simulation problem tractable from a computational standpoint while still giving realistic results.

The hydraulic conductivity profile in the model was estimated to range from 3.46 mD to 4,040.63 mD as summarized in Table 2.2.

The treatment soil, consisting primarily of clayey till, for the most part is assumed to be homogeneous. The higher permeability is associated with the fine-grained sand in the unconfined groundwater unit.

Hydraulic Conductivity	
Material	K [cm/s]
Gravel	10^{-1} to 10^{2}
Clean sand	10^{-4} to 10^{0}
Silty sand	10^{-5} to 10^{-1}
Silt	10^{-7} to 10^{-3}
Glacial till	10^{-10} to 10^{-4}
Clay	10^{-10} to 10^{-6}
Limestone	10^{-7} to 10^{0}
Fractured basalt	10^{-5} to 10^{0}
Sandstone	10^{-8} to 10^{-3}
Igneous rock	10^{-11} to 10^{-2}
Shale	10^{-14} to 10^{-8}

Table 2.1.: Typical Values of Hydraulic Conductivity.

Permeabilty [mD]				
Layer	Depth [m]	k_x	k_y	k_z
1	0.30	4,040	4,040	808
2	0.91	67	67	13
3	1.52	68	68	13
4	2.13	68	68	13
5	2.74	67	67	13
6	3.35	67	67	13
7	3.96	68	68	13
8	4.62	33	33	6
9	5.33	34	34	6
10	6.05	33	33	6
11	6.71	33	33	6
12	7.32	33	33	6
13	7.92	35	35	7
14	8.53	33	33	6
15	9.14	33	33	6
16	10.06	36	36	7
17	11.89	3	3	0
	Average	279	279	55
	Maximum	4,040	4,040	4,040
	Minimum	3	3	3

Table 2.2.: Input permeability, k_x, k_y, and k_z data.

2.2.5. Saturation, Porosity, and σ

It is convenient to discuss these three data input sets (saturation, S_w porosity, ϕ and σ) in one section since they are interrelated in accordance with Equation 2.3, the equation we use for modelling the electrical conductivity of the soil. The values of the data were obtained by experimental modelling of similar site soil samples at the McMillan-McGee electro-thermal laboratory and confirmed with information provided by CH2M Hill.

$$\sigma_s\left(S_w, T\right) = \underbrace{\sigma_w \frac{\phi^m}{a} S_w^2}_{Salinity\,Effects} \cdot \underbrace{\sum_{i=0}^{N} a_i \cdot \left(T - T_o\right)^i}_{Temperature\,Effects} \tag{2.3}$$

The pore space compressibility C_p is 1.1500 10^-6 /kPa and is estimated from Van der Knaap's correlation $C_p = \frac{A}{\phi}$. The reference pressure, P_{ref}, and temperature, T_{ref} for calculating the porosity are 101 kPa and 20 °C respectively (typically, initial pressure and temperature are used for the reference values). A positive and typical value, 0.0005 1 /°C is used for the pore space thermal expansion, E that causes the porosity to decrease with temperature. The porosity is calculated using Equation 2.4. The base porosity on average is 0.33.

$$\phi \simeq \frac{1 + C_p \cdot (P - P_i)}{1 + E \cdot (T - T_i)} \tag{2.4}$$

In Equation 2.4 P_i and T_i are the initial pressure and temperature. As the temperature increases the porosity of the soil changes at a thermal expansion rate defined by E. As the temperature of the liquids filling the pore space increase they will tend to expand in accordance with E_t, the coefficient of thermal expansion of the liquid (water). As the pressure increases, the liquid will compress in accordance with C_p. Our experience has been that the change in porosity with temperature and pressure has resulted in a dramatic increase in the permeability of the soil, especially if that soil is a clay. Figure 2.7 shows how the texture of the clay changes during thermal treatment. It is obvious from the figure that the permeability increases, partly as a result of thermal expansion.

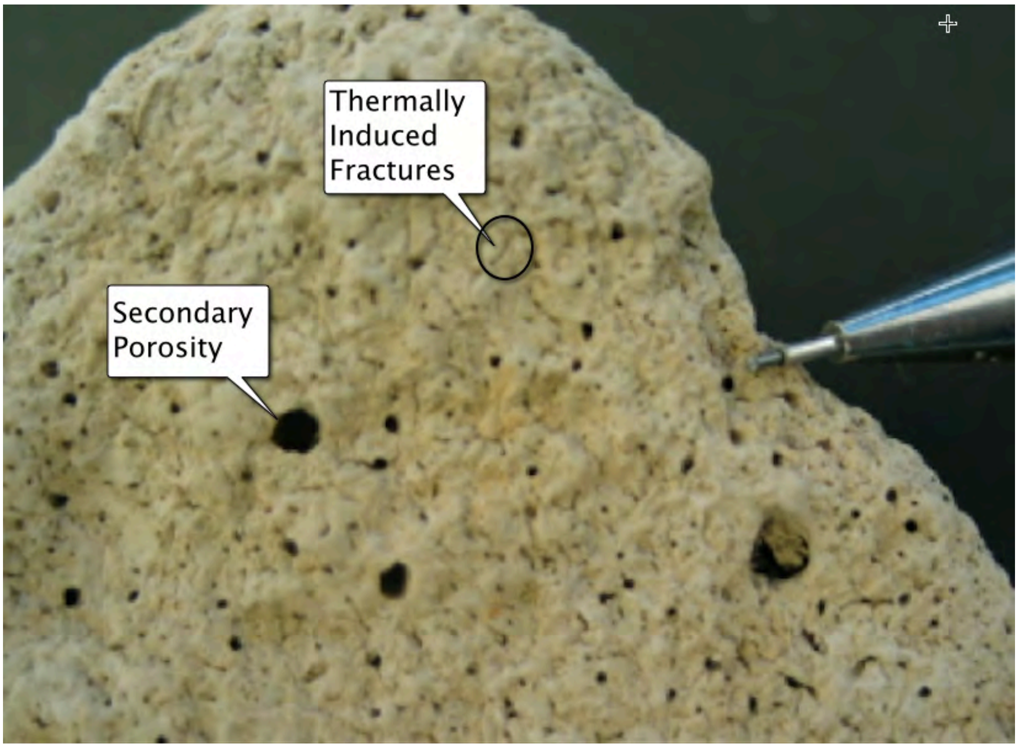


Figure 2.7.: Clay removed from a project post heating.

2.2.6. Thermal Properties

Component Properties

The properties for the chemicals, water, soil (rock), and gas phases are obtained from the public domain. The *base* physical and thermal property data are summarized in Table 2.3. The density of the liquids and solids change as a function of pressure and temperature, which are accounted for in the model.

Physical Properties

Saturation Input Data		
Chemical	S_c	S_c < 0.000448, $\hat{S}_o = 0.00$
Water	S_w	$\hat{S}_w = 1.00$
Compressibility Input Data $[kPa^{-1}]$		
Chemical	cp_c	$4.63 \cdot 10^{-7}$
Water	cp_w	$4.64 \cdot 10^{-7}$
Rock	cp_r	$1.15 \cdot 10^{-6}$
Coefficient of Thermal Expansion $[^\circ C^{-1}]$		
Chemical	ct_c	$7.85 \cdot 10^{-4}$
Water	ct_w	$2.66 \cdot 10^{-4}$
Rock	ct_r	$5.00 \cdot 10^{-4}$
Specific Heat Input Data $[kJ/(kg\ ^\circ C)]$		
Chemical	C_c	0.837
Water	C_w	4.180
Rock	C_r	2.430
Thermal Conductivity Input Data $[W/(m\ ^\circ C)]$		
Chemical	λ_c	0.21
Water	λ_w	0.79
Rock	λ_r	2.56
Overburden	λ_{ob}	2.56
Underburden	λ_{ub}	2.56

Table 2.3.: Fluid and thermal data for the model.

A semi-analytic heat loss model is attached to the sides of the grid to eliminate grid blocks that may otherwise be needed to model the heat losses outside the heated volume. Table 2.4 summarizes the input data used to determine the heat losses. It is noted that a low value for thermal conductivity is used on the ground surface to account for a surface cap with an R-Value of between 4 and 5.

Thermal Conductivity

Temperature, saturation, and dry density are parameters that determine the thermal conductivity of soils. An increase in any of these parameters will result in an increase in thermal conductivity of the soil, with temperature having the least influence of the three [9] and saturation having the most significant impact.

Several correlations for predicting the thermal conductivity of soils are available in the literature. The correlations are generally developed for five soil types; gravels, sands, silts, clays, and peats. These soil types correspond to those used in the Unified Soil Classification System (USCS)[2].

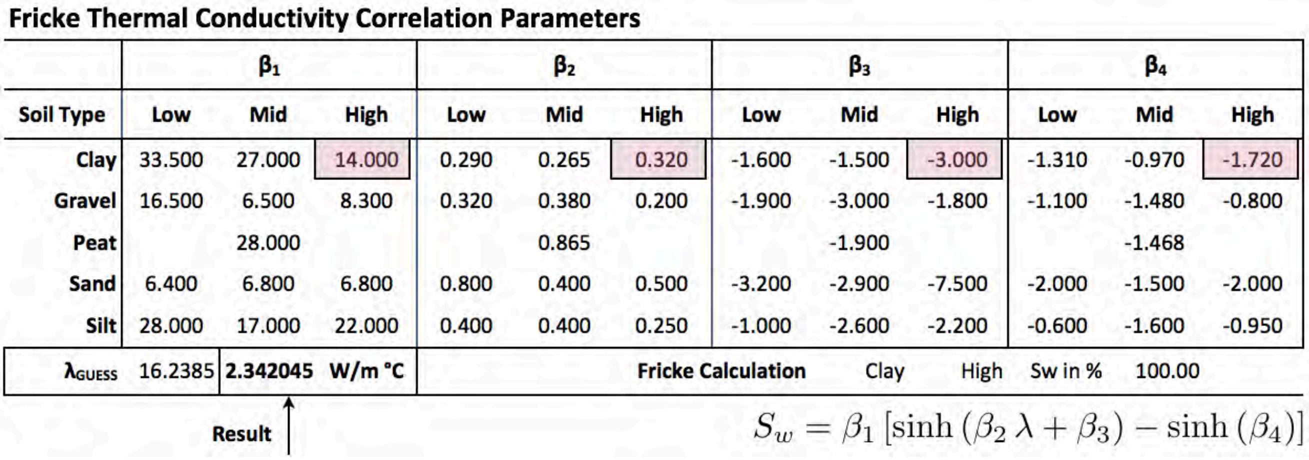
A unified approach has been developed by Fricke et. al. [6] for estimating the thermal conductivity for different soil types at different water saturations. The water saturation implicitly accounts for the density of the soil as indicated in Equation 2.5. The Fricke approach is used here to estimate the thermal conductivity of the various lithologies in the subsurface. The calculations are summarized in Figures 2.8 and Figures 2.9 respectively. Using the Fricke method and correlations, the input data for thermal conductivity are summarized in Figure 2.10.

$$S_w = \frac{\rho_d \, w}{\rho_w \left[1 - \dfrac{\rho_d}{\rho_S}\right]} \tag{2.5}$$

The dry density is $\rho_d = \dfrac{M_S}{V_T}$ and the solid density is $\rho_S = \dfrac{M_S}{V_S}$, where M_S is the mass of solid soil particles, V_S is the volume of the solid particles (no porosity), and V_T is the total volume (with porosity).

The model developed by Fricke et. al. to describe the behaviour of changing thermal conductivity as a function of moisture content is as follows:

$$S_w = \beta_1 \left[\sinh\left(\beta_2\,\lambda + \beta_3\right) - \sinh\left(\beta_4\right)\right] \tag{2.6}$$



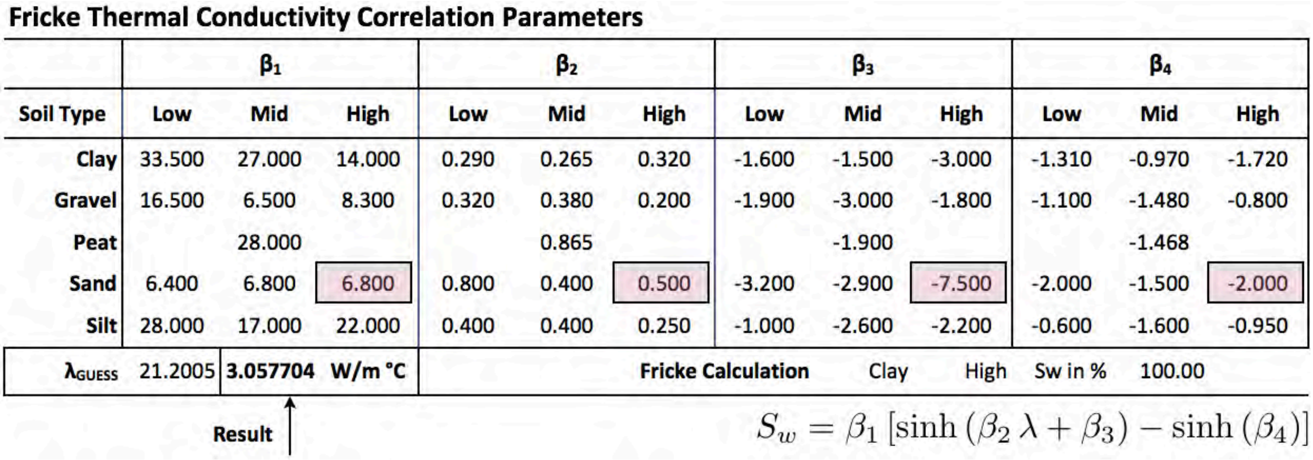
Fricke Thermal Conductivity Correlation Parameters

	β_1			β_2			β_3			β_4		
Soil Type	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**
Clay	33.500	27.000	14.000	0.290	0.265	0.320	-1.600	-1.500	-3.000	-1.310	-0.970	-1.720
Gravel	16.500	6.500	8.300	0.320	0.380	0.200	-1.900	-3.000	-1.800	-1.100	-1.480	-0.800
Peat		28.000			0.865			-1.900			-1.468	
Sand	6.400	6.800	6.800	0.800	0.400	0.500	-3.200	-2.900	-7.500	-2.000	-1.500	-2.000
Silt	28.000	17.000	22.000	0.400	0.400	0.250	-1.000	-2.600	-2.200	-0.600	-1.600	-0.950
λ_{GUESS}	16.2385	**2.342045**	**W/m °C**			**Fricke Calculation**		Clay	High	Sw in %	100.00	

Result

$$S_w = \beta_1 \left[\sinh\left(\beta_2\,\lambda + \beta_3\right) - \sinh\left(\beta_4\right)\right]$$

Figure 2.8.: Fricke et. al. correlation is used to determine the thermal conductivity of the clay. The *high* correlation parameters are used based on the work of Farouki [4] shown in Figure 9 of the reference.



Fricke Thermal Conductivity Correlation Parameters

	β_1			β_2			β_3			β_4		
Soil Type	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**	**Low**	**Mid**	**High**
Clay	33.500	27.000	14.000	0.290	0.265	0.320	-1.600	-1.500	-3.000	-1.310	-0.970	-1.720
Gravel	16.500	6.500	8.300	0.320	0.380	0.200	-1.900	-3.000	-1.800	-1.100	-1.480	-0.800
Peat		28.000			0.865			-1.900			-1.468	
Sand	6.400	6.800	6.800	0.800	0.400	0.500	-3.200	-2.900	-7.500	-2.000	-1.500	-2.000
Silt	28.000	17.000	22.000	0.400	0.400	0.250	-1.000	-2.600	-2.200	-0.600	-1.600	-0.950
λ_{GUESS}	21.2005	**3.057704**	**W/m °C**			**Fricke Calculation**		Clay	High	Sw in %	100.00	

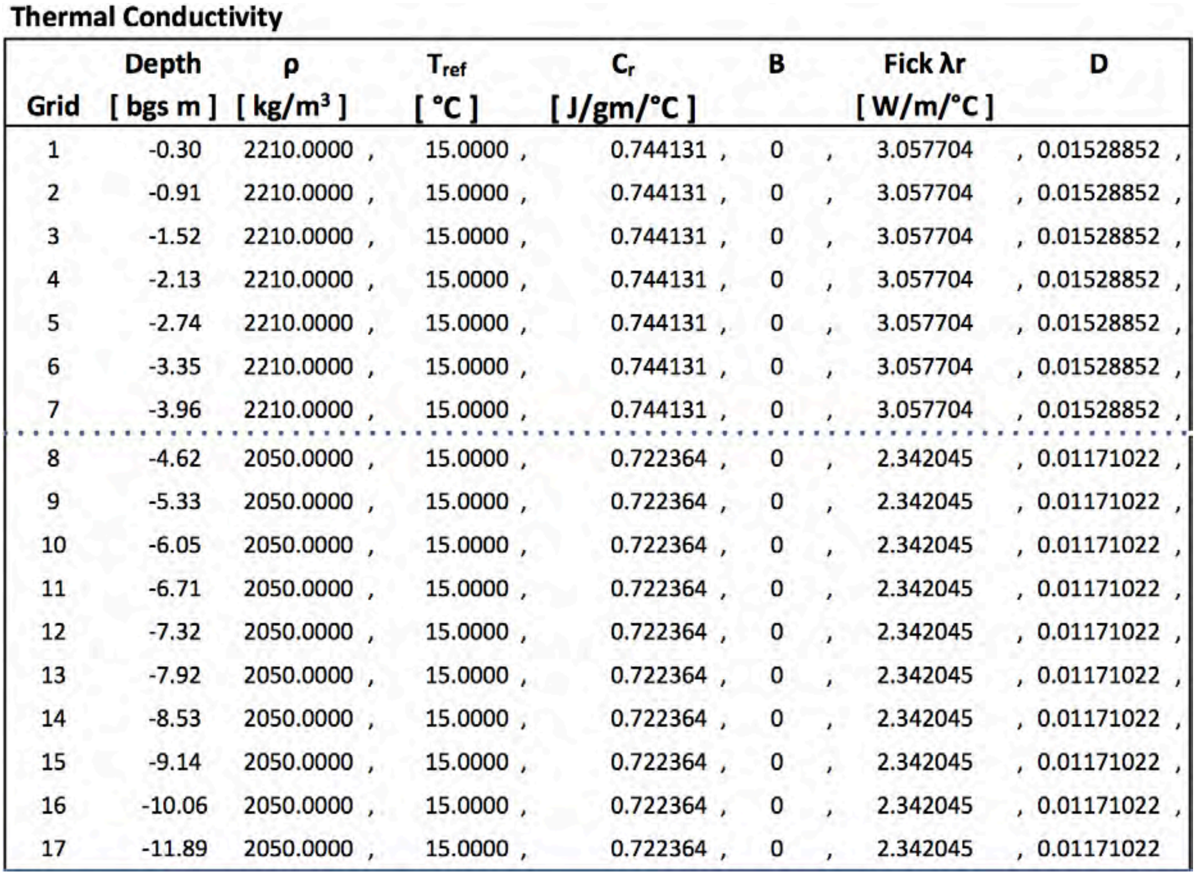
Result

$$S_w = \beta_1 \left[\sinh\left(\beta_2\,\lambda + \beta_3\right) - \sinh\left(\beta_4\right)\right]$$

Figure 2.9.: Fricke et. al. correlation to determine thermal conductivity of the sand.

Saturation is a measure of the moisture contained within the pore space of the soil and dry density is the mass per unit volume with the pore space void of moisture.

Table 2.6 summarizes the typical values of thermal conductivity.



Thermal Conductivity

Grid	Depth [bgs m]	ρ [kg/m³]	T_{ref} [°C]	C_r [J/gm/°C]	B	Fick λr [W/m/°C]	D
1	-0.30	2210.0000 ,	15.0000 ,	0.744131 ,	0 ,	3.057704	, 0.01528852 ,
2	-0.91	2210.0000 ,	15.0000 ,	0.744131 ,	0 ,	3.057704	, 0.01528852 ,
3	-1.52	2210.0000 ,	15.0000 ,	0.744131 ,	0 ,	3.057704	, 0.01528852 ,
4	-2.13	2210.0000 ,	15.0000 ,	0.744131 ,	0 ,	3.057704	, 0.01528852 ,
5	-2.74	2210.0000 ,	15.0000 ,	0.744131 ,	0 ,	3.057704	, 0.01528852 ,
6	-3.35	2210.0000 ,	15.0000 ,	0.744131 ,	0 ,	3.057704	, 0.01528852 ,
7	-3.96	2210.0000 ,	15.0000 ,	0.744131 ,	0 ,	3.057704	, 0.01528852 ,
8	-4.62	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
9	-5.33	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
10	-6.05	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
11	-6.71	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
12	-7.32	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
13	-7.92	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
14	-8.53	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
15	-9.14	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
16	-10.06	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022 ,
17	-11.89	2050.0000 ,	15.0000 ,	0.722364 ,	0 ,	2.342045	, 0.01171022

Figure 2.10.: Thermal properties by layer.

Table 2.6.: Base Case Thermal Conductivity.

Component	Symbol	Thermal Conductivity $\frac{W}{m^\circ C}$
Oil	λ_o	.13889
Water	λ_w	.67083
Rock	λ_r	7.40000
Steel Pipe	λ_q	50.00000
Fluid	λ_f	.27188
Reservoir	λ_r	2.04100

Table 2.4.: Thermal properties for the heat loss model.

Direction	ΔT_t °C	λ W/m/°C	ρc J/cm^3°C	T_i °C
-3	2.00	33.00	4.50	20.00
+3	2.00	153.00	4.50	20.00
-2	2.00	153.00	4.50	20.00
+2	2.00	153.00	4.50	20.00
-1	2.00	153.00	4.50	20.00
+1	2.00	153.00	4.50	20.00

Table 2.5.: Fricke Mid-Value Correlation Coefficients.

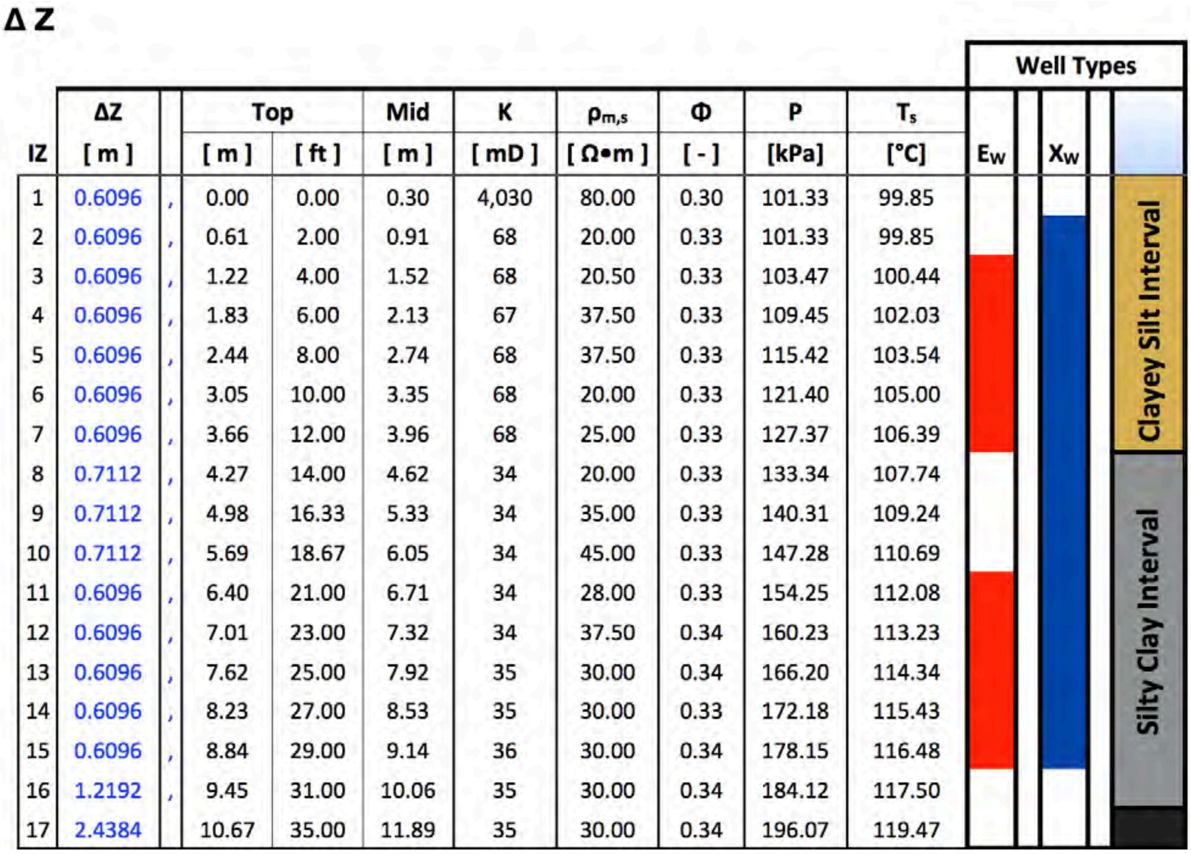
Soil Type	β_1	β_2	β_3	β_4
Clay	27.0	0.27	-1.5	-0.97
Gravel	6.5	0.38	-3.0	-1.48
Peat	28.0	0.86	-1.9	-1.47
Sand	6.8	0.40	-2.9	-1.55
Silt	17.0	0.40	-2.6	-1.61

2.2.7. Well Layout and Grid

The treatment area is shown in Figure 3.1. The grid is designed so that electrodes and extraction wells are located to ensure complete vertical heating of the treatment volumes in accordance with the remediation objectives. This is considered a large simulation study with 43 grid blocks in the x direction, 31 grid blocks in the y direction, and 17 grid blocks in the z direction, for a total of 22,661 grid blocks.

Figure 2.11 shows the *base* vertical grid profile used in the simulation study along with values for porosity, permeability, and estimated steam saturation temperature based on the hydrostatic subsurface pressure below the water table.

Figure 2.12, shows the location of the 44 electrodes and 15 extraction wells in alignment with the simulation grid for the thermal treatment volume of the simulation study.



Δ Z

	ΔZ		Top		Mid	K	$\rho_{m,s}$	Φ	P	T_s	Well Types		
IZ	[m]		[m]	[ft]	[m]	[mD]	[Ω•m]	[-]	[kPa]	[°C]	Ew	Xw	
1	0.6096	,	0.00	0.00	0.30	4,030	80.00	0.30	101.33	99.85			Clayey Silt Interval
2	0.6096	,	0.61	2.00	0.91	68	20.00	0.33	101.33	99.85		🟦	
3	0.6096	,	1.22	4.00	1.52	68	20.50	0.33	103.47	100.44	🟥	🟦	
4	0.6096	,	1.83	6.00	2.13	67	37.50	0.33	109.45	102.03	🟥	🟦	
5	0.6096	,	2.44	8.00	2.74	68	37.50	0.33	115.42	103.54	🟥	🟦	
6	0.6096	,	3.05	10.00	3.35	68	20.00	0.33	121.40	105.00	🟥	🟦	
7	0.6096	,	3.66	12.00	3.96	68	25.00	0.33	127.37	106.39	🟥	🟦	
8	0.7112	,	4.27	14.00	4.62	34	20.00	0.33	133.34	107.74		🟦	Silty Clay Interval
9	0.7112	,	4.98	16.33	5.33	34	35.00	0.33	140.31	109.24		🟦	
10	0.7112	,	5.69	18.67	6.05	34	45.00	0.33	147.28	110.69		🟦	
11	0.6096	,	6.40	21.00	6.71	34	28.00	0.33	154.25	112.08	🟥	🟦	
12	0.6096	,	7.01	23.00	7.32	34	37.50	0.34	160.23	113.23	🟥	🟦	
13	0.6096	,	7.62	25.00	7.92	35	30.00	0.34	166.20	114.34	🟥	🟦	
14	0.6096	,	8.23	27.00	8.53	35	30.00	0.33	172.18	115.43	🟥	🟦	
15	0.6096	,	8.84	29.00	9.14	36	30.00	0.34	178.15	116.48	🟥	🟦	
16	1.2192	,	9.45	31.00	10.06	35	30.00	0.34	184.12	117.50			
17	2.4384		10.67	35.00	11.89	35	30.00	0.34	196.07	119.47			⬛

Figure 2.11.: *Base* vertical grid with distribution of physical properties.

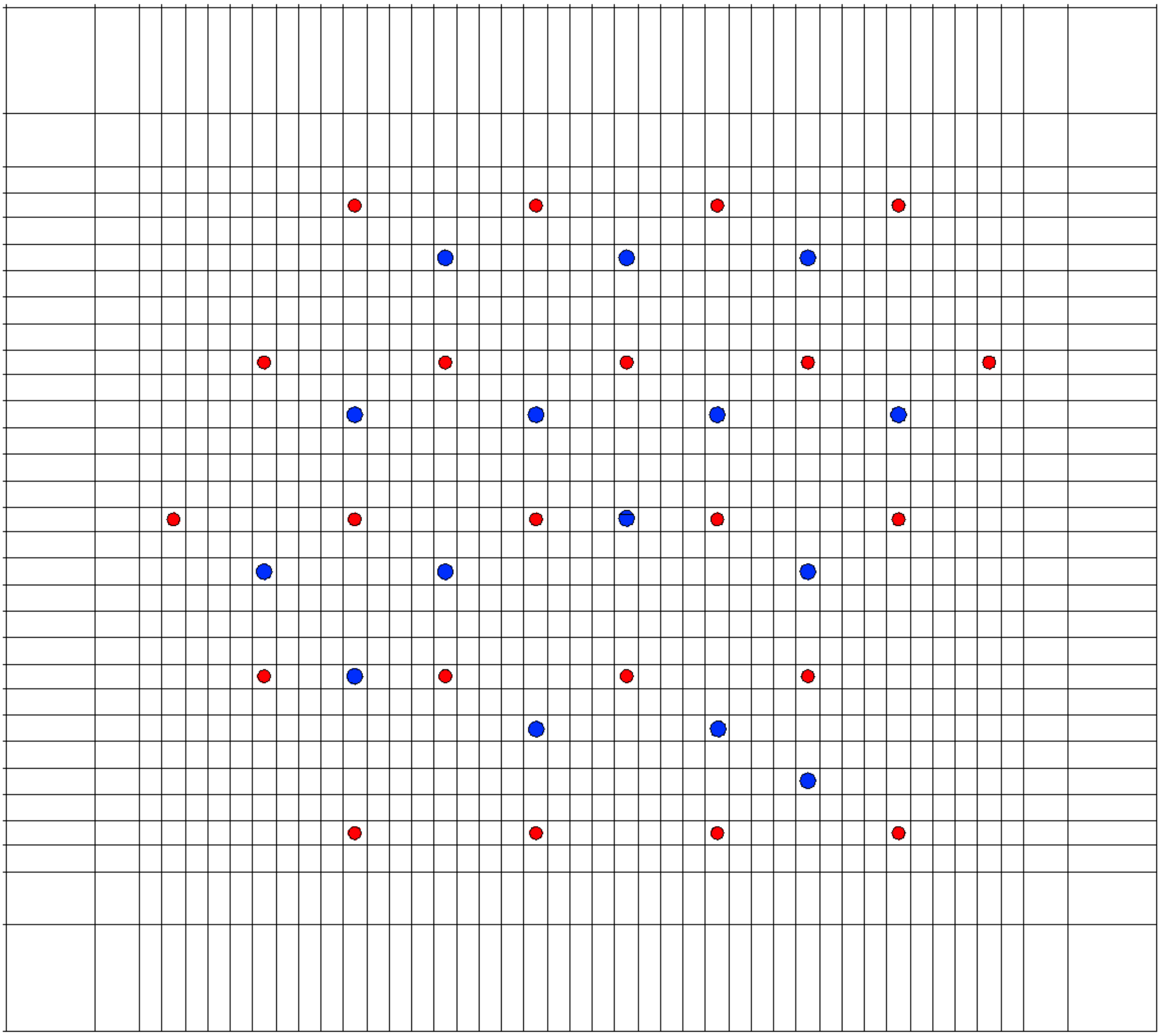


Figure 2.12.: Electrode and extraction well simulation grid layout in 2D.

3

Results

This section presents the results of the study for the simulation area as shown in Figure 3.1. Uniform peak temperatures throughout the treatment volume can be reached in approximately 52 to 57 days of thermal operations (assuming 100% operational uptime). Although target temperatures will be achieved in this time frame, the simulation study along with previous experience indicates that approximately 180 day of operations is needed to achieve the cleanup goals.

Table 3.1 is a summary of the project details. It is noted that:

1. The ancillary energy represents the estimated energy used to run the treatment system and other surface facilities. It is an estimate based on experience with other projects this size.

2. A relatively high energy density is needed to achieve target temperatures. This is primarily because of the closely spaced electrodes and aggressive heating strategy. Aggressive heating of the lower electrodes is assumed to ensure rapid development of a *hot floor* at the bottom of the treatment volume.

3. High thermal efficiency and achievement of target temperatures near the surface are primarily because of a thermally insulating surface cap. An R-value for the surface cap of 5.00 $\left[\frac{\mathrm{ft}^2\,{}^\circ F\,\mathrm{hr}}{\mathrm{BTU}}\right]$ is assumed.[1]

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[1] Several R-Values are available at the webpage: `https://en.wikipedia.org/wiki/R-value_(insulation)`.

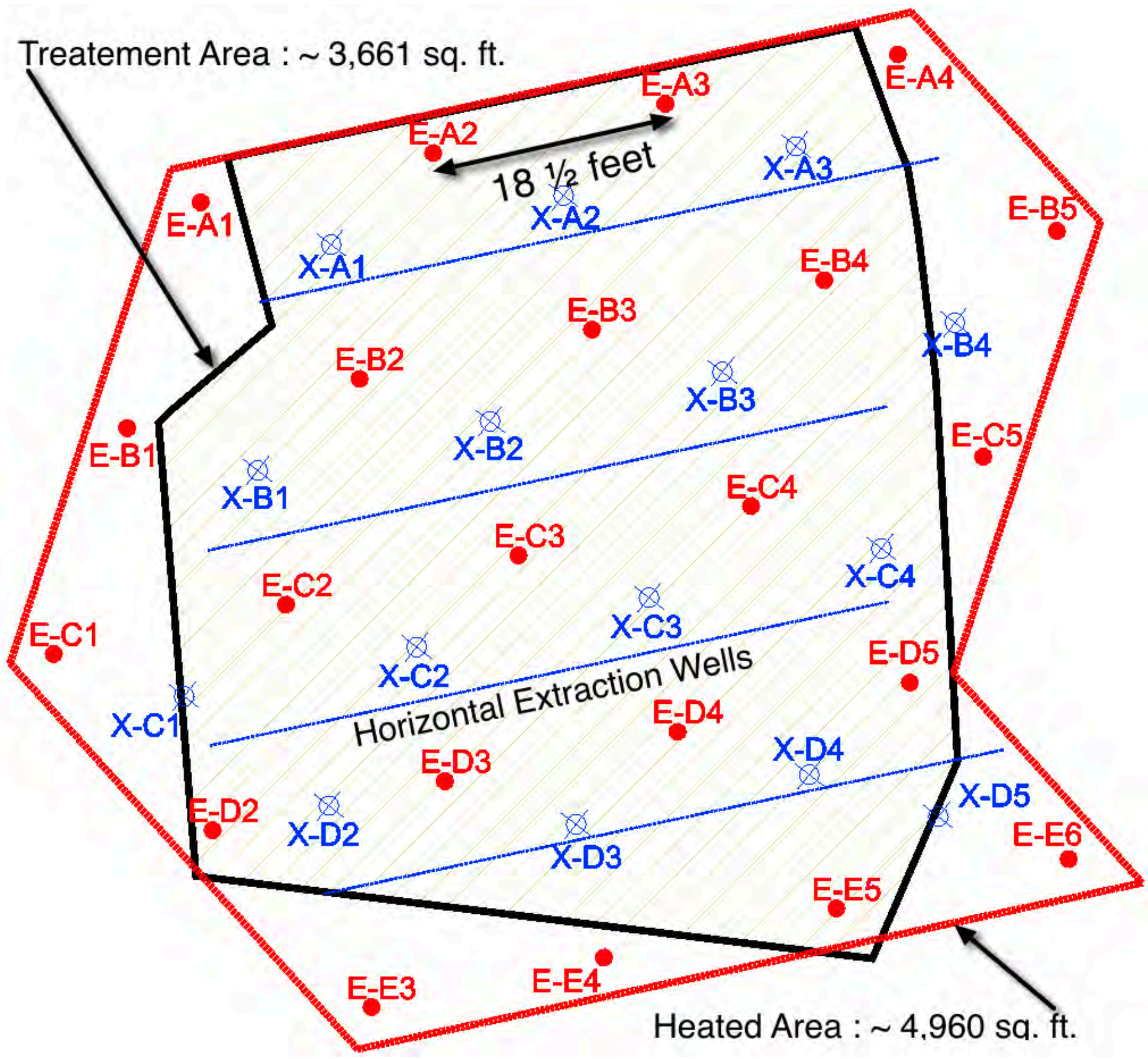


Figure 3.1.: Simulation study area.

4. Maximum temperatures in the soil will reach the boiling temperature of water at depth. In the 3D graphical presentation of the temperature data, the maximum has been limited to about 100 °C to visually identify regions that are heated sufficiently and those that are not.

5. The maximum limit of the applied vacuum is based on the design of the treatment plant. The operating vacuum will need to over come piping pressure drops, varying lengths of screened intervals at the extraction wells, and thermo-dynamic effects. These parameters are not accounted for in this study.

6. The design of the project calls for horizontal extraction wells. The wells are placed near the surface and below the thermal insulating cap. They are not part of this study. However, it is important to maintain hydraulic control during operations, thus the liquid extracted from these wells needs to be included in the water balance calculation.

7. When average values are presented in tables they are not weighted averages unless specified. Any weighted averages are performed on a volumetric basis.

Table 3.2 provided here summarizes the technical approach for the project. The water balance calculations for the project are provided in Figure 3.3 and Table 3.3. Note that the *Recycle Supply* is water supplied from the onsite treatment plant. The energy balance calculations for the project are provided in Figure 3.5. The drilling scope for the entire project are provided in Table 3.4. Figure 3.6 shows a plot of the average power up over the entire site. Figure 3.7 shows a plot of the average temperature ramp up over the entire site.

Project Summary

Item		Comments
Location	Depew	
Treatment Area	340 m^2	
	3,661 ft^2	
Vertical Extent	9.45 m	depth to clay varies
	31.00 ft	
Heated Volume	3,109 m^3	
	4,066 yd^3	
Electrical Energy	1,281 MW·h	ET-DSP™ subsurface
	412 kWh/m^3	includes heat losses
	315 kWh/yd^3	
Ancillary Energy	173 MW·h	
Duration	180 day	
Primary Target Chemical	111-TCA, DPs, VOCs, CVOCs	
Mass Estimate	45 kg	
	100 lbs	
	15 g/m^3	per unit of treatment volume
Target Temperature	100 °C	depth dependent
	212 °F	
Time to Reach Temperature	52 to 57	days
Energy Chemical Ratio	28,248 kWh/kg	
Average Resistivity	32.71 Ωm	average at T_o
Dynamic Resistivity Ratio	2.37	$\frac{\rho_o}{\rho(T_{max})}$

Table 3.1.: Summary of the Depew Project.

Technical Approach

Item		Detail
Electrodes	44	3 m length
Electrode Spacing	5.639 m	± 0.6 m
	18.50 ft	
Electrode Wells	22	
Extraction Wells	15	
Sensor Wells	10	
Average Electrode Well Depth	8.53 m	
	28.00 ft	deep extent
Average Electrode Power	6.74 kW	changes with time
Peak Electrode Power	11.35 kW	$S_f = 1.68$
Total Average Power	297 kW	without ancillary power
Total Peak Power	499 kW	
Water Injection Rate	0.379 L/min	per electrode
	0.100 gal/min	
Water Injection Rate	16.66 L/min	total
	4.40 gal/min	
Water Extraction Rate	1.138 L/min	per extraction Well
	0.301 gal/min	
Water Extraction Rate	17.07 L/min	total
	4.51 gal/min	
XWell Vapour Extraction Rate	9.28 scfm	
Vapour Extraction Rate	139 scfm	
Applied Vacuum (up to)	12 inches Hg	estimate

Table 3.2.: Technical approach and design basis for Depew.

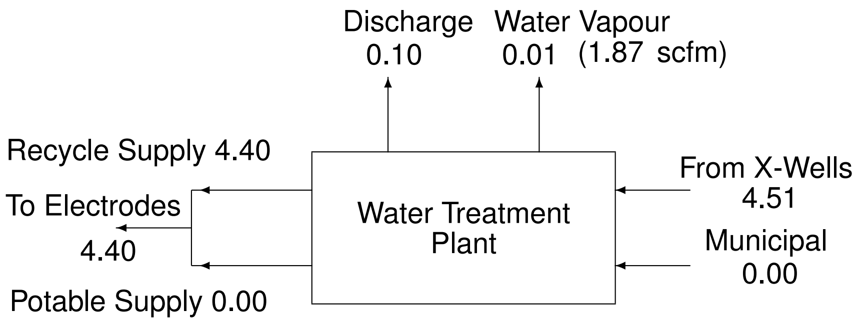


Figure 3.2.: Depew water balance in gpm.

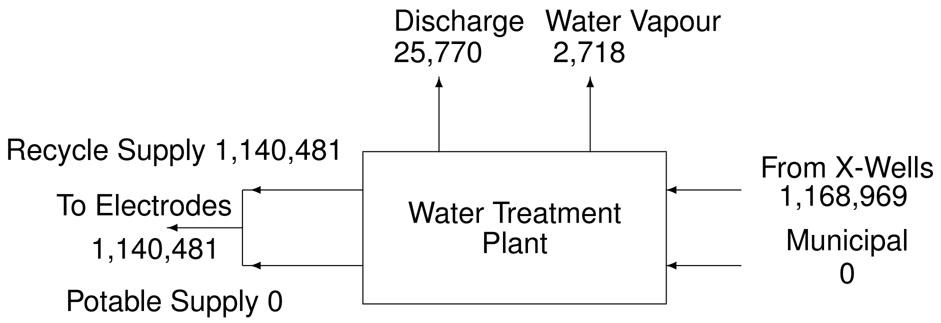
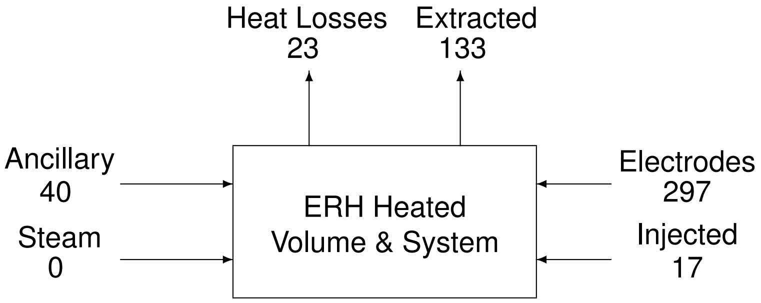


Figure 3.3.: Depew water balance in gallons.

Water Balance

Item	Rate		Volume	
Water Plant Effluent	**L/min**	**gal/min**	**L**	**gal**
Recycle Supply	16.66	4.40	4,317,192	1,140,481
Potable Supply	0.00	0.00	0	0
To Electrodes	16.66	4.40	4,317,192	1,140,481
Discharge to Sewer	0.38	0.10	97,550	25,770
Vapour (CWE)	0.04	0.01	10,288	2,718
Total Effluent	17.07	4.51	4,425,030	1,168,969
Water Plant Influent	**L/min**	**gal/min**	**L**	**gal**
From X-Wells	17.07	4.51	4,425,030	1,168,969
Hydraulic Ratio				$\frac{Q_X}{Q_E} = 1.02$
From Municipal	0.00	0.00	0	0
Total Influent	17.07	4.51	4,425,030	1,168,969

Table 3.3.: Water balance estimates for treatment plant design.



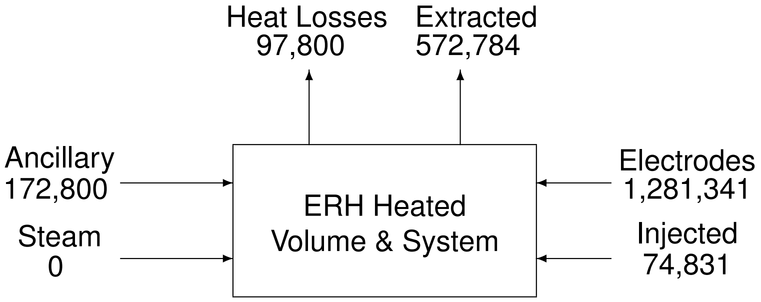
Notes:

① Ancillary power is an estimate.

② Heat loss power is determined on heat leaving the grid providing a conservative estimate for heat losses.

③ Steam is for contingency only.

Figure 3.4.: Depew average power flow in kW.



Notes:

① Injected energy based on water temperature of 20 °C.

② Calculated energy density is 412 kWh/m^3 (315 kWh/yd^3).

③ Fraction of heat loss to electrode energy is 7.63 percent.

Figure 3.5.: Depew energy balance in kWh.

Drilling Scope

Item	Value	Comments
Electrode Boreholes	22	
Total Electrode Drill Depth	199 m	includes overdrill
	652 ft	
Electrode Wellbore Diameter	254 mm	
	10 in	
Electrode Well IDW	10.07 m^3	all wellbore material
	13.17 yd^3	
Extraction Well Boreholes	15	
Total Extraction Well Drill Depth	136 m	includes overdrill
	445 ft	
Extraction Wellbore Diameter	191 mm	
	7.50 in	
Extraction Well IDW	3.86 m^3	all wellbore material
	5.05 yd^3	
Number of Sensor Well Boreholes	10	
Sensor Well Drill Depth	126 m	
	415 ft	
Sensor Wellbore Diameter	0 mm	
	0.00 in	vary by type
Sensor Well IDW	0.00 m^3	
	0.00 yd^3	
Total IDW	**13.93 m^3**	
	18.22 yd^3	

Table 3.4.: Depew drilling scope summary.

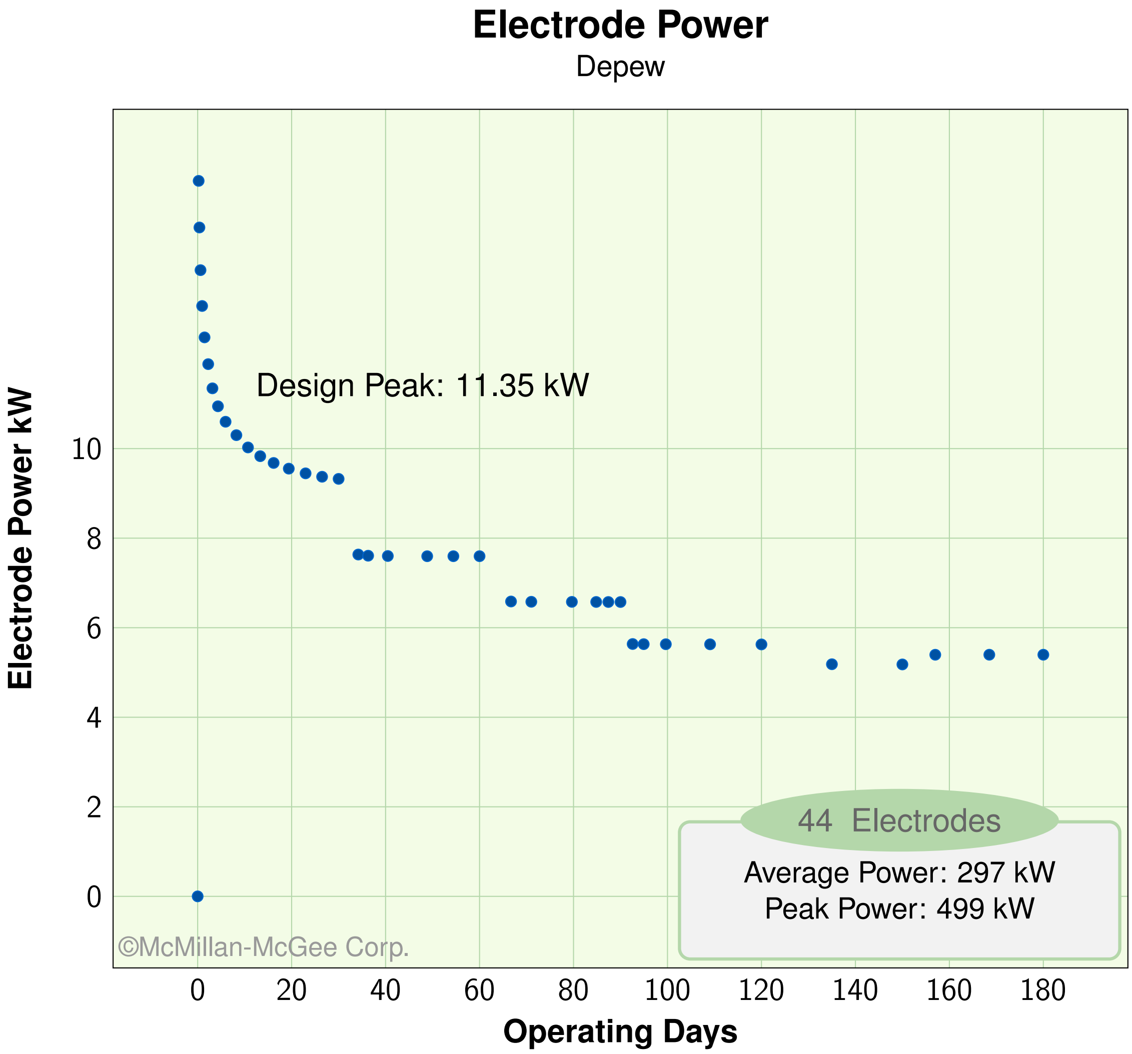


Figure 3.6.: .
] Average electrode input power [kW].

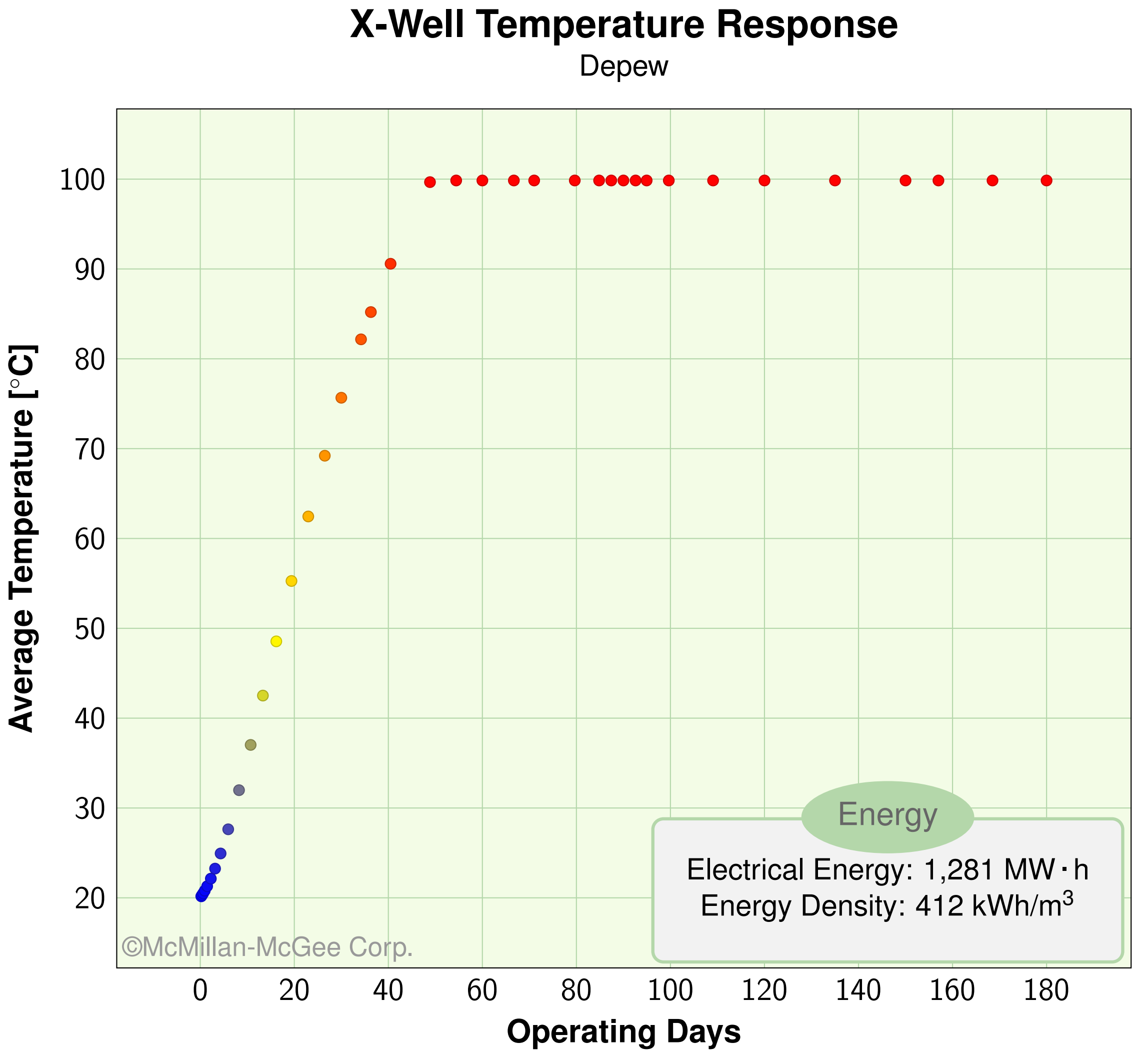


Figure 3.7.: Average temperature response at the extraction wells [°C].

3.1. Results Summary

Installation and operational parameters for individual subsurface components determined for the treatment area from the model are adapted for the contaminants of concern and assume equitable distribution. The estimated mass in place is 45 kg, (100 lbs) and is assumed to be uniformly distributed in the treatment volume (a conservative approach) of 3,109 m^3, (4,066 yd^3). The chemical concentration on a volumetric basis is 15 g/m^3. A more realistic interpretation of the chemical distribution in the soil can be derived from Figure 3.8.

In addition to the treatment objectives, there are several operational performance goals that may include the following:

1. Maintaining system uptime of 95% or more;
2. Attaining a final temperature goal of achieving the boiling point of water in a predetermined percentage of the temperature sensors in the treated volume; and,
3. Reaching CVOC concentration shutdown criteria in the treatment system influent, and verifying that soil and groundwater sample data indicate performance criteria have been met in accordance with the afore-mentioned goals.

The study resulted in the following technical approach for the remediation of Depew in Depew, New York 14043 USA:

1. The project consists of a single operational area. The total treatment area is 340 m^2 in size with an estimated treatment volume of 3,109 m^3 (4,066 yd^3).
2. The estimated electrical energy delivered to the electrodes is 1,281 $MW \cdot h$ resulting in an energy density of 412 kWh/m^3, (315 kWh/yd^3). The electrical energy accounts for heat losses and energy produced with the water. The ancillary energy used for the treatment plant and other electrical facilities is estimated from experience at 173 $MW \cdot h$. Energy balance calculations are provided in Figure 3.5.
3. The time to reach target temperature is between 52 and 57 days. This is based on reaching the target temperature at the extraction wells[2].

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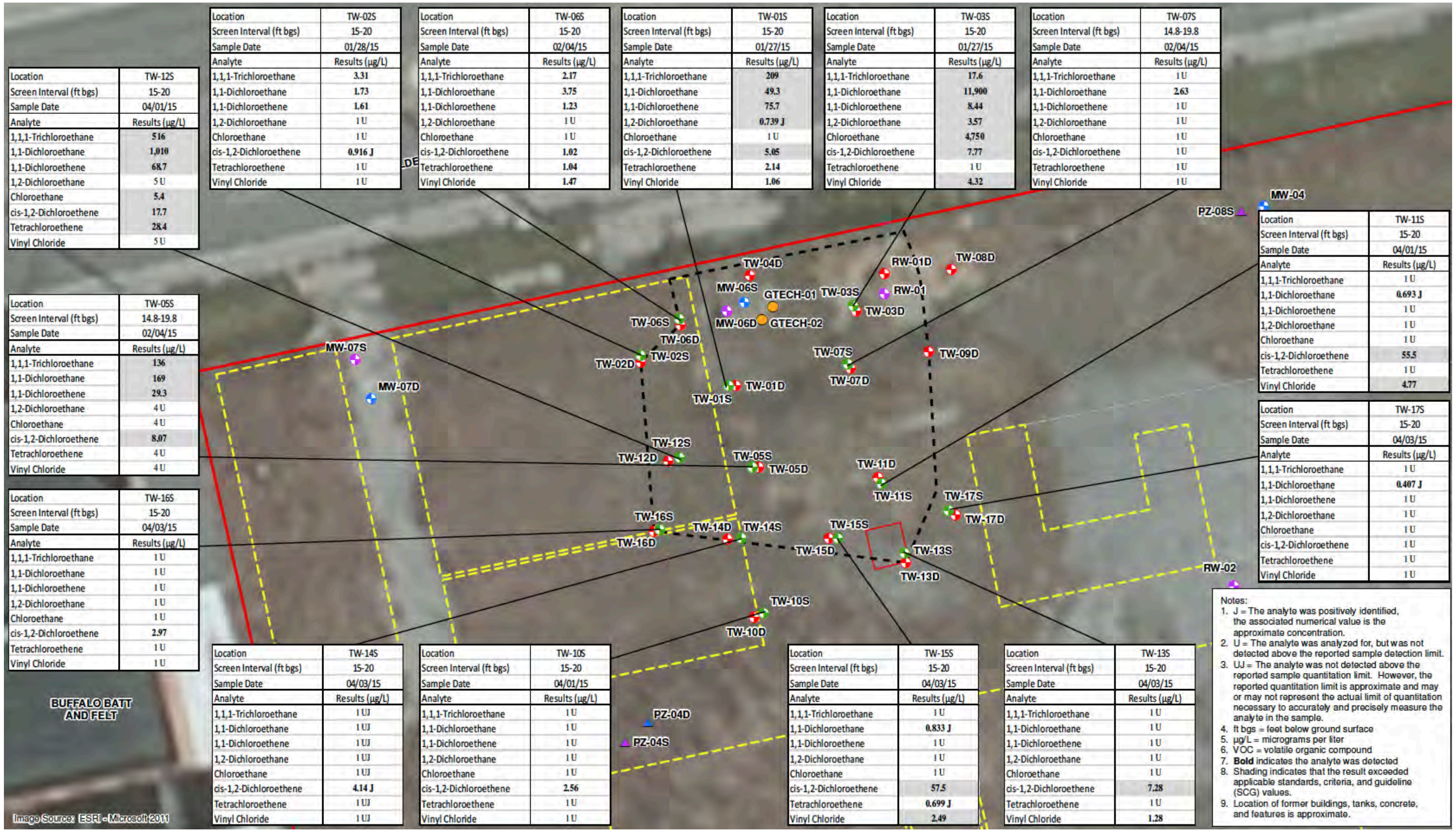
[2] The extraction wells are typically located farthest from the electrodes and therefore these are the last locations to reach target temperature.



Location	TW-12S
Screen Interval (ft bgs)	15-20
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**516**
1,1-Dichloroethane	**1,010**
1,1-Dichloroethene	**68.7**
1,2-Dichloroethane	5 U
Chloroethane	**5.4**
cis-1,2-Dichloroethene	**17.7**
Tetrachloroethene	**28.4**
Vinyl Chloride	5 U

Location	TW-05S
Screen Interval (ft bgs)	14.8-19.8
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**136**
1,1-Dichloroethane	**169**
1,1-Dichloroethene	**29.3**
1,2-Dichloroethane	4 U
Chloroethane	4 U
cis-1,2-Dichloroethene	**8.07**
Tetrachloroethene	4 U
Vinyl Chloride	4 U

Location	TW-16S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**2.97**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-02S
Screen Interval (ft bgs)	15-20
Sample Date	01/28/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**3.31**
1,1-Dichloroethane	**1.73**
1,1-Dichloroethene	**1.61**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**0.916 J**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-06S
Screen Interval (ft bgs)	15-20
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**2.17**
1,1-Dichloroethane	**3.75**
1,1-Dichloroethene	**1.23**
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**1.02**
Tetrachloroethene	**1.04**
Vinyl Chloride	**1.47**

Location	TW-01S
Screen Interval (ft bgs)	15-20
Sample Date	01/27/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**209**
1,1-Dichloroethane	**49.3**
1,1-Dichloroethene	**75.7**
1,2-Dichloroethane	**0.739 J**
Chloroethane	1 U
cis-1,2-Dichloroethene	**5.05**
Tetrachloroethene	**2.14**
Vinyl Chloride	**1.06**

Location	TW-03S
Screen Interval (ft bgs)	15-20
Sample Date	01/27/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	**17.6**
1,1-Dichloroethane	**11,900**
1,1-Dichloroethene	**8.44**
1,2-Dichloroethane	**3.57**
Chloroethane	**4,750**
cis-1,2-Dichloroethene	**7.77**
Tetrachloroethene	1 U
Vinyl Chloride	**4.32**

Location	TW-07S
Screen Interval (ft bgs)	14.8-19.8
Sample Date	02/04/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**2.63**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	1 U
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-11S
Screen Interval (ft bgs)	15-20
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.693 J**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**55.5**
Tetrachloroethene	1 U
Vinyl Chloride	**4.77**

Location	TW-17S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.407 J**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	1 U
Tetrachloroethene	1 U
Vinyl Chloride	1 U

Location	TW-14S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 UJ
1,1-Dichloroethane	1 UJ
1,1-Dichloroethene	1 UJ
1,2-Dichloroethane	1 UJ
Chloroethane	1 UJ
cis-1,2-Dichloroethene	**4.14 J**
Tetrachloroethene	1 UJ
Vinyl Chloride	1 UJ

Location	TW-10S
Screen Interval (ft bgs)	15-20
Sample Date	04/01/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**2.56**
Tetrachloroethene	1 U
Vinyl Chloride	1 U

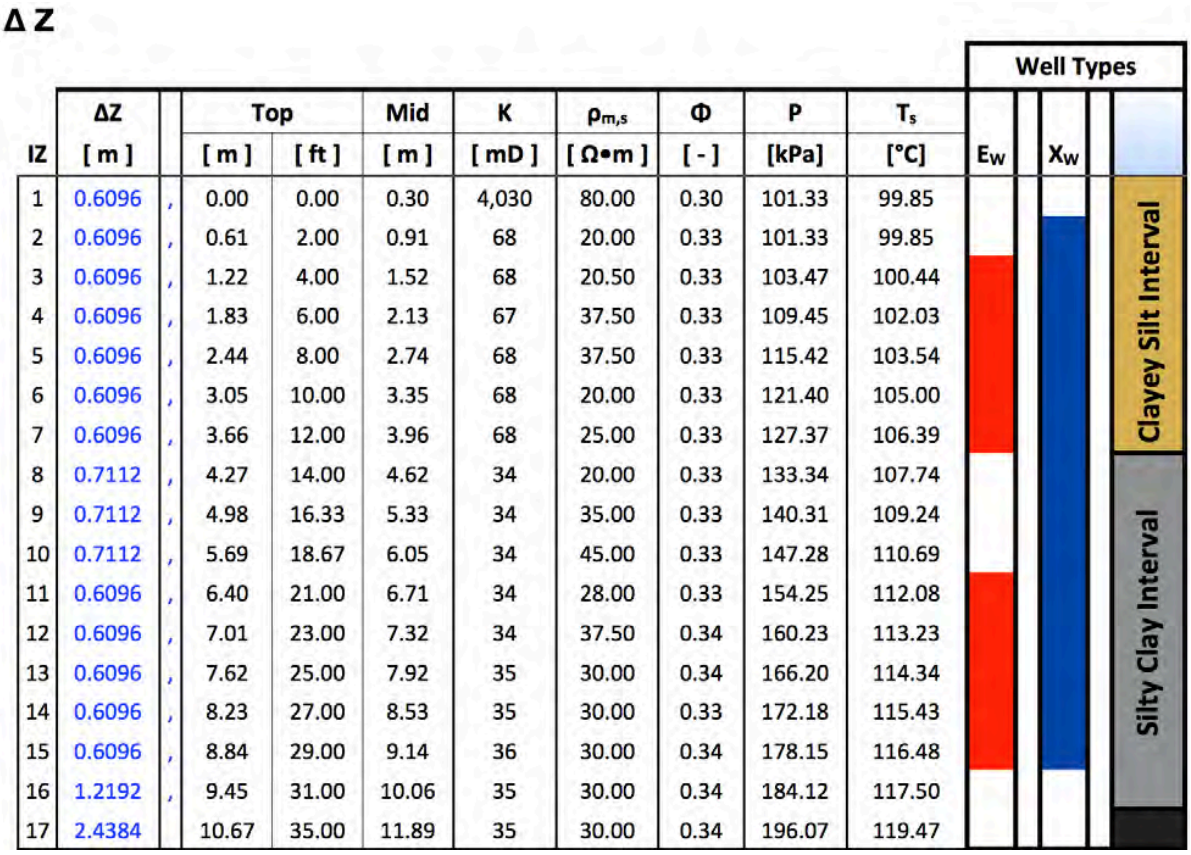
Location	TW-15S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	**0.833 J**
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**57.5**
Tetrachloroethene	**0.699 J**
Vinyl Chloride	**2.49**

Location	TW-13S
Screen Interval (ft bgs)	15-20
Sample Date	04/03/15
Analyte	Results (µg/L)
1,1,1-Trichloroethane	1 U
1,1-Dichloroethane	1 U
1,1-Dichloroethene	1 U
1,2-Dichloroethane	1 U
Chloroethane	1 U
cis-1,2-Dichloroethene	**7.28**
Tetrachloroethene	1 U
Vinyl Chloride	**1.28**

Notes:
1. J = The analyte was positively identified, the associated numerical value is the approximate concentration.
2. U = The analyte was analyzed for, but was not detected above the reported sample detection limit.
3. UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
4. ft bgs = feet below ground surface
5. µg/L = micrograms per liter
6. VOC = volatile organic compound
7. **Bold** indicates the analyte was detected
8. Shading indicates that the result exceeded applicable standards, criteria, and guideline (SCG) values.
9. Location of former buildings, tanks, concrete, and features is approximate.

Figure 3.8.: Chemical distribution.

4. 44 electrodes of constant length and electrode wellbore configuration in 22 boreholes are required to provide thermal remediation of the the impacted area. The electrode wellbore configuration is summarized in Figure 3.9. Electrode wells are completed with more than one electrode. For the Depew project, two electrodes are installed in each of the E-Wells.



ΔZ

	ΔZ		Top		Mid	K	$\rho_{m,s}$	Φ	P	T_s	Well Types		
IZ	[m]		[m]	[ft]	[m]	[mD]	[Ω•m]	[-]	[kPa]	[°C]	E_W	X_W	
1	0.6096	,	0.00	0.00	0.30	4,030	80.00	0.30	101.33	99.85			Clayey Silt Interval
2	0.6096	,	0.61	2.00	0.91	68	20.00	0.33	101.33	99.85		🟦	
3	0.6096	,	1.22	4.00	1.52	68	20.50	0.33	103.47	100.44	🟥	🟦	
4	0.6096	,	1.83	6.00	2.13	67	37.50	0.33	109.45	102.03	🟥	🟦	
5	0.6096	,	2.44	8.00	2.74	68	37.50	0.33	115.42	103.54	🟥	🟦	
6	0.6096	,	3.05	10.00	3.35	68	20.00	0.33	121.40	105.00	🟥	🟦	
7	0.6096	,	3.66	12.00	3.96	68	25.00	0.33	127.37	106.39	🟥	🟦	
8	0.7112	,	4.27	14.00	4.62	34	20.00	0.33	133.34	107.74		🟦	Silty Clay Interval
9	0.7112	,	4.98	16.33	5.33	34	35.00	0.33	140.31	109.24		🟦	
10	0.7112	,	5.69	18.67	6.05	34	45.00	0.33	147.28	110.69		🟦	
11	0.6096	,	6.40	21.00	6.71	34	28.00	0.33	154.25	112.08	🟥	🟦	
12	0.6096	,	7.01	23.00	7.32	34	37.50	0.34	160.23	113.23	🟥	🟦	
13	0.6096	,	7.62	25.00	7.92	35	30.00	0.34	166.20	114.34	🟥	🟦	
14	0.6096	,	8.23	27.00	8.53	35	30.00	0.33	172.18	115.43	🟥	🟦	
15	0.6096	,	8.84	29.00	9.14	36	30.00	0.34	178.15	116.48	🟥	🟦	
16	1.2192	,	9.45	31.00	10.06	35	30.00	0.34	184.12	117.50			
17	2.4384		10.67	35.00	11.89	35	30.00	0.34	196.07	119.47			

Figure 3.9.: Electrode wellbore configuration.

Table B.1 provided in Appendix B gives the x and y co-ordinates for each wellbore relative to the first electrode, which has as its co-ordinates, $x = 0$, $y = 0$. Positive $+x$ indicates a displacement to the West, $+y$ indicates a displacement to the South ($-x$ to the East and $-y$ to the North). For example, referring to the co-ordinates for E007-U in Table B.1, this electrode well is 8.46 m to the East and 4.88 m to the South of E001-U.

This configuration of electrodes will provide the heat transfer to heat the soil to a target temperature of approximately 100 °C or the boiling temperature of water below the water table at hydrostatic pressure. The peak temperature will vary depending on depth and will be based on the azeotrope of the CVOC's as well as the boiling temperature of water in the subsurface.

5. The power to each electrode will typically vary with its length and location in the well field. The average power to an electrode is approximately 6.74 kW with a peak power of 11.35 kW. This results in a total average and peak power to the well field of 297 kW and 499 kW respectively. It is assumed that the power to boundary electrodes is 1.21 times the power to interior electrodes to account for heat losses. The operating strategy will be deliver maximum power to the electrodes while the temperature is increasing and reduce power while at target temperature to maintain temperatures.

6. The average water injection rate to each electrode is estimated at 0.379 L/min (0.100 gal/min). The water balance calculations for the project are provided in Figure 3.3 and Table 3.3. The *Recycle Supply* is water supplied from the onsite treatment plant.

7. The electrodes will be connected to a sufficient number of PDS units needed to deliver the necessary power, using power values summarized in Table 3.2 as a guideline. As a matter of contingency the number of PDS units are allocated approximately 25% additional electrode connections than designed for.

8. Boundary electrodes are operated at higher current by a factor of 1.14 . The water injection rate into the boundary electrodes is the same as for interior electrodes unless otherwise indicated.

9. The cumulative water injected during thermal operations is 1,140,481 gal with an average injection rate of 4.40 gal/min or 0.100 gal/min per electrode.

10. The average liquid phase extraction rate from an extraction well is 1.138 L/min (0.301 gal/min), which accumulates into a total volume of extracted water of 1,168,969 gal. It is noted that the water will be re-circulated and heat recovery will be used to reduce operating costs. Minimal heating of the injected water was assumed for this study.

11. The targeted hydrodynamic control factor, the ratio of extracted water to injected water rate is, 1.02. Operating the water balance close to this control factor will ensure hydraulic control during the thermal treatment.

12. 15 extraction wells have been included for capturing vaporized contaminants from the soil and groundwater. The expected average vapor extraction rate from each well is 9.28 scfm at a vacuum pressure of less than 12 inches Hg. Once target temperatures are achieved we expect the vacuum needed to achieve the vapor flow rates to decrease.

13. The total maximum[3] IDW for all types of wells drilled is approximately 13.93 m^3. This does not include the water used in the drilling process.

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[3] It is understood that the volume of IDW depends on the drilling method. The estimate given in this study asssumes a maximum volume for the IDSW.

3.2. Radius of Capture Calculations

The calculations in this section provide an estimate for the maximum spacing between extraction wells recommended in the design of an electro-thermal system and for this simulation study. It is based on solving equations, 3.1 through 3.5. The analytic model evolved from a problem submitted by McMillan-McGee to the Pacific Institute for Mathematical Sciences annual Industrial Problem Solving Workshops[4] and is in the *PIMS Industrial Proceedings*[5] authored by Huaxiong Huang et. al.[7]. Figure 3.10 shows the general concept behind the model.

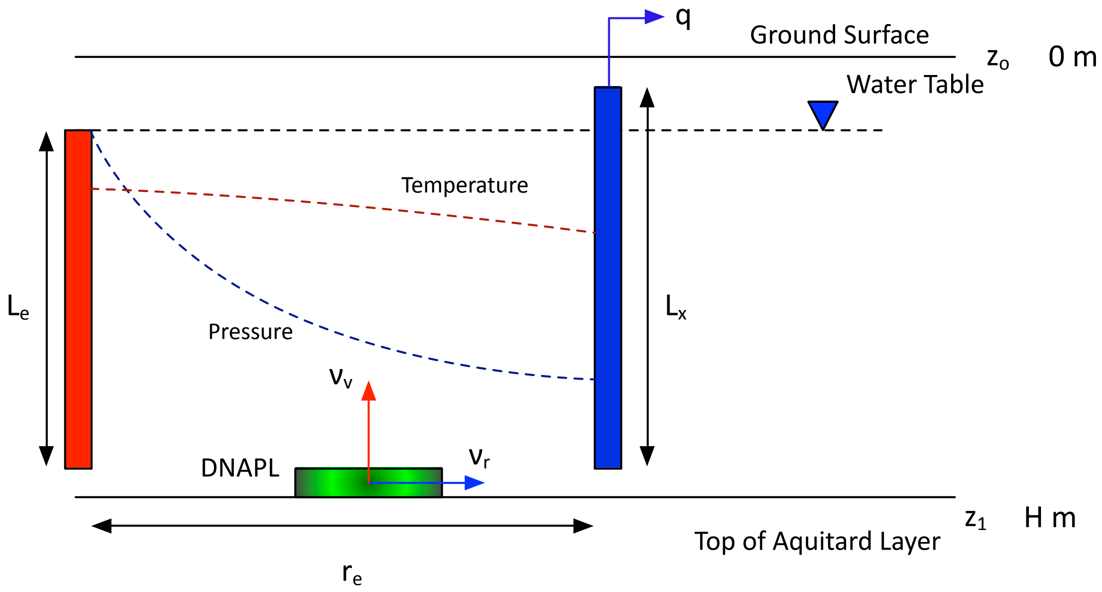

Figure 3.10.: Conceptual model for the radius of capture.

Electrical energy is introduced to the contaminated soil using a multitude of finite length cylindrical electrodes. Current is forced to flow though the soil by the voltage differentials at the electrodes. The soil is resistive in nature and consequently heat losses occur in accordance with the power density distribution established by the voltage gradient between the electrodes, for example, $q_e = \sigma \mathbf{E} \cdot \mathbf{E}^{\mathbf{T}}$ where $\mathbf{E} = \vec{\nabla} \cdot V$.

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[4] The Pacific Institute for Mathematical Sciences (PIMS) has sponsored an annual Industrial Problem Solving Workshop (IPSW) since 1997. The aim of the IPSW is to create a mutually beneficial link between researchers in industry and academic mathematical scientists. Faculty and students from the academic community study problems brought by industrial participants during the week-long workshop. Their results are presented at the end of the week.

[5] `http://www.pims.math.ca/resources/publications/pims-industrial-proceedings`

As the soil heats up contaminated liquids and vapours are produced at the extraction wells. The rate of energy removed from the soil at the extraction wells is less than the electrical energy injected so that during extraction the soil will increase in temperature up to some maximum value, which is usually the boiling temperature of water.

At initial conditions the pressure and temperature in the soil are P_i and T_i respectively. Initially there is no vapour in the soil, only a liquid phase consisting of water, a dissolved chemical phase (the contaminant), and a free product DNAPL resting on the aquitard layer. As the temperature increases toward $T = T_c$, the vapourization temperature of the chemicals in the liquid, the chemical *boils* out of the water and exists in the soil as a vapour, but only to the limited extent of several bubbles. The vapour-equilibrium for the system is estimated from $k-$values.

Given the temperature and pressure conditions in the soil it is possible to approximate where the bubbles will exist. There is a pressure gradient in the soil created by the draw-down of liquids at the extraction well. This imposes a horizontal force on the bubble and accelerates it toward the extraction well. The other force on the bubble is buoyancy, and is acting in the vertical direction. The objective of the model is to determine the horizontal velocity of the bubble so that it is removed at the extraction well before it leaves the vertical extent of the heated volume. Outside the heated volume the bubble, comprised mainly of the DNAPL, may condense back to a liquid and reduce the efficiency of the mass recovery.

Equation 3.1 first determines the average velocity of bubbles, υ_b, as they exit the top of heated volume. The hydraulic constant for vertical flow, F, is developed in Huaxiong Huang et. al. and incorporates soil parameters into its value as indicated in Equation 3.4. The Eötvös (or Bond number), E_o, is determined in Equation 3.2 and is used to determine the capillary number, C_a, based on the correlation[1] presented in Equation 3.3. Finally, the minimum liquid extraction rate needed to capture the bubbles is given in Equation 3.5.

$$\upsilon_b = \tau F \frac{\Delta \rho g d^2}{3\mu_l} \tag{3.1}$$

$$E_o = \frac{\Delta \rho g d^2}{\gamma} \tag{3.2}$$

$$C_a = c_1 E_o^{d_1} + c_2 E_o^{d_2} \tag{3.3}$$

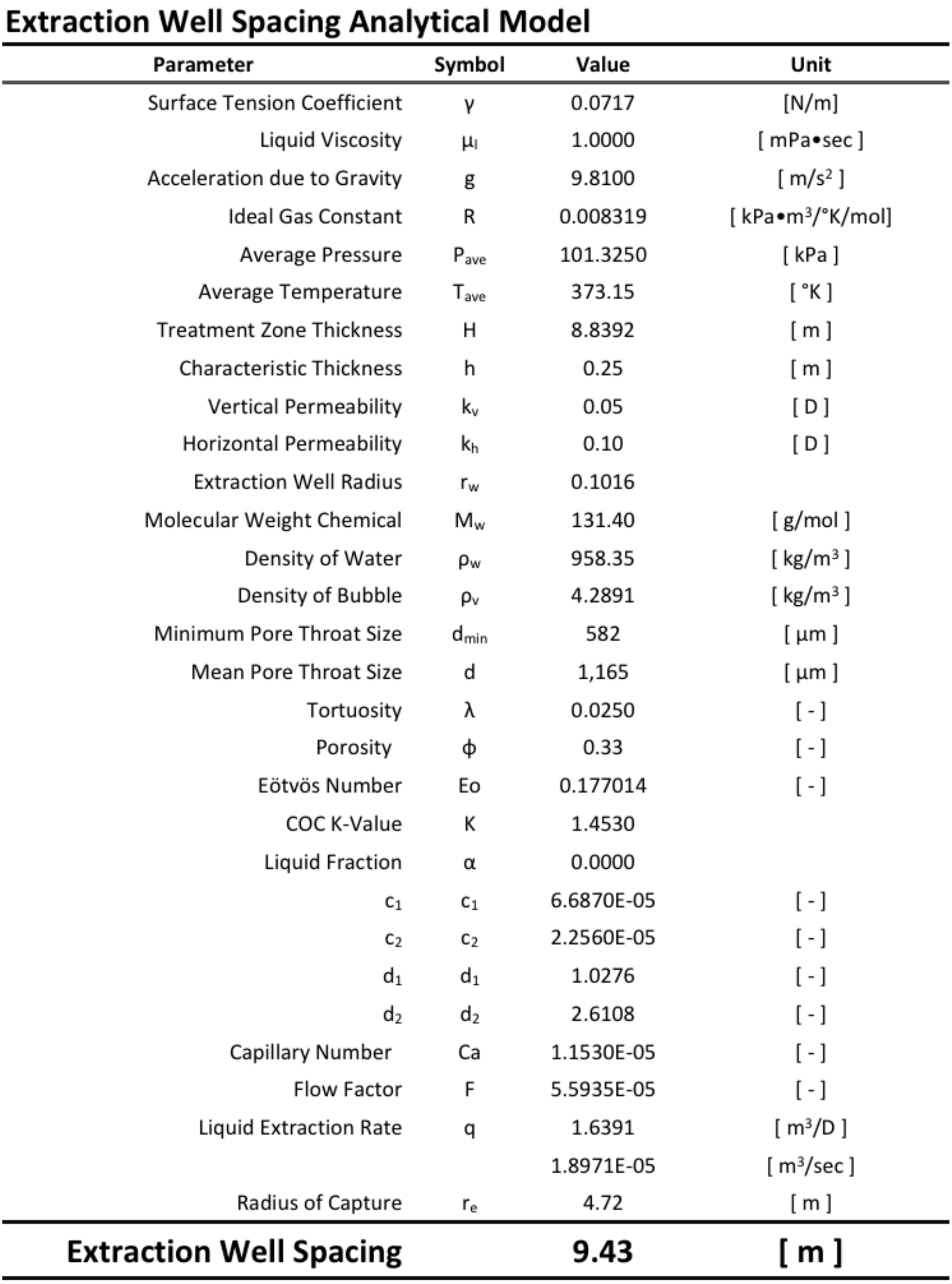
$$F = \frac{3\phi\,(1-\alpha)}{d^3}\,\frac{\gamma\mu_l}{\Delta\rho g}\left(c_1 E_o^{d_1} + c_2 E_o^{d_2}\right) \tag{3.4}$$

$$q \geq \frac{\pi\,\tau F \Delta\rho g d^2}{3\mu_l} \cdot \frac{k_v\,H}{k_h\,h} \cdot \frac{r_e^2 - r_w^2}{1+K} \tag{3.5}$$

Equation 3.5 is rearranged and solved for r_e. The value of $2 \cdot r_e$ determines the maximum spacing between extraction wells that will ensure the capture of bubbles. This spacing is used as a guideline for setting up the array of extraction wells within the heated volume.

Figure 3.11 summarizes the calculation for the extraction well spacing assuming the vertical permeability is half that of the horizontal. Figure 3.12 presents the extraction well spacing for non-anisotropic permeability ($k_v = k_h$). The maximum spacing is not exceeded in this simulation study.

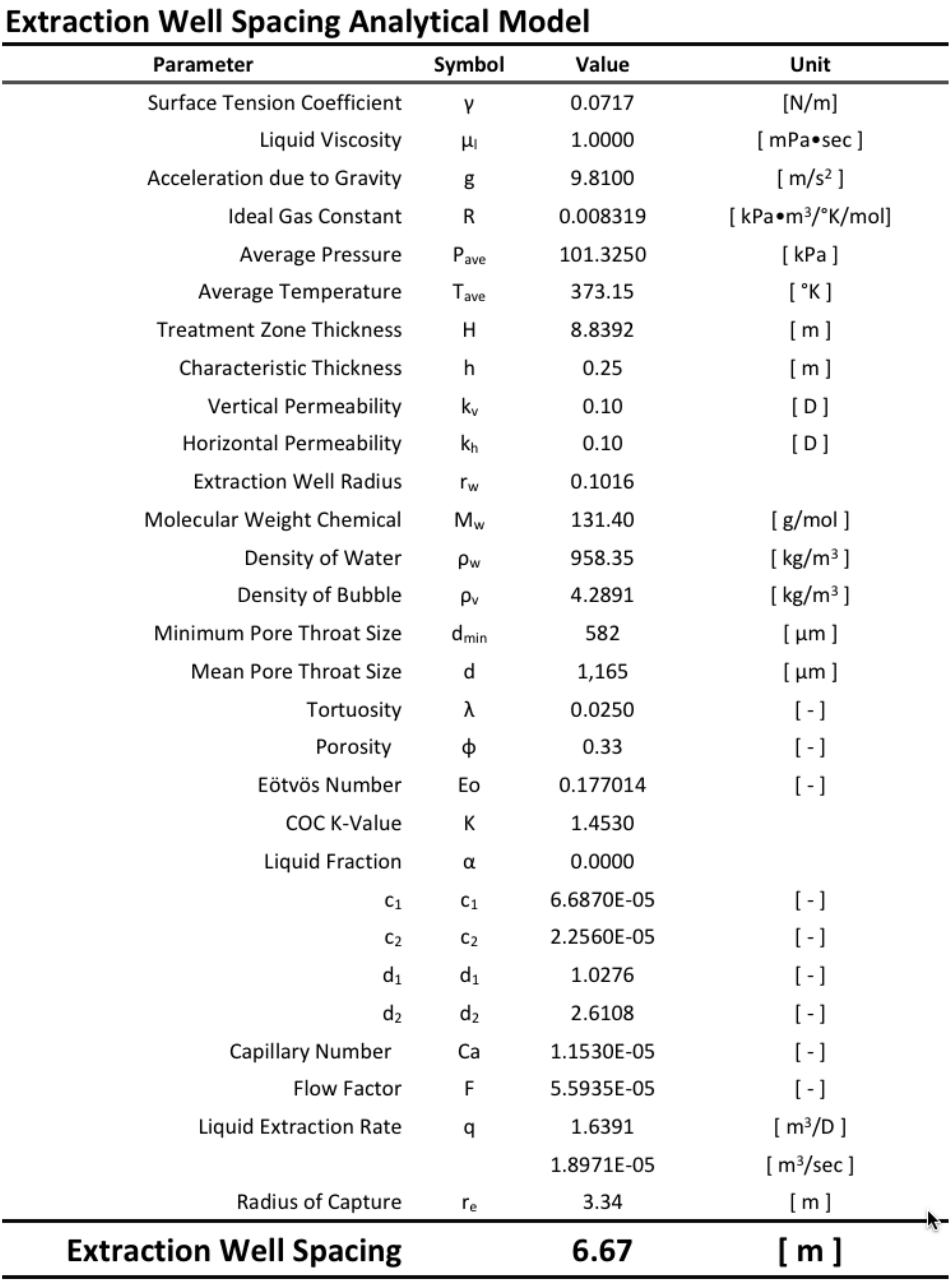
This is a simple model for estimating the transport of DNAPL contaminants during thermal remediation. Based on the model, the maximum spacing between extraction wells is calculated and its value is within the practical range. This simple model does not address the effect of temperature variation in the vertical direction and near the edge of the heated zone. The effect of possible condensation near the cold region is not examined, however it is believed that condensed DNAPL would find a path back into the heated volume and with time be removed at the extraction wells. The possibility that bubbles may be trapped in the isolated pore space has been assumed negligible in comparison to the mobile bubbles that are extracted. The behaviour of bubble flow in porous media, as assumed in this analysis, is further described in Hunt et. al.[8].



Extraction Well Spacing Analytical Model

Parameter	Symbol	Value	Unit
Surface Tension Coefficient	γ	0.0717	[N/m]
Liquid Viscosity	μ_l	1.0000	[mPa•sec]
Acceleration due to Gravity	g	9.8100	[m/s^2]
Ideal Gas Constant	R	0.008319	[$kPa \bullet m^3/°K/mol$]
Average Pressure	P_{ave}	101.3250	[kPa]
Average Temperature	T_{ave}	373.15	[°K]
Treatment Zone Thickness	H	8.8392	[m]
Characteristic Thickness	h	0.25	[m]
Vertical Permeability	k_v	0.05	[D]
Horizontal Permeability	k_h	0.10	[D]
Extraction Well Radius	r_w	0.1016	
Molecular Weight Chemical	M_w	131.40	[g/mol]
Density of Water	ρ_w	958.35	[kg/m^3]
Density of Bubble	ρ_v	4.2891	[kg/m^3]
Minimum Pore Throat Size	d_{min}	582	[µm]
Mean Pore Throat Size	d	1,165	[µm]
Tortuosity	λ	0.0250	[-]
Porosity	ϕ	0.33	[-]
Eötvös Number	Eo	0.177014	[-]
COC K-Value	K	1.4530	
Liquid Fraction	α	0.0000	
c_1	c_1	6.6870E-05	[-]
c_2	c_2	2.2560E-05	[-]
d_1	d_1	1.0276	[-]
d_2	d_2	2.6108	[-]
Capillary Number	Ca	1.1530E-05	[-]
Flow Factor	F	5.5935E-05	[-]
Liquid Extraction Rate	q	1.6391	[m^3/D]
		1.8971E-05	[m^3/sec]
Radius of Capture	r_e	4.72	[m]
Extraction Well Spacing		**9.43**	**[m]**

Figure 3.11.: Maximum extraction well spacing for $k_v = \frac{1}{2}k_h$.



Extraction Well Spacing Analytical Model

Parameter	Symbol	Value	Unit
Surface Tension Coefficient	γ	0.0717	[N/m]
Liquid Viscosity	μ_l	1.0000	[mPa•sec]
Acceleration due to Gravity	g	9.8100	[m/s^2]
Ideal Gas Constant	R	0.008319	[kPa•m^3/°K/mol]
Average Pressure	P_{ave}	101.3250	[kPa]
Average Temperature	T_{ave}	373.15	[°K]
Treatment Zone Thickness	H	8.8392	[m]
Characteristic Thickness	h	0.25	[m]
Vertical Permeability	k_v	0.10	[D]
Horizontal Permeability	k_h	0.10	[D]
Extraction Well Radius	r_w	0.1016	
Molecular Weight Chemical	M_w	131.40	[g/mol]
Density of Water	ρ_w	958.35	[kg/m^3]
Density of Bubble	ρ_v	4.2891	[kg/m^3]
Minimum Pore Throat Size	d_{min}	582	[µm]
Mean Pore Throat Size	d	1,165	[µm]
Tortuosity	λ	0.0250	[-]
Porosity	ϕ	0.33	[-]
Eötvös Number	Eo	0.177014	[-]
COC K-Value	K	1.4530	
Liquid Fraction	α	0.0000	
c_1	c_1	6.6870E-05	[-]
c_2	c_2	2.2560E-05	[-]
d_1	d_1	1.0276	[-]
d_2	d_2	2.6108	[-]
Capillary Number	Ca	1.1530E-05	[-]
Flow Factor	F	5.5935E-05	[-]
Liquid Extraction Rate	q	1.6391	[m^3/D]
		1.8971E-05	[m^3/sec]
Radius of Capture	r_e	3.34	[m]
Extraction Well Spacing		**6.67**	**[m]**

Figure 3.12.: Maximum extraction well spacing for $k_v = k_h$.

3.3. Temperature and Energy Results

Figures 3.13 and 3.14 show the layout of electrode and extraction wells for the temperature distribution plots in a two and three dimensional perspective. Additionally, Figure 3.15 shows the layout of the simulation grid relative to the placement of electrodes and extraction wells.

Figure A.1 through Figure A.20 (attached in Appendix A) show the simulated temperature distribution in 3-D view looking down towards the treatment area. The maximum temperature is set to the boiling temperature of water.

Figure A.21 through to Figure A.36 (attached in Appendix A) show the simulated temperature distribution in vertical slice view throughout the treatment interval.

The results confirm that subsurface temperatures needed to volatilize the chemicals of concern can be reached. The energy balance needed to achieve the temperature goals are summarized in Table 3.5. Also summarized are average power estimates to the electrodes.

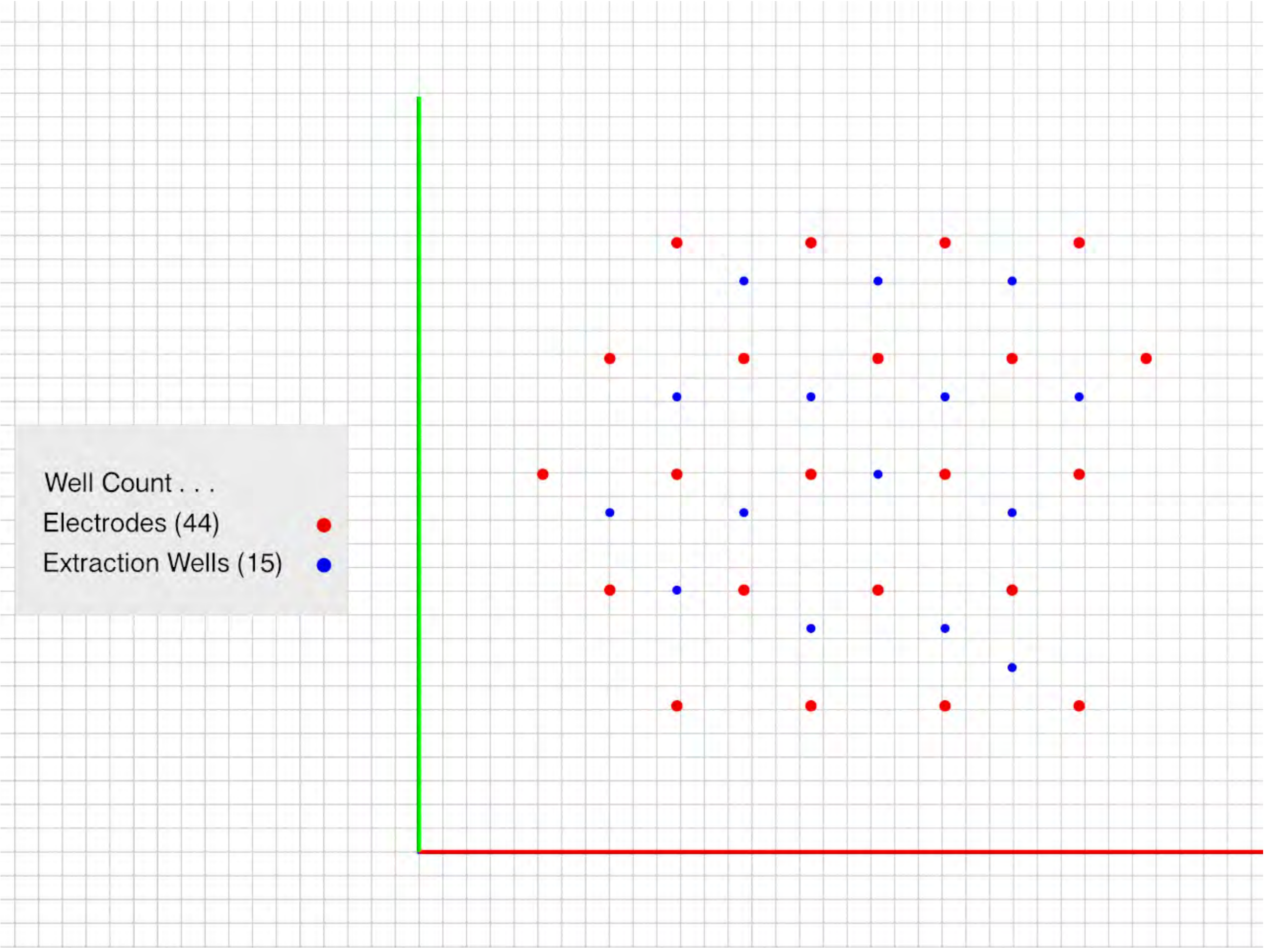


Figure 3.13.: Electrode and extraction well layout in 2D.

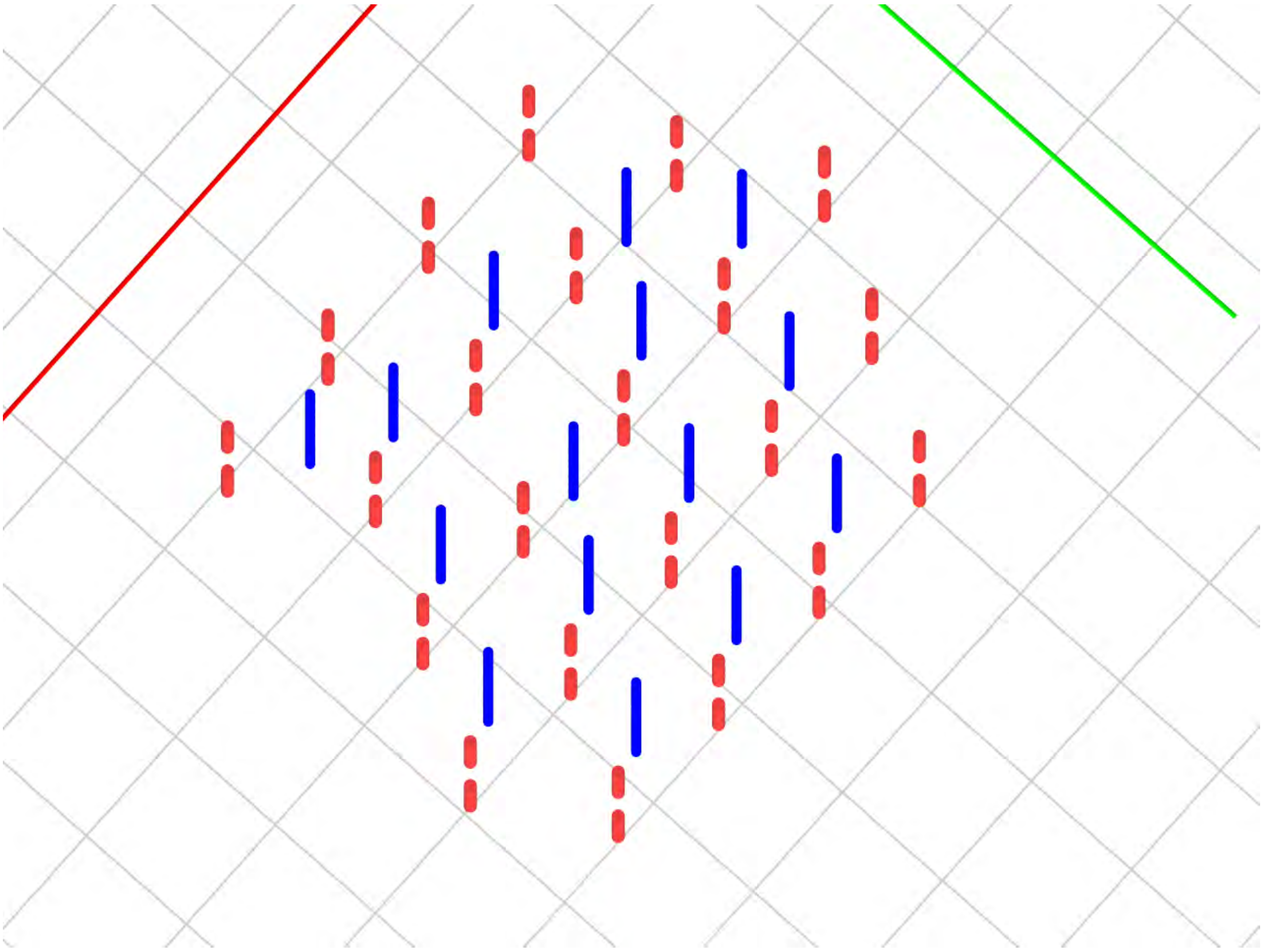


Figure 3.14.: Electrode and extraction well layout in 3D.

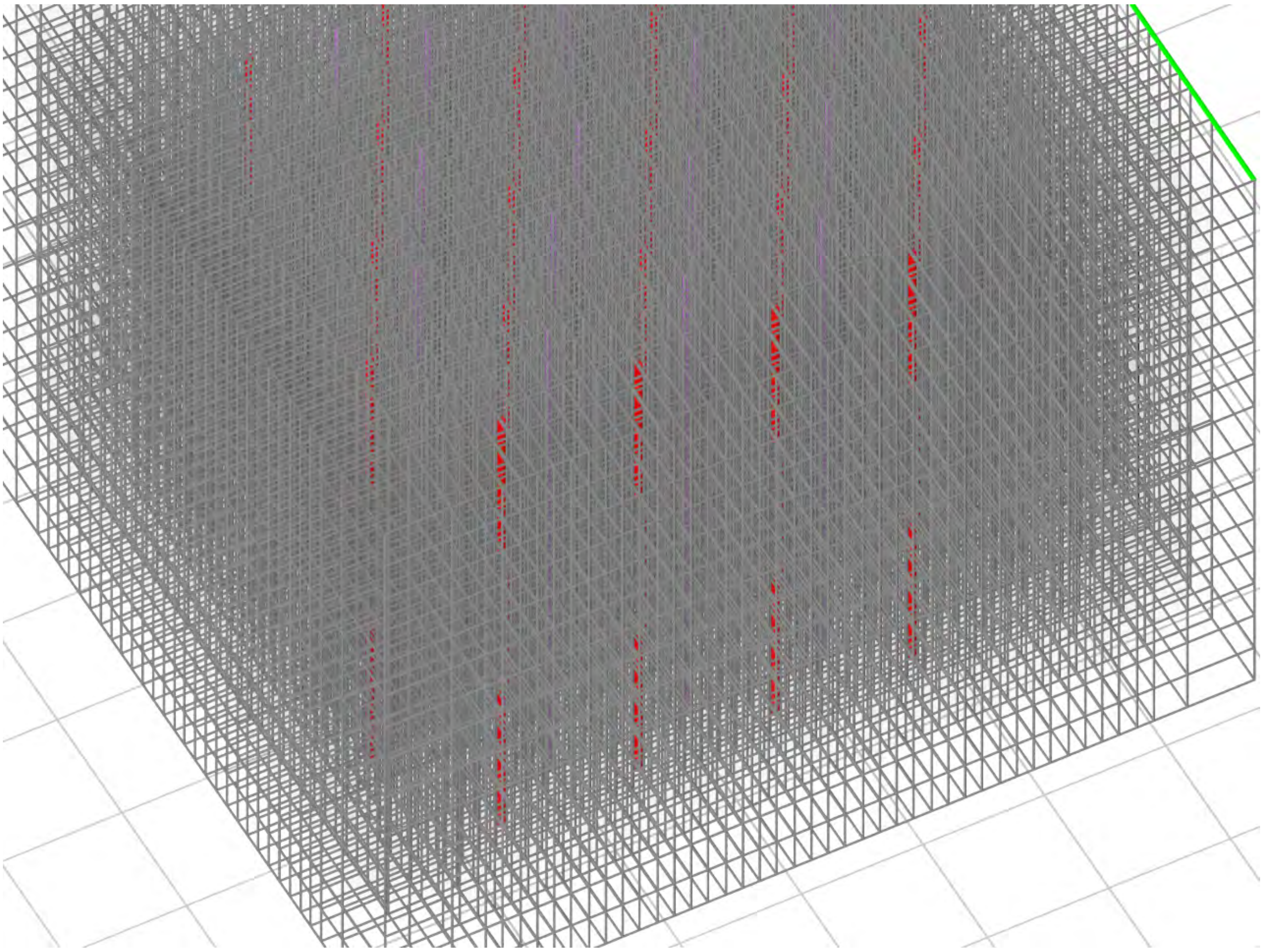


Figure 3.15.: Simulation grid (embedded electrodes shown in red).

3.4. Mass Recovery Curve

The chemicals of concern in the soil are initially at equilibrium and in a liquid phase (dissolved in water or as a free product). The introduction of heat by electrothermal energy raises the temperature sufficiently to separate the liquid mixture into multiple components in the vapor phase. This distillation of the chemicals is a complicated thermodynamic process, however at temperatures above the boiling point of the chemicals, and at induced vacuum, the volatile chemicals are in the vapor phase. Less volatile chemicals will not boil and will be extracted in the liquid phase.

From the temperature ramp-up, estimated mass in place, and experience from similar projects, The treatment plant needs to be designed to accept a peak chemical extraction rate of approximately 1 kg/day (3 lbs/day).

Figure 3.16 shows the rate of contaminant mass recovery from the target volume. The results predict that after 180 day of operation, greater than 99% of the chemical mass can be removed from the soil.

Assuming an estimated mass in place of 45 kg and that steam temperatures within a significant volume of the treatment area will be achieved after 60 to 75 days of operations (uniform target temperatures will be reached in 52 to 57 days) then peak chemical mass flow rates in excess of 1 kg/day are expected during this period. The estimated peak chemical mass flow rate is part of the design basis for the operation of the multi-phase extraction system.

The mass recovery curve is the result of multi-function calculations using a thermodynamic model and the temperature response predicted by the numerical simulation. These calculations account for the concentrations of the chemicals and water in the liquid and vapor phases as a function of temperature and pressure using k-values. The initial increase in mass recovery shown in the curve is the result of increasing vapor phase saturations as the soil approaches target temperature. As this mass is then extracted from the pore space, the relative concentration of mass in the vapor phase decreases exponentially. Therefore, the curve calculated by the simulation is used to provide an estimate of the expected duration of treatment to achieve the remediation goals.

