Corrective Action Plan - Final

Gasoline Fueling Station – Royal Farms #96
500 Mechanics Valley Road
North East, Cecil County, Maryland 21901

OCP Case No. 2011-0729-CE
MDE Facility No. 13326

AEC Project Number: 05-056 RF096

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ADVANTAGE ENVIRONMENTAL CONSULTANTS, LLC

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1.0 INTRODUCTION

1.1 Project Overview and History

As required by the Maryland Department of the Environment (MDE) Oil Control Program (OCP), Advantage Environmental Consultants, LLC (AEC) has prepared this Final Corrective Action Plan (CAP) which presents the design of a dual-phase enhanced fluid recovery (EFR) system for the property located at 500 Mechanics Valley Road in North East, Maryland. The MDE OCP Case Number is 2011-0729-CE. The MDE Facility Identification Number is 13326. This report was prepared in accordance with the MDE OCP guidelines set forth in the Maryland Environmental Assessment Technology (MEAT) for Leaking Underground Storage Tanks (LUSTs) document, Revised February 2003. Other guidance for this report included a document titled “RF 96 Meeting Minutes” prepared by MDE and distributed on March 13, 2012.

Based on abbreviated EFR pilot studies conducted on July 21 and 22, 2011 a CAP was prepared and submitted to the MDE on July 25, 2011. The CAP presented the following remediation system design criteria: radius of influence (ROI) - 20 feet; individual recovery well flow rate – 3.2 gallons per minute (gpm); individual recovery well drawdown – up to 5 feet below static groundwater; and, individual recovery well air flow rate - 50 cubic feet per minute (cfm). Data collected during the course of the initial pilot study did not provide some necessary final design parameters associated with the feasibility of the technology and process/treatment equipment sizing. As such, the performance of a full scale EFR pilot study was recommended in the CAP.

Based on the full scale EFR pilot study conducted on July 27, 2011, using equipment enabling the necessary design data to be collected, a CAP Addendum (August 3, 2011) was developed. The full scale EFR pilot study indicated the following remediation system design criteria: ROI - 25 feet; individual recovery well flow rate – 4 to 6 gpm; individual recovery well drawdown - 4 feet below static groundwater; and, individual recovery well air flow rate - 50 cfm.

Both the CAP and the CAP Addendum planned on an EFR design using liquid ring pump (LRP) technology. The CAP and CAP Addendum selected the LRP technology based on extraction at eight recovery wells. Based on a technical meeting with the MDE, an expansion of the recovery system to a range of 10 to 13 wells was required. As a result of the increased system flow rates from the additional wells, the standard LRP equipment would be reaching its maximum design capabilities. As such, a Design Basis Summary was created that introduced the dual phase approach using integrated vapor extraction/groundwater extraction (VE/GE) technology. The VE/GE will be implemented using pneumatic submersible pumps for liquid removal and a positive displacement vacuum blower for vapor removal. This technology is similar to LRP induced EFR but offers the capability for increased flow rates.

This final CAP presents the design and the means and methods for the design implementation for the selected system. The CAP also provides startup and operational guidance for the system.

1.2 Site Description and Background

The Site is situated in a commercial/residential area located southeast of the intersection of Mechanics Valley Road and Pulaski Highway in North East, Cecil County, Maryland. The Site is developed with a convenience store/gasoline fueling station and associated landscaped, asphalt- and concrete-paved areas. Site Vicinity and Site Features Maps are provided in Appendix A as Figures 1 and 2, respectively. The surrounding properties include single family residences to the west, and commercial properties to the south, east and north. A Site Area Map is included as Figure 3 in Appendix A.

On June 8, 2011, AEC was performing an annual groundwater sampling event in accordance with Code of Maryland Regulations (COMAR) 26.10.02.03-04, when approximately two-inches of liquid phase hydrocarbon (LPH) were detected in groundwater monitoring well MW-3. The LPH was observed to be golden in color, indicating 'un-weathered' gasoline. AEC inspected the submersible turbine pump (STP) containment sumps, which were observed to be free of LPH. Royal Farms was informed of the field observations made by AEC and a suspected release of petroleum was reported to the MDE OCP on June 8, 2011. On June 13, 2011 the MDE opened a case in response to a report of evidence of a petroleum spill at the Site. Based on LPH plume configuration and visual observations during underground storage tank (UST) system piping removal, the source of the release was probably between dispensers 3-4 and 7-8 (see Figure 2 in Appendix A).