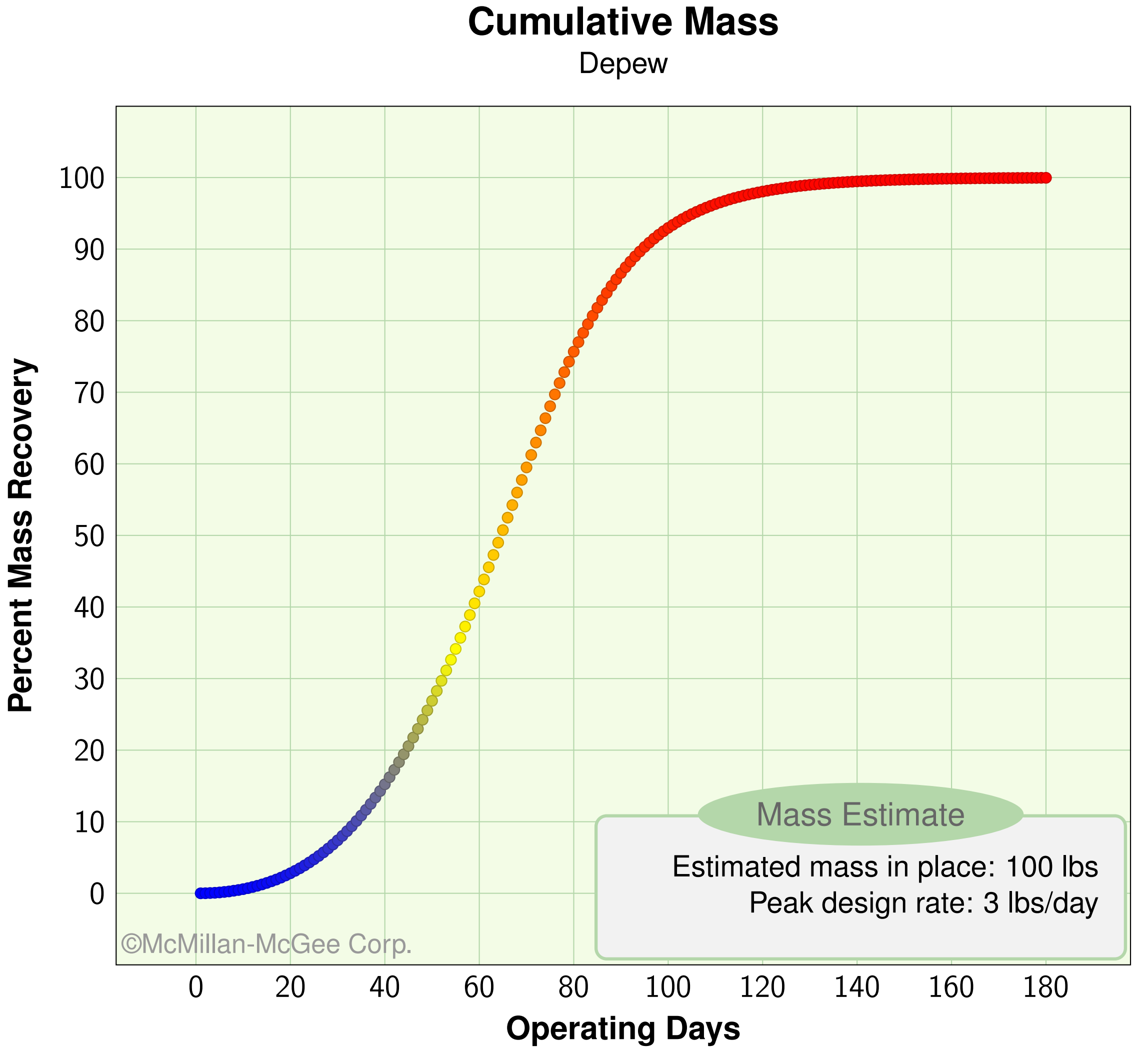


Figure 3.16.: Mass recovery curve [Estimate Only].

4

Conclusions

Results from the numerical simulation study are the foundation for a design basis and insight to thermal operations by quantifying several of the technical elements of the process shown in Figure 1.1 for the Depew project. Based on these results the following conclusions and recommendations are put forward for the design of an electro-thermal and extraction treatment system for the project:

1. Total energy input of 1,281 MW $\cdot$ h or 412 kWh/m^3 (315 kWh/yd^3);
2. Total water extraction volume of 4,425,030 L (1,168,969 gallons);
3. Total water injection volume of 4,317,192 L (1,140,481 gallons);
4. Vapor extraction rate of 139 scfm ;
5. Time to reach target temperatures 52 to 57 days;
6. Peak temperatures are the boiling temperature of water at depths;
7. The anticipated contaminant mass recovery is 45 kg (100 lbs);
8. Electrode spacing of 5.639 m (18.50 ft); and,
9. A minimum extraction well spacing of 8 m.

Additionally;

Treatment Region Treatment is confined to the area defined by the distribution of chemicals in the subsurface. The heated volume extends from surface to an average depth of 9.45 m BGS. The total treatment area is 340 m^2 (3,661 ft^2) and the treatment volume is 3,109 m^3 (4,066 yd^3).

Vapor Cap The entire treatment area should be covered with an insulating material with a minimum insulating value of 5.00 $\left[\frac{\text{ft}^2\,{}^{\circ}F\,\text{hr}}{\text{BTU}}\right]$. The cap enhances the systems thermal efficiency by reducing the migration of cool vapor into the treatment area during heating. It is needed to facilitate heating of shallow soils and ensure mobilized constituents of concern (COCs) are captured and extracted from the treatment area. The vapor cap extends 3 m outside of the thermal treatment area.

Electrodes The design simulation model calls for an electrode well configuration as summarized in Figure 1.4. The well configuration is a function the thickness. This design of electrode wells is needed to achieve target temperatures. All in all there are 22 electrode wells with two electrodes in each well. The horizontal spacing between electrodes varies slightly but on average is 5.639 m. The recommended drilling method for the electrode wellbores is Sonic. The average power per electrode is 6.74 kW over a project duration of 180 day, with an estimated peak electrode power of 11.35 kW. The average water injection rate into each electrode is 0.379 L/min. Should highly resistive soil be encountered electrolyte can be injected into the electrodes to increase power to design levels.

Extraction Well The simulation study resulted in 15 extraction wellbores extending through the treatment volume as shown in Figure 1.4. The extraction rate for each well is easily determined by taking the total project extraction rate (17.07 L/min) and dividing by the total number of wells with a result of 0.301 gal/min (1.138 L/min). Though the extraction wells may be of different lengths, it was assumed that the extraction per well is the same throughout the well field[1]. The estimated vapor extraction rate per well for achieving mass recovery is 9.28 scfm with a total vapor flow into the plant of 139 scfm . The maximum estimated vacuum needed to achieve the vapor flow rates is 12 inches Hg.

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[1] It is a practical impossibility to monitor the extraction rate on a well by well basis with any degree of accuracy during thermal operations.

Sensors To monitor temperature and optimize electric power input, the appropriate number of temperature monitoring wells will be used.

Existing Infrastructure Remediation is to occur in an area of the site with existing infrastructure and in an area with a residential community. Sub-surface infrastructure consists primarily of the existing product recovery system.

Electrical Properties Electrical properties of the soil are variable in the treatment volume as there are different soil conditions present. The resistivity profile for the site (and assumed for this numerical simulation study) is shown in Figure 1.5. Average static electrical resistivity of the soil was assumed to be 32.71 Ωm and ranges in value from 20 Ωm to 80 Ωm. The resistivity changes (approximately) by a factor of 2.37 through the operating temperature range as was measured by the dynamic resistivity tests at the McMillan-McGee thermal laboratory. The assumed temperature dependence on resistivity is shown in Figure 1.6. Data beyond 90 °C is extrapolated using methods developed by Chute and Vermeulen[3].

Water Table The depth to the water table is 0.30 m. For soil depths above the water table, moisture content is critical to maintaining electrical conductivity. For soil above the aquifer, treatability will depend on maintaining moisture content in the soil during electro-thermal heating. The electrical properties measured during the resistivity testing of vadose zone soil samples from the site, indicate that the vadose and saturated zone soil is conductive and suitable for electro-thermal heating processes. Saline injection through the electrodes is likely not needed for this site, but remains an option if necessary. It is also assumed that the ground water flow velocity is negligible within the treatment volume.

Simulation Study The optimization of the heating strategy and operations through detailed data monitoring are to minimize the overall energy consumption of the project while still achieving the clean up goals. The simulation study provides a conservative (aggressive heating) estimate of the energy.

The average vapor extraction rate is estimated at 9.28 scfm for each extraction well. Total vapor extraction rates are not likely to exceed approximately 139 scfm . The total liquid flow rate from the MPE wells will remain steady at approximately 1.02 times the injection rate during treatment (approximately 1.138 L/min per extraction well). This figure includes condensate. These extraction rates will ensure that all volatilized contaminants are captured and hydraulic control is maintained during operations.

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Appendices

A

Temperature Plots

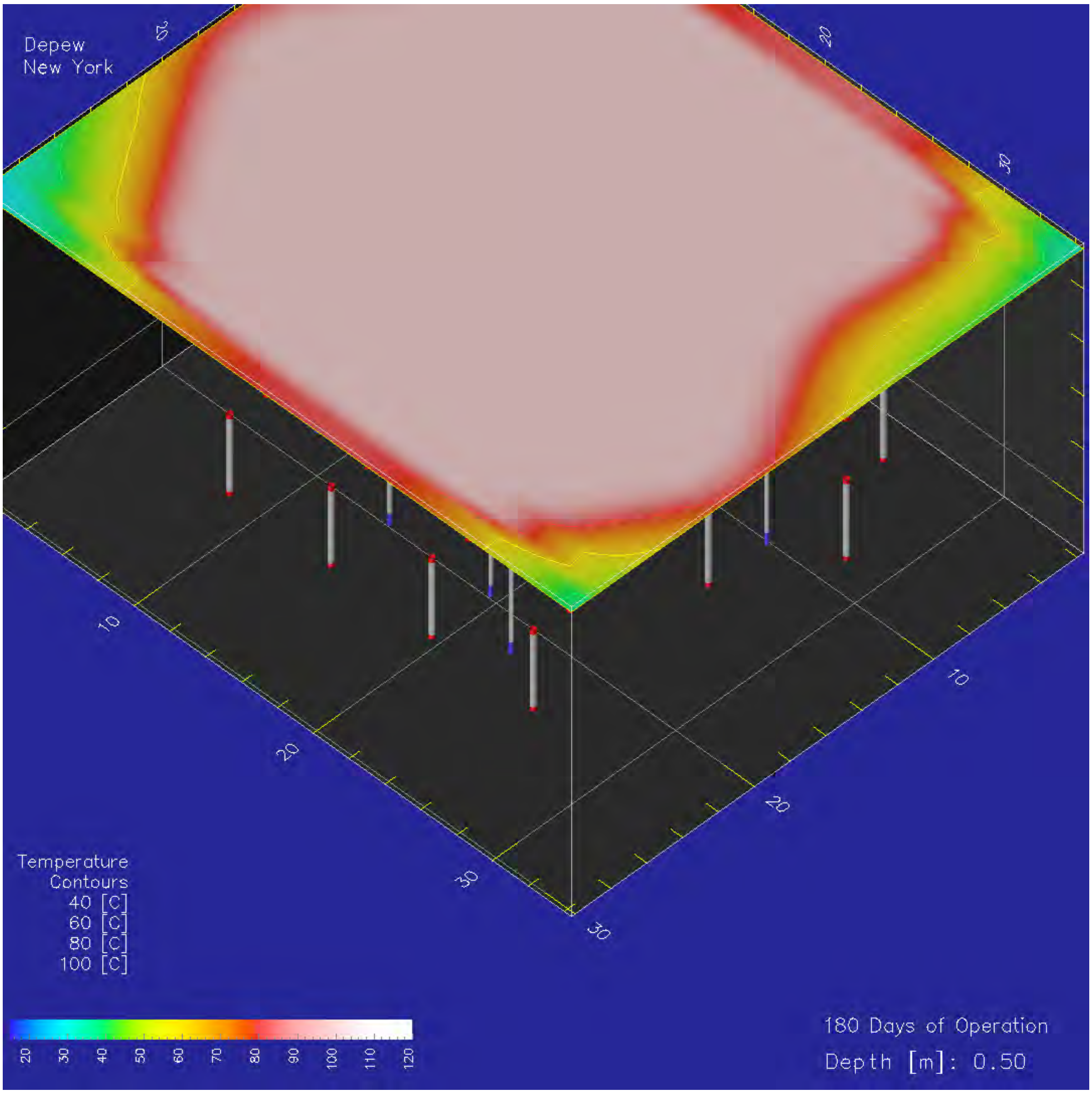

Figure A.1.: Temperature distribution in layer 1 after 180 days.

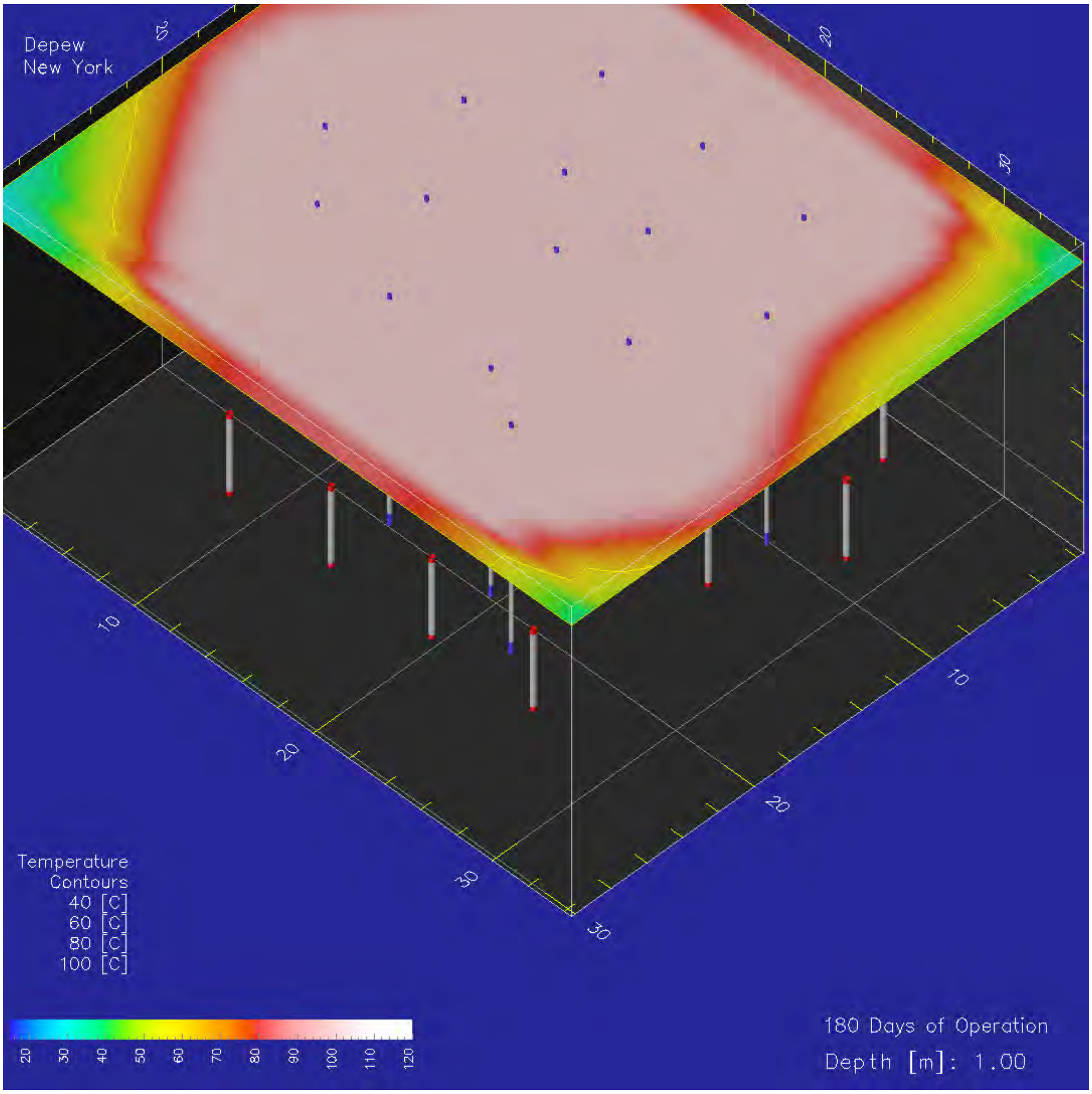

Figure A.2.: Temperature distribution in layer 2 after 180 days.

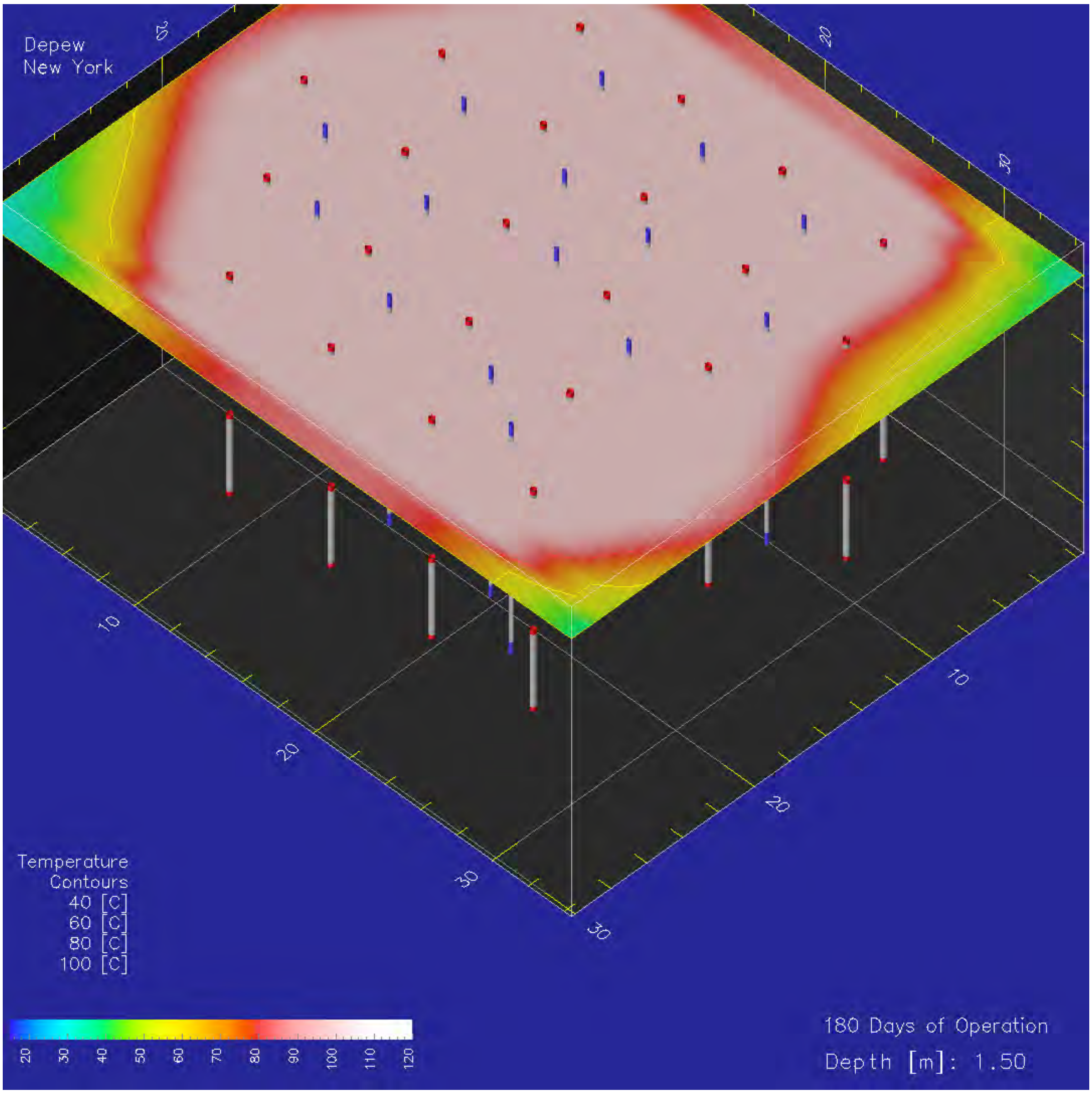

Figure A.3.: Temperature distribution in layer 3 after 180 days.

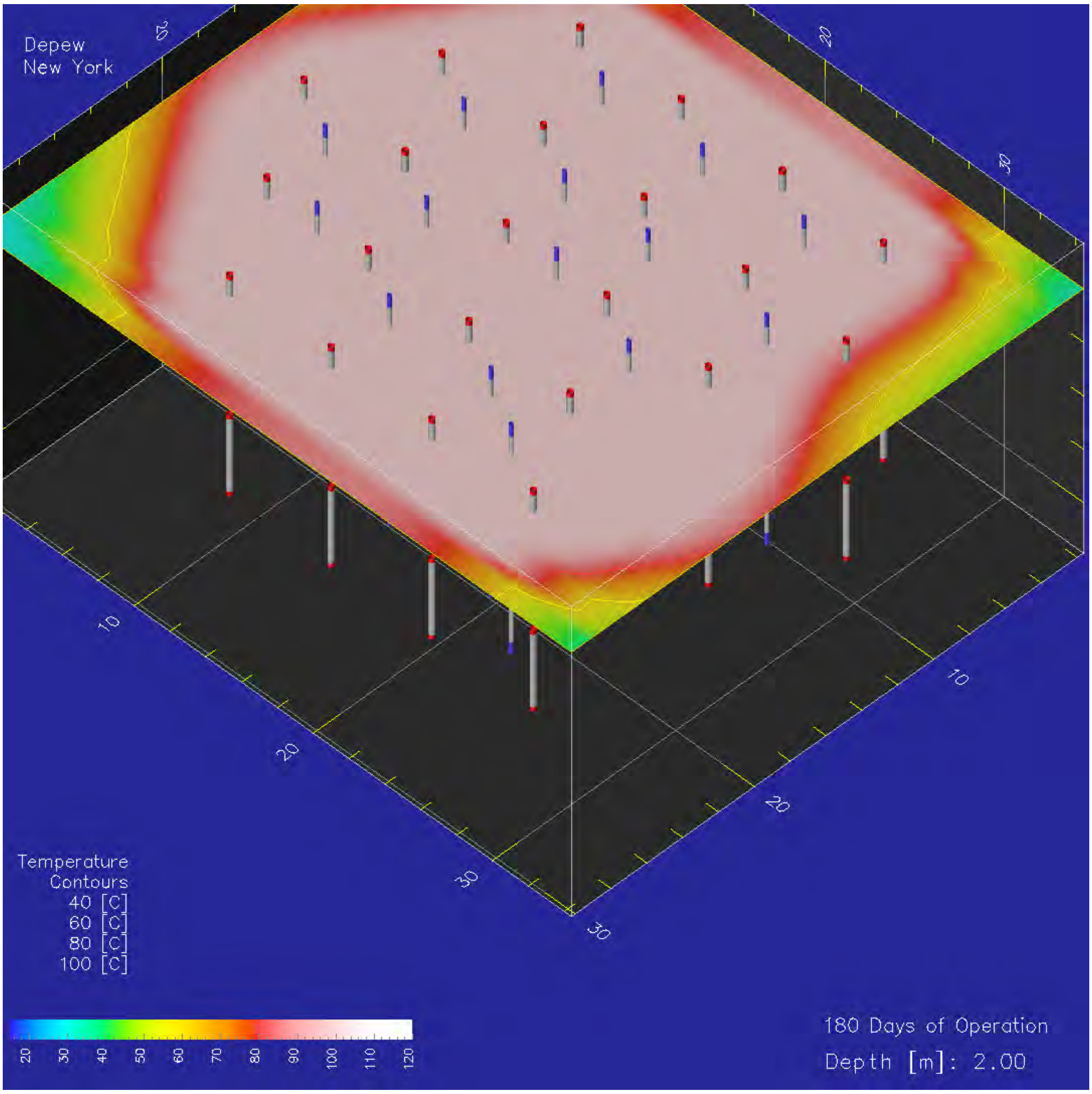

Figure A.4.: Temperature distribution in layer 4 after 180 days.

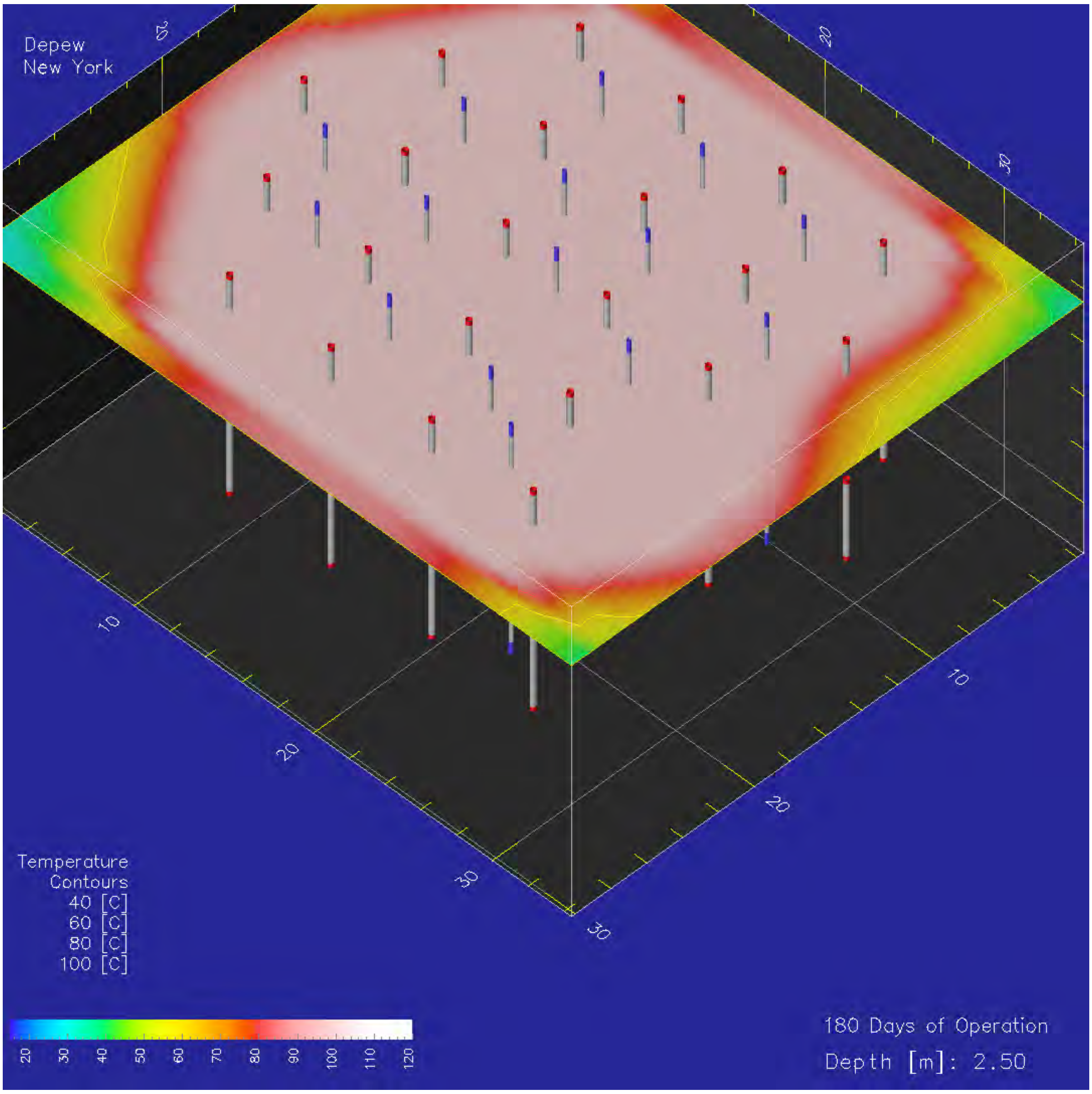

Figure A.5.: Temperature distribution in layer 5 after 180 days.

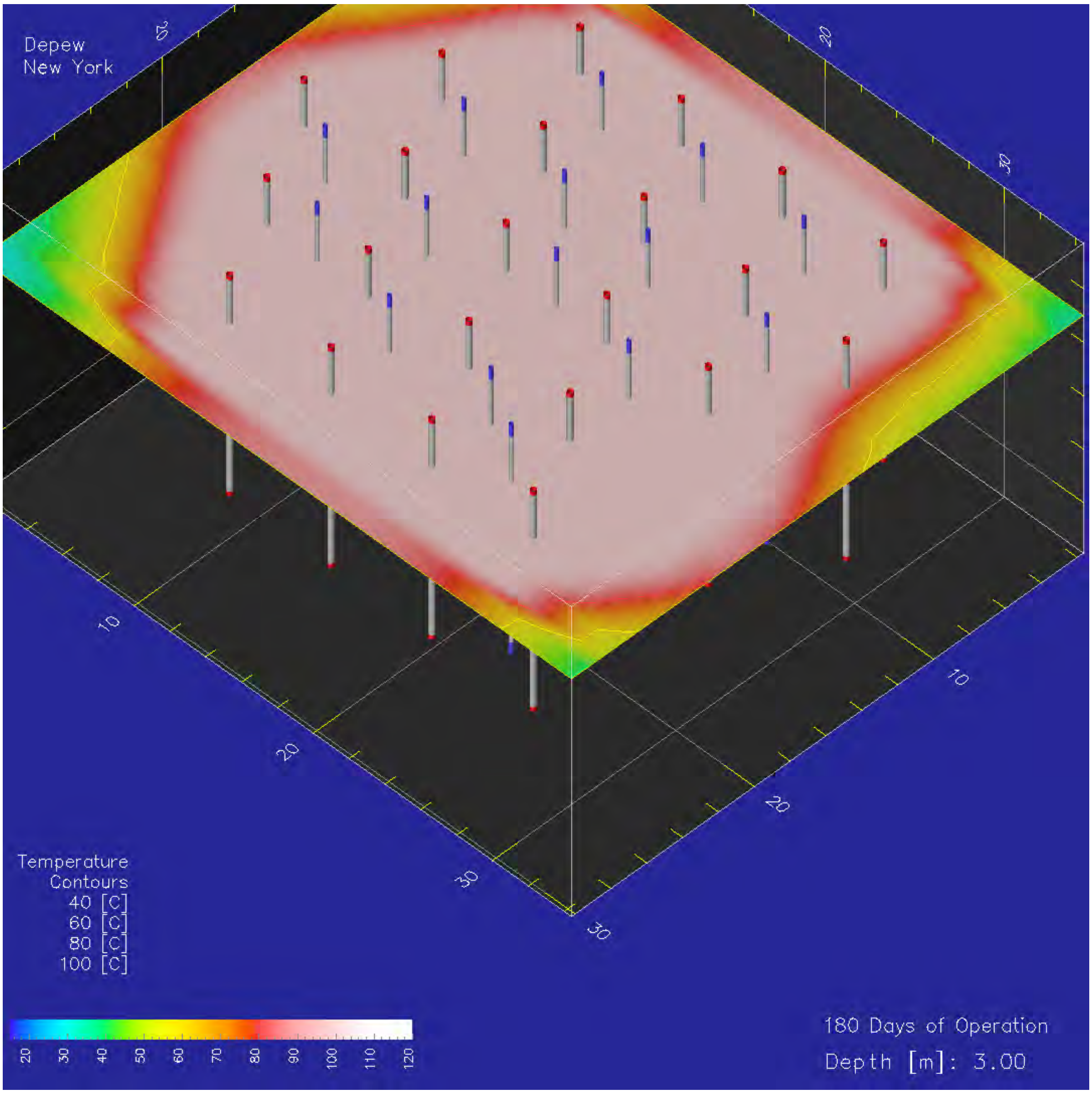

Figure A.6.: Temperature distribution in layer 6 after 180 days.

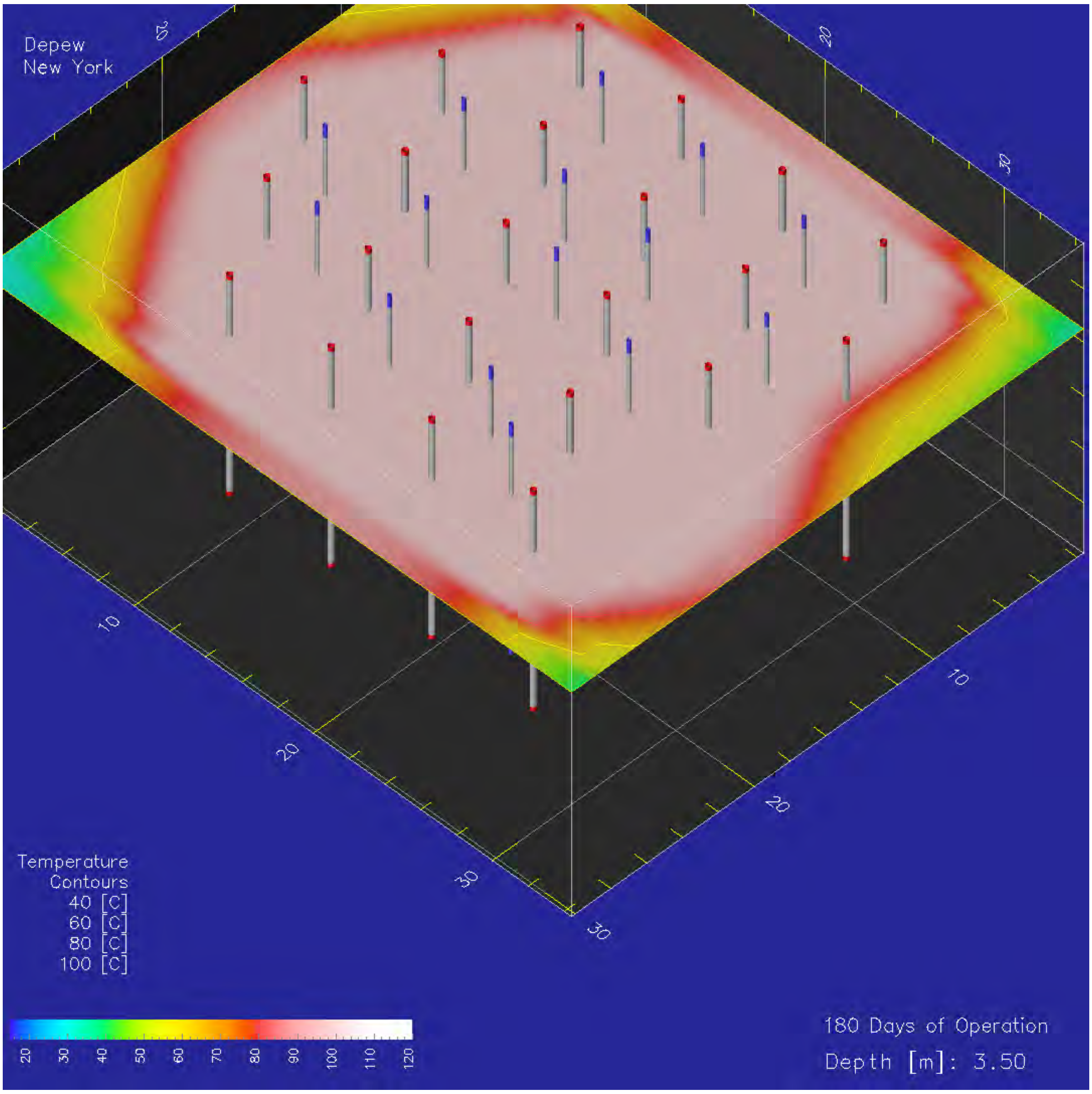

Figure A.7.: Temperature distribution in layer 7 after 180 days.

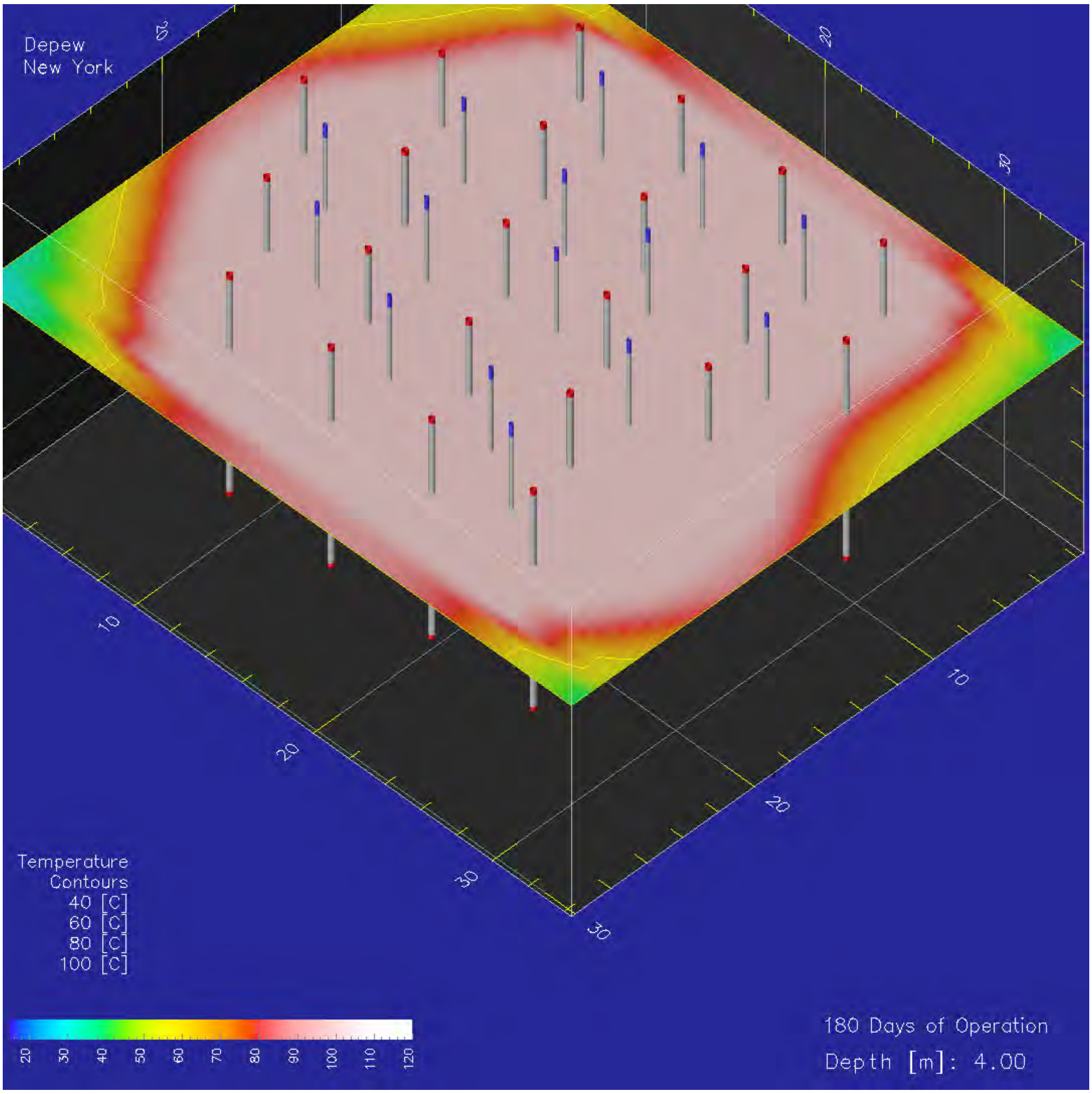

Figure A.8.: Temperature distribution in layer 8 after 180 days.

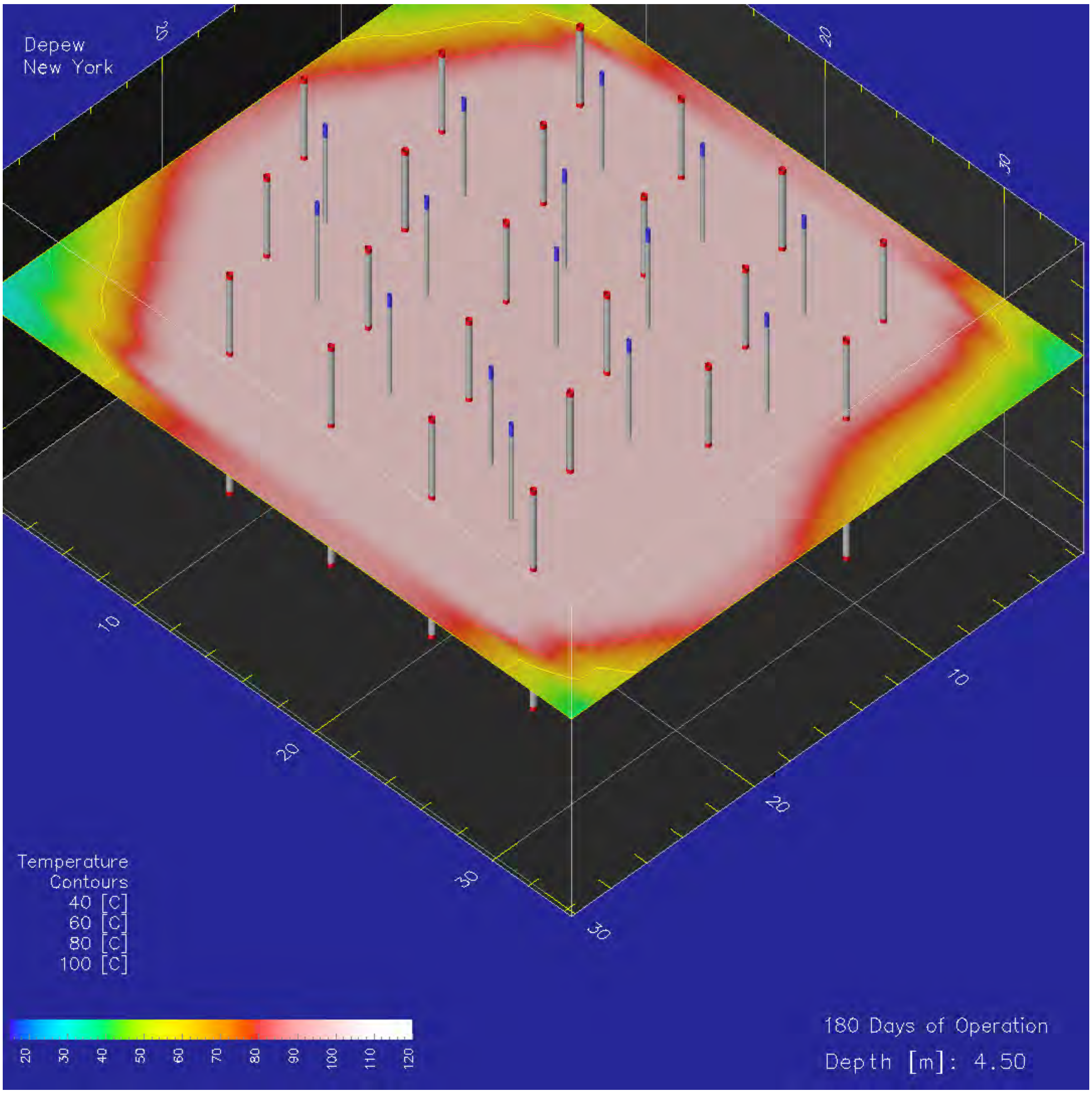

Figure A.9.: Temperature distribution in layer 9 after 180 days.

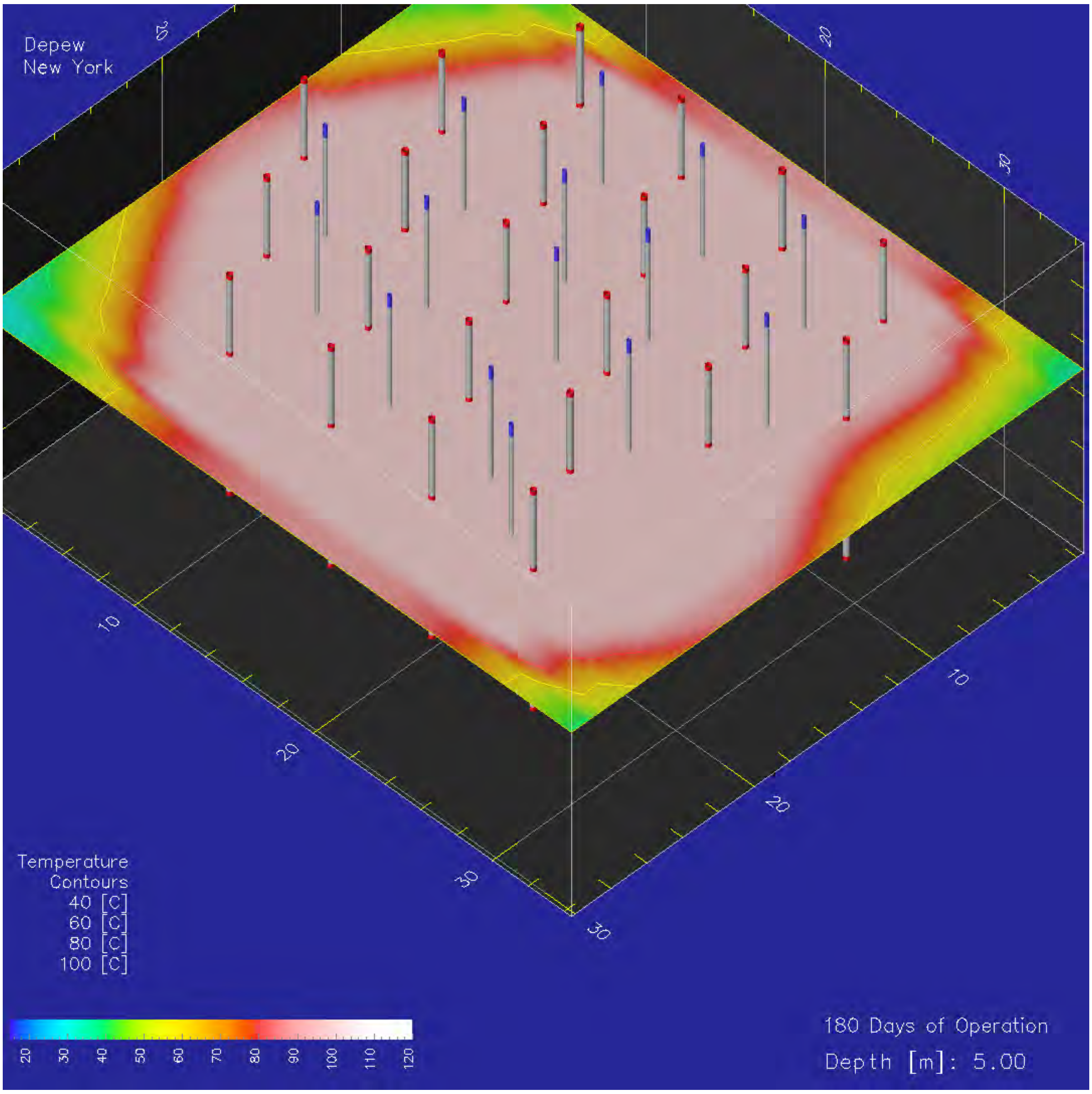

Figure A.10.: Temperature distribution in layer 10 after 180 days.

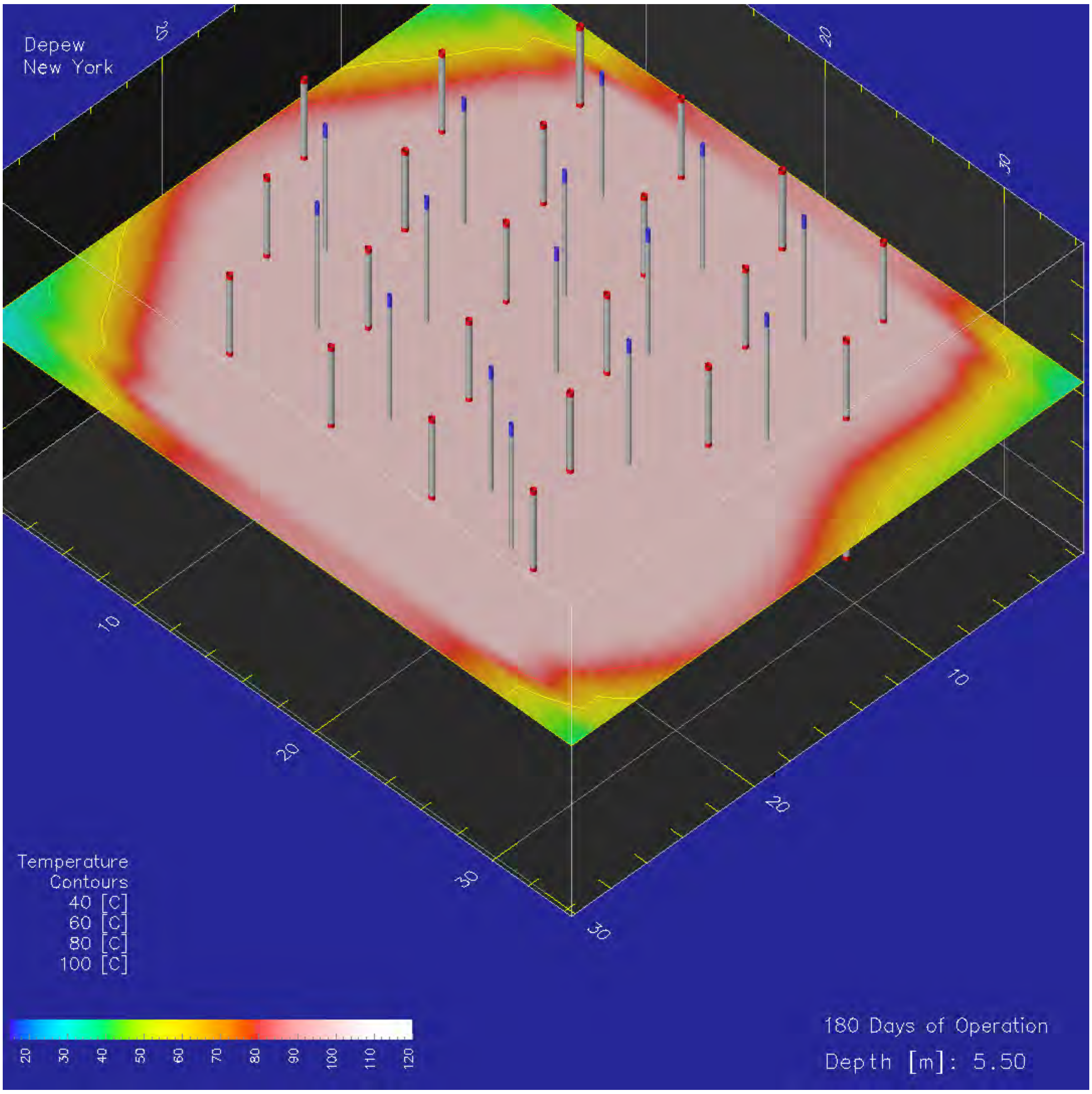

Figure A.11.: Temperature distribution in layer 11 after 180 days.

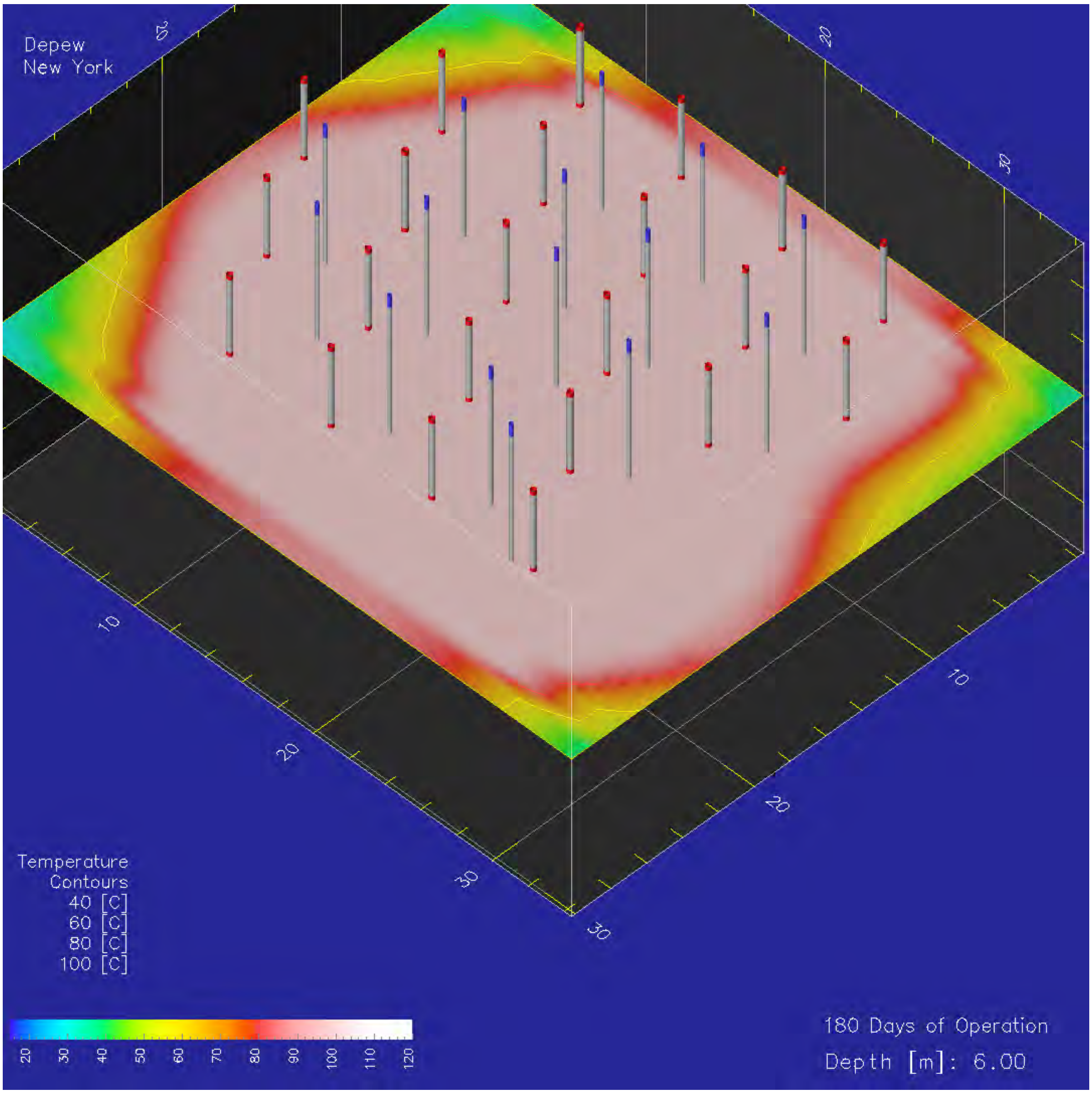

Figure A.12.: Temperature distribution in layer 12 after 180 days.

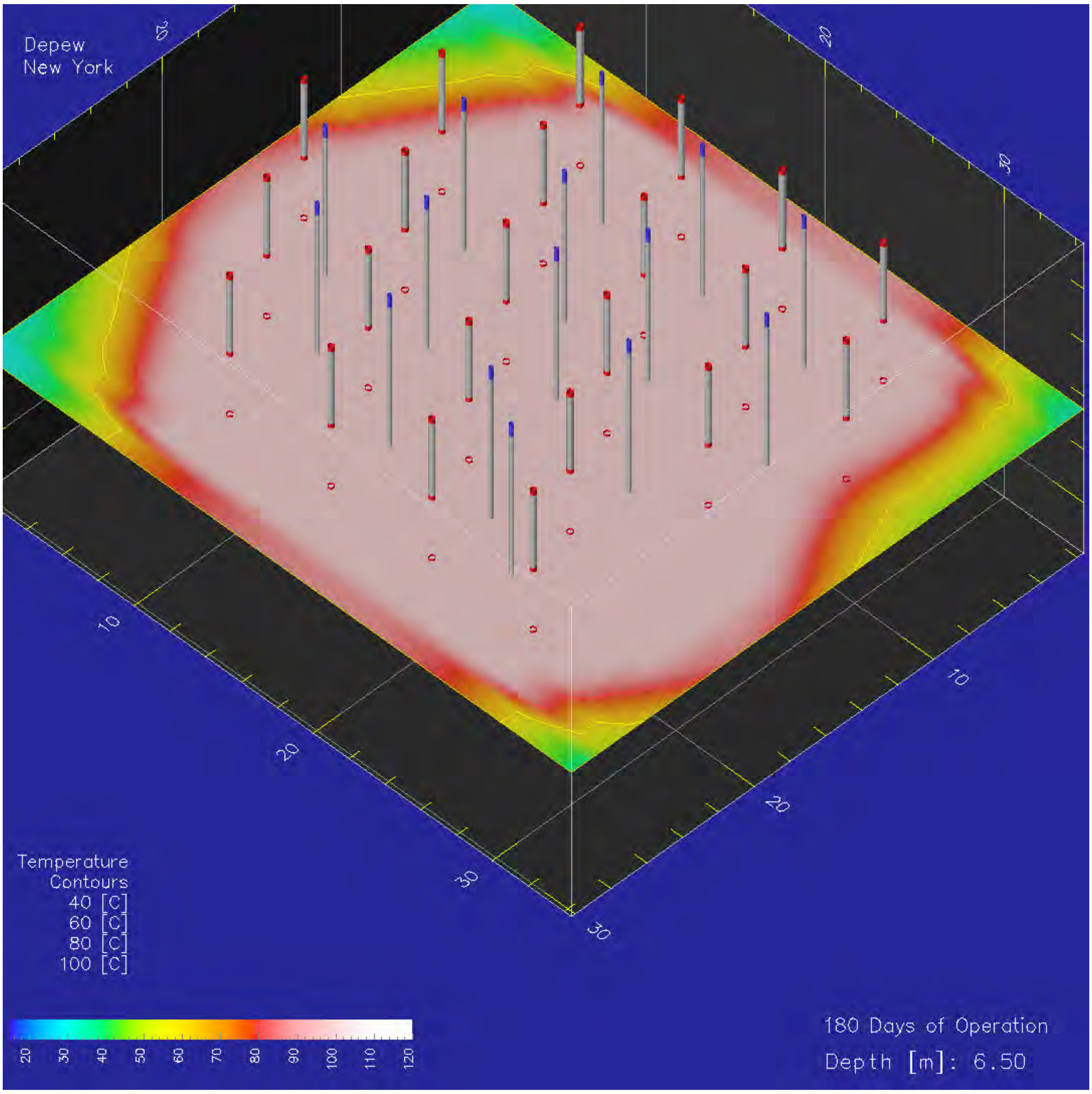

Figure A.13.: Temperature distribution in layer 13 after 180 days.

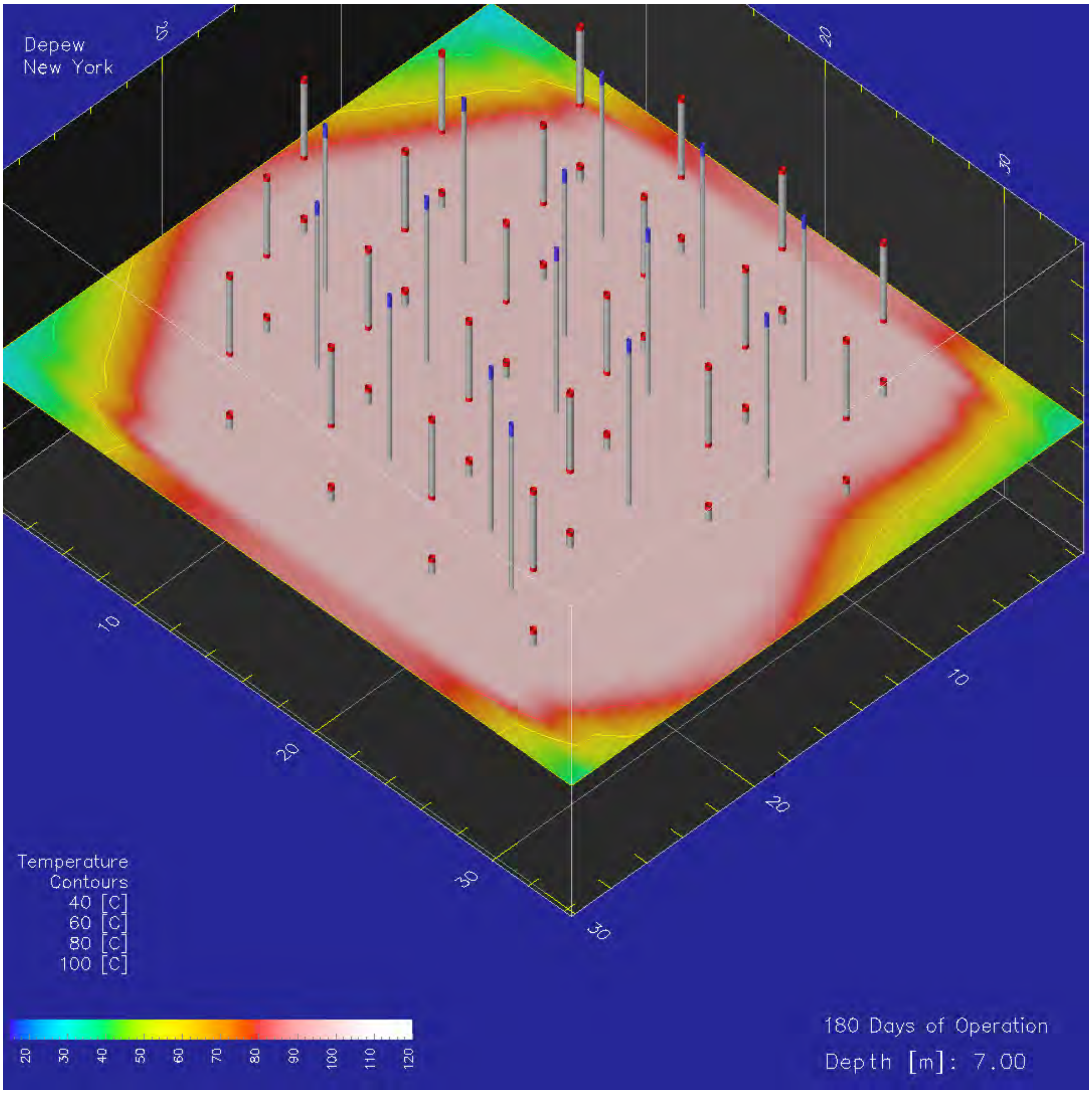

Figure A.14.: Temperature distribution in layer 14 after 180 days.

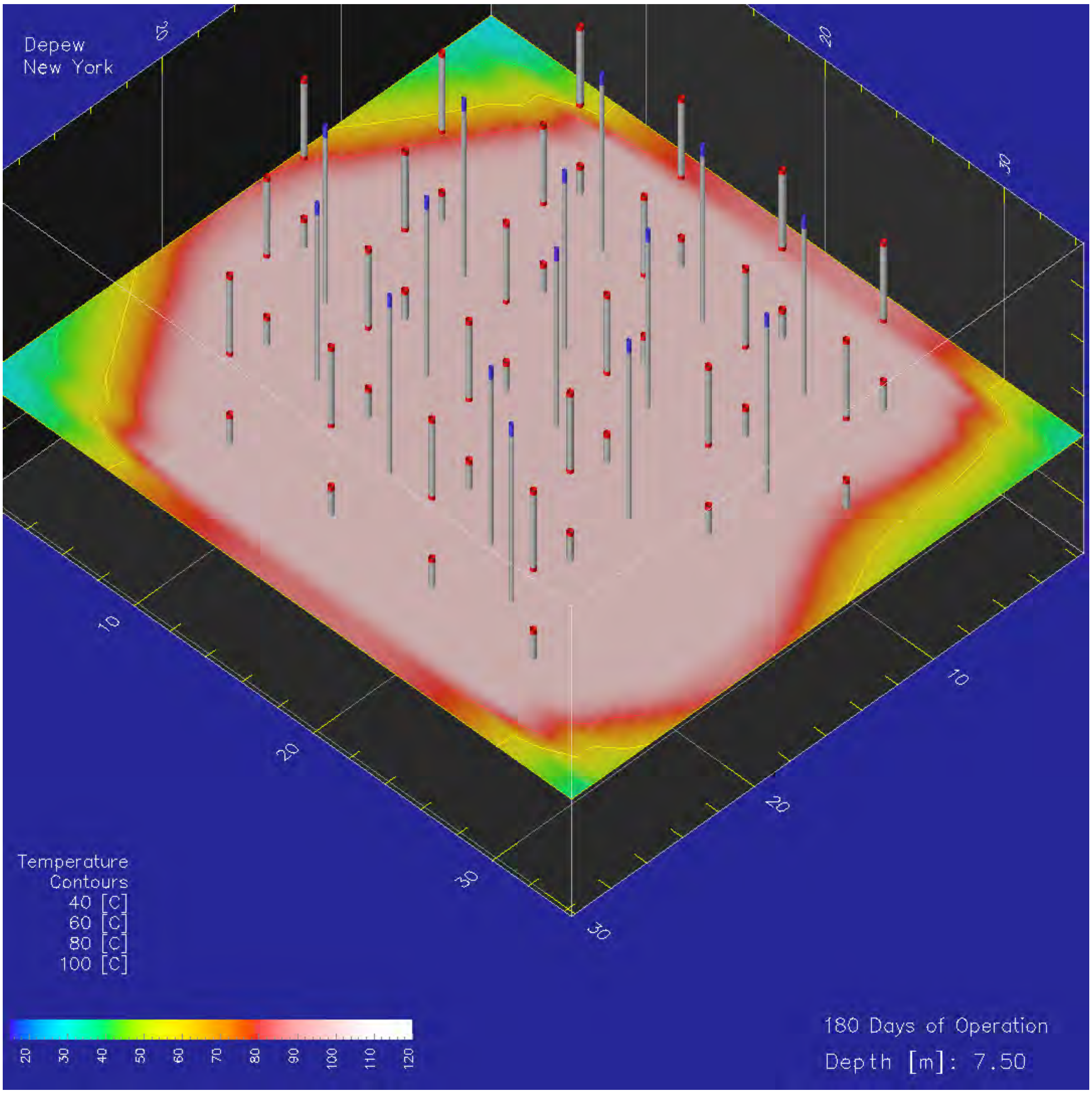

Figure A.15.: Temperature distribution in layer 15 after 180 days.

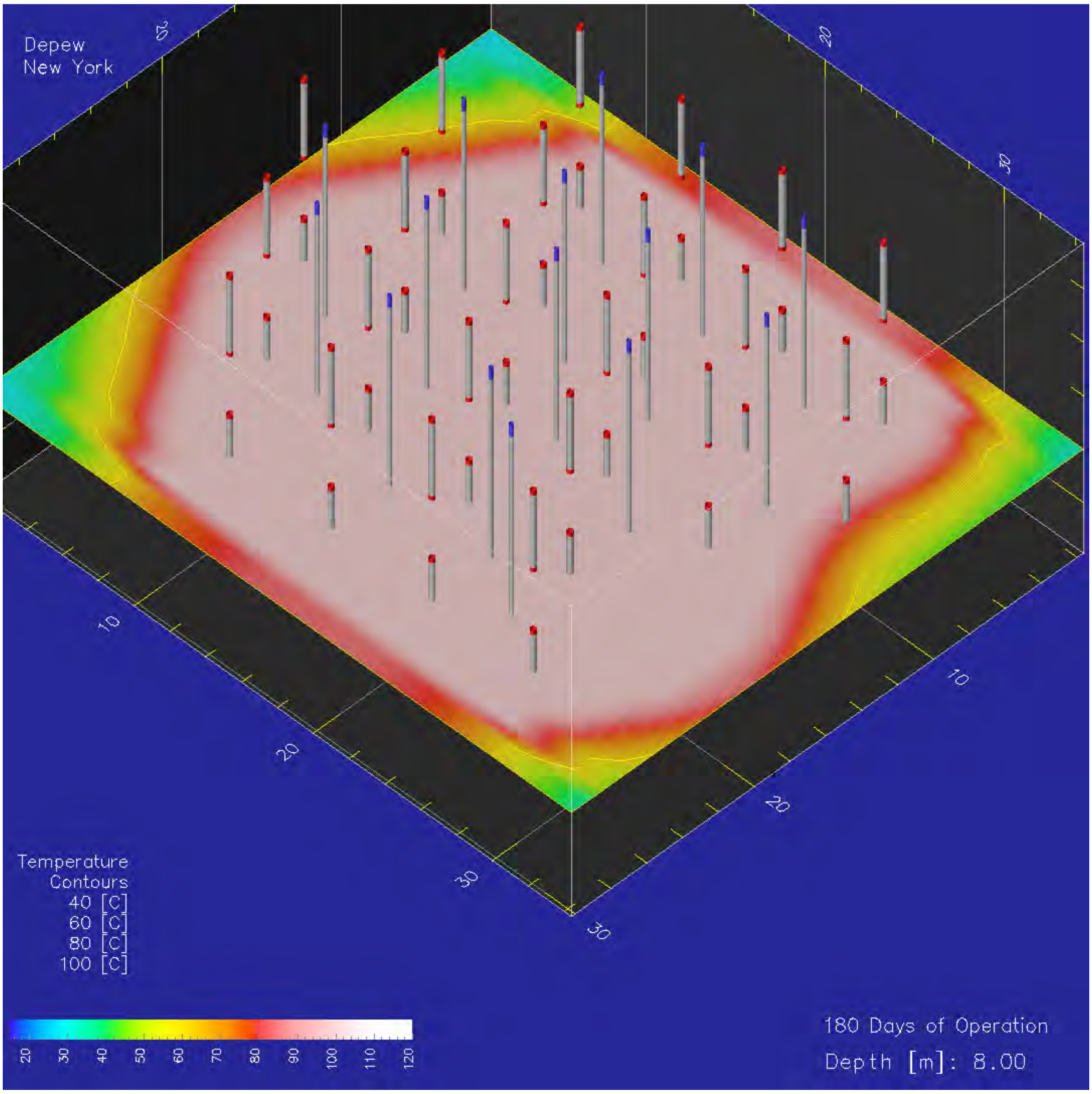

Figure A.16.: Temperature distribution in layer 16 after 180 days.

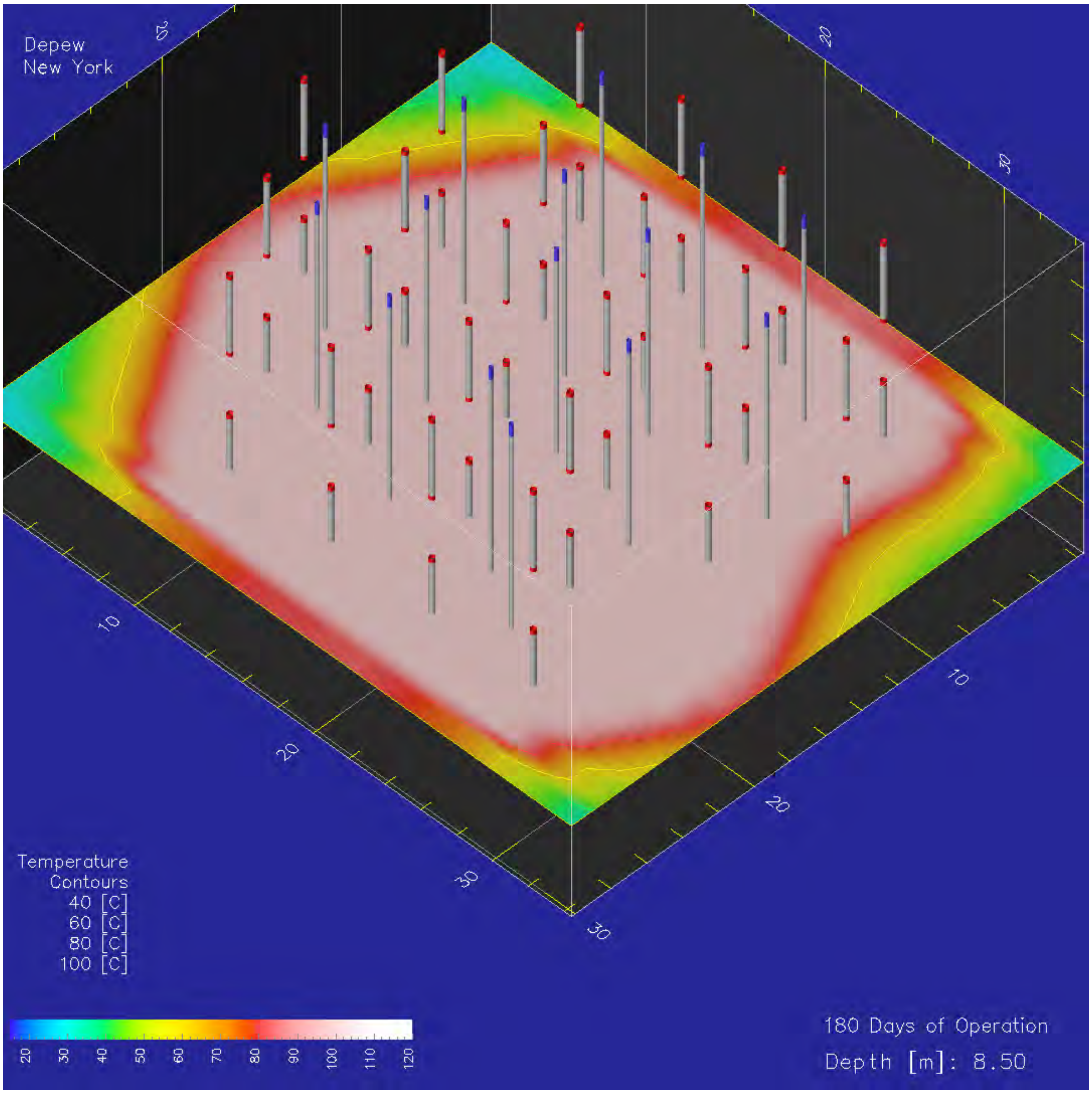

Figure A.17.: Temperature distribution in layer 17 after 180 days.

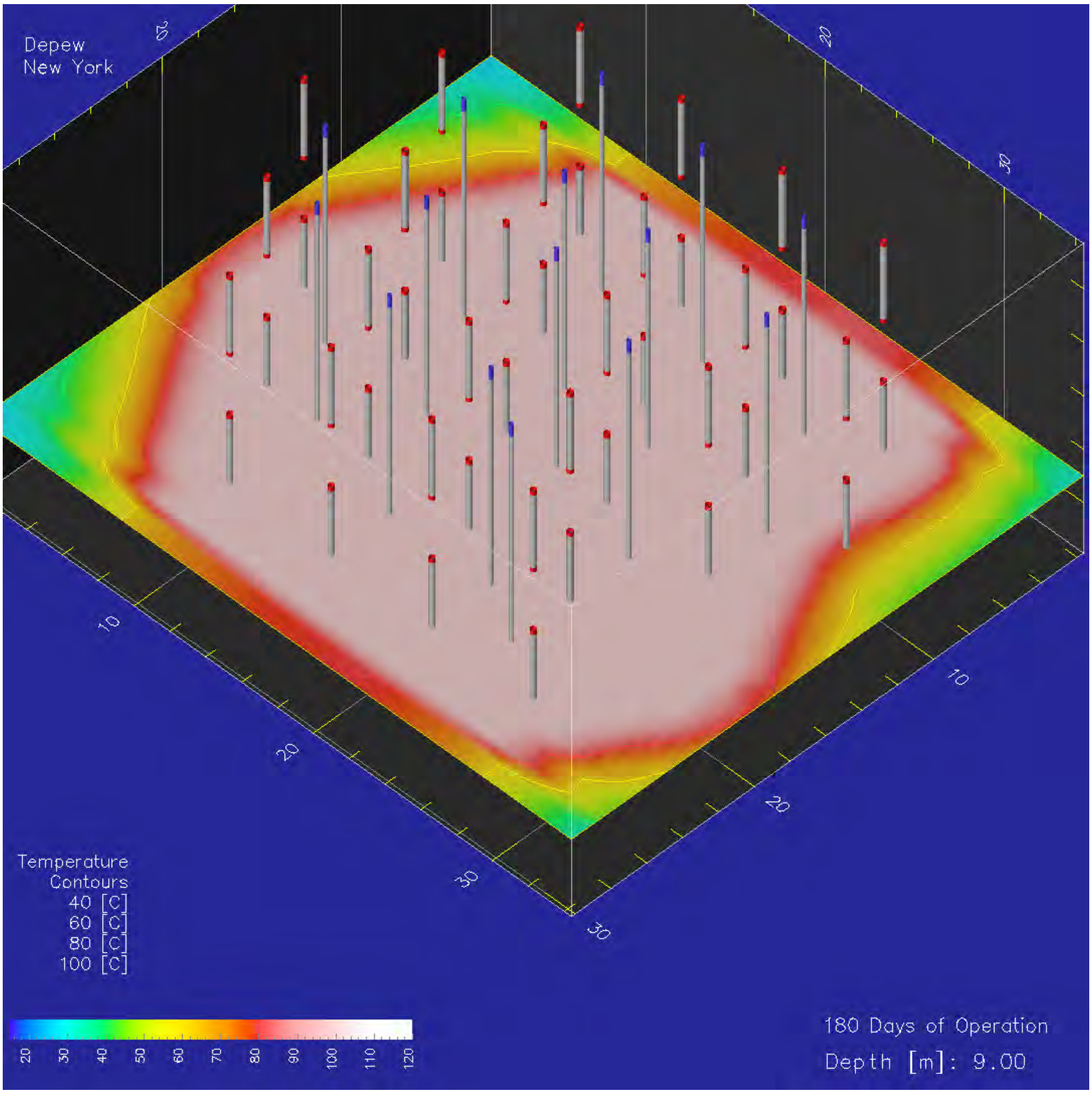

Figure A.18.: Temperature distribution in layer 18 after 180 days.

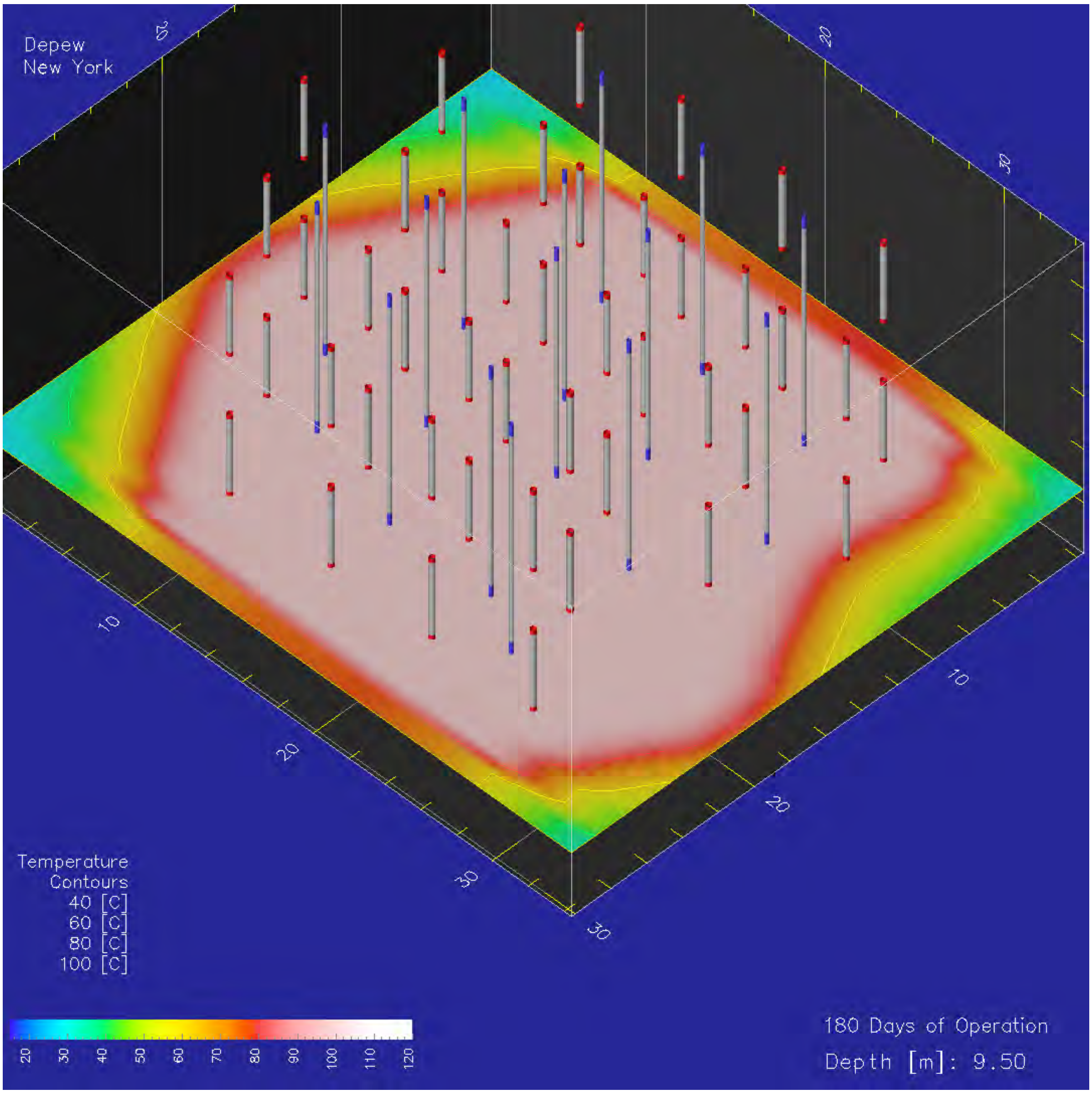

Figure A.19.: Temperature distribution in layer 19 after 180 days.

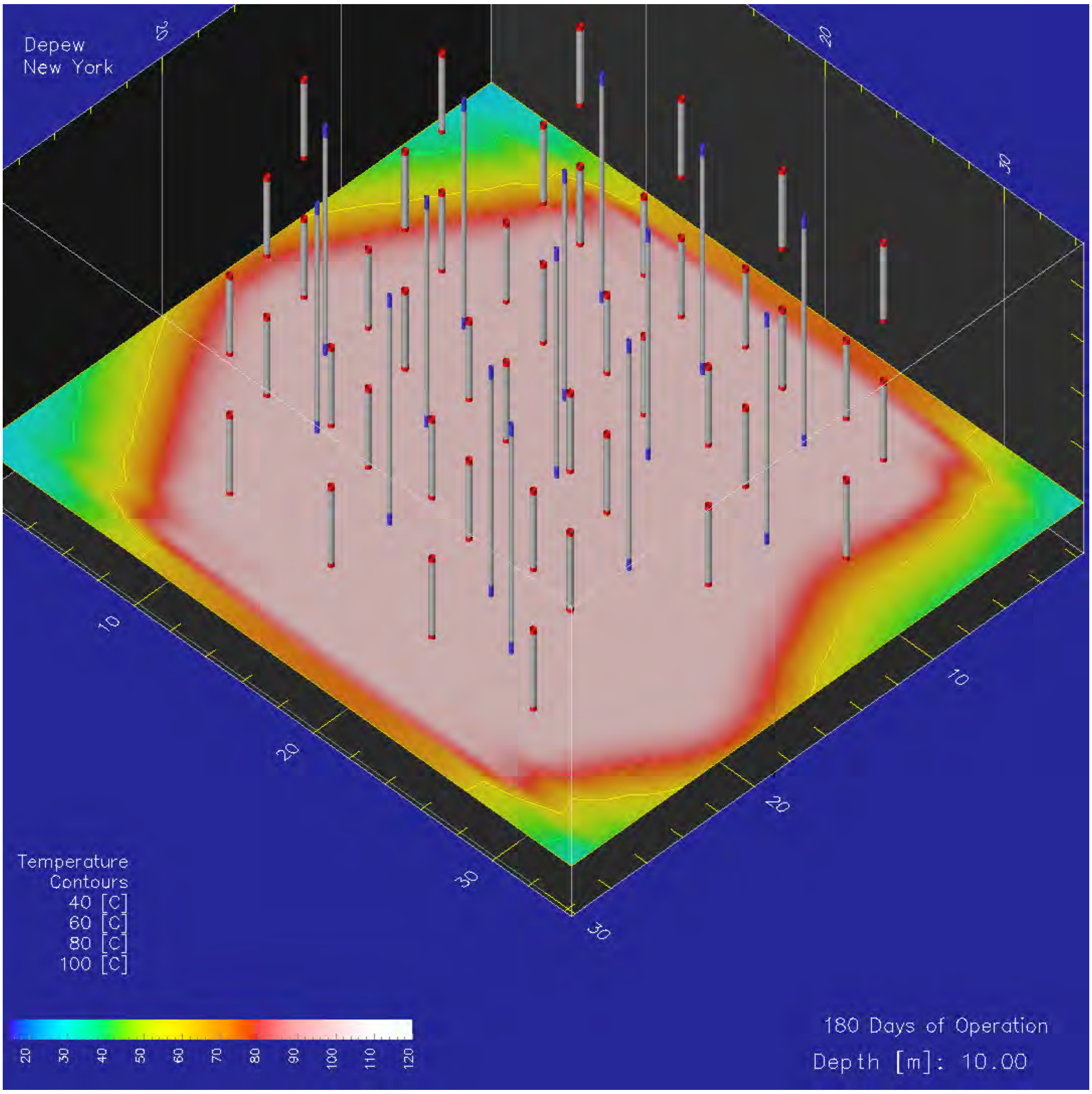

Figure A.20.: Temperature distribution in layer 20 after 180 days.

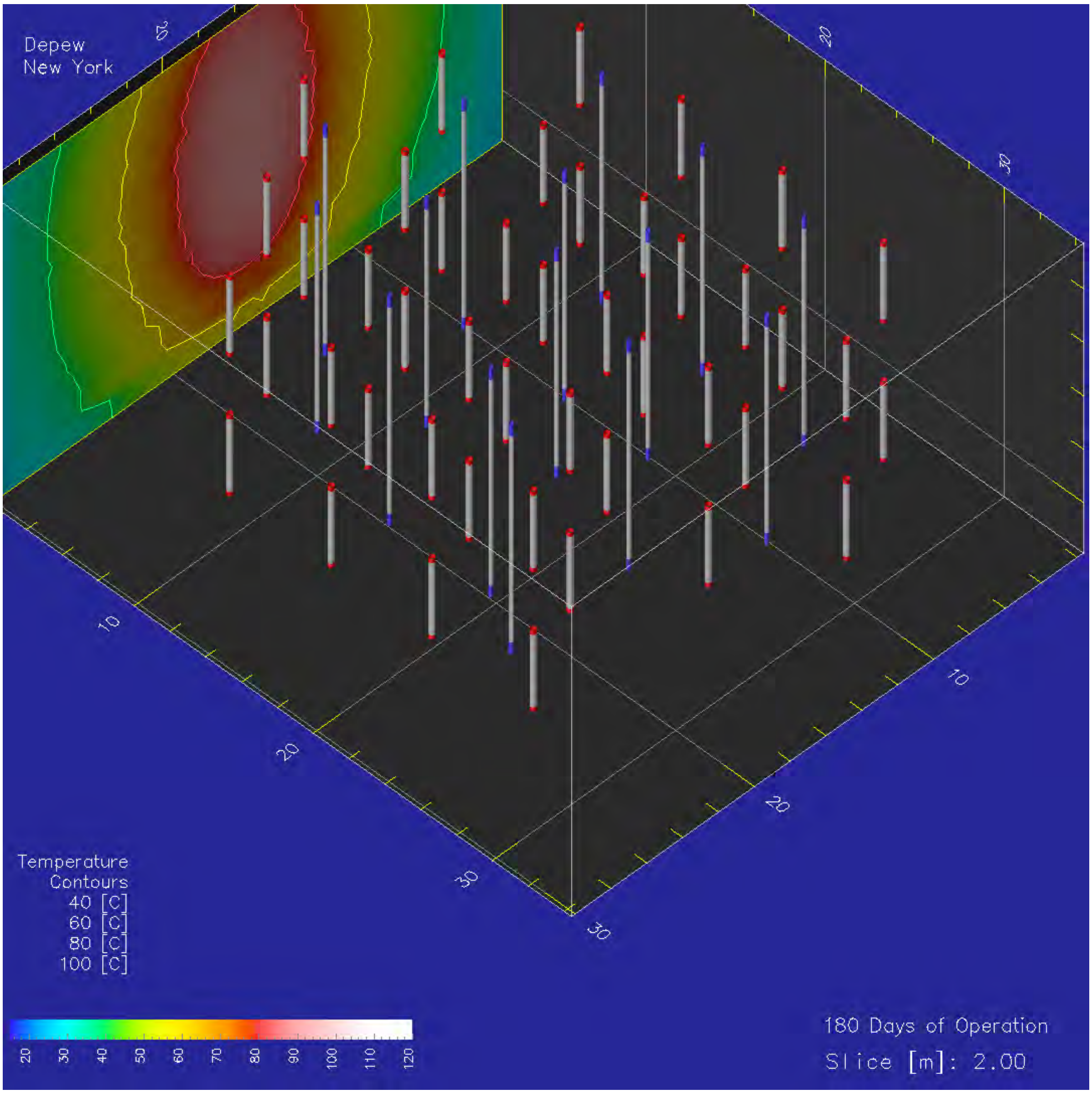

Figure A.21.: Temperature distribution in slice 1 after 180 days.

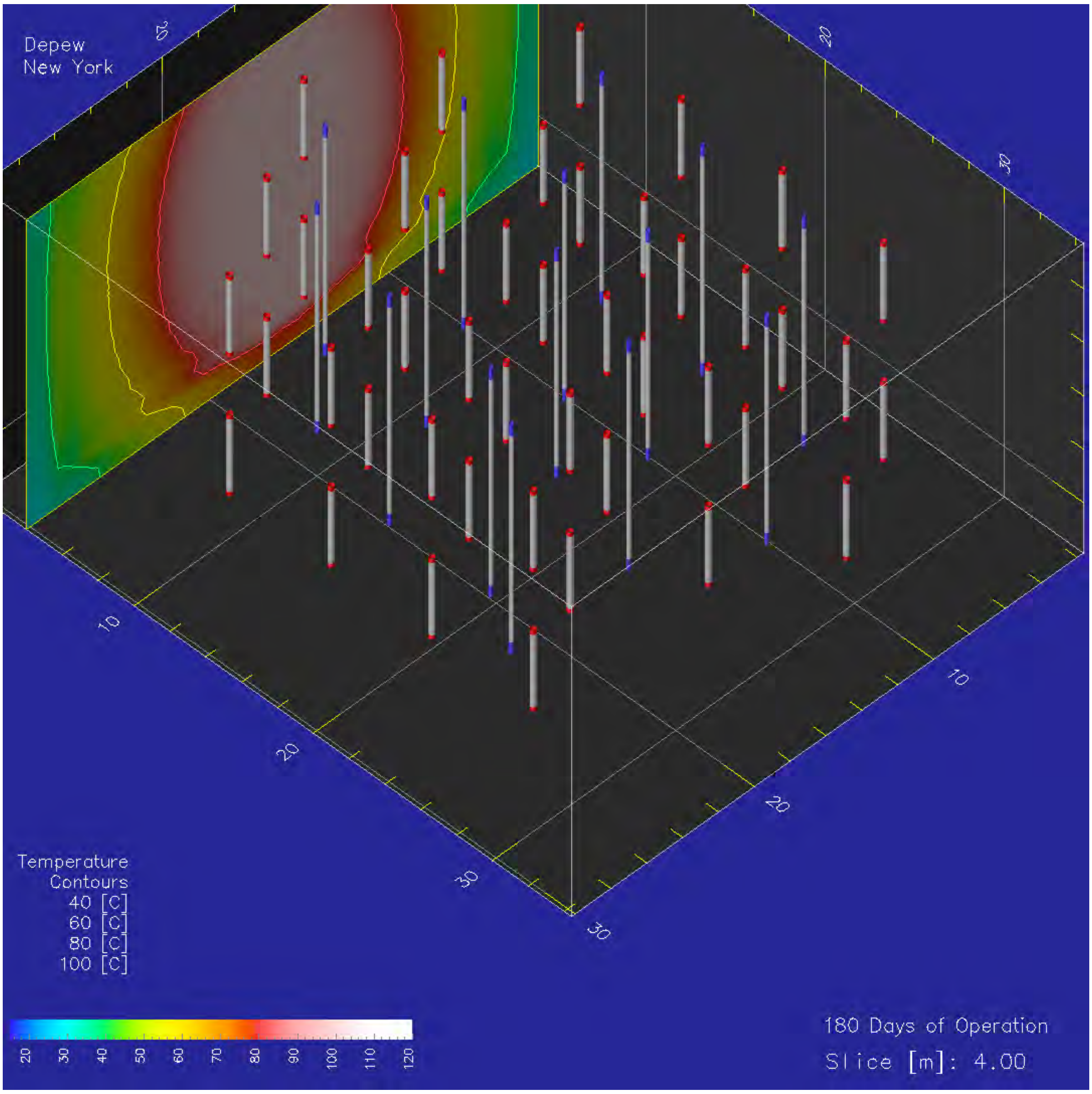

Figure A.22.: Temperature distribution in slice 2 after 180 days.

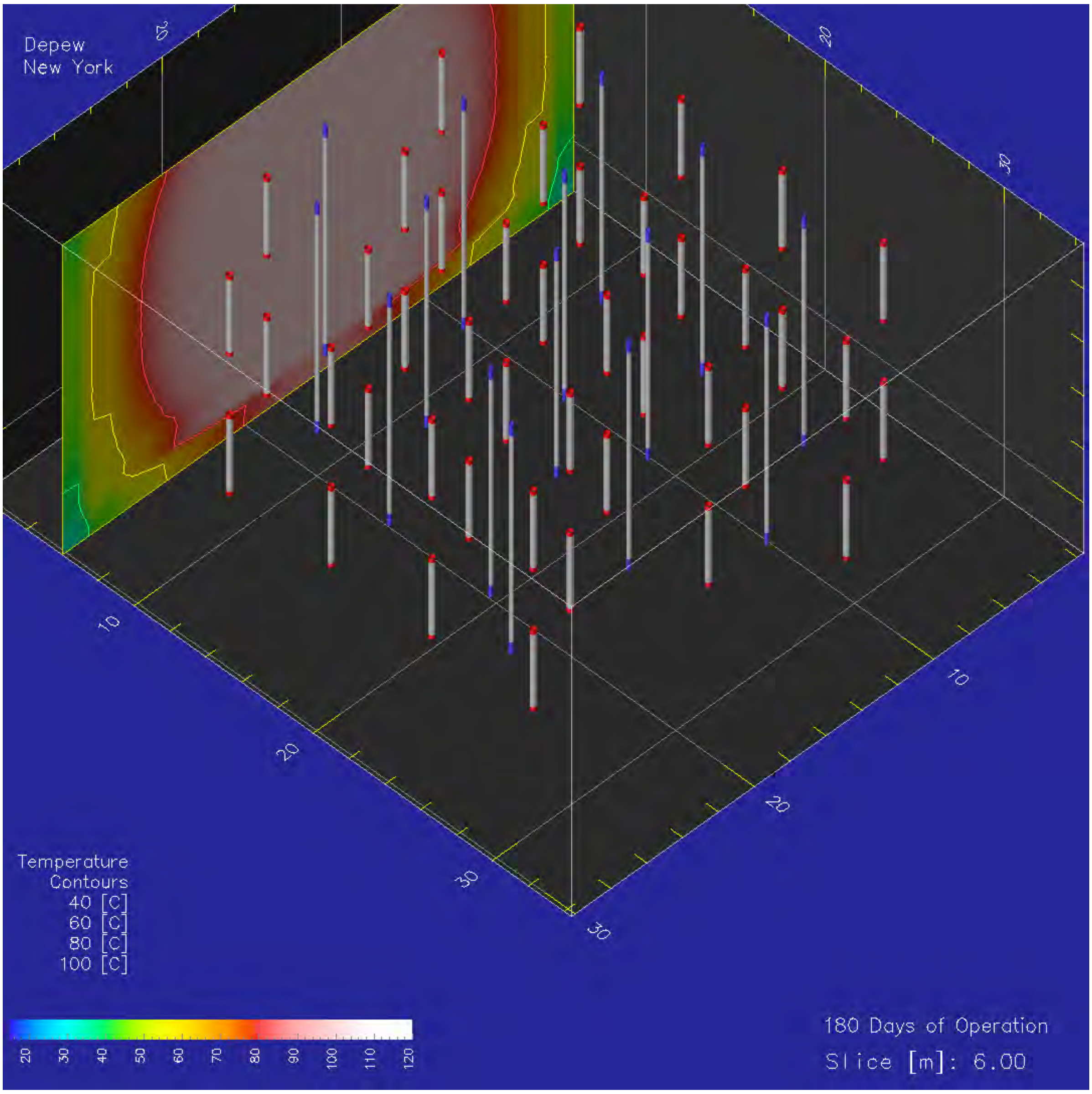

Figure A.23.: Temperature distribution in slice 3 after 180 days.

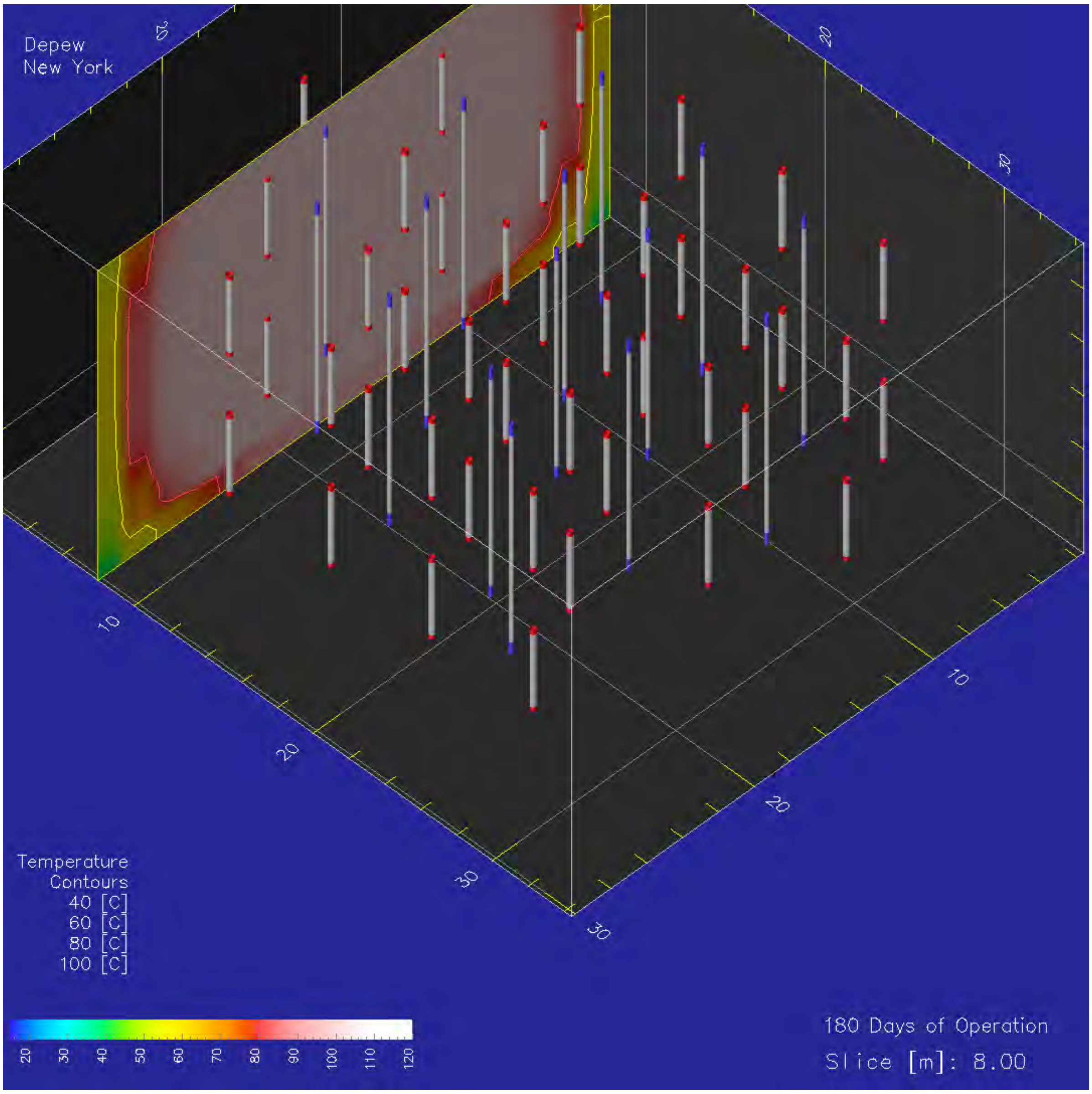

Figure A.24.: Temperature distribution in slice 4 after 180 days.

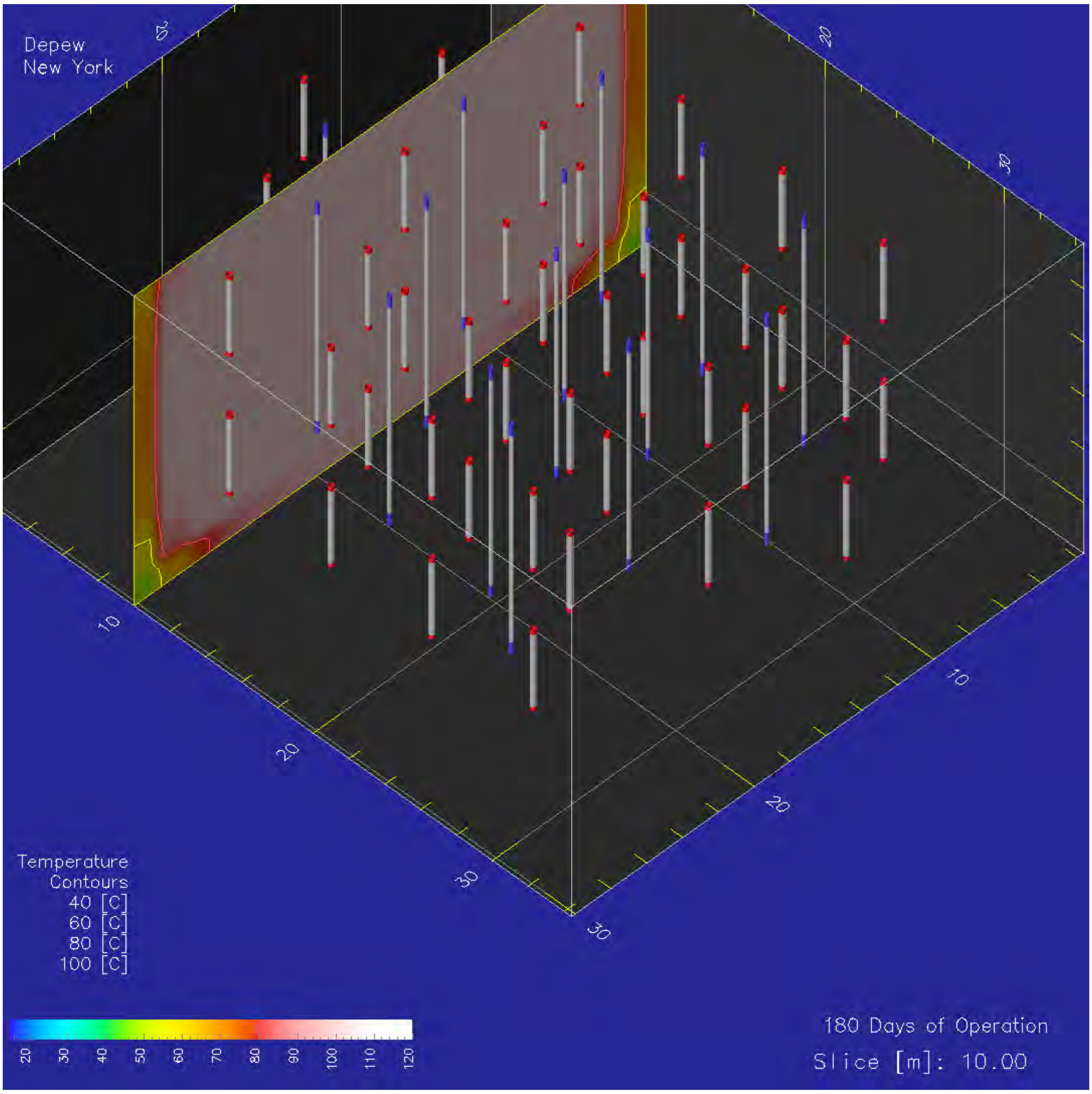

Figure A.25.: Temperature distribution in slice 5 after 180 days.

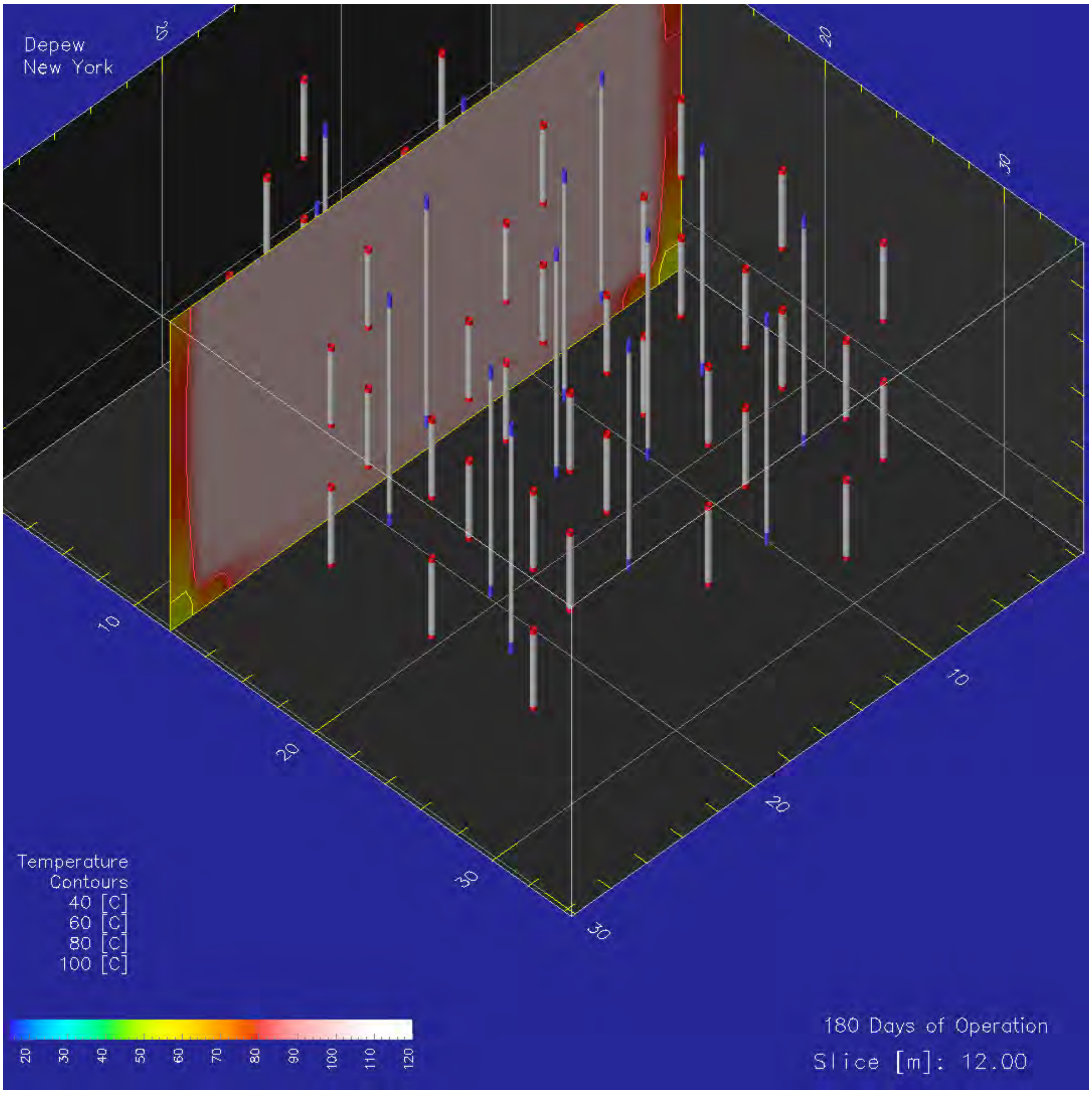

Figure A.26.: Temperature distribution in slice 6 after 180 days.

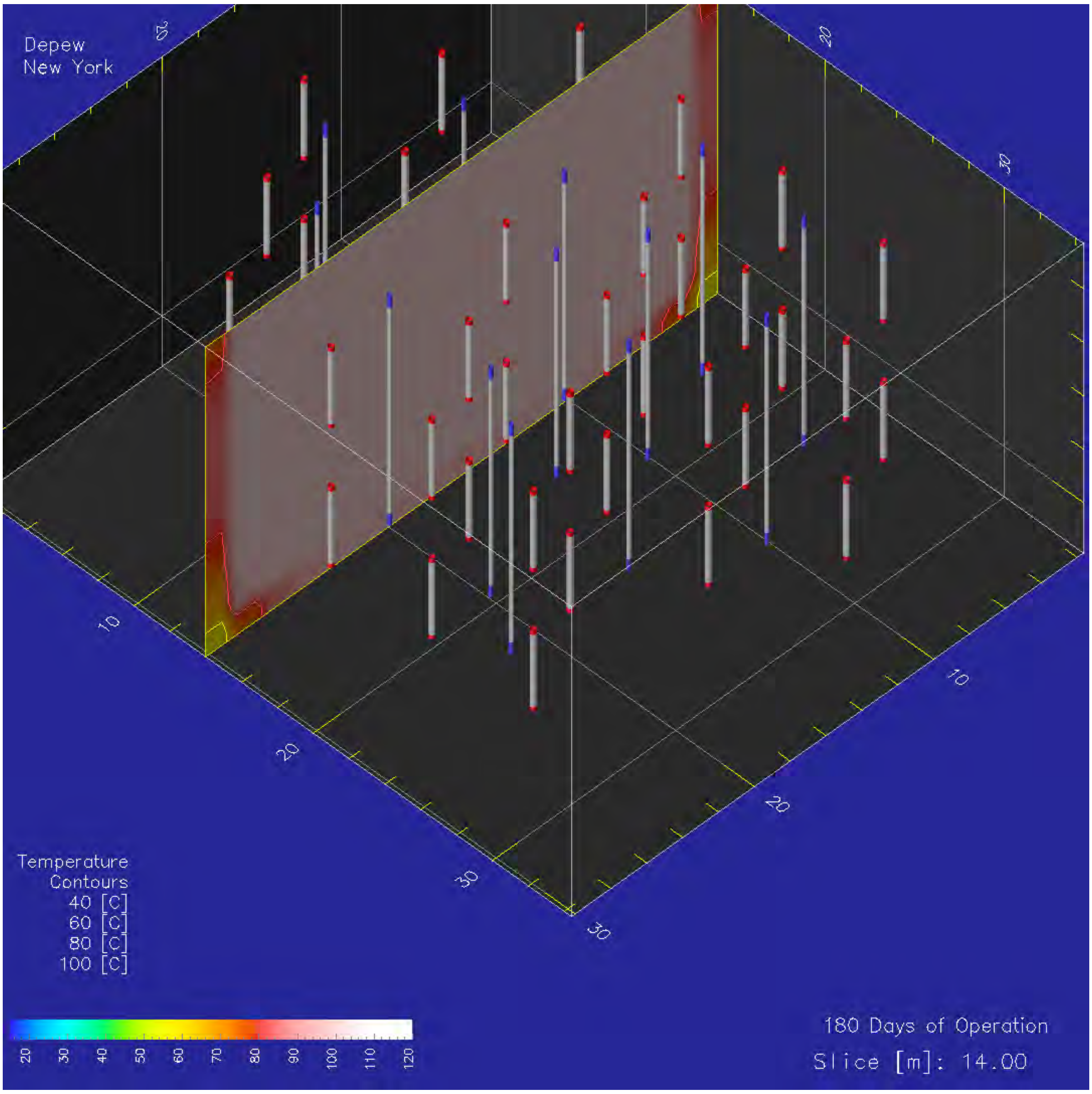

Figure A.27.: Temperature distribution in slice 7 after 180 days.

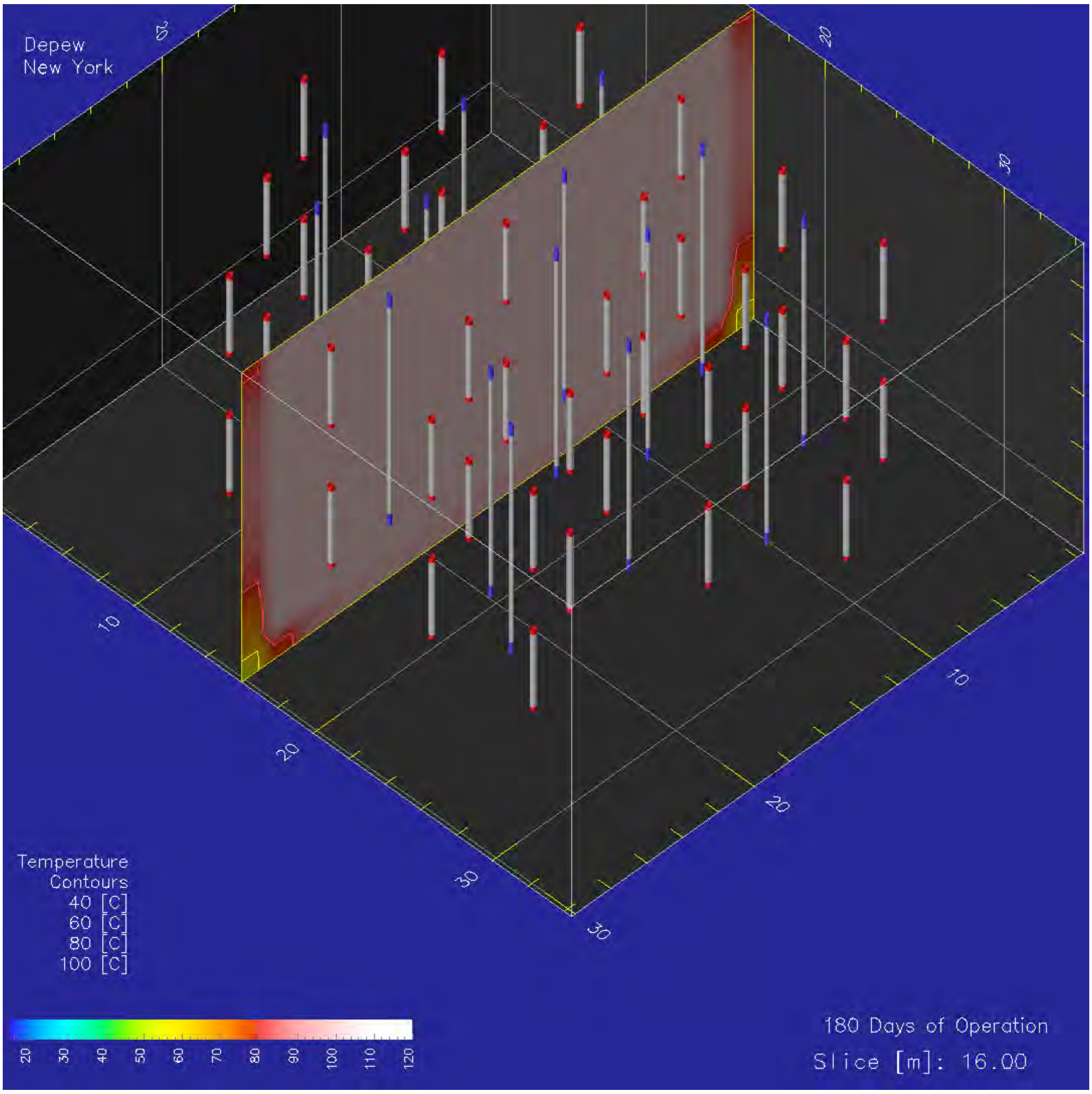

Figure A.28.: Temperature distribution in slice 8 after 180 days.

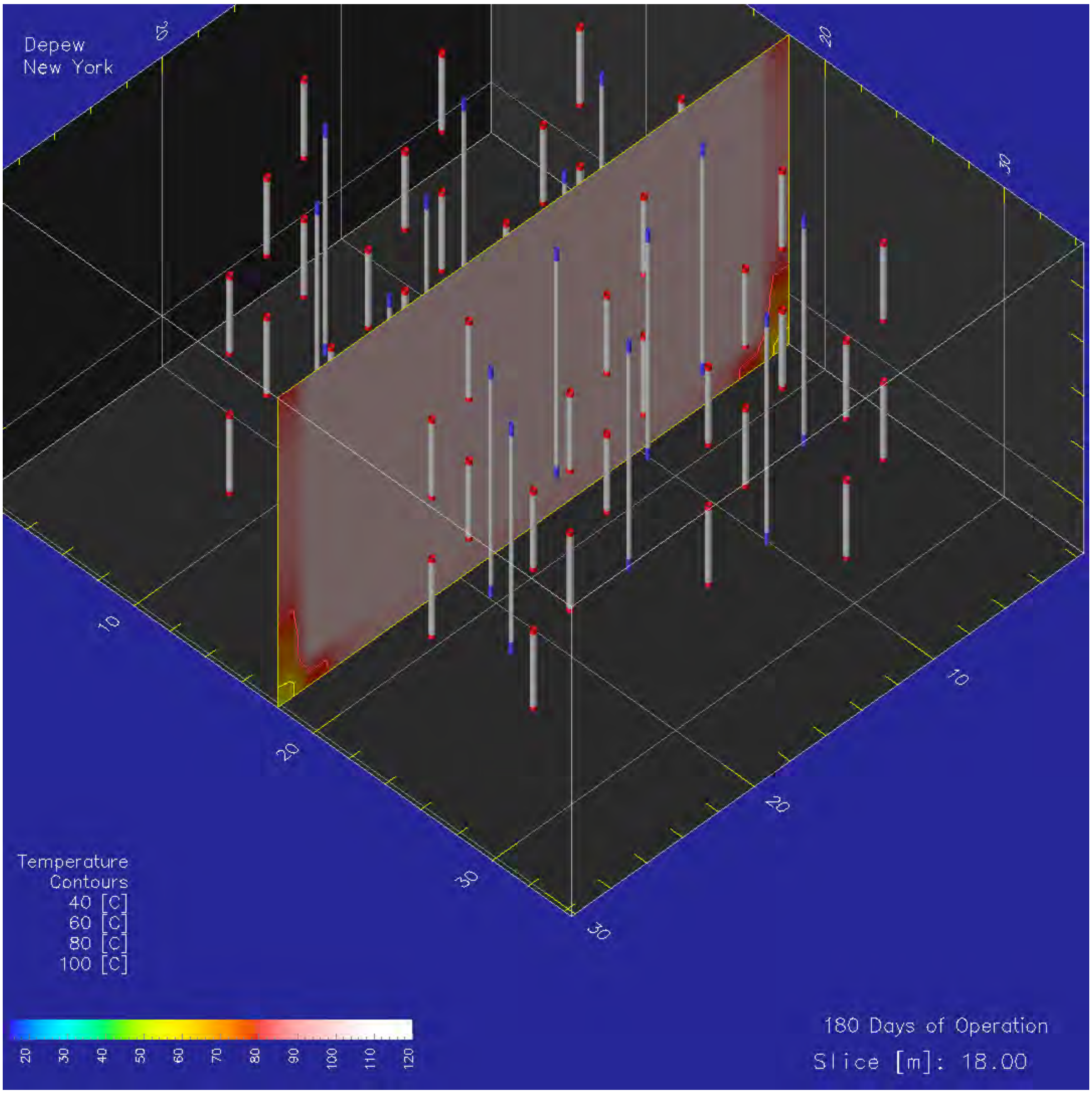

Figure A.29.: Temperature distribution in slice 9 after 180 days.

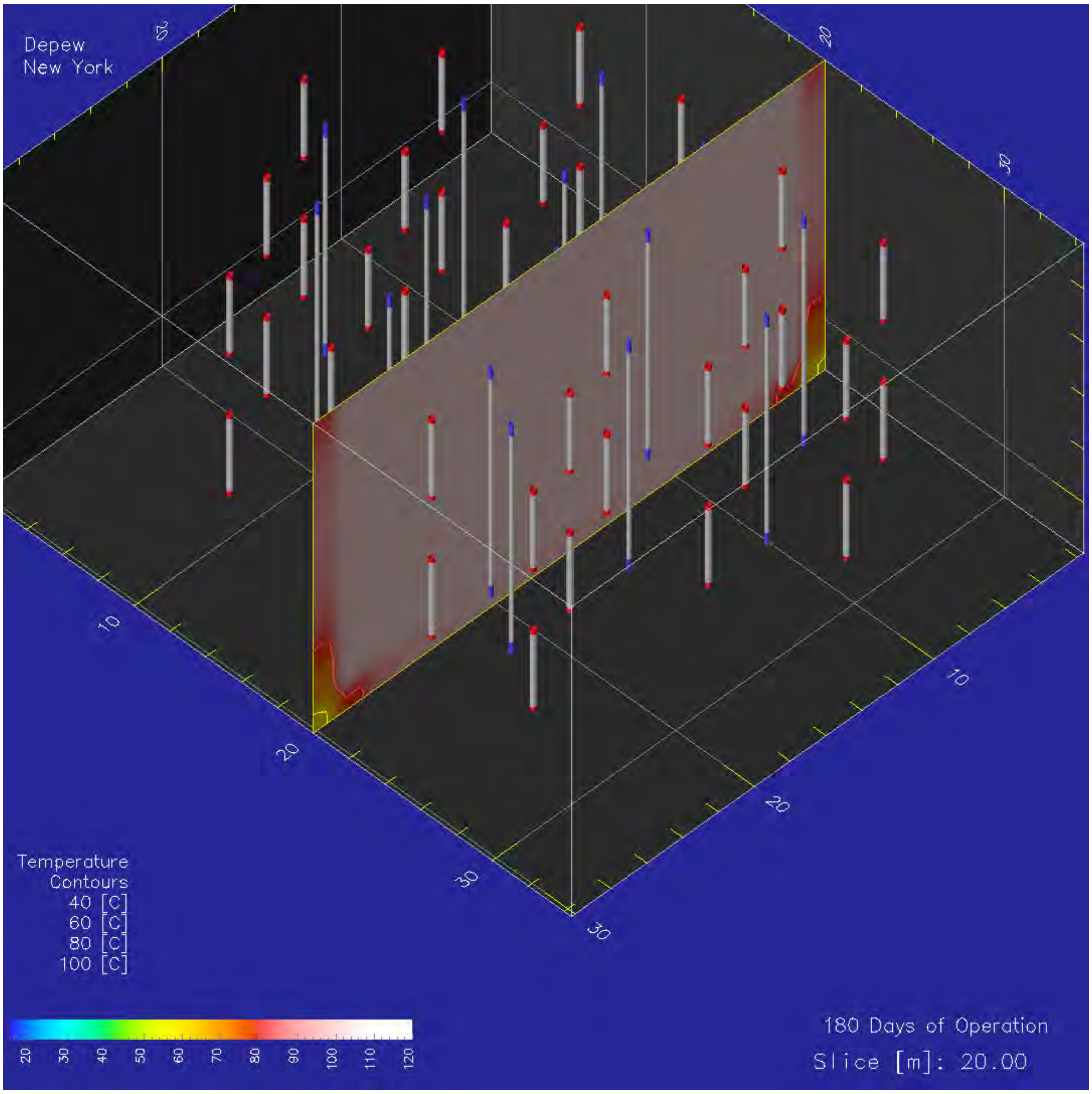

Figure A.30.: Temperature distribution in slice 10 after 180 days.

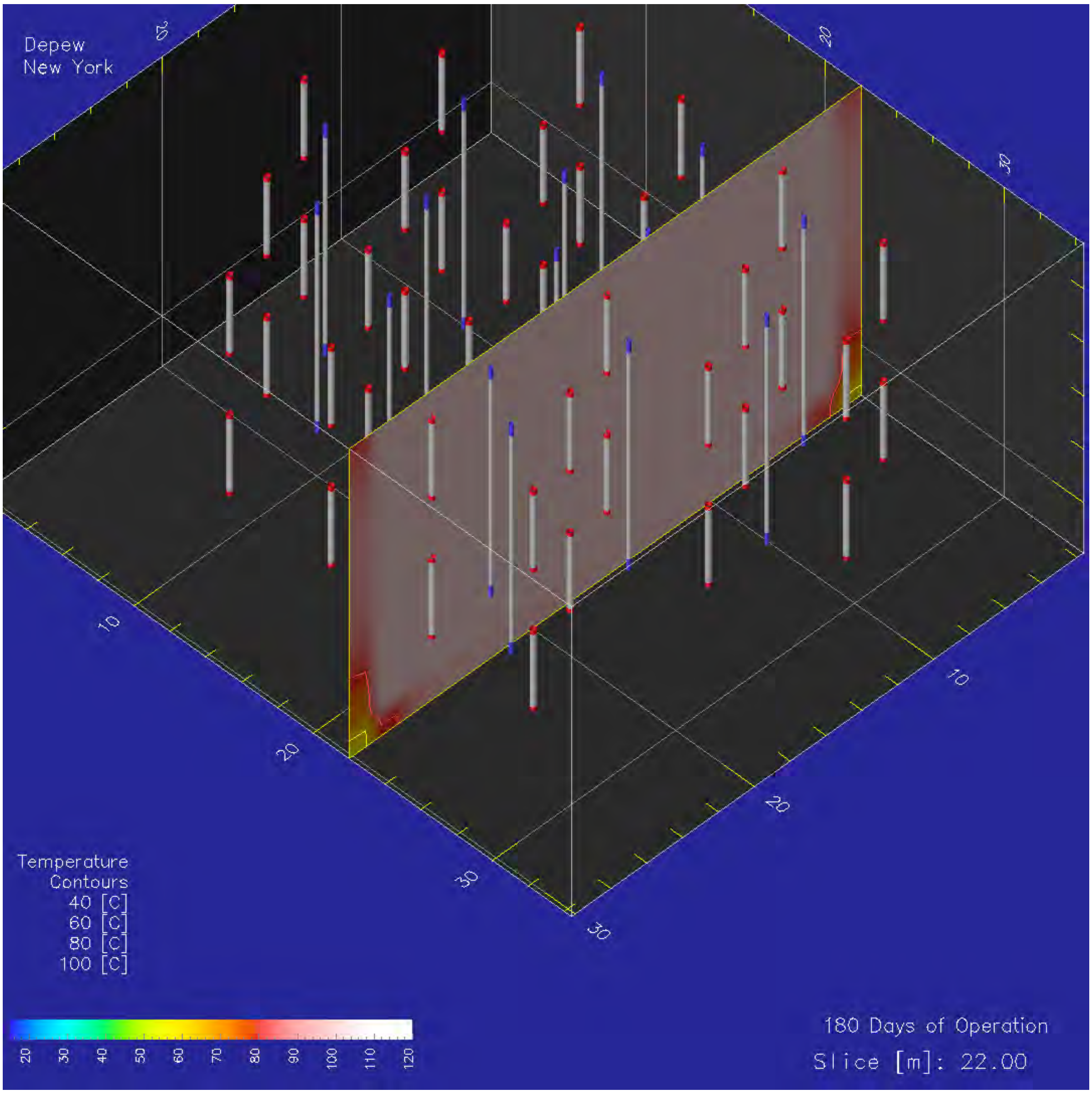

Figure A.31.: Temperature distribution in slice 11 after 180 days.

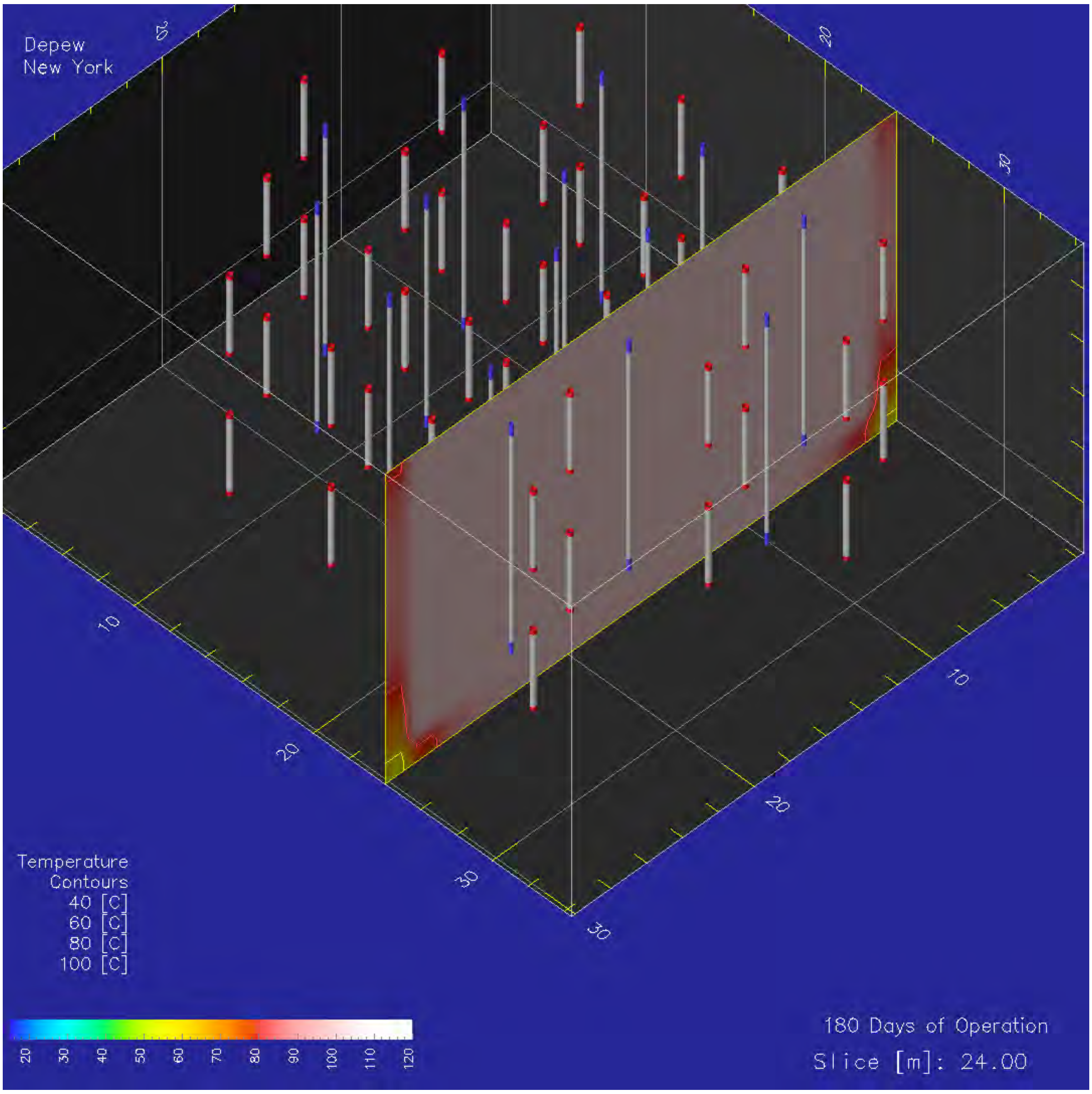

Figure A.32.: Temperature distribution in slice 12 after 180 days.

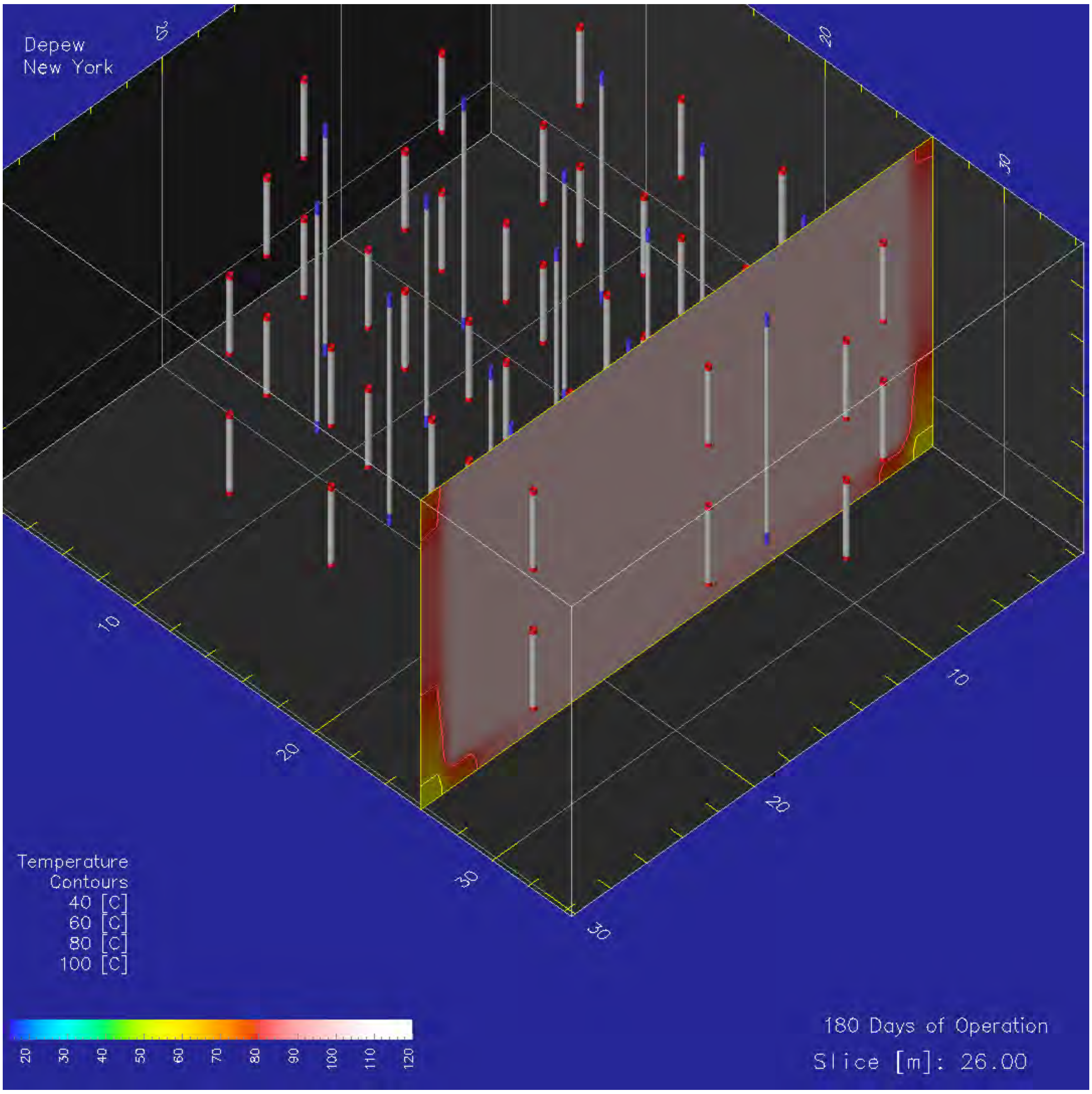

Figure A.33.: Temperature distribution in slice 13 after 180 days.

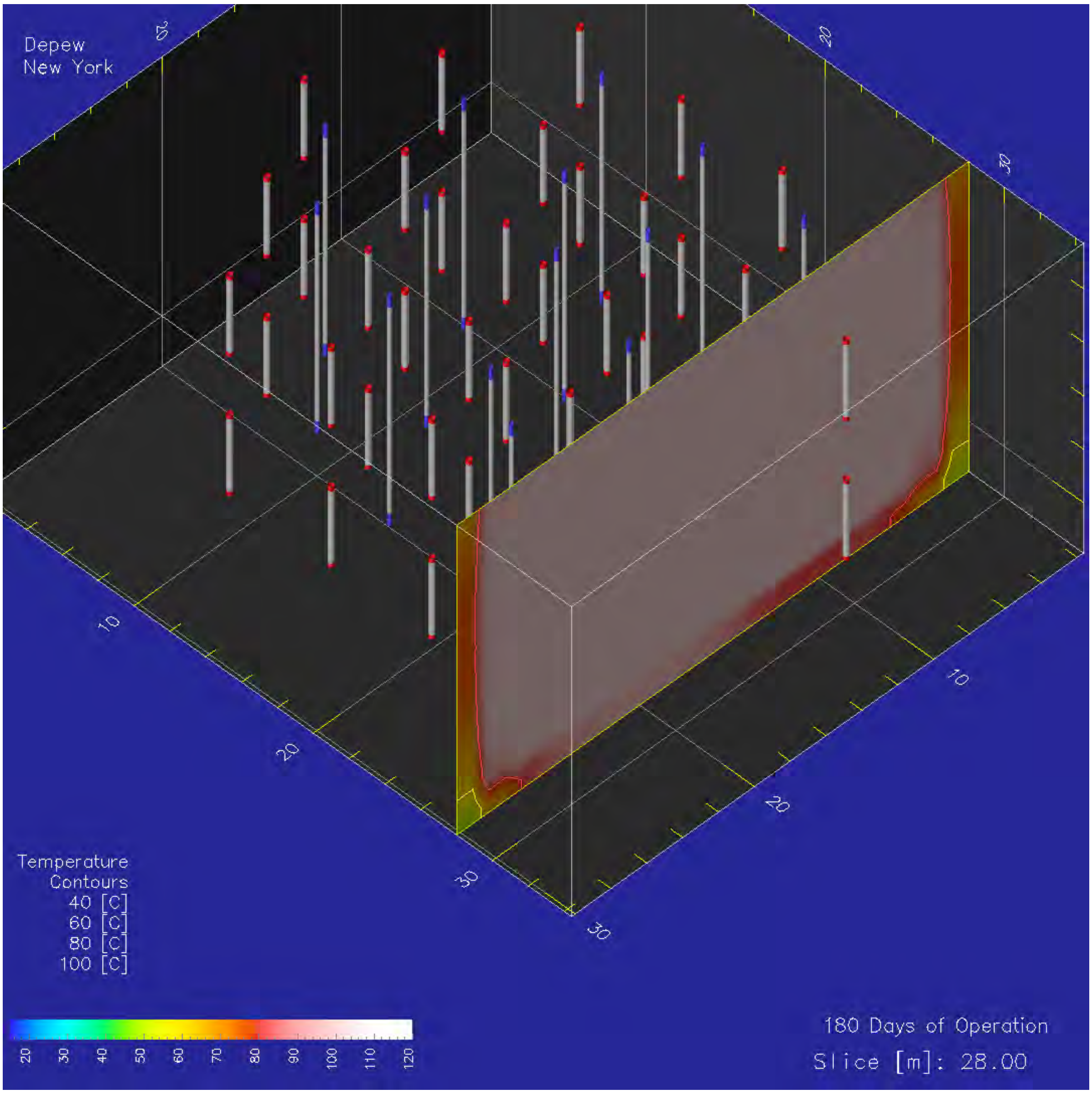

Figure A.34.: Temperature distribution in slice 14 after 180 days.

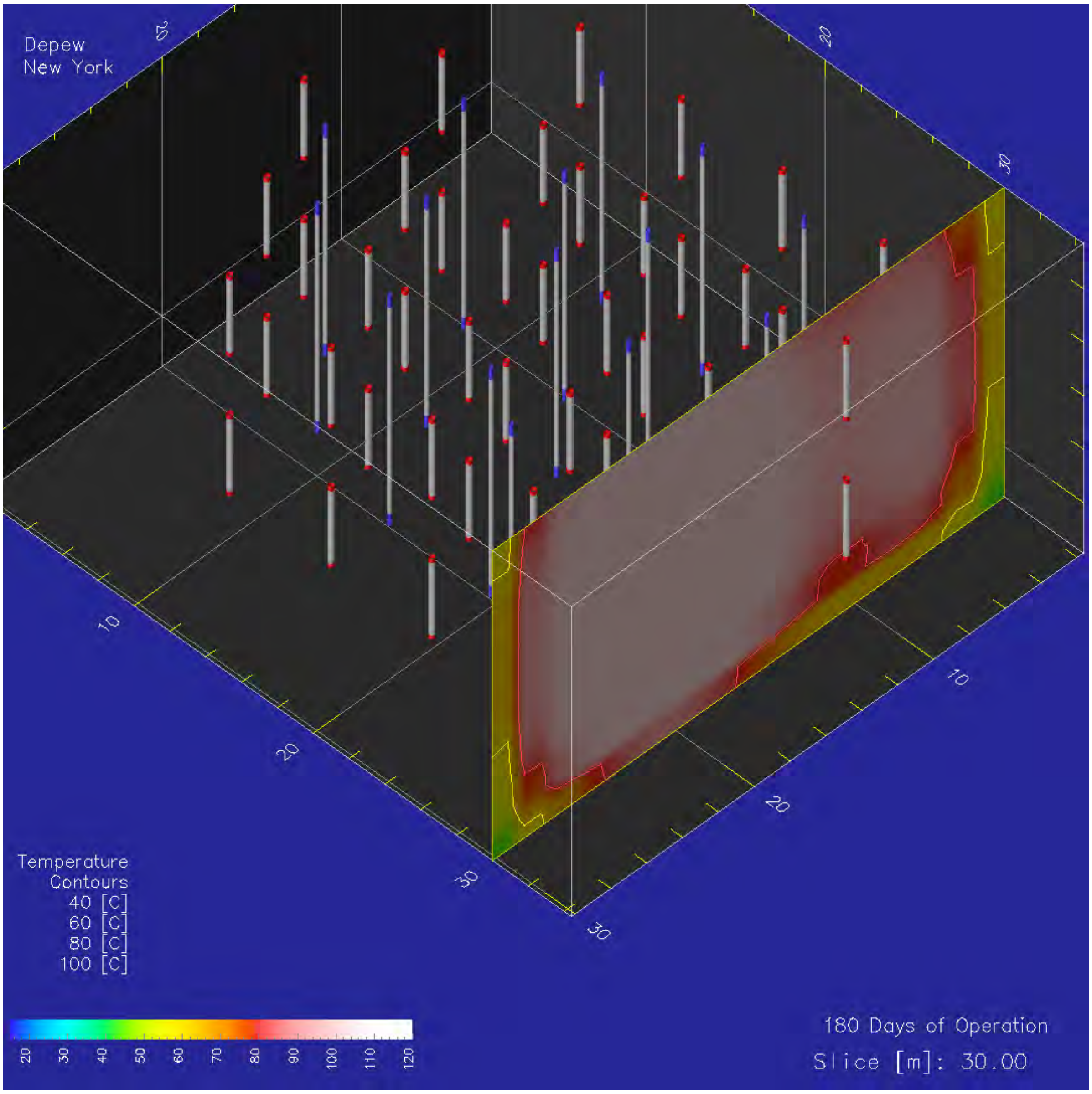

Figure A.35.: Temperature distribution in slice 15 after 180 days.

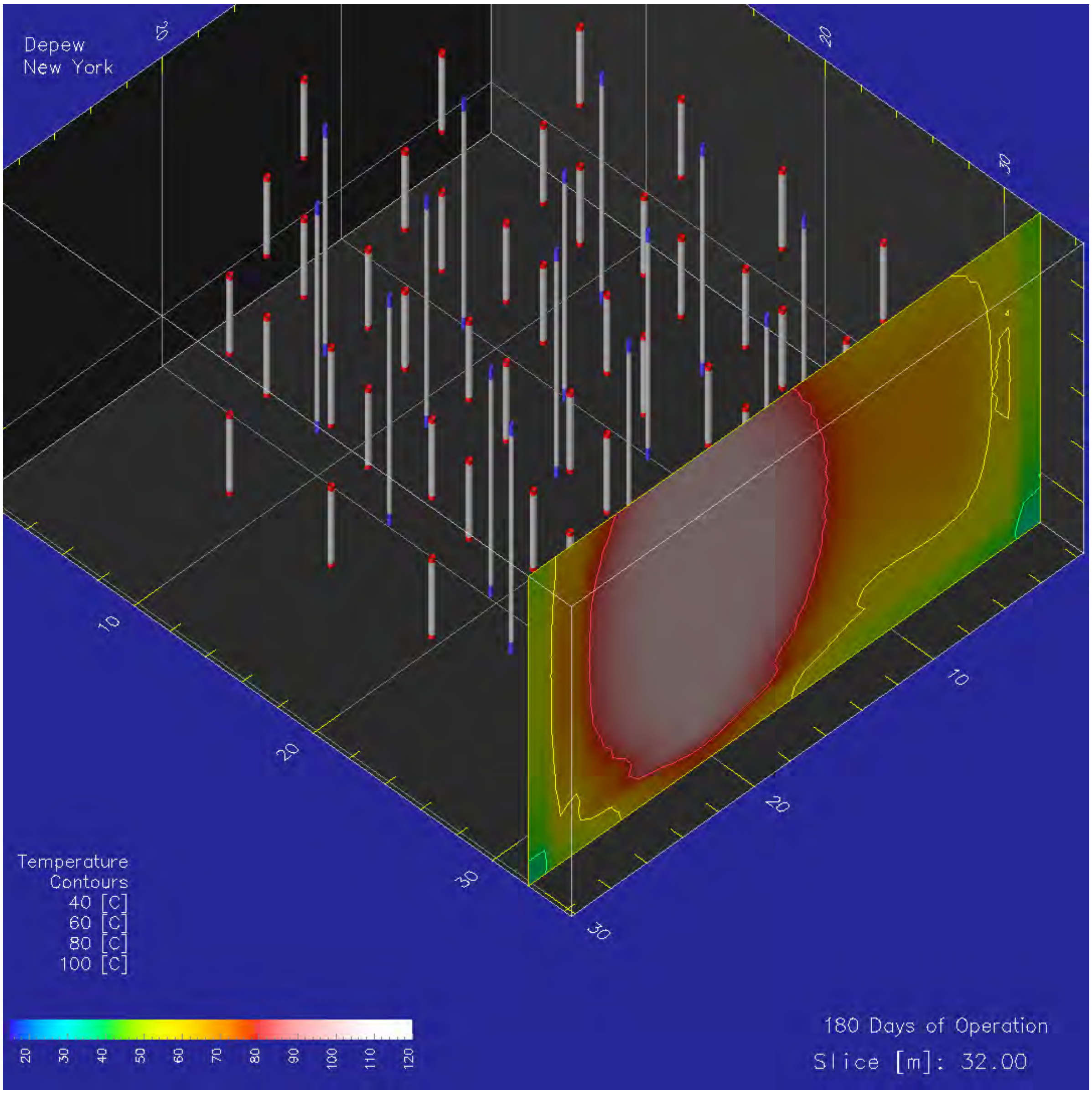

Figure A.36.: Temperature distribution in slice 16 after 180 days.

B

Well-field Well Locations

DPM1 Well Summary						
Well		*Location [m]*		*Depth [m]*	*Length*	*Completion*
Name	*Type*	*x*	*y*	*z*	*[m]*	*Code*
'E001-U'	Electrode	0.00	0.00	1.52	3.05	1
'E002-U'	Electrode	5.64	0.00	1.52	3.05	1
'E003-U'	Electrode	11.28	0.00	1.52	3.05	1
'E004-U'	Electrode	16.92	0.00	1.52	3.05	1
'E005-U'	Electrode	-2.82	4.88	1.52	3.05	1
'E006-U'	Electrode	2.82	4.88	1.52	3.05	1
'E007-U'	Electrode	8.46	4.88	1.52	3.05	1
'E008-U'	Electrode	14.10	4.88	1.52	3.05	1
'E009-U'	Electrode	19.74	4.88	1.52	3.05	1
'E010-U'	Electrode	-5.64	9.77	1.52	3.05	1
'E011-U'	Electrode	0.00	9.77	1.52	3.05	1
'E012-U'	Electrode	5.64	9.77	1.52	3.05	1
'E013-U'	Electrode	11.28	9.77	1.52	3.05	1
'E014-U'	Electrode	16.92	9.77	1.52	3.05	1
'E015-U'	Electrode	-2.82	14.65	1.52	3.05	1
'E016-U'	Electrode	2.82	14.65	1.52	3.05	1
'E017-U'	Electrode	8.46	14.65	1.52	3.05	1
'E018-U'	Electrode	14.10	14.65	1.52	3.05	1
'E019-U'	Electrode	0.00	19.53	1.52	3.05	1
'E020-U'	Electrode	5.64	19.53	1.52	3.05	1
'E021-U'	Electrode	11.28	19.53	1.52	3.05	1
'E022-U'	Electrode	16.92	19.53	1.52	3.05	1
'E001-L'	Electrode	0.00	0.00	6.71	3.05	1
'E002-L'	Electrode	5.64	0.00	6.71	3.05	1
'E003-L'	Electrode	11.28	0.00	6.71	3.05	1
'E004-L'	Electrode	16.92	0.00	6.71	3.05	1
'E005-L'	Electrode	-2.82	4.88	6.71	3.05	1
'E006-L'	Electrode	2.82	4.88	6.71	3.05	1
'E007-L'	Electrode	8.46	4.88	6.71	3.05	1
'E008-L'	Electrode	14.10	4.88	6.71	3.05	1
'E009-L'	Electrode	19.74	4.88	6.71	3.05	1
'E010-L'	Electrode	-5.64	9.77	6.71	3.05	1
'E011-L'	Electrode	0.00	9.77	6.71	3.05	1
'E012-L'	Electrode	5.64	9.77	6.71	3.05	1
'E013-L'	Electrode	11.28	9.77	6.71	3.05	1
'E014-L'	Electrode	16.92	9.77	6.71	3.05	1
'E015-L'	Electrode	-2.82	14.65	6.71	3.05	1
'E016-L'	Electrode	2.82	14.65	6.71	3.05	1
'E017-L'	Electrode	8.46	14.65	6.71	3.05	1
'E018-L'	Electrode	14.10	14.65	6.71	3.05	1

table continued on next page

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DPM1 Well Summary						
Well		*Location [m]*		*Depth [m]*	*Length*	*Completion*
Name	*Type*	*x*	*y*	*z*	*[m]*	*Code*
'E019-L'	Electrode	0.00	19.53	6.71	3.05	1
'E020-L'	Electrode	5.64	19.53	6.71	3.05	1
'E021-L'	Electrode	11.28	19.53	6.71	3.05	1
'E022-L'	Electrode	16.92	19.53	6.71	3.05	1
'X01'	Extraction	2.82	1.62	0.91	8.84	0
'X02'	Extraction	8.46	1.62	0.91	8.84	0
'X03'	Extraction	14.10	1.62	0.91	8.84	0
'X04'	Extraction	0.00	6.50	0.91	8.84	0
'X05'	Extraction	5.64	6.50	0.91	8.84	0
'X06'	Extraction	11.28	6.50	0.91	8.84	0
'X07'	Extraction	16.92	6.50	0.91	8.84	0
'X08'	Extraction	8.46	9.77	0.91	8.84	0
'X09'	Extraction	-2.82	11.38	0.91	8.84	0
'X10'	Extraction	2.82	11.38	0.91	8.84	0
'X11'	Extraction	14.10	11.38	0.91	8.84	0
'X12'	Extraction	0.00	14.65	0.91	8.84	0
'X13'	Extraction	5.64	16.27	0.91	8.84	0
'X14'	Extraction	11.28	16.27	0.91	8.84	0
'X15'	Extraction	14.10	17.92	0.91	8.84	0

Table B.1.: Summary of E-Wells and X-Wells.

C

Resistivity Profiles

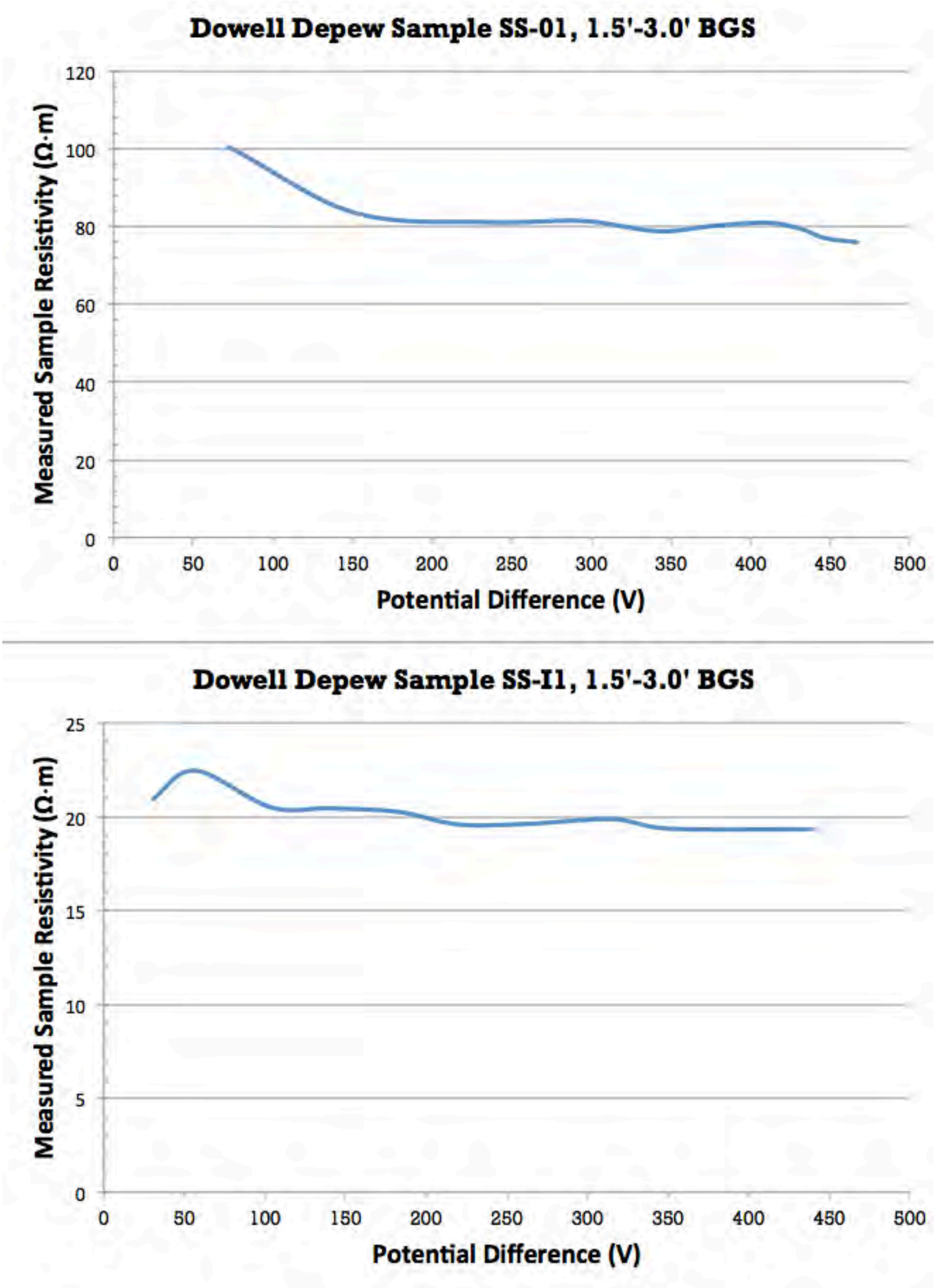


Figure C.1.: Measured resistivity data for the Depew project.

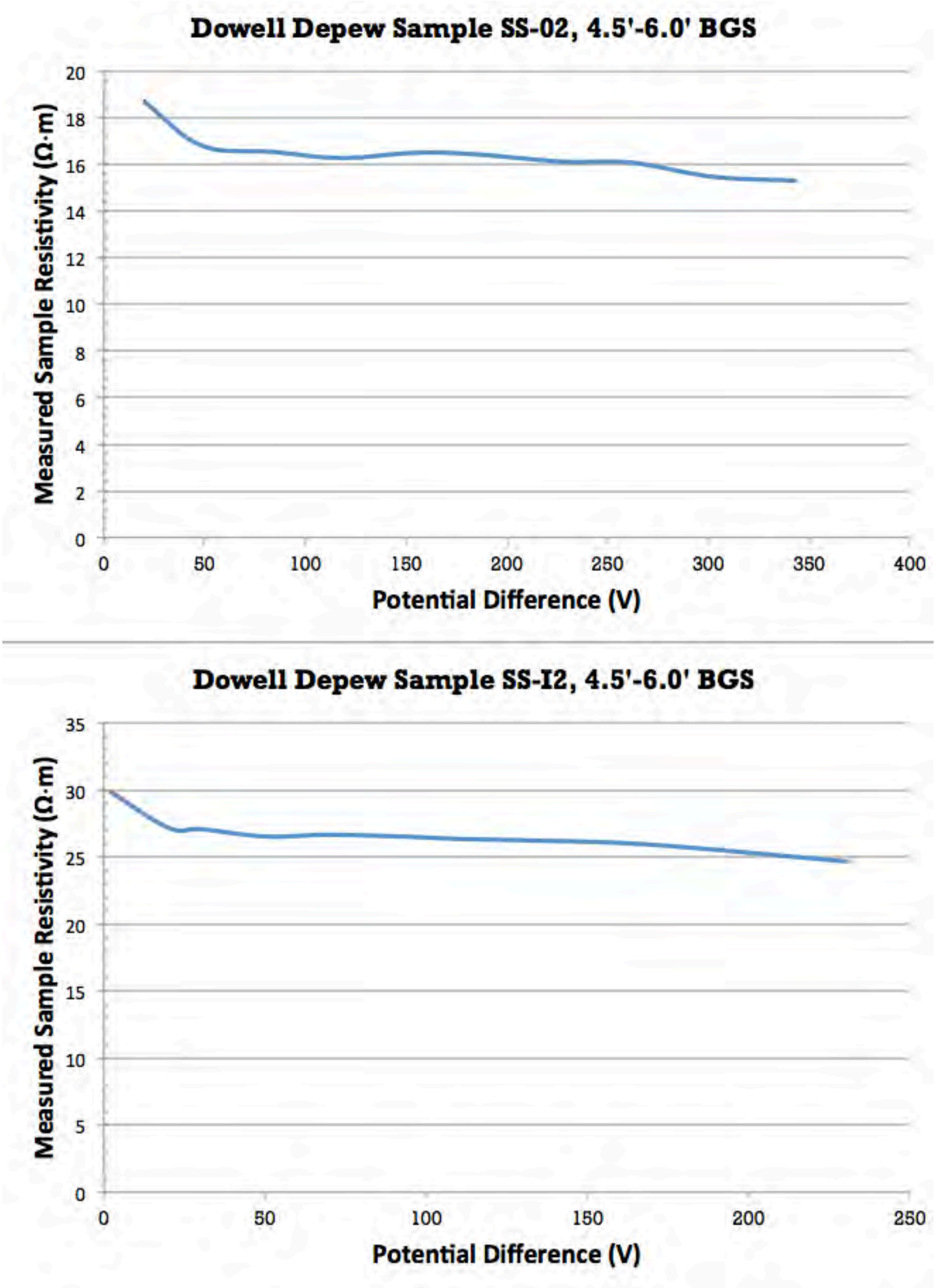
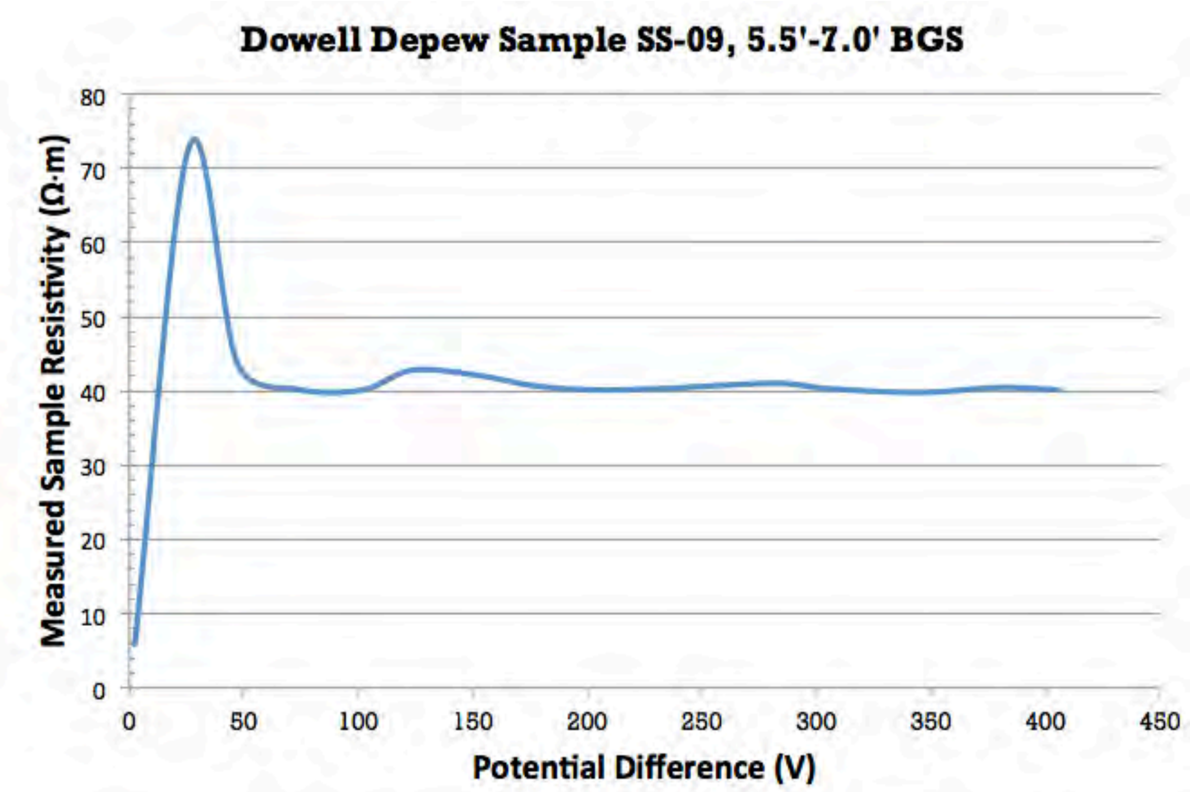


Figure C.2.: Measured resistivity data for the Depew project.



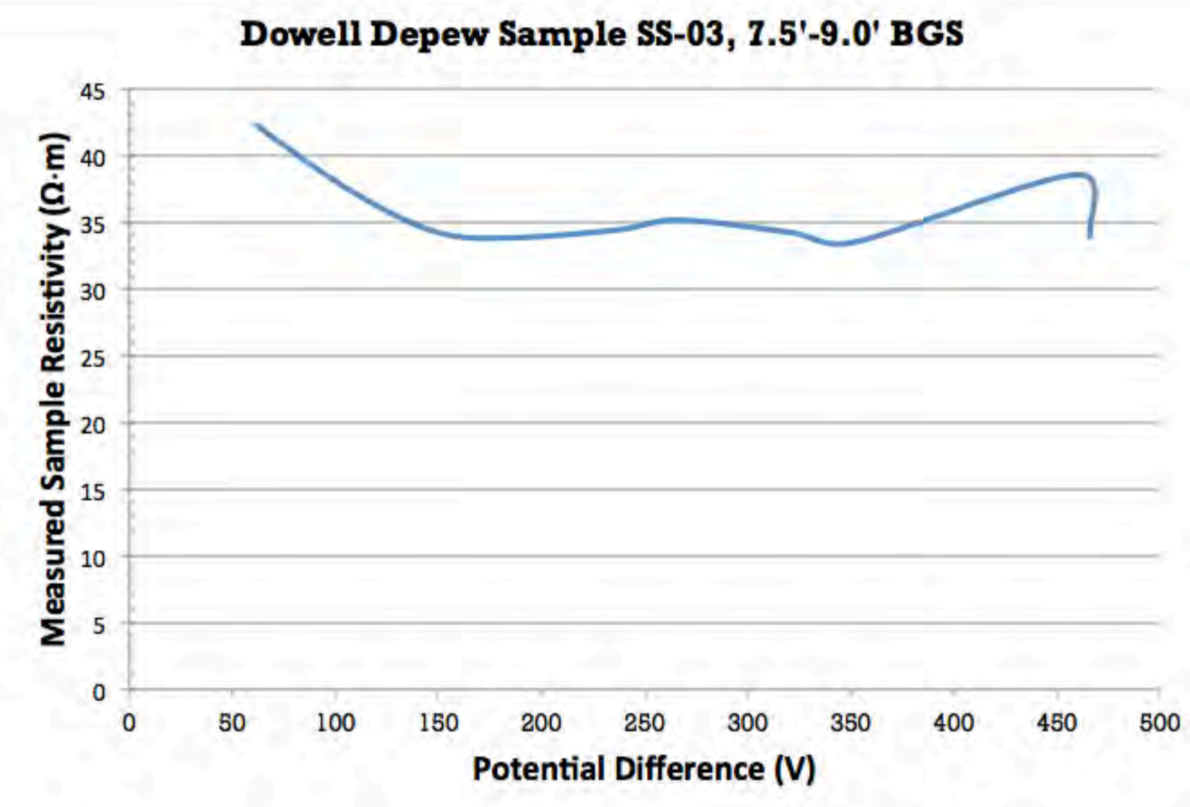
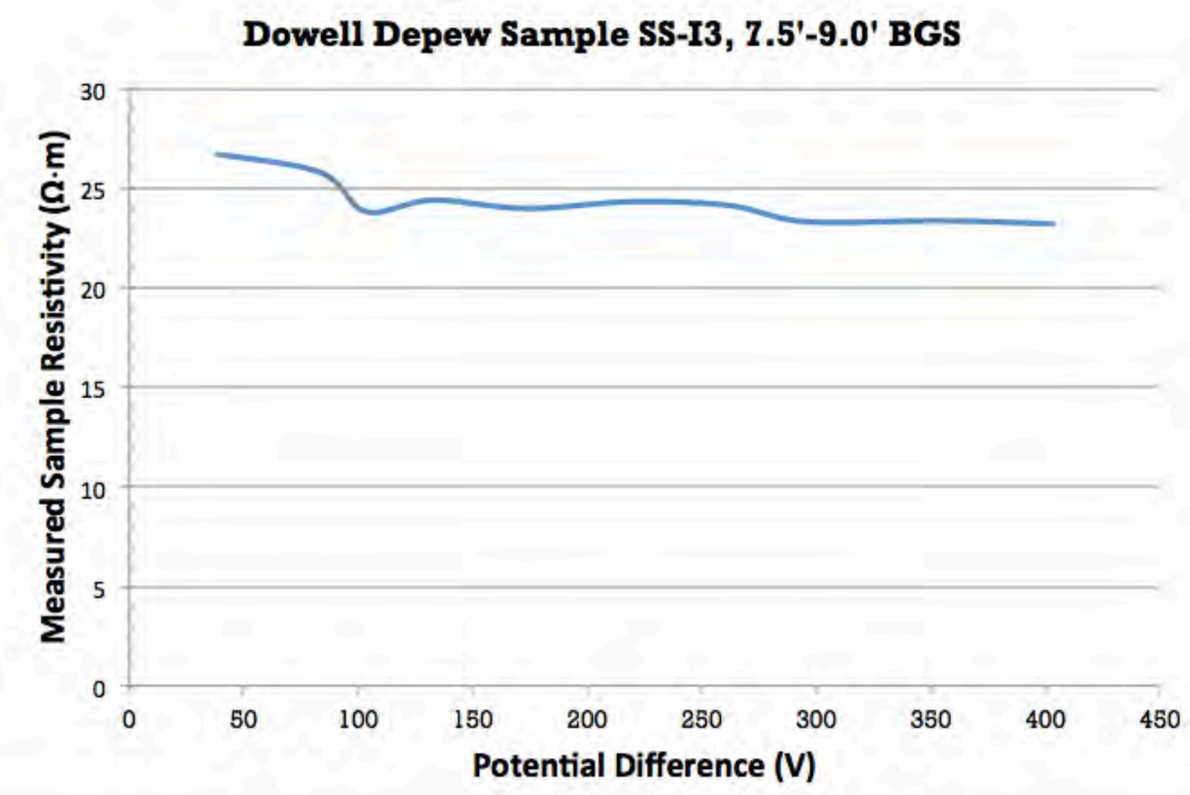


Figure C.3.: Measured resistivity data for the Depew project.



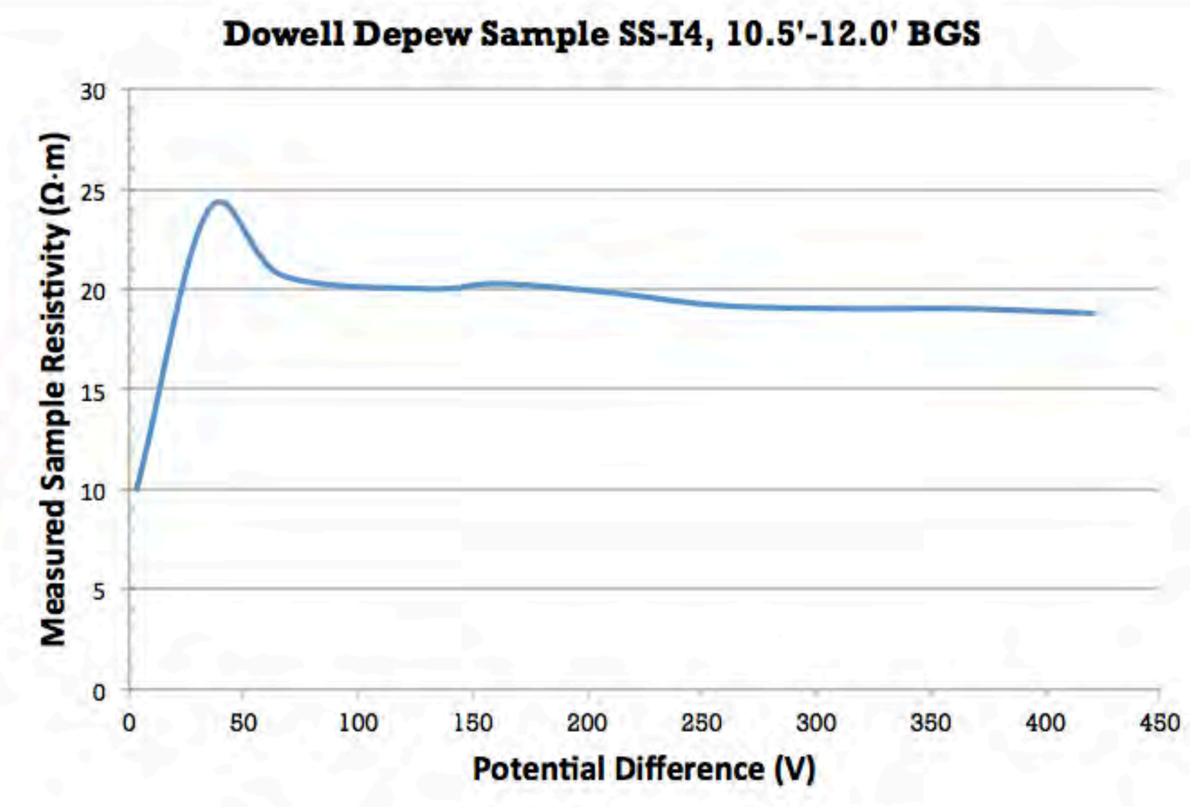
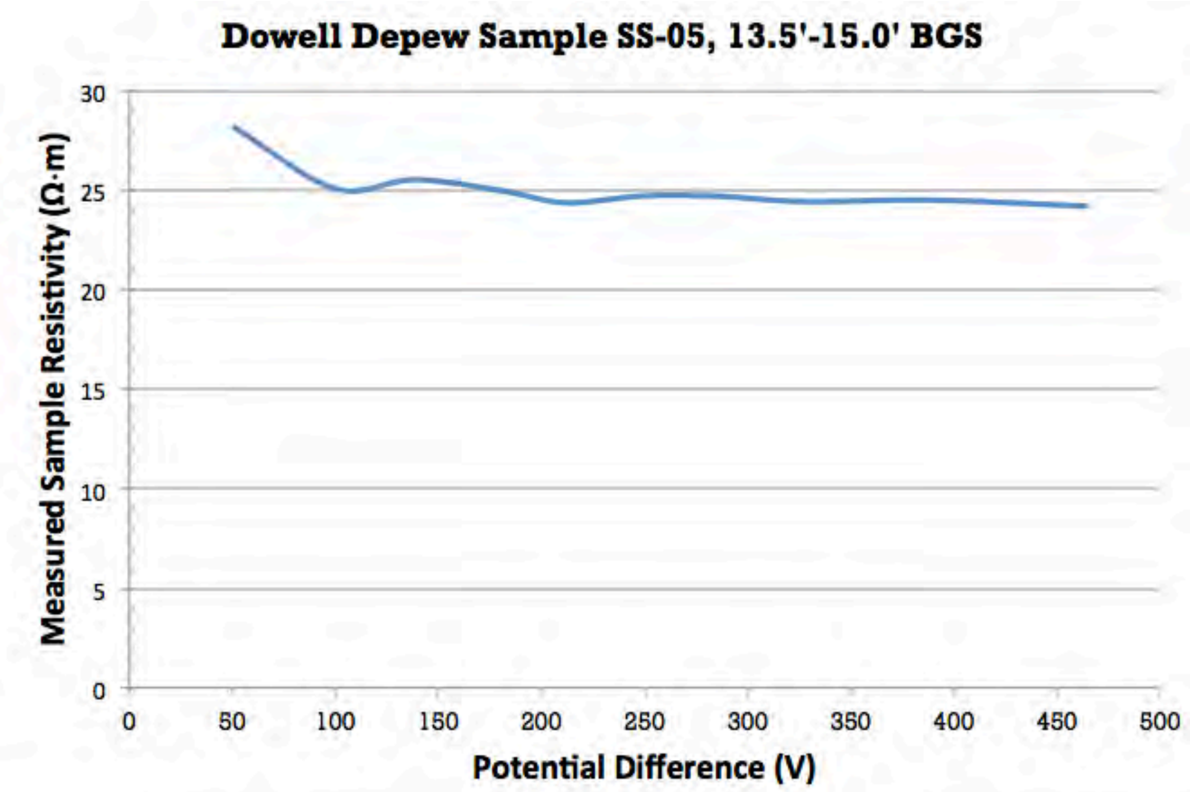


Figure C.4.: Measured resistivity data for the Depew project.



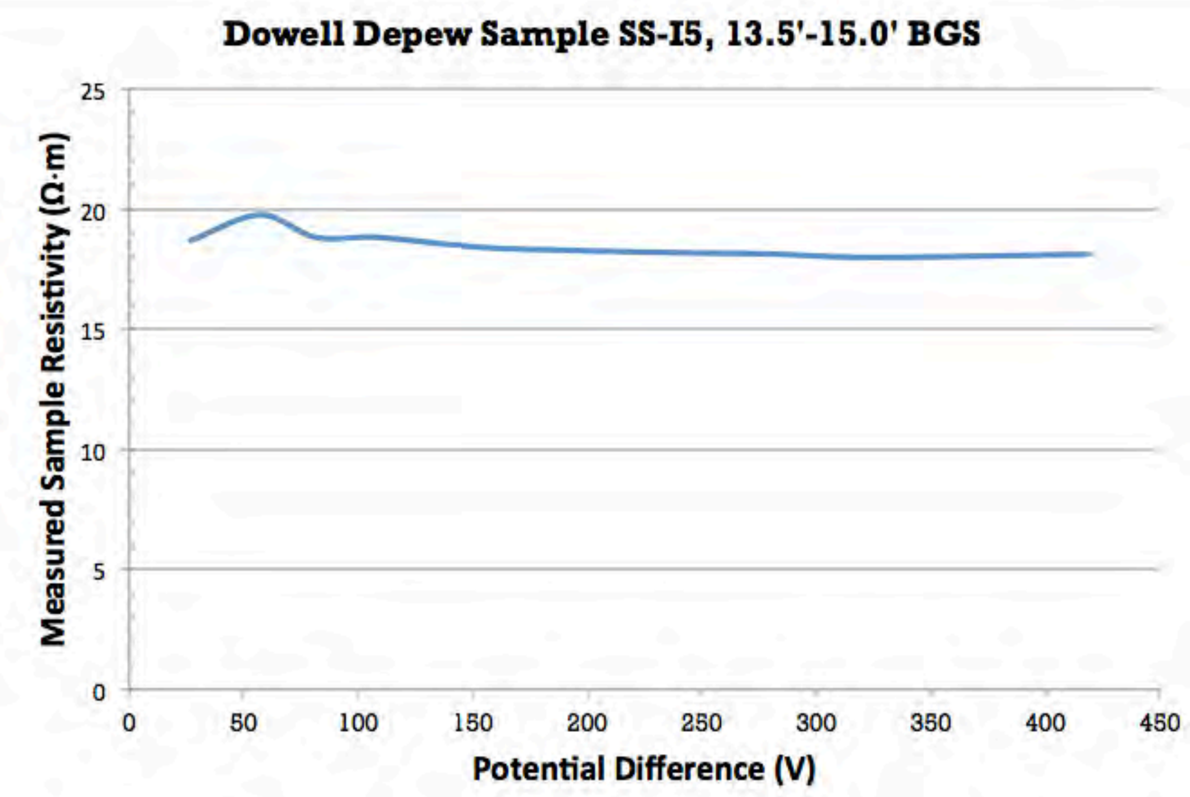
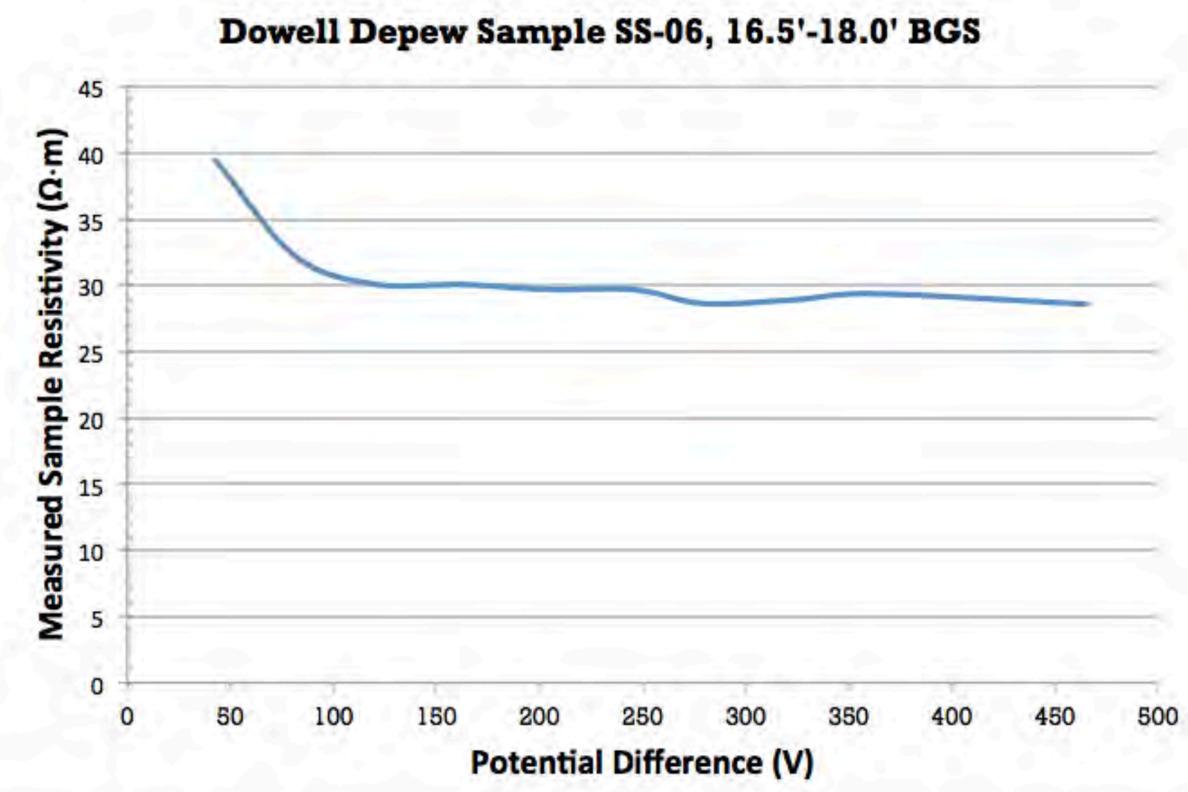


Figure C.5.: Measured resistivity data for the Depew project.



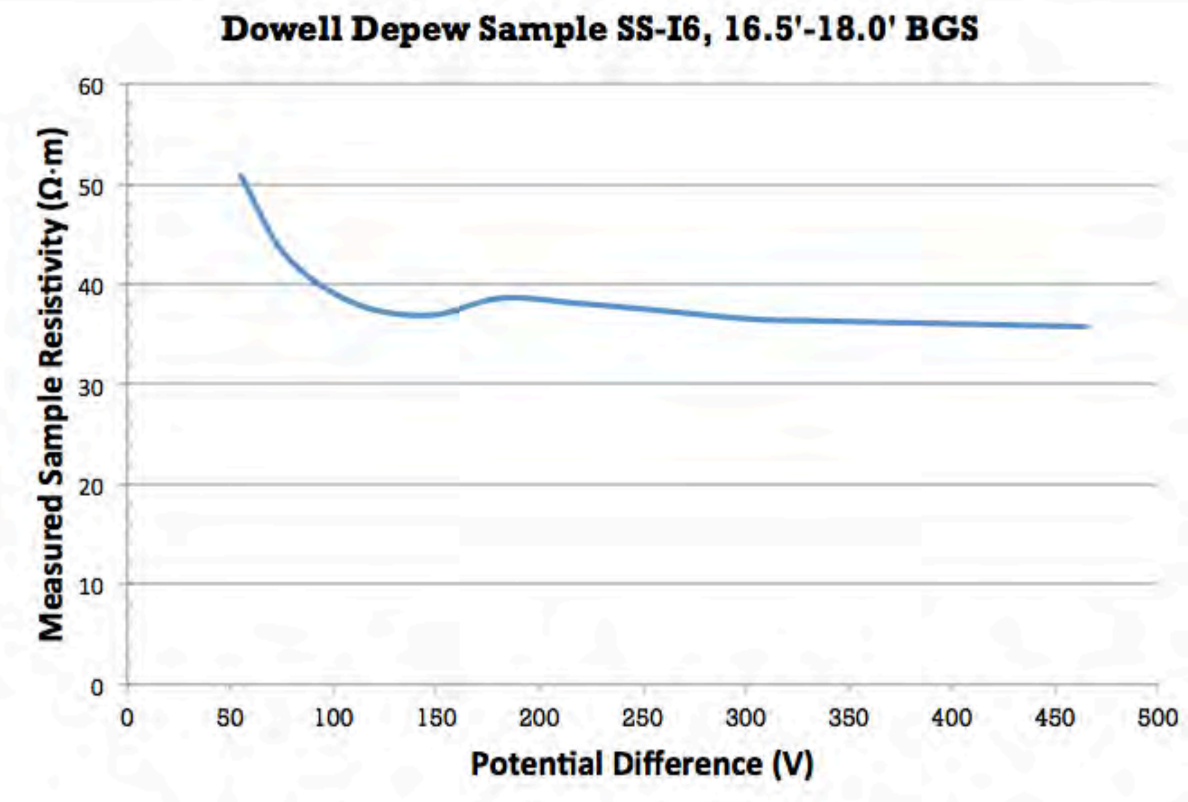
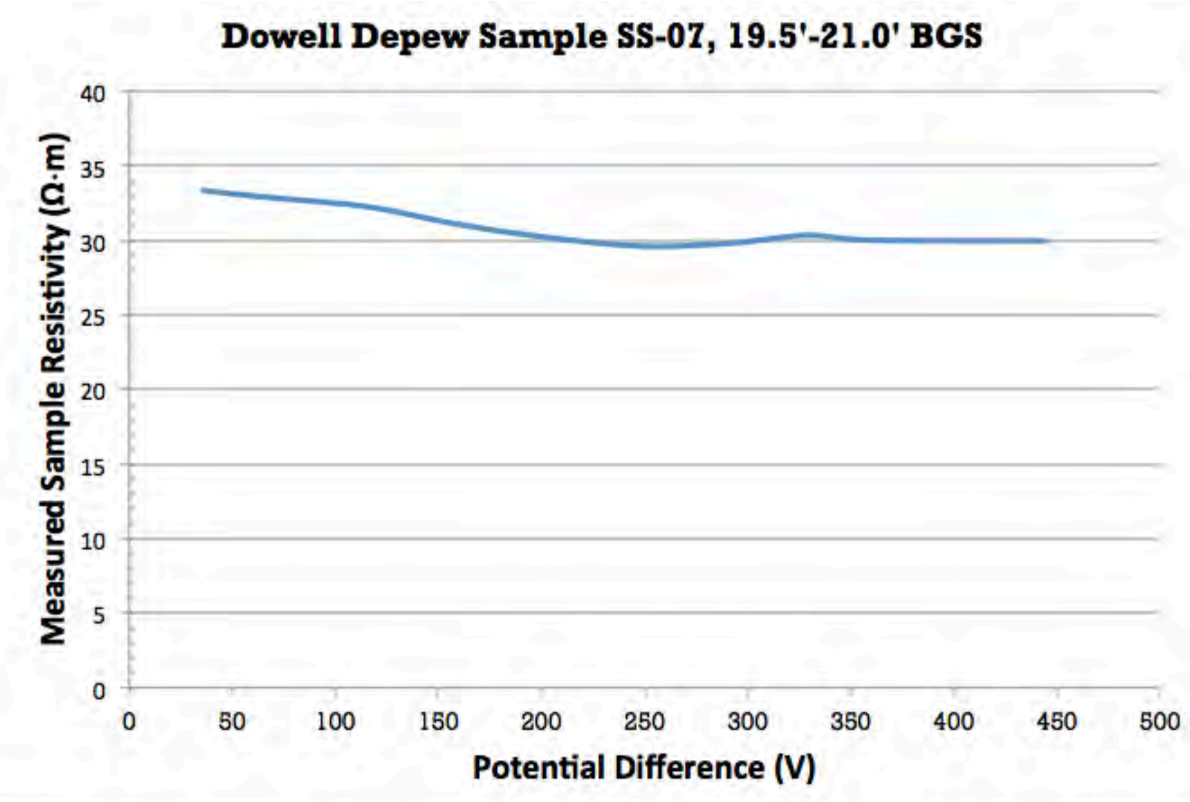


Figure C.6.: Measured resistivity data for the Depew project.



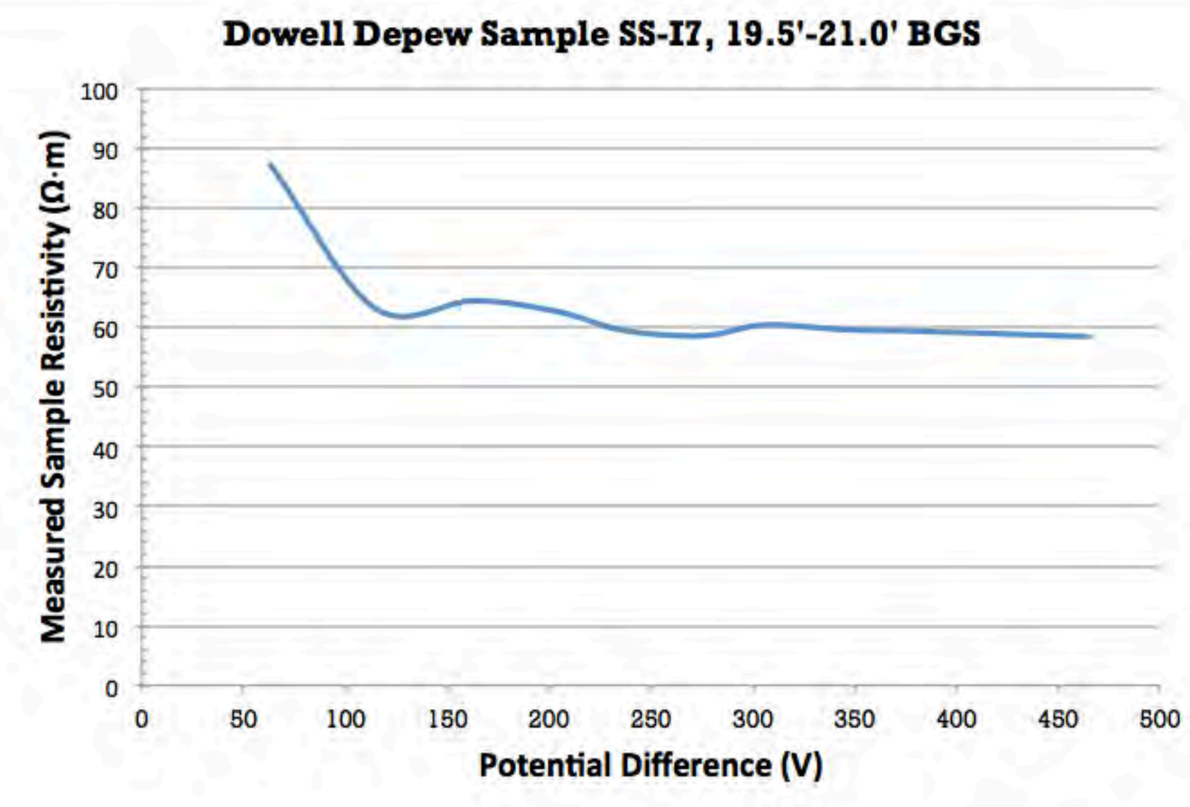
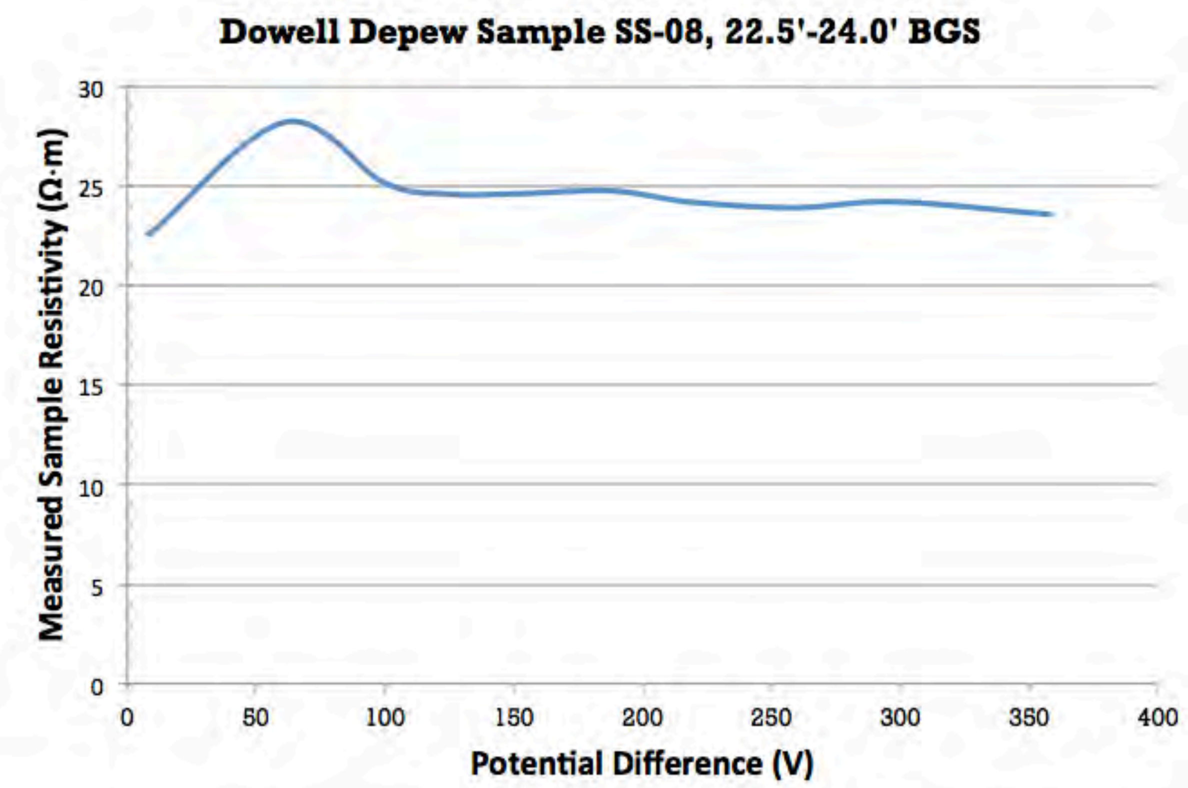


Figure C.7.: Measured resistivity data for the Depew project.



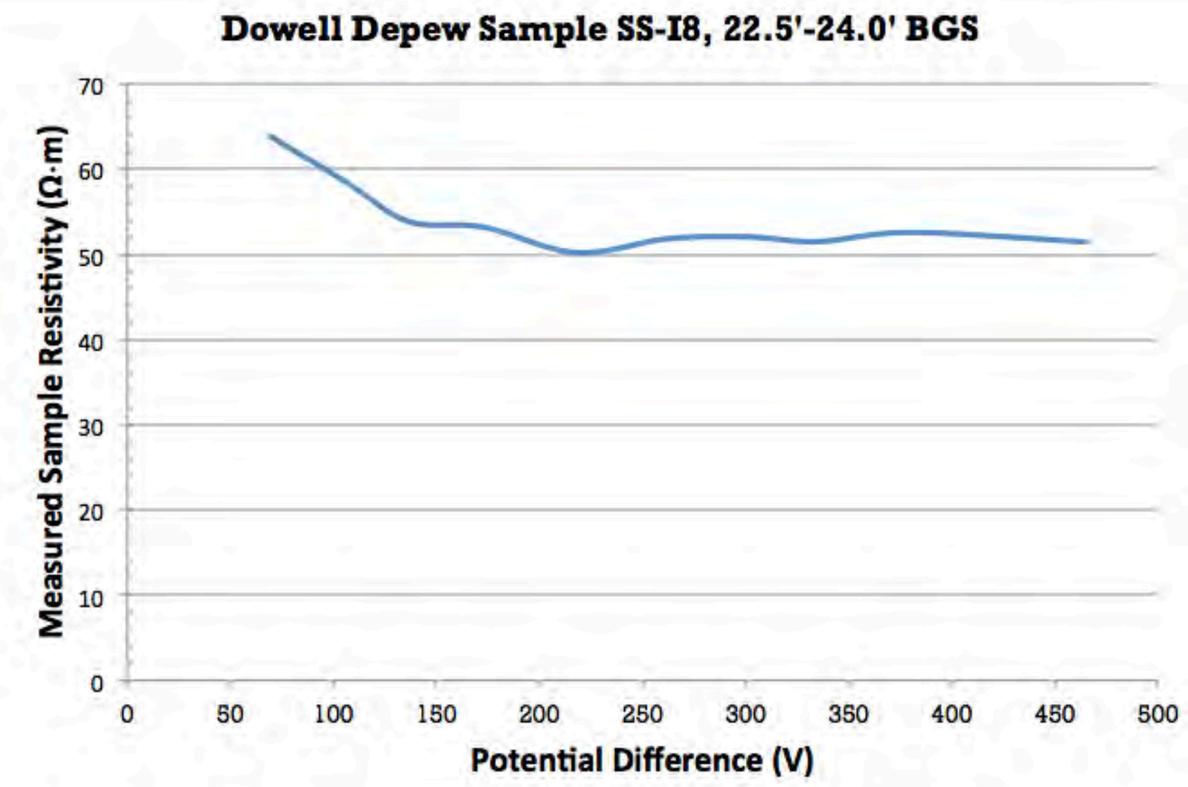


Figure C.8.: Measured resistivity data for the Depew project.

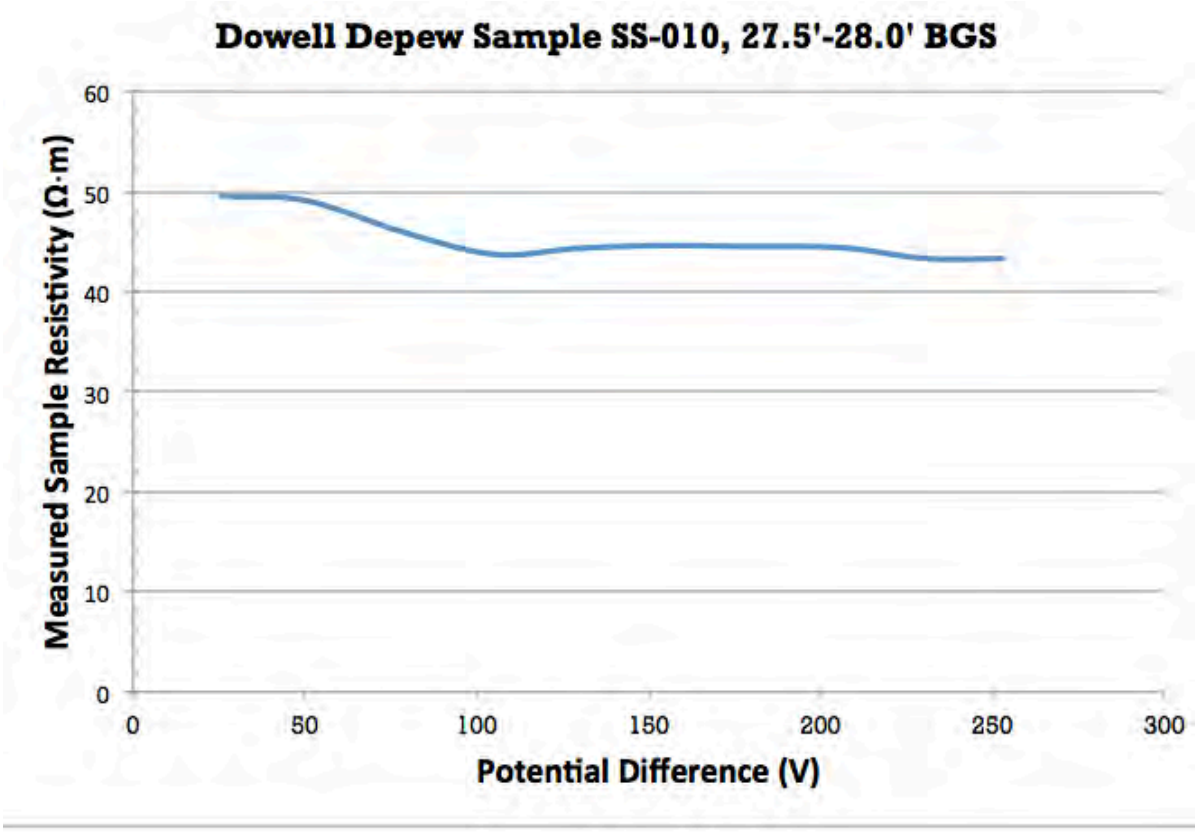


Figure C.9.: Measured resistivity data for the Depew project.

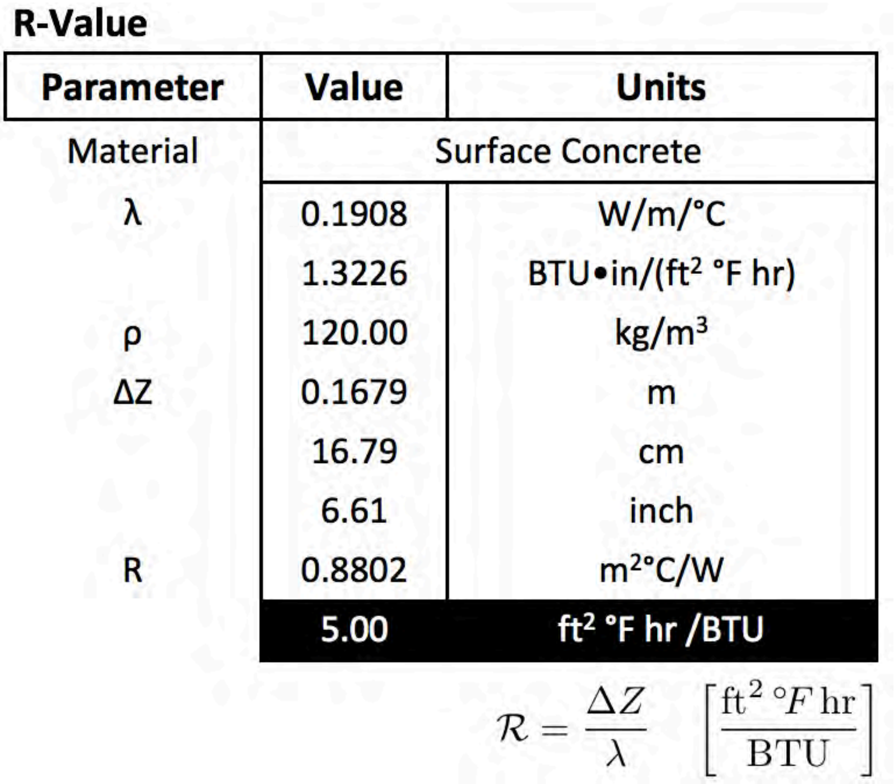
D

Convert Hydraulic Conductivity to Darcy’s

$$
\begin{aligned}
v = \frac{k}{\mu} \cdot \frac{\Delta\, P}{\Delta x} = \hat{k} \cdot \frac{\Delta H}{\Delta x} \quad \left[\frac{m}{s}\right] \\
\Delta P = \rho g \Delta H \\
\frac{k\,\rho g}{\mu} \cdot \frac{\Delta H}{\Delta x} = \hat{k} \cdot \frac{\Delta H}{\Delta x} \\
\mathrm{k} = 9.869233 \cdot 10^{-13}\,\mathrm{m}^2 \text{ per Darcy,} \\
\text{Assume properties for water} \\
\mu = 0.001\ \mathrm{kg} \cdot \frac{\mathrm{m}}{\mathrm{s}^2}\frac{1}{\mathrm{m}^2} \cdot \mathrm{s} \\
g = 9.8\ \frac{\mathrm{m}}{\mathrm{s}^2} \\
\rho = \rho_w = 1{,}000\ \frac{\mathrm{kg}}{\mathrm{m}^3} \\
\frac{k\,\rho g}{\mu} = 9.671848 \cdot 10^{-6}\ \left[\frac{m}{s}\right] = 9.671848 \cdot 10^{-4}\ \left[\frac{cm}{s}\right] \\
\therefore \quad 1\ \left[\frac{cm}{s}\right] \equiv\ 1{,}033.9285 \text{ Darcy}
\end{aligned}
$$

E

Calculation of R-Value



R-Value

Parameter	Value	Units
Material	Surface Concrete	
λ	0.1908	W/m/°C
	1.3226	BTU•in/(ft^2 °F hr)
ρ	120.00	kg/m^3
ΔZ	0.1679	m
	16.79	cm
	6.61	inch
R	0.8802	m^2°C/W
	5.00	**ft^2 °F hr /BTU**

$$\mathcal{R} = \frac{\Delta Z}{\lambda} \quad \left[\frac{\mathrm{ft}^2\,{}^{\circ}F\,\mathrm{hr}}{\mathrm{BTU}}\right]$$

Figure E.1.: Calculation of the R-Value.

Appendix B – Resistivity Report

Declaration of Quality Assurance

The undersigned declares that all reasonable efforts were made to strictly follow quality standards in the measurement and analysis of laboratory data. The following assurances are made regarding lab procedures:

1. The water and soil samples, collected on September 10, 2015, were received in good order.
2. The samples were kept sealed and stored in a cool but not freezing location until testing on September 18, 2015.
3. Laboratory test procedures began as soon as possible after each sample was opened to ensure the material remained representative of site conditions.

Nicholas Dumaresq, E.I.T.
Project Engineer
McMillan-McGee Corp.

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1. Summary

The soil samples were received in polyvinylchloride (PVC) sleeves with duct-tape sealed end caps, and were kept in a cool and controlled environment until testing commenced. The samples were brought to room temperature prior to testing. The electrical properties of site-representative soil samples were measured. The following results were obtained:

1. The average resistivity of the soil samples at ambient temperature ranged from 16.4 – 82.0 ohm-meters (Ω•m). All of the samples in the depth profile are ideal for ET-DSP™ operations.
2. Based on analysis of the samples, the resistivity of the soil at the site is expected to decrease by a minimum factor of approximately 2.02 during heating to the target temperature, assuming the soil is kept moist.
3. With an appropriate moisture control strategy, the site should be fully treatable using ET-DSP™.

2. Introduction

This laboratory investigation was conducted in the electro-thermal laboratory of McMillan-McGee Corporation (Mc^2). The purpose of this report is to present results of the electrical resistivity tests conducted on the former Dowell Depew facility in Depew, New York.

When an electric potential difference is applied across installed electrodes, electric current is made to flow through the soil depending on the electrical resistivity of the soil. Through this process, soil can be heated by electricity. The power dissipated by this process (i.e. the heating rate) is determined by this potential difference and the resulting current flow. Therefore, the suitability of this electrical process for the thermal treatment of the soil depends on the electrical resistivity of the soil.

The Static Resistivity Test is conducted to determine the general power requirements of the Electro-Thermal Dynamic Stripping Process (ET-DSP™) at the project site. The optimal soil resistivity range for ET-DSP™ technology at ambient temperature is between 10 and 300 $\Omega \cdot m$. For soil with a resistive profile greater than 300 $\Omega \cdot m$, steam injection can be used to assist ET-DSP™ operations.

The electrical resistivity of soil tends to vary as a function of temperature. As water-saturated soil is heated to boiling temperature, the electrical resistivity of the soil generally decreases to one third of its initial value. Power controls for the electrical heating system must be capable of adjusting for these variations. In the Dynamic Resistivity Test, the effect of temperature on the soil resistivity is determined as the sample is heated.

Seventeen soil samples were received in PVC sleeves with duct-tape sealed end caps from the former Dowell Depew facility. The samples were kept cool upon arrival, at approximately 5 degrees Celsius (°C), and were allowed to reach room temperature immediately prior to testing. The samples consisted of primarily sandy clay. The moisture level of the samples ranged from slightly dry to moist, and exhibited an odour consistent with levels of contamination.

3. Procedures

3.1. Preparation

To prepare for the Static Resistivity Tests and the Dynamic Resistivity Test, the laboratory test bench and equipment were cleaned. All of the samples were removed from refrigerated storage prior to testing and were allowed to reach room temperature.

Each test was prepared individually to ensure that the integrity of each sample was preserved in the condition they were received. The initial static resistivity sample and the dynamic resistivity sample were tested in a test box with two copper electrodes, of known cross sectional area, placed against opposing sides of the container (shown in **Appendix A**) which was then packed with the sample soil. The electrodes were connected to an alternating current (AC) power supply in series with an ammeter. A voltmeter was also connected across the electrodes in parallel to measure the potential difference. The mass and dimensions of each sample was recorded.

The remaining static resistivity samples were tested within the sleeves using special end caps that each contained a copper electrode of known cross sectional area. In this case, the soil sample sleeves were cut or trimmed to ensure full soil contact with the end cap electrodes. The mass and dimensions of the sample was taken, and the end caps were put in place and compressed into the soil to ensure full electrode contact. This ensures that each electrode and sample had the same cross-sectional area, allowing the electricity to flow evenly across the sample. As before, the electrodes were connected to an AC power supply in series with an ammeter, and a voltmeter was also connected across the electrodes in parallel to measure the potential difference.

The Dynamic Resistivity Test required additional preparation and set-up. Samples from various depths were combined and the weight of each sample used was recorded. A digital thermocouple sensor was inserted and buried into the center of the combined sample to allow temperature measurements. It should be noted that the insertion of the thermocouple into the sample is expected to have a negligible effect on the measured resistance of the sample. Furthermore, the test sample was saturated with the provided groundwater sample, in order to simulate the conditions of ET-DSP™, prior to connecting to power.

Photographs of a typical resistivity test can be seen in **Appendix A**.

3.2. Static Resistivity Tests

The Static Resistivity Test is used to determine the electrical resistivity of a soil sample at ambient temperature. With the samples prepared as explained above, the applied electric potential difference was varied and the measured voltages and currents were recorded.

The following procedure for the Static Resistivity Test was adhered to for the first sample.

3.2.1. Static Resistivity Test 1

1. Two copper electrodes, of known cross sectional area were positioned at opposite ends of the clean test box. The electrodes and box were weighed and this data was recorded.
2. The soil sample was removed from its PVC shipping sleeve and evenly packed down between the two electrodes ensuring full contact with the cross sectional surface area of the electrodes.
3. The dimensions of the sample were measured using callipers and a ruler, the mass was weighed, and the data was recorded.
4. The voltmeter, ammeter and electrodes were connected to the AC power supply.
5. The AC power supply was turned on and the voltage was set to a small initial value. The voltage and current that were applied to the sample were recorded.
6. The voltage was steadily increased by approximately 50 Volt (V) increments to allow for 10-15 data recordings. The voltages and currents were recorded as quickly as possible to minimize heating of the sample.
7. The power supply was turned off and the sample was removed from the test box. The sample was placed in a sealed container and refrigerated at approximately 5 °C.
8. The container was thoroughly cleaned and prepared for the next sample.

The following procedure for the Static Resistivity Test was adhered to for the remaining samples.

3.2.2. Static Resistivity Test 2-17

1. The duct-tape sealed end caps were removed from the PVC sleeves and the sleeve ends were trimmed to be flush with the soil.
2. The laboratory end caps, containing the electrodes of known cross sectional area, were firmly placed on the sleeves, ensuring full contact between the electrode and the soil sample.
3. The dimensions of the sample were measured using callipers and a ruler, the mass was weighed, and the data was recorded.