1.3 Site Investigation Activities

Pursuant to the various MDE OCP directives the following documents and reports have been prepared for the release investigation activities:

Emergency Subsurface Environmental Investigation Report, prepared by AEC and dated July 19, 2011. This report details the collection of soil and groundwater samples from 24 boring locations (B-1 through B-24). The borings were advanced to depths ranging from 15 to 20 feet bgs. Temporary piezometers were installed in all but one of the borings. In order to delineate the horizontal and vertical extent of the release, the initial borings were advanced around MW-3 and the subsequent borings arrayed outward from MW-3. These boring locations are illustrated on Figure 4 in Appendix A.

Corrective Action Plan, prepared by AEC and dated July 22, 2011. The CAP presents the design for a multi-phase EFR system. The design is based upon data collected from the abbreviated EFR pilot studies performed in July 2011, as well as site characterization investigations, review of historical well gauging/sampling data, and vac-truck EFR performance characteristics. Since data collected during the course of the initial pilot study associated with the CAP did not provide some necessary final design parameters with regard to feasibility of the technology and process/treatment equipment sizing, it recommended that a 4- to 8-hour pilot study be conducted using a LRP skid.

Recovery Well Install Data Pack, prepared by AEC and dated August 2, 2011. This document included boring logs, well construction diagrams and soil sample laboratory analytical results from the installation of six groundwater recovery (RW-1 thru RW-6) and five groundwater monitoring (MW-4 thru MW-8) wells between July 14 and 19, 2011. The wells were completed to depths ranging from 24 to 26 feet bgs. Figure 2 in Appendix A illustrates the recovery and monitoring well locations.

Corrective Action Plan Addendum, prepared by AEC and dated August 3, 2011. The CAP Addendum describes the results of the EFR pilot study using the LRP skid. The report concluded that the high permeability of the coarse grained soils below the Site presents a challenging environment for the EFR remedy. The combined water flow rate necessary for providing hydraulic control and meeting the primary remedial objective (LPH removal to a sheen) will necessitate the use of relatively large capacity process equipment.

Surfactant Flush Pilot Study Work Plan, prepared by AEC and dated August 9, 2011. This document was prepared as a companion to the August 3, 2011 CAP Addendum. The primary objective of the work plan was to evaluate the effectiveness of surfactant flushing assisted by EFR extraction for LPH removal. This approach would augment current groundwater remediation efforts by promoting increased solubility and mobility of the residual and mobile LPH within the release area. The work plan described the surfactant injection/extraction means and methods, and pre- and post-flushing groundwater monitoring activities. This plan was not approved by the MDE.

Design Basis Summary, prepared by AEC and dated September 13, 2011. The Design Basis Summary was based on the July 27, 2011 EFR pilot study findings which developed remediation system design criteria. The Design Basis Summary described the dual phase recovery technology which replaced the EFR technology due to water and vapor recovery limitations of the EFR equipment. The main design change was the use of pneumatic submersible pumps for liquid removal and a positive displacement vacuum blower for vapor removal. A copy of this document is included in Appendix B.

Underground Storage Tank System Closure Report, prepared by AEC and dated October 17, 2011. This report described the UST system removal activities and the excavation oversight and confirmatory sampling associated with this task. The UST system was removed in order to upgrade the storage and piping infrastructure and further investigate the petroleum release.

4th Quarter 2011 Groundwater Monitoring Report, prepared by AEC and dated January 10, 2012 (this is the latest on-site monitoring well sampling report as of the writing of this document). This document included a groundwater gradient map, a groundwater quality map, a table of onsite and offsite groundwater sample analytical results, and laboratory analytical reports from the December 11, 2011 testing event.

Dual Phase System Design Pilot Study Report, prepared by AEC and dated January 31, 2012. This report describes the results of the dual phase integrated VE/GE pilot study using pneumatic submersible pumps for liquid removal and a positive displacement vacuum blower for vapor removal. The MDE required these additional pilot studies to confirm that proposed system modifications outlined in the Design Basis Summary will be capable of achieving the previously established ROI. Excerpts of this document are included in Appendix C.

Deep Well Installation Data Package, prepared by AEC and dated February 6, 2012. This document included MDE well completion reports from the installation of three deep bedrock wells between January 26 and February 2, 2012. The wells were completed to depths ranging from 161.5 to 201 feet bgs. Figure 2 in Appendix A illustrates the deep bedrock well locations.

Offsite Potable Well Sample Results Data Package, prepared by AEC and dated February 21, 2012 (this is the latest off-site potable well sampling report as of the writing of this document). This document included a groundwater quality map, a table of offsite groundwater sample analytical results, and laboratory analytical reports from the February 8, 2012 testing event.