4. The voltmeter, ammeter and electrodes were connected to the AC power supply.
5. The AC power supply was turned on and the voltage was set to a small initial value. The voltage and current that were applied to the sample were recorded.
6. The voltage was steadily increased by approximately 50 V increments to allow for 10-15 data recordings. The voltages and currents were recorded as quickly as possible to minimize heating of the sample.
7. The power supply was turned off and the laboratory end caps were removed from the sample sleeve and replaced by the original end caps, which were sealed with duct-tape. The sample was refrigerated at approximately 5 °C.
8. The laboratory end caps (and electrodes) were thoroughly cleaned and prepared for the next sample.

3.3. Dynamic Resistivity Tests

The Dynamic Resistivity Test was performed on a combined sample after the Static Resistivity Tests were completed. The composite sample was composed of similar amounts of the seventeen samples. **Table 1** shows the amount of each sample taken to conduct the test.

For the Dynamic Resistivity Test the sample was prepared in a similar manner as the first Static Resistivity Test. As described above, the Dynamic Resistivity Test required additional preparation prior to connecting power and completing the test.

The following procedure was adhered to for the Dynamic Resistivity Test:

1. A subsample of each of the samples used in the Static Resistivity Test was taken to create a composite sample. Each subsample weight was recorded.
2. The composite sample was left in a safe and contained environment where it was given time to reach ambient air temperature.
3. Two copper electrodes, of known cross sectional area were positioned at opposite ends of the clean test box. The electrodes and box were weighed and this data was recorded.
4. The composite sample was evenly packed down in the test box between the two electrodes ensuring full contact with the cross sectional surface area of the electrodes.

5. The dimensions of the sample were measured using callipers and a ruler, and the total composite sample was weighed and the data recorded.
6. A thermocouple was inserted into the center of the soil, making sure it did not touch the bottom of the sample box, and was then covered by sample soil. The soil was evenly compressed around the sensor.
7. The voltmeter, ammeter and electrodes were connected to the AC power supply.
8. Sixty-seven milliliters of groundwater from the site was added to the sample until saturation was achieved.
9. The AC power supply was turned on and the voltage was adjusted so the heating rate caused by the current flow was timed to allow for accurate data recordings as well as maximum time efficiency.
10. The temperature, voltage and current passing through the sample were measured and recorded every minute until the heating rate began to slow due to increased resistivity. The increased resistivity of the sample occurs as the moisture in the ground sample vaporizes at treatment temperatures.
11. The power was turned off and the sample was disposed of appropriately.
12. All lab equipment was thoroughly cleaned and put away for future testing.

Table 1: Composition of the samples for the Dynamic Resistivity Test

Sample #	Depth Interval (ft. BGS)	Mass (g)	% of Sample
SS-01	1.5-3.0	111.4	6.01%
SS-I1	1.5-3.0	108.6	5.86%
SS-02	4.5-6.0	99.0	5.34%
SS-I2	4.5-6.0	116.5	6.29%
SS-09	5.5-7.0	108.9	5.88%
SS-03	7.5-9.0	119.5	6.45%
SS-I3	7.5-9.0	102.9	5.56%
SS-I4	10.5-12	109.9	5.93%
SS-05	13.5-15.0	101.6	5.49%
SS-I5	13.5-15.0	110.3	5.96%
SS-06	16.5-18.0	105.9	5.72%
SS-I6	16.5-18.0	113.8	6.14%
SS-07	19.5-21.0	115.4	6.23%
SS-I7	19.5-21.0	108.5	5.86%
SS-08	22.5-24.0	102.0	5.51%
SS-I8	22.5-24.0	111.8	6.04%
SS-010	27.5-28.0	106.1	5.73%

4. Results

4.1. Static Resistivity

The results of the Static Resistivity Tests for the entire sample set are presented in **Figures 1–17**. Raw data for the generation of these figures are included in **Appendix B**. Resistivity values were calculated from the following expression:

$$\rho = \frac{V}{I}\frac{A}{L},$$

where ρ is the resistivity (Ω · m); V is the potential difference between the two electrodes (measured in Volts); I is the current flowing between the electrodes (measured in Amps); A is the cross-sectional area of the sample (measured in meters squared); and L is the distance between the electrodes (measured in meters). Average resistivity values for each sample are shown in **Table 2** below.

Table 2: Average Static Resistivity Results at the Various Depth Intervals

Sample #	Depth Interval (ft. BGS)	Average Resistivity (Ω-m)
SS-01	1.5-3.0	82.0
SS-I1	1.5-3.0	20.2
SS-02	4.5-6.0	16.4
SS-I2	4.5-6.0	26.7
SS-09	5.5-7.0	40.7
SS-03	7.5-9.0	35.8
SS-I3	7.5-9.0	24.3
SS-I4	10.5-12	19.1
SS-05	13.5-15.0	24.1
SS-I5	13.5-15.0	18.5
SS-06	16.5-18.0	30.7
SS-I6	16.5-18.0	39.1
SS-07	19.5-21.0	31.0
SS-I7	19.5-21.0	63.4
SS-08	22.5-24.0	24.6
SS-I8	22.5-24.0	53.9
SS-010	27.5-28.0	45.3

The resistivity values found in **Table 1** vary due to the variable composition of the soil samples. This variability is apparent when comparing two samples from the same depth interval (i.e. samples

SS-03 and SS-I3). The samples all fall within the ideal levels for normal ET-DSP™ operations.

Generally, the first data point for each Static Test should be ignored as an outlier. Additionally, note that resistivity values often appear to decrease with higher voltage. This resistivity change can be attributed to the small amount of sample heating that occurs during data recording.

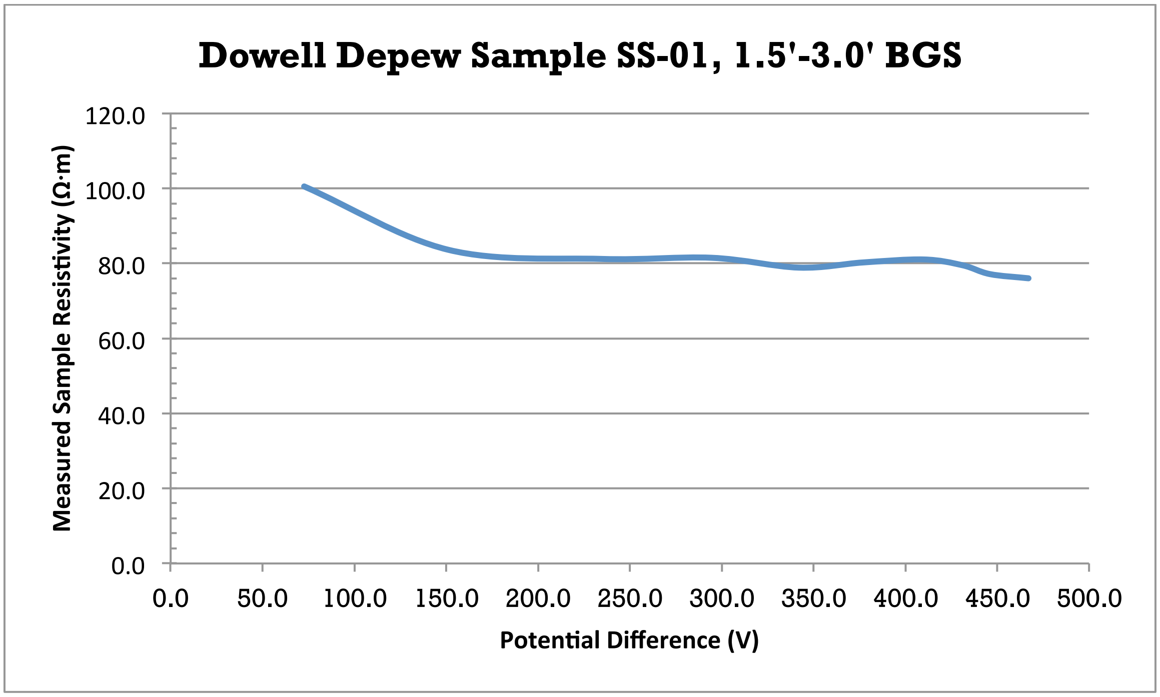


Figure 1: Static Resistivity Test: 1.5 to 3.0ft BGS – SS-01

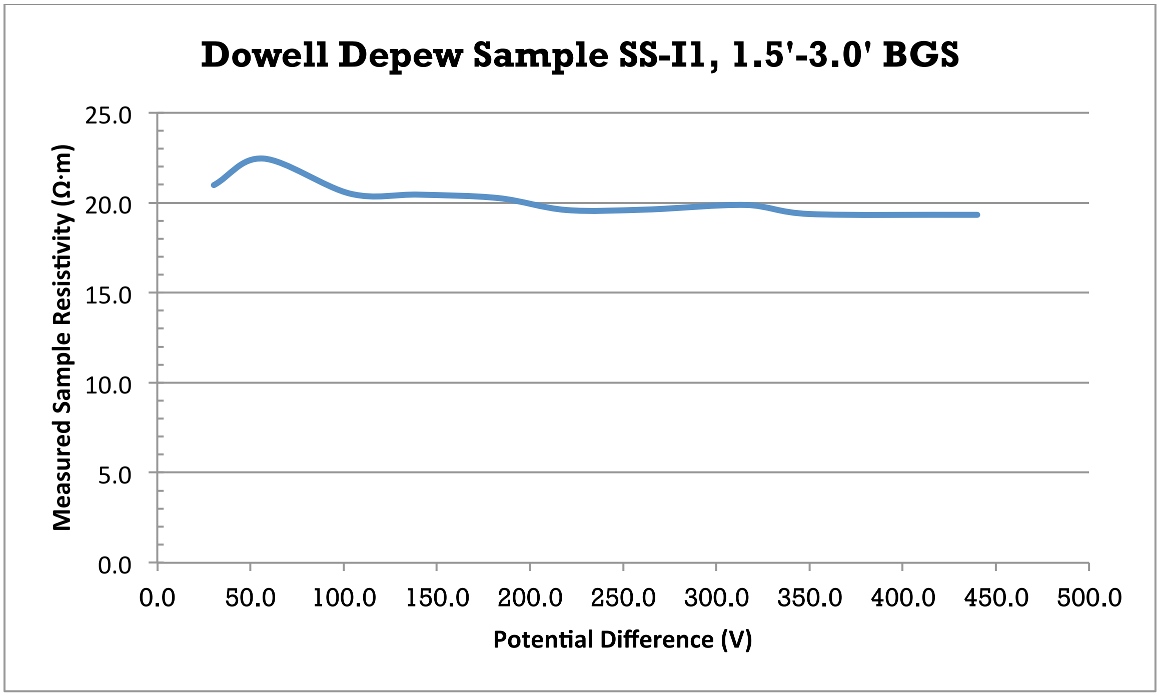


Figure 2: Static Resistivity Test: 1.5 to 3.0ft BGS – SS-I1

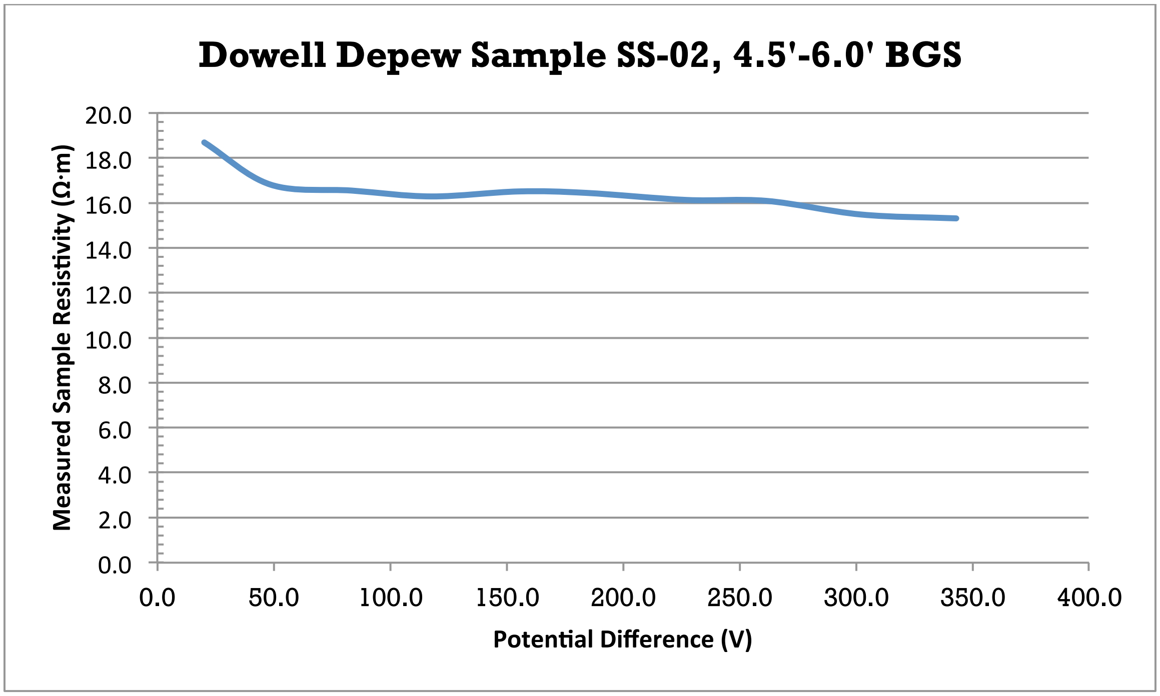


Figure 3: Static Resistivity Test: 4.5 to 6.0ft BGS – SS-02

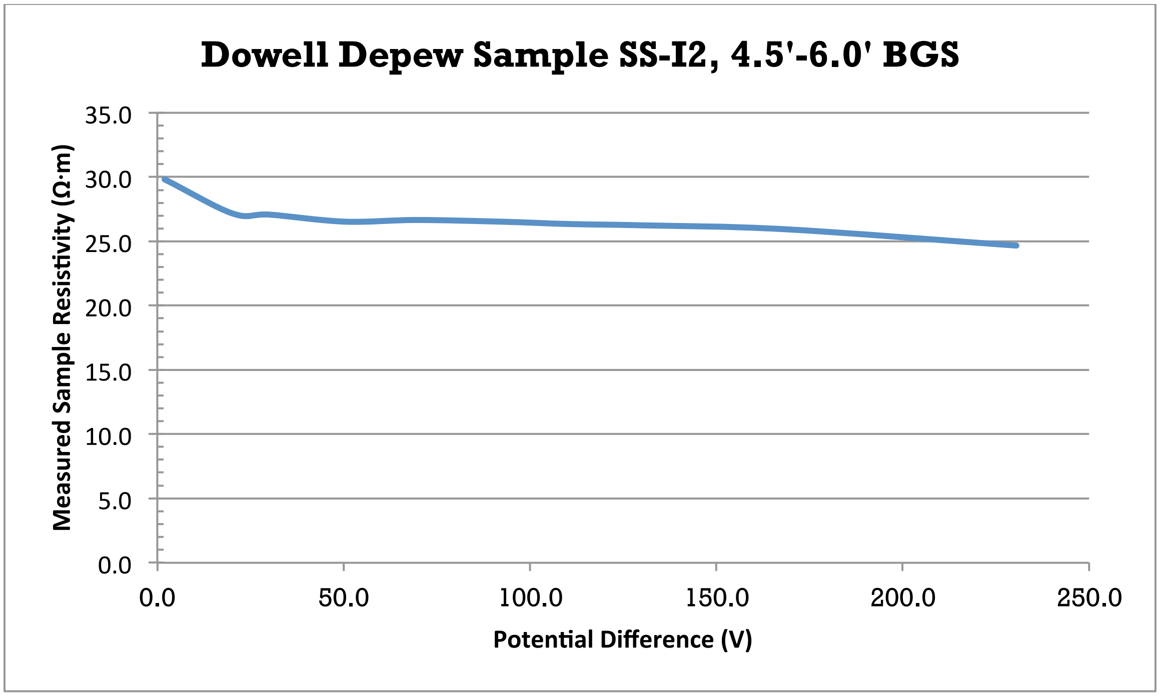


Figure 4: Static Resistivity Test: 4.5 to 6.0ft BGS – SS-I2

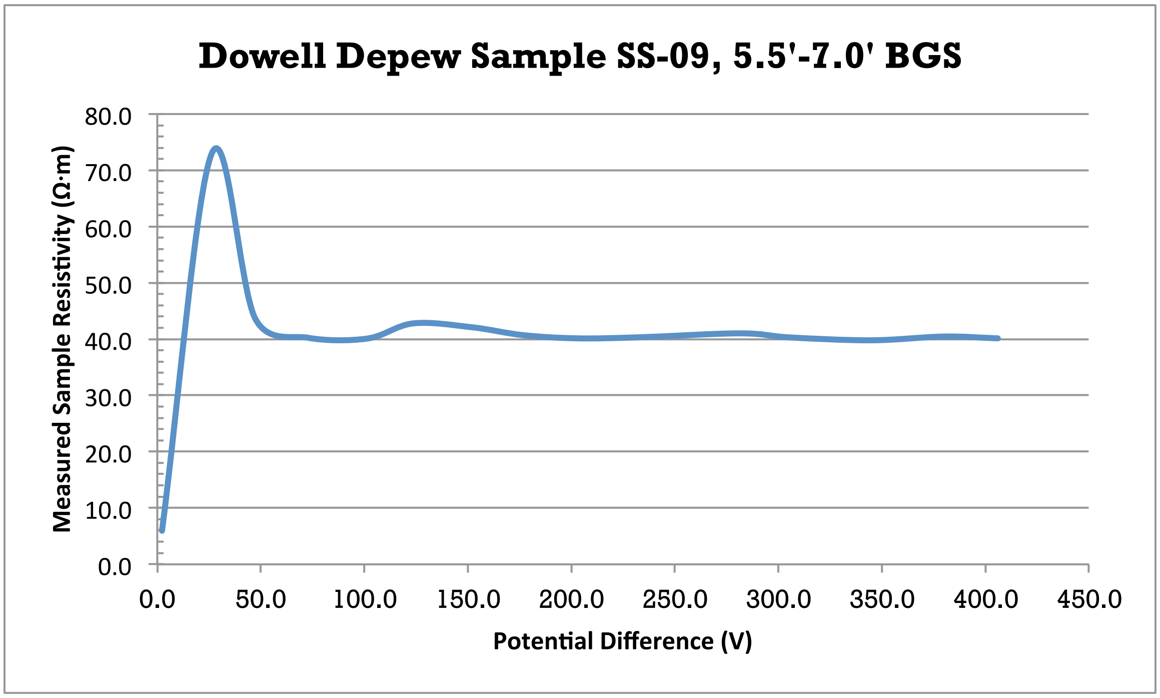


Figure 5: Static Resistivity Test: 5.5 to 7.0ft BGS – SS-09

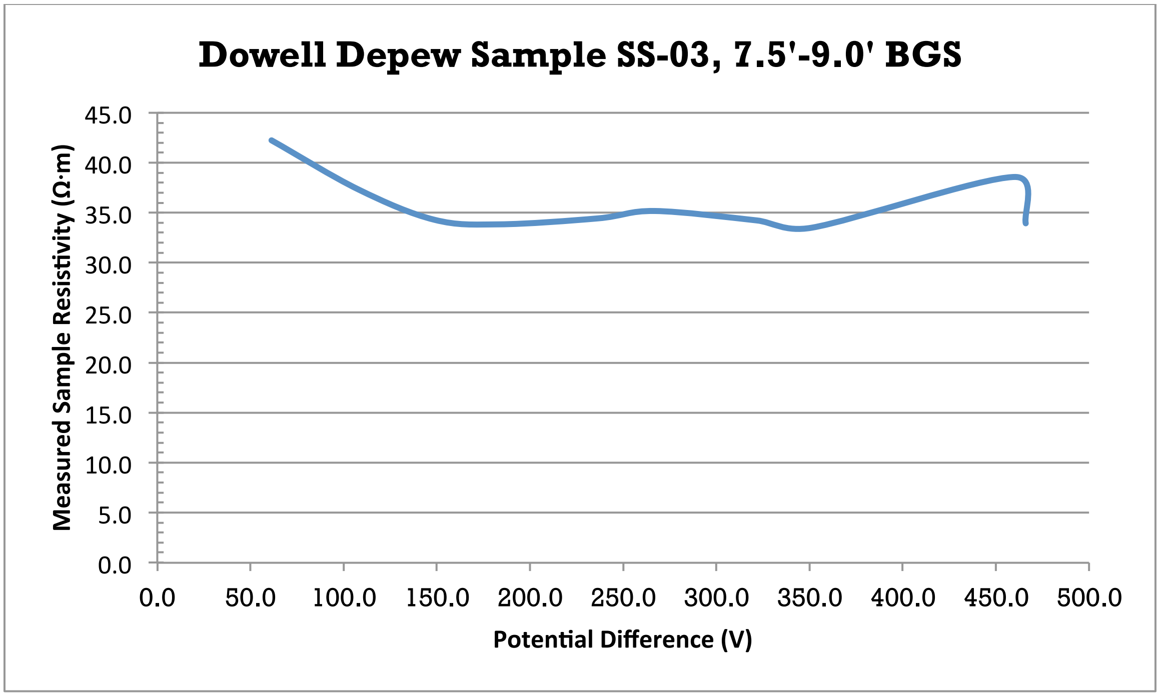


Figure 6: Static Resistivity Test: 7.5 to 9.0ft BGS – SS-03

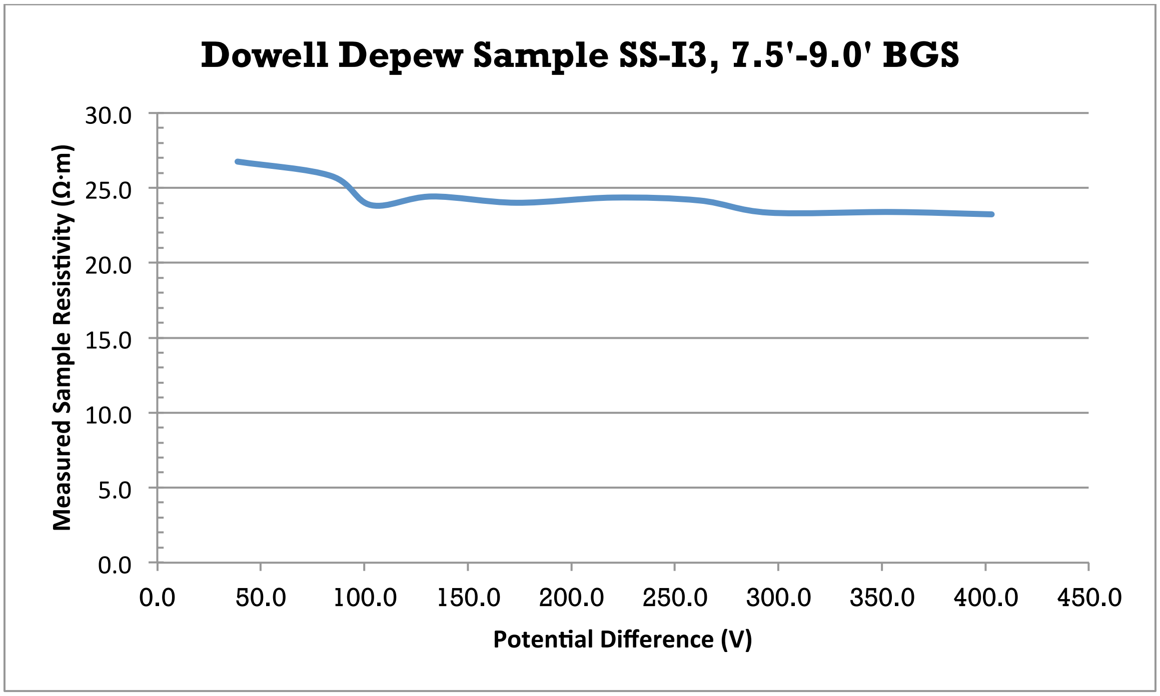


Figure 7: Static Resistivity Test: 7.5 to 9.0ft BGS – SS-I3

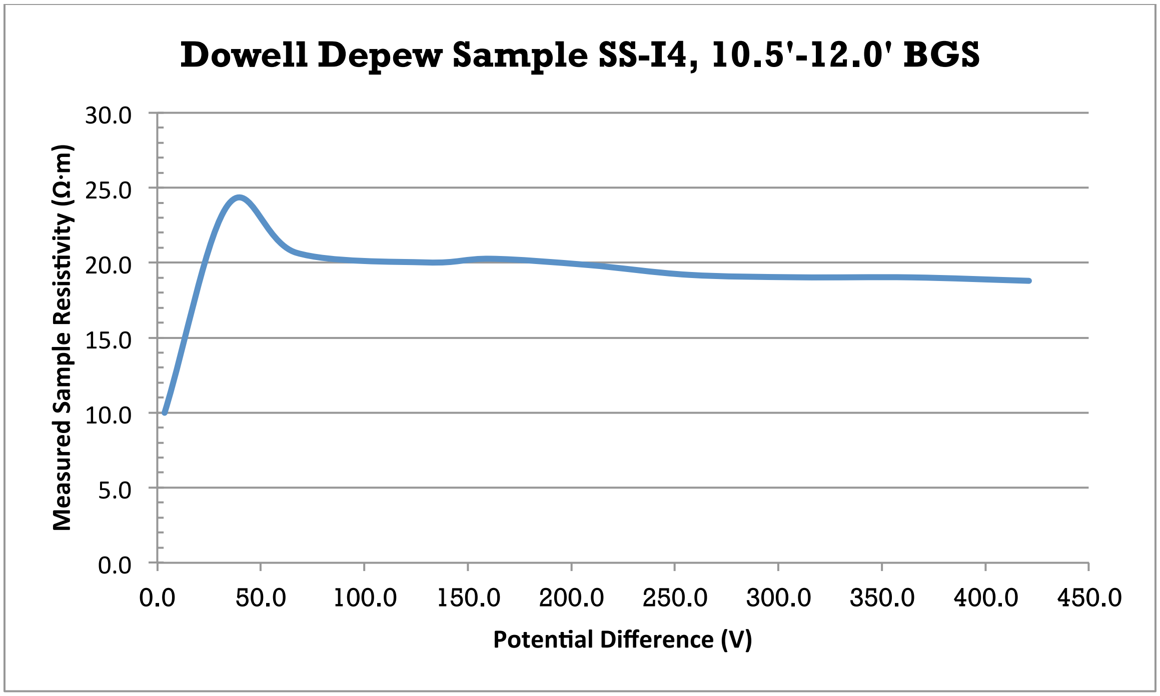


Figure 8: Static Resistivity Test: 10.5 to 12.0ft BGS – SS-I4

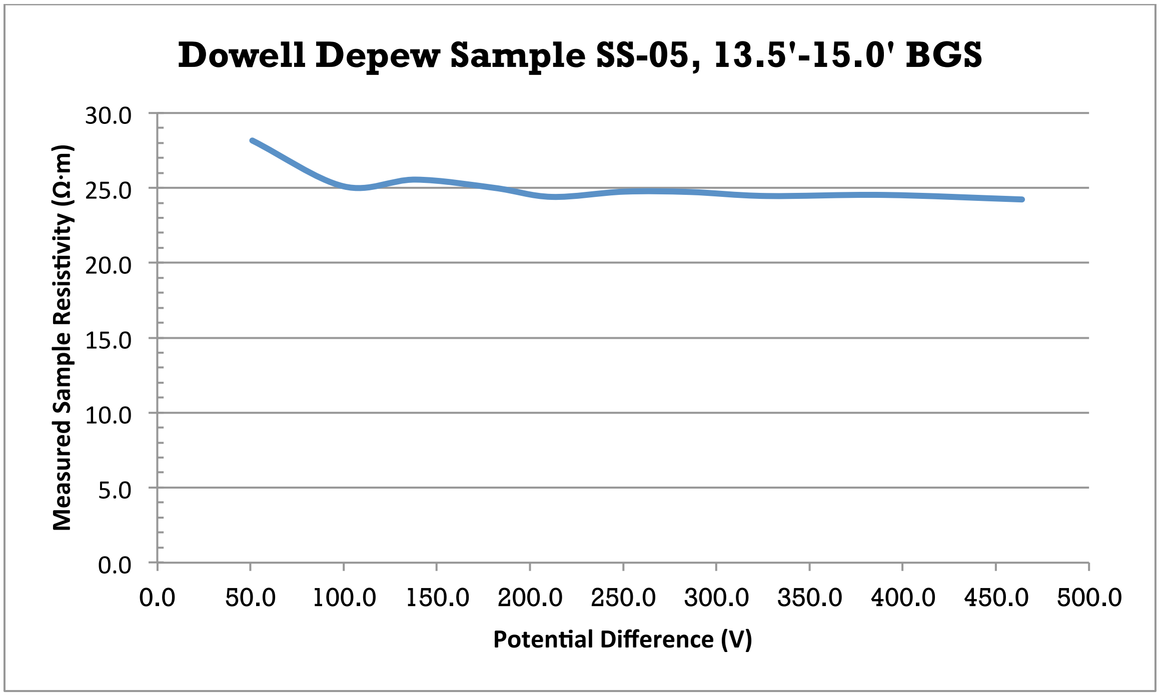


Figure 9: Static Resistivity Test: 13.5 to 15.0ft BGS – SS-05

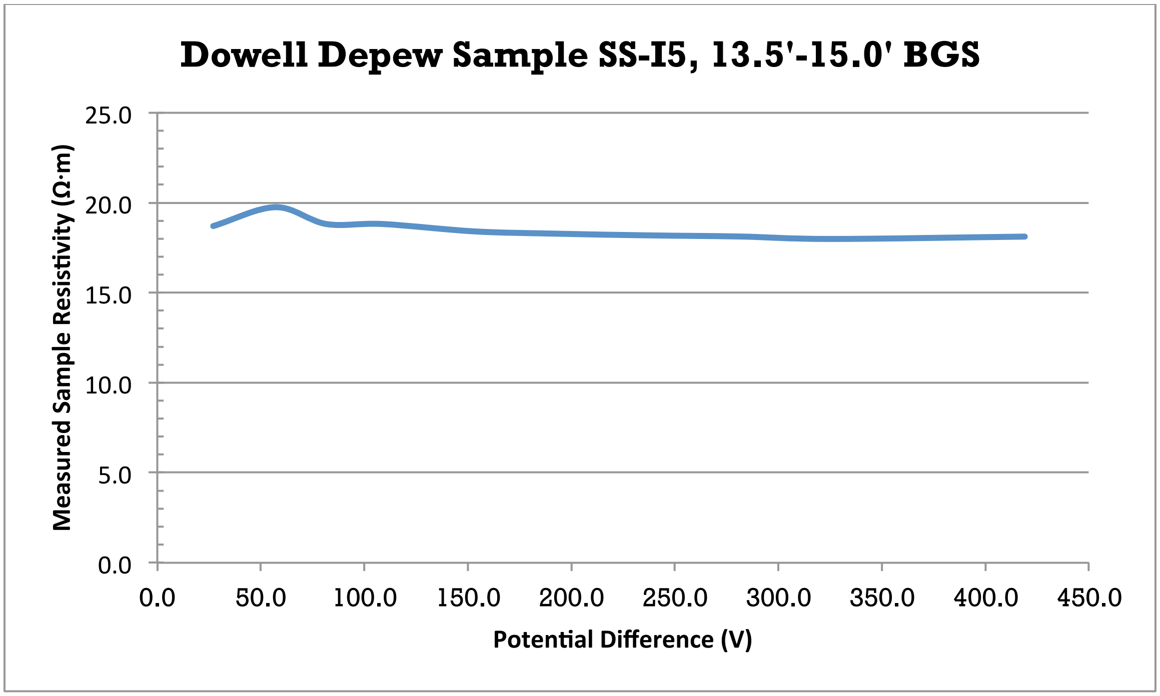


Figure 10: Static Resistivity Test: 13.5 to 15.0ft BGS – SS-I5

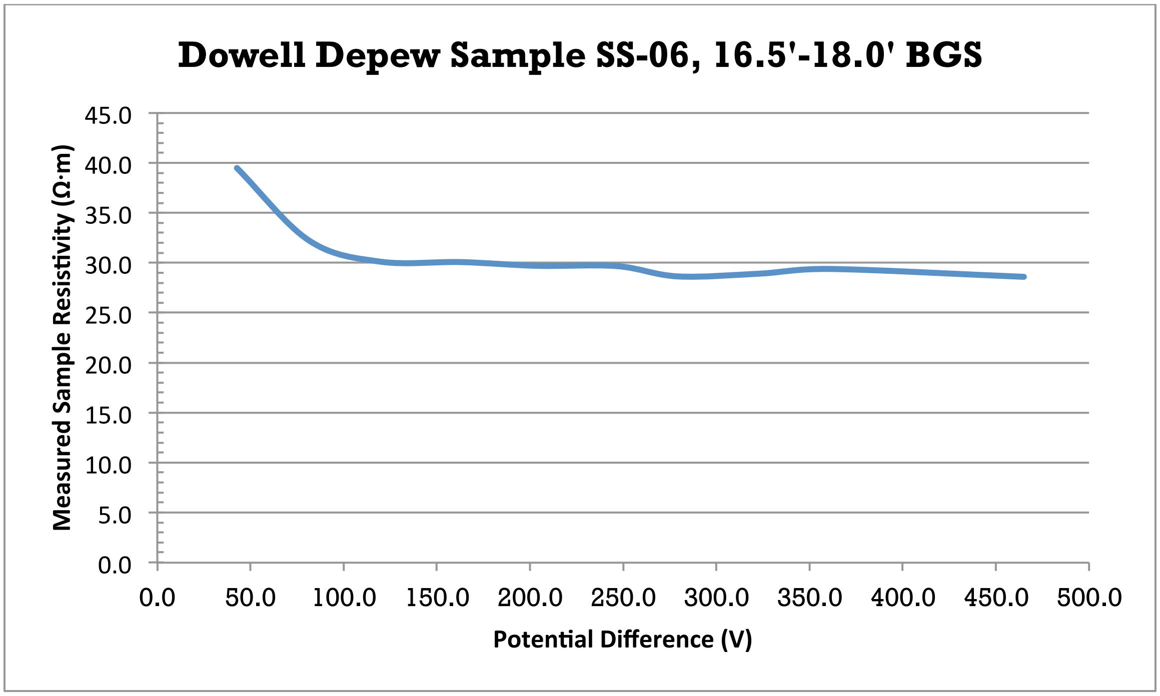


Figure 11: Static Resistivity Test: 16.5 to 18.0ft BGS – SS-06

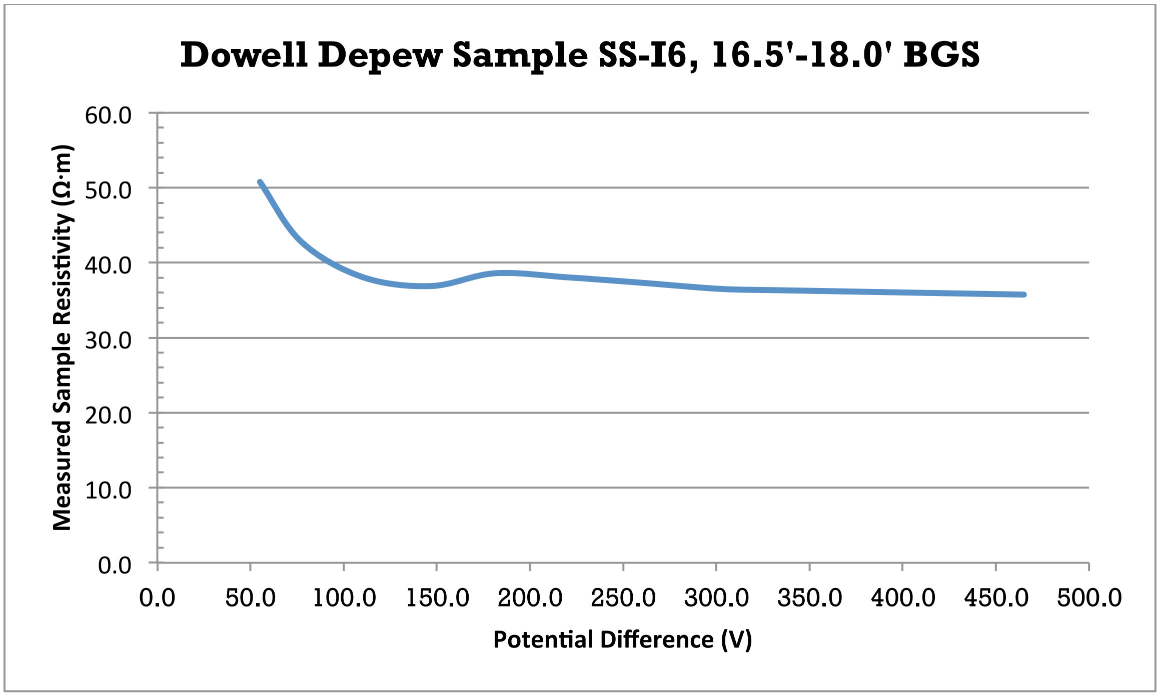


Figure 12: Static Resistivity Test: 16.5 to 18.0ft BGS – SS-I6

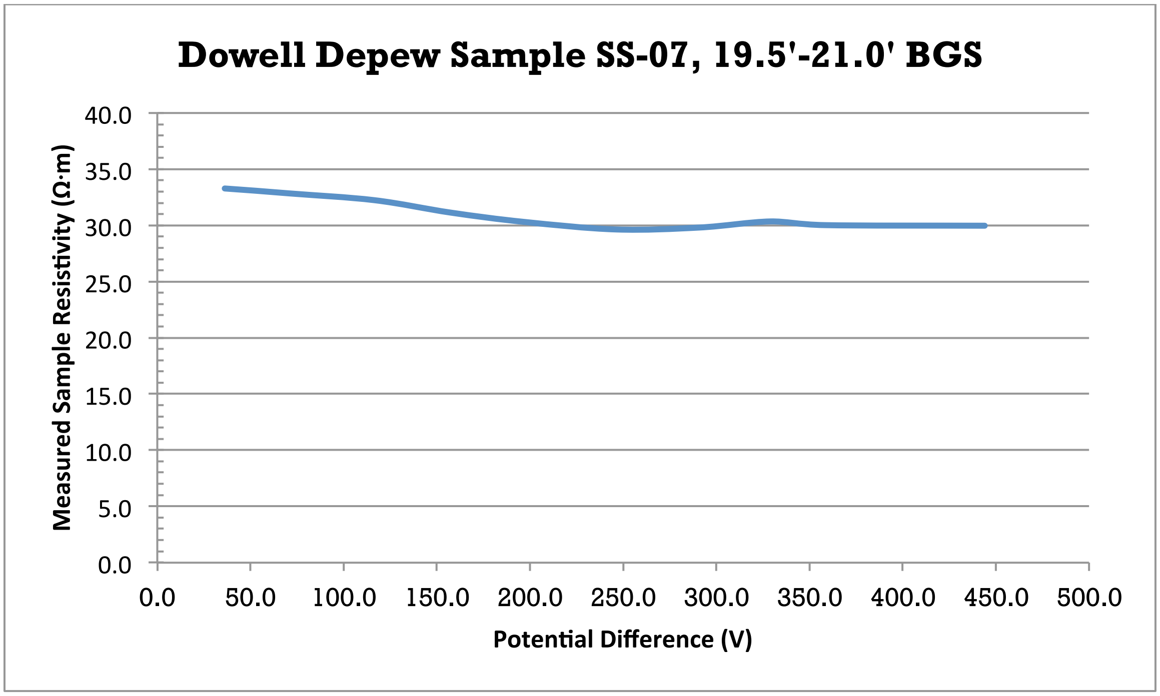


Figure 13: Static Resistivity Test: 19.5 to 21.0ft BGS – SS-07

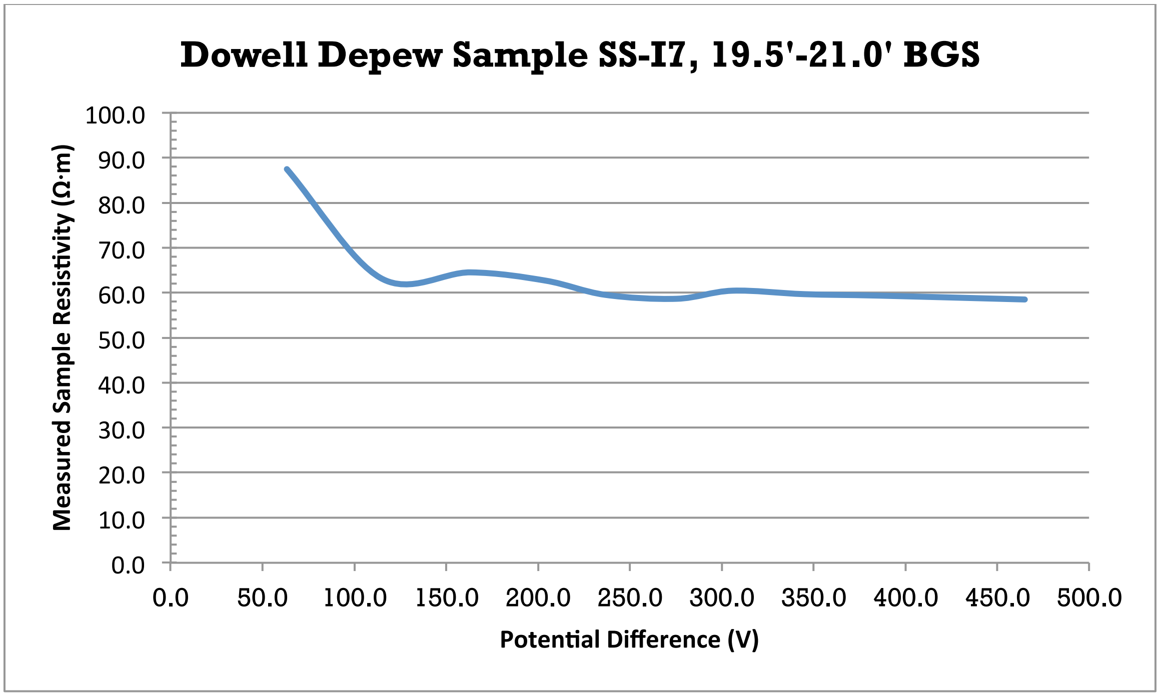


Figure 14: Static Resistivity Test: 19.5 to 21.0ft BGS – SS-I7

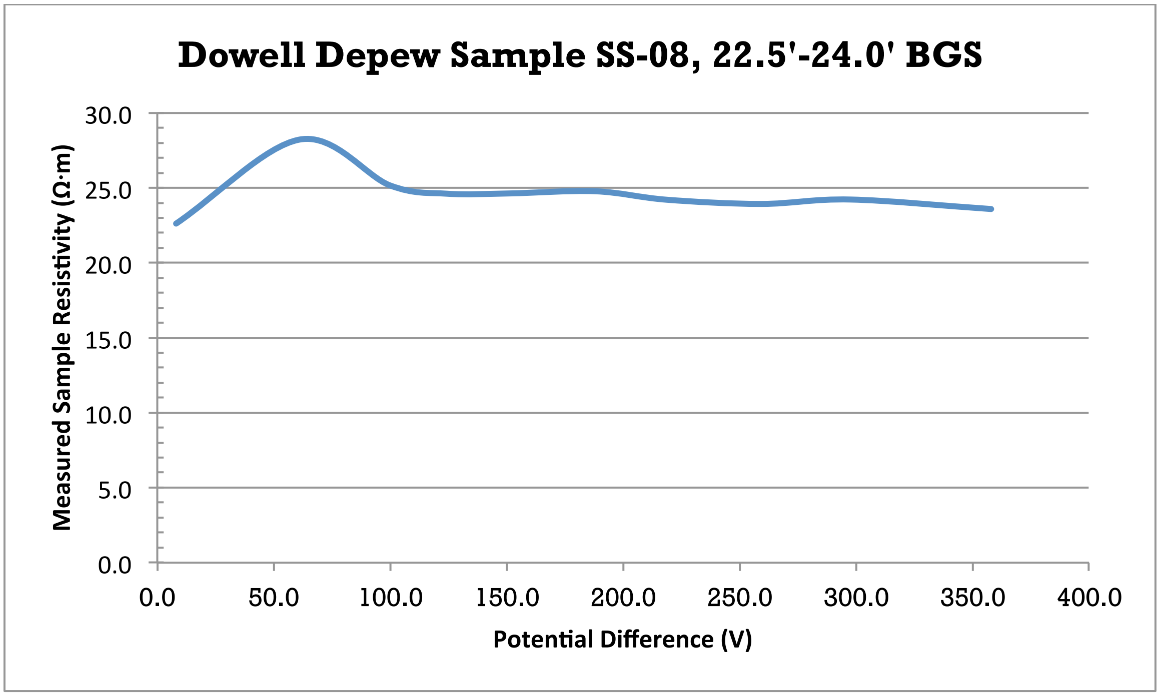


Figure 15: Static Resistivity Test: 22.5 to 24.0ft BGS – SS-08

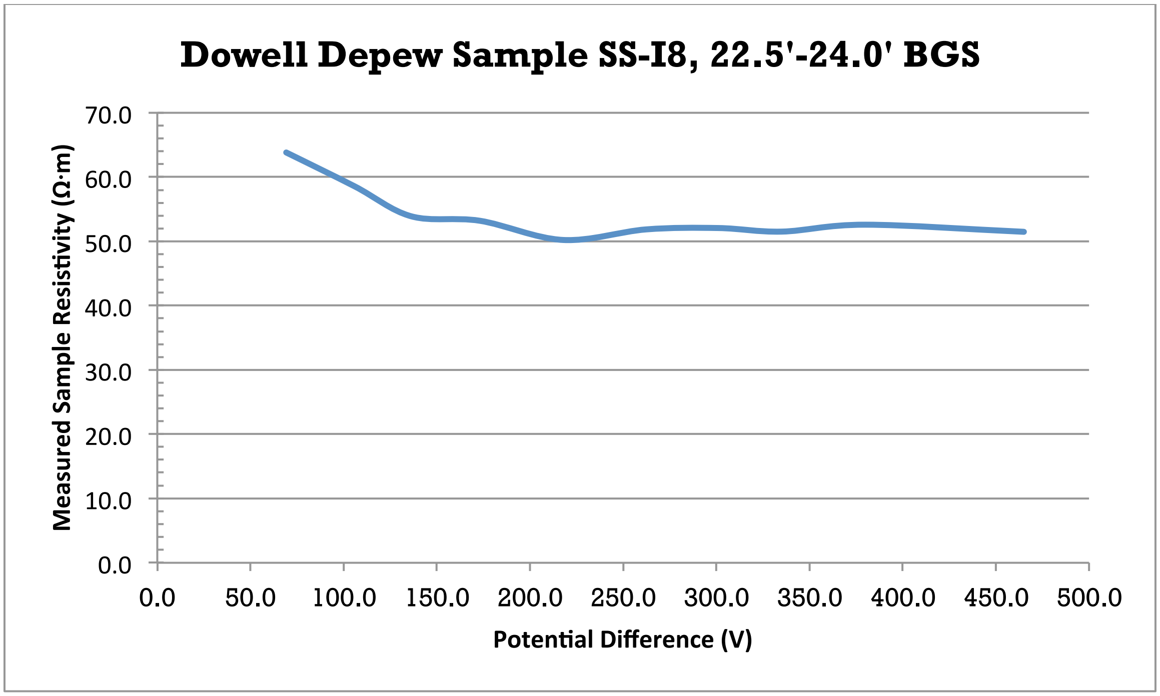


Figure 16: Static Resistivity Test: 22.5 to 24.0ft BGS – SS-I8

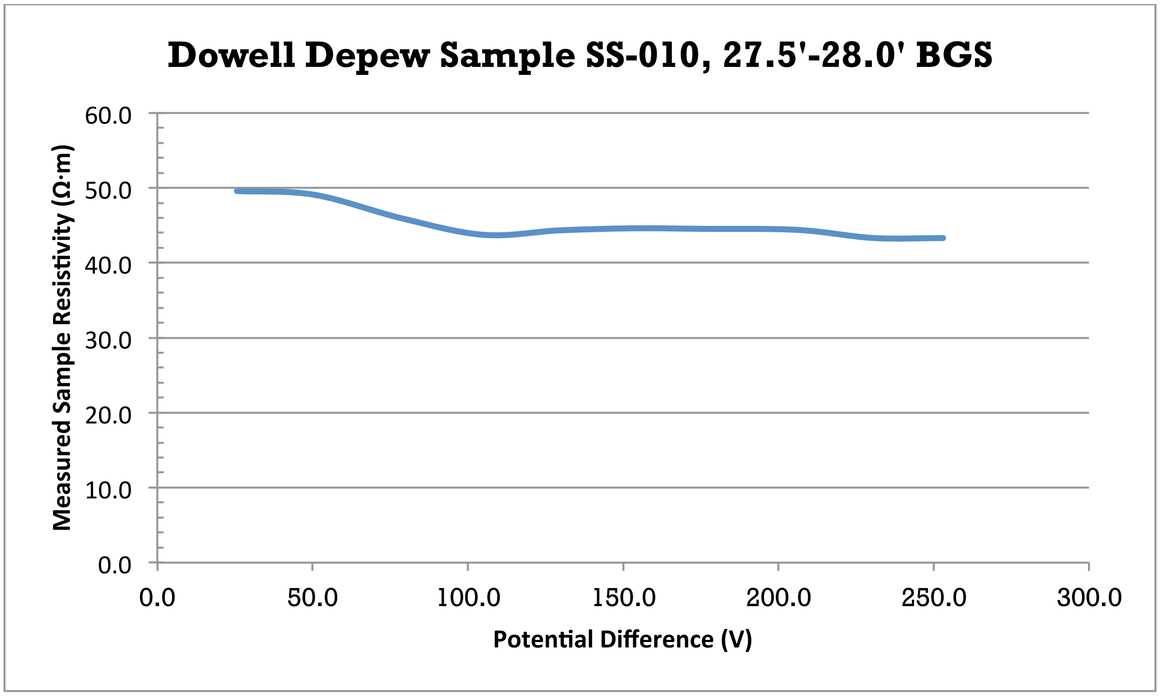


Figure 17: Static Resistivity Test: 27.5 to 28.0ft BGS – SS-010

4.2. Dynamic Resistivity

The results of the Dynamic Resistivity Tests for the combined sample are presented in **Figure 18**. As desiccation occurs at higher temperatures, resistivity begins to increase dramatically. ET-DSP™ technology uses water as a coolant and conductor. Raw data for the generation of this figure are included in **Appendix B**. The resistivity values were calculated in the same manner as the Static Resistivity Tests.

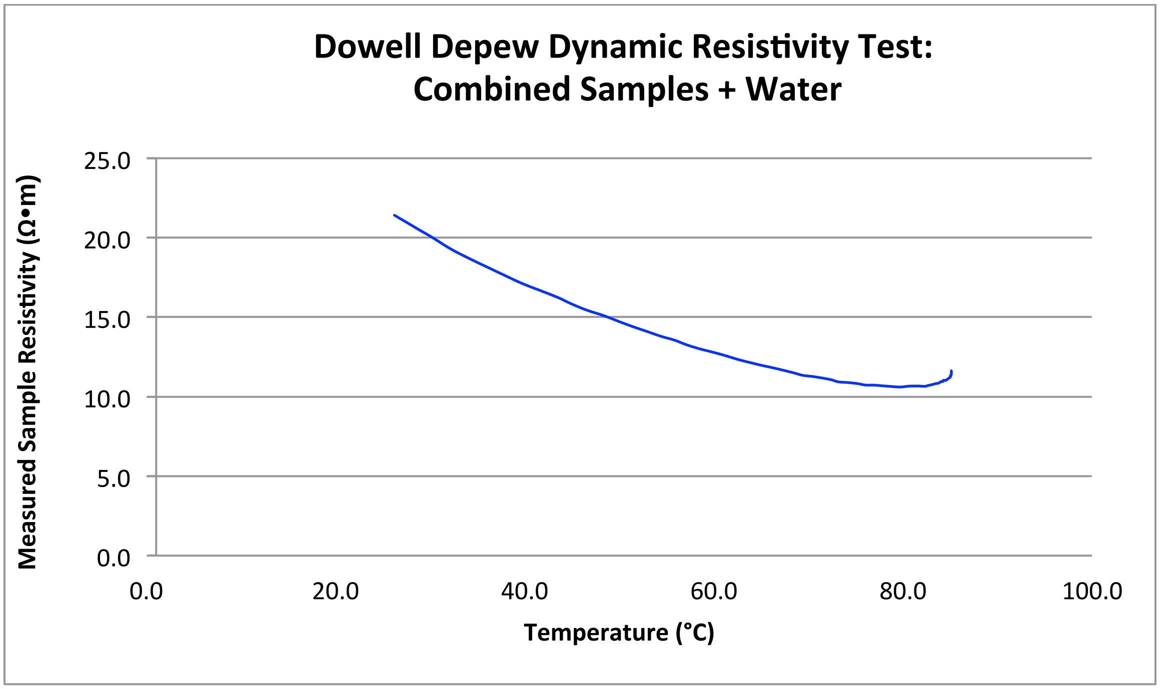


Figure 18: Dynamic Resistivity Test - Combined Samples

5. Conclusions & Recommendations

The following conclusions are presented from the results of this laboratory investigation:

1. The electrical properties measured in the Static Resistivity Test indicate the soil samples are within the normal range for ET-DSP™ treatment.
2. Electrical resistivity is expected to decrease by an approximate factor of 2.02 during heating from ambient to treatment temperature. The ET-DSP™ system will be designed to compensate for the increase in conductivity observed.

The following recommendations are made:

1. Based on the results of the electrical resistivity tests, the design of the thermal remediation system should consist of a custom electrode layout for electrical heating combined with a multi-phase extraction strategy. The electrodes will be evenly spaced with extraction wells situated within the electrode array to achieve high extraction rates. A circulation system capable of injecting water at each electrode is required to maintain electrical resistivity within the effective range for ET-DSP™.
2. The data obtained can be used to quantify electrical power requirements, voltage and current operating conditions, operating strategy, and other field-scale considerations for ET-DSP™ at the site.
3. Additional analysis may be required to determine heating and recovery rates expected in a field-scale operation. This can be done through numerical modeling conducted by Mc^2.

Appendix A: Equipment

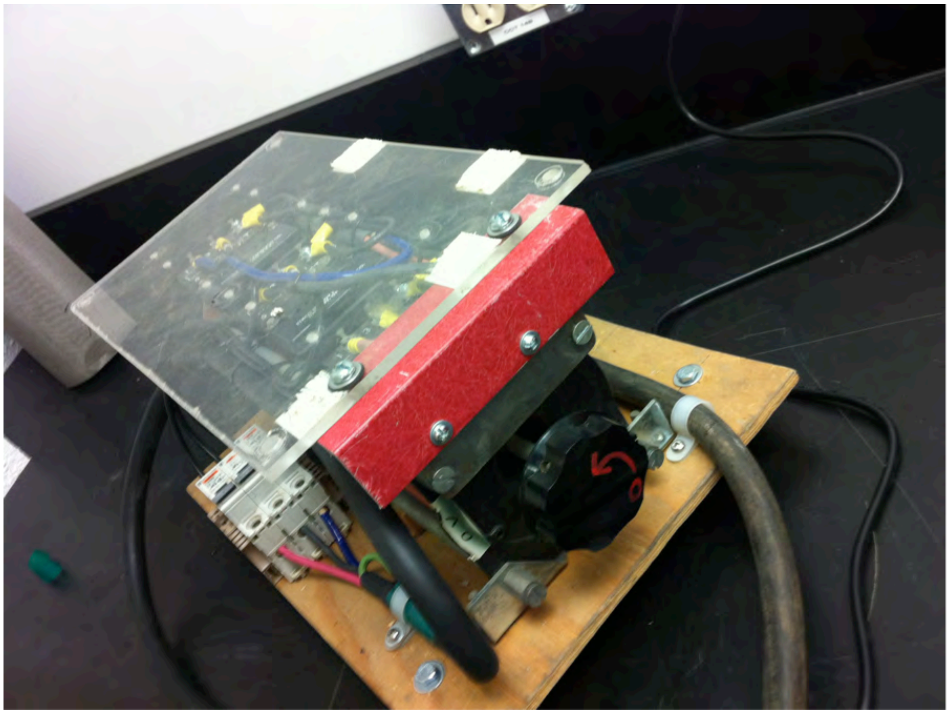


Figure 19: Three-phase transformer

The system will be heated using a 240volt, 10 amps, and 3-phase variable transformer. The transformer is used to supply power to the electrodes in the static, dynamic and bench scale tests.

Figure 20: Multi meter and ammeter

The multi meter and ammeter are used to measure the current and voltage that passes through the soil in the static and dynamic resistivity testing.

Figure 21: Testing Box for Static and Dynamic Resistivity Testing

The test box contains two copper electrodes that protrude on opposite ends. A three-phase transformer and ammeter are attached in series to electrodes. A hand held voltmeter is attached in parallel.

Appendix B: Raw Data

Static Resistivity Data

Sample SS-01, 1.5-3.0’ BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.405
Sample volume (m^3):	5.09E-04
Sample mass (kg):	1.239
⇒Sample density (kg/m^3):	2435.019

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
72.7	0.05	2	0.5	36350.0	0.25	100.6	0.1
151.1	0.05	5	0.5	30220.0	0.10	83.6	0.1
234.7	0.05	8	0.5	29337.5	0.06	81.2	0.1
294.5	0.05	10	0.5	29450.0	0.05	81.5	0.1
342	0.5	12	0.5	28500.0	0.04	78.9	0.1
377	0.5	13	0.5	29000.0	0.04	80.3	0.1
410	0.5	14	0.5	29285.7	0.04	81.1	0.1
431	0.5	15	0.5	28733.3	0.03	79.5	0.1
446	0.5	16	0.5	27875.0	0.03	77.2	0.1
467	0.5	17	0.5	27470.6	0.03	76.0	0.1
					Average:	82.0	0.0

Sample SS-I1, 1.5-3.0’ BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.305
Sample volume (m^3):	3.83E-04
Sample mass (kg):	0.890
⇒**Sample density (kg/m^3):**	2323.620

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
30.3	0.05	4	0.5	7575.0	0.13	21.0	0.1
56.8	0.05	7	0.5	8114.3	0.07	22.5	0.1
103.7	0.05	14	0.5	7407.1	0.04	20.5	0.1
140.4	0.05	19	0.5	7389.5	0.03	20.5	0.1
183.0	0.05	25	0.5	7320.0	0.02	20.3	0.1
219.5	0.05	31	0.5	7080.6	0.02	19.6	0.1
262.3	0.05	37	0.5	7089.2	0.01	19.6	0.1
316.0	0.05	44	0.5	7181.8	0.01	19.9	0.1
350	0.5	50	0.5	7000.0	0.01	19.4	0.1
440	0.5	63	0.5	6984.1	0.01	19.3	0.1
					Average:	20.2	0.0

Sample SS-02, 4.5'-6.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.152
Sample volume (m^3):	1.92E-04
Sample mass (kg):	0.385
⇒**Sample density (kg/m^3):**	2010.323

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
20.26	0.005	3	0.5	6753.3	0.17	18.7	0.1
48.6	0.05	8	0.5	6075.0	0.06	16.8	0.1
83.7	0.05	14	0.5	5978.6	0.04	16.5	0.1
117.7	0.05	20	0.5	5885.0	0.03	16.3	0.1
155.1	0.05	26	0.5	5965.4	0.02	16.5	0.1
184.2	0.05	31	0.5	5941.9	0.02	16.4	0.1
227.3	0.05	39	0.5	5828.2	0.01	16.1	0.1
261.6	0.05	45	0.5	5813.3	0.01	16.1	0.1
302.1	0.05	54	0.5	5594.4	0.01	15.5	0.1
343	0.5	62	0.5	5532.3	0.01	15.3	0.1
					Average:	16.4	0.0

Sample SS-I2, 4.5'-6.0' BGS

	Value
Sample width (m):	0.128
Sample depth (m):	0.030
Cross-sectional area (m^2):	0.00384
Sample length (m):	0.130
Sample volume (m^3):	4.99E-04
Sample mass (kg):	1.3732
⇒**Sample density (kg/m^3):**	2750.801

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
2.02	0.005	2	0.5	1010.0	0.3	29.8	0.1
20.23	0.005	22	0.5	919.5	0.0	27.2	0.1
30.25	0.005	33	0.5	916.7	0.0	27.1	0.1
50.3	0.05	56	0.5	898.2	0.0	26.5	0.1
69.5	0.05	77	0.5	902.6	0.0	26.7	0.1
92.5	0.05	103	0.5	898.1	0.0	26.5	0.1
110.6	0.05	124	0.5	891.9	0.0	26.3	0.1
130.6	0.05	147	0.5	888.4	0.0	26.2	0.1
168.6	0.05	192	0.5	878.1	0.0	25.9	0.1
230.5	0.05	276	0.05	835.1	0.0	24.7	0.1
					Average:	26.7	0.0

Sample SS-09, 5.5'-7.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.454
Sample volume (m^3):	5.71E-04
Sample mass (kg):	1.5573
⇒ **Sample density (kg/m^3):**	2729.497

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
2.129	0.0005	1	0.5	2129.0	0.50	5.9	0.1
26.40	0.005	1	0.5	26400.0	0.50	73.1	0.1
47.3	0.05	3	0.5	15766.7	0.17	43.6	0.1
72.7	0.05	5	0.5	14540.0	0.10	40.2	0.1
101.4	0.05	7	0.5	14485.7	0.07	40.1	0.1
123.7	0.05	8	0.5	15462.5	0.06	42.8	0.1
152.1	0.05	10	0.5	15210.0	0.05	42.1	0.1
176.5	0.05	12	0.5	14708.3	0.04	40.7	0.1
203.0	0.05	14	0.5	14500.0	0.04	40.1	0.1
233.1	0.05	16	0.5	14568.8	0.03	40.3	0.1
281.6	0.05	19	0.5	14821.1	0.03	41.0	0.1
305.7	0.05	21	0.5	14557.1	0.02	40.3	0.1
345	0.50	24	0.5	14375.0	0.02	39.8	0.1
380	0.50	26	0.5	14615.4	0.02	40.5	0.1
406	0.50	28	0.5	14500.0	0.02	40.1	0.1
					Average:	40.7	0.0

Sample SS-03, 7.5'-9.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.464
Sample volume (m^3):	5.83E-04
Sample mass (kg):	1.2862
⇒Sample density (kg/m^3):	2208.015

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity ($\Omega\cdot$m)**	
V	$\pm\ \delta V$	I	$\pm\ \delta I$	R	$\pm\ \delta R$	ρ	$\pm\ \delta\rho$
61.1	0.005	4	0.5	15275.0	0.13	42.3	0.1
107.9	0.05	8	0.5	13487.5	0.06	37.3	0.1
148.7	0.05	12	0.5	12391.7	0.04	34.3	0.1
183.4	0.05	15	0.5	12226.7	0.03	33.8	0.1
236.4	0.05	19	0.5	12442.1	0.03	34.4	0.1
266.9	0.05	21	0.5	12709.5	0.02	35.2	0.1
321.6	0.05	26	0.5	12369.2	0.02	34.2	0.1
351	0.5	29	0.5	12103.4	0.02	33.5	0.1
460	0.5	33	0.5	13939.4	0.02	38.6	0.1
466	0.5	38	0.5	12263.2	0.01	33.9	0.1
Average:						35.8	0.0

Sample SS-I3, 7.5'-9.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.438
Sample volume (m^3):	5.51E-04
Sample mass (kg):	1.2925
⇒Sample density (kg/m^3):	2347.458

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
38.7	0.050	4	0.5	9675.0	0.13	26.8	0.1
83.9	0.050	9	0.5	9322.2	0.06	25.8	0.1
103.4	0.050	12	0.5	8616.7	0.04	23.8	0.1
132.4	0.050	15	0.5	8826.7	0.03	24.4	0.1
173.5	0.050	20	0.5	8675.0	0.03	24.0	0.1
220.0	0.050	25	0.5	8800.0	0.02	24.4	0.1
261.9	0.050	30	0.5	8730.0	0.02	24.2	0.1
295.3	0.050	35	0.5	8437.1	0.01	23.4	0.1
355.0	0.050	42	0.5	8452.4	0.01	23.4	0.1
403.0	0.050	48	0.5	8395.8	0.01	23.2	0.1
					Average:	24.3	0.0

Sample SS-I4, 10.5'-12.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.451
Sample volume (m^3):	5.67E-04
Sample mass (kg):	1.3198
⇒**Sample density (kg/m^3):**	2329.519

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
3.61	0.005	1	0.5	3610.00	0.50	9.99	0.11
34.6	0.05	4	0.5	8650.0	0.1	23.9	0.1
67.2	0.05	9	0.5	7466.7	0.06	20.7	0.1
130.2	0.05	18	0.5	7233.3	0.03	20.0	0.1
161.1	0.05	22	0.5	7322.7	0.02	20.3	0.1
208.0	0.05	29	0.5	7172.4	0.02	19.9	0.1
256.6	0.05	37	0.5	6935.1	0.01	19.2	0.1
309.4	0.05	45	0.5	6875.6	0.01	19.0	0.1
364.3	0.05	53	0.5	6873.6	0.01	19.0	0.1
421	0.5	62	0.5	6790.3	0.01	18.8	0.1
					Average:	19.1	0.0

Sample SS-05, 13.5'-15.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.457
Sample volume (m^3):	5.75E-04
Sample mass (kg):	1.3982
⇒Sample density (kg/m^3):	2433.623

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
50.9	0.05	5	0.5	10180.0	0.10	28.2	0.1
99.8	0.05	11	0.5	9072.7	0.05	25.1	0.1
138.5	0.05	15	0.5	9233.3	0.03	25.6	0.1
180.7	0.05	20	0.5	9035.0	0.03	25.0	0.1
211.6	0.05	24	0.5	8816.7	0.02	24.4	0.1
250.4	0.05	28	0.5	8942.9	0.02	24.8	0.1
285.9	0.05	32	0.5	8934.4	0.02	24.7	0.1
327	0.5	37	0.5	8837.8	0.01	24.5	0.1
390	0.5	44	0.5	8863.6	0.01	24.5	0.1
464	0.5	53	0.5	8754.7	0.01	24.2	0.1
					Average:	25.1	0.0

Sample SS-I5, 13.5'-15.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.457
Sample volume (m^3):	5.75E-04
Sample mass (kg):	1.4402
⇒Sample density (kg/m^3):	2506.725

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
27.04	0.005	4	0.5	6760.0	0.13	18.7	0.1
57.1	0.05	8	0.5	7137.5	0.06	19.8	0.1
81.6	0.05	12	0.5	6800.0	0.04	18.8	0.1
108.8	0.05	16	0.5	6800.0	0.03	18.8	0.1
153.0	0.05	23	0.5	6652.2	0.02	18.4	0.1
191.6	0.05	29	0.5	6606.9	0.02	18.3	0.1
236.6	0.05	36	0.5	6572.2	0.01	18.2	0.1
281.6	0.05	43	0.5	6548.8	0.01	18.1	0.1
325	0.5	50	0.5	6500.0	0.01	18.0	0.1
419	0.5	64	0.5	6546.9	0.01	18.1	0.1
					Average:	18.5	0.0

Sample SS-06, 16.5'-18.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.457
Sample volume (m^3):	5.75E-04
Sample mass (kg):	1.5524
⇒**Sample density (kg/m^3):**	2702.014

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
42.8	0.05	3	0.5	14266.7	0.17	39.5	0.1
81.5	0.05	7	0.5	11642.9	0.07	32.2	0.1
119.7	0.05	11	0.5	10881.8	0.05	30.1	0.1
163.0	0.05	15	0.5	10866.7	0.03	30.1	0.1
203.9	0.05	19	0.5	10731.6	0.03	29.7	0.1
246.6	0.05	23	0.5	10721.7	0.02	29.7	0.1
279.4	0.05	27	0.5	10348.1	0.02	28.6	0.1
324.0	0.05	31	0.5	10451.6	0.02	28.9	0.1
361	0.5	34	0.5	10617.6	0.01	29.4	0.1
465	0.5	45	0.5	10333.3	0.01	28.6	0.1
					Average:	30.7	0.0

Sample SS-I6, 16.5'-18.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.467
Sample volume (m^3):	5.87E-04
Sample mass (kg):	1.5713
⇒**Sample density (kg/m^3):**	2679.095

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± δV	I	± δI	R	± δR	ρ	± $\delta\rho$
55.0	0.05	3	0.5	18333.3	0.17	50.7	0.1
77.3	0.05	5	0.5	15460.0	0.10	42.8	0.1
110.1	0.05	8	0.5	13762.5	0.06	38.1	0.1
146.6	0.05	11	0.5	13327.3	0.05	36.9	0.1
181.3	0.05	13	0.5	13946.2	0.04	38.6	0.1
220.0	0.05	16	0.5	13750.0	0.03	38.1	0.1
256.7	0.05	19	0.5	13510.5	0.03	37.4	0.1
303.3	0.05	23	0.5	13187.0	0.02	36.5	0.1
341	0.5	26	0.5	13115.4	0.02	36.3	0.1
465	0.5	36	0.5	12916.7	0.01	35.8	0.1
					Average:	39.1	0.0

Sample SS-07, 19.5'-21.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.438
Sample volume (m^3):	5.51E-04
Sample mass (kg):	1.5084
⇒**Sample density (kg/m^3):**	2739.579

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± δV	I	± δI	R	± δR	ρ	± $\delta\rho$
36.1	0.05	3	0.5	12033.3	0.17	33.3	0.1
71.2	0.05	6	0.5	11866.7	0.08	32.8	0.1
116.5	0.05	10	0.5	11650.0	0.05	32.2	0.1
157.5	0.05	14	0.5	11250.0	0.04	31.1	0.1
197.1	0.05	18	0.5	10950.0	0.03	30.3	0.1
246.3	0.05	23	0.5	10708.7	0.02	29.6	0.1
290.8	0.05	27	0.5	10770.4	0.02	29.8	0.1
329	0.5	30	0.5	10966.7	0.02	30.4	0.1
358	0.5	33	0.5	10848.5	0.02	30.0	0.1
444	0.5	41	0.5	10829.3	0.01	30.0	0.1
					Average:	31.0	0.0

Sample SS-I7, 19.5'-21.0' BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.457
Sample volume (m^3):	5.75E-04
Sample mass (kg):	1.5995
⇒**Sample density (kg/m^3):**	2783.993

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
63.2	0.05	2	0.5	31600.0	0.25	87.5	0.1
114.3	0.05	5	0.5	22860.0	0.10	63.3	0.1
163.2	0.05	7	0.5	23314.3	0.07	64.5	0.1
203.9	0.05	9	0.5	22655.6	0.06	62.7	0.1
236.6	0.05	11	0.5	21509.1	0.05	59.5	0.1
275.5	0.05	13	0.5	21192.3	0.04	58.7	0.1
305.8	0.05	14	0.5	21842.9	0.04	60.5	0.1
345	0.5	16	0.5	21562.5	0.03	59.7	0.1
386	0.5	18	0.5	21444.4	0.03	59.4	0.1
465	0.5	22	0.5	21136.4	0.02	58.5	0.1
					Average:	63.4	0.0

Sample SS-08, 22.5-24.0’ BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.394
Sample volume (m^3):	4.95E-04
Sample mass (kg):	1.3165
⇒Sample density (kg/m^3):	2661.004

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
8.17	0.005	1	0.5	8170.0	0.50	22.6	0.1
61.2	0.05	6	0.5	10200.0	0.08	28.2	0.1
100.0	0.05	11	0.5	9090.9	0.05	25.2	0.1
124.5	0.05	14	0.5	8892.9	0.04	24.6	0.1
151.3	0.05	17	0.5	8900.0	0.03	24.6	0.1
188.0	0.05	21	0.5	8952.4	0.02	24.8	0.1
218.7	0.05	25	0.5	8748.0	0.02	24.2	0.1
259.4	0.05	30	0.5	8646.7	0.02	23.9	0.1
297.6	0.05	34	0.5	8752.9	0.01	24.2	0.1
358	0.5	42	0.5	8523.8	0.01	23.6	0.1
					Average:	24.6	0.0

Sample SS-I8, 22.5-24.0’ BGS

	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.470
Sample volume (m^3):	5.90E-04
Sample mass (kg):	1.6058
⇒**Sample density (kg/m^3):**	2719.419

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
69.2	0.05	3	0.5	23066.7	0.17	63.8	0.1
105.8	0.05	5	0.5	21160.0	0.10	58.6	0.1
136.3	0.05	7	0.5	19471.4	0.07	53.9	0.1
173.0	0.05	9	0.5	19222.2	0.06	53.2	0.1
217.7	0.05	12	0.5	18141.7	0.04	50.2	0.1
262.3	0.05	14	0.5	18735.7	0.04	51.9	0.1
301.0	0.05	16	0.5	18812.5	0.03	52.1	0.1
335.0	0.05	18	0.5	18611.1	0.03	51.5	0.1
380.0	0.05	20	0.5	19000.0	0.03	52.6	0.1
465	0.5	25	0.5	18600.0	0.02	51.5	0.1
					Average:	53.9	0.0

Sample SS-10, 27.5'-28.0' BGS

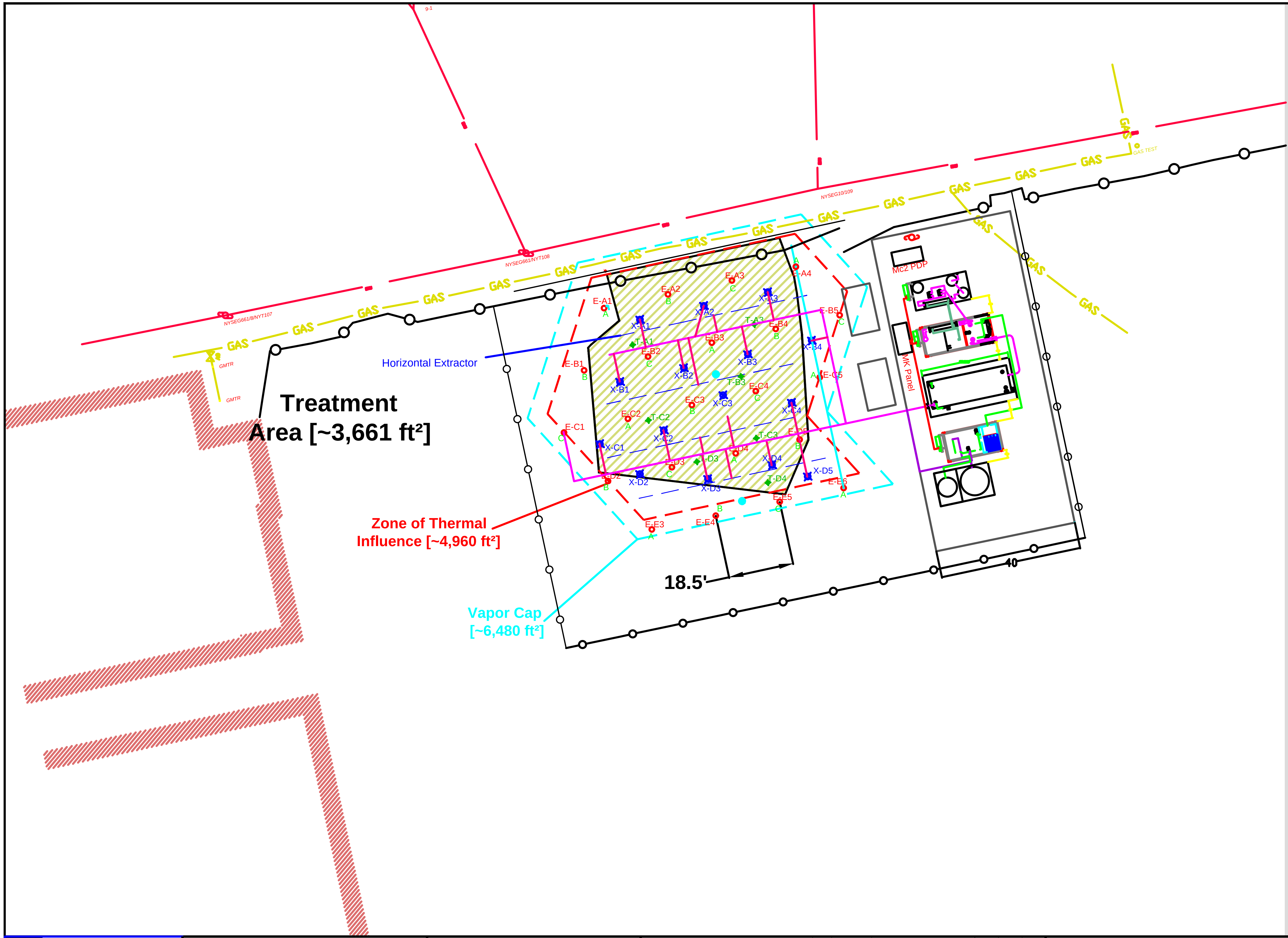
	Value
Sample diameter (m):	0.040
Cross-sectional area (m^2):	0.00126
Sample length (m):	0.216
Sample volume (m^3):	2.71E-04
Sample mass (kg):	0.753
⇒Sample density (kg/m^3):	2775.444

Pot. Difference (V AC)		**Current (mA AC)**		**Resistance (Ω)**		**Resistivity (Ω·m)**	
V	± *δV*	*I*	± *δI*	*R*	± *δR*	*ρ*	± *δρ*
1.048	0.0005	0	0.5	Undefined	Undefined	Undefined	Undefined
25.57	0.005	3	0.5	8523.3	0.2	49.6	0.1
50.6	0.05	6	0.5	8433.3	0.1	49.1	0.1
78.9	0.05	10	0.5	7890.0	0.1	45.9	0.1
105.2	0.05	14	0.5	7514.3	0.0	43.7	0.1
129.5	0.05	17	0.5	7617.6	0.0	44.3	0.1
153.3	0.05	20	0.5	7665.0	0.0	44.6	0.1
176.0	0.05	23	0.5	7652.2	0.0	44.5	0.1
206.0	0.05	27	0.5	7629.6	0.0	44.4	0.1
230.7	0.05	31	0.5	7441.9	0.0	43.3	0.1
253.0	0.05	34	0.5	7441.2	0.0	43.3	0.1
					Average:	45.3	0.0

Pot. Difference (V AC)	**Current (mA AC)**	**Resistance (Ω)**	**Resistivity (Ω·m)**	**Temperature (°C)**
V	I	R	ρ	T
201.2	398	506	21.4	26.2
201.6	416	485	20.5	28.7
201.6	426	473	20.1	30.1
200.5	440	456	19.3	32.1
200.6	454	442	18.7	34.0
200.8	468	429	18.2	35.9
200.7	482	416	17.6	37.8
200.7	496	405	17.1	39.6
200.5	508	395	16.7	41.4
200.3	522	384	16.3	43.4
200.0	535	374	15.8	44.9
199.8	548	365	15.4	46.5
199.6	560	356	15.1	48.3
199.6	574	348	14.7	49.9
199.2	586	340	14.4	51.4
199.0	598	333	14.1	52.9
199.2	612	325	13.8	54.4
199.3	623	320	13.6	55.8
198.7	636	312	13.2	57.2
198.6	648	306	13.0	58.6
198.7	659	302	12.8	60.0
198.6	670	296	12.6	61.3
197.2	678	291	12.3	62.6
196.7	688	286	12.1	64.0
196.4	696	282	12.0	65.1
196.1	704	279	11.8	66.3
196.2	713	275	11.7	67.3
196.2	723	271	11.5	68.4
196.1	733	268	11.3	69.4
196.1	738	266	11.3	70.5
196.8	753	261	11.1	72.3
196.1	760	258	10.9	73.1
196.2	764	257	10.9	74.2
196.3	769	255	10.8	75.2
196.2	775	253	10.7	76.0
196.6	777	253	10.7	76.9
197.1	782	252	10.7	77.8
196.5	782	251	10.6	78.5
196.7	785	251	10.6	79.1
196.7	786	250	10.6	79.8
196.7	782	252	10.7	80.6
196.8	782	252	10.7	81.3
196.6	781	252	10.7	81.7
196.2	781	251	10.6	82.3

196.1	777	252	10.7	82.6
196.0	773	254	10.7	83.0
196.5	770	255	10.8	83.4
196.7	769	256	10.8	83.7
196.5	764	257	10.9	83.9
196.7	762	258	10.9	84.0
197.0	762	259	11.0	84.2
197.2	758	260	11.0	84.3
197.4	759	260	11.0	84.5
196.8	748	263	11.1	84.8
197.0	743	265	11.2	85.0
197.0	737	267	11.3	85.0
196.1	731	268	11.4	85.1
197.5	725	272	11.5	85.1
197.3	719	274	11.6	85.1

Appendix C – Design Drawings



LEGEND

○	ET-DSPÊ Electrode Location [22]
⊠	Extraction Well [15 + 4]
⊕	Sensor Well Location [7]
●	Soil Sample Location [2]
▨	Treatment Area [3,661 ft¿]
⌞⌟	Thermal Influence [~4,900 ft¿]
⌞⌟	Vapor Cap [~6,480 ft¿]

NOTES:

1. ELECTRODES REQUIRE 25 cm [10"] BORING.
2. EXTRACTORS REQUIRE 15 cm [6"] BORING.
3. SENSOR WELLS REQUIRE 5 cm [2"] DROP TUBE. BORING SIZE IS MIN. 10 cm [4"].

McMillan-McGee Corp.
Creators of ET-DSP™

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LPE

DATE

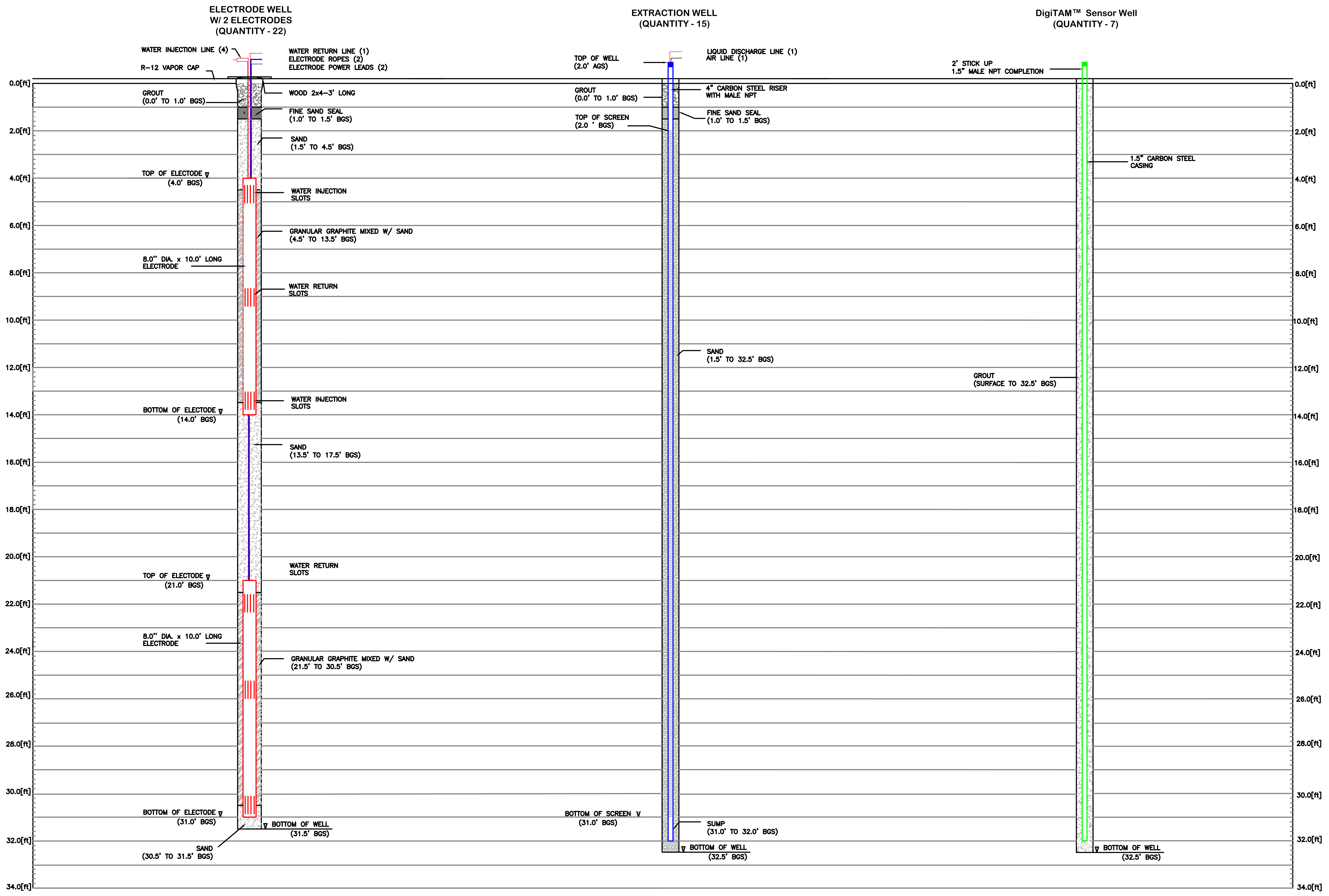
REV.	DATE (Yr/M/D)	DESCRIPTION	DRAWN BY	ORG/ ENGR	Aproved Dist
C1	2016/02/23	Final	ND	WR	DR
A6	2015/10/26	Electrical Drop	WR	DR	BW
A5	2015/10/20	THE CADD IMAGE ADDED	WR	DR	BW
A4	2015/09/04	Soil Sample locations added.	WR	XX	BW
A	2015/08/01	FIRST DRAFT	BW	XX	-

DRAWING NUMBER:
SCALE: NOT TO SCALE

TITLE:
ET-DSP™ Well Field Layout

CLIENT:
CH2M Hill
Former Dowell Site
Depew, New York

SHEET:
WFL-01



General Notes

1. MATERIAL TYPES
   - A. GROUT
     - HIGH TEMPERATURE PORTLAND TYPE 1 OR EQUIVALENT (NO BENTONITE)
   - B. SAND
     - ELECTRODE WELLS: 10 / 20 SILICA SAND OR EQUIVALENT
     - FINE SAND SEAL: 40 / 60 SILICA SAND OR EQUIVALENT
     - EXTRACTION WELLS: 20 / 40 SILICA SAND
   - C. GRAPHITE / SAND MIXTURE
     - 1:7 GRAPHITE TO SAND RATIO
   - D. BENTONITE: MEDIUM CHIPS
2. ELECTRODE WELLS
   - A. MINIMUM 10" DIAMETER BOREHOLE
   - B. WATER RETURN LINE INCLUDED TO ALLEVIATE POSSIBLE LOCALIZED PRESSURE BUILD UP WITHIN ELECTRODE WELL.
   - C. DEPTHS AND DIMENSIONS ARE TYPICAL, AND WERE FIELD-ADJUSTED TO ACCOUNT FOR THE LOCAL DEPTH OF BEDROCK.
3. TEMPERATURE WELLS
   - A. MINIMUM 4" DIAMETER BOREHOLE
   - B. 1.5" CARBON STEEL CASING
   - C. DEPTHS AND DIMENSIONS ARE TYPICAL, AND WERE FIELD-ADJUSTED TO ACCOUNT FOR THE LOCAL DEPTH OF BEDROCK.
4. EXTRACTION WELLS
   - A. MINIMUM 8" DIAMETER BOREHOLE
   - B. 4" CASING SIZE SCREEN C/W 0.010" OPENING
   - C. 4" NPT FEMALE X WELD PLATE ENDS
   - D. NOMINAL 4" DIAMETER WIRE-WRAPPED 304 STAINLESS STEEL 0.010''-SLOTTED SCREEN
   - E. FITTINGS BETWEEN PIPE SECTIONS ARE 4 THREAD PER INCH (TPI) FLUSH THREADED UNLESS SPECIFIED OTHERWISE (IE M NPT OR PLUG)
   - F. DEPTHS AND DIMENSIONS ARE TYPICAL, AND WERE FIELD-ADJUSTED TO ACCOUNT FOR THE LOCAL DEPTH OF BEDROCK.

McMillan-McGee Corp.
Creators of ET-DSP™

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LPE

DATE

C1	2016/02/23	FINAL	ND	WR	DR
A2	2015/01/20	FOR DRAFT REMEDIAL DESIGN RPT	ND	WR	DR
A1	2015/08/18	FOR CONSTRUCTION	MM	CC	DR
REV.	DATE (YR/MM/DD)	DESCRIPTION	DRAWN BY	ORG/ ENGR	Aproved Dist
APEGA PERMIT NUMBER:	P09178		SCALE:	NOT TO SCALE	

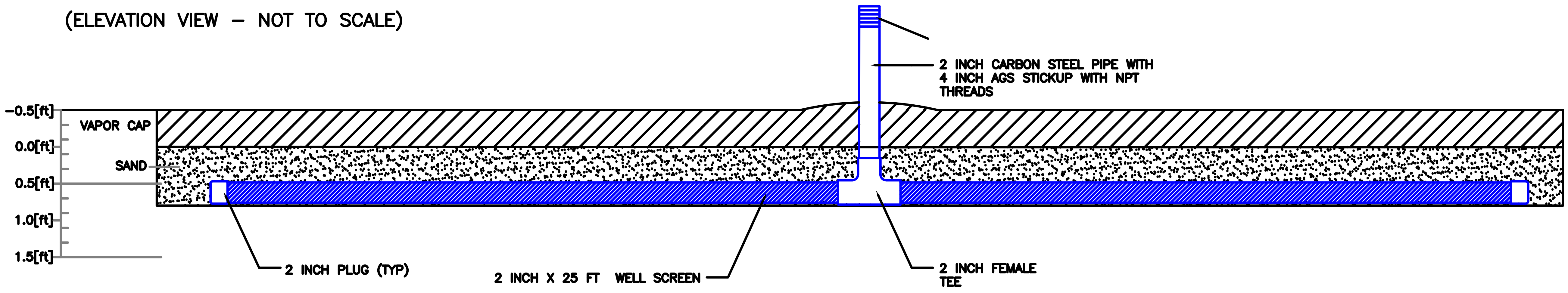
TITLE:
ET-DSP™ Well Completion Drawing

CLIENT:
CH2M HILL
Former Dowell Site
Depew, New York

SHEET:
WCD-01

TRENCH DETAIL – HORIZONTAL VAPOR EXTRACTION PIPE

(ELEVATION VIEW – NOT TO SCALE)



NOTES

1. NOMINAL 2" DIAMETER WIRE-WRAPPED 304 STAINLESS STEEL 0.010"-SLOTTED SCREEN
2. PLACE A REMOVABLE CAP OR PLUG ON TOP OF STICKUP, AND ENSURE THAT THE TOP IS > 0.30 M (1.0 FT) ABOVE GRADE FOR CONNECTION TO EXTRACTION SYSTEM
3. SAND FILL TO BE 10/20 SILICA SAND OR EQUIVALENT
4. CONNECTIONS TO BE BELL AND DEPRESSIONS UNLESS OTHERWISE SPECIFIED, TO BE EPOXIED AT TEMPERATUREDS GREATER THAN 50 DEGREES F.

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LPE

DATE

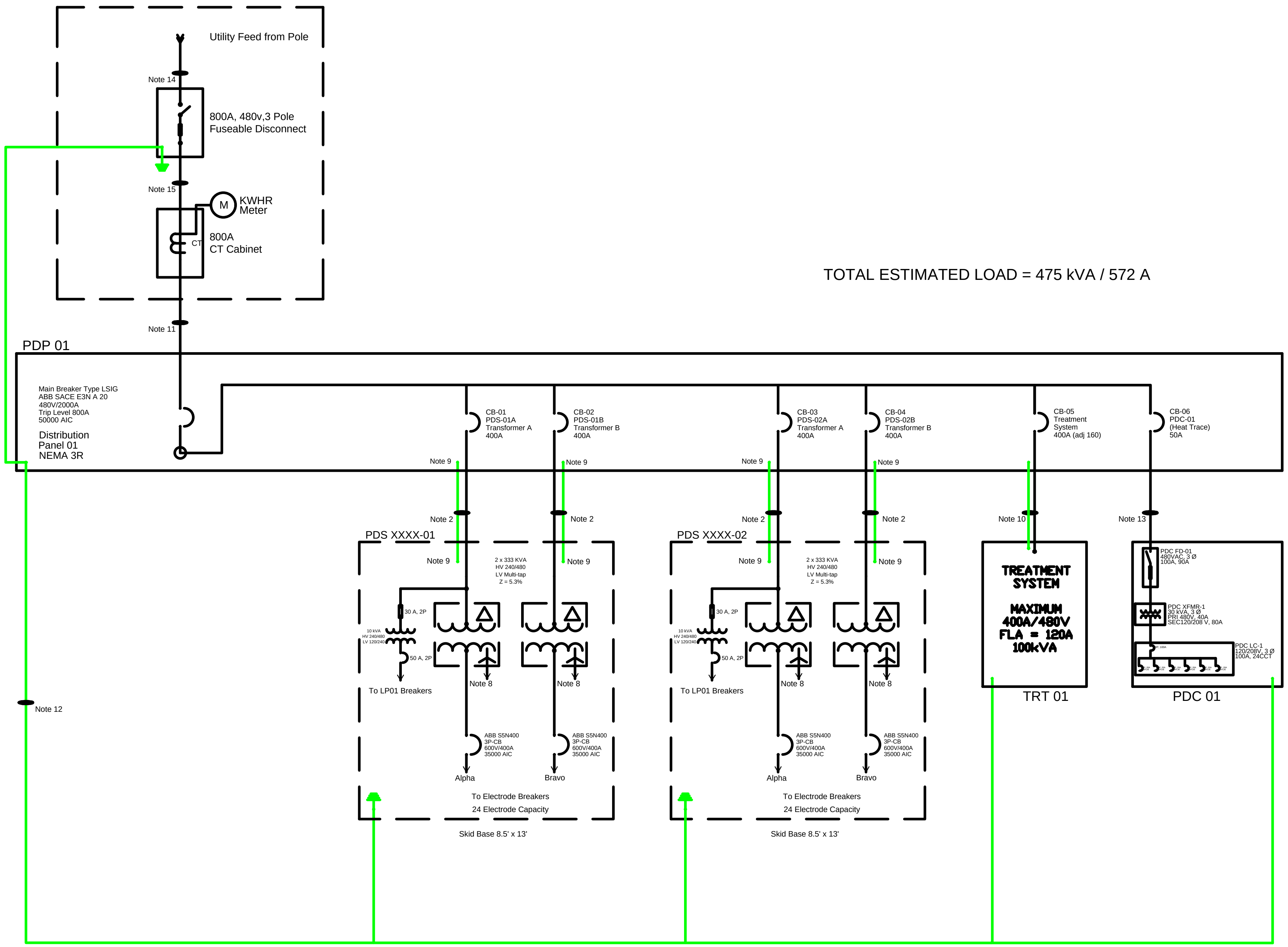
C1	2016/02/23	FINAL	ND	WR	DR
A1	2015/01/22	NOT FOR CONSTRUCTION	ND	WR	DR
REV.	DATE (YR/MM/DD)	DESCRIPTION	DRAWN BY	ORG/ ENGR	Aproved Dist
APEGA PERMIT NUMBER:	P09178		SCALE:	NOT TO SCALE	

TITLE:
ET-DSP™ Trench Detail

CLIENT:
CH2M HILL
Former Dowell Site
Depew, New York

SHEET:
TD-01

Power Distribution from Utility



TOTAL ESTIMATED LOAD = 475 kVA / 572 A

General Notes

1. Construction and material shall comply with applicable Federal, State, local building codes and the NEC.

2. Cable from PDP 01 to PDS XXXX-01 and PDS XXXX-02: 2 parallel 3C-250 kcmil c/w #2 AWG AL Ground to each transformer (A & B): STR AL NUAL Alcan Type ACWU90 XLPE INS AIA BLK PVC JKT 600V 90C HL CSA C22.2 NO.51. Above ground rated.

3. Cable from PDS to Electrodes: 1C, No. 1/0 AWG Rockbestos Type DAA1048B EXANE XLPE STR TNC 110C FT4 600V CSA CSA/UL MARINE. Above ground rated.

4. ET-DSP™ neutral cable: 1C, No. 1/0 AWG Rockbestos Type DAA1048B EXANE XLPE STR TNC 110C FT4 600V CSA CSA/UL MARINE. Above ground rated.

5. Maximum operating load for ET-DSP™ (44 electrodes) is 350 kW.

7. All electrical equipment shall be grounded in accordance with NEC. Service grounding to earth shall NOT be placed within 30 ft of electrode wellfield.

8. ET-DSP neutral grounding scheme determined during system commissioning and shall include all metal-constructed extraction wells. Derived from secondary neutral of main PDS transformers and separate from utility ground.

9. Grounding terminals of PDS feed conductors in panels: bolted AL grounding lugs.

10. Cable from PDP 01 to Treatment System TRT 01 distribution panel: One (1) 3C-250 kcmil c/w #2 AWG AL Ground: STR AL NUAL Alcan Type ACWU90 XLPE INS AIA BLK PVC JKT 600V 90C HL CSA C22.2 NO.51. Above ground rated.

11. Service conductors from CT Cabinet to Power Distribution Panel PDP-01: Two (2) parallel runs of 3 conductor 600 kcmil Cu conductors in conductor/conduit or teck cable.

12. PDP, PDS and Treatment skid bases are to be interconnected with a 2/0 ground cable that originates from electrical service ground at PDP.

13. Cable from PDP-01 to PDC-01: One (1) #6 awg CU 3 conductor teck cable c/w ground.

14. Service conductors from Power Pole to 800A fused disconnect: Two (2) parallel runs of the following; Three (3) 600 kcmil Cu conductors plus One (1) 250 kcmil Cu conductor in conduit.

15. Service conductors from 800A fused disconnect to Meter cabinet: Two (2) parallel runs of the following; Three (3) 600 kcmil Cu conductors plus One (1) 250 kcmil Cu conductor in conduit.

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LPE

DATE

REV.	DATE (YY/MM/DD)	DESCRIPTION	DRAWN	ORG/ ENGR	APPR/ DIST
C1	2016/02/23	FINAL	DP	ER	DR
A4	2015/10/06	NOT FOR CONSTRUCTION	DP	ER	
A3	2015/09/28	NOT FOR CONSTRUCTION	DP	ER	
A2	2015/08/17	NOT FOR CONSTRUCTION	DP	ER	
A1	2015/08/06	NOT FOR CONSTRUCTION	DP	ER	

APEGA PERMIT NO. P09178

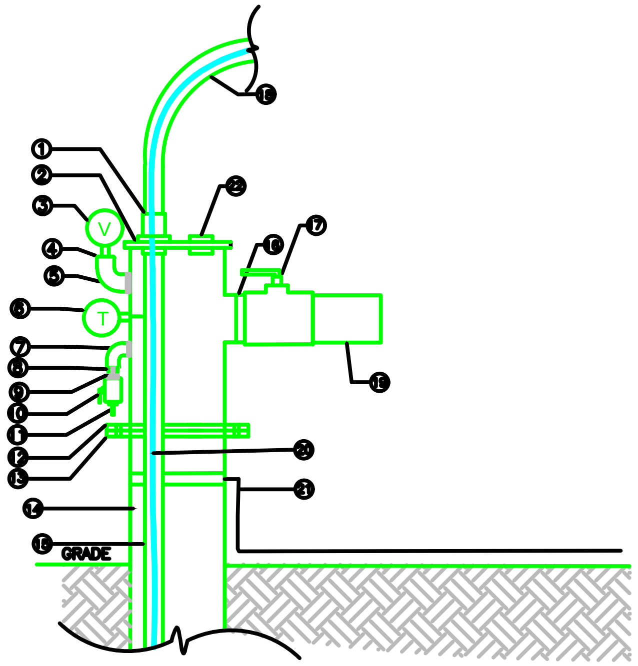
SCALE: NOT TO SCALE

TITLE: ET-DSP™ ELECTRICAL SINGLE LINE

CLIENT:
CH2M Hill
Former Dowell Site
Depew, New York

SHEET: ESL-01

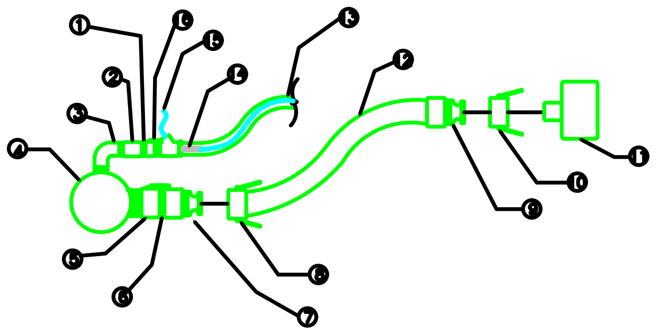
MULTI–PHASE EXTRACTION WELL WITH SLURPER TUBE DETAIL



WELLHEAD COMPONENTS

1. STRAIN RELIEF
2. 4"ø WELL SEAL
3. VACUUM GAUGE 0–30" HG
4. 1/2"M NPT X 1/4"F NPT BUSHING, GALV.
5. 1/2" NPT STREET ELBOW, GALV.
6. TEMPERATURE GAUGE 0–250 F
7. 1/2" NPT STREET ELBOW, GALV.
8. 1/2"M NPT x 3/8"F NPT REDUCER BUSHING, GALV.
9. 3/8" NPT CLOSE NIPPLE, BRASS
10. 3/8" NPT BALL VALVE, BRASS
11. 3/8"M NPT X 1/4" HOSE BARB, BRASS
12. 4"ø STEEL SCH40 FLANGE
13. 4"ø CARBON STEEL BOLT FLANGE
14. 4" NOMINAL I.D. CARBON STEEL WELL CASING
15. 1" I.D. PEX /GW EXTRACTION HOSE
16. 2"ø CLOSE NIPPLE, GALV.
17. 2"ø BALL VALVE, SS.
18. 1" I.D. PEX /GW EXTRACTION HOSE /TO MAINLINE
19. 2"ø NPT PVDF NIPPLE, 12" LONG
20. ¼" I.D. COMPRESSED AIR LINE
21. ET–DSP NEUTRAL WIRE
22. 3/4" NPT SAMPLE PORT PLUG

MPE VACUUM EXTRACTION CONNECTIONS

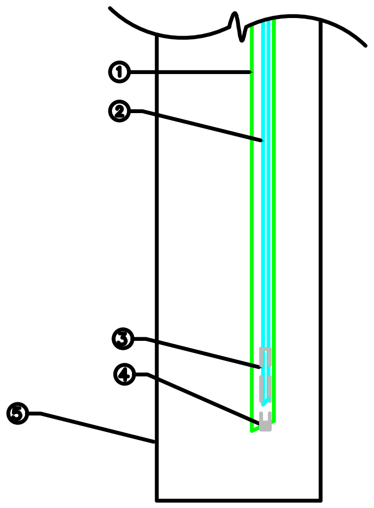


NOTE: 2" MWH Vapor Extraction Hose – Operating Temperatures: –40°F to 200°F (–40°C to 93°C), 150psi pressure rated, chemical, UV rated (Neoprene) / or equivalent.
Wellhead details are elevation views.

WELLHEAD COMPONENTS

1. 1"ø NPT CLOSE NIPPLE, GALV.
2. 1"ø NPT SPRING CHECK VALVE, BRASS
3. 1"ø NPT STREET ELBOW, GALV.
4. MPE EXTRACTION PIPING
5. 2"ø NPT BALL VALVE, GALV.
6. 2"ø NPT CLOSE NIPPLE, GALV.
7. 2"M CAM LOCK X 2"F NPT, AL. ALLOY
8. 2"F CAM LOCK X 2" HOSE BARB, AL. ALLOY
9. 2"M CAM LOCK X 2" HOSE BARB, AL. ALLOY
10. 2"F CAM LOCK X 2"F NPT, AL. ALLOY
11. MPE WELLHEAD
12. 2" VAC HOSE
13. 1" I.D. PEX /GW EXTRACTION HOSE /TO MAINLINE
14. 1"M NPT X 1" PEX BARB
15. ¾" I.D. COMPRESSED AIR LINE
16. 1"ø NPT BALL VALVE, GALV.

SLURPER TUBE DETAIL

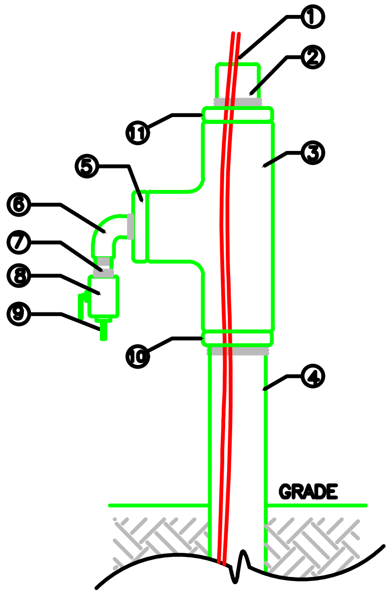


SLURPER TUBE DETAIL COMPONENTS

1. 1" I.D. PEX TUBE CUT ON 45 DEGREE ANGLE
2. ¾" I.D. COMPRESSED AIR LINE CUT ON 45 DEGREE ANGLE
3. 1/2" HDPE INNER TUBE AIRLINE HOUSING
4. 1/2" NPT PLUG, GALV.
5. 4" NOMINAL I.D. SCHED. 40 0.010" SLOTTED CONTINUOUS WIRE WRAP SCREEN

NOTE: Wellhead details are elevation views.

digiTAM™ WELLHEAD DETAIL

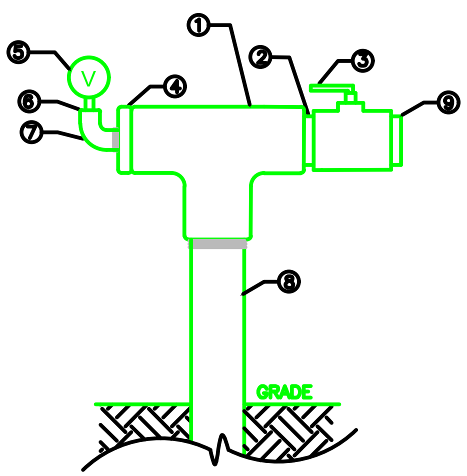


digiTAM™ WELLHEAD COMPONENTS

1. digiTAM™ SENSOR STRING
2. 1/2" STRAIN RELIEF AND 1"M NPT TO 1/2"F NPT REDUCER BUSHING (ASSEMBLED ON digiTAM)
3. 2"F NPT x 2"F NPT x 2"F NPT TEE, GALV.
4. 1–1/2" CARBON STEEL CASING
5. 2"M NPT x 3/8" F NPT BUSHING, GALV.
6. 3/8" NPT STREET ELBOW, GALV.
7. 3/8" NPT CLOSE NIPPLE, GALV.
8. 3/8" NPT BALL VALVE, BRASS
9. 3/8"M NPT X 1/4" HOSE BARB, BRASS
10. 2"M NPT x 1–1/2"F NPT BUSHING, GALV.
11. 2"M NPT x 1"F NPT BUSHING, GALV.

NOTE: Wellhead details are elevation views.

SHALLOW EXTRACTION WELLHEAD DETAIL



WELLHEAD COMPONENTS

1. 2"F x 2"F x 2"F TEE, GALV.
2. 2" CLOSE NIPPLES, GALV.
3. 2" GLOBE VALVE.
4. 2" X 3/8" REDUCER BUSHING, GALV.
5. VACUUM GAUGE, –20/0/+20 inH2O.
6. 3/8" x 1/4" REDUCER BUSHING, BRASS.
7. 3/8" STREET ELBOW, BRASS.
8. 2" FIBERGLASS CASING.
9. 2" CLOSE NIPPLE, GALV.

McMILLAN-McGEE CORP.
CREATORS OF ET-DSP™

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ELECTROMAGNETIC SYSTEMS AND SERVICES
FOR THE ENERGY AND ENVIRONMENTAL INDUSTRIES

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CALGARY, AB T2B 3M9 CANADA

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LPE

DATE

REV.	DATE (YY/MM/DD)	DESCRIPTION	DRAWN	ORG/ ENGR	APPR/ DIST
C1	2016/02/23	FINAL	ND	DR	DR
A1	2015/12/15	PRELIMINARY	ND	DR	DR

APEGA PERMIT NO. P09178
SCALE: NOT TO SCALE

TITLE:
ET-DSP™ Well Head Detail

CLIENT:
CH2M Hill
Former Dowell Site
Depew, New York

SHEET:
WHD-01

Appendix D – Design and Installation Data

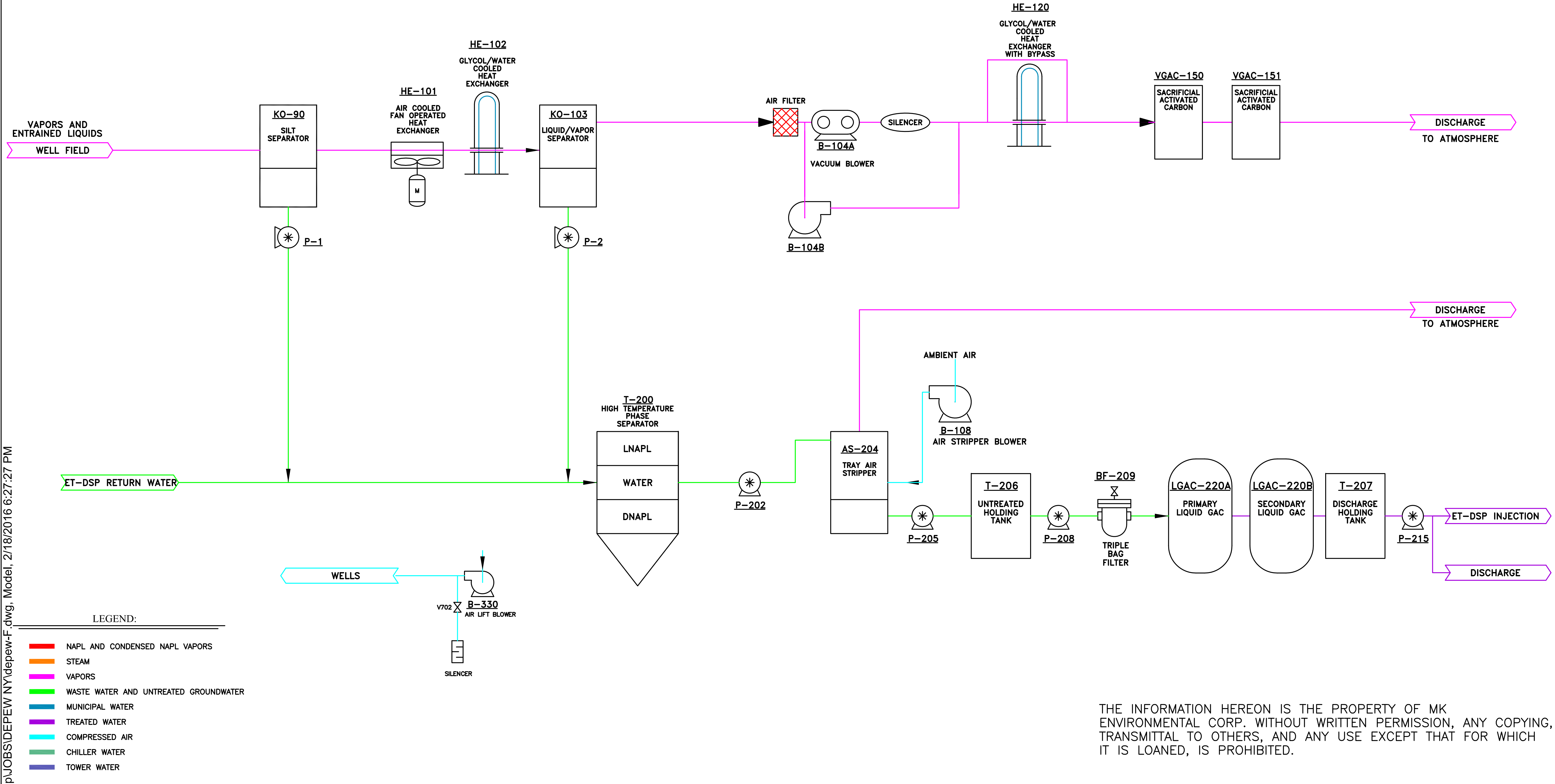
Electrodes

Identification	Design Criteria				Installation							
Electrode	**Electrodes per Borehole**	**Bottom of Well (ft BGS)**	**Top of Deep Electrode (ft BGS)**	**Top of Shallow Electrode (ft BGS)**	**Top Electrode dimensions (in. dia. X ft. length)**	**Bot. Electrode dimensions (in. dia. X ft. length)**	**Bottom of Well (ft BGS)**	**Top of Deep Electrode (ft BGS)**	**Top of Shallow Electrode (ft BGS)**	**Top of Sand (ft BGS)**	**Top of Fine Seal (ft BGS)**	**Top of Grout (ft BGS)**
E-A1	2	31.50	21.0	4.0	8" x10'	8"x10'	31	21'	4' 6"	1'8"	1.0	0.0
E-A2	2	31.50	21.0	4.0	8" x10'	8"x10'	31	21'	4.0	1' 6"	1.0	0.0
E-A3	2	31.50	21.0	4.0	8" x10'	8"x10'	28' 4"	18' 4"	3'	1' 8"	1'	0.0
E-A4	2	31.50	21.0	4.0	8" x10'	8"x10'	28'	18'	3'	1' 8"	1'	0.0
E-B1	2	31.50	21.0	4.0	8" x10'	8"x10'	31	21'	4.0	1' 7"	1.0	0.0
E-B2	2	31.50	21.0	4.0	8" x10'	8"x10'	29	19'	4.0	1' 6"	1.0	0.0
E-B3	2	31.50	21.0	4.0	8" x10'	8"x10'	6"	18'	3' 6"	1' 6"	1.0	0.0
E-B4	2	31.50	21.0	4.0	8" x10'	8"x10'	28	18'	3'	1' 6"	1'	0.0
E-B5	2	31.50	21.0	4.0	8" x10'	8"x10'	27' 10"	17' 10"	3'	1'	1' 6"	0.0
E-C1	2	31.50	21.0	4.0	8" x10'	8"x10'	28	18'	3'	1' 5"	1.0	0.0
E-C2	2	31.50	21.0	4.0	8" x10'	8"x10'	28' 6"	18' 6"	4.0	1' 7"	9"	0.0
E-C3	2	31.50	21.0	4.0	8" x10'	8"x10'	28' 6"	18' 6"	4.0	1' 3"	8"	0.0
E-C4	2	31.50	21.0	4.0	8" x10'	8"x10'	27' 6"	17" 6'	3'	1'	1' 6"	0.0
E-C5	2	31.50	21.0	4.0	8" x10'	8"x10'	27' 8"	17' 8"	3'	1'	1' 6"	0.0
E-D2	2	31.50	21.0	4.0	8" x10'	8"x10'	28'	18'	3.0	1.0	1.0	0.0
E-D3	2	31.50	21.0	4.0	6' 8" x 8"	8"x10'	26' 6"	16' 6"	3' 10"	1.0	N/A	0.0
E-D4	2	31.50	21.0	4.0	8" x10'	8"x10'	26' 7"	16' 7"	2' 7"	1' 8"	1'	0.0
E-D5	2	31.50	21.0	4.0	8" x 5'	8"x10'	26'7"	16' 7"	5'	1'	1' 6"	0.0
E-E3	2	31.50	21.0	4.0	8" x10'	8" x 5'	26' 6"	18'	3'	1'	1' 7"	0.0
E-E4	2	31.50	21.0	4.0	8" x10'	8" x 5'	27'	19'	4'	1'	1' 6"	0.0
E-E5	2	31.50	21.0	4.0	8" x10'	8" x 5'	27'	19'	4'	1'	1' 6"	0.0
E-E6	2	31.50	21.0	4.0	8" x10'	8" x 5'	27'	19'	4'	1'	1' 6"	0.0

Extraction Wells

Identification	Design Criteria				Installation								
Extraction Well	Bottom of Well (ft BGS)	Bottom of Sump (ft BGS)	Bottom of Screen (ft BGS)	Top of Screen (ft BGS)	Bottom of Well / Sump (ft BGS)	Bottom of Cap (ft BGS)	Top of Sump (ft BGS)	Bottom of Screen (ft BGS)	Top of Screen (ft BGS)	Top of Sand (ft BGS)	Top of Fine Seal (ft BGS)	Top of Grout (ft BGS)	Stick-up (ft AGS)
X-A1	32.5	31.0	31.0	2.0	31'	N/A	29' 8"	29' 8"	1' 1"	1' 6"	1'	0.0	3' 1"
X-A2	32.5	31	31	2	27' 8"	27' 8"	N/A	27' 8"	1' 8"	1'	1'	0	3' 4"
X-A3	32.5	31.0	31.0	2.0	28' 5"	28' 5"	N/A	28' 5"	2' 5"	1'	1'	0.0	2' 7"
X-B1	32.5	31.0	31.0	2.0	28' 3"	28' 3"	N/A	28' 3"	2' 3"	1'	1'	0.0	2' 4"
X-B2	32.5	31.0	31.0	2.0	28' 3"	28' 3"	N/A	28' 3"	2' 3"	1'	1'	0.0	2' 9"
X-B3	32.5	31.0	31.0	2.0	28'	28'	N/A	28'	2'	1'	1'	0.0	3'
X-B4	32.5	31.0	31.0	2.0	28' 6"	28' 6"	N/A	28' 6"	3' 6"	1'	1'	0.0	1' 6"
X-C1	32.5	31.0	31.0	2.0	28'	28'	N/A	28'	2'	1'	1'	0.0	3'
X-C2	32.5	31.0	31.0	2.0	28' 7"	28' 7"	N/A	28' 7"	2' 7"	1'	1'	0.0	2' 7"
X-C3	32.5	31.0	31.0	2.0	27'	27'	N/A	27'	2'	1'	1'	0.0	3'
X-C4	32.5	31.0	31.0	2.0	27'	27'	N/A	27'	2'	1'	1'	0.0	3'
X-D2	32.5	31.0	31.0	2.0	27' 6"	27' 6"	N/A	27' 6"	2' 6"	1'	1'	0.0	2' 6"
X-D3	32.5	31.0	31.0	2.0	27' 1"	27' 1"	N/A	27' 1"	2' 1"	1'	1'	0.0	2' 11"
X-D4	32.5	31.0	31.0	2.0	27'	27'	N/A	27'	2'	1'	1'	0.0	3'
X-D5	32.5	31.0	31.0	2.0	28' 6"	28' 6"	N/A	28' 6"	3' 6"	1'	1'	0.0	2' 6"

Appendix E – Treatment System Figures



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SCALE: NONE
DESIGNED: EHT
CHECKED BY: EHT
DRAWN BY: EHT
DRAWN DATE: 08-18-2015

MK ENVIRONMENTAL INC.

PROCESS FLOW DIAGRAM
WATER AND VAPOR
TREATMENT SYSTEM

MCMILLAN-MCGEE
Former Dowell Site
Depew, New York

No.	DATE:	BY:	REVISION:
2	10-5-15	MAL	REVIEW CHANGE AS-204 BLOWER, B-104
1	9-28-15	MAL	ADDED ADITIONAL B104, T-206, P-208

FIGURE NUMBER
M-1

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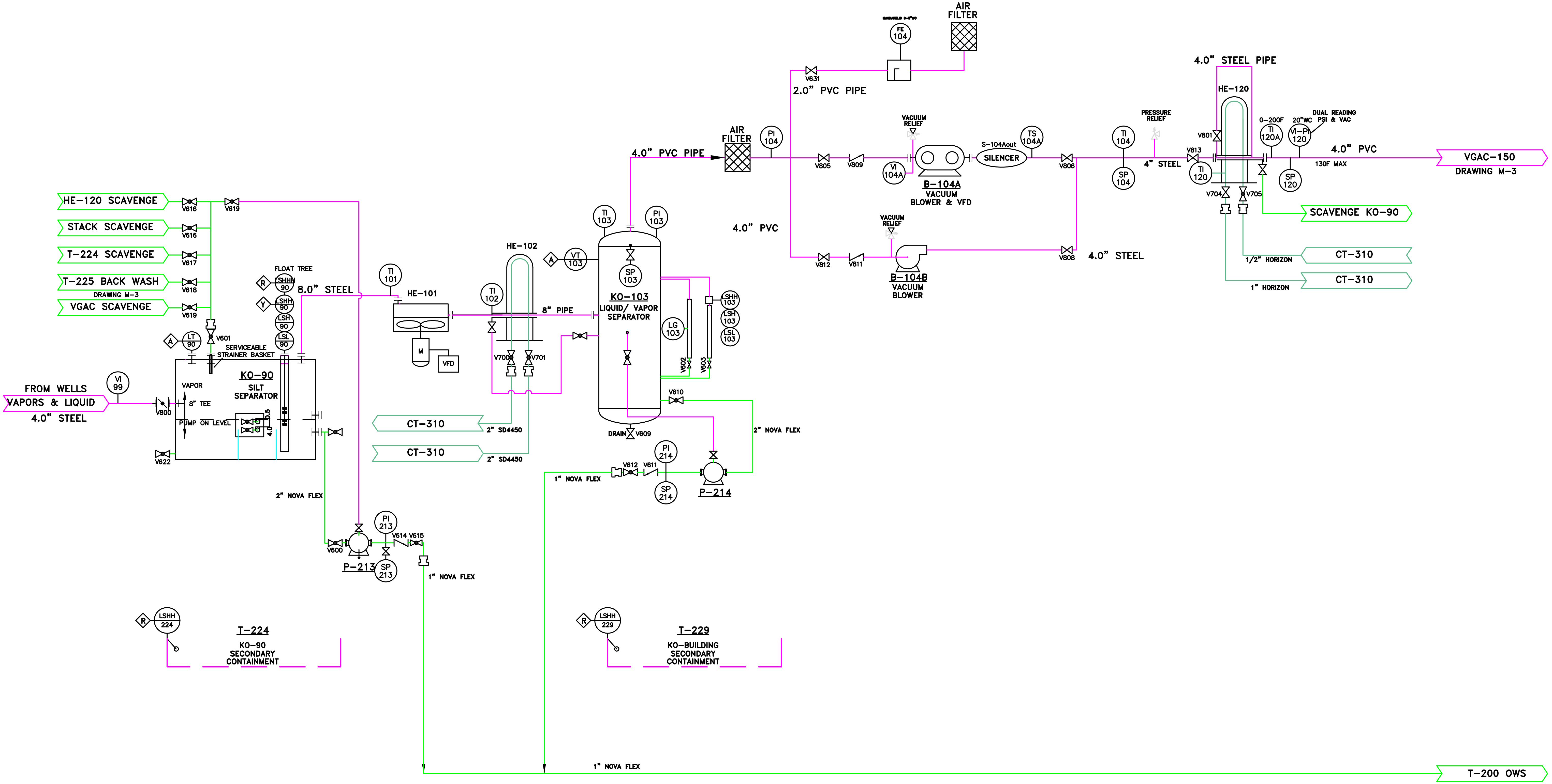

LEGEND:

🟪	VAPORS
🟩	GROUND WATER
🟦	CHILLER WATER
🟦	COMPRESSED AIR

SCALE:
NONE

DESIGNED: EHT
CHECKED BY: EHT
DRAWN BY: MAL
DRAWN DATE: 8-25-15

MK ENVIRONMENTAL INC.

P&ID DIAGRAM
VAPOR
TREATMENT SYSTEM

MCMILLAN-MCGEE
Former Dowell Site
Depew, New York

No.	DATE:	BY:	REVISION:
2	10-12-15	MAL	ADD SECONDARY CONTAINMENT KO BUILDING
1	10-5-15	MAL	REVIEW CHANGE AS-204 BLOWER, B-104, LT-90

FIGURE NUMBER
M-2

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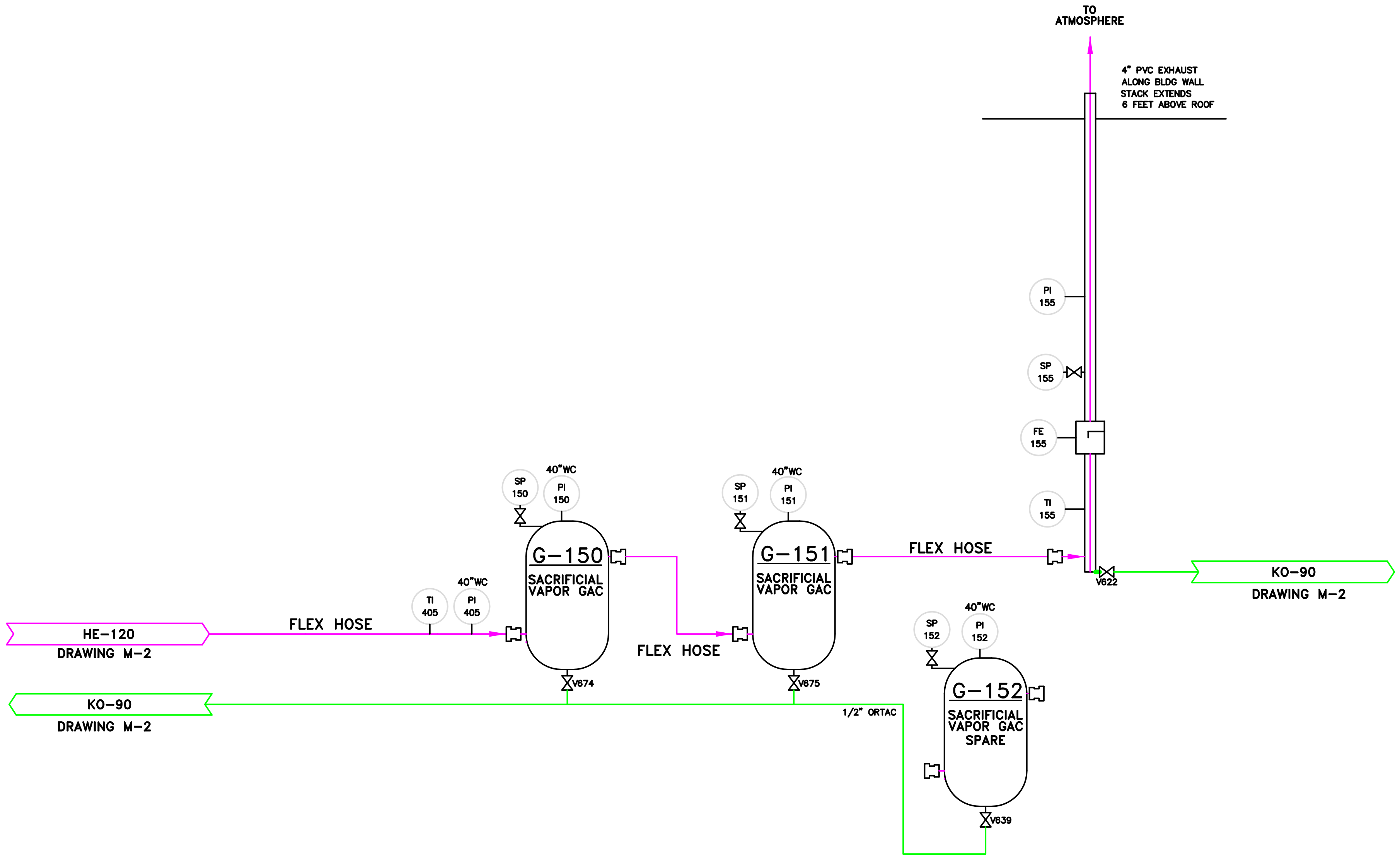

LEGEND:

- 🟥 NAPL AND CONDENSED NAPL VAPORS
- 🟧 STEAM
- 🟪 VAPORS
- 🟩 WASTE WATER AND UNTREATED GROUNDWATER
- 🟦 MUNICIPAL WATER
- 🟪 TREATED WATER
- 🟦 COMPRESSED AIR
- 🟩 CHILLER WATER
- 🟦 TOWER WATER

SCALE:
NONE

DESIGNED: EHT
CHECKED BY: EHT
DRAWN BY: ML
DRAWN DATE: 09–21–15

MK
ENVIRONMENTAL INC.

P&ID
VAPOR EXTRACTION AND
TREATMENT SYSTEM

MCMILLAN–MCGEE
Former Dowell Site
Depew, New York

No.	DATE:	BY:	REVISION:

FIGURE
NUMBER
M–3

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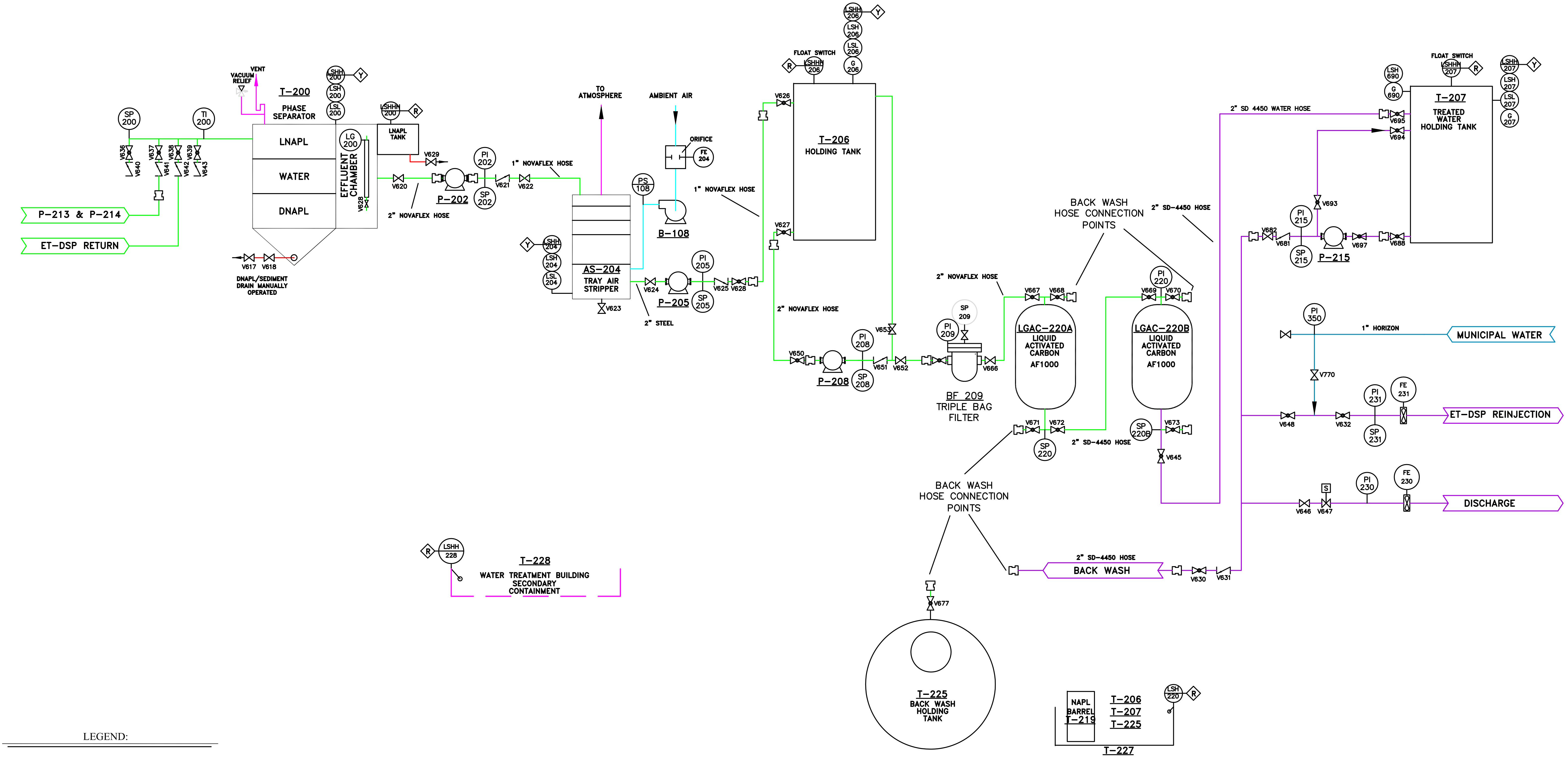

LEGEND:

- 🟪 VAPORS
- 🟩 GROUND WATER
- 🟦 CHILLER WATER
- 🟦 COMPRESSED AIR

SCALE: NONE	
DESIGNED: EHT	CHECKED BY: EHT
DRAWN BY: MAL	DRAWN DATE: 9-25-2015

MK ENVIRONMENTAL INC.

P&ID SYSTEM DIAGRAM
GROUNDWATER
TREATMENT SYSTEM

MCMILLAN-MCGEE
Former Dowell Site
Depew, New York

No.	DATE:	BY:	REVISION:
2	10-5-15	MAL	MODIFIED T-228, T-200, AS-204, T-206, T-207
1	10-5-15	MAL	REVIEW CHANGE AS-204 BLOWER, B-108, ORIFICE

FIGURE NUMBER
M-4

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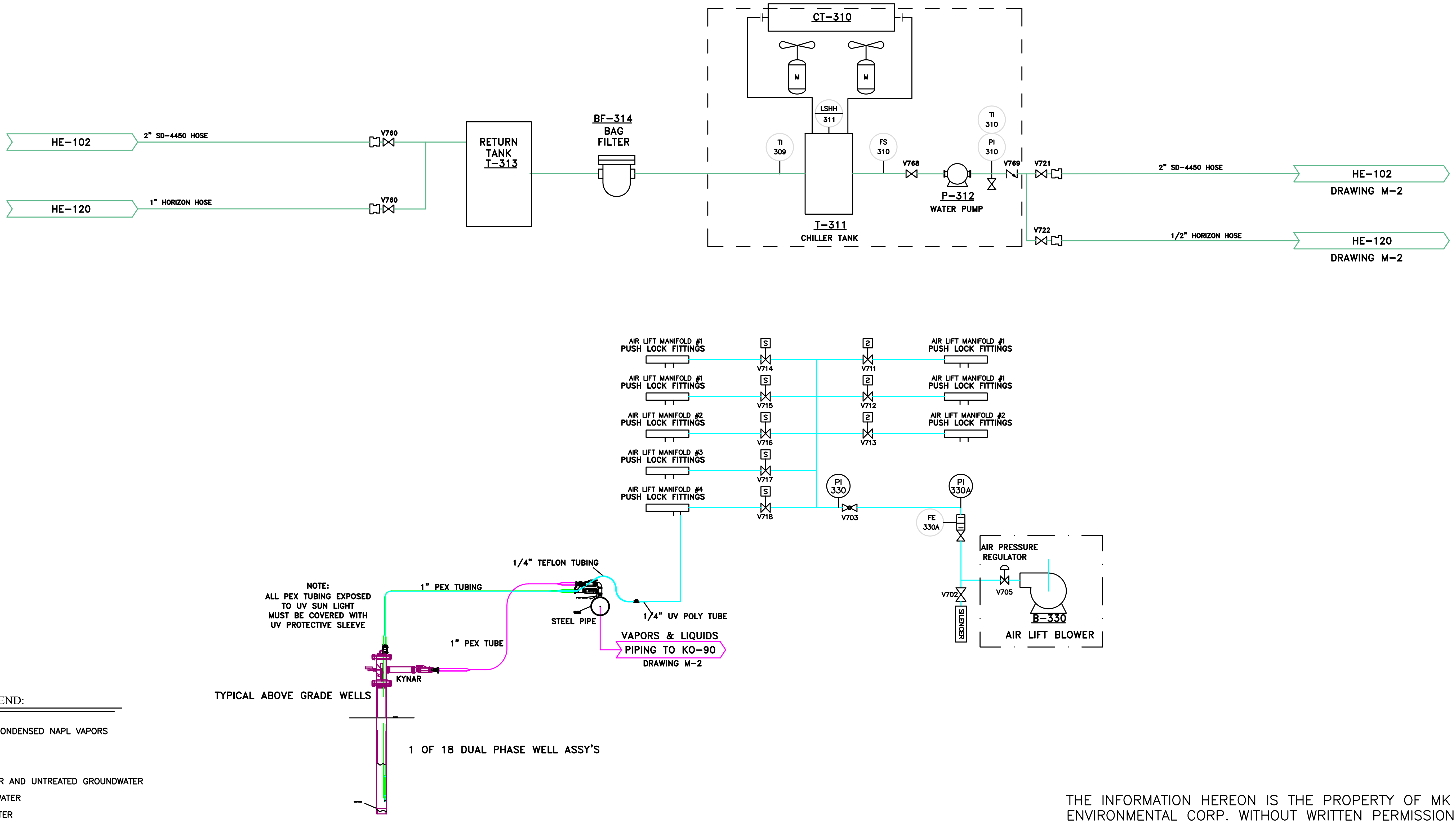

LEGEND:

🟥 NAPL AND CONDENSED NAPL VAPORS
🟧 STEAM
🟪 VAPORS
🟩 WASTE WATER AND UNTREATED GROUNDWATER
🟦 MUNICIPAL WATER
🟪 TREATED WATER
🟦 COMPRESSED AIR
🟩 CHILLER WATER
🟦 TOWER WATER

SCALE: NONE
DESIGNED: EHT
CHECKED BY: EHT
DRAWN BY: ML
DRAWN DATE: 09-21-15

MK
ENVIRONMENTAL INC.

P&ID
ANCILLARY
EQUIPMENT

MCMILLAN-MCGEE
Former Dowell Site
Depew, New York

No.	DATE:	BY:	REVISION:

FIGURE NUMBER
M-5

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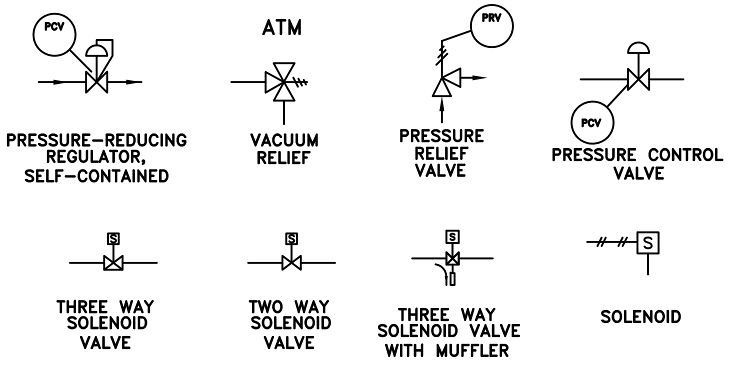
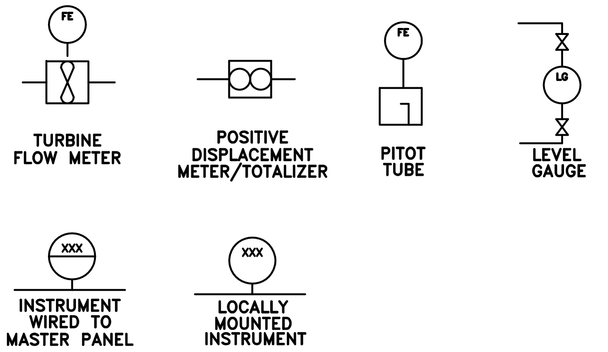
SYMBOLS FOR SELF-ACTUATED REGULATORS, VALVES, AND OTHER DEVICES



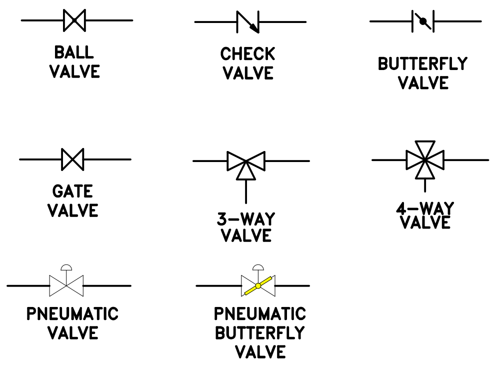
MEASUREMENT DEVICES



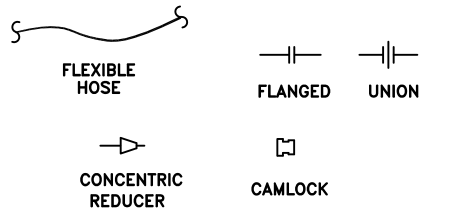
ABBREVIATIONS

ATM	ATMOSPHERE
DNAPL	DENSE NON AQUEOUS PHASE LIQUIDS
DPI	DIFFERENTIAL PRESSURE INDICATOR
ESD	EMERGENCEY SHUT DOWN
FE	FLOW ELEMENT
FM	FLOW METER
HOA	HAND/OFF/AUTO
LAH	LEVEL ALARM HIGH
LAHH	LEVEL ALARM HIGH-HIGH
LAL	LEVEL ALARM LOW
LNAPL	LIGHT NON-AQUEOUS PHASE LIQUIDS
LSH	LEVEL SWITCH HIGH
LSHH	LEVEL SWITCH HIGH-HIGH
LSL	LEVEL SWITCH LOW
LSLL	LEVEL SWITCH LOW LOW
LT	LEVEL TRANSMITTER
M	MOTOR
NAPL	NON-AQUEOUS PHASE LIQUIDS
NC	NORMALLY CLOSED
PI	PRESSURE INDICATOR
PT	PRESSURE TRANSMITTER
PVR	PRESSURE VACUUM RELIEF
TI	TEMPERATURE INDICATOR
TIT	TEMPERATURE INDICATING TRANSMITTER
TS	TEMPERATURE SWITCH
VAH	VACUUM ALARM HIGH
VI	VACUUM INDICATOR
VS	VACUUMSWITCH
VSH	VACUUM SWITCH HIGH
VT	VACUUM TRANSMITTER
TAH	TEMPERATURE ALARM HIGH
TT	TEMPERATURE TRANSMITTER
FRP	FIBERGLASS REINFORCED PIPE
MOV	MOTOR OPERATED VALVE
SP	SAMPLE PORT

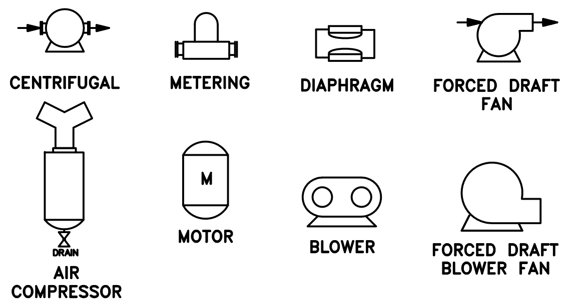
VALVES



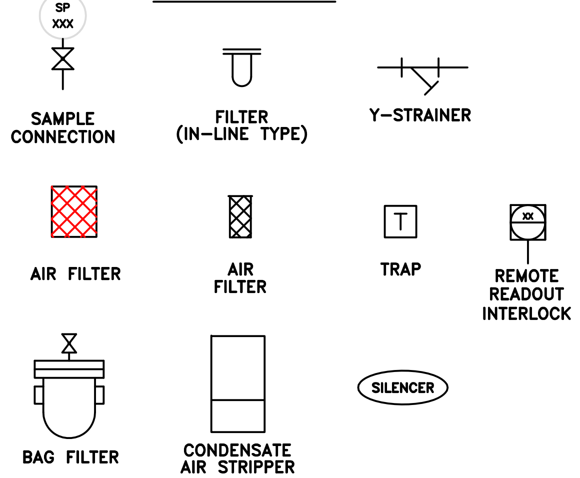
PIPING AND PIPING CONNECTIONS



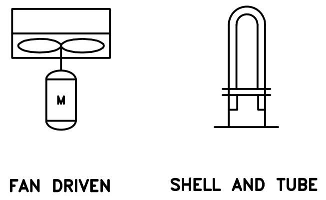
PUMPS



MISCELLANEOUS



HEAT EXCHANGERS



LEGEND:

- 🟥 NAPL AND CONDENSED NAPL VAPORS
- 🟧 STEAM
- 🟪 VAPORS
- 🟩 WASTE WATER AND UNTREATED GROUNDWATER
- 🟦 MUNICIPAL WATER
- 🟪 TREATED WATER
- 🟦 COMPRESSED AIR
- 🟩 CHILLER WATER
- 🟦 TOWER WATER

CONTROL INTERLOCKS

ALARM CONDITIONS

◇G GREEN – NO ALARMS OK TO OPERATE
◇Y YELLOW – STOPS WATER FLOW FROM WELLS & REDUCES SYSTEM VACUUM
◇R RED – IMMEDIATELY SHUTS DOWN ALL OPERATION OF ALL LIQUID AND VAPOR PROCESSING EQUIPMENT

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DRAWN DATE: 09-21-15

MK
ENVIRONMENTAL INC.

VAPOR EXTRACTION AND
TREATMENT SYSTEM
SYMBOLS

MCMILLAN-MCGEE
Former Dowell Site
Depew, New York

No.	DATE:	BY:	REVISION:

FIGURE NUMBER
M-6

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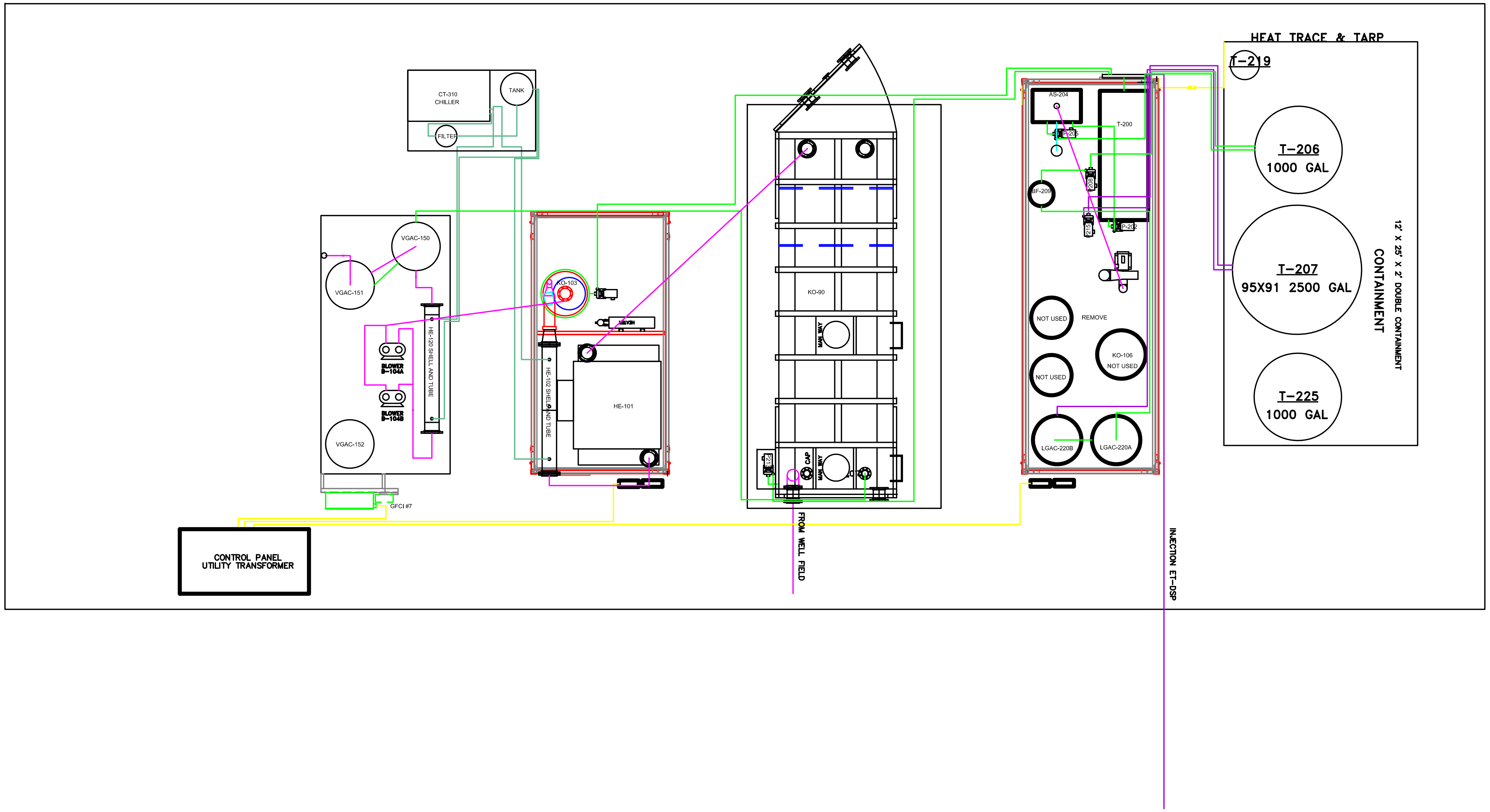


LEGEND:

🟥	NAPL AND CONDENSED NAPL VAPORS
🟧	STEAM
🟪	VAPORS
🟩	WASTE WATER AND UNTREATED GROUNDWATER
🟦	MUNICIPAL WATER
🟪	TREATED WATER
🟦	COMPRESSED AIR
🟩	CHILLER WATER
🟦	TOWER WATER
🟨	ELECTRIC WIRES

REV: R

SCALE:
1:1

DESIGNED: EHT
CHECKED BY: EHT
DRAWN BY: MAL
DRAWN DATE: 09-21-15

MK
ENVIRONMENTAL INC.

LAYOUT

MCMILLAN-MCGEE
Former Dowell Site
Depew, New York

No.	DATE:	BY:	REVISION:
6			
5			
4			
3			
2			
1			

FIGURE NUMBER
M-7

Appendix F – Equipment Lifting Plan

Prepared For:

ch2m:

Equipment Lifting Plan

Dowell Depew Site
Depew, New York

McMillan-McGee Corp.

Emergency Contact

NAME	TITLE	CELL#
Dr. Bruce McGee	Senior Technical Advisor	(403) 621-5101
Brent Winder	Project Manager	(403) 589-8726
Wayne Robella	Field Operations Manager	(403) 461-1669
Nicholas Dumaresq	Project Engineer	(403) 869-7645
Dave Perley	Master Electrician	(403) 921-0845
David Rountree	Senior Remediation Specialist	(403) 569-5116

Objective

All personnel involved with the activity of loading and unloading of the PDS units, and other ET-DSP™ equipment will comply with all applicable federal, state, and local laws as well as the safe operating procedures governed by the former Dowel Depew Site (Site).

Purpose

The purpose of this document is to outline the safe placement and removal of the PDS units and or other ET-DSP™ equipment using a crane. Further guidelines for the use of cranes and hoisting can be found in 29 CFR 1910.79, 1910.180 and 29 CFR 1926.552 (a) and (b) which should be used as a reference.

Pre Lift Meeting

Prior to the lift, the crane operator, the Heath and Safety Officer, and a member of the Mc^2 personnel must conduct a pre lift meeting and site walk to ensure the success of the lift, as well as the safety of all personnel affected by, and involved in the lifting operations. This meeting will consist of the following activities:

1. Ensuring the crane and all related equipment is capable of accessing the necessary areas within the site without impacting the existing infrastructure.
2. Verifying the crane company has attained the necessary test certificates and examinations.
3. Confirming the competency of all individuals involved or affected by the lift, and ensuring that all unqualified personnel will be removed from the immediate vicinity of the lift.
4. Ensuring the appropriate crane and related equipment have been selected to perform the lifting operations. The working

load and reach should be taken into consideration during the selection of the crane and equipment.

Certification

All equipment and individuals used in performing this task will arrive on site with the appropriate documentation. McMillan-McGee and the site manager reserve all rights to refuse access to any individual(s) that have been deemed unfit to perform their tasks. A McMillan-McGee employee or the site manager is responsible for verifying that all procedures outlined in the following section are properly carried out:

1. The crane and its operator must have current certification. The subcontractor of the crane company must provide proof of their damage and liability coverage. If requested, the crane's maintenance log must be provided.
2. The subcontractor is responsible for provide the crane operator's license and certification.
3. All slings, shackles, and spreader bars must have current certification accompanying the crane on site.
4. All documentation and certifications will be photocopied or photographed and placed on file.

Personal Protective Equipment

Hard hats, safety shoes, reflective safety vests, and safety glasses must be worn at all times by all personnel working in or around the lift area.

Structure

The following table gives the weights and dimensions of Mc^2 equipment:

Equipment	Weight (lbs)	Length (ft)	Width (ft)	Height (ft)
60 Electrode PDS	17,500	20	8	8.5
24 Electrode PDS	12,500	13.5	8	7.5
12 Electrode PDS	7,800	9	5	7.5
60 Electrode WCS	2,500	8	4	7
12/24 Electrode WCS	500	5	3	4
PDP	2,500	8	4.5	8

Equipment

Due to the weight and physical size of the PDS units, it is recommended that:

1. Only a crane rated to perform the lift is used.
2. For the 12/24 electrode PDS units a spreader bar which is longer than the piece of equipment (to avoid pressing straps on the side) with two 8' nylon slings 3″ wide 2 ply, and four 12′ nylon slings 2″ wide 2 ply should be used when lifting to and from a flat deck truck. Four 1″ shackles are required to securely attach to the base.
3. For the 60 electrode PDS units two spreader bars which is longer than the piece of equipment (to avoid pressing straps on the side) with four 8' nylon slings 3″ wide 2 ply, and four 20'' nylon slings 2″ wide 2 ply should be used when lifting to and from a flat deck truck. Make sure the eye of the sling can fit over the lifting bracket located on the corner of the skids.
4. The PDP units have lifting eyes at the top of the device and must only be lifted using a crane. The PDP lifting eyes must be carefully inspected prior to lifting the unit, and rejected if they show any signs of damage.
5. All WCS units can be moved with a forklift or crane.
6. A minimum of one tag line is required at the base of the equipment to be lifted with a crane. More may be required in windier conditions. Do not attempt to lift the any equipment with a crane in excessively windy conditions.

Requirements

1. Prior to the lift commencing, all personnel in control or involved in the lifting operation must receive site specific safety briefings pertaining to the lift with Mc^2 personnel and Arcadis safety officer.
2. Prior to the lift commencing, a meeting will be held to ensure that all personnel are aware of their specific duties relating to the lift. All site personnel should be notified of the lift and its general requirements. The truck and the crane routes must be established at this time. Spotter will be used to maneuver the crane and truck into place.
3. Outriggers and support plates must be available for use to ensure stable and level ground conditions while positioning the crane.

4. All cranes, slings, shackles, and spreader bars will be thoroughly inspected prior to the lift commencing. The hook on the crane must have a functioning safety clasp. The safety clasps must also be inspected prior to use to ensure that they are suitable and adequate. Any equipment showing signs of damage or deemed unfit by Mc^2 or Arcadis personnel must be rejected, and replaced before the lifting can commence.
5. McMillan-McGee Corp. personnel or the site manager must verify that the lift being performed is not deemed a critical lift (the load is not equal to 75% or greater than the capacity rating of the crane or any other lift equipment).
6. Care must be exercised to ensure the slings are not crossed or twisted while being attached to the spreader bar or equipment. **Do not position your hand between the slings and the equipment.**
7. If an unsafe situation arises anytime during the lift, the procedure will cease if safe to do so, and the load lowered if possible. If the load or crane cannot be moved, the area will be barricaded off and no one will be permitted to enter. This situation must be properly documented.
8. Any lift in a heavy traffic area must be properly barricaded. This area shall not be less than 10’ more than the required swing radius of the crane.
9. No personnel are permitted to walk under or along side the equipment or spreader bar once it has been hoisted into the air. Use a tag line to allow a safe distance to control the equipment while lifting is in progress.
10. The signal operator is the only one that should give any signals directly to the crane operator.
11. The signal operator must make sure that they are in constant contact with all personnel involved in the lift. If visual contact is not possible, lift personnel must be equipped with an operating radio. These radios must be tested prior to the start of the lift.
12. When the equipment has been lowered to a safe distance to the ground or on top of the flat deck truck, care must be taken in order to properly place it. Operators must take care not to place hands or feet under the equipment skid.
13. **Never situate yourself between the load and another object.**
14. If it is necessary to perform two or more lifts in order to properly place the equipment, the crane will detach from the equipment prior to being repositioned.

15. The operator of the flat deck truck will ensure that the equipment is securely strapped down prior to moving off or into place.

Figure 1: 1330 kVA PDS Lifting into place

Figure 2: 660 kVA PDS Lifting into place

Appendix G – Equipment Cut Sheets

McMillan McGee Corp.
digiTAM Temperature Acquisition Module

Networking

Multiple digiTAMs are accessed from a data server using Mc^2's communication protocols. Temperatures are immediately accessible via the Internet.

Easily Powered

DigiPAMs require only 7.5 mW of power per sensor during temperature conversions. External power supply over the 3 line digital bus means no batteries are required.

Digital at the Source

The temperatures are converted directly to digital signals to limit the effects of high electromagnetic interference due to thermal remediation systems. DigiTAMs and digiPAM pressure sensors are connected on the same digital bus for simple installation, automated process monitoring and real-time data access.

Instantaneous Temperature Profiling

The digiTAM strings make use of multiple temperature sensors on a common 3 line digital bus. Typically 30 temperature sensors are embedded in the Santoprene cable at 2.5 ft intervals. Thus a complete temperature profile is obtained for a narrow borehole within seconds.

digiTAM
Sensor String Specifications

Temperature	Principle	Integrated silicon temperature sensors
	Range	-55 to 125°C
	Accuracy	±0.5 °C
	Resolution	±0.125 °C
Environmental	Media compatibility	Air, water, steam, fuels, oils (Contact Mc^2 for specific contaminants)
	Wetted material	Teflon
Dimensions	Bottom Seal	1-1/16" (max)
	Cable	1/2 "
	Sensor interval (typ)	3.0 ft
Weight	Cable	50g/ft.
Connection	Power	External supply, 3.0 to 5.5 V DC; no batteries needed Power consumption of 7.5 mW per sensor during measurement
	Communication	Data acquisition occurs using Mc^2's 3 line digital serial bus Individual temperature measurements occur within 750 ms Data immediately accessible via the internet
	Sensor string	Placed in a drop-tube at required depth and anchored to surface
	Data server	Data lines connected with CAT5 cable Connects to site server through Mc^2 communication hub

Extreme Environments

DigiTAMs are fully submersible and measure temperatures of up to 125°C. The sensor is compatible with most chemical contaminants seen at remediation sites.

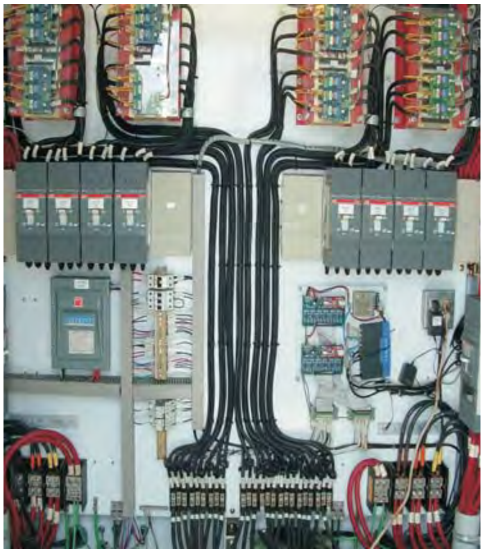
Fast Installation

DigiTAMs are simply lowered into a monitoring well and anchored to the surface. The sensor is linked to the data server using standard CAT5 network cable and Mc^2's communication.

McMillan-McGee Corp.
4895 35B. St. SE. Calgary, Ab. Canada. T2B 3M9
www.mcmillan-mcgee.com

McMillan-McGee Corp.

24 Electrode Power Delivery System (PDS)



ET-DSP™ Power Delivery System. 24 Electrode Unit Specifications

Electrical Performance	Principle	Two 3-phase high voltage utility transformers
	Power Rating	2-330 kVA Transformers
	Amperage	2-12 Electrode Busses at 400A Per Phase
		100 A per electrode. 4 Electrodes/Phase/Buss
	Voltage	Multi-tap secondary, 600 V max. phase to phase
		Field adjustable tap settings
Power Control	Principle	Time distributed control - Half-wave AC switching rectifiers SCR triggering-electronics with internet capability
	Power Selection	Current duty cycle from off to 100% Adjustment increment to 5%
Power Monitoring	Principle	High performance current transducers Internet-enabled, full wave CT monitoring electronics
	Measurement	Current amplitude; rms and effective values Independent TDCM duty cycle verification

McMillan-McGee Corp.
4895 35B. St. SE. Calgary, Ab. Canada. T2B 3M9
www.mcmillan-mcgee.com

MCMILLAN-MCGEE CORP.

CREATORS OF ET-DSP™

McMillan-McGee Corp.
24 Electrode Water Circulation System

Water Circulation System 24 Electrode Unit Specifications		
Flow Performance	Principle	Utility water supply with internal pump Individual electrode injection valves
	Pressure	Rated at 100 psi
	Temperature	Water at 90ºC
Injection Control	Principle	One voltage fired solenoid valve per electrode Electronic Relay
	Operation	Designed for simultaneous injection to 8 electrodes
Injection Monitoring	Principle	Inline paddle turbine flow meters Internet-enabled pulse counting electronics
	Operation	One flow meter per solenoid valve assembly Each meter monitors injection to 3 electrodes

MCMILLAN-MCGEE CORP.

CREATORS OF ET-DSP™

McMillan-McGee Corp.
60 Electrode Power Delivery System (PDS)

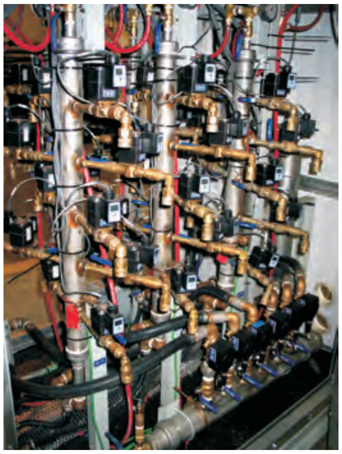
ET-DSP™ Power Delivery System. 60 Electrode Unit Specifications

Electrical Performance	Principle	Two 3-phase high voltage utility transformers
	Power Rating	1330 kVA - 2-660 kVA Transformers
	Amperage	4-15 Electrode Busses at 400A Per Phase
		100 A per electrode. 5 Electrodes/Phase/Buss
	Voltage	Multi-tap secondary, 600 V max. phase to phase
		Field adjustable tap settings
Power Control	Principle	Time distributed control - Half-wave AC switching rectifiers SCR triggering-electronics with internet capability
	Power Selection	Current duty cycle from off to 100% Adjustment increment to 5%
Power Monitoring	Principle	High performance current transducers Internet-enabled, full wave CT monitoring electronics
	Measurement	Current amplitude; rms and effective values Independent TDCM duty cycle verification

McMillan-McGee Corp.
4895 35B. St. SE. Calgary, Ab. Canada. T2B 3M9
www.mcmillan-mcgee.com

McMillan-McGee Corp.

60 Electrode Water Circulation System



Water Circulation System 60 Electrode Unit Specifications		
Flow Performance	Principle	Utility water supply with internal pump Individual electrode injection valves
	Pressure	Rated at 100 psi
	Temperature	Water at 90ºC
Injection Control	Principle	One voltage fired solenoid valve per electrode Proportional Valve 0-100%
	Operation	Designed for simultaneous injection to 6 electrodes
Injection Monitoring	Principle	Inline ultrasonic flow meters Internet-enabled pulse counting electronics
	Operation	One flow meter per solenoid valve assembly Each meter monitors injection to 10 electrodes

Appendix B
NYSDEC VCP Fact Sheet

New York State Department of Environmental Conservation

September 2015

FACT SHEET

Voluntary Cleanup Program

Receive Site Fact Sheets by *Email.* See "For More Information" to Learn How.

Have questions? See "Whom to Contact" Below

Site Name: Former Dowell Facility
DEC Site #: V00410
Address: 3311-3313 Walden Ave.; Depew, NY
Website: http://www.dec.ny.gov/cfmx/extapps/derexternal/index.cfm?pageid=3

Former Dowell Facility: Community Update

Highlights of Completed Activities

In 2004 a Remedial Action was performed by the Volunteers. The remedial action included building/structure demolition, asbestos-containing material abatement, contaminated soil excavation/disposal, monitoring well removal/installation, and site restoration. No engineering controls were installed as part of the site remedy; however, a Declaration of Covenants and Restrictions granted to DEC was recorded with the Erie County Clerk on June 22, 2005.

Following completion of 2004 Remedial Action, a long-term groundwater monitoring program was implemented to monitor volatile organic compounds (VOC)-impacted groundwater. Since the inception of the long-term groundwater monitoring program, groundwater samples have been collected from site monitoring wells by the Volunteers to monitor the residual contamination.

A supplemental off-site groundwater investigation was completed in 2008 to determine if residential structures on the North side of Walden Avenue might be impacted by the residual groundwater contamination. Off-site groundwater samples collected during the investigation determined that no detectable levels of site contaminants were present in the samples. Based on this data, the Volunteers and DEC concluded that there was no potential for vapor intrusion into residences north of Walden Avenue.

A Site Management Plan (SMP) was prepared in May 2011 for the site to identify how the residual on-site contamination would be managed. The SMP details monitoring activities for the site and requirements for future use of the site. The SMP requires the Volunteers to performed regular monitoring and reporting activities and for DEC to routinely review and approval monitoring data to insure that the monitoring and reporting activities are performed by the Volunteers are in compliance with the SMP.

DEC issued a Certificate of Completion on December 7, 2011, for the 2004 site remediation. Since issuance of the Certificate of Completion, the long-term monitoring program and site maintenance activities have been conducted in accordance with the SMP and DEC-approved modifications.

Highlights of Upcoming Cleanup Activities

To address the residual on-site groundwater contamination, the Volunteers have developed a Remedial Action Work Plan which includes the installation of an in situ thermal treatment (ISTT) system to remove residual VOCs still present in groundwater within a limited area of the site. The proposed ISTT system involves the placement of multiple electrode groups in the subsurface and the application of an electrical current that generates heat, which in turn heats the surrounding soil formation and forces the contaminants to rise to the surface where the contaminants are collected in recovery wells as either vapor or liquid. The extracted waste streams (that is, vapor and liquids) are then treated at the surface by an air stripper and/or granular activated carbon (GAC). Spent GAC (with VOCs adsorbed in the porous material) will be transported off-site for disposal at an approved facility. Treated liquid will be discharged to the local sewer in accordance with Erie County permits and regulations.

Project Schedule for Upcoming Cleanup Activities

The project schedule for the upcoming cleanup activities has been provided below. The Volunteers anticipated that the ISTT system will operate for approximately six-months. After the residual groundwater contamination has been extracted and treated, the ISTT system will be dismantled and the site will be restored to its previous condition.

- Construction of ISTT system components – projected start date, October 5, 2015
- Start-up of ISTT system – projected start date, December 28, 2015
- Operation of ISTT system – projected end date, June 30, 2016

Background

Location: The Former Dowell Facility is located at 3311-3313 Walden Avenue in the Village of Depew, New York. The facility resides within a mixed residential and industrial/commercial area and consists of two parcels identified on Erie County tax maps as parcels 104.09-1-14 and 104.09-1-15. The vacant property covers approximately 1.78 acres, is triangular shaped and relatively flat, and is fronted to the north by Walden Avenue. A 6-foot-high chain-linked fence with a locked entrance gate along Walden Avenue surrounds the site.

Current Use: The entire site is zoned industrial/commercial. Surrounding uses include a railroad line to the south, a manufacturing facility to the west, and a commercial lumber yard to the east. The closest residential structures are to the north across Walden Avenue. Former activities at the site included servicing industrial facilities and limited oilfield-related project. Dowell discontinued facility operations in the late 1980s and the facility was permanently closed.

Historical Use(s):

The parcels included buildings such as office space, storage, and equipment repair garages that supported operations relating to the development and maintenance of natural gas and oil wells. Various industrial cleaning and oil-field chemicals were stored on-site and transferred into tank trucks for use at job sites.

Spillage and poor housekeeping during active facility operations may have led to release of VOCs including trichloroethene into the soil and shallow groundwater. The Volunteers entered the site into DEC's Voluntary Cleanup Program (VCP) on February 26, 2001, under Voluntary Cleanup Agreement (No. B9-0586-00-10).

Additional site details, including environmental and health assessment summaries, are available on DEC's website at http://www.dec.ny.gov/cfmx/extapps/derexternal/haz/details.cfm?pageid=3&progno=V00410.

We encourage you to share this fact sheet with neighbors and tenants, and/or post this fact sheet in a prominent area of your building for others to see.

Brownfield Cleanup Program: New York's Brownfield Cleanup Program (BCP) encourages the voluntary cleanup of contaminated properties known as "brownfields" so that they can be reused and redeveloped. These uses include recreation, housing, business or other uses.

A brownfield is any real property that is difficult to reuse or redevelop because of the presence or potential presence of contamination.

For more information about the BCP, visit: http://www.dec.ny.gov/chemical/8450.html

FOR MORE INFORMATION

Where to Find Information

Project documents are available at the following location to help the public stay informed.

NYS DEC Region 9 Office
270 Michigan Avenue
Buffalo, New York 14203
716-851-7220
(Call for appointment)

For more information about the Voluntary Cleanup Program (VCP,) visit: http://www.dec.ny.gov/chemical/8442.html.

Whom to Contact

Comments and questions are always welcome and should be directed as follows:

Project Related Questions
David Szymanski
NYS DEC, Division of Environmental Remediation
270 Michigan Ave
Buffalo, NY 14203
716-851-7220
David.Szymanski@dec.gov.ny

Site-Related Health Questions
Matthew Forcucci
NYS DOH
584 Delaware Ave
Buffalo, NY 14202
716-847-4501
BEEI@health.ny.gov

Receive Site Fact Sheets by Email

Have site information such as this fact sheet sent right to your email inbox. DEC invites you to sign up with one or more contaminated sites county email listservs available at the following web page: http://www.dec.ny.gov/chemical/61092.html. It’s quick, it’s free, and it will help keep you *better informed*.

As a listserv member, you will periodically receive site-related information/announcements for all contaminated sites in the county(ies) you select.


Brewster St
Lincoln St
Rumford St
Walden Ave
V00410 Former Dowell Facility
© 2015 Google
Google earth

Appendix C
ISTT Implementation Photographic Log

APPENDIX C

ISTT Implementation Photographic Log

Phase I – Electrode and extraction well surveying stakes – September 2015.

Phase I – Delivery of electrodes – September 2015.

Phase I – Removal of existing injection and monitoring wells – September 2015.

Phase I – Drilling boreholes for Installation of electrodes – October 2015.

Phase I – Installation of electrodes down hole – October 2015.

Phase I – Drilling boreholes for Installation of electrodes and vertical extraction wells – October 2015.

Phase I – Borehole drill cuttings – October 2015.

Phase I – Installation of horizontal extraction wells – October 2015.

Phase I – Electrode and horizontal and vertical extraction well installation complete – October 2015.

Phase I – Vapor cap forms installation – October 2015.

Phase I – Vapor cap pour – October 2015.

Phase I – Cured vapor cap – October 2015.

Phase II – Gravel bed installation for above ground ISTT system components – November 2015.

Phase II – Delivery of Power Distribution System Units – November 2015.

Phase II – Placement of Power Distribution System Units – November 2015.

Phase II – Delivery of liquid and vapor treatment units – November 2015.

Phase II – Placement of liquid and vapor treatment units – November 2015.

Phase II – Delivery of liquid and vapor knock out tank – November 2015.

Phase II – Final placement of Power Distribution System Units – November 2015.

Phase II – Final placement of liquid and vapor treatment units and control panel – November 2015.

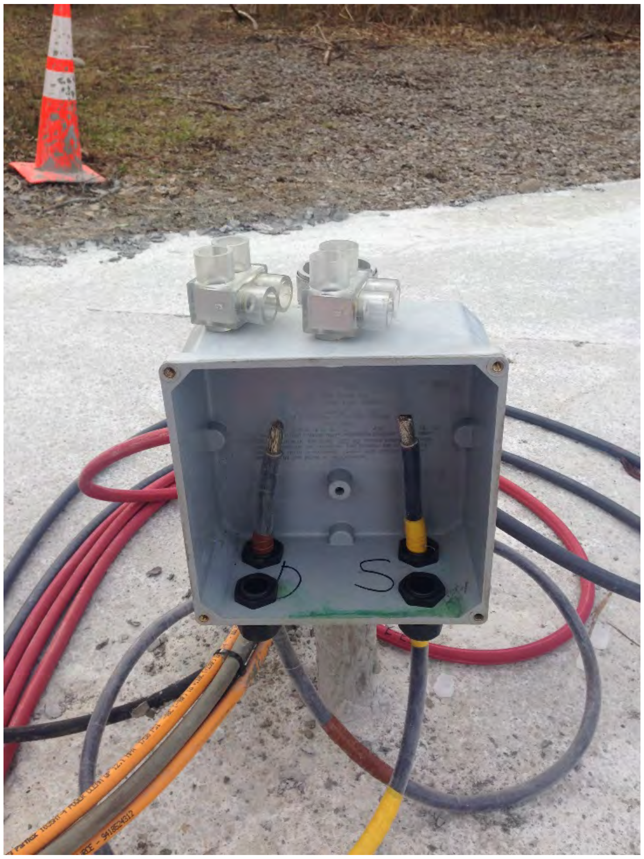
Phase II – Final placement of process water transfer tanks – November 2015.

Phase II – Final placement of chiller unit and conveyance flex piping manifold – November 2015.

Phase II – Laying out electrode power lines – November 2015.

Phase II – Laying out electrode power lines – November 2015.

Phase II – Testing electrode leads prior to making power connections – November 2015.



Phase II – Connecting electrode leads to power connections – November 2015.

Phase II – Construction of liquid and vapor extraction conveyance pipeline – November 2015.

Phase II – Installed liquid and vapor extraction conveyance pipeline – November 2015.

Phase II – Construction of vertical extraction well manifolds – November 2015.

Phase II – Horizontal and vertical extraction well manifold connection to conveyance pipeline – November 2015.

Phase II – Installation of treated groundwater electrode injection lines – November 2015.

Phase II – Installation of heat tracing and winter insulation – November 2015.

Phase II – Winterizing injection water circulation lines – November 2015.

Phase II – Winterizing process lines and tanks – December 2015.

Phase II – Pick up of soil cutting roll-offs – December 2015.

Phase II – Delivery of treated groundwater temporary storage tank – December 2015.

Phase II – ISTT well field construction complete – December 2015.

Phase II – Installation of onsite power pole – December 2015.

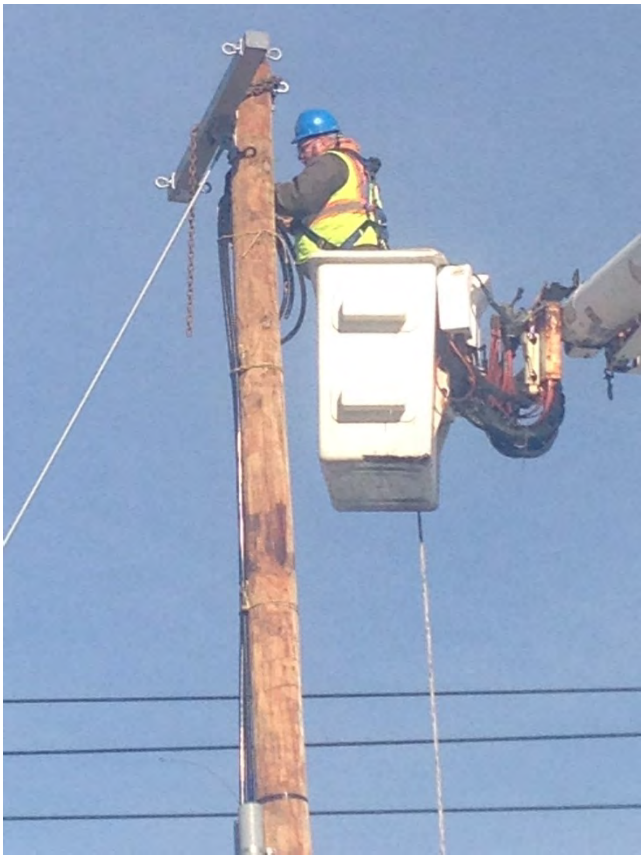
Phase II – Placement of onsite power pole – December 2015.

Phase II – Final placement of onsite power pole – December 2015.

Phase II – Installation of underground electrical conduit – December 2015.

Phase II – Installation underground electrical conduit – December 2015.

Phase II – Installation of electric lines from power panel to transformers – January 2016.



Phase II – Installation of electric lines from power panel to transformers – January 2016.

Phase II – Installation of electric lines from main power panel to power distribution panel – January 2016.

Phase II – Connection of electric lines from main power panel to power distribution panel – January 2016.

Phase II – Connection of electric lines to transformers – January 2016.

Phase II – Installation of transformers and connection of electric lines – January 2016.

Phase III –System Commissioning – February 2016.

Phase III –System Commissioning – February 2016.

Phase III –Inside Groundwater treatment unit. Oil-water separator and air stripper in picture – March 2016.

Phase III –Inside Groundwater treatment unit. Granular activated carbon vessels in picture – March 2016.

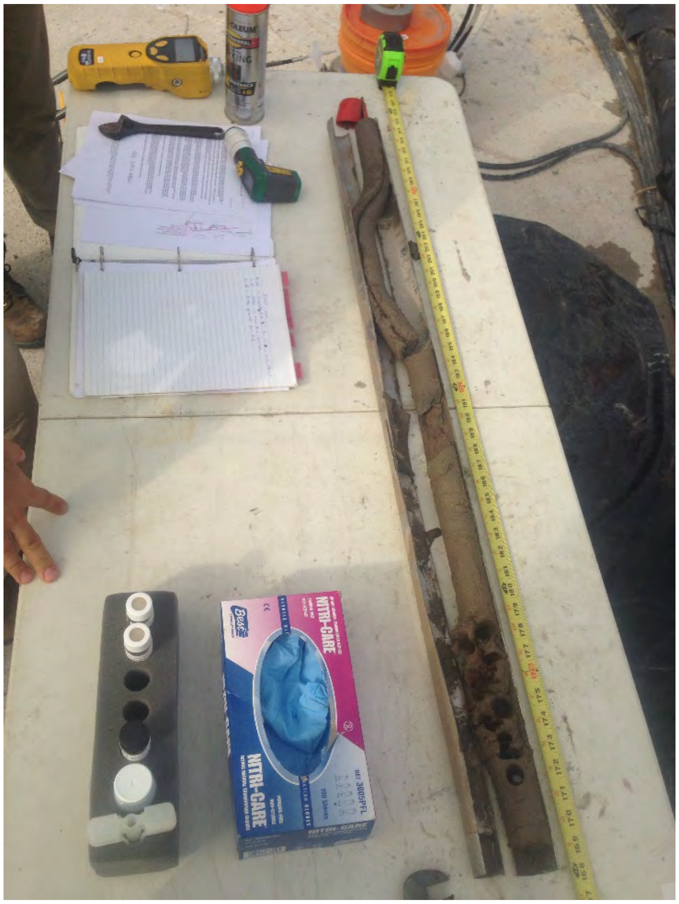
Phase III – Interim performance sampling – June 2016.

Phase III – Interim performance sampling – June 2016.

Phase III – Publicly owned treatment works discharge of treated groundwater to storm sewer manhole – July 2016.

Phase III – Publicly owned treatment works discharge of treated groundwater to storm sewer manhole – July 2016.

Phase III – Confirmation performance sampling – October 2016.



Phase III – Confirmation performance sampling – October 2016.

Phase IV – Abandonment of electrodes and extraction wells – December 2016.

Phase IV –Removal of vapor cap – December 2016.

Phase IV –Vapor cap removed. Site restored to previous site conditions – December 2016.

Phase IV –Vapor cap removed. Site restored to previous site conditions – December 2016.

Appendix D
Well Abandonment Forms

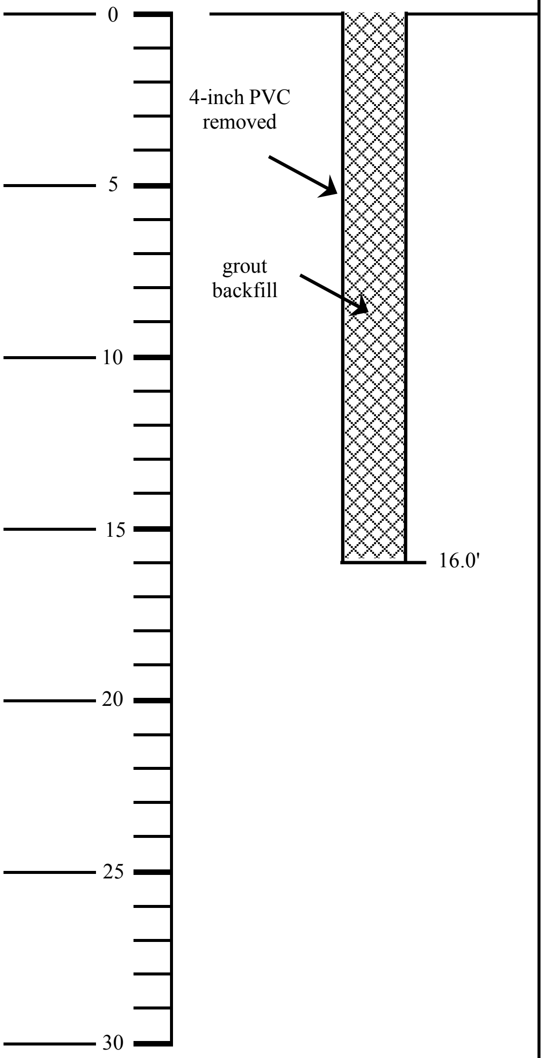
FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name:	**Former Dowell Depew Site**	Well I.D.:	**RW-01**
Site Location:	**Depew, New York**	Driller:	**Joe Percy**
Drilling Co.:	**Parratt-Wolff, Inc.**	Inspector:	
		Date:	**10/6/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING	
Interval Drilled	0 - 16'
Drilling Method(s)	HSA
Borehole Dia. (in.)	10 1/4"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA
CASING PULLING	
Method employed	Pull
Casing retrieved (feet)	16.0
Casing type/dia. (in)	PVC / 4"
CASING PERFORATING	
Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA
GROUTING	
Interval grouted (FBLS)	0.0 - 16.0'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	23.5
Quantity of cement used (lbs.)	282
Cement type	Portland
Quantity of bentonite used (lbs.)	12
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	30
Volume of grout used (gal.)	30

WELL SCHEMATIC*
Depth
(feet)



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **MW-06D**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/7/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING

Interval Drilled	0 - 30'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA

CASING PULLING

Method employed	Pull
Casing retrieved (feet)	30.0
Casing type/dia. (in)	PVC / 2"

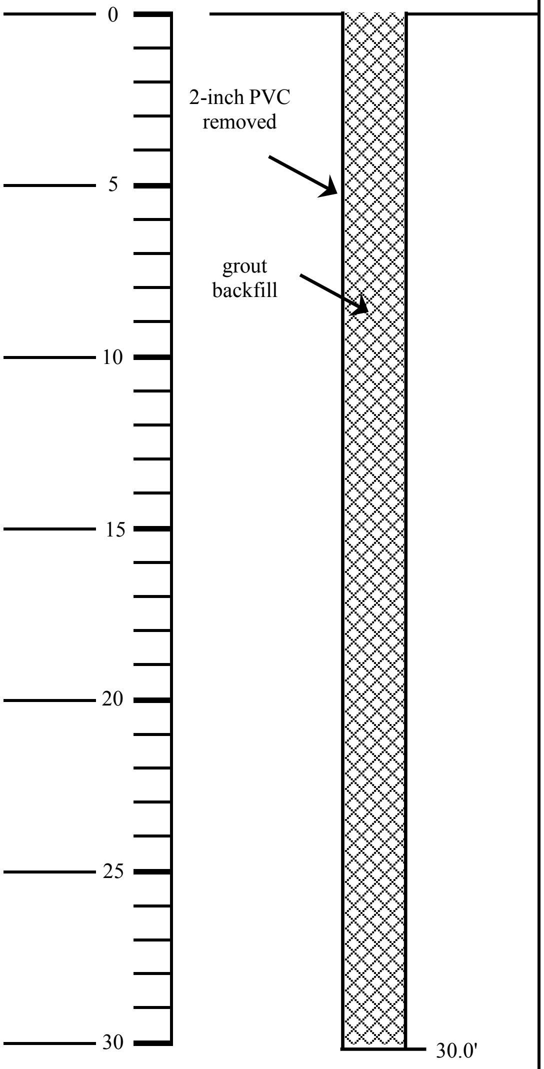
CASING PERFORATING

Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA

GROUTING

Interval grouted (FBLS)	0.0 - 30.0'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	35
Quantity of cement used (lbs.)	423
Cement type	Portland
Quantity of bentonite used (lbs.)	20
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	45
Volume of grout used (gal.)	45

WELL SCHEMATIC*
Depth
(feet)



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **MW-06S**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/7/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING

Interval Drilled	0 - 20'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA

CASING PULLING

Method employed	Pull
Casing retrieved (feet)	20.0
Casing type/dia. (in)	PVC / 2"

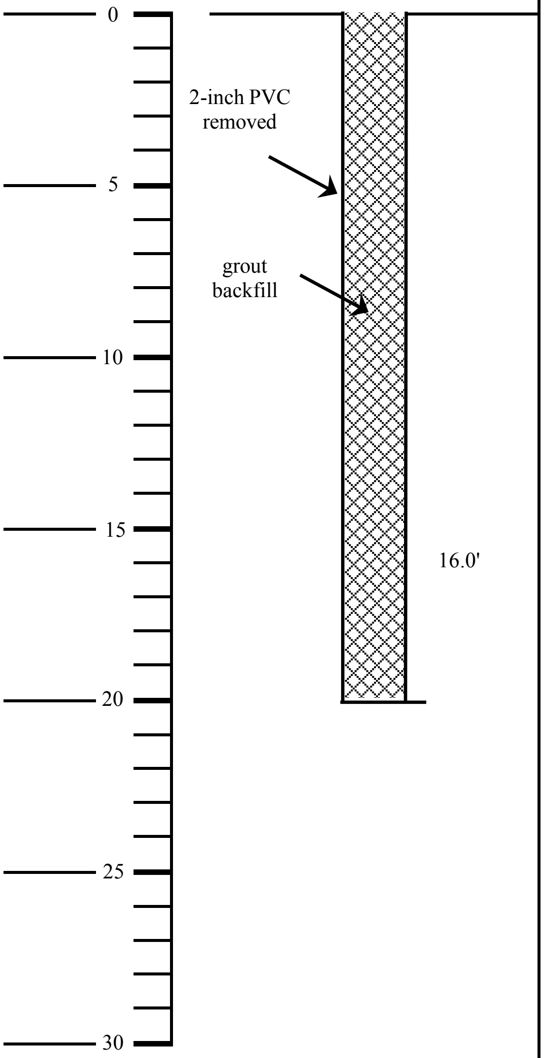
CASING PERFORATING

Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA

GROUTING

Interval grouted (FBLS)	0.0 - 20.0'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	23.5
Quantity of cement used (lbs.)	282
Cement type	Portland
Quantity of bentonite used (lbs.)	12
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	30
Volume of grout used (gal.)	30

WELL SCHEMATIC*
Depth
(feet)



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

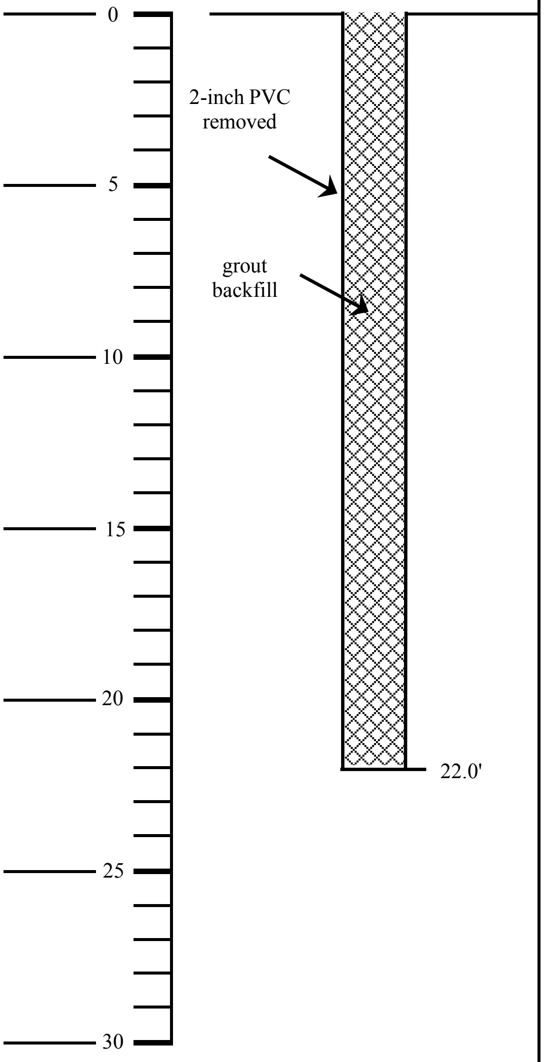
FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **IW-01S**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/5/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING	
Interval Drilled	0 - 22'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA
CASING PULLING	
Method employed	Pull
Casing retrieved (feet)	22.0
Casing type/dia. (in)	PVC / 2"
CASING PERFORATING	
Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA
GROUTING	
Interval grouted (FBLS)	0.0 - 22.0'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	23.5
Quantity of cement used (lbs.)	282
Cement type	Portland
Quantity of bentonite used (lbs.)	12
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	30
Volume of grout used (gal.)	30

WELL SCHEMATIC*
Depth
(feet)



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

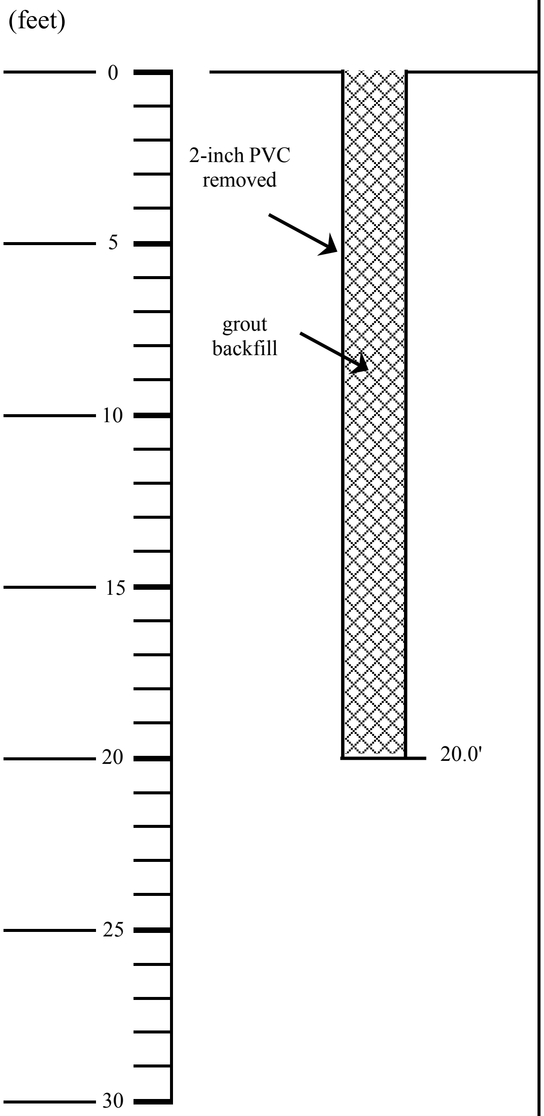
FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **IW-02S**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/6/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING	
Interval Drilled	0 - 20.0'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA
CASING PULLING	
Method employed	Pull
Casing retrieved (feet)	20.0
Casing type/dia. (in)	PVC / 2"
CASING PERFORATING	
Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA
GROUTING	
Interval grouted (FBLS)	0.0 - 20.0'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	23.5
Quantity of cement used (lbs.)	282
Cement type	Portland
Quantity of bentonite used (lbs.)	12
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	30
Volume of grout used (gal.)	30

WELL SCHEMATIC*



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

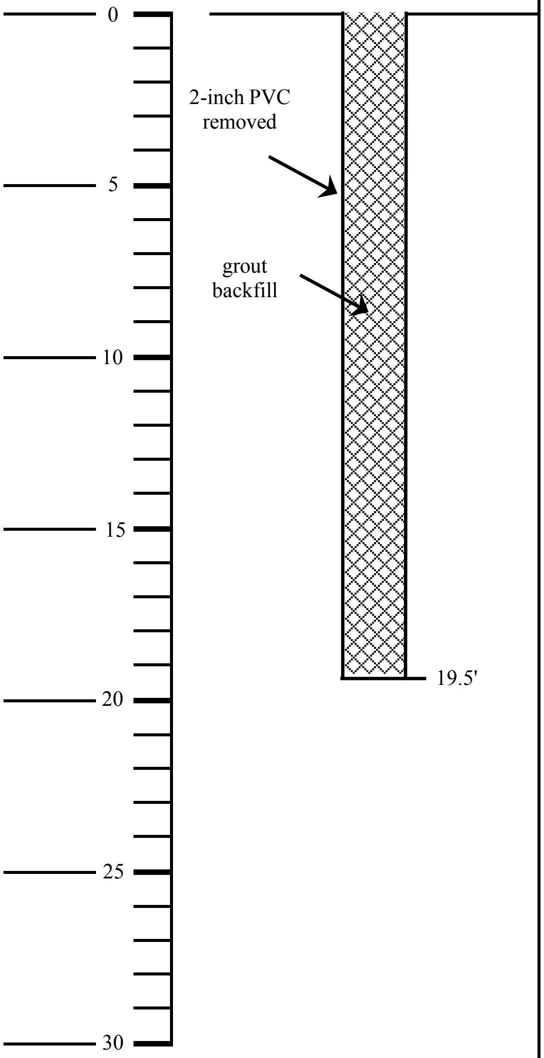
FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **IW-03S**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/6/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING	
Interval Drilled	0 - 19.5'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA
CASING PULLING	
Method employed	Pull
Casing retrieved (feet)	19.5
Casing type/dia. (in)	PVC / 2"
CASING PERFORATING	
Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA
GROUTING	
Interval grouted (FBLS)	0.0 - 19.5'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	23.5
Quantity of cement used (lbs.)	282
Cement type	Portland
Quantity of bentonite used (lbs.)	12
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	30
Volume of grout used (gal.)	30

WELL SCHEMATIC*
Depth
(feet)



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

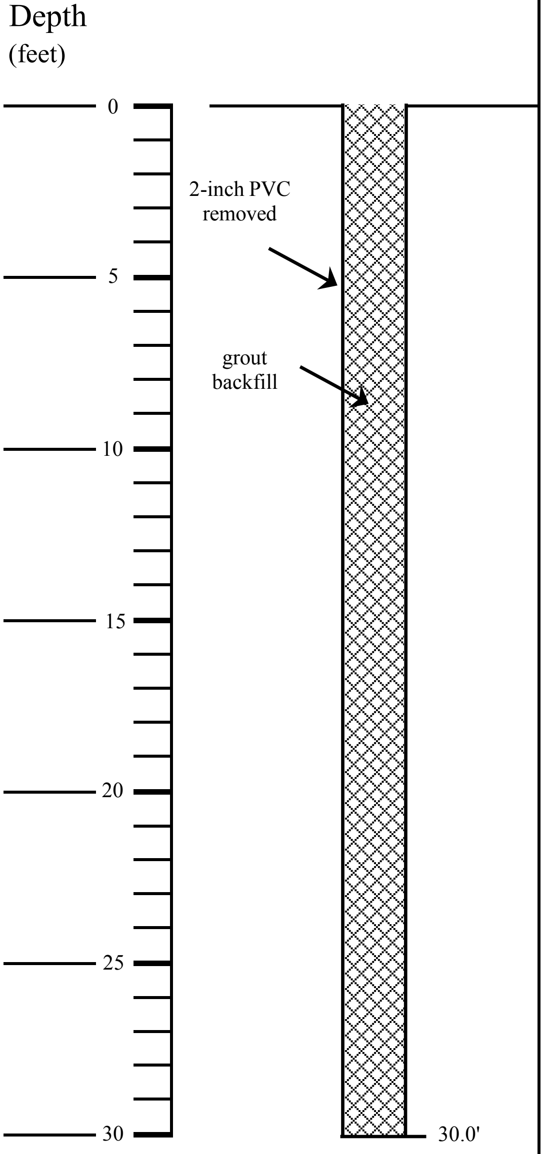
FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **IW-04D**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/6/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING	
Interval Drilled	0 - 30'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA
CASING PULLING	
Method employed	Pull
Casing retrieved (feet)	30.0
Casing type/dia. (in)	PVC / 2"
CASING PERFORATING	
Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA
GROUTING	
Interval grouted (FBLS)	0.0 - 30.0'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	35
Quantity of cement used (lbs.)	423
Cement type	Portland
Quantity of bentonite used (lbs.)	20
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	45
Volume of grout used (gal.)	45

WELL SCHEMATIC*



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **IW-05D**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/6/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING

Interval Drilled	0 - 29.5'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA

CASING PULLING

Method employed	Pull
Casing retrieved (feet)	29.5
Casing type/dia. (in)	PVC / 2"

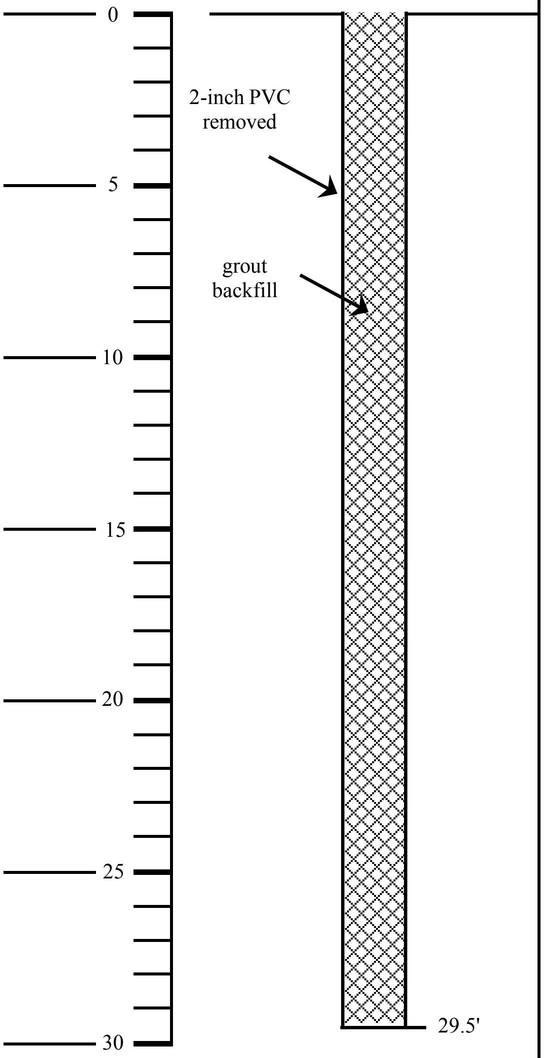
CASING PERFORATING

Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA

GROUTING

Interval grouted (FBLS)	0.0 - 29.5'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	35
Quantity of cement used (lbs.)	423
Cement type	Portland
Quantity of bentonite used (lbs.)	20
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	45
Volume of grout used (gal.)	45

WELL SCHEMATIC*
Depth
(feet)



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

Department Representative

FIGURE 3
WELL DECOMMISSIONING RECORD

Site Name: **Former Dowell Depew Site**	Well I.D.: **IW-06D**
Site Location: **Depew, New York**	Driller: **Joe Percy**
Drilling Co.: **Parratt-Wolff, Inc.**	Inspector:
	Date: **10/7/15**

DECOMISSIONING DATA
(Fill in all that apply)

OVERDRILLING

Interval Drilled	0 - 30'
Drilling Method(s)	HSA
Borehole Dia. (in.)	6 5/8"
Temporary Casing Installed? (y/n)	N
Depth temporary casing installed	NA
Casing type/dia. (in.)	NA
Method of installing	NA

CASING PULLING

Method employed	Pull
Casing retrieved (feet)	30.0
Casing type/dia. (in)	PVC / 2"

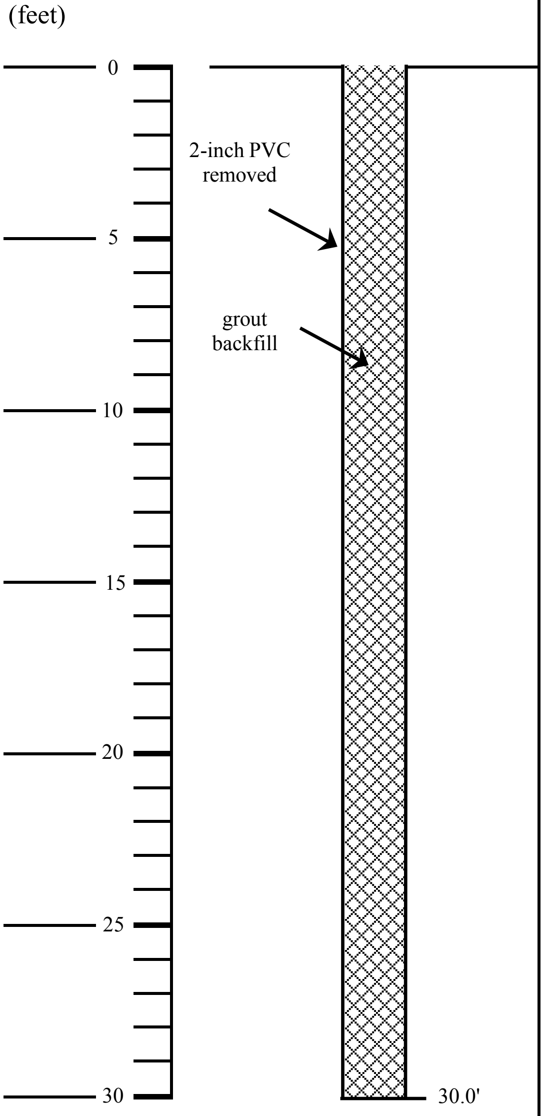
CASING PERFORATING

Equipment used	NA
Number of perforations/foot	NA
Size of perforations	NA
Interval perforated	NA

GROUTING

Interval grouted (FBLS)	0.0 - 30.0'
# of batches prepared	1
For each batch record:	
Quantity of water used (gal.)	35
Quantity of cement used (lbs.)	423
Cement type	Portland
Quantity of bentonite used (lbs.)	20
Quantity of calcium chloride used (lbs.)	0
Volume of grout prepared (gal.)	45
Volume of grout used (gal.)	45

WELL SCHEMATIC*



* Sketch in all relevant decommissioning data, including: interval overdrilled, interval grouted, casing left in hole, well stickup, etc.

COMMENTS:

Drilling Contractor

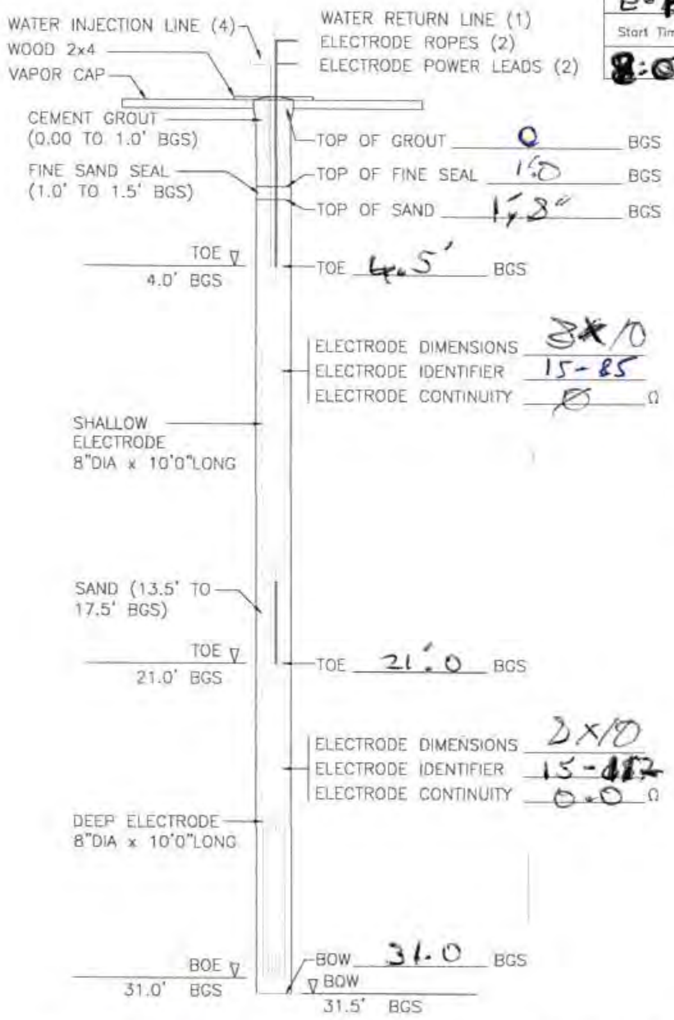
Department Representative

Appendix E

ISTT System Component Well Completion Diagrams

DOUBLE ELECTRODE

Date	Signature	Checked
8/10/15		✓
Electrode Well	Electrode Designation	
E-A	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
8:03	9:35	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1.0 BGS

TOP OF SAND 1.8" BGS

TOE 4.5' BGS

ELECTRODE DIMENSIONS 8x/10

ELECTRODE IDENTIFIER 15-85

ELECTRODE CONTINUITY 0 Ω

TOE 21.0 BGS

ELECTRODE DIMENSIONS 2X/0

ELECTRODE IDENTIFIER 15-482

ELECTRODE CONTINUITY 0.0 Ω

BOW 31.0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: Portland I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 21 50lb bags
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1 bag (50lb)

DRILLING DETAILS:

DRILLING CONTRACTOR: RW

DRILLING METHOD: HS Auger

DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 12"

BOREHOLE DEPTH: 31'

DEPTH TO WATER: 0

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

DOUBLE ELECTRODE

DRILLING:QA/QC

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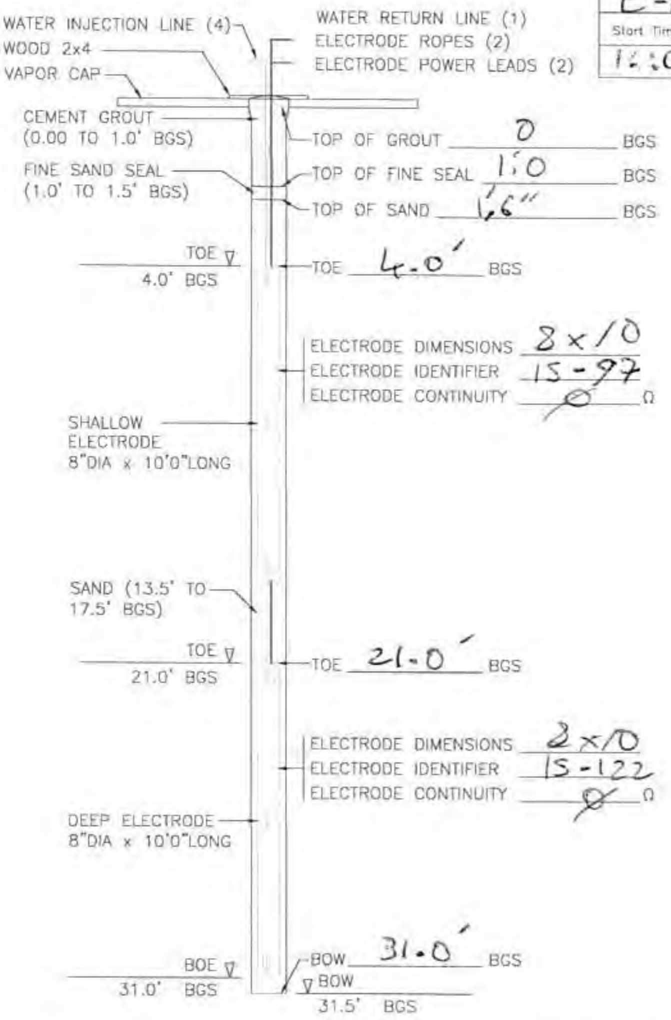
DOUBLE ELECTRODE

Date	Signature	Checked
8/10/15		
Electrode Well	Electrode Designation	
E-A2	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
12:00	17:25	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1.0 BGS
TOP OF SAND 1.6" BGS
TOE 4.0' BGS

ELECTRODE DIMENSIONS 8 x 10
ELECTRODE IDENTIFIER 15-97
ELECTRODE CONTINUITY 0 Ω

TOE 21.0' BGS

ELECTRODE DIMENSIONS 8 x 10
ELECTRODE IDENTIFIER 15-122
ELECTRODE CONTINUITY 0 Ω

BOW 31.0' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I / II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 21
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HS Auger
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 11"
BOREHOLE DEPTH: 31.0
DEPTH TO WATER: —

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

DOUBLE ELECTRODE

DRILLING:QA/QC

Edition REV.A1

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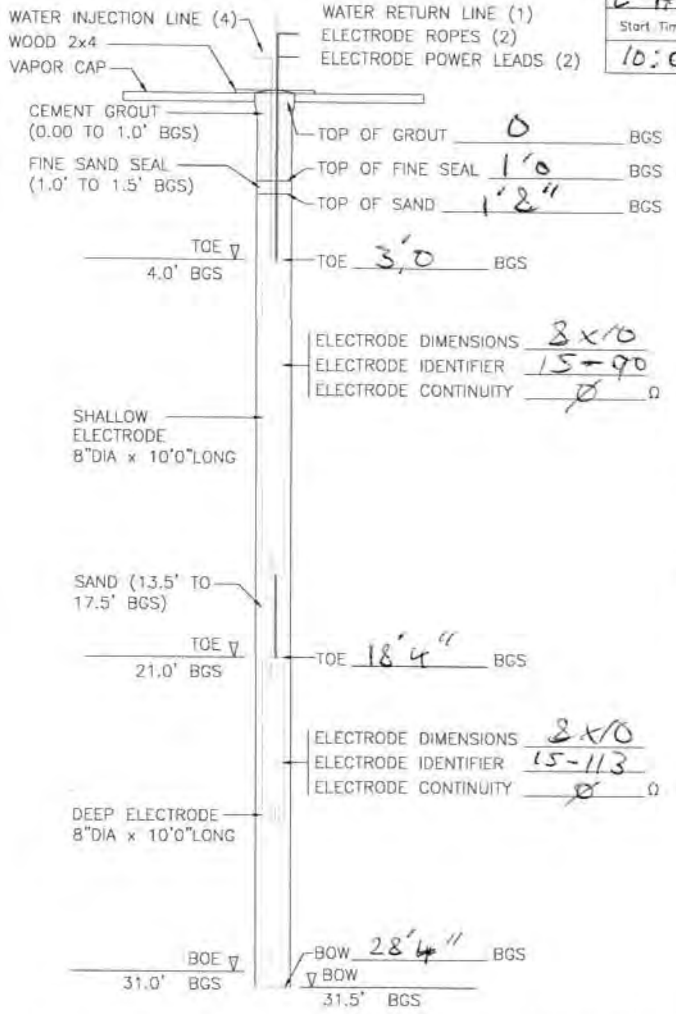
DOUBLE ELECTRODE

Date	Signature	Checked
13/10/15	T	
Electrode Well	Electrode Designation	
E-A3	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
10:00	14:20	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'2" BGS

TOE 3'0 BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-90

ELECTRODE CONTINUITY 0 Ω

TOE 18'4" BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-113

ELECTRODE CONTINUITY 0 Ω

BOW 28'4" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #1
   QUANTITY USED: 37
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 12"O

BOREHOLE DEPTH: 28'4"

DEPTH TO WATER: /

inside Auger installation

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

DOUBLE ELECTRODE

DRILLING:QA/QC

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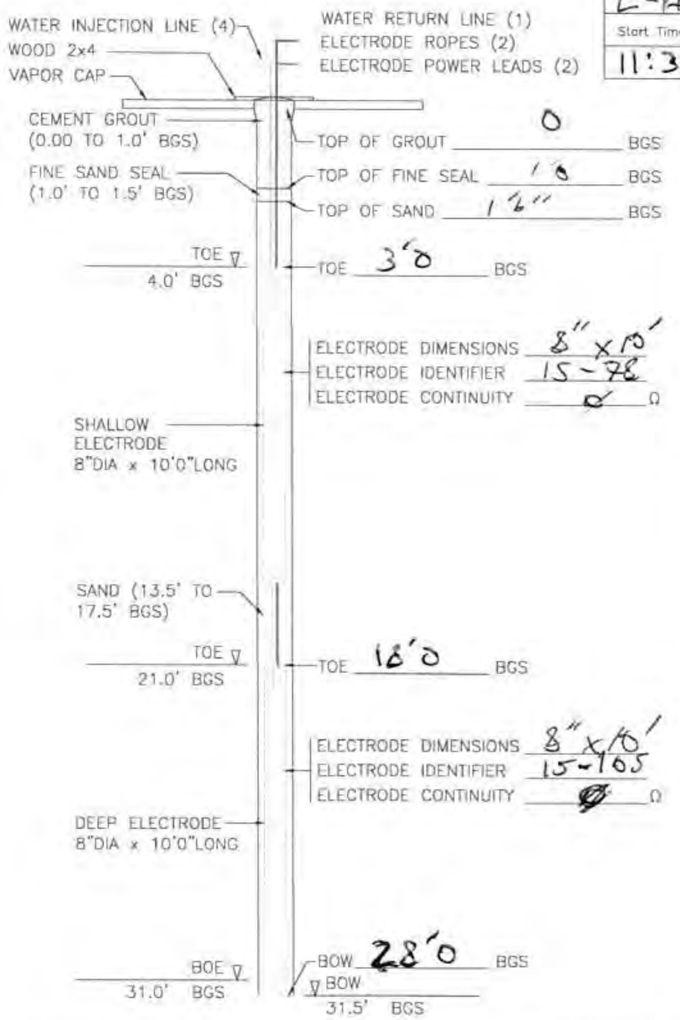
DOUBLE ELECTRODE

Date	Signature	Checked
15/10/15	T	✓
Electrode Well	Electrode Designation	
E-1A4	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
11:30	16:10	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1'0 BGS
TOP OF SAND 1'2" BGS
TOE 3'0 BGS

ELECTRODE DIMENSIONS 8" x 10'
ELECTRODE IDENTIFIER 15-78
ELECTRODE CONTINUITY 0 Ω

TOE 18'0 BGS

ELECTRODE DIMENSIONS 8" x 10'
ELECTRODE IDENTIFIER 15-105
ELECTRODE CONTINUITY 0 Ω

BOW 28'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 42
3. FINE SAND SEAL:
   MATERIAL USED: #00N
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 12"0
BOREHOLE DEPTH: 28'0
DEPTH TO WATER: –

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

Went down first with 6.25" ID augers and then with 10.25 ID augers. Hole was collapsing.

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

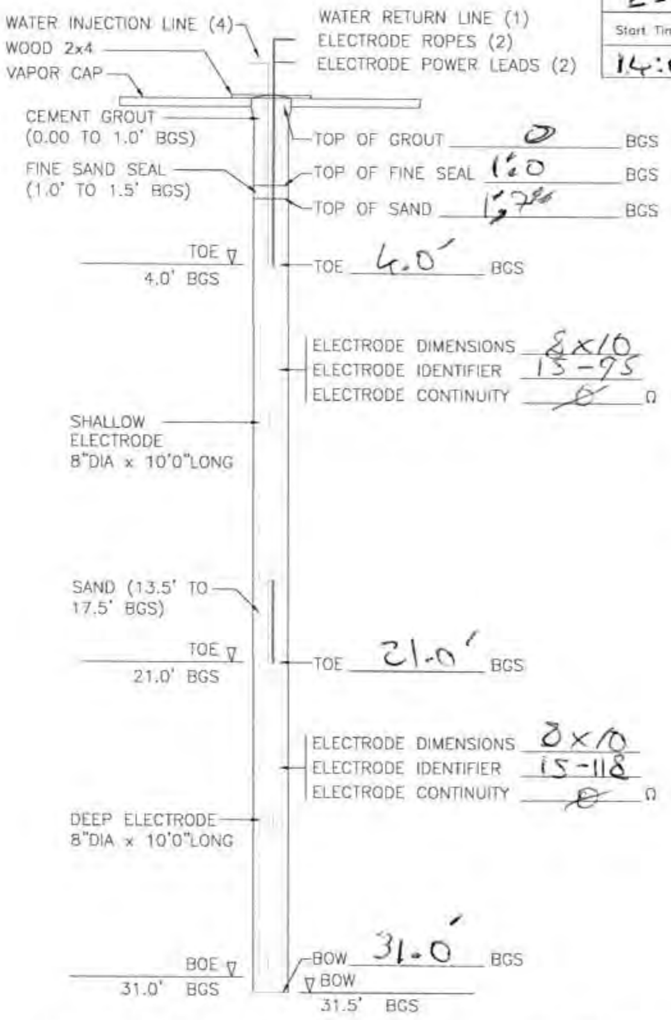
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition REV.A1
Sheet OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
3/10/15	T	✓
Electrode Well	Electrode Designation	
E-B1	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
14:00	15:30	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1.0 BGS
TOP OF SAND 1.7' BGS
TOE 4.0' BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-95
ELECTRODE CONTINUITY 0 Ω

TOE 21.0' BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-118
ELECTRODE CONTINUITY 0 Ω

BOW 31.0' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #1
   QUANTITY USED: 22
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HS Auger
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 11"
BOREHOLE DEPTH: 31.0'
DEPTH TO WATER: –

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN–MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN–MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

DOUBLE ELECTRODE

DRILLING:QA/QC

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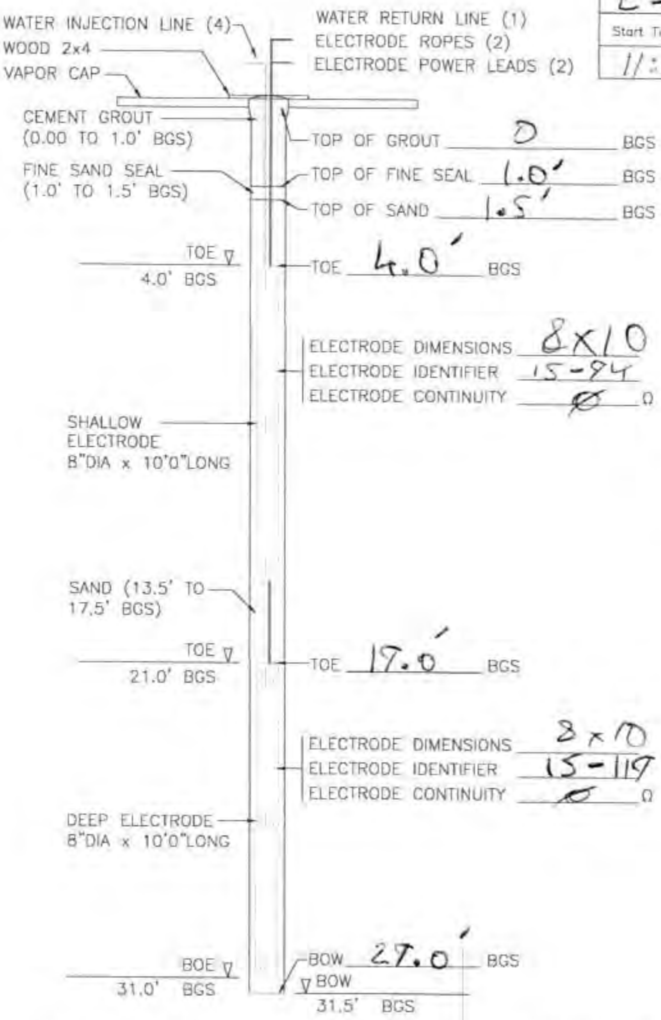
DOUBLE ELECTRODE

Date	Signature	Checked
8/10/15		
Electrode Well	Electrode Designation	
E-B2	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
11:00	13:15	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1.0' BGS
TOP OF SAND 1.5' BGS
TOE 4.0' BGS

ELECTRODE DIMENSIONS 8X10
ELECTRODE IDENTIFIER 15-94
ELECTRODE CONTINUITY 0 Ω

TOE 17.0' BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-119
ELECTRODE CONTINUITY 0 Ω

BOW 27.0' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PIT
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #1
   QUANTITY USED: 17
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HS Auger
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 11"
BOREHOLE DEPTH: 27.0'
DEPTH TO WATER: —

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

DOUBLE ELECTRODE

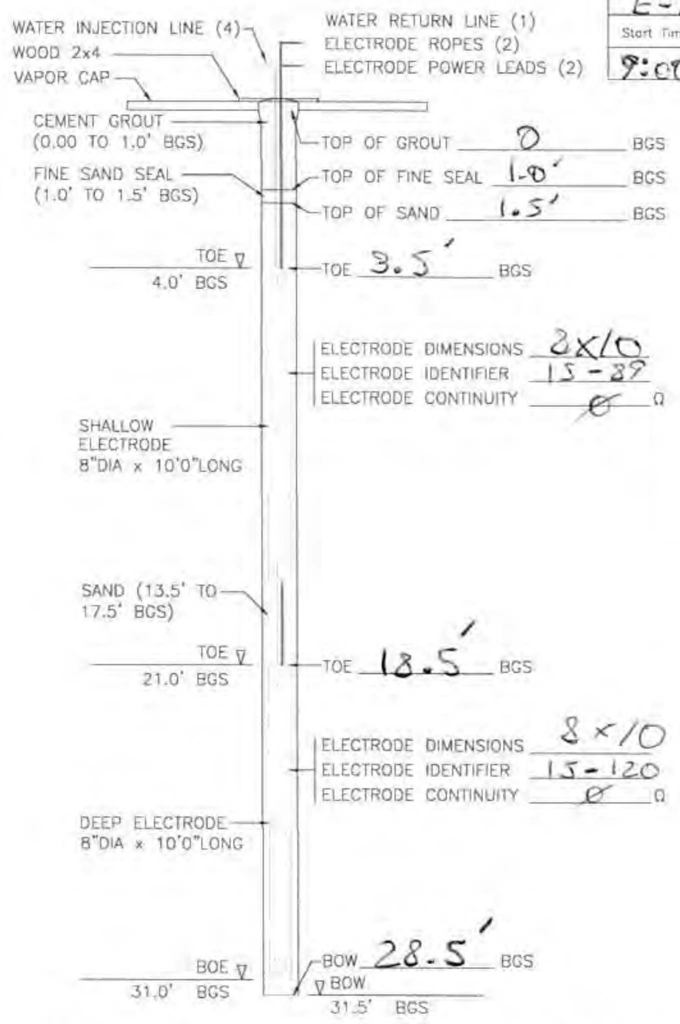
DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
8/10/15	I	✓

Electrode Well	Electrode Designation
E-B3	DOUBLE 8" DIA. x 10'0"
Start Time	**Completion Time**
9:00	11:10



WATER INJECTION LINE (4)
WOOD 2x4
VAPOR CAP
WATER RETURN LINE (1)
ELECTRODE ROPES (2)
ELECTRODE POWER LEADS (2)

CEMENT GROUT (0.00 TO 1.0' BGS)
FINE SAND SEAL (1.0' TO 1.5' BGS)

TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1.0' BGS
TOP OF SAND 1.5' BGS

TOE ∇ 4.0' BGS
TOE 3.5' BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-89
ELECTRODE CONTINUITY 0 Ω

SHALLOW ELECTRODE 8"DIA x 10'0"LONG

SAND (13.5' TO 17.5' BGS)

TOE ∇ 21.0' BGS
TOE 18.5' BGS

ELECTRODE DIMENSIONS 8×10
ELECTRODE IDENTIFIER 15-120
ELECTRODE CONTINUITY 0 Ω

DEEP ELECTRODE 8"DIA x 10'0"LONG

BOE ∇ 31.0' BGS
BOW 28.5' BGS
∇ BOW 31.5' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED:
2. SAND:
   MATERIAL USED: #1
   QUANTITY USED: 15 bags
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1 bag

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HS Auger
DRILLING EQUIPMENT: CME 85

BOREHOLE DIAMETER: 11.5"
BOREHOLE DEPTH: 28.5'
DEPTH TO WATER: -
Can't see water during installation

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

McMILLAN-McGEE CORP.

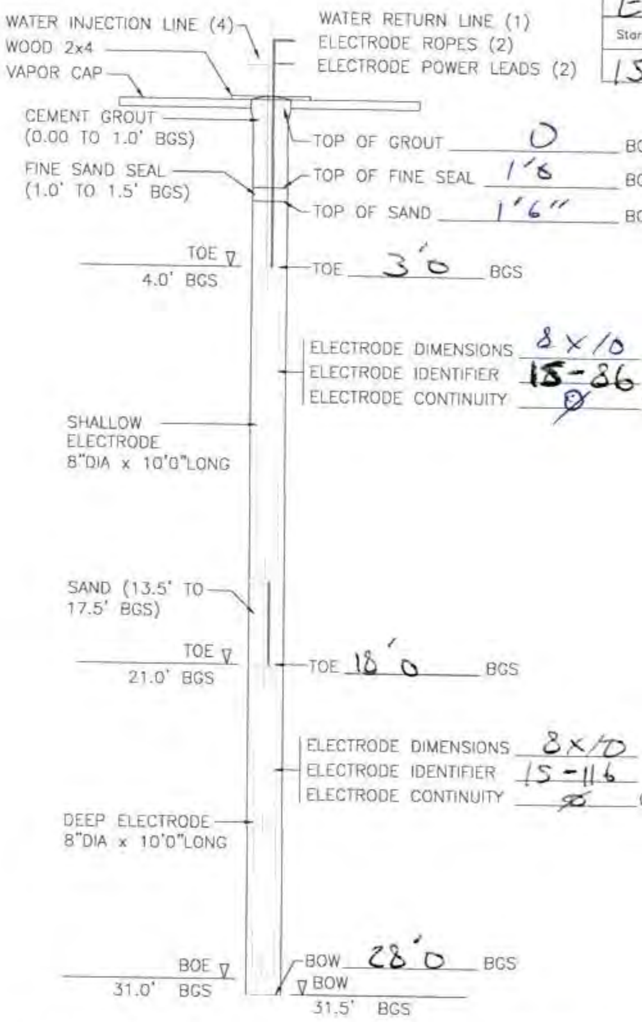
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
13/10/15	TL	
Electrode Well	Electrode Designation	
E-134	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
15:10	17:00	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'8 BGS

TOP OF SAND 1'6" BGS

TOE 3'0 BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-86

ELECTRODE CONTINUITY 0 Ω

TOE 18'0 BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-116

ELECTRODE CONTINUITY 0 Ω

BOW 28'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED:
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 22
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: 2

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 11"0

BOREHOLE DEPTH: 28'0

DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

- backfilled sand up to 5 feet bgs and ran out of sand.
- backfilled remaining sand on 21/10/15

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

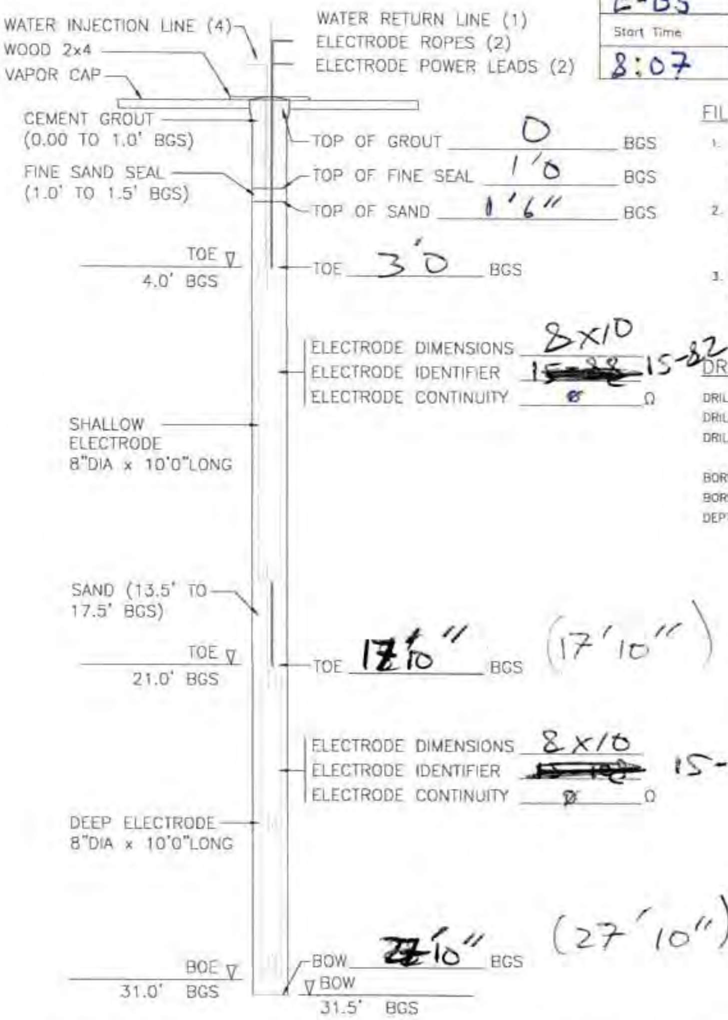
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
14/10/15	T	✓
Electrode Well	Electrode Designation	
E-B5	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
8:07	17:20	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'6" BGS

TOE 3'0 BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-82

ELECTRODE CONTINUITY 0 Ω

TOE 17'10" BGS (17'10")

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-107

ELECTRODE CONTINUITY 0 Ω

BOW 27'10" BGS (27'10")

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 23
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 12"0

BOREHOLE DEPTH: 27'10"

DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN–MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN–MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
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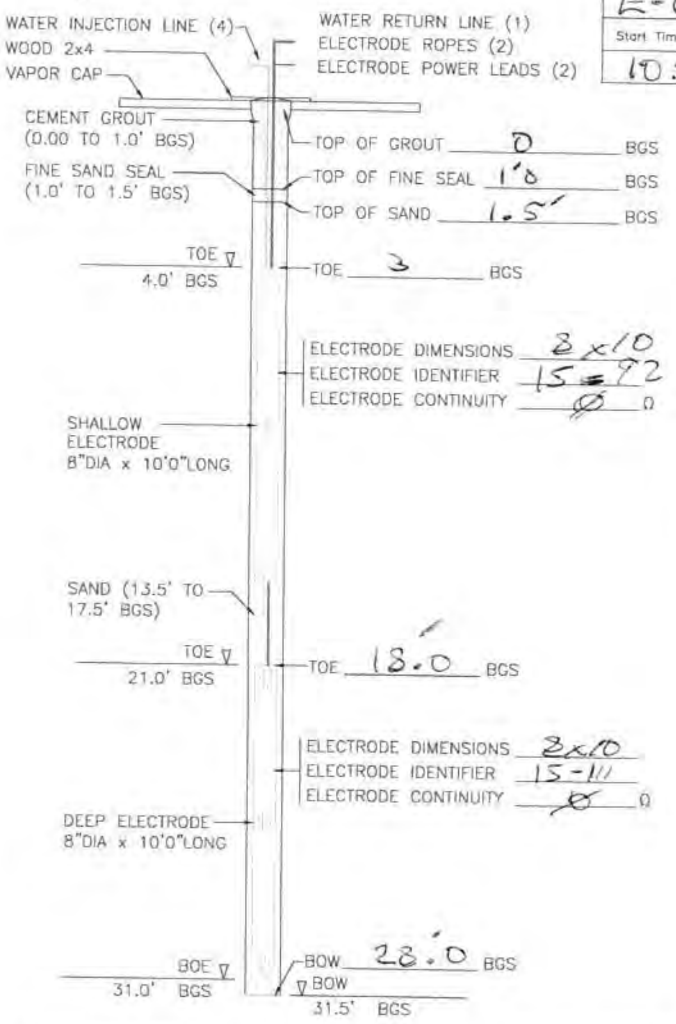
DOUBLE ELECTRODE

Date	Signature	Checked
12/10/15	T	
Electrode Well	Electrode Designation	
E-C1	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
10:25	12:30	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1.5' BGS

TOE 3 BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-92

ELECTRODE CONTINUITY 0 Ω

TOE 18.0 BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-111

ELECTRODE CONTINUITY 0 Ω

BOW 28.0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #7
   QUANTITY USED: 19
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: BW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 11"

BOREHOLE DEPTH: 28.0'

DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

DOUBLE ELECTRODE

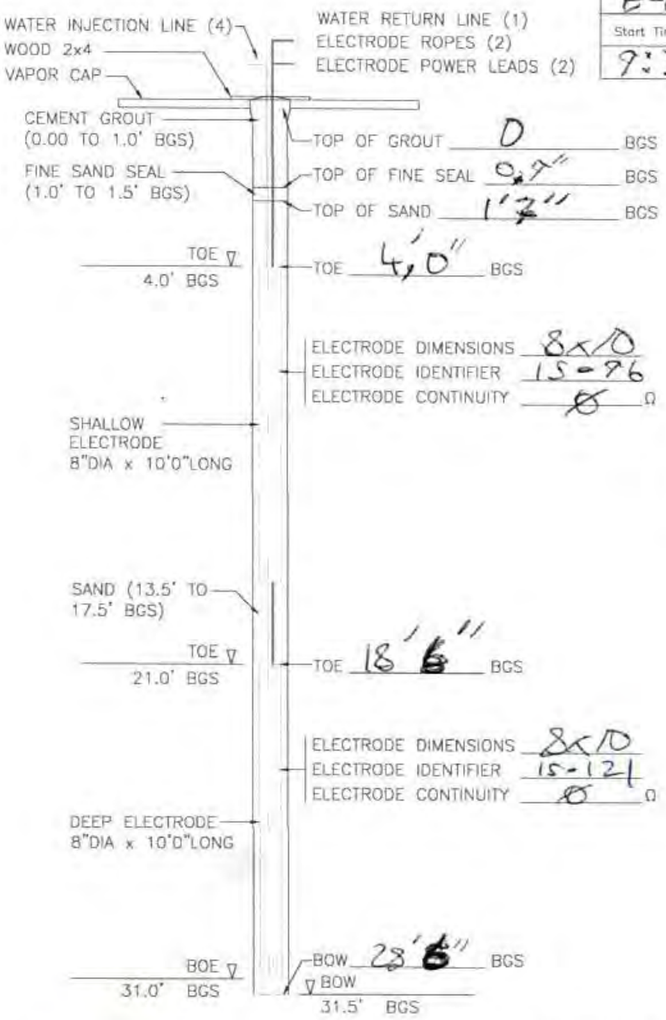
DRILLING:QA/QC

Edition REV.A1

Sheet OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
9/10/15	T	
Electrode Well	Electrode Designation	
E-C2	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
9:30	11:00	



TOP OF GROUT D BGS

TOP OF FINE SEAL 0.7" BGS

TOP OF SAND 1'7" BGS

TOE 4'0" BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-96

ELECTRODE CONTINUITY 0 Ω

TOE 18'6" BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-121

ELECTRODE CONTINUITY 0 Ω

BOW 28'6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #1
   QUANTITY USED: 17
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HS Auger

DRILLING EQUIPMENT: CME 85

BOREHOLE DIAMETER: 10.5"

BOREHOLE DEPTH: 28'2"

DEPTH TO WATER: —

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

McMILLAN-McGEE CORP.

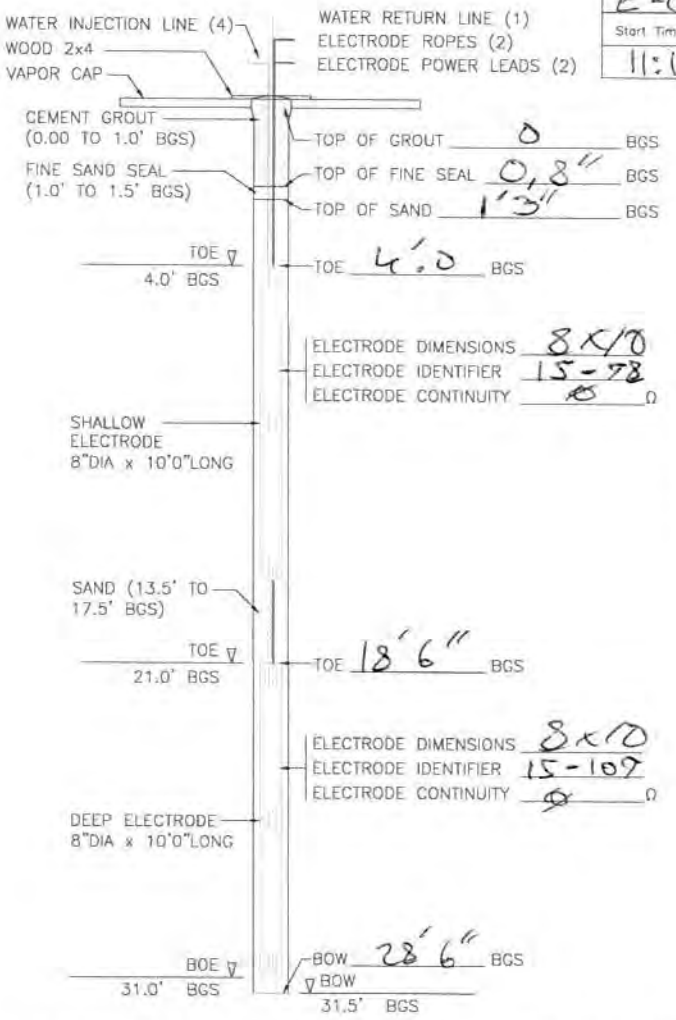
DOUBLE
ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
9/10/15		
Electrode Well	Electrode Designation	
E-C3	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
11:15	12:30	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 0,8" BGS
TOP OF SAND 1'3" BGS
TOE 4'.0 BGS

ELECTRODE DIMENSIONS 8X10
ELECTRODE IDENTIFIER 15-78
ELECTRODE CONTINUITY 0 Ω

TOE 18' 6" BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-109
ELECTRODE CONTINUITY 0 Ω

BOW 28' 6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 20
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28' 6"
DEPTH TO WATER: –

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

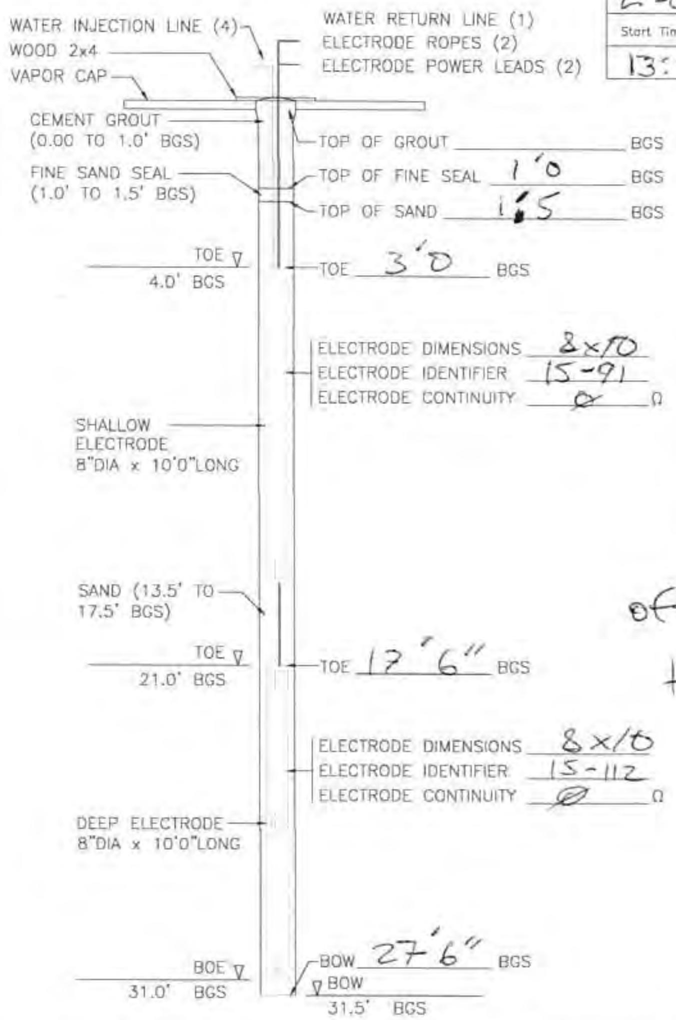
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
12/10/15	T	✓
Electrode Well	Electrode Designation	
E-CK	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
13:00	15:00	



TOP OF GROUT ______ BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'5 BGS

TOE 3'0 BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-91

ELECTRODE CONTINUITY 0 Ω

TOE 17'6" BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-112

ELECTRODE CONTINUITY 0 Ω

BOW 27'6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 17
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 11"

BOREHOLE DEPTH: 27'6"

DEPTH TO WATER: /

offset 2" towards EC3

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

DOUBLE ELECTRODE

DRILLING:QA/QC

Edition REV.A1

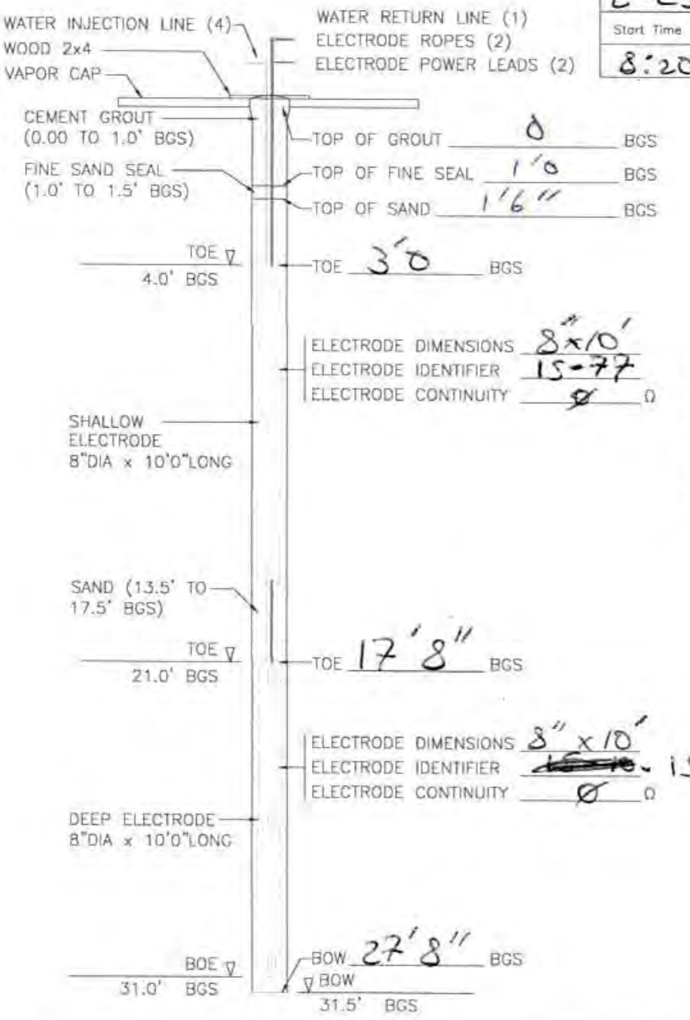
Sheet OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
15/10/15		✓

Electrode Well	Electrode Designation
E-C5	DOUBLE 8" DIA. x 10'0"

Start Time	Completion Time
8:20	11:00



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1'0 BGS
TOP OF SAND 1'6" BGS
TOE 3'0 BGS

ELECTRODE DIMENSIONS 8"x10'
ELECTRODE IDENTIFIER 15-77
ELECTRODE CONTINUITY 0 Ω

TOE 17'8" BGS

ELECTRODE DIMENSIONS 8" x 10'
ELECTRODE IDENTIFIER 15-106
ELECTRODE CONTINUITY 0 Ω

BOW 27'8" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 17
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME75

BOREHOLE DIAMETER: 11"
BOREHOLE DEPTH: 27'8"
DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

Open hole but seemed like loose wet Clay.

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

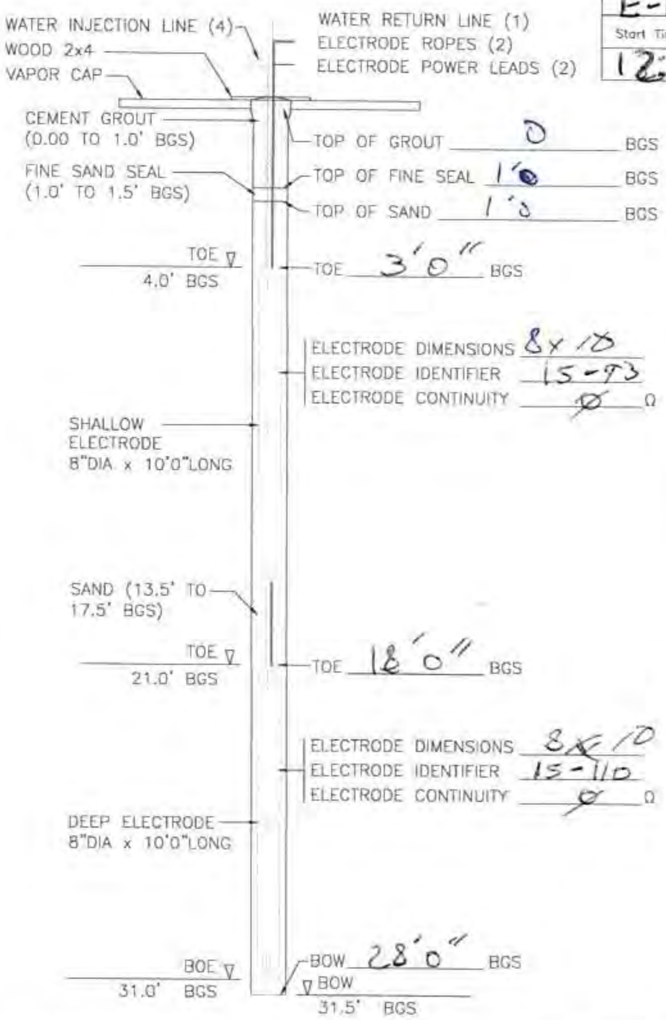
DOUBLE
ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
9/10/15		
Electrode Well	Electrode Designation	
E-D2	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
12:45	14:10	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'5 BGS

TOE 3'0" BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-93
ELECTRODE CONTINUITY 0 Ω

TOE 18'0" BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-110
ELECTRODE CONTINUITY 0 Ω

BOW 28'0" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #1
   QUANTITY USED: 17
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER:
BOREHOLE DEPTH: 28'0"
DEPTH TO WATER:

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN–MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN–MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
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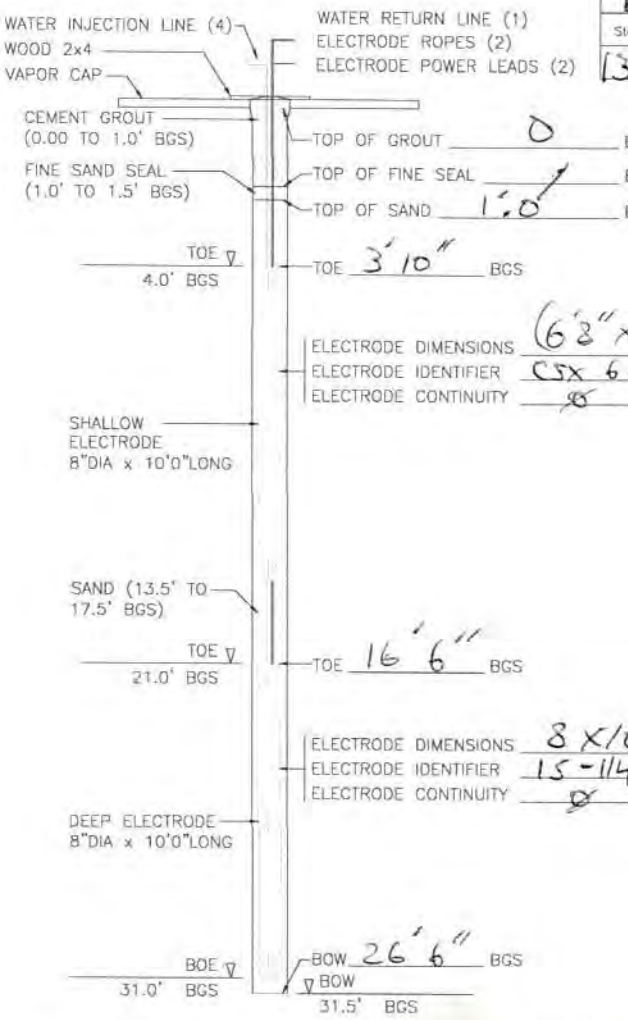
DOUBLE ELECTRODE

Date	Signature	Checked
13/10/15		
Electrode Well	Electrode Designation	
E-D3	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
13:00	15:00	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL / BGS
TOP OF SAND 1'.0 BGS
TOE 3' 10" BGS

ELECTRODE DIMENSIONS (6'8" x 8")
ELECTRODE IDENTIFIER CSX 6 footer
ELECTRODE CONTINUITY 0 Ω

TOE 16' 6" BGS

ELECTRODE DIMENSIONS 8 X 10
ELECTRODE IDENTIFIER 15-114
ELECTRODE CONTINUITY 0 Ω

BOW 26' 6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #7
   QUANTITY USED: 18
3. FINE SAND SEAL:
   MATERIAL USED: #00
   QUANTITY USED:

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR (Ingersol Rand)

BOREHOLE DIAMETER: 10' 6"
BOREHOLE DEPTH: 26' 6"
DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

Left Deep 10 footer installed backfilled with Sand to 13'.0 and then installed Shallow 6'8" with tripod.

ABBREVIATIONS:

1. BOW - BOTTOM OF WELL
2. TOE - TOP OF ELECTRODE
3. BOE - BOTTOM OF ELECTRODE
4. BGS - BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

McMILLAN-McGEE CORP.

DOUBLE ELECTRODE

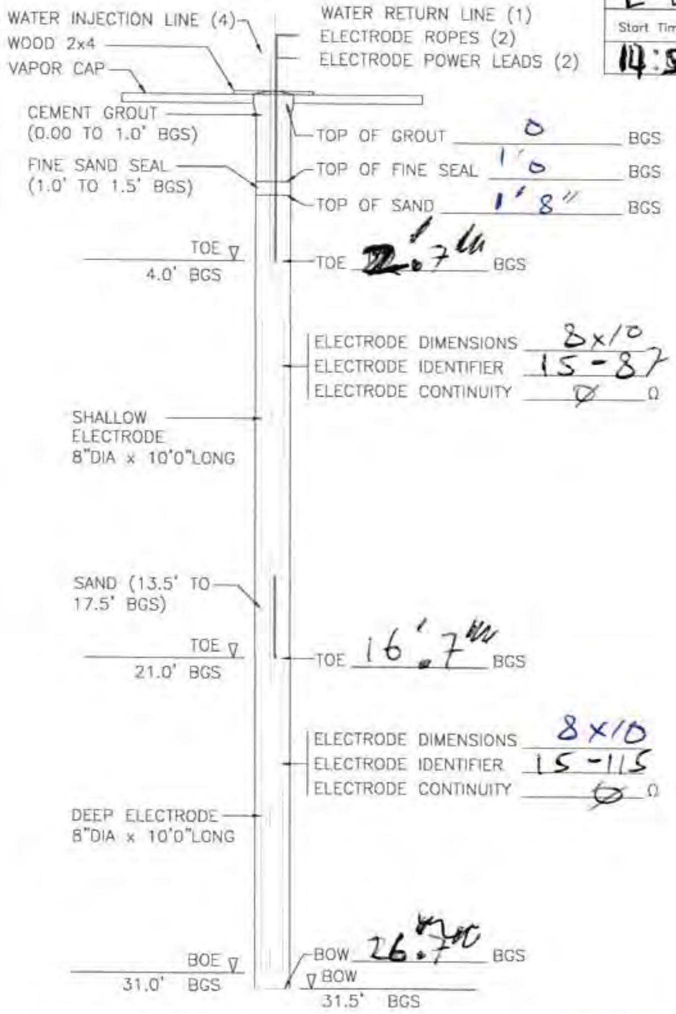
DRILLING:QA/QC

Edition REV.A1

Sheet OF 72

DOUBLE ELECTRODE

Date	Signature	Checked
13/10/15	T	
Electrode Well	Electrode Designation	
E-D4	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
14:50	16:45	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'8" BGS

TOE ~~22~~ 2'.7" BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-87

ELECTRODE CONTINUITY 0 Ω

TOE 16'.7" BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-115

ELECTRODE CONTINUITY 0 Ω

BOW 26.7' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: # 1
   QUANTITY USED: 18
3. FINE SAND SEAL:
   MATERIAL USED: 00 N
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10'6"

BOREHOLE DEPTH: 26.7'

DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

DOUBLE ELECTRODE

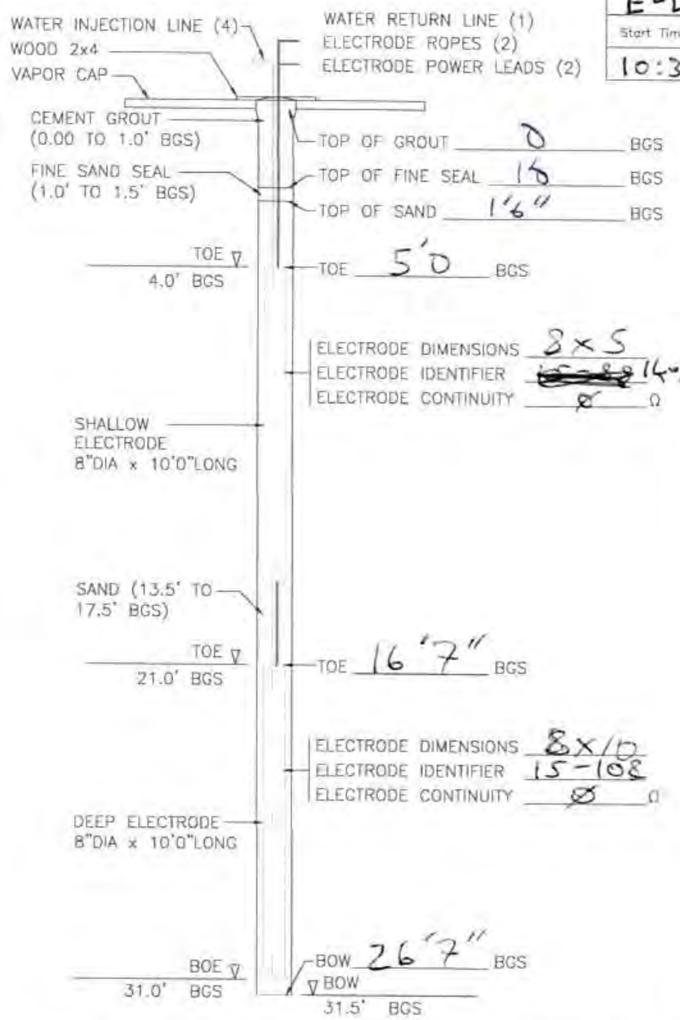
DRILLING:QA/QC

Edition REV.A1

Sheet OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
14/10/15	T	
Electrode Well	Electrode Designation	
E-D5	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
10:30	14:30	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 18 BGS

TOP OF SAND 1'6" BGS

TOE 5'0 BGS

ELECTRODE DIMENSIONS 8 x 5

ELECTRODE IDENTIFIER 14-897

ELECTRODE CONTINUITY 0 Ω

TOE 16'7" BGS

ELECTRODE DIMENSIONS 8x10

ELECTRODE IDENTIFIER 15-108

ELECTRODE CONTINUITY 0 Ω

BOW 26'7" BGS

FILL MATERIAL:

1. GROUT:
   - MATERIAL USED: P I/II
   - QUANTITY USED: /
2. SAND:
   - MATERIAL USED: #2
   - QUANTITY USED: 38
3. FINE SAND SEAL:
   - MATERIAL USED: 00N
   - QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: IR and CME 75

BOREHOLE DIAMETER: 10"6"

BOREHOLE DEPTH: 26'7"

DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

11:20 ~~got down to 0~~

Pulled all augers out and the hole collapsed. Need to redo with 10.25 augers.

Rig #1 moving over to finish this at 12:08

Rig #2 moving to E-E3

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

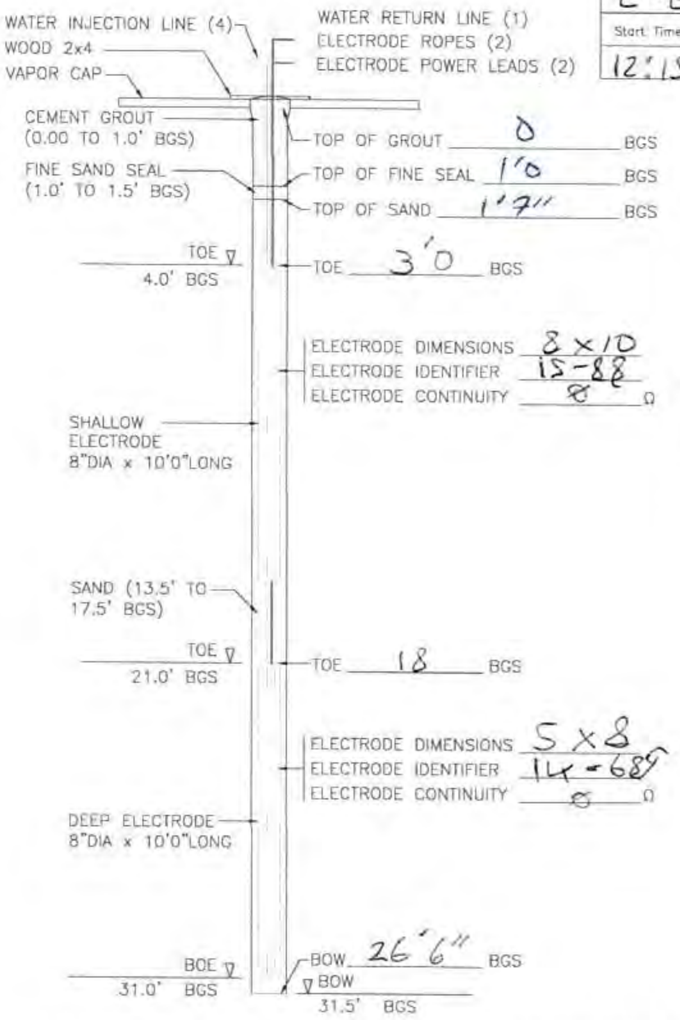
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
14/10/15	T	✓
Electrode Well	Electrode Designation	
E-E3	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
12:15	14:10	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'7" BGS

TOE 3'0 BGS

ELECTRODE DIMENSIONS 8 x 10

ELECTRODE IDENTIFIER 15-88

ELECTRODE CONTINUITY 0 Ω

TOE 18 BGS

ELECTRODE DIMENSIONS 5 x 8

ELECTRODE IDENTIFIER 14-689

ELECTRODE CONTINUITY 0 Ω

BOW 26'6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 20
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 11"

BOREHOLE DEPTH: 26'6"

DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

Short C5x electrode set at 23'0 feet bgs

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

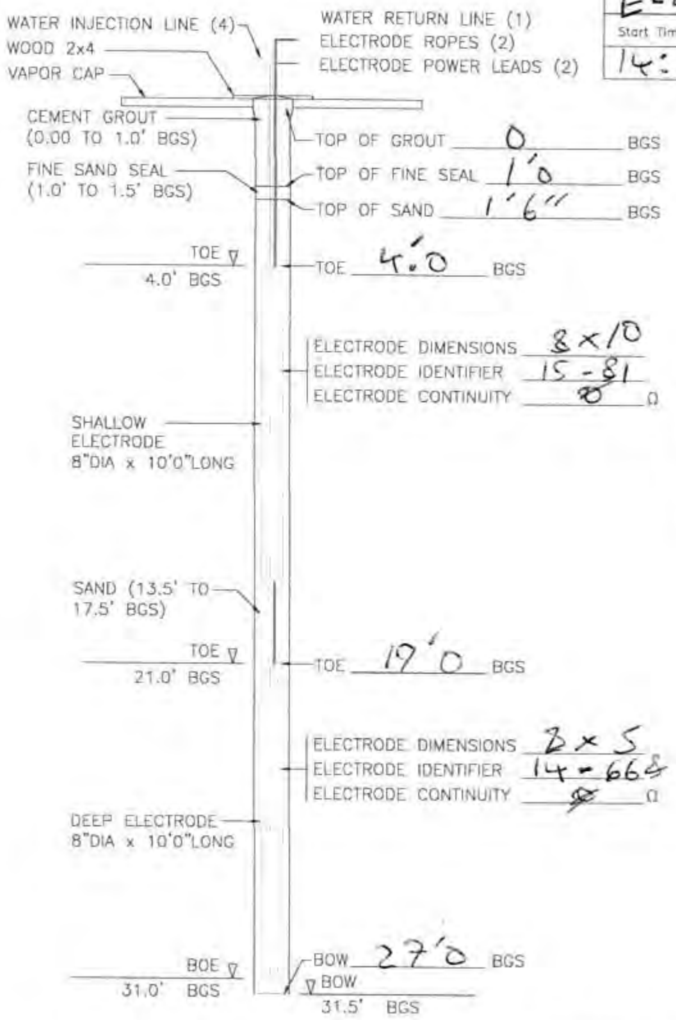
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
14/10/15	T.	
Electrode Well	Electrode Designation	
E-E4	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
14:30	15:40	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1'0 BGS
TOP OF SAND 1'6" BGS
TOE 4'0 BGS

ELECTRODE DIMENSIONS 8x10
ELECTRODE IDENTIFIER 15-81
ELECTRODE CONTINUITY 0 Ω

TOE 19'0 BGS

ELECTRODE DIMENSIONS 8 x 5
ELECTRODE IDENTIFIER 14-668
ELECTRODE CONTINUITY 0 Ω

BOW 27'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 21
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 27'0
DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

CSX short deep electrode from 24'0 to 19'6

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

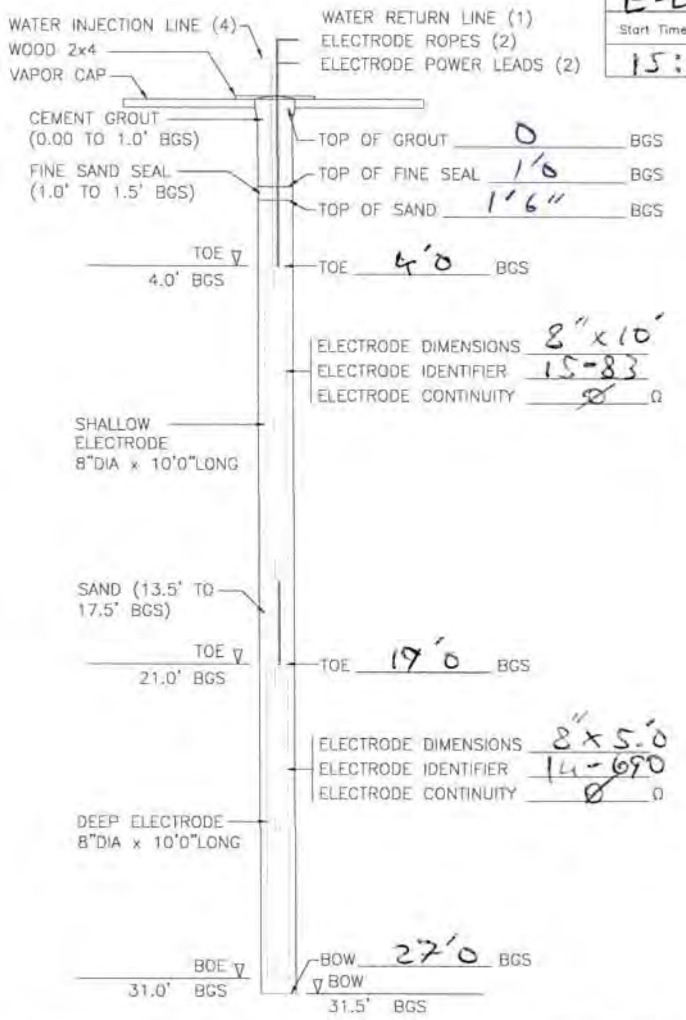
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV A1	OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
14/10/15	T	✓
Electrode Well	Electrode Designation	
E-E5	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
15:55	17:20	



TOP OF GROUT 0 BGS
TOP OF FINE SEAL 1'0 BGS
TOP OF SAND 1'6" BGS
TOE 4'0 BGS

ELECTRODE DIMENSIONS 8"x10'
ELECTRODE IDENTIFIER 15-83
ELECTRODE CONTINUITY 0 Ω

TOE 19'0 BGS

ELECTRODE DIMENSIONS 8"x5.0'
ELECTRODE IDENTIFIER 14-690
ELECTRODE CONTINUITY 0 Ω

BOW 27'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 20
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 27'0
DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW – BOTTOM OF WELL
2. TOE – TOP OF ELECTRODE
3. BOE – BOTTOM OF ELECTRODE
4. BGS – BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

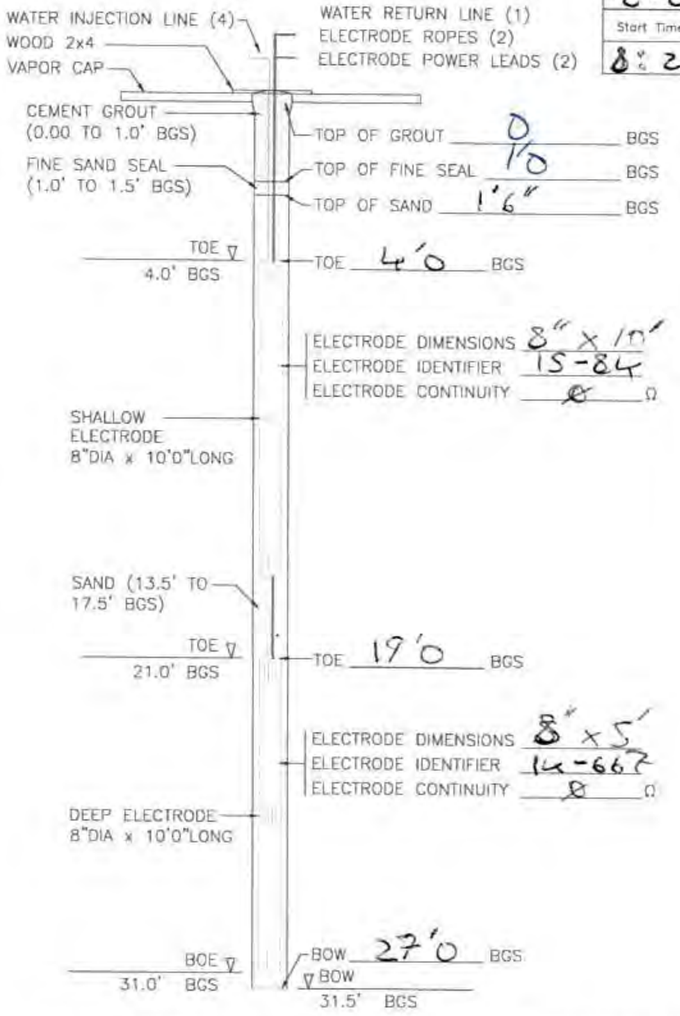
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition REV.A1
Sheet OF 22

DOUBLE ELECTRODE

Date	Signature	Checked
15/10/15		
Electrode Well	Electrode Designation	
E-E6	DOUBLE 8" DIA. x 10'0"	
Start Time	Completion Time	
8:20	9:50	



TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'6" BGS

TOE 4'0 BGS

ELECTRODE DIMENSIONS 8" x 10'

ELECTRODE IDENTIFIER 15-84

ELECTRODE CONTINUITY 0 Ω

TOE 19'0 BGS

ELECTRODE DIMENSIONS 8" x 5'

ELECTRODE IDENTIFIER 14-667

ELECTRODE CONTINUITY 0 Ω

BOW 27'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #2
   QUANTITY USED: 19
3. FINE SAND SEAL:
   MATERIAL USED: 00N
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 11"

BOREHOLE DEPTH: 27'0

DEPTH TO WATER: /

GENERAL NOTES:

1. ELECTRODE POWER LEAD FOR EACH ELECTRODE MUST BE TESTED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
2. TOP AND BOTTOM WATER INJECTION LINES FOR EACH ELECTRODE MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
3. SHALLOW ELECTRODE HAS A WATER RETURN LINE THAT MUST BE TIGHTENED PRIOR TO DEPLOYING THE ELECTRODE IN THE WELL.
4. ELECTRODES ARE CONNECTED TO A TECHNORA ROPE FOR LOWERING INTO THE HOLE AND TIED TO A PIECE OF 2X4 WOOD PLACED ACROSS THE TOP OF THE COMPLETED HOLE IN THE EVENT THAT THE SAND SETTLES WITHIN THE BORING.
5. I.D. OF ALL ELECTRODE BORINGS IS MIN 10".
6. SAND IS 20/30 SILICA OR EQUIVALENT.
7. NO GRAPHITE FILL ADJACENT TO ELECTRODES.
8. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
9. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).

INSTALLATION NOTES:

ABBREVIATIONS:

1. BOW - BOTTOM OF WELL
2. TOE - TOP OF ELECTRODE
3. BOE - BOTTOM OF ELECTRODE
4. BGS - BELOW GROUND SURFACE

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

McMILLAN-McGEE CORP.

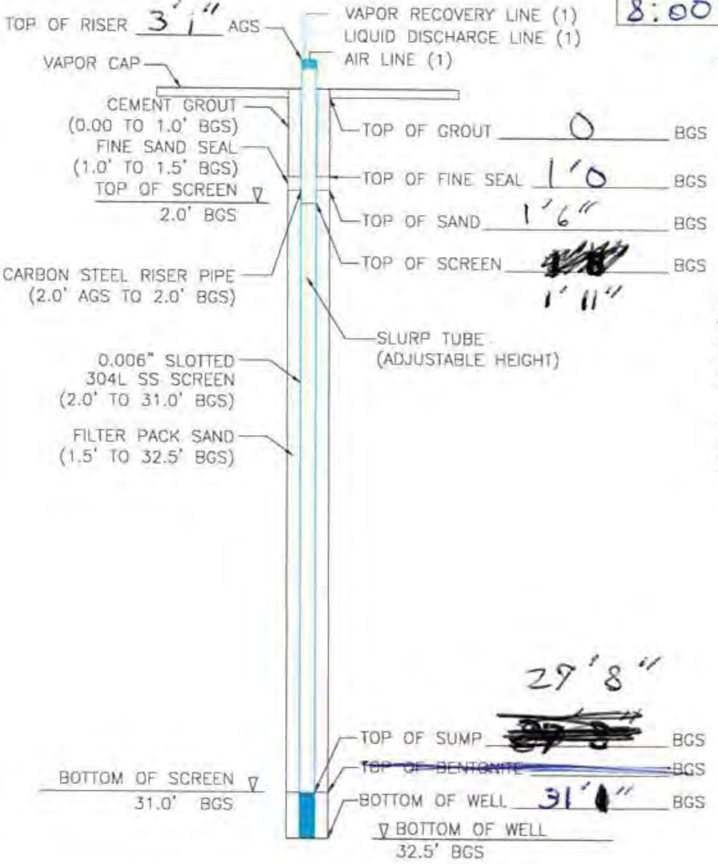
DOUBLE ELECTRODE

DRILLING:QA/QC

Edition	Sheet
REV A1	OF 22

EXTRACTION WELL

Date	Signature	Checked
14/10/15	T	
Extraction Well	Extraction Well Designation	
X-A1	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
8:00	9:50	



TOP OF RISER 3'1" AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'6" BGS

TOP OF SCREEN 1'11" BGS

TOP OF SUMP 29'8" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 31'1" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #00N
   QUANTITY USED: 28
3. FINE SEAL:
   MATERIAL USED: 90
   QUANTITY USED: 1

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"

BOREHOLE DEPTH: 31'1"

DEPTH TO WATER: -

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS, CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

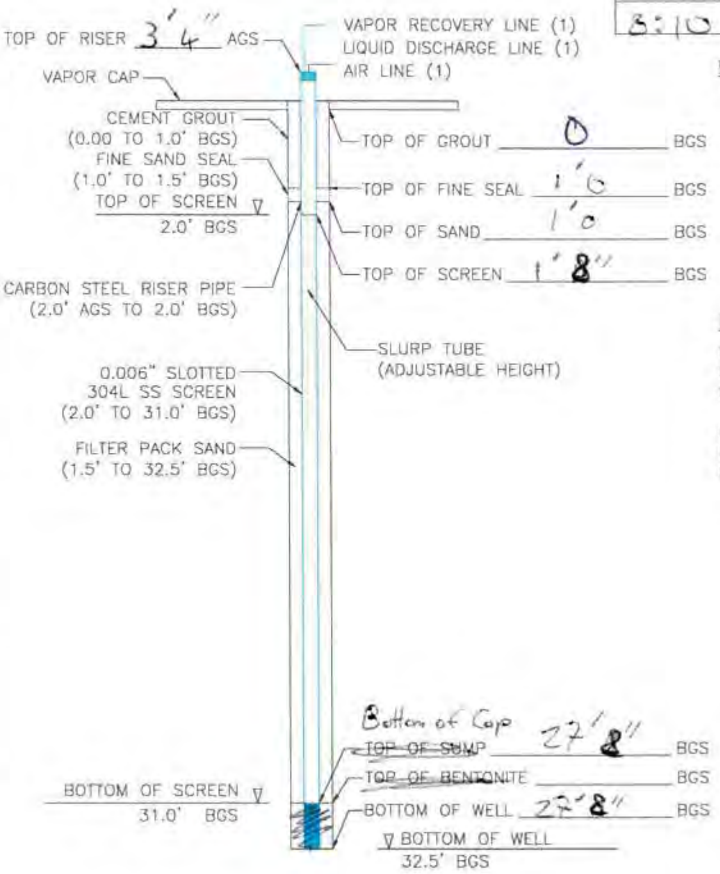
DRILLING:QA/QC

Edition REV.A1

Sheet OF 15

EXTRACTION WELL

Date	Signature	Checked
16/10/15	T	
Extraction Well	Extraction Well Designation	
X-AZ	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
8:10	11:00	



TOP OF RISER 3'4" AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 1'8" BGS

Bottom of Cap ~~TOP OF SUMP~~ 27'8" BGS

~~TOP OF BENTONITE~~ ______ BGS

BOTTOM OF WELL 27'8" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #00
   QUANTITY USED: 28
3. FINE SEAL:
   MATERIAL USED: /
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 27'8"
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS. CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

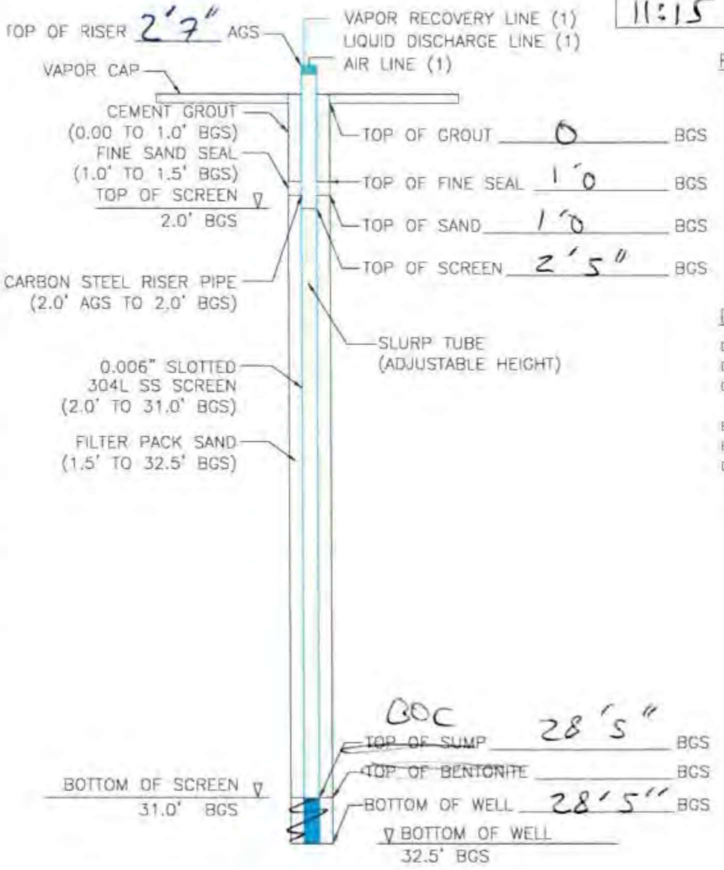
DRILLING:QA/QC

Edition REV.A1

Sheet OF 15

EXTRACTION WELL

Date	Signature	Checked
16/10/15	T	✓
Extraction Well	Extraction Well Designation	
X-A3	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
11:15	13:30	



TOP OF RISER 2'7" AGS

VAPOR CAP

CEMENT GROUT (0.00 TO 1.0' BGS)

FINE SAND SEAL (1.0' TO 1.5' BGS)

TOP OF SCREEN ▽ 2.0' BGS

CARBON STEEL RISER PIPE (2.0' AGS TO 2.0' BGS)

0.006" SLOTTED 304L SS SCREEN (2.0' TO 31.0' BGS)

FILTER PACK SAND (1.5' TO 32.5' BGS)

VAPOR RECOVERY LINE (1)
LIQUID DISCHARGE LINE (1)
AIR LINE (1)

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'5" BGS

SLURP TUBE (ADJUSTABLE HEIGHT)

OOC ~~TOP OF SUMP~~ 28'5" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 28'5" BGS

BOTTOM OF SCREEN ▽ 31.0' BGS

▽ BOTTOM OF WELL 32.5' BGS

FILL MATERIAL:

1. GROUT:
MATERIAL USED: PI/II
QUANTITY USED: /
2. SAND:
MATERIAL USED: #00
QUANTITY USED: 23
3. FINE SEAL:
MATERIAL USED: /
QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28'5"
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS, CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

Had trouble with the gravel coming into the well while he was sanding and pulling up his auger.

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

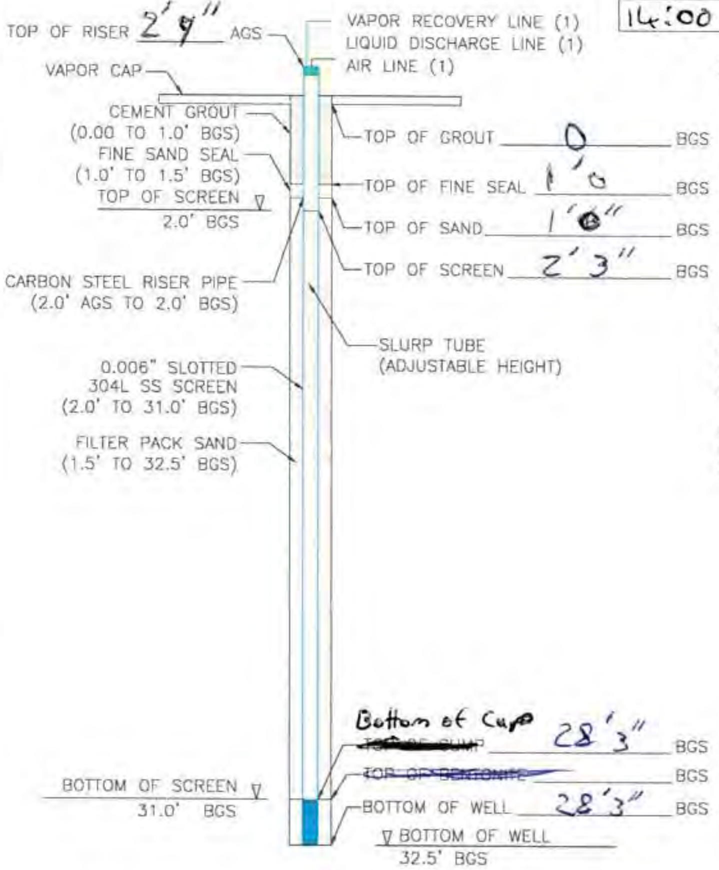
DRILLING:QA/QC

Edition REV.A1

Sheet OF 15

EXTRACTION WELL

Date	Signature	Checked
15/10/15		
Extraction Well	Extraction Well Designation	
X-131	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
14:00	16:30	



TOP OF RISER 2' 9" AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1' 0 BGS

TOP OF SAND 1' 6" BGS

TOP OF SCREEN 2' 3" BGS

Bottom of Cup ~~TOP OF SUMP~~ 28' 3" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 28' 3" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #00
   QUANTITY USED: 24
3. FINE SEAL:
   MATERIAL USED: ~~#~~
   QUANTITY USED: ~~/~~

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28' 3"
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS, CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

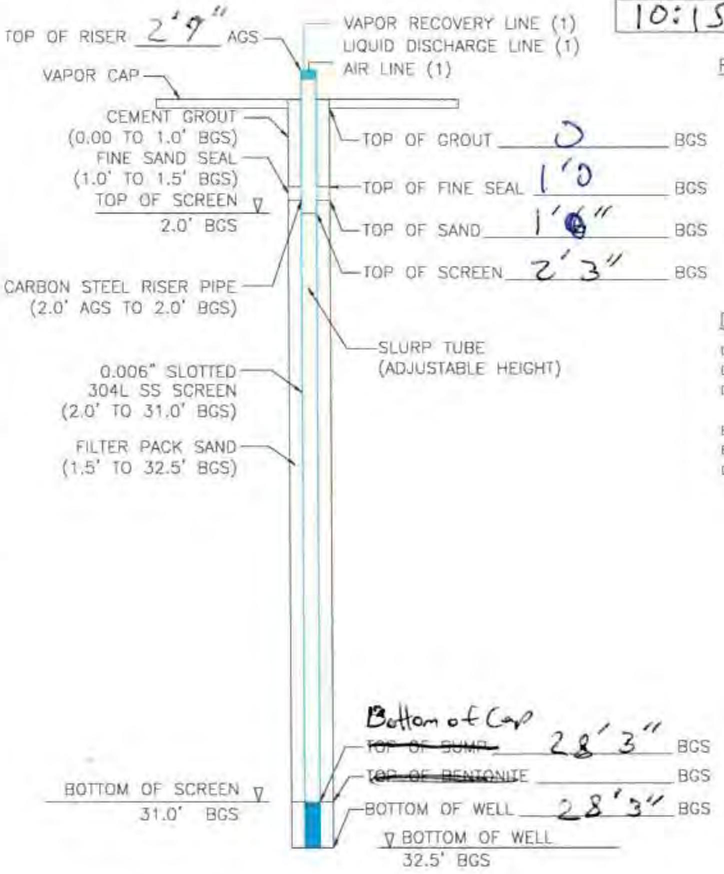
DRILLING:QA/QC

Edition REV.A1

Sheet OF 15

EXTRACTION WELL

Date	Signature	Checked
15/10/15	T	✓
Extraction Well	Extraction Well Designation	
X-B2	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
10:15	13:30	



TOP OF RISER 2'9" AGS

VAPOR RECOVERY LINE (1)
LIQUID DISCHARGE LINE (1)
AIR LINE (1)

VAPOR CAP

CEMENT GROUT (0.00 TO 1.0' BGS)

FINE SAND SEAL (1.0' TO 1.5' BGS)

TOP OF SCREEN 2.0' BGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'6" BGS

TOP OF SCREEN 2'3" BGS

CARBON STEEL RISER PIPE (2.0' AGS TO 2.0' BGS)

SLURP TUBE (ADJUSTABLE HEIGHT)

0.006" SLOTTED 304L SS SCREEN (2.0' TO 31.0' BGS)

FILTER PACK SAND (1.5' TO 32.5' BGS)

Bottom of Cap ~~TOP OF SUMP~~ 28'3" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 28'3" BGS

BOTTOM OF SCREEN 31.0' BGS

BOTTOM OF WELL 32.5' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #00
   QUANTITY USED: 24
3. FINE SEAL:
   MATERIAL USED: /
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28'3"
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS, CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

No sump just cap

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

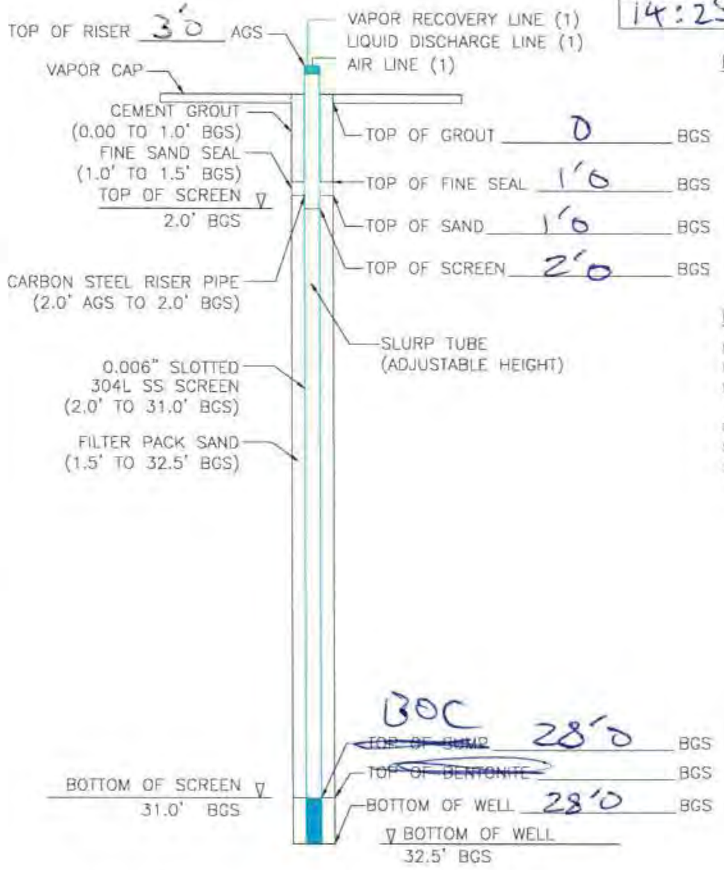
EXTRACTION WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 15

EXTRACTION WELL

Date	Signature	Checked
19/10/15	T	✓
Extraction Well	Extraction Well Designation	
X-B3	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
14:25	17:30	



TOP OF RISER 3'0 AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'0 BGS

BOC ~~TOP OF SUMP~~ 28'0 BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 28'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: 00
   QUANTITY USED: 25
3. FINE SEAL:
   MATERIAL USED:
   QUANTITY USED:

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28'0
DEPTH TO WATER: –

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
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6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

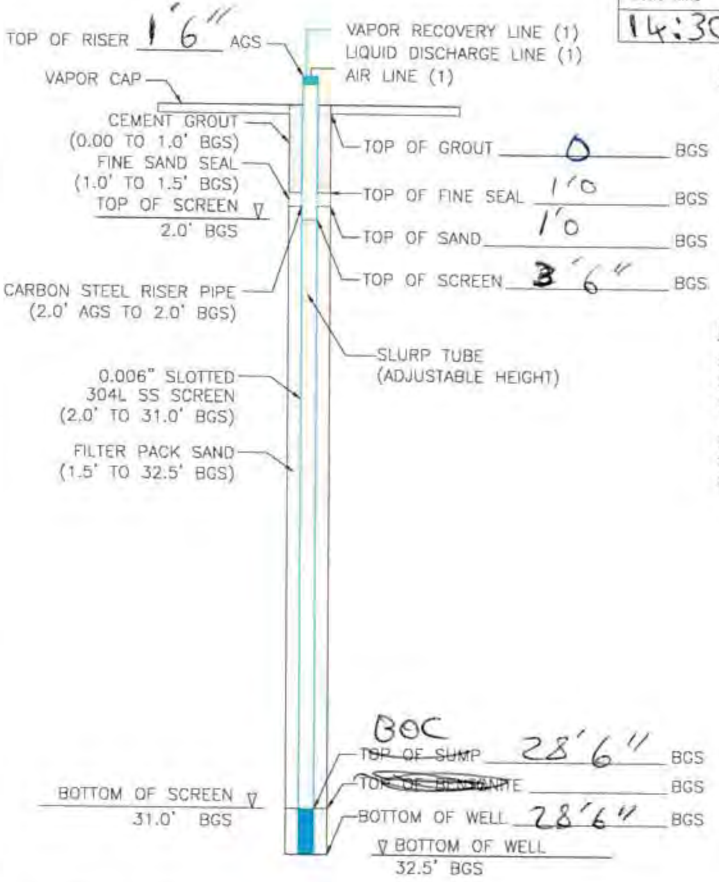
EXTRACTION WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 15

EXTRACTION WELL

Date	Signature	Checked
20/10/15		✓
Extraction Well	Extraction Well Designation	
X-B4	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
14:30	16:55	



TOP OF RISER 1'6" AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 3'6" BGS

BOC ~~TOP OF SUMP~~ 28'6" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 28'6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: 00
   QUANTITY USED: 22
3. FINE SEAL:
   MATERIAL USED: /
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28'6"
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS, CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

Not enough screen sections to bring it up to 2'0

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN–MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN–MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

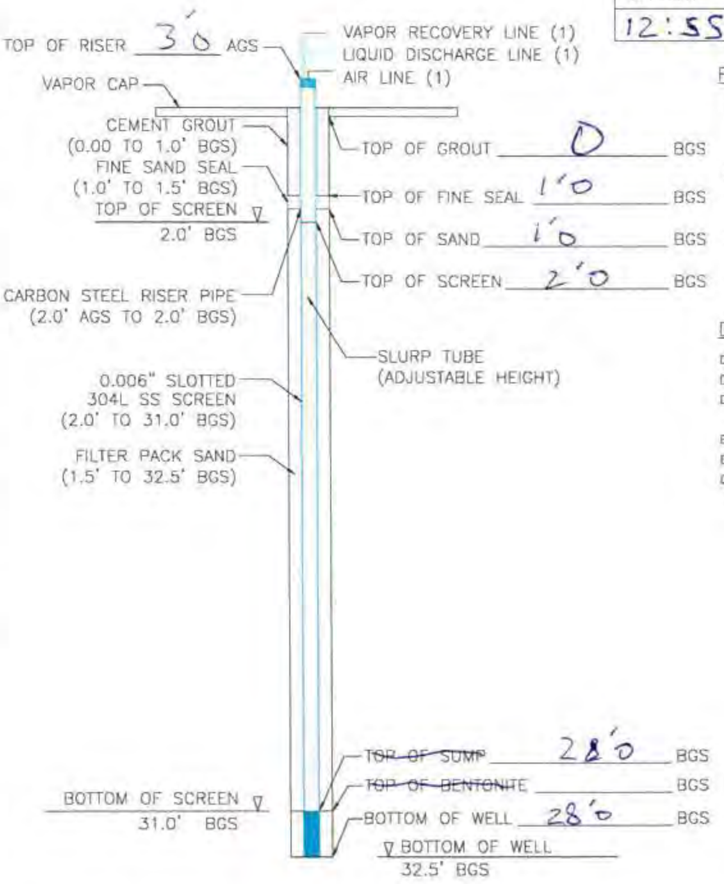
EXTRACTION WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 15

EXTRACTION WELL

Date	Signature	Checked
19/10/15	T	✓
Extraction Well	Extraction Well Designation	
X-C1	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
12:55	15:30	



TOP OF RISER 3'0 AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'0 BGS

~~TOP OF SUMP~~ 28'0 BGS

~~TOP OF BENTONITE~~ ______ BGS

BOTTOM OF WELL 28'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: 00
   QUANTITY USED: 22
3. FINE SEAL:
   MATERIAL USED: 00
   QUANTITY USED: —

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28'0
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS, CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

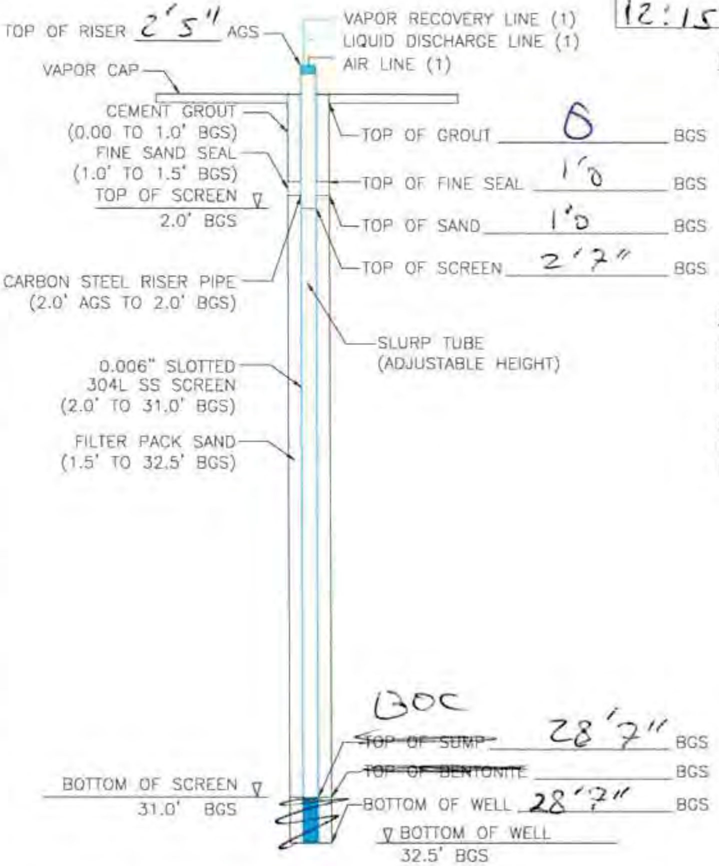
EXTRACTION WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 15

EXTRACTION WELL

Date	Signature	Checked
16/10/15	T	✓
Extraction Well	**Extraction Well Designation**	
X-C2	MPE C/W SLURPER TUBE	
Start Time	**Completion Time**	
12:15	13:50	



TOP OF RISER 2'5" AGS

TOP OF GROUT 6 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'7" BGS

BOC

~~TOP OF SUMP~~ 28'7" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 28'7" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #00
   QUANTITY USED: 23
3. FINE SEAL:
   MATERIAL USED: #00
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28'7"
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
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7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
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4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

MCMILLAN-MCGEE CORP.

EXTRACTION WELL

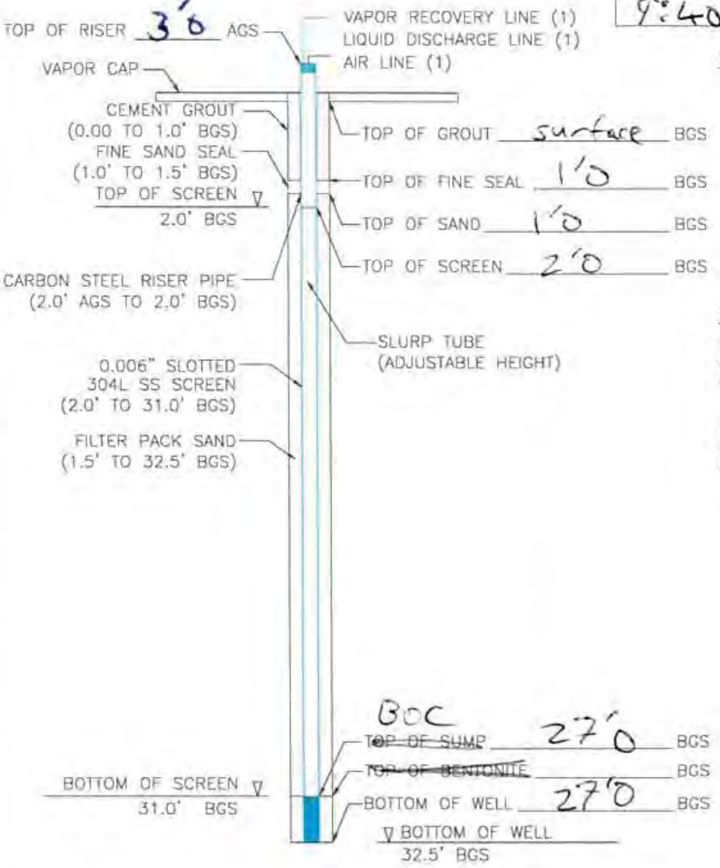
DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 15

X-C3

EXTRACTION WELL

Date	Signature	Checked
16/10/15	T	✓
Extraction Well	Extraction Well Designation	
X-[illegible]3	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
9:40	12:00	



TOP OF RISER 3'0 AGS

TOP OF GROUT surface BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'0 BGS

BOC ~~TOP OF SUMP~~ 27'0 BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 27'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/III
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: #00
   QUANTITY USED: 24
3. FINE SEAL:
   MATERIAL USED: /
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: (IR)

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 27'0
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
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7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
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4. ID – INNER DIAMETER
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Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

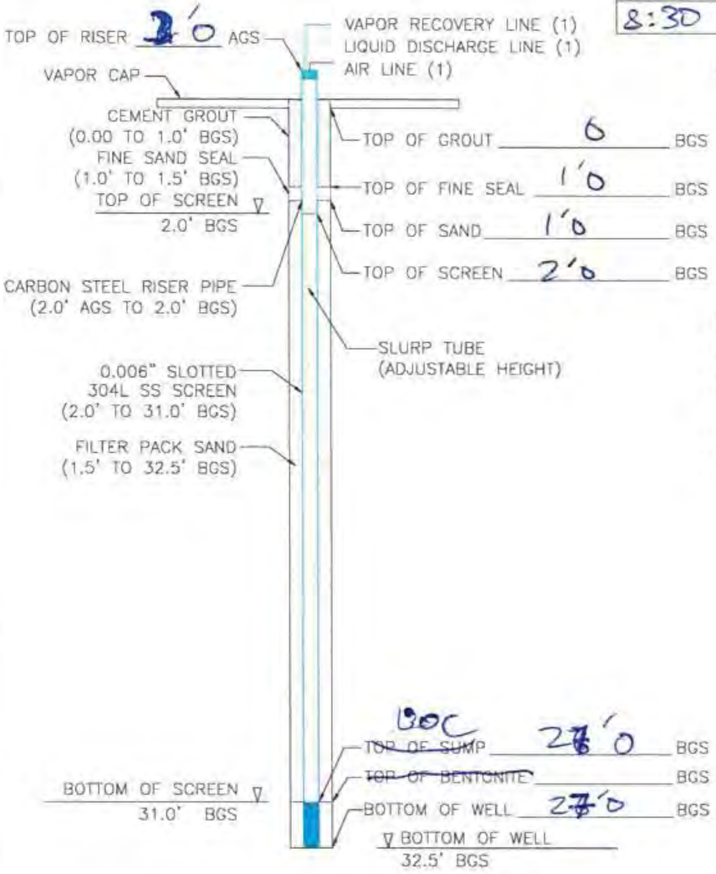
DRILLING:QA/QC

Edition REV.A1

Sheet OF 15

EXTRACTION WELL

Date	Signature	Checked
21/10/15		
Extraction Well	Extraction Well Designation	
X-C4	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
8:30	13:00	



TOP OF RISER 2'0 AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'0 BGS

BOC ~~TOP OF SUMP~~ 27'0 BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 27'0 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: 00
   QUANTITY USED: 22
3. FINE SEAL:
   MATERIAL USED: /
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 27'0
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
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INSTALLATION NOTES:

ABBREVIATIONS:

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4. ID – INNER DIAMETER
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Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

DRILLING:QA/QC

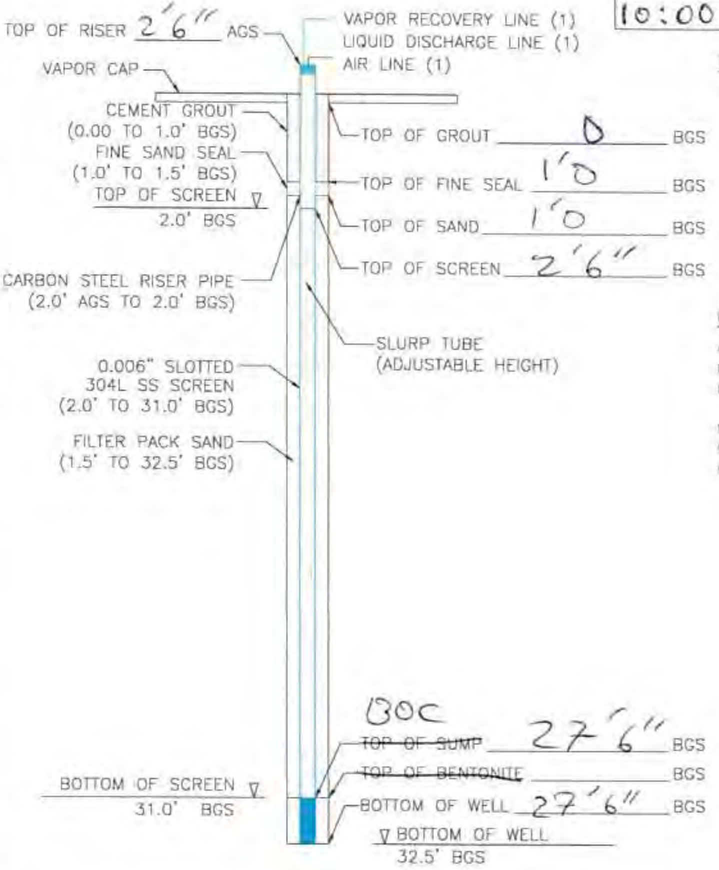
Edition	Sheet
REV.A1	OF 15

EXTRACTION WELL

Date	Signature	Checked
20/10/15	T	✓

Extraction Well	Extraction Well Designation
X-D2	MPE C/W SLURPER TUBE

Start Time	Completion Time
10:00	13:30



TOP OF RISER 2'6" AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'6" BGS

BOC

~~TOP OF SUMP~~ 27'6" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 27'6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: 06
   QUANTITY USED: 22.5
3. FINE SEAL:
   MATERIAL USED: 0
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"

BOREHOLE DEPTH: 27'6"

DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
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INSTALLATION NOTES:

ABBREVIATIONS:

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4. ID – INNER DIAMETER
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Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

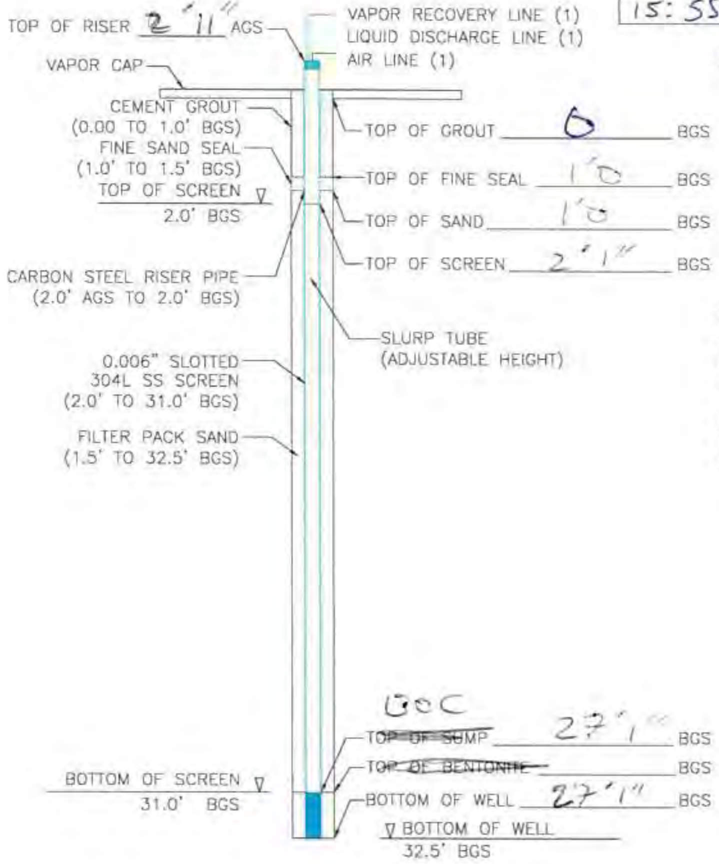
EXTRACTION WELL

DRILLING:QA/QC

Edition	Sheet
REV A1	OF 15

EXTRACTION WELL

Date	Signature	Checked
19/10/15	T	✓
Extraction Well	Extraction Well Designation	
X-D3	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
15:55	8:30 (20/10/15) → next day	



TOP OF RISER 2'11" AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'1" BGS

BOC

~~TOP OF SUMP~~ 27'1" BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 27'1" BGS

FILL MATERIAL:

1. GROUT:
   - MATERIAL USED: PI/II
   - QUANTITY USED: 1
2. SAND:
   - MATERIAL USED: OO
   - QUANTITY USED: 24
3. FINE SEAL:
   - MATERIAL USED: /
   - QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW

DRILLING METHOD: HSA

DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 10.5"

BOREHOLE DEPTH: 27'1"

DEPTH TO WATER: —

GENERAL NOTES:

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6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

Took out two 5 foot sections of Auger with X-well inside. They will finish tomorrow.

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

DRILLING:QA/QC

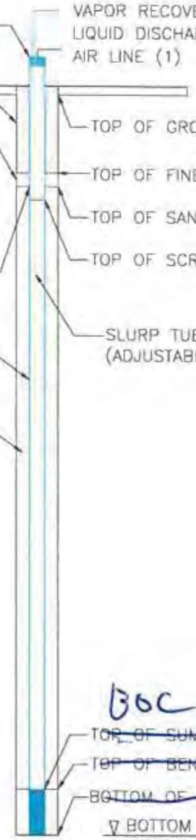
Edition REV.A1

Sheet OF 15

EXTRACTION WELL

Date	Signature	Checked
20/10/15	T	
Extraction Well	Extraction Well Designation	
X-D4	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
16:00	15:55 (21/10/15)	

Rig 1 installed.



TOP OF RISER 3'8 AGS

VAPOR CAP

VAPOR RECOVERY LINE (1)
LIQUID DISCHARGE LINE (1)
AIR LINE (1)

CEMENT GROUT (0.00 TO 1.0' BGS)

FINE SAND SEAL (1.0' TO 1.5' BGS)

TOP OF SCREEN 2.0' BGS

CARBON STEEL RISER PIPE (2.0' AGS TO 2.0' BGS)

0.006" SLOTTED 304L SS SCREEN (2.0' TO 31.0' BGS)

FILTER PACK SAND (1.5' TO 32.5' BGS)

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 2'0 BGS

SLURP TUBE (ADJUSTABLE HEIGHT)

BOC ~~TOP OF SUMP~~ 27'0 BGS

~~TOP OF BENTONITE~~ BGS

~~BOTTOM OF WELL~~ 27'0 BGS

BOTTOM OF SCREEN 31.0' BGS

BOTTOM OF WELL 32.5' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: 00
   QUANTITY USED: 24
3. FINE SEAL:
   MATERIAL USED: /
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSVT
DRILLING EQUIPMENT: DR and CME 75

BOREHOLE DIAMETER: 10.5''
BOREHOLE DEPTH: 27'0
DEPTH TO WATER: /

GENERAL NOTES:

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2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
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6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

INSTALLATION NOTES:

Stopped drilling at 16:40. Left four 5 foot auger sections in ground. Will finish tomorrow.
-8:00 AM (Rig #2) installs last two augers and leaves, Rig #1 will finish up.

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

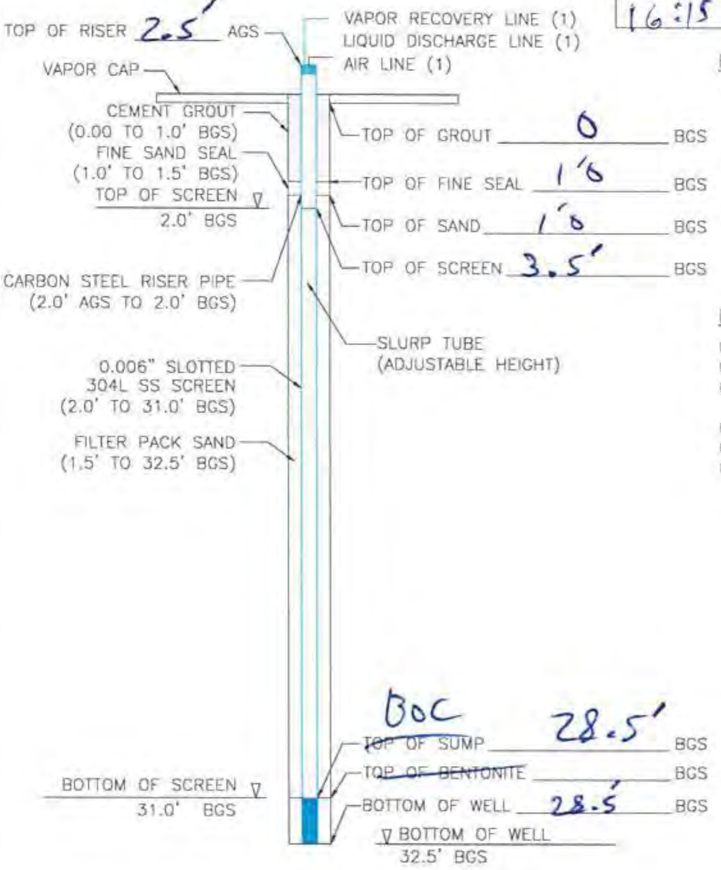
EXTRACTION WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 15

EXTRACTION WELL

Date	Signature	Checked
21/10/15	T	✓
Extraction Well	Extraction Well Designation	
X-05	MPE C/W SLURPER TUBE	
Start Time	Completion Time	
16:15	10:30 (22/10/15)	



TOP OF RISER 2.5' AGS

TOP OF GROUT 0 BGS

TOP OF FINE SEAL 1'0 BGS

TOP OF SAND 1'0 BGS

TOP OF SCREEN 3.5' BGS

BOC ~~TOP OF SUMP~~ 28.5' BGS

~~TOP OF BENTONITE~~ BGS

BOTTOM OF WELL 28.5 BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: P I/II
   QUANTITY USED: /
2. SAND:
   MATERIAL USED: 00
   QUANTITY USED: 22
3. FINE SEAL:
   MATERIAL USED: /
   QUANTITY USED: /

DRILLING DETAILS:

DRILLING CONTRACTOR: CW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 10.5"
BOREHOLE DEPTH: 28.5'
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL EXTRACTION WELL BORINGS IS MIN 8".
2. FILTER PACK SAND IS 40/60 SILICA OR EQUIVALENT.
3. FINE SAND SEAL IS 40/60 SILICA OR EQUIVALENT.
4. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II)
5. 4" O.D. 304L STAINLESS STEEL SCREEN C/W 0.006" SLOTS, CONTINUOUS KEYSTONE WIRE WRAP WITH ROUND RIB WIRE.
6. 4" NPT MALE STICKUP X WELD PLATE BOTTOM.
7. 4" O.D. CARBON STEEL RISER PIPE WITH MIN. 2'0" AGS STICKUP.
8. 1.0' SUMP TO BE INSTALLED BELOW EACH WELL SCREEN.

INSTALLATION NOTES:

Installed augers and left overnight

ABBREVIATIONS:

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2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
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Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

EXTRACTION WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 15

TEMPERATURE SENSOR WELL

Date	Signature	Checked
16/10/15	T Lutt	✓
Sensor Well	Sensor Well Designation	
T-A1	Temperature (digiTAM™) Sensor	
Start Time	Completion Time	
8:10	9:30	

TOP OF RISER 2'7" AGS

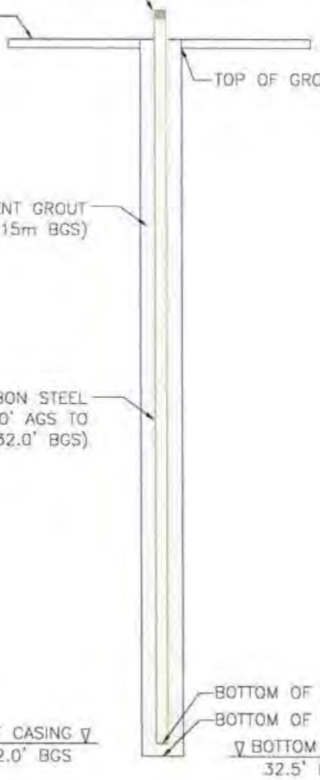
digiTAM™ SENSOR STRING (1) 0

VAPOR CAP

TOP OF GROUT Surface BGS

CEMENT GROUT (0.00 TO 8.15m BGS)

1.5" O.D. CARBON STEEL CASING (2.0' AGS TO 32.0' BGS)



BOTTOM OF CASING 27'5" BGS

BOTTOM OF BORING 27'5" BGS

BOTTOM OF CASING ∇ 32.0' BGS

∇ BOTTOM OF BORING 32.5' BGS

FILL MATERIAL:

1. GROUT:
MATERIAL USED: P I/II
QUANTITY USED: 8 bags

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: TR

BOREHOLE DIAMETER: 6"
BOREHOLE DEPTH: 27'5"
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL TEMPERATURE SENSOR WELL BORINGS IS MIN 4".
2. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).
3. 1.5" O.D. CARBON STEEL CASING WITH MIN. 2'0" AGS STICKUP.
4. 1.5" NPT MALE STICKUP X WELD PLATE BOTTOM.
5. NO WELL SCREEN.
6. ALL JOINTS TO BE TIGHTENED WITH PIPE WRENCH USING PIPE THREAD COMPOUND AND PTFE TAPE.

INSTALLATION NOTES:

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

TEMPERATURE SENSOR WELL

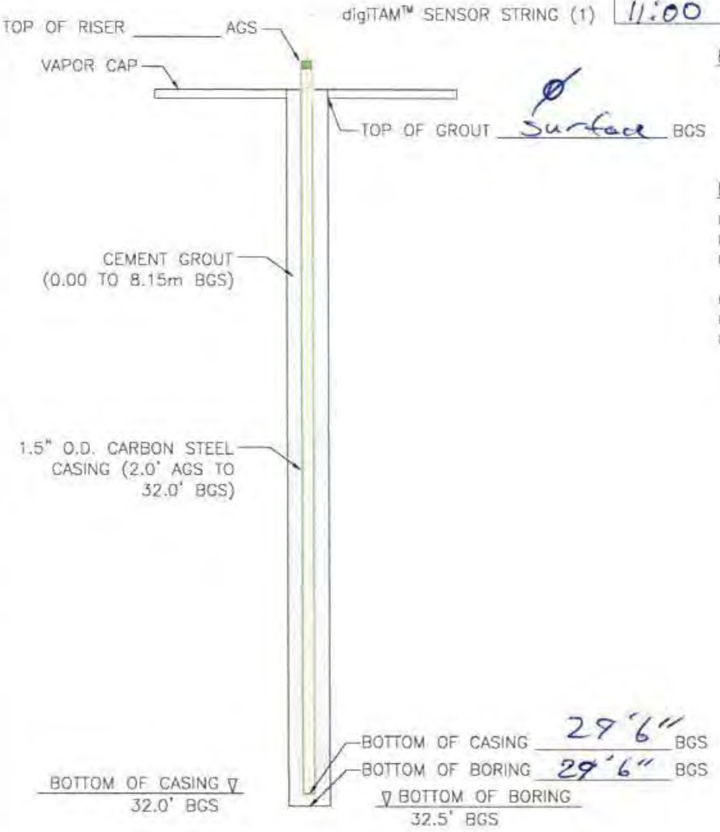
DRILLING:QA/QC

Edition REV A1

Sheet OF 7

TEMPERATURE SENSOR WELL

Date	Signature	Checked
19/10/15		✓
Sensor Well	Sensor Well Designation	
T-A3	Temperature (digiTAM™) Sensor	
Start Time	Completion Time	
11:00	14:00	



TOP OF GROUT Ø Surface BGS

BOTTOM OF CASING 29'6" BGS

BOTTOM OF BORING 29'6" BGS

FILL MATERIAL:

1. GROUT:
MATERIAL USED: P I/II
QUANTITY USED: 6 bags

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 4"
BOREHOLE DEPTH: 29'6"
DEPTH TO WATER: —

GENERAL NOTES:

1. I.D. OF ALL TEMPERATURE SENSOR WELL BORINGS IS MIN 4".
2. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).
3. 1.5" O.D. CARBON STEEL CASING WITH MIN. 2'0" AGS STICKUP.
4. 1.5" NPT MALE STICKUP X WELD PLATE BOTTOM.
5. NO WELL SCREEN.
6. ALL JOINTS TO BE TIGHTENED WITH PIPE WRENCH USING PIPE THREAD COMPOUND AND PTFE TAPE.

INSTALLATION NOTES:

No helper for driller Joe. Helper showed up at 11:30. Jaysen and I served as drilling help. Installed inside auger,

ABBREVIATIONS:

1. BGS – BELOW GROUND SURFACE
2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN–MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN–MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

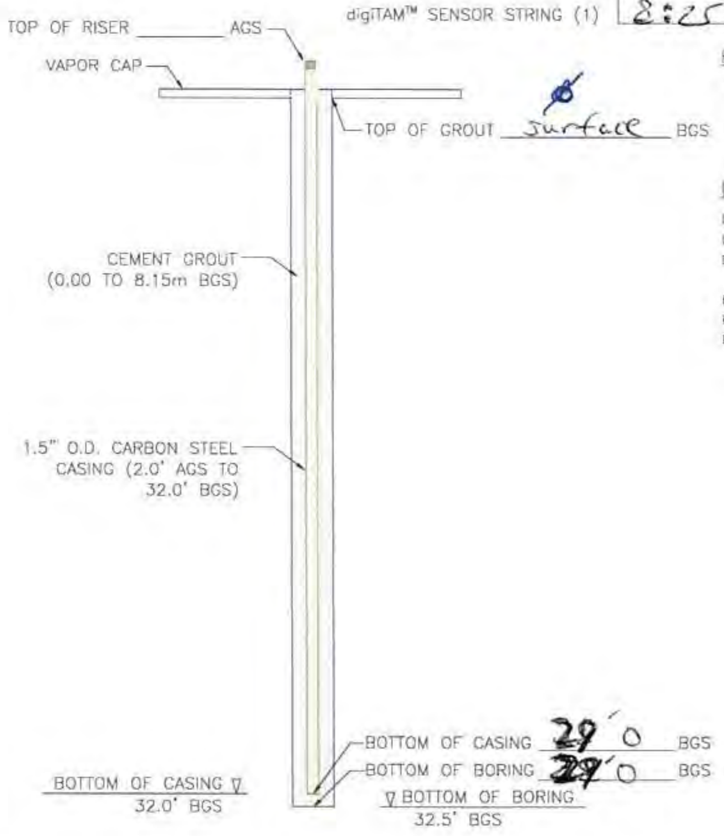
TEMPERATURE SENSOR WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 7

TEMPERATURE SENSOR WELL

Date	Signature	Checked
20/10/15	T	✓
Sensor Well	Sensor Well Designation	
T-B3	Temperature (digiTAM™) Sensor	
Start Time	Completion Time	
8:25	11:00	



0

TOP OF GROUT surface BGS

BOTTOM OF CASING 29'0 BGS

BOTTOM OF BORING 29'0 BGS

FILL MATERIAL:

1. GROUT:
MATERIAL USED: P I/II
QUANTITY USED: 6

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75

BOREHOLE DIAMETER: 4"
BOREHOLE DEPTH: 29'0
DEPTH TO WATER: /

GENERAL NOTES:

1. I.D. OF ALL TEMPERATURE SENSOR WELL BORINGS IS MIN 4".
2. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).
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4. 1.5" NPT MALE STICKUP X WELD PLATE BOTTOM.
5. NO WELL SCREEN.
6. ALL JOINTS TO BE TIGHTENED WITH PIPE WRENCH USING PIPE THREAD COMPOUND AND PTFE TAPE.

INSTALLATION NOTES:

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2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
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Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

McMILLAN-McGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

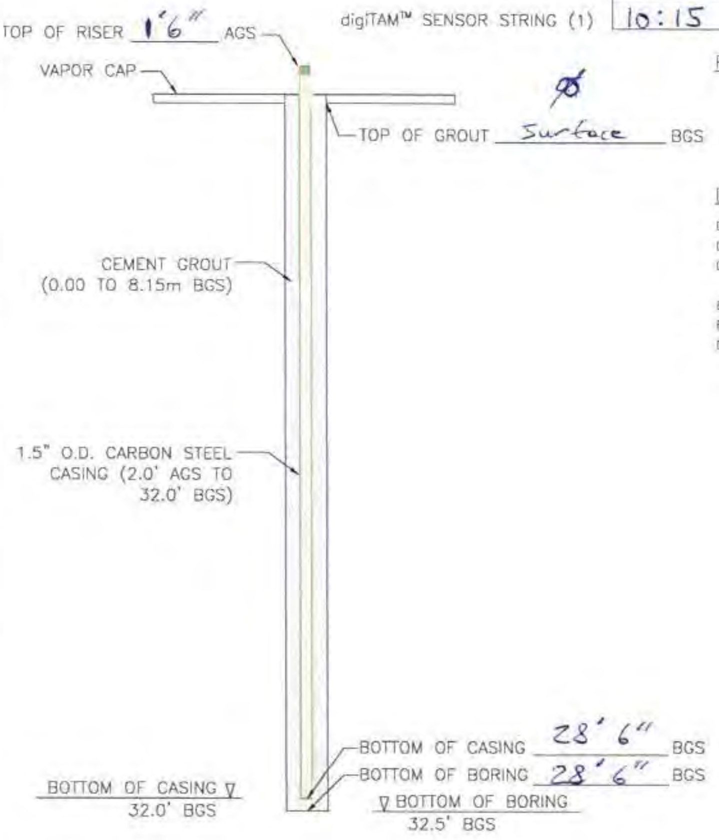
TEMPERATURE SENSOR WELL

DRILLING:QA/QC

Edition	Sheet
REV.AT	OF 7

TEMPERATURE SENSOR WELL

Date	Signature	Checked
19/10/15	T	—
Sensor Well	Sensor Well Designation	
T-C2	Temperature (digiTAM™) Sensor	
Start Time	Completion Time	
10:15	12:00	



TOP OF RISER 1'6" AGS

VAPOR CAP

digiTAM™ SENSOR STRING (1) 0

TOP OF GROUT Surface BGS

CEMENT GROUT (0.00 TO 8.15m BGS)

1.5" O.D. CARBON STEEL CASING (2.0' AGS TO 32.0' BGS)

BOTTOM OF CASING 28'6" BGS

BOTTOM OF BORING 28'6" BGS

BOTTOM OF CASING ▽ 32.0' BGS

▽ BOTTOM OF BORING 32.5' BGS

FILL MATERIAL:

1. GROUT:
MATERIAL USED: P I/II
QUANTITY USED: 8 bags

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 4"
BOREHOLE DEPTH: 28'6"
DEPTH TO WATER: —

GENERAL NOTES:

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3. 1.5" O.D. CARBON STEEL CASING WITH MIN. 2'0" AGS STICKUP.
4. 1.5" NPT MALE STICKUP X WELD PLATE BOTTOM.
5. NO WELL SCREEN.
6. ALL JOINTS TO BE TIGHTENED WITH PIPE WRENCH USING PIPE THREAD COMPOUND AND PTFE TAPE.

INSTALLATION NOTES:

All sensor wells are installed in auger except this one. This was open hole.

ABBREVIATIONS:

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2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
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Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

TEMPERATURE SENSOR WELL

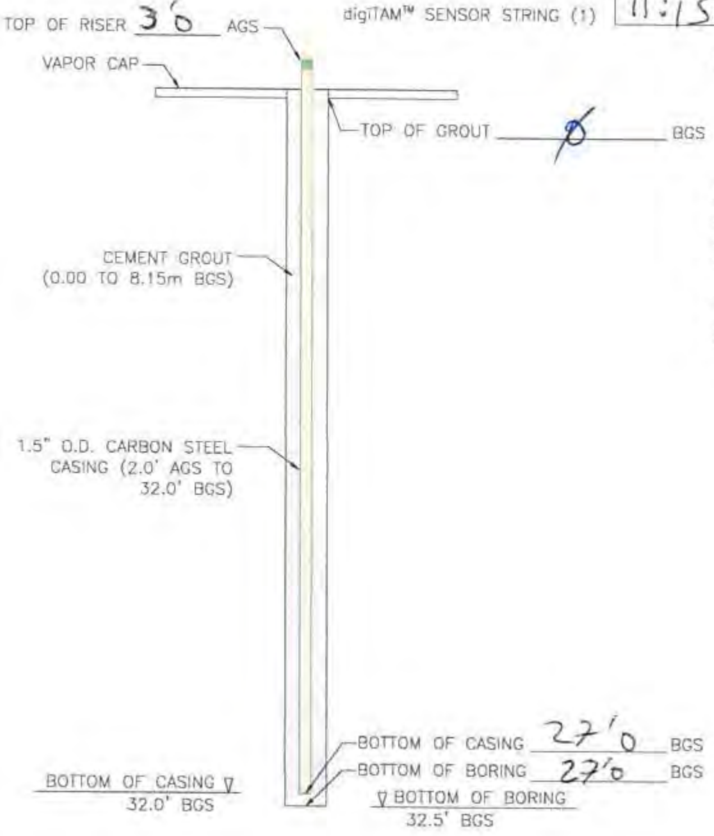
DRILLING:QA/QC

Edition REV.A1

Sheet OF 7

TEMPERATURE SENSOR WELL

Date	Signature	Checked
20/10/15		✓
Sensor Well	Sensor Well Designation	
T-C3	Temperature (digiTAM™) Sensor	
Start Time	Completion Time	
11:15	13:40	


TOP OF RISER 3'0 AGS

VAPOR CAP

digiTAM™ SENSOR STRING (1)

TOP OF GROUT Ø BGS

CEMENT GROUT (0.00 TO 8.15m BGS)

1.5" O.D. CARBON STEEL CASING (2.0' AGS TO 32.0' BGS)

BOTTOM OF CASING 27'0 BGS

BOTTOM OF BORING 27'0 BGS

BOTTOM OF CASING ▽ 32.0' BGS

▽ BOTTOM OF BORING 32.5' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: Portland type I / II
   QUANTITY USED: 6

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: CME 75
BOREHOLE DIAMETER: 4"
BOREHOLE DEPTH: 27'0
DEPTH TO WATER: /

GENERAL NOTES:

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2. GROUT IS NEAT PORTLAND CEMENT (ASTM TYPE I/II).
3. 1.5" O.D. CARBON STEEL CASING WITH MIN. 2'0" AGS STICKUP.
4. 1.5" NPT MALE STICKUP X WELD PLATE BOTTOM.
5. NO WELL SCREEN.
6. ALL JOINTS TO BE TIGHTENED WITH PIPE WRENCH USING PIPE THREAD COMPOUND AND PTFE TAPE.

INSTALLATION NOTES:

ABBREVIATIONS:

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2. AGS – ABOVE GROUND SURFACE
3. OD – OUTER DIAMETER
4. ID – INNER DIAMETER
5. NPT – NATIONAL PIPE THREAD TAPER

Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

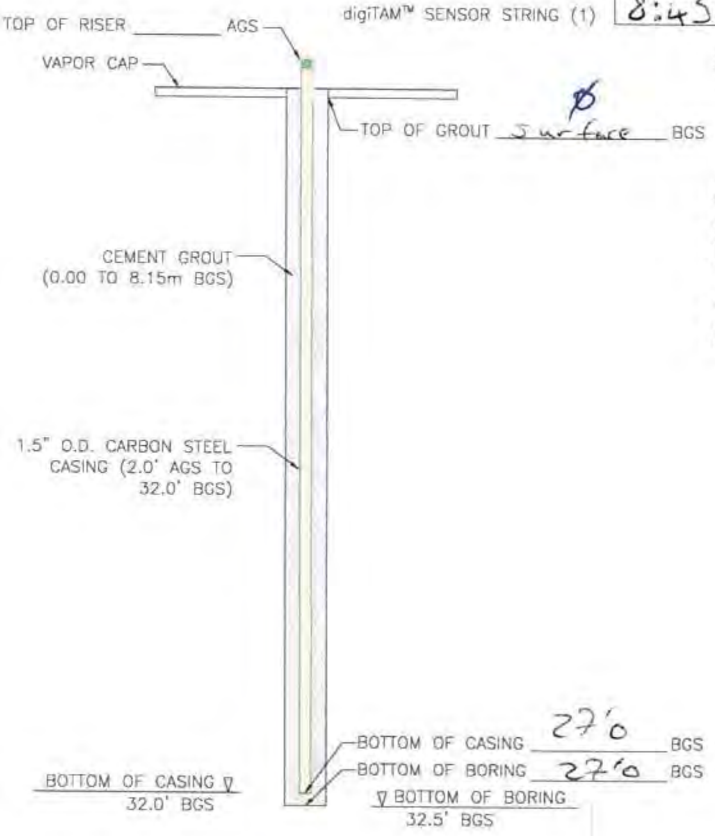
TEMPERATURE SENSOR WELL

DRILLING:QA/QC

Edition	Sheet
REV.A1	OF 1

TEMPERATURE SENSOR WELL

Date	Signature	Checked
20/10/15	T	✓
Sensor Well	Sensor Well Designation	
T-D3	Temperature (digiTAM™) Sensor	
Start Time	Completion Time	
8:45	10:30	


TOP OF RISER ________ AGS
digiTAM™ SENSOR STRING (1)
VAPOR CAP
TOP OF GROUT 0 Surface BGS
CEMENT GROUT (0.00 TO 8.15m BGS)
1.5" O.D. CARBON STEEL CASING (2.0' AGS TO 32.0' BGS)
BOTTOM OF CASING 27'0 BGS
BOTTOM OF BORING 27'0 BGS
BOTTOM OF CASING ▽ 32.0' BGS
▽ BOTTOM OF BORING 32.5' BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: PI/II
   QUANTITY USED: 8 → eight

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 4"
BOREHOLE DEPTH: 27'0
DEPTH TO WATER: /

GENERAL NOTES:

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5. NO WELL SCREEN.
6. ALL JOINTS TO BE TIGHTENED WITH PIPE WRENCH USING PIPE THREAD COMPOUND AND PTFE TAPE.

INSTALLATION NOTES:

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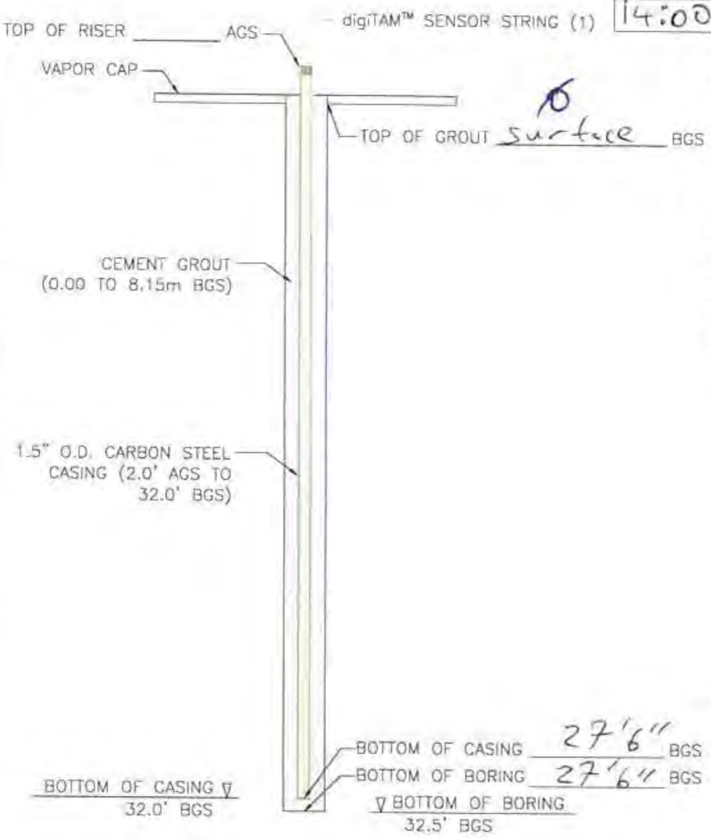
Representative		Name		Signature	
MCMILLAN-MCGEE CORP.					
ENGINEERING CONSULTANT					
DRILLING CONTRACTOR					
Designed by MCMILLAN-MCGEE	Checked by WR	Approved by DR	File name CH2/DEP	Date 09/23/2015	Scale NTS

MCMILLAN-MCGEE CORP.

TEMPERATURE SENSOR WELL	DRILLING:QA/QC		
	PROPRIETARY AND TRADE SECRET INFORMATION ANY USE OR REPRODUCTION OF THIS DOCUMENT, IN PART OR WHOLE, WITHOUT PRIOR EXPRESS WRITTEN PERMISSION IS STRICTLY PROHIBITED.	Edition REV.A1	Sheet OF 7

TEMPERATURE SENSOR WELL

Date	Signature	Checked
20/10/15	T	✓
Sensor Well	Sensor Well Designation	
T-04	Temperature (digiTAM™) Sensor	
Start Time	Completion Time	
14:00	15:30	



TOP OF RISER ________ AGS

TOP OF GROUT 0 surface BGS

BOTTOM OF CASING 27'6" BGS

BOTTOM OF BORING 27'6" BGS

FILL MATERIAL:

1. GROUT:
   MATERIAL USED: Portland type I/II
   QUANTITY USED: 6

DRILLING DETAILS:

DRILLING CONTRACTOR: PW
DRILLING METHOD: HSA
DRILLING EQUIPMENT: IR

BOREHOLE DIAMETER: 4"
BOREHOLE DEPTH: 27'6"
DEPTH TO WATER: /

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Representative	Name	Signature
MCMILLAN-MCGEE CORP.		
ENGINEERING CONSULTANT		
DRILLING CONTRACTOR		

MCMILLAN-MCGEE CORP.

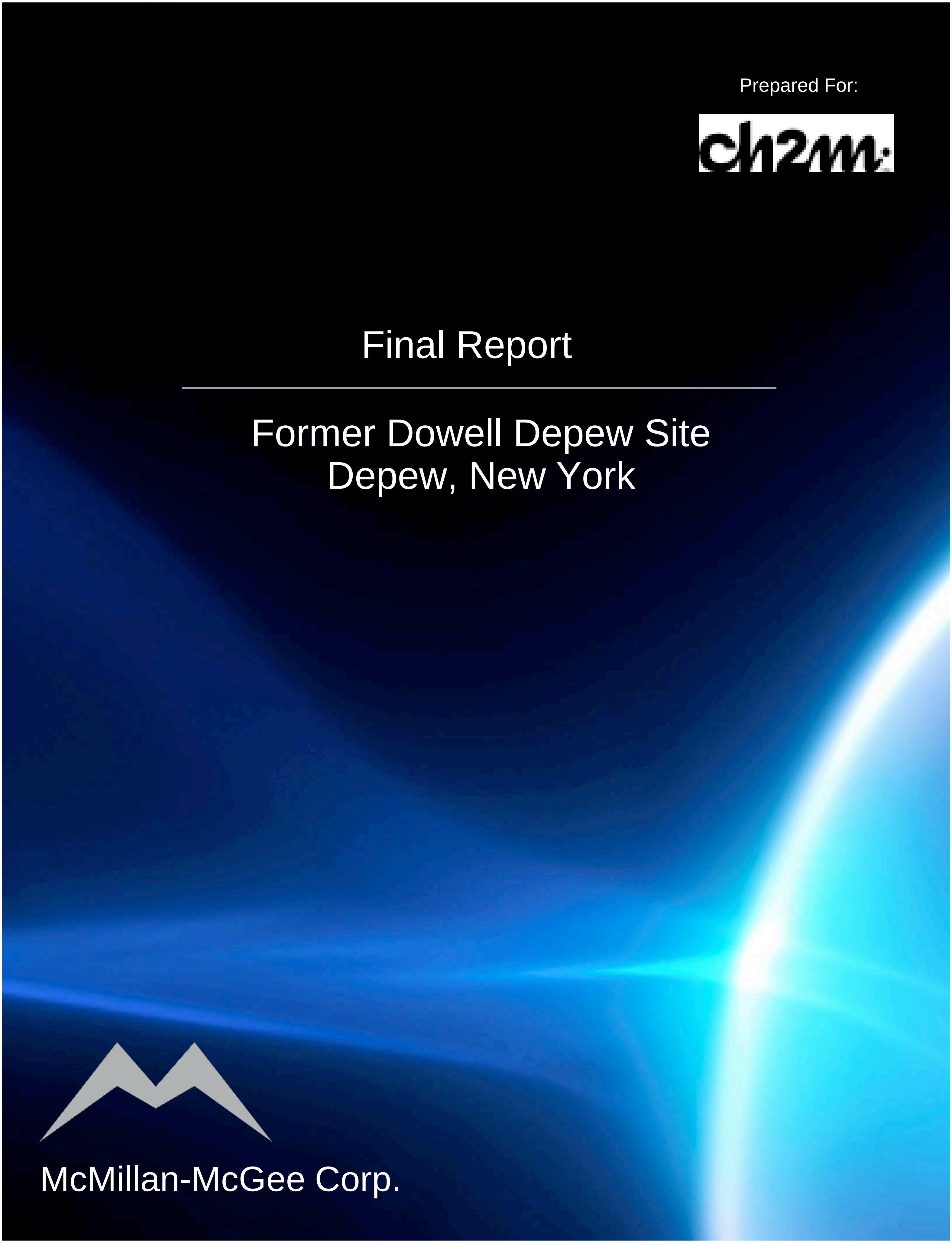
Designed by	Checked by	Approved by	File name	Date	Scale
MCMILLAN-MCGEE	WR	DR	CH2/DEP	09/23/2015	NTS

TEMPERATURE SENSOR WELL

DRILLING:QA/QC

Edition REV.A1
Sheet OF 7

Appendix F
Mc^2 Final Report



Prepared For:

ch2m:

Final Report

Former Dowell Depew Site
Depew, New York

McMillan-McGee Corp.

Final Report
Former Dowell Depew Site
Depew, New York

McMillan-McGee Corp.
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Calgary, Alberta T2B 3M9 Canada
Ph: 403.279.7948
Fx: 403.272.7201
Web: www.mcmillan-mcgee.com
McMillan-McGee Corp. Point of Contact
Mr. Brent Winder, BA, B.S.Sc., MBA
Ph: 403.569.5103
Email: brent.winder@mcmillan-mcgee.com

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February 3, 2017

Electromagnetic Systems & Services for the Energy & Environmental Industries

Certification

This document, *Final Report for the Former Dowell Depew Facility,* has been prepared under the supervision and control of the undersigned Alberta licensed Professional Engineer. The work and professional opinions rendered in this report were conducted or developed in accordance with commonly accepted protocols and procedures. If conditions are discovered that differ from those described, the undersigned engineer should be notified to evaluate the effects of any additional information on the assessment and recommendations in this document. This document was prepared to provide information for the Former Dowell Depew Facility project in Depew, New York, and should not be construed to apply to any other site.

Note that Alberta engineering regulations require this final document to be sealed by an Alberta-registered professional engineer, since the report preparation was performed in Alberta, even though the project site is located in New York. This in no way is intended to infringe upon engineering laws and regulations of the State of New York, or any other jurisdiction. Please be aware that this document may require further engineering review and certification in accordance with the laws and regulations of the State of New York.

Prepared by Nick Dumaresq

Reviewed and approved by:

David A. Rountree, P. Eng.

Association of Professional Engineers and Geoscientists of Alberta member 170197

Through the engineering business of McMillan-McGee Corporation, APEGA Permit to Practice P09178

Executive Summary

Overview

CH2M and McMillan-McGee Corporation (Mc^2) have successfully completed thermal remediation of the former Dowell facility using the Electro-Thermal Dynamic Stripping Process (ET-DSP™) combined with soil vapor and liquid extraction. The objectives for this project were to design, construct, and operate a thermal remediation system using ET-DSP™ technology to reduce volatile organic compound (VOC) concentrations in groundwater to below applicable regulatory criteria and remove VOC mass within the source zone.

Under the direction of CH2M, Mc^2 subcontracted drilling and civil construction firms to carry out the installation of subsurface infrastructure, vapor cap, and conveyance piping to conduct in-situ thermal treatment (ISTT) using ET-DSP™. Mc^2 subcontracted MK Environmental (MK) to provide the multiphase treatment system.

Site Description

The treatment volume delineated for ET-DSP™ application had an approximate areal extent of 3,636 square feet (ft^2) and extended from 0 to 30 feet (ft) below ground surface (BGS), for a total estimated treatment volume of 4,040 cubic yards (yd^3). Three distinct unconsolidated stratigraphic units have been identified on the site as a poorly sorted silt sand, fine to coarse gravel fill and cinders unit from ground surface to 4 ft BGS, followed by clayey silt unit with a trace of fine gravel, which extends from the bottom of the upper fill unit to 10 ft BGS, followed by a silty clay unit. The groundwater was encountered at depths ranging from 1-3 ft BGS.

Technology

ET-DSP™ is an electro-thermal process used to heat the subsurface that combines electrical resistive heating with heat transfer by convection and conduction for rapid and uniform heat transfer. The three main components of the ET-DSP™ system are the electrodes, power delivery systems (PDSs), and water circulation systems (WCSs).

The ET-DSP™ system at the Site consisted of 22 electrode well locations each with 2 electrodes, 2 PDS units, 2 WCS units, and 7 Digital Temperature Acquisition Module (digiTAM™) sensor elements, with an aggregate total of 70 individual sensors vertically spaced at 3 ft intervals. The digiTAMs™ were used to monitor subsurface temperatures.

The electrodes were spaced 18.5 ft apart on centers in a triangular pattern. Electrodes were double-stacked with 10 ft long and 8-inch (in) diameter electrodes.

Operations

The key project milestones and dates are shown below. Table 1: Key Project Milestones and Dates

Activity	Start	End
Drilling & Construction	Sept. 11, 2015	Dec.10, 2015
Acceptance testing	Dec. 11, 2015	Dec. 17, 2015
Heating Operations	Feb 22, 2016	Aug 16, 2016
Extended Operations	August 19, 2016	October 19, 2016
Demobilization	October 20th, 2016	December 5, 2016

ET-DSP™ operations lasted 176 days. Heating ceased on August 16, 2016 to verify that target soil concentrations had been met. However, the detection of vinyl chloride concentrations above treatment goals resulted in the operation of the system for another 61 days.

Approximately 1,208,516 gallons (gal) of water were injected into the electrodes during the heating operations at an average injection rate of 3.54 gallons per minute (gpm) and the total amount of energy used was 1,497.2 Megawatt-hours (MWh). According to calculations based on analytical data obtained from the treatment processes, the total contaminant mass (exclusive of acetone) removed was 7.1 pounds (lbs).

TABLE OF CONTENTS

List of Tables

1. Introduction

1.1.Project Scope

Under contract with CH2M, Mc^2 provided, installed, and operated an ET-DSP™ system at the Former Dowell Facility in Depew, New York. Detailed site and background information can be found in the 100% Remedial Design Report (RDR) (McMillan-McGee Corp, 2016).

1.2.Site background

The Former Dowell Facility is located at 3311 Walden Avenue in the Village of Depew, New York, United States of America. The facility resides within a mixed residential and industrial/commercial area. The entire site is zoned industrial/commercial. Surrounding uses include a railroad line to the south, a manufacturing facility to the west, and a commercial lumberyard to the east. The closest residential structures are to the north across Walden Avenue. The property has previously included buildings such as office space, storage, and equipment repair garages that supported operations relating to the development and maintenance of natural gas and oil wells. Various industrial cleaning and oil-field chemicals were stored on-site and transferred into tank trucks for use at job sites (New York State Department of Environmental Conservation (NYSDEC), 2016).

Current VOCs detected in ground water at the site are likely a result of historical activities, which included servicing industrial facilities and limited oilfield-related projects. Dowell discontinued facility operations in the late 1980s and the facility was permanently closed.

1.3.Geology and Hydrogeology

Three distinct unconsolidated stratigraphic units have been identified in the test boring log (URS Corporation (URS), 2011) with supporting data provided by CH2M (2015): (i) the higher permeability and poorly sorted silt sand, fine to coarse gravel fill and cinders unit, which extends from ground surface to 4 ft BGS, (ii) the clayey silt unit with a trace of fine gravel, which extends from the bottom of the upper fill unit to 10 ft BGS, and (iii) the silty clay unit, with 5% fine to coarse sand, which extends from 10 to 20.5 ft BGS, where the test boring log ended. Clay content increases with depth beginning at 4 ft BGS. Between 4 ft and 30 ft BGS, the layer has been described as glacial till. The Marcellus Shale and/or Skaneateles Shale were anticipated to be encountered at 30 ft BGS, but the drilling program (October 5 – October 20, 2015) encountered these bedrock shales at depths as shallow as 26.5 ft BGS.

Undisturbed geotechnical samples were collected from 15-17 ft BGS and 22-24 ft BGS and analyzed for hydraulic properties; conductivity was reported as 2.44×10^{-6} and 1.15×10^{-8} inches per second, and porosity as 0.38 and 0.22, respectively for these two intervals (CH2M, 2015). Hydraulic gradients for these zones was reported as 0.057 ft/ft, and 0.4 ft/ft, respectively.

The depth to the groundwater was reported as 3 ft BGS based on previous investigations (CH2M, 2015); however, during the drilling program groundwater was encountered at depths ranging from 1-3 ft BGS.

1.4.Nature & Extent of Contamination

The treatment volume has an approximate areal extent of 3,636 ft^2 and extends vertically from 0 to approximately 30 ft BGS, for a total estimated treatment volume of 4,040 yd^3. The area of thermal influence for the electrode network was approximately 4,997 ft^2 and extends from 0 to 30 ft BGS, for a total estimated heated volume of about 5,552 yd^3. The preliminary estimate of the contaminant mass was 100 lbs. Please refer to the **Scope of Work Table** in **Appendix A** for a historic characterization of the COC concentrations observed at the site.

2. Project Description

2.1. Supplemental Information

While this report provides a brief description of the operational results achieved, the data contained herein is supplemented by the following site specific reports submitted separately:

1. Remedial Design Report (RDR)
2. Resistivity Report
3. Simulation Report

Please refer to these additional reports for a complete list of design parameters, design drawings, and calculations. These reports provide a complete description of ET-DSP™ technology and site specific information.

2.2.Remedial Objectives

The remedial objectives at the site were to reduce COC concentrations in groundwater to the levels specified by CH2M. Please refer to the **Scope of Work Table** in **Appendix A** for a list of remedial objectives at the site. The secondary remedial objectives at the site were to:

1. Prevent the mobilization of COCs to areas outside of the limits that define the treatment volume;
2. Maintain hydraulic and pneumatic control throughout thermal remediation;
3. Achieve the design target temperature of approximately 212°F; and,

Treat and dispose of vapors, groundwater, and COCs that are recovered by the extraction system

Further details and additional remedial objectives can be found in the RDR.

2.3.Roles & Responsibilities

The thermal remediation team consisted of CH2M, Mc², and MK Environmental. The role and contact information of each team member is outlined in **Table 2.**

Table 2: Project Organization

Organization	Role	Contact Name(s)	Contact Information
CH2M	Engineering consultant; oversight and verification	Jason Burkard	Jayson.burkard@ch2m.com +1 (314) 335-3046
McMillan-McGee Corp. (Mc²)	ET-DSP™ contractor; in-situ thermal treatment	David Rountree	drountree@mcmillan-mcgee.com +1 (403) 569-5116
		Wayne Robella	wrobella@mcmillan-mcgee.com +1 (403) 569-5106
		Nicholas Dumaresq	ndumaresq@mcmillan-mcgee.com +1 (403) 569-5113
MK Environmental	Soil vapor and groundwater treatment	Ed Tung	etung@mkenv.com +1 (630) 848-0585

All parties attended project meetings throughout the design, construction, operation, demobilization, and final reporting phases of work. During the operations phase, weekly conference calls were held to review progress, evaluate data and monitoring, and make joint operational decisions.

2.4. Technology Description

ET-DSP™ is an electro-thermal process designed to overcome limitations in energy transfer, achieve rapid energy input, and ensure uniform heating. Refer to the RDR and the simulation (each submitted under a separate cover) for more information of how the ET-DSP™ technology was engineered to meet remedial goals at the Depew site.

2.5. ET-DSP™ Equipment

There are three main components of the ET-DSP™ system: the power delivery systems (PDS), the electrodes, and the water circulation systems (WCS).

A 664 kilovolt-ampere (kVA) power drop was provided, feeding two 24 electrode PDS/WCS units, which controlled 44 electrodes and the main treatment system.

The PDS units were rated at 660-kVA each. They were equipped with time-distributed control capabilities and were Internet controlled. **Figure 1** in **Appendix B** depicts the PDS units used at this site.

The electrodes were designed to conduct high current through the targeted volume of soil. A small volume of water was injected through each electrode to maintain electrical conductivity of the soil, achieve convective heat transfer, and enhance the displacement of the chemicals towards the extraction wells. A water return line was installed in the top electrode of each borehole to prevent the subsurface pressure from exceeding the local fracture pressure.

Electrodes were fabricated with high temperature and chemically resistive materials and connected to a PDS with appropriately sized electrical cables. Each electrode was also connected to a WCS unit with a high temperature and pressure rated hose. To ensure that the system was operating within the design parameters, each electrode was equipped with an automated monitoring device, water and current control mechanisms, and preset breakers to prevent the electrodes from exceeding the designed amperage. The electrode return water was plumbed into the liquid conveyance piping and returned to the main surface treatment system. A typical shallow electrode is shown in **Figure 2** in **Appendix B**.

For this project, two WCS units were used to deliver water to the electrodes. **Figure 1** in **Appendix B** shows the WCS units used at this site.

2.6.ET-DSP™ Design

Resistivity testing indicated that the soil's resistivity ranged from 16.4 to 82.0 ohm meters (Ω·m). This was factored into the design along with all other pertinent site data during modeling and numerical simulation of the subsurface. Please refer to the Simulation Report and resistivity Report for more detail.

The key ET-DSP™ design elements for this site were as follows:

1. 22 electrode locations with double-stacked electrodes, for a total of 44 electrodes.
2. 15 vertical multiphase extraction (MPE) wells and four horizontal MPE wells.
3. Seven digiTAM™ (digital temperature acquisition module) temperature sensor strings with 70 sensors on 3 ft intervals.

2.7.Electrode Layout

The ET-DSP™ electrodes were placed vertically throughout the treatment area based on the concentration data provided by CH2M and placed horizontally according to resistivity data acquired from the Mc^2 electro-thermal laboratory. Please refer to the Wellfield Layout (**WFL-01** in **Appendix C**) for a plan view representation of the electrode layout

The electrodes were placed on 18.5-ft centers in a triangular pattern. This spacing provided optimal heating, reducing the cost and number of electrodes required, while minimizing the formation of cold spots. The electrodes were double-stacked with 10 ft long by 8 in diameter electrodes. The drilling crew encountered bedrock at shallower than anticipated locations, and as a result, shorter electrodes were used to preserve the space between shallow and deep electrodes. Please refer to the electrode and extraction well design and installation details provided in **Appendix D** for a complete list of wells completed at shallower than anticipated depths.

2.8. Temperature Sensors

There were 7 vertical sensor strings, each with 10 digiTAM^{TM} sensors for a total of 70 modules on site. These sensors were used to monitor temperatures during heating operations.

2.9. Injection System

There were two WCS units used to inject water to the electrodes at the site. Each WCS included a pump to increase the water supply's pressure when required. Water injection to the electrodes was controlled using a series of solenoid valve manifolds equipped with flow meters to monitor the volume of water injected to the electrodes. An internet-controlled solenoid valve was set to deliver water at the design rate of 0.1 gallons per minute (gpm) average to each electrode. Water injection rates varied considerably, due to the difference in conductivity between the saturated and non-saturated zones. At the initial startup, potable municipal water was used for testing. Re-circulated treatment water was used for injection for the remainder of operations. Biofouling resulted in incorrect readings from the totalizers, and the addition of a biocide was initiated on June 25th. Please refer to **Sections 2.10.2** and **3.10** for discussions on the extraction totalizer readings and water balance, respectively.

2.10. Extraction System

The extraction system included 15 vertical MPE wells and four horizontal SVE wells. Liquids were extracted from the MPE wells using compressed air assisted vacuum-lift groundwater recovery (i.e. slurper) tube assemblies. The extraction wells were equipped with a 0.5-ft sump (unless the drill rig encountered bedrock at shallower than anticipated depths) to decrease the frequency of silt removal. The MPE wells were connected to a vacuum blower, which was used as the driving force for the extraction and transport to the treatment system. The horizontal SVE wells were installed in trenches at depths between 1-2 ft BGS and extended east to west, parallel to the conveyance piping. Horizontal extraction lines were constructed of fiberglass to mitigate any stray voltage potentials.

2.10.1. Well Field Conveyance

The well field consisted of two mains of lateral piping that ran from west to east and connected immediately before the treatment equipment. Vapor was conveyed through multiphase, carbon steel pipe to the treatment system. Liquid extraction from the slurper tube assemblies was conveyed in the same multiphase line. A photograph of the extraction wellhead and piping at this site is provided in **Figure 3** in **Appendix B**.

2.10.2. Extracted Fluids and Treatment System

Extracted liquid and the condensed vapors from the knock-out tanks KO-90 and KO-103 were pumped through the phase separator (T-200) to remove any entrained DNAPL. After biological growth was determined to be the cause of the system fouling, an in-line glutaraldehyde (GTA) injection system was added to kill and help remove existing biomass, and inhibit future growth. The effluent from T-200 was pumped to the low profile air stripper (AS-204) to remove dissolved contaminants. Effluent liquid was pumped to a 21,000-gal holding tank. Before the process water was re-injected to the electrodes or discharged to the sewer, it was pumped from the holding tank through the triple bag filter (BF-209) to remove suspended solids, and sent through a series of two 1000-lbs liquid carbon vessels (LGAC-220A and LGAC-220B). An untreated holding tank (T-206) was installed upstream of the carbon vessels to enhance sediment settling before the water was returned to the formation or discharged to the sanitary sewer system.

2.10.3. Extracted Vapors and Treatment System

Extracted vapors first entered knock-out tank KO-90 where NAPL, water, and solid fines carried from the well field were removed from the vapor stream. Next, the vapors passed through an air cooled, fan operated heat exchanger (HE-101) followed by a water and glycol cooled shell and tube heat exchanger (HE-102), to reduce the temperature. The cooled condensate was removed from the vapor stream in a second knockout tank (KO-103). Prior to entering a series of two 750-lbs vapor carbon vessels (VGAC-150 and VGAC-151), the vapors were cooled in HE-120 to a temperature suitable (approximately 70-100° F) for optimal carbon absorption. A third sacrificial vapor carbon vessel was kept onsite as contingency, but this was not used. These treated vapors were then discharged to atmosphere. Effluent vapors, pushed from blower B-108 through the air stripper, were vented directly to atmosphere. Cooling was achieved through a closed loop, fan chilled, refrigerated glycol unit.

3. Operations and Results

3.1. Operation Phase & Timeline

The general timeline for the project schedule and implementation phases were summarized in **Table 1.**

3.2. Acceptance Testing and System Initiation

3.2.1. Initial Startup

During acceptance testing the ET-DSP™ system was tested to ensure that it was functioning properly. Acceptance testing involved making sure all Emergency Shutdown Devices (ESD) were functional, onsite/offsite server controller/safeties were communicating properly, measuring the resistive load between electrodes to make sure they were within design parameters, balancing the phase currents in the system, and checking that the induced surface potentials did not exceed 15 volts. An ESD was located on all PDS units and the PDP.

Individual electrodes were triggered by the server both on the PDS and WCS site to confirm communication and correct installation of the system. Current, voltage, and flow totalizers were subject to a rigorous set of quality assurance and quality control (QA/QC) tests for accuracy and reporting capabilities during this process. The QA/QC test procedure was performed with calibrated equipment as these components were used throughout the project for optimizing system performance. Calibration of the system confirms that all data was being recorded and controlled by the onsite server.

The initial start-up (commissioning) of the ET-DSP™ system involved activating the various components and ensuring the components would operate safely and within the design parameters. Once the hydraulic and pneumatic control of the treatment area was established the initial startup of the ET-DSP™ system began. Initial optimization was established and continued to occur throughout operations.

Before performing any tasks, personnel were required to familiarize themselves with the appropriate safety protocols, procedures, personal protective equipment (PPE) and task-specific activity hazard analysis (AHA) or JSAs. JSAs and start up procedure details can be found in the Operations and Maintenance and Demobilization Plan.

3.2.2. Electrical Safety & Grounding

The electrical system design was engineered with personnel safety as the paramount concern. As per NEC and IEEE guidelines, the limit of 15 volts for step and touch potentials was never exceeded anywhere throughout the treatment area. This was due to a properly engineered ET-DSP™ grounding system that worked in conjunction with the utility ground.

3.3. ET-DSP^{TM} System Optimization

During the ET-DSP^{TM} start up, Mc^2 representatives remotely monitored the heating phase and performed all operational tasks. The on-site operator was available on a regular basis to make system adjustments as requested by Mc^2 along with routine maintenance. Once the system was energized, optimizing adjustments included:

1. Monitoring power levels of the electrodes and adjusting voltage tap settings on the PDS transformers;
2. Obtaining a hydraulic balance within the subsurface;
3. Ensuring no leaks within the treatment system;
4. Performing step and touch potential tests and isolating necessary pieces of equipment;
5. Monitoring all field readings taken by the operator to ensure the extraction system was operating appropriately;
6. Adjusting blower speed in conjunction with extraction well head ball valves to maintain target vapor recovery rates;
7. Ensuring slurper tube assemblies were producing groundwater.

3.4. Operational Summary

Table 3 summarizes the technical approach of the ET-DSP™ system at the Site, with predicted and actual values displayed. The system was de-activated during sampling events, repairs, adjustments, and maintenance of the extraction and treatment system, as well as during operational adjustments for the ET-DSP^{TM} system. A complete set of tabulated operational monitoring parameters, including power and water use, mass removed, and temperatures recorded can be found in electronic format, submitted with this report.

1. The electrode down time during operations was approximately 3.75 days or 2%. The total unplanned shutdown time was 0.36 days.
2. The total amount of energy used to heat the subsurface was 1,426 MWh, amounting to an approximate energy density of 346 kWh/yd^3. This is more than the design power consumption 1,281-MW-Hr. Refer to **section 3.7** for further detail on energy usage.
3. The amount of water injected into the electrodes during the design heating operations was approximately 1,083,527 gal, approximately 85,000 gallons less than predicted. This is equal to a total average injection rate of approximately 3.9 gpm. Extended operations resulted in an additional 125,020 gal. being injected.

   Refer to **Section 3.10** for further detail on water balance.

Table 3: Design and Operational Parameters

Site Characteristics		
Item	**Value**	**Comment**
Treatment Area [ft^2]	3,636	Approximate; scaled from a figure provided
Heated Volume [yd^3]	5,552	Thermal influence x depth interval
Deep Extent of Treatment [ft BGS]	30	Except where refusal was encountered
Shallow Extent of Treatment [ft BGS]	0	Treatment assumed close to surface
Design Depth to Groundwater expected [ft BGS]	3.0	As per RFP
Actual Depth to Groundwater [ft BGS]	1.0-3.0	As per field reports
Contaminants of Concern	VOCs	Primarily 1,1-DCA, chloroethane, 1,1,1-TCA; refer to **Table 1** for detailed concentration information
Design Mass Estimate [lbs.]	100	Preliminary mass estimate
Actual Mass Extracted [lbs]	65.9	Based on PID readings and flow rates
Remedial Goals [µg/L]	Variable	Refer to **Appendix A** for COCs and performance goals
Soil Resistivity (ohm·m)	16.4-82.0	As per Mc^2's Resistivity Report
Remedial Approach		
ET-DSP™ Electrode Locations	22	8” OD, 2/boring, ET-DSP™ HT design, 10’ long, (unless this length was restricted by encountered shale)
Power Delivery Systems [kVA]	2 x 1,330	Web power control, 480V primary, multi-tap sec.
digiTAM™ Temp. Sensors	70	7 strings, 10 temperature sensors at 3’ intervals
Electrode Spacing [ft]	18.5	Based on expected resistivity, electrode layout, and performance goals
Bottom of Electrodes [ft BGS]	26.5-31	As per drilling reports
Top of Electrode [ft. BGS]	~4	Conductive heat transfer above
Design Target Temperature [°C]	100	Avg. in treatment zone, steam stripping of COCs
Actual Achieved Temperature [°C]	101.2	Maximum daily average achieved
Vapor/Liquid Extraction Wells	15+4	4” SS304 cont. wire wrap well screen, 0.006” slot size, C/W slurper tubes, four horizontal wells set at approximately 1-3 foot BGS
Design Extraction Rate [scfm]	139	9.28 SCFM per electrode
Actual Vapor Recovery Air Flow [scfm]	64.94	Shallow water able affected vapor recovery
Vapor Treatment Method	VGAC	Dependent on mass & abatement requirements
Liquid Treatment Method	AS/LGAC	Air stripper, granular activated carbon
Vapor Cap [ft^2]	5,472	Cellular concrete type, approximately R6
Summary Information		
Design Power Input [MW·Hr]	~1,281	Cumulative estimate based on 315 kWHr/yd^3
Actual Power Input [MW·Hr]	1,427	Reported from the ET-DSP^{TM} project page
Design Electrical Power Input [kW]	~297	Avg. for project duration ~ 6.74 kW per electrode
Actual Electrical Power Input [kW]	248	Avg. for project duration, includes extended operations with reduced foot print
Water Demand [GPM]	0	~0.1 GPM/electrode, Re-circulation design
Design Time to Target Temp [days]	~60	Approximately
Actual Time to Target Temp. [days]	79	Based on achieving design temp on May 12th
Design Est. Project Duration [days]	180	Base case for expected conditions
Actual Project Duration [days]	237	Affected by the presence of Vinyl Chloride

Unfortunately, the numbers provided were read from totalizers that were severely impacted by biofouling for periods of time. Based on previous experience with similar equipment, Mc^2 expects that a deviation of up to 10% from the true value can result from biofouling.

4. Power to electrodes in rows C, D & E was suspended on August 30th at 12:22. The remaining 2 rows (A & B) were targeted with high power to achieve operational temperatures. Power to electrodes in rows A & B was suspended on October 19th .

5. Extraction from wells in rows B, C, & D was suspended on August 30th at 12:22. Extraction from the remaining row A was suspended on October 19th.

6. Total contaminant mass removed based on the vapor stream was 65.94 lbs (including acetone). Please see **Figures 4** and **5** in **Appendix B** for a graphical representation of the mass recovered from vapor and liquid phases during operations. Chemical specific removals were not calculated.

3.5.Subsurface Monitoring

The following section describes some additional data management and display features Mc^2 used during the remediation. Mc^2 employed a web-based control and data acquisition system. This system allowed authorized users to access critical operational information in real-time from any computer with access to the Internet via a secure web page.

3.5.1. Temperature Monitoring and Data Collection

The 70 individual sensors transmitted directly to the secure project web page where data were available in real-time in order to determine how the zone was heating.

The target average temperature, 100°C (212°F), was achieved on May 12th, 2016 at most sensors, and the heating of the site responded closely to the prediction of the numerical simulation (design) during the start of operations based on the simulated heating curve (**Figure 6** in **Appendix B**). Biofouling and the associated diminished hydraulic control at each electrode resulted in a gradual thermal decrease after July 15th. High power per electrode (approx. 8.4 kW each) was delivered to the zone throughout the first 90 days, compared to the simulated average of 6.74, and this resulted in a slightly better temperature response than predicted. Temperatures remained above 96°C (205°F) from April 19th to September 11th, long after the majority of the electrodes had been shut off. **Figure 7** in **Appendix B** shows average temperatures at the Site by depth.

In June, heating was hindered by the inability to properly control the water delivery to the zone (caused by biofouling). The injection rates were manually controlled, injection solenoids were cleaned using a biocide solution, and totalizers were disassembled for cleaning, permitting greater water delivery and site thermal control on a regular basis. Dynamic permeability across the northeast corner of the site resulted in greater recharge, leading to higher extraction rates of water and thermal energy (granular backfill material had been placed in this area during previous remediation efforts). Power was focused aggressively in the recalcitrant regions in the periods of extended operations. Possible reasons for subsurface temperature lags include:

1. Increased resistivity due to steam formation;
2. Desiccation of electrode wells, resulting in increased electrical resistance (possibly caused by lack of water injection control due to WCS fouling);
3. Possible preferential groundwater flow through permeable zones (previously excavated) on the periphery of the treatment volume, allowing unheated groundwater into the heated volume.

3.6. Treatment System and Monitoring

Photo Ionization Detector (PID) readings were taken to provide influent vapor concentration results immediately upstream of the carbon vessels. Laboratory data correlating weekly PID field readings to vapor concentrations were used to calculate the cumulative mass removed from the vapor stream. Laboratory results for liquid collected (at T-200) were used to calculate mass removed from liquid phase. The results were summed to present the total mass removed. Please see **Figure 8** in **Appendix B** for PID readings charted over time.

3.6.1. Solids

Solids were removed from the phase separators, air strippers, bag filters, and holding tanks throughout the project as part of routine maintenance and were containerized for disposal. This cleaning was predominantly required due to the accumulation of biomass.

3.7. Electrical Energy & Power Summary

Energy input is a function of soil resistivity, the spacing of electrodes, the effectiveness of the convective heat transfer (steam injection from the electrodes) and the rates of extraction. Soil Resistivity as a function of depth is provided in **Figure 9** in **Appendix B.**

A total of 1,426 MWh of energy were directed into the subsurface over the course of operations (237 days). The actual power usage versus the predicted power use is shown in **Figure 10** in **Appendix B**. **Figure 11** in **Appendix B** shows the average power usage of shallow and deep electrodes over time.

3.8. Mass Removal

The mass estimate of 100-lbs was estimated based on client-provided data. The mass removed was calculated based on the vapor and liquid streams.

Acetone, a common by-product of ISTT operations, was noted in high concentrations. The project team decided to record both total mass removed and total AF mass removed.

The mass removed was calculated using measured data from the field and using a PID and Dwyer Capsuhelic gauge. The Dwyer calculation is used to calculate vapor flow rates in standard cubic feet per minute (scfm) using the Capsuhelic gauge measurement and the pipe size. Readings from the Dwyer gauge were recorded a few times per week, and the calculated reading in scfm were applied to the period between two consecutive readings.

The PID readings that were manually taken from the influent of the Vapor-Phase Granular Activated Carbon (VGAC) in units of parts per million (ppm) were converted to units of mg/m^3 using the correction factor calculated from comparing results of the PID and lab analyses. This calculation informed the total mass removed. The calculated average well field extraction rate over operations was 64.9 scfm. The extraction and dilution vapor flow rates are represented in **Figure 12** (**Appendix B**). Please note that on May 31st, a variable frequency drive was installed to allow a reduced blower speed, and as such, the dilution valve was closed for the remaining duration of the project.

The PID readings (in units of mg/m^3) could then be converted to mass per unit time period, by using the calculated flow rate, elapsed time, and the appropriate unit conversions. Using the time interval between readings, the total mass removed of COCs between two consecutive readings could be calculated. The total mass removed from the site, based on the vapor stream, was 65.94 lbs. Liquid and vapor contaminant mass removed, shown for both total and AF mass, is shown in **Figures 4** and **5** in **Appendix B**. No DNAPL was observed or measured by the onsite operator at any time.

3.9.Adjustments & Modifications

Throughout ET-DSP™ operations there were several modifications and adjustments made to address operational challenges encountered. The operational challenges and modifications are discussed below.

1. As previously mentioned, biofouling was encountered, and the treatment and circulation systems were significantly impacted. CH2M, Mc^2, and MK worked together to resolve the issue by following the following steps:
    - Identifying that the fouling was not the result of scaling or metals precipitation through a series of lab tests;
    - Identifying a remedial solution with MK (injection of a biocide) by having MK consult with professional chemists and chemical suppliers at Analytix Technologies , LLC.;

  - Applying for and obtaining permits and supplying the required supporting and supplemental information to the environmental regulatory bodies; and,
  - Designing and implementing an injection and monitoring plan to ensure that the stipulations of the permit were followed.
2. Variable permeability in the subsurface resulted in a variable groundwater and vapor production from extraction wells across the site. In order to accommodate this, zones of high recharge were identified, and liquid extraction rates were increased in these areas (by increasing the air supply to the slurper tubes).
3. Soil concentrations of vinyl chloride at the end of the normal operations period did not meet the concentrations outlined in the scope of work table (**Scope of Work Table** in **Appendix A**) and thus, operations were extended in electrode and extraction rows previously identified. This period extended from August 19th – October 19th, 2016, and higher than design levels of energy were targeted to the problem areas. Additional rounds of sampling over the course of the extended periods indicated that VC did not meet its remediation goal stipulated in the SOW, despite the extended operations.

3.10. Water Balance

Based on operator input data, water was extracted from the subsurface at an average rate of 3.62 gpm over 237 days of operations, for a total extracted volume of 1,251,517 gal. Please note that there were some intermittent down times and scheduled shut downs that have not been considered in this calculation, and that totalizer readings are not precise due to periods of biofouling. During this time period, 1,208,51 gal (3.50 gpm) of treated water was reinjected through the electrodes. Intermittent discharges released the remainder of water to the sewer, in accordance with the discharge permit issued by the Joint Meeting of the Essex and Union County (JMEUC – the local sewer authority). Discrepancies in recorded values result from biofouling otherwise compromised flow meters. Due to biomass accumulation in the water return, there was a clogging effect noted on the flow meter, slowing its flywheel. This flow meter was removed, cleaned, and replaced several times throughout the span of the project. Due to formation characteristics, a high vacuum was required to maintain the appropriate radius of influence (ROI) for extraction in extraction wells located in the previously excavated zone. Municipal water was also used for wet testing the system.

4. Summary

The ET-DSP™ system design proved to be effective for the thermal treatment for the reduction of contaminants at the site in Depew, New York.

4.1.Drilling and Installation

The ET-DSP^{TM} equipment used at the site included 44 electrodes in 22 boreholes, 15 vertical extraction wells, four horizontal extraction wells, and seven sensor wells. All below ground equipment was installed as per specifications included in the RDR. Bedrock encountered at shallower than anticipated depths resulted in the well lengths being field adjusted to the available space. The above ground ET-DSP^{TM} components included 2 x 660 kVA PDS units, 2 x 24 channel WCS units, and 1 PDP unit. MK provided liquid and vapor treatment equipment.

4.2.Operations

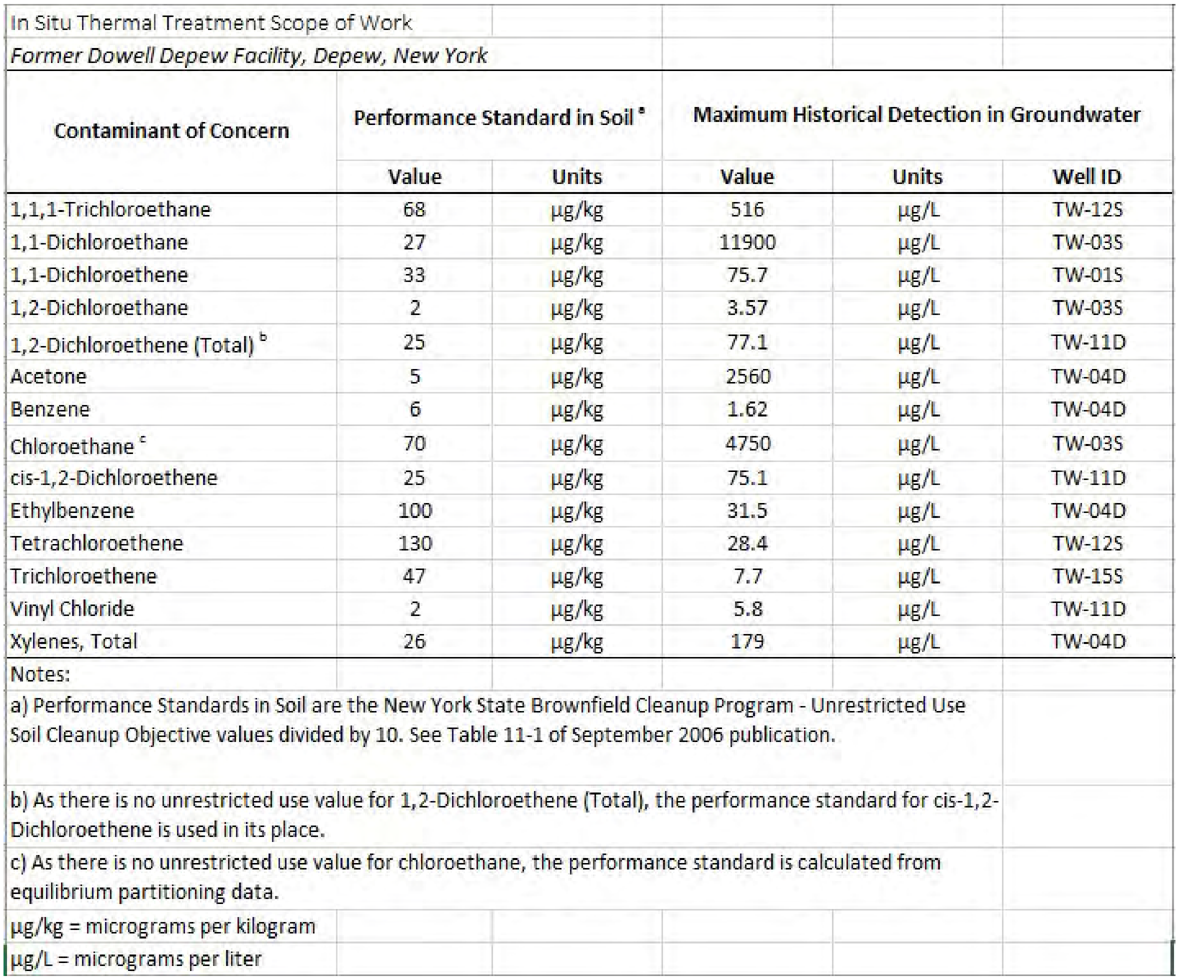
Normal and extended operations ran for 237 days, starting on February 22nd, and ending on October 19th, 2015. Operations were terminated as daily mass recovery was diminishing, and the project team decided that is was no longer cost effective to continue operations.

4.3.Project summary

- The highest daily average temperature reached was 101.2 °C (214.2°F).
- The average target temperature of 100°C (212°F) was maintained between May 12th and July 18th.
- A calculated mass of 65.94 lbs of contaminants including acetone were removed from the vapor phase.
- A calculated mass of 5.29 lbs of contaminants including acetone were removed from the liquid phase.
- No free phase liquids were recovered.
- 1,426 MWh of energy was directed into the subsurface through the electrodes, more than the 1,281 MWh predicted by the simulation, an increase attributable to the extended operation period.
- 1,251,517 gal was extracted from the treatment zone and 1,208,516 gal was injected through the electrodes.
- 114,656.9 gal was discharged to the nearby sanitary sewer.

Appendix A

Scope of Work Table



In Situ Thermal Treatment Scope of Work

Former Dowell Depew Facility, Depew, New York

Contaminant of Concern	Performance Standard in Soil [a]		Maximum Historical Detection in Groundwater		
	Value	Units	Value	Units	Well ID
1,1,1-Trichloroethane	68	µg/kg	516	µg/L	TW-12S
1,1-Dichloroethane	27	µg/kg	11900	µg/L	TW-03S
1,1-Dichloroethene	33	µg/kg	75.7	µg/L	TW-01S
1,2-Dichloroethane	2	µg/kg	3.57	µg/L	TW-03S
1,2-Dichloroethene (Total) [b]	25	µg/kg	77.1	µg/L	TW-11D
Acetone	5	µg/kg	2560	µg/L	TW-04D
Benzene	6	µg/kg	1.62	µg/L	TW-04D
Chloroethane [c]	70	µg/kg	4750	µg/L	TW-03S
cis-1,2-Dichloroethene	25	µg/kg	75.1	µg/L	TW-11D
Ethylbenzene	100	µg/kg	31.5	µg/L	TW-04D
Tetrachloroethene	130	µg/kg	28.4	µg/L	TW-12S
Trichloroethene	47	µg/kg	7.7	µg/L	TW-15S
Vinyl Chloride	2	µg/kg	5.8	µg/L	TW-11D
Xylenes, Total	26	µg/kg	179	µg/L	TW-04D

Notes:

a) Performance Standards in Soil are the New York State Brownfield Cleanup Program - Unrestricted Use Soil Cleanup Objective values divided by 10. See Table 11-1 of September 2006 publication.

b) As there is no unrestricted use value for 1,2-Dichloroethene (Total), the performance standard for cis-1,2-Dichloroethene is used in its place.

c) As there is no unrestricted use value for chloroethane, the performance standard is calculated from equilibrium partitioning data.

µg/kg = micrograms per kilogram

µg/L = micrograms per liter

Appendix B

Figure 1: PDS and WCS units at the western edge of the wellfield

Figure 2: ET-DSP^{TM} shallow electrodes prior to install

Figure 3: Extraction Wells and Piping

Figure 4: Mass Removal in Vapor and Liquid Phases

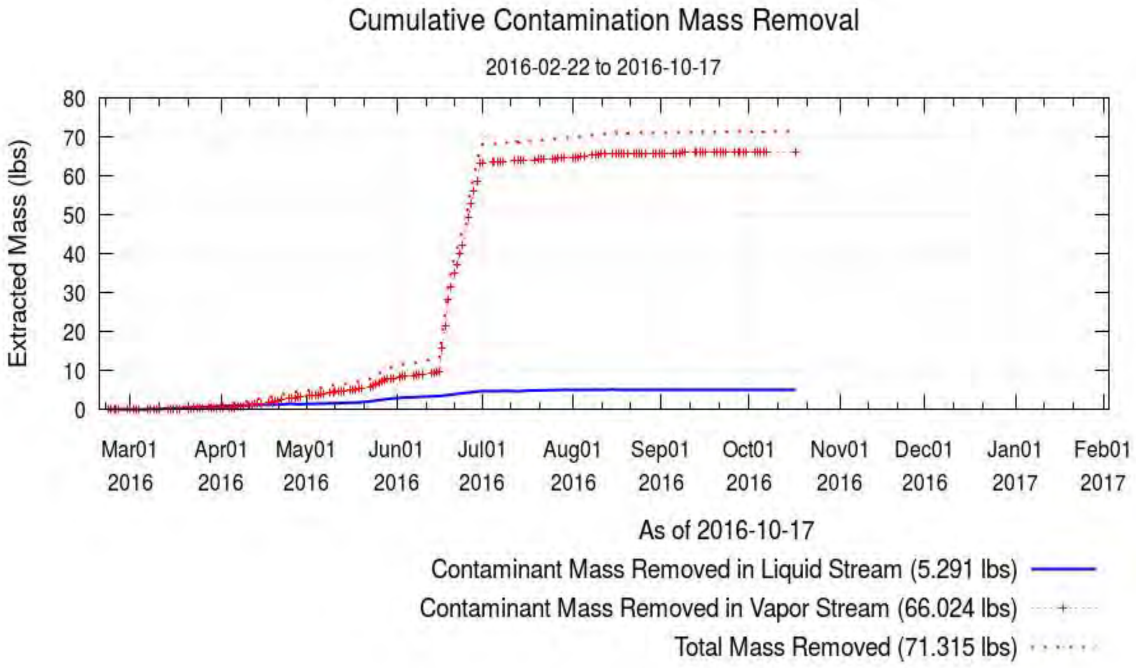


Figure 5: Acetone Free Mass Removal Curves for Liquid and Vapor Phases

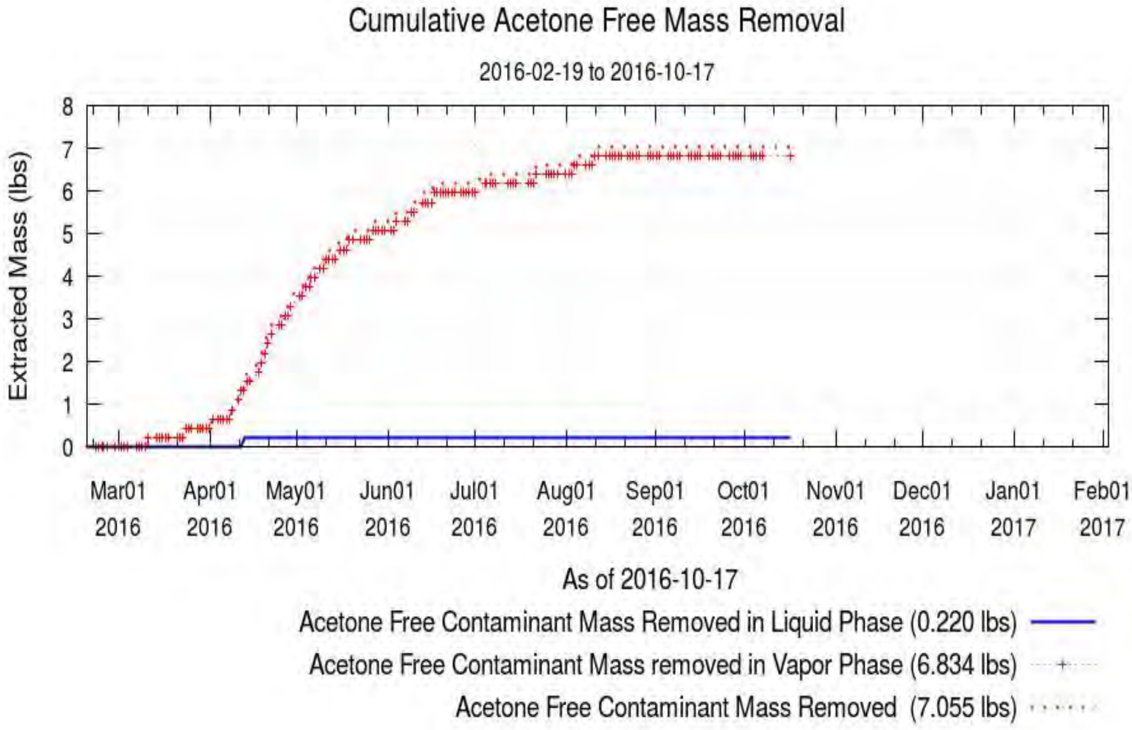


Figure 6: Average Temperature Recorded at the Site

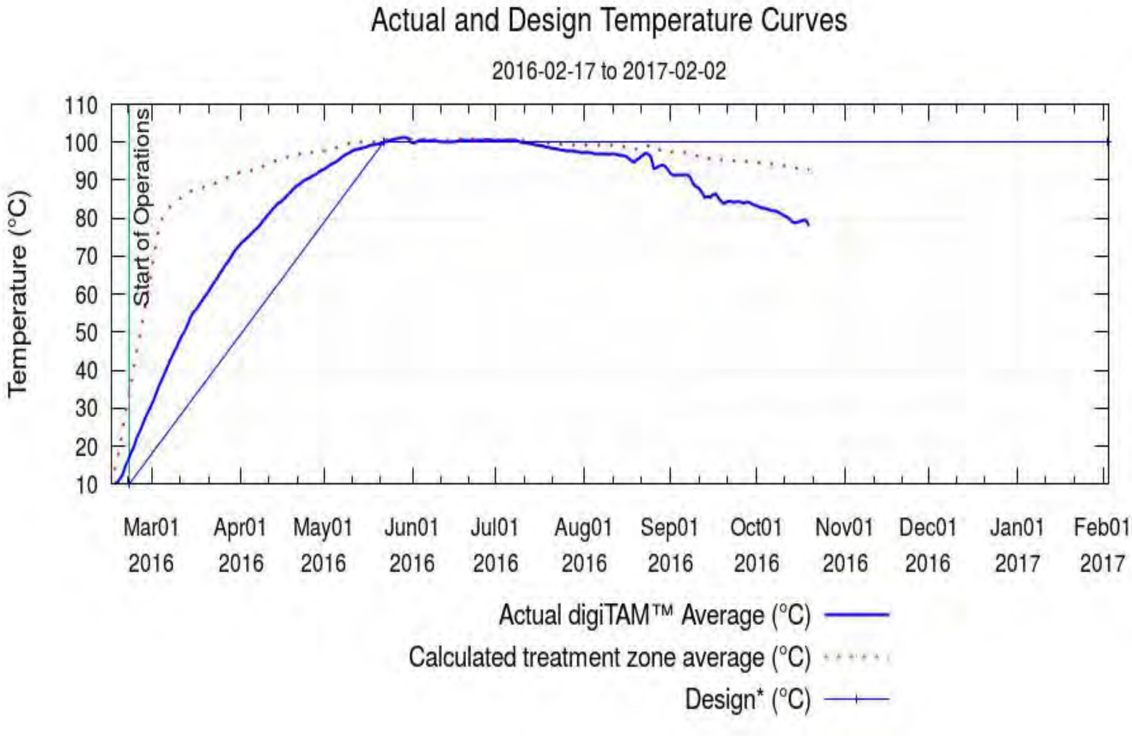


Figure 7: Average Temperature Recorded at the Site Plotted by Depth

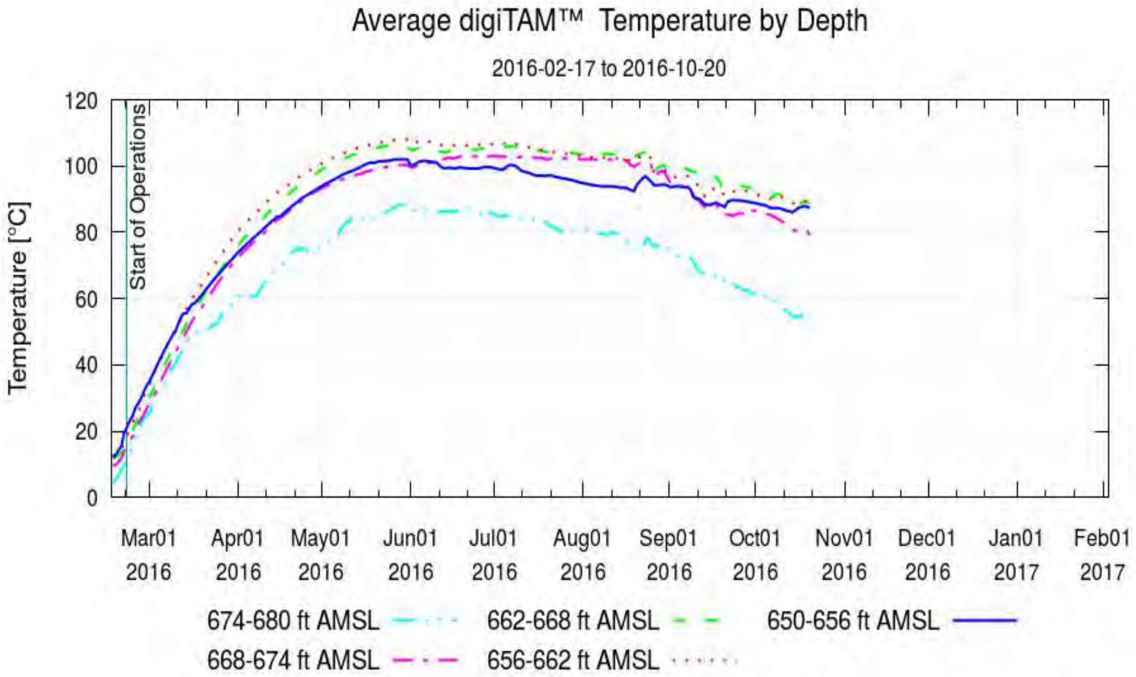


Figure 8: PID readings taken at various points along the treatment train

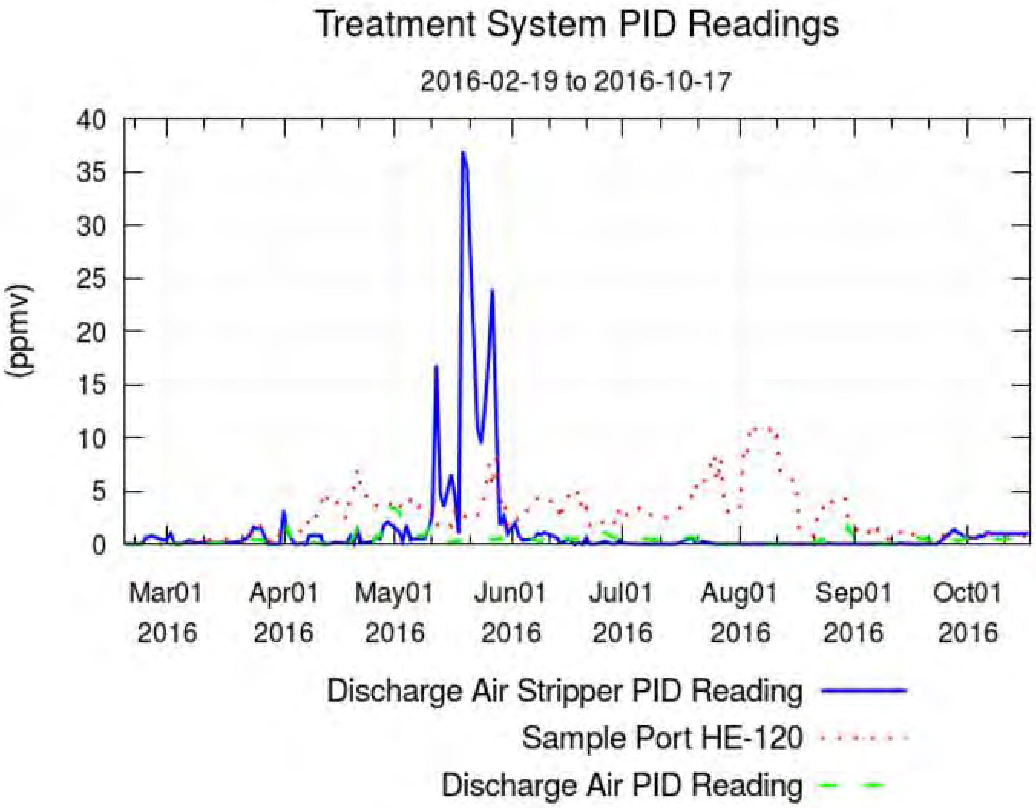
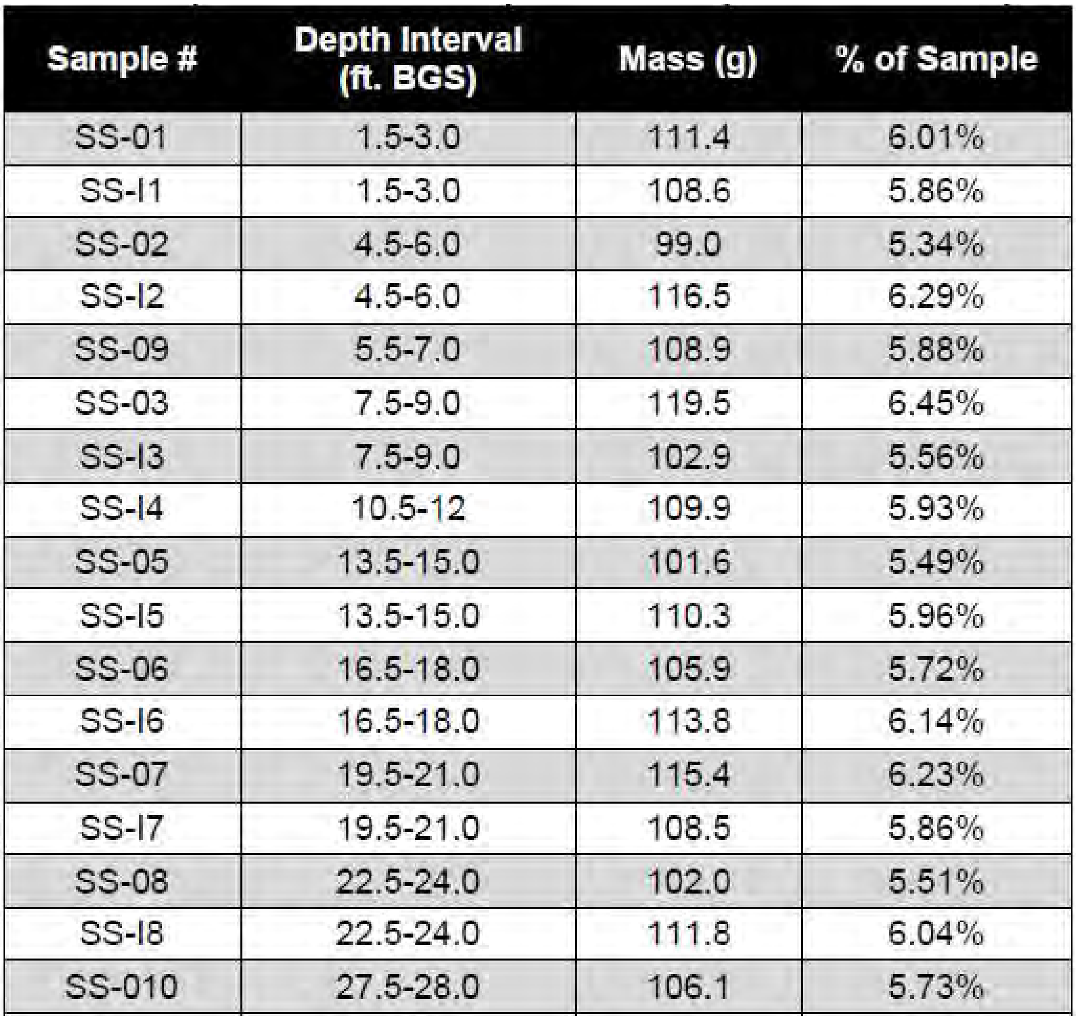


Figure 9: Site Specific Soil Resistivity across specific depth intervals from the *Resistivity Report*



Sample #	Depth Interval (ft. BGS)	Mass (g)	% of Sample
SS-01	1.5-3.0	111.4	6.01%
SS-I1	1.5-3.0	108.6	5.86%
SS-02	4.5-6.0	99.0	5.34%
SS-I2	4.5-6.0	116.5	6.29%
SS-09	5.5-7.0	108.9	5.88%
SS-03	7.5-9.0	119.5	6.45%
SS-I3	7.5-9.0	102.9	5.56%
SS-I4	10.5-12	109.9	5.93%
SS-05	13.5-15.0	101.6	5.49%
SS-I5	13.5-15.0	110.3	5.96%
SS-06	16.5-18.0	105.9	5.72%
SS-I6	16.5-18.0	113.8	6.14%
SS-07	19.5-21.0	115.4	6.23%
SS-I7	19.5-21.0	108.5	5.86%
SS-08	22.5-24.0	102.0	5.51%
SS-I8	22.5-24.0	111.8	6.04%
SS-010	27.5-28.0	106.1	5.73%

Figure 10: Actual and Design Energy Curves

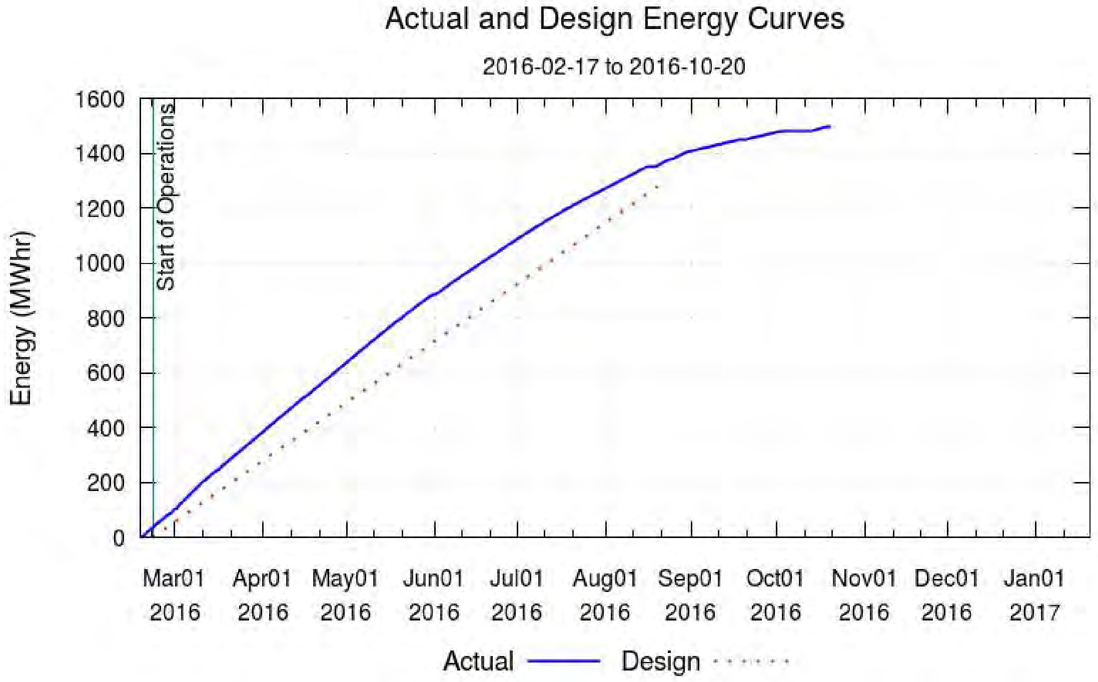


Figure 11: Average Power Usage by Electrode Layer

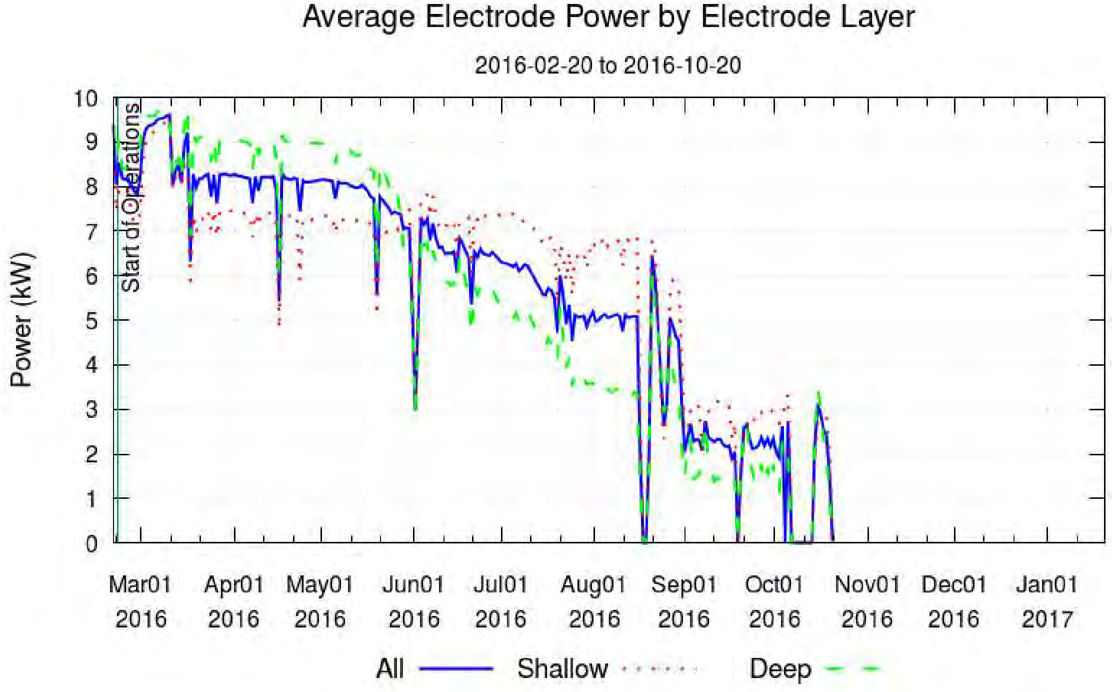
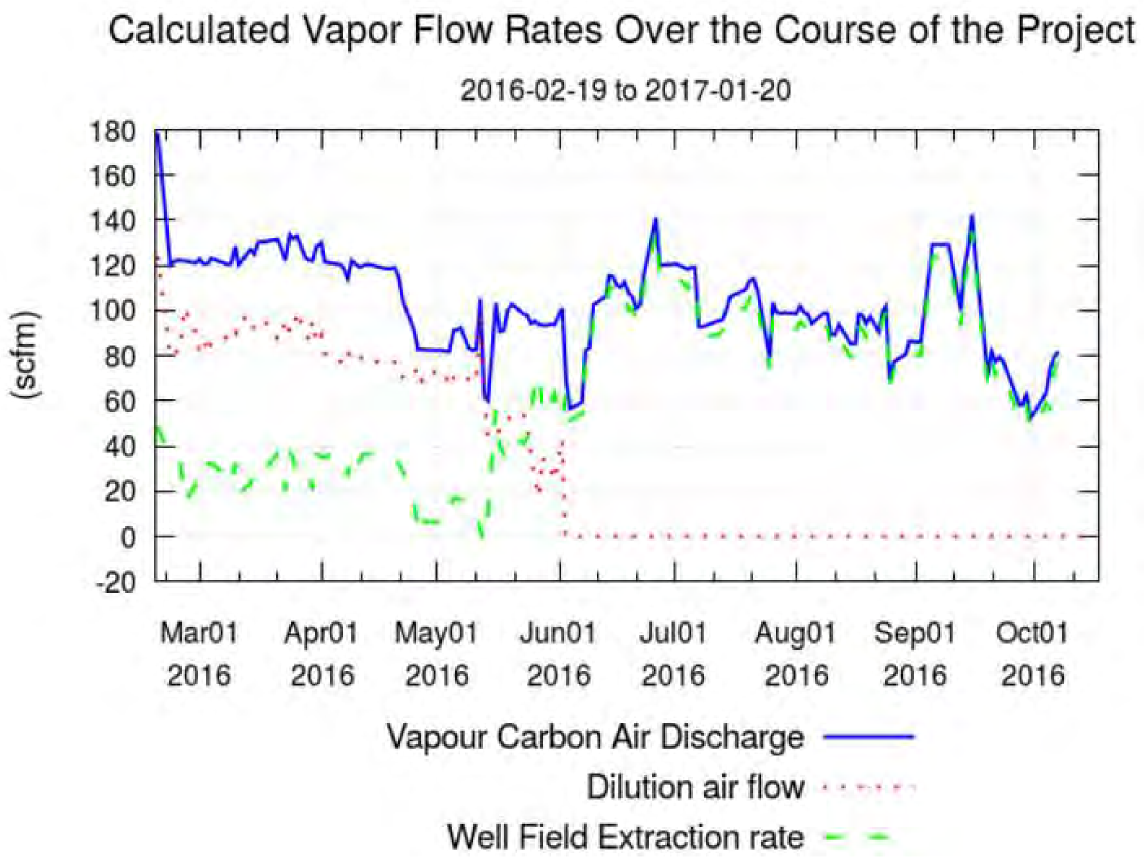
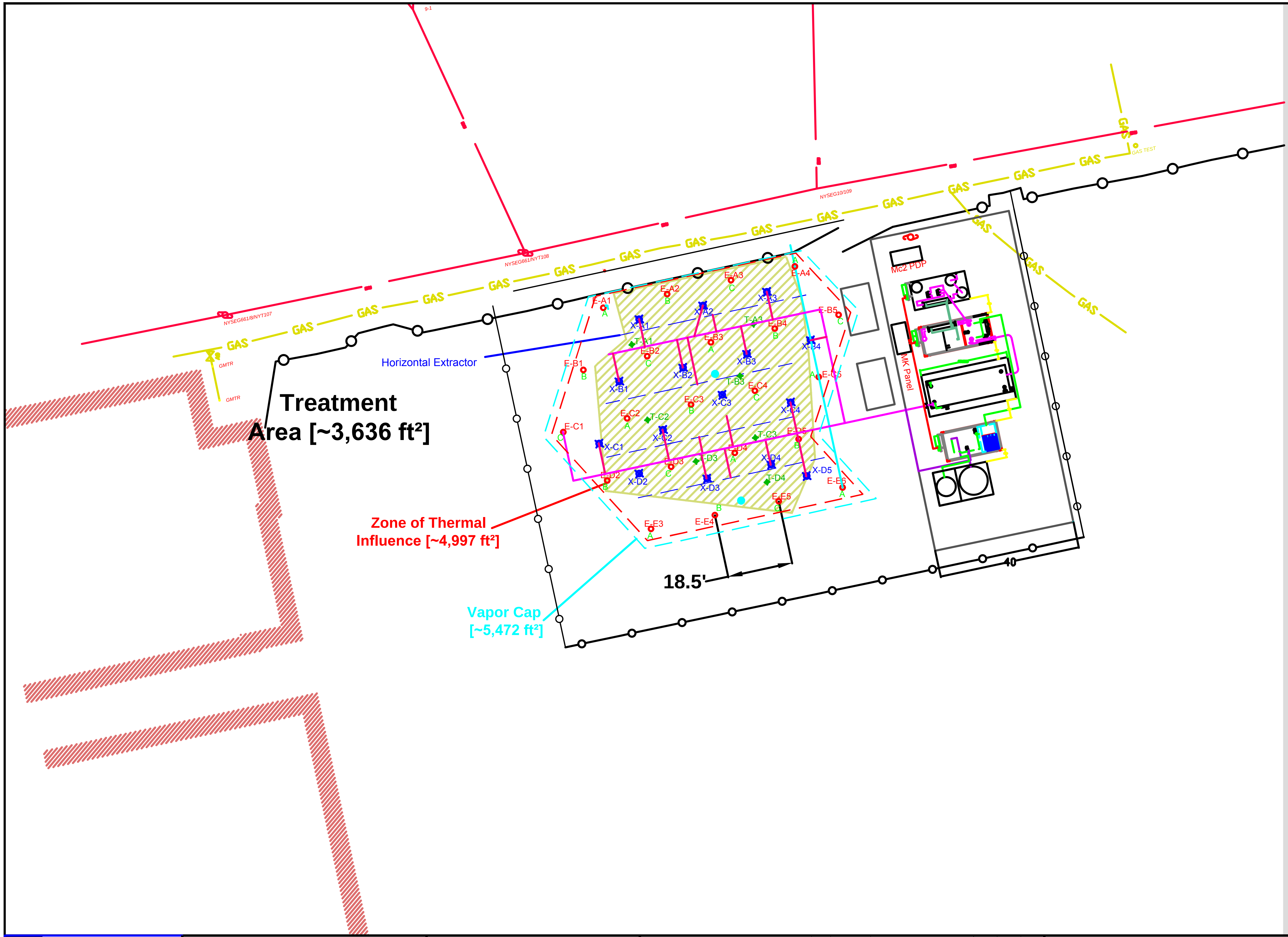


Figure 12: Calculated Vapor Flow Over the Course of the Project


Calculated Vapor Flow Rates Over the Course of the Project
2016-02-19 to 2017-01-20
(scfm)
180
160
140
120
100
80
60
40
20
0
-20
Mar01 2016
Apr01 2016
May01 2016
Jun01 2016
Jul01 2016
Aug01 2016
Sep01 2016
Oct01 2016
Vapour Carbon Air Discharge
Dilution air flow
Well Field Extraction rate

Appendix C

1. Well Field Layout (WFL-01)



LEGEND

○	ET-DSP™ Electrode Location [22]
⊠	Extraction Well [15 + 4]
✚	Sensor Well Location [7]
●	Soil Sample Location [2]
▨	Treatment Area [3,636 ft²]
⌐ ¬	Thermal Influence [~4,997 ft²]
⌐ ¬	Vapor Cap [~5,472 ft²]

NOTES:

1. ELECTRODES REQUIRE 25 cm [10"] BORING.
2. EXTRACTORS REQUIRE 15 cm [6"] BORING.
3. SENSOR WELLS REQUIRE 5 cm [2"] DROP TUBE. BORING SIZE IS MIN. 10 cm [4"].

McMillan-McGee Corp.
Creators of ET-DSP™

McMillan-McGee Corp.
Electromagnetic Systems and Services
For the Energy and Environmental Industries

4895 - 35B Street SE
Calgary, AB T2B 3M9 Canada

www.mcmillan-mcgee.com
Ph: 403.569.5100, Fx: 403.272.7201

LPE

DATE

REV.	DATE (Yr/M/D)	DESCRIPTION	DRAWN BY	ORG/ ENGR	Aproved Dist
C2	2016/02/26	Final	ND	WR	DR
C1	2016/02/23	Completed	ND	WR	DR
A6	2015/10/26	Electrical Drop	WR	DR	BW
A5	2015/10/20	THE CADD IMAGE ADDED	WR	DR	BW
A4	2015/09/04	Soil Sample locations added.	WR	XX	BW
A	2015/08/01	FIRST DRAFT	BW	XX	-

DRAWING NUMBER:
SCALE: NOT TO SCALE

TITLE:
ET-DSP™ Well Field Layout

CLIENT:
CH2M Hill
Former Dowell Site
Depew, New York

SHEET:
WFL-01

Appendix D

1. Electrode Design and Installation Details
2. Extraction Wells Design and Installation Details

Electrodes

Identification	Design Criteria				Installation							
Electrode	Electrodes per Borehole	Bottom of Well (ft BGS)	Top of Deep Electrode (ft BGS)	Top of Shallow Electrode (ft BGS)	Top Electrode dimensions (in. dia. X ft. length)	Bot. Electrode dimensions (in. dia. X ft. length)	Bottom of Well (ft BGS)	Top of Deep Electrode (ft BGS)	Top of Shallow Electrode (ft BGS)	Top of Sand (ft BGS)	Top of Fine Seal (ft BGS)	Top of Grout (ft BGS)
E-A1	2	31.50	21.0	4.0	8" x10'	8"x10'	31	21'	4' 6"	1'8"	1.0	0.0
E-A2	2	31.50	21.0	4.0	8" x10'	8"x10'	31	21'	4.0	1' 6"	1.0	0.0
E-A3	2	31.50	21.0	4.0	8" x10'	8"x10'	28' 4"	18' 4"	3'	1' 8"	1'	0.0
E-A4	2	31.50	21.0	4.0	8" x10'	8"x10'	28'	18'	3'	1' 8"	1'	0.0
E-B1	2	31.50	21.0	4.0	8" x10'	8"x10'	31	21'	4.0	1' 7"	1.0	0.0
E-B2	2	31.50	21.0	4.0	8" x10'	8"x10'	29	19'	4.0	1' 6"	1.0	0.0
E-B3	2	31.50	21.0	4.0	8" x10'	8"x10'	6"	18'	3' 6"	1' 6"	1.0	0.0
E-B4	2	31.50	21.0	4.0	8" x10'	8"x10'	28	18'	3'	1' 6"	1'	0.0
E-B5	2	31.50	21.0	4.0	8" x10'	8"x10'	27' 10"	17' 10"	3'	1'	1' 6"	0.0
E-C1	2	31.50	21.0	4.0	8" x10'	8"x10'	28	18'	3'	1' 5"	1.0	0.0
E-C2	2	31.50	21.0	4.0	8" x10'	8"x10'	28' 6"	18' 6"	4.0	1' 7"	9"	0.0
E-C3	2	31.50	21.0	4.0	8" x10'	8"x10'	28' 6"	18' 6"	4.0	1' 3"	8"	0.0
E-C4	2	31.50	21.0	4.0	8" x10'	8"x10'	27' 6"	17" 6'	3'	1'	1' 6"	0.0
E-C5	2	31.50	21.0	4.0	8" x10'	8"x10'	27' 8"	17' 8"	3'	1'	1' 6"	0.0
E-D2	2	31.50	21.0	4.0	8" x10'	8"x10'	28'	18'	3.0	1.0	1.0	0.0
E-D3	2	31.50	21.0	4.0	6' 8" x 8"	8"x10'	26' 6"	16' 6"	3' 10"	1.0	N/A	0.0
E-D4	2	31.50	21.0	4.0	8" x10'	8"x10'	26' 7"	16' 7"	2' 7"	1' 8"	1'	0.0
E-D5	2	31.50	21.0	4.0	8" x 5'	8"x10'	26'7"	16' 7"	5'	1'	1' 6"	0.0
E-E3	2	31.50	21.0	4.0	8" x10'	8" x 5'	26' 6"	18'	3'	1'	1' 7"	0.0
E-E4	2	31.50	21.0	4.0	8" x10'	8" x 5'	27'	19'	4'	1'	1' 6"	0.0
E-E5	2	31.50	21.0	4.0	8" x10'	8" x 5'	27'	19'	4'	1'	1' 6"	0.0
E-E6	2	31.50	21.0	4.0	8" x10'	8" x 5'	27'	19'	4'	1'	1' 6"	0.0

Extraction Wells

Identification	Design Criteria				Installation								
Extraction Well	**Bottom of Well (ft BGS)**	**Bottom of Sump (ft BGS)**	**Bottom of Screen (ft BGS)**	**Top of Screen (ft BGS)**	**Bottom of Well / Sump (ft BGS)**	**Bottom of Cap (ft BGS)**	**Top of Sump (ft BGS)**	**Bottom of Screen (ft BGS)**	**Top of Screen (ft BGS)**	**Top of Sand (ft BGS)**	**Top of Fine Seal (ft BGS)**	**Top of Grout (ft BGS)**	**Stick-up (ft AGS)**
X-A1	32.5	31.0	31.0	2.0	31'	N/A	29' 8"	29' 8"	1' 1"	1' 6"	1'	0.0	3' 1"
X-A2	32.5	31	31	2	27' 8"	27' 8"	N/A	27' 8"	1' 8"	1'	1'	0	3' 4"
X-A3	32.5	31.0	31.0	2.0	28' 5"	28' 5"	N/A	28' 5"	2' 5"	1'	1'	0.0	2' 7"
X-B1	32.5	31.0	31.0	2.0	28' 3"	28' 3"	N/A	28' 3"	2' 3"	1'	1'	0.0	2' 4"
X-B2	32.5	31.0	31.0	2.0	28' 3"	28' 3"	N/A	28' 3"	2' 3"	1'	1'	0.0	2' 9"
X-B3	32.5	31.0	31.0	2.0	28'	28'	N/A	28'	2'	1'	1'	0.0	3'
X-B4	32.5	31.0	31.0	2.0	28' 6"	28' 6"	N/A	28' 6"	3' 6"	1'	1'	0.0	1' 6"
X-C1	32.5	31.0	31.0	2.0	28'	28'	N/A	28'	2'	1'	1'	0.0	3'
X-C2	32.5	31.0	31.0	2.0	28' 7"	28' 7"	N/A	28' 7"	2' 7"	1'	1'	0.0	2' 7"
X-C3	32.5	31.0	31.0	2.0	27'	27'	N/A	27'	2'	1'	1'	0.0	3'
X-C4	32.5	31.0	31.0	2.0	27'	27'	N/A	27'	2'	1'	1'	0.0	3'
X-D2	32.5	31.0	31.0	2.0	27' 6"	27' 6"	N/A	27' 6"	2' 6"	1'	1'	0.0	2' 6"
X-D3	32.5	31.0	31.0	2.0	27' 1"	27' 1"	N/A	27' 1"	2' 1"	1'	1'	0.0	2' 11"
X-D4	32.5	31.0	31.0	2.0	27'	27'	N/A	27'	2'	1'	1'	0.0	3'
X-D5	32.5	31.0	31.0	2.0	28' 6"	28' 6"	N/A	28' 6"	3' 6"	1'	1'	0.0	2' 6"

Appendix G
Site Permits

TECHNICAL MEMORANDUM

Air Permit Requirements for Former Dowell Depew Facility In Situ Thermal Treatment System

PREPARED FOR:	File
COPY TO:	
PREPARED BY:	Linda Colella/DEN
DATE:	November 18, 2015
PROJECT NUMBER:	666076.15.04.02

Title 6, Part 201 of the New York Codes, Rules, and Regulations (6 CRR-NY 201) was reviewed to determine air permit and registration requirements for the in situ thermal treatment (ISTT) system at the Former Dowell Depew Facility in Depew, New York. Section 6 CRR-NY 201.3.3 indicates that soil vents that are operated under an agreement with and under the supervision of the department are considered a “trivial activity” and are exempt from the registration and permitting provisions of Subparts 201-4, 201-5, and 201-6.

Department Supervision. The ISTT system is being installed under the New York State Department of Environmental Conservation (NYSDEC) Voluntary Cleanup Program (VCP). A remedial action work plan (RAWP), which has been submitted and approved by the NYSDEC, includes details regarding the design and operation of the system, confirmation sampling, and follow-up reporting to the NYSDEC. NYSDEC approval of the RAWP provides verification that the soil vents will be operated under an agreement with and under the supervision of the department. In addition, Mr. David Szymanski/ NYSDEC VCP Site Project Manager was contacted to verify that their review met the definition of “supervision.”

Trivial Activity. The requirements for an air emission source that is list as “trivial” in 6 CRR-NY 201.3.3 are as follows:

- The source may be required to certify that it operated within the specific criteria described in this Subpart. The owner or operator of any such emission source or activity must maintain all required records on-site for a period of five years and make them available to representatives of the department upon request.
- Appropriate emission controls must be used, and those controls shall be operated and maintained in a manner consistent with manufacturer’s specifications and good engineering practices.
- Required records must be maintained on-site for a period of five years and made available to representatives of the department upon request. “Required records” are not defined in 6 CRR-NY 201, but is taken to mean operating, monitoring, and sampling records that are kept as part of the agreement with the supervising NYSDEC department, and those that document that the emission controls are operated and maintained in a manner consistent with manufacturer’s specifications and good engineering practices.

In an email dated November 17, 2015, Mr. Szymanski indicated that he discussed this activity with the Division of Air, and based on the description provided to him, the air emission source would qualify as “trivial activity,” and that the project may proceed with the work as proposed.

From: Szymanski, David (DEC)
To: Burkard, Jayson/STL
Cc: Shores, Christopher/RAL; Stokes, James/NSC; Colella, Linda/DEN; wrobella@mcmillan-mcgee.com
Subject: RE: Dowell Depew Question
Date: Tuesday, November 17, 2015 3:19:31 PM

Jayson –

I swung by last week and saw that the cap was installed. Glad to see this proceeding.

I discussed with Division of Air, and based on your description, it would qualify as “trivial activity”, so you may proceed with your work as proposed.

Please let me know if you have any additional questions.

- David Szymanski

From: Jayson.Burkard@CH2M.com [mailto:Jayson.Burkard@CH2M.com]
Sent: Monday, November 16, 2015 11:30 AM
To: Szymanski, David (DEC)
Cc: Christopher.Shores@ch2m.com; James.Stokes@ch2m.com; Linda.Colella@CH2M.com; wrobella@mcmillan-mcgee.com
Subject: Dowell Depew Question

Good Morning David,

If you have not made a trip out to the site lately, then I just wanted to let you know that we are steadily making progress. We have completed the installation of all of the underground ISTT system components and are currently constructing the aboveground ISTT system components starting today. If you would like to make a site visit, my onsite construction manager’s name is James “Clint” Stokes, his cell phone number is 907-3940-3771. We will be out, onsite until two days before Thanksgiving and we will then re-group after thanksgiving, to continue construction of ISTT system components.

I do have a question that I was hoping that you could address for me. We are currently in the process of completing the necessary permits for when we turn the system on. After doing some research of NY regulations we believe that the air stripper registration is not required based on the research my Environmental Compliance Manager has completed but we would like for you to confirm. Please see text below.

CH2M is evaluating whether the proposed ISTT system may qualify as a “trivial activity” as defined under Section 6 CRR-NY 201.3.3: soil vents that are operated under an agreement with, and under the supervision of, the department (any), are considered a “trivial activity” and are exempt from the registration and permitting provisions of Subparts 201-4, 201-5, and 201-6.

If NYSDEC’s review and approval of CH2M’s RAWP, will qualify as supervision, then CH2M would proceed with requesting the exemption. Our thermal vendor (McMillan-McGee) plans to use a ShallowTray Low Profile Air Stripper Model to treat vapors - Model 2341 (please see attached PDF). The PDF attached gives an example of 10,000 ppb of some of our primary COCs at 55 degrees F to illustrate its mass destruction ability.

If agreeable, CH2M would appreciate confirmation in writing that this supervisory requirement of the trivial exemption would be met under the existing VCP agreement. If you need some more clarification and information, please let me know and I can set up a call with appropriate staff.

Thanks and have a good day,

Jayson

2015 Work Schedule
Monday, Wednesday, Friday = Work from home (please call cell first, then office line)
Tuesday and Thursday = Work from office (please call office line first, then cell)

Jayson Burkard R.G.
Associate Project Manager
Environmental Services Business Group

CH2M – STL Office
300 Hunter Avenue – Suite #305
St. Louis, Missouri – 63124
Direct: 314-335-3046
Mobile: 314-477-7284
Jayson.burkard@ch2m.com
www.ch2m.com

From:	Rhoades, Katie/NJO
Sent:	Friday, July 08, 2016 9:35 AM
To:	Rhoades, Katie/NJO
Subject:	FW: changed condition notification Reference UICID: 16NY02999011 the Former Dowell Depew Facility

---

From: Ortega, Norma [mailto:Ortega.Norma@epa.gov]
Sent: Thursday, July 07, 2016 5:21 PM
To: Colella, Linda/DEN <Linda.Colella@CH2M.com>
Subject: RE: changed condition notification Reference UICID: 16NY02999011 the Former Dowell Depew Facility

Hi Linda:

Pertaining to *the Former Dowell Depew Facility*-EPA concurs with both the information/approval provided by David Szymaski of NYSDEC via e-mail dated May 25, 2016. And also we concur with the May 24, 2016 e-mail approval provided by Laura Surdej of Erie County and the Buffalo Sewer Authority . The information in the two e-mails granted approval to your request to include/add 45 glutaraldehyde to the holding tank at this facility in order to treat for biofouling. The initial dosing will be 100-125 ppm for a duration of 12 hours, then to be adjusted to an ongoing maintenance dose of 25-30 ppm.

EPA may send you a formal letter if it is deemed necessary, during the week of July 18th as I will be on travel next week.

Thanks so much and happy week-end!

Nonny

Rhoades, Katie/NJO

From:	Surdej, Laura <Laura.Surdej@erie.gov>
Sent:	Tuesday, May 24, 2016 10:36 AM
To:	Colella, Linda/DEN; Burkard, Jayson/STL
Cc:	Absolom, Glenn; Rehac, Richard; Strzeszynski, William; Phil Fleck (PFleck@villageofdepew.org); Anthony Fischione (AFischione@villageofdepew.org); Leslie Sedita
Subject:	Walden Ave Temporary Discharge- Biofouling treatment

Linda/Jayson,
Erie County and the Buffalo Sewer Authority reviewed your request to add AQUCAR™ GA 45 Water Treatment Microbiocide to the holding tank to treat for biofouling. The request is approved provided that the tank is treated and held for the 12 hours(as indicated) and that the pH of the tank is checked prior to discharge. The acceptable pH range is 5-12 SU. Please include dosage, hold time and pH on the weekly discharge reports that are emailed to me. If you have any questions, please feel free to contact me.
Thanks,
Laura

--
Laura Surdej | Industrial Wastewater Specialist
Erie County | Div. of Sewerage Management
260 Lehigh Ave., | Lackawanna, NY 14218
P:(716) 823-5888 | F:(716) 823-1327
Laura.Surdej@erie.gov | http://www.erie.gov

From: Linda.Colella@CH2M.com [mailto:Linda.Colella@CH2M.com]
Sent: Friday, May 20, 2016 3:03 PM
To: Surdej, Laura
Cc: Jayson.Burkard@CH2M.com
Subject: SDS for proposed biofouling treatment

Hi Laura –

Per your request attached is the SDS for the solution we are proposing to use for the temporary batch discharge from the Depew site located on Walden Avenue. Also attached are a Spills, Deactivation, and Disposal fact sheet, and Environmental Fate fact sheet for glutaraldehyde

As we just discussed, we have encountered biofouling in our treated-water holding tank which is restricting our treatment system flow. We would like to introduce a 45% glutaraldehyde solution to break up and disperse the biofouling observed in the water treatment and water injection systems. The proposed initial shock dosing is 100 – 125 ppm for a period of 12 hours, which will then be adjusted down to an ongoing maintenance dosage of 25-30 ppm. The lowest effective dosage will be used, and records will be maintained of chemical dosage quantities. All other parameters remain the same.

Thank you for your time and consideration!

Linda

Linda S. Colella, P.E.
P.E. in CO, WY, and KS

Rhoades, Katie/NJO

From:	Szymanski, David (DEC) <david.szymanski@dec.ny.gov>
Sent:	Wednesday, May 25, 2016 11:26 AM
To:	Burkard, Jayson/STL
Cc:	Colella, Linda/DEN; Rhoades, Katie/NJO; Moore, Maurice (DEC); Staniszewski, Chad (DEC)
Subject:	RE: changed condition notification Reference UICID: 16NY02999011

If the POTW is OK with the conditions, then DEC has no issue with it, as it is covered under the pretreatment program.

We should be good with this application as you have presented it. Please let EPA know of your intent to proceed.

Please let me know if you'll be in town soon, so we can drop by and see how the system is running.

Best regards,
David Szymanski

From: Jayson.Burkard@CH2M.com [mailto:Jayson.Burkard@CH2M.com]
Sent: Wednesday, May 25, 2016 10:33 AM
To: Szymanski, David (DEC) <david.szymanski@dec.ny.gov>
Cc: Linda.Colella@CH2M.com; Katie.Rhoades@ch2m.com
Subject: RE: changed condition notification Reference UICID: 16NY02999011

David,

My apologies for the slow response as I was out in the field the last two days. We have been in contact with Erie County and Buffalo Sewer Authority and they are okay with our proposed treatment, the request is approved provided that the tank is treated and held for the 12 hours(as CH2M indicated) and that the pH of the tank is checked prior to discharge. The acceptable pH range is 5-12 SU.

Hopefully this addresses any additional concerns Division of Water may have had.

Jayson

2016 Work Schedule
Monday, Wednesday, Friday = Work from home (please call mobile line first, then try office line)
Tuesday and Thursday = Work from office (please call office line first, then try mobile line)

Jayson Burkard R.G.
Associate Project Manager
Environmental Services Business Group

CH2M – STL Office
300 Hunter Avenue – Suite #305
St. Louis, Missouri – 63124
Direct: 314-335-3046
Mobile: 314-477-7284

County of Erie

MARK C. POLONCARZ
County Executive

THOMAS J. DEARING
Commissioner

DEPARTMENT OF ENVIRONMENT AND PLANNING

JOSEPH L. FIEGL, P.E.
Deputy Commissioner

February 18, 2016

Mr. Jayson Burkard
CH2M Hill Engineers Inc.
300 Hunter Avenue
St. Louis, MO 63124

RE: Erie County Sewer District No.4 (ECSD No.4)
Discharge Request – Dowell Schlumberger Inc.
3311-3313 Walden Avenue
Depew, New York

Dear Mr. Burkard:

The Division of Sewerage Management (DSM) has reviewed your request to accept the contaminated water from the above referenced site. The water will be generated from the In Situ Thermal Treatment (ISTT) system on site that will heat the subsurface and force the groundwater contaminants out. The liquid will be treated, accumulated and discharged. Discharge will take place once every five to six days from a holding tank.

The request to discharge approximately 350,000 gallons of this water is approved provided that the discharge is in compliance with the terms outlined in the discharge request and the following conditions:

1. Notification to the Erie County Sewer District No. 4 office must be made at least twenty-four (24) hours prior to initiating the discharge (tel. 684-1234 or 823-5888, ext 223).
2. A Sewer District representative shall be present upon initiation of discharge.
3. The flow shall enter the sanitary sewer system at the designated discharge point. Due to location of discharge point, a written Right of Entry from Buffalo Batt must be received prior to commencement of discharge.
4. CH2M must be aware of NYSDEC requirements for Sanitary Sewer Overflow (SSO) reporting in the event that there is a spill at the site. CH2M will be responsible for reporting any spills to the DEC.
5. Discharge shall not take place during wet weather.
6. The flow rate shall not exceed 15 gpm. The total volume discharged shall be recorded with a flow meter and reported to the DSM.

7. A representative of CH2M or their designee must be on site at all times while discharge is taking place.
8. If at any time a problem arises in the collection system, as a result of the discharge, the District may require that operations cease.
9. An emergency contact list needs to be distributed prior to commencement of discharge.
10. Groundwater must be treated prior to discharge. Treatment through an oil/water separator, air stripper and activated carbon vessel is required.
11. When discharge is taking place, a ramp will need to be used over the hose for driveway access.
12. CH2M is responsible for pedestrian and vehicle safety.

To obtain a permit to discharge, please bring this letter with payment to the ECSD No.4 office at the Northern Region District Office located at 3789 Walden Avenue, Lancaster. A check or money order for $282.75 payable to the "Erie County Comptroller" will cover the permit, inspection and discharge fees (includes 91,250 gallons). Additional flow charges will be billed to you at project completion. The rate is $2.45per 1,000 gallons.

If you should have any questions or concerns please contact me at 823-5888, ext 223.

Sincerely,

Laura A Surdej

Laura A. Surdej
Industrial Wastewater Specialist

cc: J. Fiegl/M. Salah/file
G. Absolom/K. Kaminski/3.2.4 Temporary Discharge Requests
R. Rehac
B. Strzeszynski/T. Herr
L. Sedita (BSA)
David Britton, PE (GHD)
Maureen Jerackas (Village of Depew)

DISCHARGE

PERMIT EXPIRES 90 DAYS AFTER DATE OF ISSUE

Erie County Sewer - ~~[illegible] Region~~ Northern Region 17322

APPLICATION TO CONNECT SEWER

SBL Number - 104.09-1-15 -14

In District Y - #4 Out District ______

Inspection Date ______, 20 ______

Permit Date February 23, 2016

Owner Dowell Schlumerger

Owner's Address ______

Building Address 3311-3313 Walden Av Depew, NY

FOR INSPECTION AND TAPS CALL [redacted] 684.1234

Building Sewer Laid By ______

Address 3311-3313 Walden Av

Applicant's Signature * T Saat CH2M Hill Engineers

Address 300 Hunter Av (% Jason Burkard) St Louis, MO 63124.

Single Dwelling ______

Multiple Dwelling ______ Families

Commercial ______ Employees

Sump Pump ______

Date of Construction ______

Inspection Fee Due ______

Inspection Fee Paid ______

Connection Fee Due ______

Connection Fee Paid ______

Ck # [redacted] 120

Other: $282.75

APPROVED BY: Erie County Inspector ______

Board of Managers ______

PAYABLE TO: ERIE COUNTY DIR. OF BUDGET, MGMT. & FINANCE

SD-3 (Rev. 6.10) ECSD

* Tyler Saatcioglu signing for applicant Jayson Burkard

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

DEC 29 2015

CERTIFIED MAIL - RETURN RECEIPT REQUESTED
Article Number: 7015 1520 0003 0792 1937

Virgilio Cocianni
Former Dowell Depew Facility
Schlumberger Technology Corporation
100 Gillingham Lane
Sugar Land, TX 77478

Re: Underground Injection Control (UIC) Program Regulation
Former Dowell Depew Facilit (**Reference UICID: 16NY02999011**)
3311-3313 Walden Avenue
Depew, NY 14043
Erie County
Authorization to Inject

Dear Mr. Cocianni:

This letter serves to inform you that the U.S. Environmental Protection Agency is in receipt of inventory information addressing a well authorized by rule located at the above-referenced facility in accordance with 40 Code of Federal Regulations (CFR) §144.26. The operation of the following Underground Injection Control well is authorized by rule, pursuant to 40 CFR §144.24:

Perform the installation of an In situ Thermal Treatment (ISTT) system to remediate ground water contamination at this facility. Operation will include the installation of 22 electrodes. An electrical current will be applied to each electrode to heat the subsurface forcing the ground water contaminants into vertical and horizontal recovery wells. Wells will then be remediated at the surface as either vapor or liquid. Water will be added to each electrode to keep the electrodes from trying out. The operation has been approved by New York State Department of Environmental Conservation, DEC #VOO410.

Should any conditions change in the operation of the well listed above (such as injectate composition, closure of the well, injection of cooling water greater than 98 degrees Fahrenheit, construction of additional wells, etc.) you are required to notify this office within five (5) days. Any accidental spills into a well should be reported within twenty-four (24) hours after the event. Change in operation information should be addressed to:

Nicole Foley Kraft, Chief
Groundwater Compliance Section
United States Environmental Protection Agency
290 Broadway, 20th Floor
New York, NY 10007-1866
Re: 16NY02999011
Attn: Nonny Ortega

Should you own or operate **other** facilities using underground injection wells, please use the enclosed inventory form (EPA Form 7520-16) and instructions, copy for multiple facilities, and submit them to the address listed above. The form can also be found on the internet at:

http://www2.epa.gov/sites/production/files/2015-10/documents/7520-16_508c.pdf

Failure to respond to this letter truthfully and accurately within the time provided may subject you to sanctions authorized by federal law. Please also note that all information submitted by you may be used in an administrative, civil judicial, or criminal action. In addition, making a knowing submission of materially false information to the U.S. Government may be a criminal offense.

Should you have any questions, please contact Nonny Ortega of my staff at (212) 637-4234 or ortega.norma@epa.gov.

Sincerely,

Nicole Foley Kraft, Chief
Groundwater Compliance Section

Enclosure

cc: Jeffrey Konsella, Regional Water Engineer
NYSDEC, Region 9
270 Michigan Avenue
Buffalo, NY 14203-2999

Tom Casey, P.E.
Erie County Division of Environmental Health
95 Franklin Street
Buffalo, NY 14202

USEPA REGION II SUPPLEMENTAL INSTRUCTIONS FOR COMPLETING INVENTORY OF INJECTION WELLS

EPA FORM 7520-16 (Rev. 8-01)

SECTION 2. FACILITY ID NUMBER: Leave blank. EPA will assign an ID number.

SECTION 3. TRANSACTION TYPE: Check either First Time Entry or Entry Change. If this is the first time you have submitted this form for your injection wells(s), check First Time Entry and fill in all the appropriate information. If you are modifying information you sent in before, check Entry Change, fill in the Facility Name and Location and fill in the information that has changed. (Note: If the facility name has changed, in the blank space in the upper left hand corner write the prior facility name under which the form was first submitted, and the date it was submitted.)

SECTION 4. FACILITY NAME AND LOCATION: If you know the latitude and longitude of your facility, fill in line 4C and 4D. You do <u>not</u> need to fill in 4E, Township/Range. If you know the Numeric County Code, fill in line 4I, otherwise just write in the name of the County.

SECTION 5. LEGAL CONTACT: Under 5A, if the Legal Contact you are identifying owns the land, check Owner. If the Legal Contact owns and/or operates the business but someone else owns the land, check Operator. Under 5I, "Private" means privately owned. "Public" means owned by local/municipal government. "State" and Federal" mean owned by state/federal government.

SECTION 6. WELL INFORMATION: Under 6A CLASS AND TYPE, use the attached table "USEPA Region II List of Class V Injection Well Types" to determine the **CLASS V** "TYPE". Enter the appropriate Type Code in 6A (the Type Code does <u>not</u> have to fit within the two boxes on the Inventory Form). Select the Class V well type(s) that most accurately fit the well(s) at your facility. When reviewing the attached table and making your determination, be sure to consider all of the fluids entering the well or having the potential to enter the well. For example, Storm Water Drainage Wells located in industrial areas which are susceptible to spills, leaks or other chemical discharges are inventoried as Industrial Drainage Wells. If Cesspools and Septic Systems are receiving fluids other than sanitary waste (human excreta), that should be noted in the Additional Information below.

IMPORTANT: ADDITIONAL INFORMATION

In order to ensure that the **Class V** Well(s) at your facility are accurately inventoried you must also submit on a separate piece of paper: (1) a brief description characterizing your facility and the types of activities conducted; (2) a brief description of what you use each of your injection well(s) for; (3) a brief description of the types of fluids that enter, or have the potential to enter, each of your injection well(s). (Note: wells with the same information may be grouped).

If you require assistance, please contact EPA Region II at (212) 637-3093.

USEPA REGION II LIST OF
CLASS V INJECTION WELL TYPES

TYPE CODE	NAME	DESCRIPTION
INDUSTRIAL/COMMERCIAL/UTILITY DISPOSAL WELLS		
5X28	MOTOR VEHICLE WASTE DISPOSAL WELLS	- wells that receive or have received fluids from vehicular repair or maintenance activities, such as an auto body repair shop, automotive repair shop, new and used car dealership, specialty repair shop (e.g., transmission and muffler repair shop), or any facility that does any vehicular repair work.
5W20	INDUSTRIAL PROCESS WATER & WASTE DISPOSAL WELLS	- used to dispose of a wide variety of wastes and wastewater from industrial, commercial, or utility processes. Industries include refineries, chemical plants, smelters, pharmaceutical plants, laundromats and dry cleaners, tanneries, carwashes, laboratories, funeral homes, etc. Specify industry <u>and</u> waste stream.
5A19	COOLING WATER RETURN FLOW WELLS	- used to inject water which was used in a cooling process.
DRAINAGE WELLS		
5D4	INDUSTRIAL DRAINAGE WELL	- wells located in industrial areas which primarily receive storm water runoff but are susceptible to spills, leaks, or other chemical discharges.
5D2	STORM WATER DRAINAGE WELLS	- receive storm water runoff from paved areas, including parking lots, streets, residential subdivisions, building roofs, highways, etc.
5F1	AGRICULTURAL DRAINAGE WELLS	- receive irrigation tailwaters, other field drainage, animal yard, feedlot, or dairy runoff, etc.
5D3	IMPROVED SINKHOLES	- receive storm water runoff from developments located in karst topographic areas.
5G30	SPECIAL DRAINAGE WELLS	- used for disposing water from sources other than direct precipitation–such as landslide control drainage wells, potable water tank overflow drainage wells, swimming pool drainage wells, and lake level control drainage wells.

DOMESTIC WASTEWATER DISPOSAL WELLS		
5W9	UNTREATED SEWAGE WASTE DISPOSAL	- receive raw sewage wastes from pumping trucks or other vehicles which collect such wastes from single or multiple sources. (No treatment)
5W10	LARGE CAPACITY CESSPOOLS	- large capacity cesspools including multiple dwelling, community or regional cesspools, or other devices that receive sanitary wastes, containing human excreta, which have an open bottom and sometimes perforated sides. Includes non-residential cesspools which receive solely sanitary waste and have the capacity to serve greater than or equal to 20 persons a day. DOES NOT apply to single family residential cesspools.
5W11	SEPTIC SYSTEM (UNDIFFERENTIAT-ED DISPOSAL METHOD)	- used to inject the waste or effluent from a multiple dwelling, business establishment, community or regional business establishment septic tank to an undetermined final discharge point. Includes non-residential septic systems which receive solely sanitary waste and have the capacity to serve greater than or equal to 20 persons a day. DOES NOT apply to single family residential septic systems. (Primary Treatment)
5W31	SEPTIC SYSTEMS (WELL DISPOSAL METHOD)	- used to inject the waste or effluent from a multiple dwelling, business establishment, community or regional business establishment septic tank to a well-- examples of wells include dry wells, seepage pits, cavitettes, etc. The largest surface dimension is less than or equal to the depth dimension. Includes non-residential septic systems which receive solely sanitary waste and have the capacity to serve greater than or equal to 20 persons a day. DOES NOT apply to single family residential septic systems. (Primary Treatment)
5W32	SEPTIC SYSTEMS (DRAIN FIELD DISPOSAL METHOD)	- used to inject the waste or effluent from a multiple dwelling, business establishment , community or regional business establishment septic tank to a drainfield--examples of drainfields include drain or tile lines, and trenches. Includes non-residential septic systems which receive solely sanitary waste and have the capacity to serve greater than or equal to 20 persons a day. DOES NOT apply to single family residential septic systems. (Primary Treatment)
5W12	DOMESTIC WASTEWATER TREATMENT PLANT EFFLUENT DISPOSAL	- dispose of treated sewage or domestic effluent from small package plants up to large municipal treatment plants. Final discharge points may include drywells or leachfields. (Secondary or further treatment)

GEOTHERMAL REINJECTION WELLS		
5A5	ELECTRIC POWER REINJECTION WELLS	- reinject geothermal fluids used to generate electric power.
5A6	DIRECT HEAT REINJECTION WELLS	- reinject geothermal fluids used to provide heat for large buildings or developments.
5A7	HEAT/PUMP/AIR CONDITIONING RETURN FLOW WELLS	- reinject groundwater used to heat or cool a building in a heat pump system.
5A8	GROUNDWATER AQUACULTURE RETURN FLOW WELLS	- reinject groundwater or geothermal fluids used to support aquaculture. Non-geothermal aquaculture disposal wells are also included in this category (e.g., Marine aquariums in Hawaii use relatively cool sea water).
RECHARGE WELLS		
5R21	AQUIFER RECHARGE WELLS	- used to recharge depleted aquifers and may inject fluids from a variety of sources such as lakes, streams, domestic wastewater treatment plants, other aquifers, etc.
5B22	SALINE WATER INTRUSION BARRIER WELLS	- used to inject water into fresh water aquifers to prevent intrusion of salt water into fresh water aquifers.
5S23	SUBSIDENCE CONTROL WELLS	- used to inject fluids into a non-oil or gas producing zone to reduce or eliminate subsidence associated with overdraft of fresh water and not used for the purpose of oil or natural gas production.
OIL FIELD PRODUCTION WASTE DISPOSAL WELLS		
5X17	AIR SCRUBBER WASTE DISPOSAL WELLS	- inject waste from air scrubbers used to remove sulfur from crude oil which is burned in steam generation for thermal oil recovery projects. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.)
5X18	WATER SOFTENER REGENERATION BRINE DISPOSAL WELLS	- inject regeneration waste from water softeners which are used to improve the quality of brines used for enhanced recovery. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.)

MINERAL AND FOSSIL FUEL RECOVERY RELATED WELLS		
5X13	MINING, SAND, OR OTHER BACKFILL WELLS	- used to inject a mixture of water and sand, mill tailings, and other solids into mined out portions of subsurface mines whether what is injected is radioactive waste or not. Also includes special wells used to control mine fires and acid mine drainage wells.
5X14	SOLUTION MINING WELLS	- used for in situ solution mining in conventional mines, such as slopes leaching.
5X15	IN-SITU FOSSIL FUEL RECOVERY WELLS	- used for in situ recovery of coal, lignite, oil shale, and tar sands.
5X16	SPENT BRINE RETURN FLOW WELLS	- used to reinject spent brine into the same formation from which it was withdrawn after extraction of halogens or their salts.
MISCELLANEOUS WELLS		
5X25	EXPERIMENTAL TECHNOLOGY WELL	- wells used in experimental or unproven technologies such as pilot scale in situ solution mining wells in previously unmined areas.
5X26	AQUIFER REMEDIATION RELATED WELLS	- wells used to prevent, control, or remediate aquifer pollution, including but not limited to Superfund sites.
5X29	ABANDONED DRINKING WATER WELLS	- used for disposal of fluids. Specify well purpose and injected fluids.
5X27	OTHER WELLS	- any other unspecified Class V wells. Specify well type/purpose and injected fluids.

SOURCE. Prepared by EPA Region II. Based on 1987 *Report to Congress* on Class V Wells; and 40 C.F.R. §144.81.

May 11, 2004 (3:47pm)G:/User/Share/DECADIV\DECA-WCB\GWCS\Well Class Type Table for Inventory Form5.wpd

Type or print all information. See reverse for instructions.

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

INVENTORY OF INJECTION WELLS

EPA

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

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

1. DATE PREPARED *(Year, Month, Day)*

2. FACILITY ID NUMBER

PAPERWORK REDUCTION ACT NOTICE

The public reporting burden for this collection of information is estimated at about 0.5 hour per response including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, includingsuggestions for reducing this burden, Director, Collection Strategies Division (2822), U.S. Environmental Protection Agency, 1200 Pennsylvania Avenue, NW, Washington, DC 20460, and to the Office of Management and Budget, Paperwork Reduction Project, Washington, DC20503.

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

☐ Deletion ☐ First Time Entry
☐ Entry Change ☐ Replacement

4. FACILITY NAME AND LOCATION

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

C. LATITUDE

DEG	MIN	SEC
		.

E. TOWNSHIP/RANGE

TOWNSHIP	RANGE	SECT	1/4 SECT

B. STREET ADDRESS/ROUTE NUMBER

D. LONGITUDE

DEG	MIN	SEC
		.

F. CITY/TOWN

G. STATE

H. ZIP CODE

I. NUMERIC COUNTY CODE

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

5. LEGAL CONTACT:

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

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

C. PHONE *(area code and number)*

D. ORGANIZATION

E. STREET/P.O. BOX

I. OWNERSHIP *(mark "x")*

☐ PRIVATE ☐ PUBLIC ☐ SPECIFY OTHER
☐ STATE ☐ FEDERAL

F. CITY/TOWN

G. STATE

H. ZIP CODE

6. WELL INFORMATION:

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

COMMENTS *(Optional)*:

KEY:

DEG = Degree
MIN = Minute
SEC = Second

SECT = Section
1/4 SECT = Quarter Section

COMM = Commercial
NON-COMM = Non-Commercial

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

EPA Form 7520-16 (Rev. 12-11)

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

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

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

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

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

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

SECTION 4. FACILITY NAME AND LOCATION:

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

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

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

SECTION 5. LEGAL CONTACT:

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

SECTION 6. WELL INFORMATION:

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

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

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

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

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

CLASS III Special Process Injection Wells.

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

CLASS III (CONT'D.)

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

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

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

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

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

Type or print all information. See reverse for instructions.

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

INVENTORY OF INJECTION WELLS

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

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

1. DATE PREPARED *(Year, Month, Day)*: 15-10-15

2. FACILITY ID NUMBER:

PAPERWORK REDUCTION ACT NOTICE

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

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

☐ Deletion ☑ First Time Entry
☐ Entry Change ☐ Replacement

4. FACILITY NAME AND LOCATION

A. NAME *(last, first, and middle initial)*: Former Dowell Facility

B. STREET ADDRESS/ROUTE NUMBER: 3311-3313 Walden Ave.

C. LATITUDE

DEG	MIN	SEC
42	54	44.136

D. LONGITUDE

DEG	MIN	SEC
-78	41	33.6078

E. TOWNSHIP/RANGE

TOWNSHIP	RANGE	SECT	1/4 SECT
--	--	--	--

F. CITY/TOWN: Depew

G. STATE: NY

H. ZIP CODE: 14043

I. NUMERIC COUNTY CODE: 029

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

5. LEGAL CONTACT:

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

B. NAME *(last, first, and middle initial)*: Cocianni, Virgilio

C. PHONE *(area code and number)*: (281) 285-4747

D. ORGANIZATION: Schlumberger Technology Corporation

E. STREET/P.O. BOX: 100 Gillingham Lane

F. CITY/TOWN: Sugar Land

G. STATE: TX

H. ZIP CODE: 77478

I. OWNERSHIP *(mark "x")*

☒ PRIVATE ☐ PUBLIC ☐ SPECIFY OTHER
☐ STATE ☐ FEDERAL

6. WELL INFORMATION:

A. CLASS AND TYPE		B. NUMBER OF WELLS		C. TOTAL NUMBER OF WELLS	D. WELL OPERATION STATUS				
		COMM	NON-COMM		UC	AC	TA	PA	AN
5	X		22	22	22				
				0					
				0					
				0					
				0					
				0					
				0					

COMMENTS *(Optional)*:

Per the EPA Region II list of Class V Inejction Well Types, these wells are classifed as 5X26 - Aquifer Remediation Related Wells

New York State does not use Township/Range (Section E) for property description. The Tax Parcel No. is 104.09-1-15.

KEY:

DEG = Degree
MIN = Minute
SEC = Second
SECT = Section
1/4 SECT = Quarter Section

COMM = Commercial
NON-COMM = Non-Commercial
AC = Active
UC = Under Construction
TA = Temporarily Abandoned
PA = Permanently Abandoned and Approved by State
AN = Permanently Abandoned and not Approved by State

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

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

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

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

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

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

SECTION 4. FACILITY NAME AND LOCATION:

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

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

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

SECTION 5. LEGAL CONTACT:

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

SECTION 6. WELL INFORMATION:

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

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

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

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

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

CLASS III Special Process Injection Wells.

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

CLASS III (CONT’D.)

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

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

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

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

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

PAPERWORK REDUCTION ACT The public reporting and record keeping burden for this collection of information is estimated to average 0.5 hours per response. Burden means the total time, effort, or financial resource expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal Agency. This includes the time needed to review instructions; develop, acquire, install, and utilize technology and systems for the purposes of collecting, validating, and verifying information, processing and maintaining information, and disclosing and providing information; adjust the existing ways to comply with any previously applicable instructions and requirements; train personnel to be able to respond to the collection of information; search data sources; complete and review the collection of information; and, transmit or otherwise disclose the information. An agency may not conduct or sponsor, and a person is not required to respond to, a collection of information unless it displays a currently valid OMB control number. Send comments on the Agency's need for this information, the accuracy of the provided burden estimates, and any suggested methods for minimizing respondent burden, including the use of automated collection techniques to Director, Collection Strategies Division, U.S. Environmental Protection Agency (2822), 1200 Pennsylvania Ave., NW., Washington, D.C. 20460. Include the OMB control number in any correspondence. Do not send the completed forms to this address.

FIGURE 1

Site Location Map

Underground Injection Control Permit Application

Former Dowell Depew Facility, Depew, New York

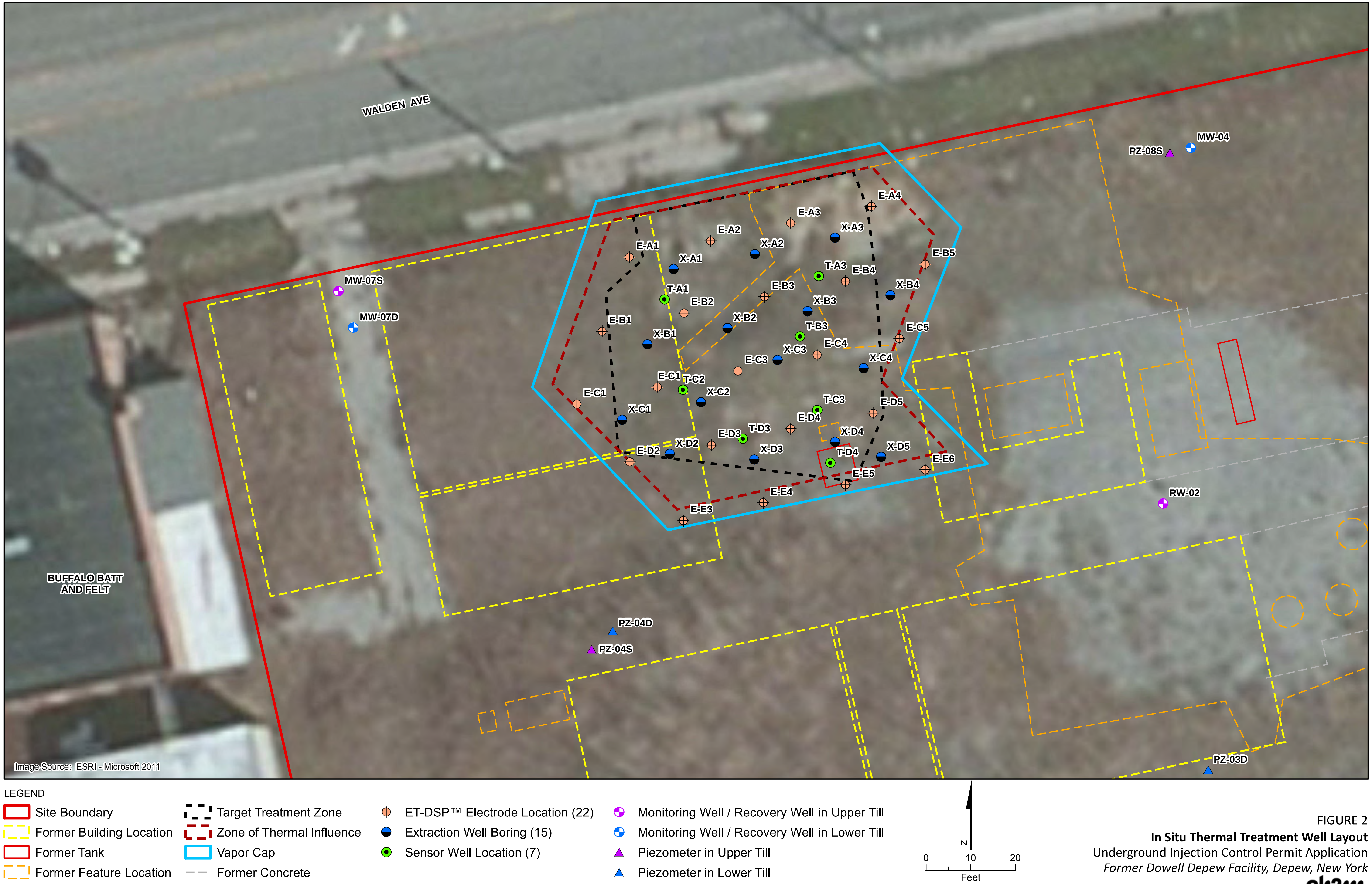


FIGURE 2

In Situ Thermal Treatment Well Layout

Underground Injection Control Permit Application

Former Dowell Depew Facility, Depew, New York

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Appendix H
Analytical Laboratory Reports and Data Quality Evaluation

TECHNICAL MEMORANDUM

Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

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DATE:	February 22, 2017

Introduction

The objective of this data quality evaluation (DQE) technical memorandum is to assess the data quality of analytical results for groundwater, soil, and air sample collected from the Former Dowell Depew Facility in Depew, New York (Dowell Depew). CH2M HILL Engineers, Inc. (CH2M) collected samples March 4 through December 3, 2016, and February 1, 2017. Guidance for this DQE technical memorandum came from the site-specific *Quality Assurance Project Plan, June 2011*; *U.S. Environmental Protection Agency (USEPA) Contract Laboratory National Functional Guidelines (NFG) for Superfund Organic Review, August 2014;* and individual method requirements.

The analytical results were evaluated using the criteria of precision, accuracy, representativeness, comparability, and completeness (PARCC). This report is intended as a general data quality assessment designed to summarize data issues.

Analytical Data

This DQE report covers 55 groundwater samples, 57 air samples, 33 soil samples, 8 groundwater field duplicates (FDs), 9 air FDs, 3 soil FDs, 4 groundwater matrix spike (MS)/matrix spike duplicates (MSDs), one soil MS/MSD, and 26 trip blanks (TBs). The samples were reported in 50 sample delivery groups identified in Table 1.

Table 1. Sample Delivery Groups

Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

200-32459-1	200-35310-1	480-102536-1	480-105949-1	480-91209-1
200-32717-1	200-35325-1	480-103189-1	480-106102-1	480-95395-1
200-32982-1	200-35406-1	480-103879-1	480-106229-1	480-96057-1
200-33269-1	200-35438-1	480-103880-1	480-106476-1	480-97953-1
200-33498-1	200-35529-1	480-104507-1	480-106594-1	480-98922-1
200-33634-1	200-35581-1	480-104696-1	480-106805-1	480-99757-1
200-33868-1	200-35647-1	480-104765-1	480-106936-1	
200-34270-1	480-100485-1	480-104805-1	480-107180-1	
200-34832-1	480-101044-1	480-105112-1	480-107181-1	
200-35055-1	480-101109-1	480-105524-1	480-110467-1	
200-35264-1	480-101875-1	480-105649-1	480-112920-1	

Samples were collected and delivered to TestAmerica Laboratories, Inc., in Amherst, New York, and Burlington, Vermont. The samples were analyzed by the methods listed in Table 2.

Table 2. Analytical Parameters
Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New Y

Parameter	Method	Laboratory
Volatile Organic Compounds (VOCs)	SW8260C	Amherst
VOCs	TO-15	Burlington

The sample delivery groups were assessed by reviewing the following: (1) the chain-of-custody documentation, (2) holding-time compliance, (3) calibration criteria, (4) method blanks/field blanks, (5) laboratory control sample (LCS)/laboratory control sample duplicates (LCSD), (6) surrogate spike recoveries, (7) MS/MSD, (8) internal standard recoveries, (9) field duplicate recoveries, and (10) the required quality control (QC) samples at the specified frequencies.

Data flags were assigned according to the NFG, substituting method criteria where applicable. Multiple flags are routinely applied to specific sample method/matrix/analyte combinations, but there will only be one final flag. A final flag is applied to the data and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample impacts.

The data flags are those listed in the NFG and are defined as follows:

- J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
- R = The sample result was rejected due to serious deficiencies in the ability to analyze the sample and meet the QC criteria. The presence or absence of the analyte could not be verified.
- U = The analyte was analyzed for but was not detected above the reported sample quantitation limit.
- UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Findings

The overall summaries of the data validation are contained in the following subsections.

Holding Time/Preservation

All acceptance criteria were met with the following exception:

- Several groundwater samples associated with Method SW8260C were received at the laboratory with headspace greater than 6 millimeters, resulting in the data being qualified as estimated detected and nondetected results and flagged “J” and “UJ”, respectively, in the associated samples.

Calibration

Initial and continuing calibration analyses were performed as required by the methods, and all acceptance criteria were met, with the following exceptions:

- The percent difference (%D) for chloroethane was greater than method criteria in one initial calibration verification standard (ICVS) associated with Method SW8260C, indicating a possible high bias. The data were not qualified because the associated sample did not contain a reportable level of chloroethane.

- The %Ds for several analytes were less than method criteria in a few continuing calibration verification standards (CCV) associated with Method SW8260C, indicating a possible low bias. The data were qualified as estimated nondetected results and flagged “UJ” in the associated samples.
- The %Ds for several analytes were greater than method criteria in a few CCVs associated with Method SW8260C, indicating a possible high bias. Detected results were qualified as estimated and flagged “J” in the associated samples. Nondetected results were not qualified.
- Acetone exceeded the calibration range of the instrument in samples AIR-INF-01-050616, AIR-INF-01-050616-DUP and AIR-INF-01-061716. The data were qualified as estimated and flagged “J” in the respective samples.

Method Blanks

Method blanks were analyzed at the required frequency and were free of contamination, with the following exceptions:

- Acetone was detected at a concentration less than the reporting limit (RL) in a few method blanks associated with Method SW8260C. Data were qualified as nondetected and flagged “U” when the associated sample concentrations were less than 10 times the blank concentrations.
- Isopropyl alcohol was detected at a concentration less than the RL in one method blank associated with Method TO-15. Data were qualified as estimated and flagged “U” when the associated sample concentrations were less than five times the blank concentration.

Laboratory Control Samples

LCS/LCSDs were analyzed as required, and all accuracy and precision criteria were met, with the following exception:

- The recovery of 1,1,1-trichloroethane was greater than the upper control limit in one LCS associated with Method SW8260C. The data were not qualified because the associated samples did not contain reportable levels of 1,1,1-trichloroethane.

Matrix Spike

MS/MSD samples were analyzed as required, and all accuracy and precision criteria were met, with the following exceptions:

- Several analytes were recovered less than the lower control limits in the MS/MSD for sample SB-03-GW26.5-081716, indicating a possible low bias. The data were qualified as estimated detected and nondetected results and flagged “J” and “UJ”, respectively, in the parent sample.
- Vinyl chloride was recovered greater than the upper control limit in the MSD for sample GW-EFF-01-072916, indicating a possible high bias. The result was not qualified because the parent sample did not contain a reportable level of vinyl chloride.
- Chloroethane and vinyl chloride were recovered greater than the upper control limits in the MS/MSD for sample X-C3-120316, indicating a possible high bias. Detected results were qualified as estimated and flagged “J” in the parent sample. Nondetects were not qualified.
- Several analytes were recovered less than the lower control limits in the MS/MSD for sample SB05-SL15-081816, indicating a possible low bias. The data were qualified as estimated detected and nondetected results and flagged “J” and “UJ”, respectively, in the parent sample.
- The relative percent differences (RPDs) for several analytes recovered greater than criteria in the MS/MSD for sample SB05-SL15-081816. The data were qualified as estimated nondetects and flagged “UJ” in the sample.

Internal Standards

Internal standards were added to all samples, and all acceptance criteria were met.

Surrogates

Surrogates were added to all samples, and all acceptance criteria were met.

Field Duplicates

FDs were collected as required, and all precision criteria were met, with the following exceptions:

- The RPD for acetone recovered greater than criteria in FD pairs GW-INF-01-060316/GW-INF-01-060316-DUP and SB03-SL25-081716/ SB03-SL25-081716-DUP. The data were qualified as estimated and flagged “J” in the respective FD pairs.

Field Blanks

TBs were collected, analyzed, and were free of contamination, with the following exception:

- Dichloromethane was detected at a concentration less than the RL in one TB associated with Method SW8260C. The data were qualified as nondetected and flagged “U” when the associated sample concentrations were less than five times the blank concentration.

Chain of Custody

Required procedures were followed and were generally free of errors.

Overall Assessment

The goal of this assessment is to demonstrate that a sufficient number of representative samples were collected, and the resulting analytical data can be used to support the decision making process.
The following summary highlights the PARCC findings for the above-defined events:

- Precision of the data was verified through the review of the field and laboratory data quality indicators that include FD, LCS/LCSD, and MS/MSD RPDs. Precision was generally acceptable, with the exception of a few analytes that were qualified as estimated detected and nondetected results due to FD and/or MS/MSD RPD issues. Data users should consider the impact to any result that is qualified because it may contain a bias that could affect the decision making process.
- Accuracy of the data was verified through the review of the calibration data, LCS/LCSD, MS/MSD, internal standards, and surrogate standard recoveries, as well as the evaluation of method/field blank data. Accuracy was generally acceptable, with the exception of several analytes that were qualified as estimated detected and nondetected results due to calibration and/or MS/MSD issues. Several analytes were qualified as nondetected in a few samples due to method and/or trip blank contamination.
- Representativeness of the data was verified through the sample’s collection, storage, and preservation procedures, and the verification of holding-time compliance. A few samples were received with headspace greater than 6 millimeters, resulting in the data being qualified as estimated. All samples were reported within the recommended USEPA hold time.
- Comparability of the data was verified through the use of standard USEPA analytical procedures and standard units for reporting. Results obtained are comparable to industry standards in that the collection and analytical techniques followed approved, documented procedures.
- Completeness is a measure of the number of valid measurements obtained in relation to the total number of measurements planned. Completeness is expressed as the percentage of valid or usable measurements compared to planned measurements. Valid data are defined as all data that are not

rejected for project use. All data were considered valid. The completeness goal of 90 percent was met for all method/analytes combinations. The data can be used for project decisions taking into consideration the validation flags applied to the data.

Table 2. Qualified Data
Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
AIR-EFF-01-031016	TO15-PPBV	Isopropyl Alcohol (Isopropanol)	ppb v/v	11	U	LB<RL
AIR-EFF-01-031016	TO15-UGM3	Isopropyl Alcohol (Isopropanol)	μg/m^3	26	U	LB<RL
AIR-EFF-AS-01-031016	TO15-PPBV	Isopropyl Alcohol (Isopropanol)	ppb v/v	8.4	U	LB<RL
AIR-EFF-AS-01-031016	TO15-UGM3	Isopropyl Alcohol (Isopropanol)	μg/m^3	21	U	LB<RL
AIR-INF-01-050616	TO15-PPBV	Acetone	ppb v/v	15,000	J	>ICLinearRange
AIR-INF-01-050616	TO15-UGM3	Acetone	μg/m^3	37,000	J	>ICLinearRange
AIR-INF-01-050616-DUP	TO15-PPBV	Acetone	ppb v/v	12,000	J	>ICLinearRange
AIR-INF-01-050616-DUP	TO15-UGM3	Acetone	μg/m^3	28,000	J	>ICLinearRange
AIR-INF-01-061716	TO15-PPBV	Acetone	ppb v/v	260,000	J	>ICLinearRange
AIR-INF-01-061716	TO15-UGM3	Acetone	μg/m^3	620,000	J	>ICLinearRange
GW-EFF-01-030416	SW8260C	1,2-Dibromo-3-chloropropane	μg/L	0.390	UJ	CCV<LCL
GW-EFF-01-030416	SW8260C	Chloromethane	μg/L	0.350	UJ	CCV<LCL
GW-EFF-01-030416	SW8260C	Dichlorodifluoromethane	μg/L	0.680	UJ	CCV<LCL
GW-EFF-01-060316	SW8260C	1,1-Dichloroethene	μg/L	0.290	UJ	CCV<LCL
GW-EFF-01-060316	SW8260C	Chloroethane	μg/L	0.320	UJ	CCV<LCL
GW-EFF-01-060316	SW8260C	Vinyl Chloride	μg/L	0.900	UJ	CCV<LCL
GW-INF-01-030416	SW8260C	1,1,1-Trichloroethane	μg/L	4.10	UJ	SI
GW-INF-01-030416	SW8260C	1,1,2,2-Tetrachloroethane	μg/L	1.05	UJ	SI
GW-INF-01-030416	SW8260C	1,1,2-Trichloroethane	μg/L	1.15	UJ	SI
GW-INF-01-030416	SW8260C	1,1-Dichloroethane	μg/L	3.98	J	SI

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Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
GW-INF-01-030416	SW8260C	1,1-Dichloroethene	µg/L	1.45	UJ	SI
GW-INF-01-030416	SW8260C	1,2,4-Trichlorobenzene	µg/L	2.05	UJ	SI
GW-INF-01-030416	SW8260C	1,2-Dibromo-3-chloropropane	µg/L	1.95	UJ	SI
GW-INF-01-030416	SW8260C	1,2-Dibromoethane	µg/L	3.65	UJ	SI
GW-INF-01-030416	SW8260C	1,2-Dichlorobenzene	µg/L	3.95	UJ	SI
GW-INF-01-030416	SW8260C	1,2-Dichloroethane	µg/L	1.05	UJ	SI
GW-INF-01-030416	SW8260C	1,2-Dichloropropane	µg/L	3.60	UJ	SI
GW-INF-01-030416	SW8260C	1,3-Dichlorobenzene	µg/L	3.90	UJ	SI
GW-INF-01-030416	SW8260C	1,4-Dichlorobenzene	µg/L	4.20	UJ	SI
GW-INF-01-030416	SW8260C	2-Butanone	µg/L	6.60	UJ	SI
GW-INF-01-030416	SW8260C	2-Hexanone	µg/L	6.20	UJ	SI
GW-INF-01-030416	SW8260C	4-Methyl-2-Pentanone	µg/L	10.5	UJ	SI
GW-INF-01-030416	SW8260C	Acetone	µg/L	1040	J	SI
GW-INF-01-030416	SW8260C	Benzene	µg/L	2.05	UJ	SI
GW-INF-01-030416	SW8260C	Bromodichloromethane	µg/L	1.95	UJ	SI
GW-INF-01-030416	SW8260C	Bromoform	µg/L	1.30	UJ	SI
GW-INF-01-030416	SW8260C	Bromomethane	µg/L	3.45	UJ	SI
GW-INF-01-030416	SW8260C	Carbon Disulfide	µg/L	10.3	J	SI
GW-INF-01-030416	SW8260C	Carbon tetrachloride	µg/L	1.35	UJ	SI
GW-INF-01-030416	SW8260C	Chlorobenzene	µg/L	3.75	UJ	SI

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Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
GW-INF-01-030416	SW8260C	Chlorodibromomethane	µg/L	1.60	UJ	SI
GW-INF-01-030416	SW8260C	Chloroethane	µg/L	1.60	UJ	SI
GW-INF-01-030416	SW8260C	Chloroform	µg/L	1.70	UJ	SI
GW-INF-01-030416	SW8260C	Chloromethane	µg/L	1.75	UJ	SI
GW-INF-01-030416	SW8260C	cis-1,2-Dichloroethene	µg/L	8.79	J	SI
GW-INF-01-030416	SW8260C	cis-1,3-Dichloropropene	µg/L	1.80	UJ	SI
GW-INF-01-030416	SW8260C	Cyclohexane	µg/L	0.900	UJ	SI
GW-INF-01-030416	SW8260C	Dichlorodifluoromethane	µg/L	3.40	UJ	SI
GW-INF-01-030416	SW8260C	Dichloromethane	µg/L	2.22	U	TB<RL, SI (J)
GW-INF-01-030416	SW8260C	Ethylbenzene	µg/L	3.70	UJ	SI
GW-INF-01-030416	SW8260C	Freon 113	µg/L	1.55	UJ	SI
GW-INF-01-030416	SW8260C	Isopropylbenzene	µg/L	3.95	UJ	SI
GW-INF-01-030416	SW8260C	Methyl Acetate	µg/L	6.50	UJ	SI
GW-INF-01-030416	SW8260C	Methyl tert-butyl ether (MTBE)	µg/L	0.800	UJ	SI
GW-INF-01-030416	SW8260C	Methylcyclohexane	µg/L	0.800	UJ	SI, CCV<LCL
GW-INF-01-030416	SW8260C	Styrene	µg/L	3.65	UJ	SI
GW-INF-01-030416	SW8260C	Tetrachloroethene	µg/L	1.80	UJ	SI
GW-INF-01-030416	SW8260C	Toluene	µg/L	2.55	UJ	SI
GW-INF-01-030416	SW8260C	trans-1,2-Dichloroethene	µg/L	4.50	UJ	SI
GW-INF-01-030416	SW8260C	trans-1,3-Dichloropropene	µg/L	1.85	UJ	SI

Table 2. Qualified Data

Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
GW-INF-01-030416	SW8260C	Trichloroethylene	µg/L	2.30	UJ	SI
GW-INF-01-030416	SW8260C	Trichlorofluoromethane	µg/L	4.40	UJ	SI
GW-INF-01-030416	SW8260C	Vinyl Chloride	µg/L	4.50	UJ	SI
GW-INF-01-030416	SW8260C	Xylenes, Total	µg/L	3.30	UJ	SI
GW-INF-01-030416-DUP	SW8260C	1,2-Dibromo-3-chloropropane	µg/L	0.390	UJ	CCV<LCL
GW-INF-01-030416-DUP	SW8260C	Chloromethane	µg/L	0.350	UJ	CCV<LCL
GW-INF-01-030416-DUP	SW8260C	Dichlorodifluoromethane	µg/L	0.680	UJ	CCV<LCL
GW-INF-01-030416-DUP	SW8260C	Dichloromethane	µg/L	0.559	U	TB<RL
GW-INF-01-050616	SW8260C	1,1,1-Trichloroethane	µg/L	3.28	UJ	SI
GW-INF-01-050616	SW8260C	1,1-Dichloroethane	µg/L	5.06	J	SI
GW-INF-01-050616	SW8260C	1,1-Dichloroethene	µg/L	1.16	UJ	SI
GW-INF-01-050616	SW8260C	1,2-Dichloroethane	µg/L	0.840	UJ	SI
GW-INF-01-050616	SW8260C	1,2-Dichloroethene (Total)	µg/L	10.7	J	SI
GW-INF-01-050616	SW8260C	Acetone	µg/L	437	J	SI
GW-INF-01-050616	SW8260C	Benzene	µg/L	1.64	UJ	SI
GW-INF-01-050616	SW8260C	Chloroethane	µg/L	1.28	UJ	SI
GW-INF-01-050616	SW8260C	cis-1,2-Dichloroethene	µg/L	10.7	J	SI
GW-INF-01-050616	SW8260C	Ethylbenzene	µg/L	2.96	UJ	SI
GW-INF-01-050616	SW8260C	Tetrachloroethene	µg/L	2.34	J	SI
GW-INF-01-050616	SW8260C	Trichloroethylene	µg/L	1.94	J	SI

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Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
GW-INF-01-050616	SW8260C	Vinyl Chloride	µg/L	3.60	UJ	SI
GW-INF-01-050616	SW8260C	Xylenes, Total	µg/L	2.64	UJ	SI
GW-INF-01-050616-DUP	SW8260C	1,1,1-Trichloroethane	µg/L	3.28	UJ	SI
GW-INF-01-050616-DUP	SW8260C	1,1-Dichloroethane	µg/L	4.79	J	SI
GW-INF-01-050616-DUP	SW8260C	1,1-Dichloroethene	µg/L	1.16	UJ	SI
GW-INF-01-050616-DUP	SW8260C	1,2-Dichloroethane	µg/L	0.840	UJ	SI
GW-INF-01-050616-DUP	SW8260C	1,2-Dichloroethene (Total)	µg/L	10.5	J	SI
GW-INF-01-050616-DUP	SW8260C	Acetone	µg/L	390	J	SI
GW-INF-01-050616-DUP	SW8260C	Benzene	µg/L	1.64	UJ	SI
GW-INF-01-050616-DUP	SW8260C	Chloroethane	µg/L	1.28	UJ	SI
GW-INF-01-050616-DUP	SW8260C	cis-1,2-Dichloroethene	µg/L	10.5	J	SI
GW-INF-01-050616-DUP	SW8260C	Ethylbenzene	µg/L	2.96	UJ	SI
GW-INF-01-050616-DUP	SW8260C	Tetrachloroethene	µg/L	1.91	J	SI
GW-INF-01-050616-DUP	SW8260C	Trichloroethylene	µg/L	1.84	UJ	SI
GW-INF-01-050616-DUP	SW8260C	Vinyl Chloride	µg/L	3.60	UJ	SI
GW-INF-01-050616-DUP	SW8260C	Xylenes, Total	µg/L	2.64	UJ	SI
GW-INF-01-060316	SW8260C	Acetone	µg/L	1010	J	FD>RPD
GW-INF-01-060316-DUP	SW8260C	1,1-Dichloroethene	µg/L	2.90	UJ	CCV<LCL
GW-INF-01-060316-DUP	SW8260C	Acetone	µg/L	613	J	FD>RPD
GW-INF-01-060316-DUP	SW8260C	Chloroethane	µg/L	3.20	UJ	CCV<LCL

Table 2. Qualified Data

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Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
GW-INF-01-060316-DUP	SW8260C	Vinyl Chloride	µg/L	9.00	UJ	CCV<LCL
SB01-SL15-081716	SW8260C	Acetone	µg/kg	44.6	U	LB<RL
SB01-SL1620-060116	SW8260C	Acetone	µg/kg	29.3	U	LB<RL
SB01-SL2024-060116	SW8260C	Acetone	µg/kg	33.4	U	LB<RL
SB01-SL24.5-081716	SW8260C	Acetone	µg/kg	25.0	U	LB<RL
SB01-SL2428-060116	SW8260C	Acetone	µg/kg	30.8	U	LB<RL
SB02-SL0408-060116	SW8260C	Acetone	µg/kg	47.0	U	LB<RL
SB02-SL20-081716	SW8260C	Acetone	µg/kg	46.0	U	LB<RL
SB02-SL2024-060116	SW8260C	Acetone	µg/kg	32.2	U	LB<RL
SB-03-GW26.5-081716	SW8260C	1,1,1-Trichloroethane	µg/L	0.820	UJ	SD<LCL
SB-03-GW26.5-081716	SW8260C	1,1-Dichloroethane	µg/L	76.7	J	MS<LCL, SD<LCL
SB-03-GW26.5-081716	SW8260C	1,1-Dichloroethene	µg/L	26.8	J	MS<LCL, SD<LCL
SB-03-GW26.5-081716	SW8260C	Acetone	µg/L	217	J	MS<LCL, SD<LCL
SB-03-GW26.5-081716	SW8260C	Chloroethane	µg/L	0.320	UJ	SD<LCL
SB-03-GW26.5-081716	SW8260C	cis-1,2-Dichloroethene	µg/L	15.2	J	MS<LCL, SD<LCL
SB-03-GW26.5-081716	SW8260C	Tetrachloroethene	µg/L	0.360	UJ	MS<LCL, SD<LCL
SB-03-GW26.5-081716	SW8260C	Trichloroethene	µg/L	5.89	J	MS<LCL, SD<LCL
SB-03-GW26.5-081716	SW8260C	Vinyl Chloride	µg/L	7.96	J	MS<LCL, SD<LCL
SB03-SL1620-060116	SW8260C	Acetone	µg/kg	28.7	U	LB<RL
SB03-SL2024-060116	SW8260C	Acetone	µg/kg	25.7	U	LB<RL
SB03-SL2428-060116	SW8260C	Acetone	µg/kg	33.5	U	LB<RL

Table 2. Qualified Data

Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
SB03-SL25-081716	SW8260C	Acetone	µg/kg	31.7	U	LB<RL, FD>RPD (J)
SB03-SL25-081716-DUP	SW8260C	Acetone	µg/kg	201	J	FD>RPD
SB04-SL12-081716	SW8260C	Acetone	µg/kg	46.5	U	LB<RL
SB04-SL1620-060116	SW8260C	Acetone	µg/kg	2.93	U	LB<RL
SB04-SL2024-060116	SW8260C	Acetone	µg/kg	14.8	U	LB<RL
SB04-SL2428-060116	SW8260C	Acetone	µg/kg	12.1	U	LB<RL
SB05-GW23.75-081916	SW8260C	Acetone	µg/L	530	J	CCV>UCL
SB05-SL15-081816	SW8260C	1,1,1-Trichloroethane	µg/kg	0.300	UJ	SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	1,1-Dichloroethane	µg/kg	0.504	UJ	SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	1,1-Dichloroethene	µg/kg	0.506	UJ	SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	1,2-Dichloroethane	µg/kg	0.207	UJ	MS<LCL, SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	1,2-Dichloroethene, Total	µg/kg	2.17	UJ	MS<LCL, SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	Acetone	µg/kg	172	J	MS<LCL, SD<LCL
SB05-SL15-081816	SW8260C	Benzene	µg/kg	0.202	UJ	MS<LCL, SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	Chloroethane	µg/kg	0.934	UJ	SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	cis-1,2-Dichloroethene	µg/kg	0.529	UJ	MS<LCL, SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	Ethylbenzene	µg/kg	0.285	UJ	MS<LCL, SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	Tetrachloroethene	µg/kg	0.555	UJ	MS<LCL, SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	Trichloroethene	µg/kg	0.909	UJ	MS<LCL, SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	Vinyl Chloride	µg/kg	0.504	UJ	SD<LCL, MSRPD
SB05-SL15-081816	SW8260C	Xylenes, Total	µg/kg	0.694	UJ	MS<LCL, SD<LCL, MSRPD
SB08-SL12-081816	SW8260C	Acetone	µg/kg	29.4	U	LB<RL
SB10-SL14.5-100616	SW8260C	Acetone	µg/kg	42.7	U	LB<RL
SB11-SL14.5-100616	SW8260C	Acetone	µg/kg	76.9	U	LB<RL

Table 2. Qualified Data

Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
SB11-SL14.5-100616-DUP	SW8260C	Acetone	µg/kg	46.6	U	LB<RL
X-A3-120316	SW8260C	Vinyl Chloride	µg/L	24.5	J	CCV>UCL
X-A3-120316-DUP	SW8260C	Vinyl Chloride	µg/L	25.5	J	CCV>UCL
XA3-GW01-100616	SW8260C	1,1-Dichloroethene	µg/L	0.580	UJ	CCV<LCL
XA3-GW01-100616	SW8260C	Acetone	µg/L	177	J	CCV>UCL
X-A3-WELL-01-091616	SW8260C	Acetone	µg/L	133	J	CCV>UCL
X-A3-WELL-01-092316	SW8260C	1,1,1-Trichloroethane	µg/L	1.64	UJ	SI
X-A3-WELL-01-092316	SW8260C	1,1-Dichloroethane	µg/L	4.64	J	SI
X-A3-WELL-01-092316	SW8260C	1,1-Dichloroethene	µg/L	0.580	UJ	SI
X-A3-WELL-01-092316	SW8260C	1,2-Dichloroethane	µg/L	0.420	UJ	SI
X-A3-WELL-01-092316	SW8260C	1,2-Dichloroethene, Total	µg/L	3.54	J	SI
X-A3-WELL-01-092316	SW8260C	Acetone	µg/L	40.9	J	SI
X-A3-WELL-01-092316	SW8260C	Benzene	µg/L	0.820	UJ	SI
X-A3-WELL-01-092316	SW8260C	Chloroethane	µg/L	0.640	UJ	SI
X-A3-WELL-01-092316	SW8260C	cis-1,2-Dichloroethene	µg/L	3.54	J	SI
X-A3-WELL-01-092316	SW8260C	Ethylbenzene	µg/L	1.48	UJ	SI
X-A3-WELL-01-092316	SW8260C	Tetrachloroethene	µg/L	0.720	UJ	SI
X-A3-WELL-01-092316	SW8260C	Trichloroethene	µg/L	1.72	J	SI
X-A3-WELL-01-092316	SW8260C	Vinyl Chloride	µg/L	4.34	J	SI
X-A3-WELL-01-092316	SW8260C	Xylenes, Total	µg/L	1.32	UJ	SI
X-A3-WELL-01-092716	SW8260C	1,1,1-Trichloroethane	µg/L	3.28	UJ	SI
X-A3-WELL-01-092716	SW8260C	1,1-Dichloroethane	µg/L	4.92	J	SI

Table 2. Qualified Data

Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason
X-A3-WELL-01-092716	SW8260C	1,1-Dichloroethene	µg/L	1.16	UJ	SI
X-A3-WELL-01-092716	SW8260C	1,2-Dichloroethane	µg/L	0.840	UJ	SI
X-A3-WELL-01-092716	SW8260C	1,2-Dichloroethene, Total	µg/L	3.55	J	SI
X-A3-WELL-01-092716	SW8260C	Acetone	µg/L	44.7	J	SI
X-A3-WELL-01-092716	SW8260C	Benzene	µg/L	1.64	UJ	SI
X-A3-WELL-01-092716	SW8260C	Chloroethane	µg/L	1.28	UJ	SI
X-A3-WELL-01-092716	SW8260C	cis-1,2-Dichloroethene	µg/L	3.55	J	SI
X-A3-WELL-01-092716	SW8260C	Ethylbenzene	µg/L	2.96	UJ	SI
X-A3-WELL-01-092716	SW8260C	Tetrachloroethene	µg/L	1.44	UJ	SI
X-A3-WELL-01-092716	SW8260C	Trichloroethene	µg/L	2.26	J	SI
X-A3-WELL-01-092716	SW8260C	Vinyl Chloride	µg/L	3.60	UJ	SI
X-A3-WELL-01-092716	SW8260C	Xylenes, Total	µg/L	2.64	UJ	SI
X-A3-WELL-01-100316	SW8260C	1,1-Dichloroethene	µg/L	1.16	UJ	CCV<LCL
X-A3-WELL-9-093016	SW8260C	Acetone	µg/L	83.8	J	CCV>UCL
X-C3-120316	SW8260C	Vinyl Chloride	µg/L	2.35	J	MS>UCL, SD>UCL
Y-A3-WELL-01-091416	SW8260C	Acetone	µg/L	175	J	CCV>UCL

ppb v/v = parts per billion by volume
µg/m^3 = micrograms per cubic meter
µg/L = micrograms per liter

Validation Reasons:

>ICLinearRange	The analyte exceeded the calibration range of the instrument.
CCV<LCL	The continuing calibration verification standard was recovered less than method criteria.
CCV>UCL	The continuing calibration verification standard was recovered greater than method criteria.
FD>RPD	The relative percent difference exceeded criteria in the field duplicate pair.
LB<RL	The analyte was detected in the method blank at a concentration less than the reporting limit.
MS<LCL	The matrix spike sample was recovered less than the lower control limit.
MS>UCL	The matrix spike sample was recovered greater than the upper control limit.

Table 2. Qualified Data

Data Quality Evaluation for 2016 Remedial Action Investigation, Former Dowell Depew Facility, Depew, New York

Native ID	Method	Analyte	Units	Final Result	Validation Flag	Validation Reason

MSRPD	The relative percent difference exceeded criteria in the matrix spike/matrix spike duplicate.
SD<LCL	The matrix spike duplicate sample was recovered less than the lower control limit.
SD>UCL	The matrix spike duplicate sample was recovered greater than the upper control limits.
SI	Sample integrity. The samples were received with headspace.
TB<RL	The analyte was detected in the trip blank at a concentration less than the reporting limit.

Laboratory Analytical Reports Provided on CD

Appendix I
Waste Management

JCRS Spent Carbon Profile

Return form to:
Tetrasolv Filtration
1424 Abraham Dr
Anderson, IN 46013
765-643-3949 fax

FOR OFFICE USE ONLY

DATE:
RPA NUMBER:
APPROVED BY:

1. CUSTOMER INFORMATION

APPLICANT NAME: CH2M
CITY: St. Louis STATE: MO ZIP

GENERATOR NAME: Schlumberger Technology Corporation
ADDRESS: 3311 Walden Ave
CITY: Depew STATE: NY ZIP 14043

SITE NAME: Schlumberger Technology Corporation - Depew site
ADDRESS: 3311 Walden Ave
CITY: Depew STATE: NY ZIP 14043

NAME OF CONTACT: Lisa Schwan/CH2M TITLE: Waste Coordinator
PHONE: 404-414-2505 FAX:

2. STREAM COMPONENTS

A. PRINCIPLE CHEMICALS PRESENT AND ESTIMATED AMOUNT ON THE ACTIVATED CARBON.

	CHEMICAL	AMOUNT
(1)		
(2)		
(3)		
(4)		
(5)		
(6)		

B. APPLICATION

GROUNDWATER	XX	ODOR CONTROL	☐
POTABLE WATER (SURFACE/RIVER)	☐	INDOOR AIR	☐
INDUSTRIAL PROCESS (GAS)	☐	AIR STRIPPER	☐
INDUSTRIAL PROCESS (LIQUID)	☐	SOIL VENTING	☐
INDUSTRIAL WASTEWATER	☐	FOOD PROCESS	☐
SOLVENT RECOVERY	☐	UST/AST	☐
SPILL/EMERGENCY	☐	OTHER	☐

REQUIRED
PLEASE PROVIDE A DESCRIPTION OF THE PROCESS INCLUDING THE IDENTIFICATION OF THE STREAM AND POTENTIAL CONTAMINANTS.

Carbon used to treat chlorinated solvents in groundwater

3. CARBON PROPERTIES

COAL BASE: ☐
COCONUT BASE: XX
CLAY/CARBON MIX: ☐
OTHER: ☐

VAPOR: ☐
LIQUID: XX

FREE FLOWING:
YES ☐
NO ☐

PELLET: ☐
POWDER: ☐

IMPREGNATED:
YES ☐

JCRS Spent Carbon Profile

MESH SIZE: ________ GRANULAR: ☐ NO ☐

4. REGULATORY PROFILE

	YES	NO
A. IS THE ACTIVATED CARBON A HAZARDOUS WASTE AS DEFINED BY 40 CFR PART 261?	☐	XX
B. IS THE CARBON AN "F", "P", OR "U" WASTE LISTED UNDER 40 CFR 261?	☐	XX
C. WAS THE CARBON USED TO TREAT A HAZARDOUS WASTE OR TO REMEDIATE SPILLS OF A HAZARDOUS WASTE AS DEFINED BY 40 CFR 261?	☐	XX
D. IS THE SPENT ACTIVATED CARBON FROM ONE SOURCE?	XX	☐
E. DOES THE ACTIVATED CARBON CONTAIN CHEMICALS LISTED IN THE TCLP EPA RULE?	☐	XX
F. IS THE CARBON USED TO REMEDIATE PETROLEUM SPILLS FROM AN UNDERGROUND STORAGE TANK OR AN ABOVE GROUND STORAGE TANK?	☐	XX

IF YES, IDENTIFY THE STORED SOLVENT, AND WHETHER IT WAS UNUSED OR USED IN AN APPLICATION

SOLVENT: ____________ UNUSED ☐ USED ☐

5. SAFETY PROFILE

A. ARE ANY OF THE FOLLOWING TYPES OF COMPOUNDS, MATERIALS OR CONDITIONS PRESENT?
IF YES, IDENTIFY AND ESTIMATE AMOUNT IN STREAM.

	Y/N	IF YES, IDENTIFY; ESTIMATE AMOUNT
(1) POLYCHLORINATED BIPHENYLS (PCB)	XX	
(2) DIOXINS	XX	
(3) 1,2 DIBROMO-3-CHLOROPROPANE (DBCP)	XX	
(4) BIOLOGICAL, PATHOGENIC OR ETIOLOGIC AGENTS	XX	
(5) EXPLOSIVE (PYROPHORIC/SHOCK) MATERIAL	XX	
(6) HEAVY METALS	XX	
(7) STRONG ODOR/ODOR CAUSING	XX	
(8) SULFUR OR SULFUR-CONTAINING ORGANICS	XX	
(9) RADIOACTIVE MATERIAL	XX	
(10) CORROSIVE OR IGNITIABLE	XX	
(11) METHYL ETHYL KETONE/ALKYL KETONES	XX	
(12) CYCLOHEXANONE	XX	
(13) CHLORINE/CHLORINE CONTAINING ORGANICS	XX	
(14) AMINES	XX	

B. LIST ANY ACUTE OR CHRONIC HAZARDS ASSOCIATED WITH OR ALLEGED TO BE ASSOCIATED WITH HUMAN CONTACT OR EXPOSURE TO THE STREAM COMPONENTS:

None

JCRS Spent Carbon Profile

6. TCLP RESULTS

BRL - below regulatory limit

		TCLP Result
Ignitable	flash pt. < 140°F	No
Corrosive	2 ≥ pH ≥ 12.5	No
Reactive	Yes or No	No
Arsenic	≥ 5.0 mg/L	BRL
Berium	≥ 100.0 mg/L	BRL
Cadmium	≥ 1.0 mg/L	BRL
Chromium	≥ 5.0 mg/L	BRL
Lead	≥ 5.0 mg/L	BRL
Mercury	≥ 0.2 mg/L	BRL
Selenium	≥ 1.0 mg/L	BRL
Silver	≥ 5.0 mg/L	BRL
Endrin	≥ 0.02 mg/L	BRL
Lindane	≥ 0.4 mg/L	BRL
Methoxychlor	≥ 10.0 mg/L	BRL
Toxaphene	≥ 1.0 mg/L	BRL
2,4-D	≥ 10.0 mg/L	BRL
2,4,5-TP (SILVEX)	≥ 1.0 mg/L	BRL
Benzene	≥ 0.5 mg/L	BRL
Carbon Tetrachloride	≥ 0.5 mg/L	BRL
Chlordane	≥ 0.03 mg/L	BRL
Chlorobenzene	≥ 100.0 mg/L	BRL
Chloroform	≥ 5.0 mg/L	BRL

		TCLP Result
Vinyl Chloride	≥ 0.2 mg/L	BRL
2,4,6-Trichlorophenol	≥ 2.0 mg/L	BRL
2,4,5-Trichlorophenol	≥ 400.0 mg/L	BRL
Tricloroethylene (TCE)	≥ 0.5 mg/L	BRL
Pyridine	≥ 5.0 mg/L	BRL
Pentachlorophenol	≥ 100.0 mg/L	BRL
Nitrobenzene	≥ 2.0 mg/L	BRL
Methyl ethyl ketone	≥ 200.0 mg/L	BRL
Hexachloroethane	≥ 3.0 mg/L	BRL
Hexachloro-1,3-butadiene	≥ 0.5 mg/L	BRL
Hexachlorobenzene	≥ 0.13 mg/L	BRL
Heptachlor (epoxide too)	≥ 0.008 mg/L	BRL
2,4-Dinitrotoluene	≥ 0.13 mg/L	BRL
1,1 Dichloroethylene	≥ 0.7 mg/L	BRL
1,2-Dichloroethane	≥ 0.5 mg/L	BRL
1,4-Dichlorobenzene	≥ 7.5 mg/L	BRL
Tetrachloroethane (PCE)	≥ 0.7 mg/L	BRL
p-Cresol	≥ 200.0 mg/L	BRL
m-Cresol	≥ 200.0 mg/L	BRL
o-Cresol	≥ 200.0 mg/L	BRL

7. NOTES

(1) THIS APPLICATION SHOULD BE COMPLETED FOR EACH SOURCE OF THE SPENT CARBON. THE ACCURACY OF THE INFORMATION PROVIDED IS THE ORIGINATOR'S RESPONSIBILITY; YOU ARE REQUIRED TO NOTIFY US OF ANY CHANGES OF THE INFORMATION ON THE FORM.

(2) A COPY OF THE APPROVED APPLICATION HAS TO BE SUBMITTED WITH EACH SHIPMENT OF SPENT CARBON BEFORE ADVANCED RECOVERY TECHNOLOGIES CORP. ACCEPTS THE CARBON FOR REACTIVATION.

8. CERTIFICATION

TO THE BEST OF MY KNOWLEDGE AND ABILITY THE INFORMATION PROVIDED IS COMPLETE, ACCURATE AND TRUE.

NAME Lisa Schwan/CH2M as agent for Schlumberger Technology Corporation

TITLE Waste Coordinator

SIGNATURE

DATE 11/4/2016

JCRS Spent Carbon Profile

Return form to: Tetrasolv Filtration 1424 Abraham Dr Anderson, IN 46013 765-643-3949 fax	FOR OFFICE USE ONLY **DATE:** **RPA NUMBER:** **APPROVED BY:**

1. CUSTOMER INFORMATION

APPLICANT NAME: CH2M
CITY: St. Louis STATE: MO ZIP

GENERATOR NAME: Schlumberger Technology Corporation
ADDRESS: 3311 Walden Ave
CITY: Depew STATE: NY ZIP 14043

SITE NAME: Schlumberger Technology Corporation - Depew site
ADDRESS: 3311 Walden Ave
CITY: Depew STATE: NY ZIP 14043

NAME OF CONTACT: Lisa Schwan/CH2M TITLE: Waste Coordinator
PHONE: 404-414-2505 FAX:

2. STREAM COMPONENTS

A. PRINCIPLE CHEMICALS PRESENT AND ESTIMATED AMOUNT ON THE ACTIVATED CARBON.

	CHEMICAL	AMOUNT
(1)		
(2)		
(3)		
(4)		
(5)		
(6)		

B. APPLICATION

GROUNDWATER	☐	ODOR CONTROL	☐
POTABLE WATER (SURFACE/RIVER)	☐	INDOOR AIR	☐
INDUSTRIAL PROCESS (GAS)	☐	AIR STRIPPER	☐
INDUSTRIAL PROCESS (LIQUID)	☐	SOIL VENTING	XX
INDUSTRIAL WASTEWATER	☐	FOOD PROCESS	☐
SOLVENT RECOVERY	☐	UST/AST	☐
SPILL/EMERGENCY	☐	OTHER	☐

REQUIRED

PLEASE PROVIDE A DESCRIPTION OF THE PROCESS INCLUDING THE IDENTIFICATION OF THE STREAM AND POTENTIAL CONTAMINANTS.

Carbon used to treat chlorinated solvents in vapor

3. CARBON PROPERTIES

COAL BASE:	☐	VAPOR:	XX	FREE FLOWING:	
COCONUT BASE:	XX	LIQUID:	☐	YES	☐
CLAY/CARBON MIX:	☐			NO	☐
OTHER:	☐				
		PELLET:	☐	IMPREGNATED:	
		POWDER:	☐	YES	☐

JCRS Spent Carbon Profile

MESH SIZE: ________ GRANULAR: ☐ NO ☐

4. REGULATORY PROFILE

	YES	NO
A. IS THE ACTIVATED CARBON A HAZARDOUS WASTE AS DEFINED BY 40 CFR PART 261?		XX
B. IS THE CARBON AN "F", "P", OR "U" WASTE LISTED UNDER 40 CFR 261?		XX
C. WAS THE CARBON USED TO TREAT A HAZARDOUS WASTE OR TO REMEDIATE SPILLS OF A HAZARDOUS WASTE AS DEFINED BY 40 CFR 261?		XX
D. IS THE SPENT ACTIVATED CARBON FROM ONE SOURCE?	XX	
E. DOES THE ACTIVATED CARBON CONTAIN CHEMICALS LISTED IN THE TCLP EPA RULE?		XX
F. IS THE CARBON USED TO REMEDIATE PETROLEUM SPILLS FROM AN UNDERGROUND STORAGE TANK OR AN ABOVE GROUND STORAGE TANK?		XX

IF YES, IDENTIFY THE STORED SOLVENT, AND WHETHER IT WAS UNUSED OR USED IN AN APPLICATION

SOLVENT: ____________ UNUSED ☐ USED ☐

5. SAFETY PROFILE

A. ARE ANY OF THE FOLLOWING TYPES OF COMPOUNDS, MATERIALS OR CONDITIONS PRESENT?
IF YES, IDENTIFY AND ESTIMATE AMOUNT IN STREAM.

	Y/N	IF YES, IDENTIFY; ESTIMATE AMOUNT
(1) POLYCHLORINATED BIPHENYLS (PCB)	XX	
(2) DIOXINS	XX	
(3) 1,2 DIBROMO-3-CHLOROPROPANE (DBCP)	XX	
(4) BIOLOGICAL, PATHOGENIC OR ETIOLOGIC AGENTS	XX	
(5) EXPLOSIVE (PYROPHORIC/SHOCK) MATERIAL	XX	
(6) HEAVY METALS	XX	
(7) STRONG ODOR/ODOR CAUSING	XX	
(8) SULFUR OR SULFUR-CONTAINING ORGANICS	XX	
(9) RADIOACTIVE MATERIAL	XX	
(10) CORROSIVE OR IGNITIABLE	XX	
(11) METHYL ETHYL KETONE/ALKYL KETONES	XX	
(12) CYCLOHEXANONE	XX	
(13) CHLORINE/CHLORINE CONTAINING ORGANICS	XX	
(14) AMINES	XX	

B. LIST ANY ACUTE OR CHRONIC HAZARDS ASSOCIATED WITH OR ALLEGED TO BE ASSOCIATED WITH HUMAN CONTACT OR EXPOSURE TO THE STREAM COMPONENTS:

None

JCRS Spent Carbon Profile

6. TCLP RESULTS

BRL - below regulatory limit

		TCLP Result
Ignitable	flash pt. < 140°F	No
Corrosive	2 ≥ pH ≥ 12.5	No
Reactive	Yes or No	No
Arsenic	≥ 5.0 mg/L	BRL
Berium	≥ 100.0 mg/L	BRL
Cadmium	≥ 1.0 mg/L	BRL
Chromium	≥ 5.0 mg/L	BRL
Lead	≥ 5.0 mg/L	BRL
Mercury	≥ 0.2 mg/L	BRL
Selenium	≥ 1.0 mg/L	BRL
Silver	≥ 5.0 mg/L	BRL
Endrin	≥ 0.02 mg/L	BRL
Lindane	≥ 0.4 mg/L	BRL
Methoxychlor	≥ 10.0 mg/L	BRL
Toxaphene	≥ 1.0 mg/L	BRL
2,4-D	≥ 10.0 mg/L	BRL
2,4,5-TP (SILVEX)	≥ 1.0 mg/L	BRL
Benzene	≥ 0.5 mg/L	BRL
Carbon Tetrachloride	≥ 0.5 mg/L	BRL
Chlordane	≥ 0.03 mg/L	BRL
Chlorobenzene	≥ 100.0 mg/L	BRL
Chloroform	≥ 5.0 mg/L	BRL

		TCLP Result
Vinyl Chloride	≥ 0.2 mg/L	BRL
2,4,6-Trichlorophenol	≥ 2.0 mg/L	BRL
2,4,5-Trichlorophenol	≥ 400.0 mg/L	BRL
Tricloroethylene (TCE)	≥ 0.5 mg/L	BRL
Pyridine	≥ 5.0 mg/L	BRL
Pentachlorophenol	≥ 100.0 mg/L	BRL
Nitrobenzene	≥ 2.0 mg/L	BRL
Methyl ethyl ketone	≥ 200.0 mg/L	BRL
Hexachloroethane	≥ 3.0 mg/L	BRL
Hexachloro-1,3-butadiene	≥ 0.5 mg/L	BRL
Hexachlorobenzene	≥ 0.13 mg/L	BRL
Heptachlor (epoxide too)	≥ 0.008 mg/L	BRL
2,4-Dinitrotoluene	≥ 0.13 mg/L	BRL
1,1 Dichloroethylene	≥ 0.7 mg/L	BRL
1,2-Dichloroethane	≥ 0.5 mg/L	BRL
1,4-Dichlorobenzene	≥ 7.5 mg/L	BRL
Tetrachloroethane (PCE)	≥ 0.7 mg/L	BRL
p-Cresol	≥ 200.0 mg/L	BRL
m-Cresol	≥ 200.0 mg/L	BRL
o-Cresol	≥ 200.0 mg/L	BRL

7. NOTES

(1) THIS APPLICATION SHOULD BE COMPLETED FOR EACH SOURCE OF THE SPENT CARBON. THE ACCURACY OF THE INFORMATION PROVIDED IS THE ORIGINATOR'S RESPONSIBILITY; YOU ARE REQUIRED TO NOTIFY US OF ANY CHANGES OF THE INFORMATION ON THE FORM.

(2) A COPY OF THE APPROVED APPLICATION HAS TO BE SUBMITTED WITH EACH SHIPMENT OF SPENT CARBON BEFORE ADVANCED RECOVERY TECHNOLOGIES CORP. ACCEPTS THE CARBON FOR REACTIVATION.

8. CERTIFICATION

TO THE BEST OF MY KNOWLEDGE AND ABILITY THE INFORMATION PROVIDED IS COMPLETE, ACCURATE AND TRUE.

NAME Lisa Schwan/CH2M as agent for Schlumberger Technology Corporation

TITLE Waste Coordinator

SIGNATURE

DATE 11/4/2016

NON-HAZARDOUS WASTE MANIFEST

Manifest Tracking Number 111216A

Job Number T4209

tetraSOLV FILTRATION

2. Generator's Information

Schlumberger Technology Corporation Generators
Agent: CH2M
14701 St. Mary's Lane, Suite 300
Houston, TX 77079
Attn: Meghan Courtney - 314.477.7284

3. Site Address (If Different from Item 2)

Schlumberger Technology Corporation
3311 Walden Ave
Depew, NY 14043

Designated Facility Information: Cabot Norit Americas Reactivation Facility - Pryor, OK

4. Waste Shipping Name / Description	5. Quantity	6. Type of Container
a. Non-RCRA regulated waste material, spent activated carbon, liquid phase filtration media	2000#	☐ Steel Drum ■ Supersack ☐ Other ________ Disc.
b. Non-RCRA regulated waste material, spent activated carbon, Vapor phase filtration media	2250#	☐ Steel Drum ____ Gal. ■ Supersack ☐ Other ________ Disc.
c.		☐ Steel Drum ____ Gal. ☐ Supersack ☐ Other ________ Disc.
d.		☐ Steel Drum ____ Gal. ☐ Supersack ☐ Other ________ Disc.

7. Additional Descriptions / Special Handling / Additional Information

Spent activated carbon material weight basis on dry product, actual weight may vary. See attached MSDS sheet for specific product hazards.

8. GENERATOR'S CERTIFICATION: I Certify the materials described above on this manifest are not subject to federal regulations for reporting proper disposal of Hazardous Waste Materials.

Please Print Name	Please Sign Name	Date of Shipment
Wayne Conway	/CH2M As agent For Schlumberger Technolo Corporation	11-12-16

PLEASE DO NOT COMPLETE ANY INFORMATION BELOW THIS LINE

Discrepancy Indication

FACILITY OPERATOR CERTIFICATION: I Certify the receipt of materials described above except as noted above.

Please Print Name	Please Sign Name	Date of Receipt

Instructions for Completion

2 Clearly write Generator Address. Please note the signed receipt copy will be returned to this address.
3. Alternate site address if applicable
*** Note for 3,4 and 5: A separate line must be used for each different type of packaging.**
4. Cross through any lines not used
5. Quantity of item (Example: "1000 Lbs")
6. Check type of container and indicate size of drum or if other, describe (Example: "1,000 Lb. Steel Tank")
7. Use for any other information regarding items. Preface items with the appropriate letter for line.
8. Print, sign and date.

Important: ***Any shipments sent to our plant will be rejected unless the drums are marked with the Manifest Tracking Number and a completed copy of this manifest.***

Tetrasolv Services 401 N. Velasco St. Houston, TX 77003 Office (765) 643-3941 Fax (765) 643-3949

AMERICAN RECYCLERS COMPANY
Waste Profile Report (WPR)

177 Wales Avenue **Tonawanda, New York 14151** ***Phone (716) 695-6720 Fax (716) 695-0161***	**APPROVAL NUMBER:** **EXPIRATION DATE:** **HANDLING CODE:**

Generator: Schlumberger Technology Corporation
EPA ID #:
Address: 3311 Walden Ave
Contact: Lisa Schwan/CH2M
City Depew **STATE:** NY **ZIP:** 14043
Phone: 404-414-2505 **Fax:**

Waste Name: Nonhazardous sludge	**Shipping Name:** Nonhazardous, non-regulated waste
Generating Process: sludge from knockout tank during insitu VOC treatment process	
	Rate of Generation: one time
	Container Type: Vacuum truck

Composition of Waste	**%**		**%**
Water	10-50		
Sediment	30-75		
biological Scale	5-25		

Phase	**%**
Solids	
Liquid	
Sludge	100
Debris	

Is the material RCRA listed or Characteristicly Hazardous?	☐ YES	☒ NO
Does the material contain Medical or Biological Wastes?	☐ YES	☒ NO
Does the material contain etiological waste?	☐ YES	☒ NO
Does the material contain, or has it come in contact with PCB's?	☐ YES	☒ NO
Is the material radioactive?	☐ YES	☒ NO
Does the material contain septic or domestic sewage?	☐ YES	☒ NO
Is the material Non-Hazardous as defined by RCRA Title 40?	☐ YES	☒ NO

Check all below which apply:

Material is to be shipped and recycled as Universal Waste	☐ YES	☒ NO
Material is to be shipped and recycled under 6 NYCRR Part 371.1(g)(1)(ii)(b) *(ie Computer Equipment & monitors)*	☐ YES	☒ NO
Material is being shipped for disposal/recycle via facility transfer/consolidation permit	☐ YES	☒ NO
Material is a Labpack and all contents are CERTIFIED as Non-RCRA	☐ YES	☒ NO
List all Lab Pack Container Numbers: *(Attach packing slips to profile)*		

I certify that the above submitted information (including any attachments) is true, accurate and complete to the best of my knowledge and ability and that all known and suspected hazards have been disclosed. All material offered herein is deemed Non-RCRA.

Signer Title Waste Coordinator
Company CH2M

Lisa Schwan/CH2M as agent for Schlumberger Technology Corporation

Signed: **Print:** **Date:** 11/9/16

ARC Presonel Reviewed and Approved by:

Approved by: **Print:** **Date:**

Please print or type
(Form designed for use on elite (12-pitch) typewriter.)

NON-HAZARDOUS WASTE MANIFEST	1. Generator ID Number	2. Page 1 of 1	3. Emergency Response Phone 800-535-5053	4. Waste Tracking Number 22724

5. Generator's Name and Mailing Address
GENERATOR AGENT: Schlumberger Technology Corp. / Generators Agent:
CH2M Hill 14701 St. Mary's Ln, Ste 30
Houston, TX 77079
Attn: Meghan Courtney
Generator's Phone: ~~[illegible]~~ (314) 477-7284

Generator's Site Address (if different than mailing address)
Schlumberger Technology Corporation
3311 Walden Ave
Depew, NY 14043

6. Transporter 1 Company Name
Environmental Service Group, Inc 716.695.6720
U.S. EPA ID Number NYD986903904

7. Transporter 2 Company Name
U.S. EPA ID Number

8. Designated Facility Name and Site Address
American Recyclers Company
177 Wales Avenue
Tonawanda, NY 14150
Facility's Phone: 716.695.6720
U.S. EPA ID Number NYR000030809

	9. Waste Shipping Name and Description	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.
	1. Non RCRA Non DOT Regulated Water, Sludge	001	TT	1838	G
	2.				
	3.				
	4.				

13. Special Handling Instructions and Additional Information

Also Fits:
1 -
2 -
3 -

Approval #:
1 - X-11808IN
2 -
3 -
4 -

Handling Codes:
1 - None
2 -
3 -
4 -

24 Hour Emergency Contact:
INFOTRAC (Caller Must ID ESG)
Consult ERG#:

14. GENERATOR'S/OFFEROR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations.

Generator's/Offeror's Printed/Typed Name: x Wayne Conway fCH2M - As Agent for Schlumberger tech. Corporation
Signature: Wayne Conway
Month 11 Day 10 Year 16

15. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter Signature (for exports only): Date leaving U.S.:

16. Transporter Acknowledgment of Receipt of Materials
Transporter 1 Printed/Typed Name: Michael W Peterson
Signature:
Month 11 Day 10 Year 16
Transporter 2 Printed/Typed Name:
Signature:
Month Day Year

17. Discrepancy
17a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection
Manifest Reference Number:
17b. Alternate Facility (or Generator)
U.S. EPA ID Number
Facility's Phone:
17c. Signature of Alternate Facility (or Generator)
Month Day Year

18. Designated Facility Owner or Operator: Certification of receipt of materials covered by the manifest except as noted in Item 17a
Printed/Typed Name: Julian Mastropoll
Signature:
Month 11 Day 10 Year 16

GENERATOR — INT'L — TRANSPORTER — DESIGNATED FACILITY

GC Labels • Printed in the USA
1-800-997-6966

DESIGNATED FACILITY TO GENERATOR

Reorder Part# MANIFEST-C6NHWC
913-897-6966

WASTE MANAGEMENT

EZ Profile™

Requested Facility: Chaffee Landfill ☐ Unsure Profile Number:

☐ Check if there are multiple generator locations. Attach locations. ☐ COD ☐ Renewal? Original Profile Number:

A. GENERATOR INFORMATION (MATERIAL ORIGIN)

1. Generator Name: Dowell Schlumberger
2. Site Address: 3311 Walden Avenue
   (City, State, ZIP) Depew, NY 14043
3. County:
4. Contact Name: Jody Sanchez
5. Email: jody.sanchez@ch2m.com
6. Phone: 530-229-3443 7. Fax:
8. Generator EPA ID: CESQG ☐ N/A
9. State ID: ☐ N/A

B. BILLING INFORMATION

☐ SAME AS GENERATOR

1. Billing Name: Clean Harbors
2. Billing Address: 42 Longwater Drive
   (City, State, ZIP) Norwell, MA 02061
3. Contact Name: Jeff Brown
4. Email: brown.jeffrey@cleanharbors.com
5. Phone: 336-339-7179 6. Fax:
7. WM Hauled? ☐ Yes ☑ No
8. P.O. Number:

C. MATERIAL INFORMATION

1. Common Name: Non Hazardous soil

Describe Process Generating Material: ☐ See Attached

Soil removal for Remediation System Installation

2. Material Composition and Contaminants: ☐ See Attached

1. Soil	98-99%
2. PPE, plastic, debris	1-2%
3.	
4.	
	≥100%

3. State Waste Codes: ☑ N/A
4. Color: Brown
5. Physical State at 70°F: ☑ Solid ☐ Liquid ☐ Other:
6. Free Liquid Range Percentage: to ☑ N/A (Solid)
7. pH: to ☑ N/A (Solid)
8. Strong Odor: ☐ Yes ☑ No Describe:
9. Flash Point: ☐ <140°F ☐ 140°–199°F ☐ ≥200° ☑ N/A (Solid)

D. REGULATORY INFORMATION

1. EPA Hazardous Waste? ☐ Yes* ☑ No
   Code:
2. State Hazardous Waste? ☐ Yes ☑ No
   Code:
3. Is this material non-hazardous due to Treatment, Delisting, or an Exclusion? ☐ Yes* ☑ No
4. Contains Underlying Hazardous Constituents? ☐ Yes* ☑ No
5. Contains benzene **and** subject to Benzene NESHAP? ☐ Yes* ☑ No
6. Facility remediation subject to 40 CFR 63 GGGGG? ☐ Yes* ☑ No
7. CERCLA or State-mandated clean-up? ☐ Yes* ☑ No
8. NRC or State-regulated radioactive or NORM waste? ☐ Yes* ☑ No

***If Yes, see Addendum (page 2) for additional questions and space.**

9. Contains PCBs? → If Yes, answer a, b and c. ☐ Yes ☑ No
   a. Regulated by 40 CFR 761? ☐ Yes ☑ No
   b. Remediation under 40 CFR 761.61 (a)? ☐ Yes ☑ No
   c. Were PCB imported into the US? ☐ Yes ☑ No
10. Regulated and/or Untreated Medical/Infectious Waste? ☐ Yes ☑ No
11. Contains Asbestos? ☐ Yes ☑ No
    → If Yes: ☐ Non-Friable ☐ Non-Friable – Regulated ☐ Friable

E. ANALYTICAL AND OTHER REPRESENTATIVE INFORMATION

1. Analytical attached ☑ Yes

Please identify applicable samples and/or lab reports:

Lab Report 480-89374-1

2. Other information attached (such as MSDS)? ☐ Yes

F. SHIPPING AND DOT INFORMATION

1. ☑ One-Time Event ☐ Repeat Event/Ongoing Business
2. Estimated Quantity/Unit of Measure: 60
   ☑ Tons ☐ Yards ☐ Drums ☐ Gallons ☐ Other:
3. Container Type and Size: Rolloff
4. USDOT Proper Shipping Name: ☐ N/A
   Non Hazardous, Non Regulated

G. GENERATOR CERTIFICATION (PLEASE READ AND CERTIFY BY SIGNATURE)

By signing this EZ Profile™ form, I hereby certify that all information submitted in this and all attached documents contain true and accurate descriptions of this material, and that all relevant information necessary for proper material characterization and to identify known and suspected hazards has been provided. Any analytical data attached was derived from a sample that is representative as defined in 40 CFR 261 - Appendix 1 or by using an equivalent method. All changes occurring in the character of the material (i.e., changes in the process or new analytical) will be identified by the Generator and be disclosed to Waste Management prior to providing the material to Waste Management.

If I am an agent signing on behalf of the Generator, I have confirmed with the Generator that information contained in this Profile is accurate and complete.

Name (Print): Date:

Title:

Company:

Certification Signature

THINK GREEN.®

QUESTIONS? CALL 800 963 4776 FOR ASSISTANCE

WASTE MANAGEMENT

EZ Profile™ Addendum

Only complete this Addendum if prompted by responses on EZ Profile™ (page 1) or to provide additional information. Sections and question numbers correspond to EZ Profile™.

Profile Number: ____________

C. MATERIAL INFORMATION

Describe Process Generating Material (Continued from page 1): If more space is needed, please attach additional pages.

Material Composition and Contaminants (Continued from page 1): If more space is needed, please attach additional pages.

5.	
6.	
7.	
8.	
9.	
10.	
	≥100%

D. REGULATORY INFORMATION

Only questions with a "Yes" response in Section D on the EZ Profile™ form (page 1) need to be answered here.

1. EPA Hazardous Waste
   a. Please list all USEPA listed and characteristic waste code numbers:
   b. Is the material subject to the Alternative Debris standards (40 CFR 268.45)? ☐ Yes ☐ No
   c. Is the material subject to the Alternative Soil standards (40 CFR 268.49)? → If Yes, complete question 4. ☐ Yes ☐ No
   d. Is the material exempt from Subpart CC Controls (40 CFR 264.1083 and 265.1084)? ☐ Yes ☐ No
      → If Yes, please select one of the following:
      ☐ Waste has been determined to be LDR exempt [265.1083(c)(4) and 265.1084(c)(4)] based on the fact that it meets all applicable organic treatment standards (including UHCs for D-coded characteristic wastes) or a Specified Technology has been utilized.
      ☐ Waste does not qualify for a LDR exemption, but the average VOC at the point of origination is <500 ppmw and this determination was based on analytical testing (upload copy of analysis) or generator knowledge.
2. State Hazardous Waste → Please list all state waste codes: ____________
3. For material that is Treated, Delisted, or Excluded → Please indicate the category, below:
   ☐ Delisted Hazardous Waste ☐ Excluded Waste under 40 CFR 261.4 → Specify Exclusion: ____________
   ☐ Treated Hazardous Waste Debris ☐ Treated Characteristic Hazardous Waste → If checked, complete question 4.
4. Underlying Hazardous Constituents → Please list all Underlying Hazardous Constituents:
5. Benzene NESHAP → Please include percent water/moisture in chemical composition.
   a. Are you a TSDF? → If yes, please complete Benzene NESHAP questionnaire. If not, continue.
   b. What is your facility's current total annual benzene quantity in Megagrams? ☐ <1 Mg ☐ 1–9.99 Mg ☐ ≥10 Mg
      1. Flow weighted average benzene concentration is ____________ ppmw.
   c. Is this waste soil from remediation at a closed facility? ☐ Yes ☐ No
      1. Benzene concentration in remediation waste is ____________ ppmw.
   d. Has material been treated to remove 99% of the benzene or to achieve <10 ppmw? ☐ Yes ☐ No
   e. Is material exempt from controls in accordance with 40 CFR 61.342? ☐ Yes ☐ No
      → If yes, specify exemption: ____________
   f. Based on your knowledge of your waste and the BWON regulations, do you believe that this waste stream is subject to treatment and control requirements at an off-site TSDF? ☐ Yes ☐ No
6. 40 CFR 63 GGGGG → Does the material contain <500 ppmw VOHAPs at the point of determination? ☐ Yes ☐ No
7. CERCLA or State-Mandated clean up → Please submit the Record of Decision or other documentation to assist others in the evaluation for proper disposal.
8. NRC or state regulated radioactive or NORM Waste → Please identify Isotopes and pCi/g: ____________

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QUESTIONS? CALL 800 963 4776 FOR ASSISTANCE

Last Revised April 26, 2013

Additional Profile Information

Profile Number: ______________

C. MATERIAL INFORMATION

Material Composition and Contaminants (Continued from page 2): If more space is needed, please attach additional pages.

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34.	
35.	
36.	
37.	
38.	
39.	
40.	
	≥100%

D. REGULATORY INFORMATION

1. EPA Hazardous Waste
   a. Please list all USEPA listed and characteristic waste code numbers (Continued from page 2):

Site Address: 3311 Walden Avenue
Depew,NY 14043

SC PPW 9/11/2015

WORK ORDER NO. SY 1503992140 001

DOCUMENT NO. 872401

STRAIGHT BILL OF LADING

TRANSPORTER 1 Clean Harbors Environmental Service, Inc. VEHICLE ID # 41258

EPA ID # MAD039322250 TRANS. 1 PHONE (781) 792 5000

TRANSPORTER 2 VEHICLE ID #

EPA ID # TRANS. 2 PHONE

DESIGNATED FACILITY Waste Management Inc	SHIPPER ATTN:Heather McColgin-Dial Dowell Schlumberger
FACILITY EPA ID # N/A	SHIPPER EPA ID # CESQG
ADDRESS 10860 Olean Road	ADDRESS Generator Agent: CH2MHill 14701 St. Marys Lane, Suite 300
CITY Chaffee STATE NY ZIP 14030	CITY Houston STATE TX ZIP 77079

CONTAINERS NO. & SIZE	TYPE	HM	DESCRIPTION OF MATERIALS	TOTAL QUANTITY	UNIT WT/VOL
20YD	CM		A. NON HAZARDOUS, NON D.O.T. REGULATED, (BULK SOIL)	15	T
			B.		
			C.		
			D.		
			E.		
			F.		
			G.		
			H.		

SPECIAL HANDLING INSTRUCTIONS
A.115832NY PO# 4150647678
EMERGENCY PHONE #: (800) 483-3718 GENERATOR: Dowell Schlumberger

SHIPPERS CERTIFICATION: This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

SHIPPER PRINT Clint Sta [illegible] / CH2M H [illegible] Schlumberger [illegible]	SIGN [illegible]	DATE
TRANSPORTER 1 PRINT Adden R. Hunter	SIGN	DATE 12/10/15
TRANSPORTER 2 PRINT	SIGN	DATE
RECEIVED BY PRINT	SIGN	DATE

4

Site Address: 3311 Walden Avenue
Depew,NY 14043

SC PPW 9/11/2015
WORK ORDER NO. SY 1503982140-001

DOCUMENT NO. 872403

STRAIGHT BILL OF LADING

TRANSPORTER 1 Clean Harbors Environmental Service, Inc. VEHICLE ID # 41258
EPA ID # MAD039322250 TRANS. 1 PHONE (781) 792-5000
TRANSPORTER 2 VEHICLE ID #
EPA ID # TRANS. 2 PHONE

DESIGNATED FACILITY Waste Management Inc	SHIPPER ATTN:Heather McColgin-Dial Dowell Schlumberger
FACILITY EPA ID # N/A	SHIPPER EPA ID # CESQG
ADDRESS 10860 Olean Road	ADDRESS Generator Agent: CH2MHill 14701 St. Marys Lane, Suite 300
CITY Chaffee STATE NY ZIP 14030	CITY Houston STATE TX ZIP 77079

CONTAINERS NO. & SIZE	TYPE	HM	DESCRIPTION OF MATERIALS	TOTAL QUANTITY	UNIT WT/VOL
20YD	CM		A. NON HAZARDOUS, NON D.O.T. REGULATED, (BULK SOIL)	15	T
			B.		
			C.		
			D.		
			E.		
			F.		
			G.		
			H.		

SPECIAL HANDLING INSTRUCTIONS
EMERGENCY PHONE #: (800) 483-3718 GENERATOR: Dowell Schlumberger
A.115832NY A# 150647678

SHIPPERS CERTIFICATION: This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

SHIPPER PRINT [illegible]	SIGN [illegible]	DATE [illegible]
TRANSPORTER 1 PRINT Alden R Hunter	SIGN Alden R	DATE 12/10/15
TRANSPORTER 2 PRINT	SIGN	DATE
RECEIVED BY PRINT	SIGN	DATE

4

CHI 107

Site Address: 3311 Walden Avenue
Depew,NY 14043

SC PPW 9/11/2015

WORK ORDER NO: 1503982140-001

DOCUMENT NO. 872404

STRAIGHT BILL OF LADING

TRANSPORTER 1 Clean Harbors Environmental Service, Inc. VEHICLE ID #

EPA ID # MAD039322250 TRANS. 1 PHONE (781) 792-5000

TRANSPORTER 2 VEHICLE ID #

EPA ID # TRANS. 2 PHONE

DESIGNATED FACILITY Waste Management Inc			SHIPPER ATTN:Heather McColgin-Dial Dowell Schlumberger		
FACILITY EPA ID # N/A			SHIPPER EPA ID # CESQG		
ADDRESS 10860 Olean Road			ADDRESS Generator Agent: CH2MHill 14701 St. Marys Lane, Suite 300		
CITY Chaffee	STATE NY	ZIP 14030	CITY Houston	STATE TX	ZIP 77079

CONTAINERS NO. & SIZE	TYPE	HM	DESCRIPTION OF MATERIALS	TOTAL QUANTITY	UNIT WT/VOL
20 YD	CM		A. NON HAZARDOUS, NON D.O.T. REGULATED, (BULK SOIL)	15	T
			B.		
			C.		
			D.		
			E.		
			F.		
			G.		
			H.		

SPECIAL HANDLING INSTRUCTIONS
EMERGENCY PHONE #: (800) 483-3718 GENERATOR: Dowell Schlumberger
A.115832NY PO# W150647678

SHIPPERS CERTIFICATION: This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

SHIPPER PRINT [illegible]	SIGN	DATE
TRANSPORTER 1 PRINT [illegible]	SIGN	DATE 10/12/15
TRANSPORTER 2 PRINT	SIGN	DATE
RECEIVED BY PRINT	SIGN	DATE

4

CHI 107