Recovery Well Installation Data Package, prepared by AEC and dated March 20, 2012. This document included boring logs/well completion reports and MDE well completion reports from the installation of seven groundwater recovery (RW-7 thru RW-13) and nine groundwater monitoring (MW-1R and MW-9 thru MW-16) wells between October 13 and 27, 2011. The borings were completed to depths ranging from 25 to 30 feet bgs. Figure 2 in Appendix A illustrates the recovery and monitoring well locations.

AEC has conducted EFR operations via a vac-truck since June 13, 2011. The EFR is conducted using a “stinger” tube which is lowered into the wells to a depth of approximately two-feet below the static water level. The stinger tube is fitted at the well head with a well seal to allow for both fluid and vapor extraction. Between June 13 and July 18, 2011 the vac-truck EFR operations were conducted on MW-3. As the recovery wells became operational between July 16 through 19, 2011 and October 13 through 27, 2011, select wells were added to the EFR program via a piping manifold. The vac-truck EFR operation is currently conducted weekly for four hours per event.

A recent review of the liquid level gauging data from June 13, 2011 through March 23, 2012 indicates the following regarding LPH thicknesses in the recovery and monitoring wells:

Well Identification	Date of Last Appearance of LPH
MW-1, MW-1R, MW-2, MW-4, MW-5, MW-9, MW-10, MW-11, MW-12, MW-13, MW-14, MW-15, MW-16, MW-10-D, MW-12-D, MW-13-D	No LPH observed since well installation
MW-6 (Sheen)	LPH last observed January 3, 2012
MW-8 (Sheen)	LPH last observed January 21, 2012
RW-5 (Sheen), RW-12 (Sheen)	LPH last observed January 31, 2012
MW-7 (Sheen), RW-1 (Sheen), RW-9(Sheen)	LPH last observed February 1, 2012
RW-11 (Sheen)	LPH last observed February 7, 2012
RW-8 (Sheen)	LPH last observed February 8, 2012

Well Identification	Date of Last Appearance of LPH
RW-7 (Sheen)	LPH last observed February 9, 2012
MW-3 (Sheen), RW-6 (Sheen), RW-13 (Sheen)	LPH last observed February 16, 2012
RW-10 (Sheen)	LPH last observed March 1, 2012
RW-2 (Sheen)	LPH last observed March 15, 2012
RW-3 (0.01'), RW-4 (0.03')	LPH last observed March 23, 2012

These reductions in LPH thicknesses have been realized by the sustained vacuum truck recovery efforts.

There has been a reduction of the dissolved phase hydrocarbon (DPH) plume as demonstrated by comparison of the two groundwater testing data sets (September 15, 2011 and December 15, 2011). This comparison is tabulated below:

Well Identification	Groundwater Gradient Position Relative to Release Area	Relative Comparison of DPH Quality (9-15-11 and 12-15-11 data sets)	Specific Comparison of Total BTEX (9-15-11 and 12-15-11 data sets)
MW-2	Down	Decrease	66/BDL
MW-4	Side	Decrease	12.2/BDL
MW-5	Up	Static	BDL/BDL
MW-6	Up	Decrease	60/BDL
MW-7	Down	Decrease	26,800/2,293
MW-8	Down	Decrease	72.2/24.9

B = Benzene; T = Toluene; E = Ethylbenzene; X = Xylene
All results in parts per billion or µg/l BDL = Below Detection Limits

The DPH plume generally resides in the coarse grained soil layer within the water bearing unit. EFR pilot studies have shown that this coarse grained soil layer is highly transmissive for fluid and vapor flow.

Specific findings, results and conclusions from the various testing and investigation events are detailed in the documents introduced in the preceding pages.

2.0 CONCEPTUAL MODEL

2.1 Geology and Hydrology

According to the United States Geological Survey (USGS) 7.5-Minute Series North East, MD Topographic Quadrangle, the Site elevation is approximately 70 feet above mean sea level (msl). Surface drainage at the Site is generally to the west towards Little North East Creek, a tributary of the North East Creek, located approximately 1,400 feet west of the Site at its closest point. The site area topography is illustrated on Figure 1 in Attachment A.

According to the Maryland Geological Survey's Geologic Map of Maryland (1968); the Site is located in the Atlantic Coastal Plain physiographic province, which is situated east of the fall line that separates the unconsolidated sediments of the Atlantic Coastal Plain province from the metamorphic units of the Piedmont. According to the map, the Site is underlain by Quaternary (Pleistocene to present) Lowland Deposits. This formation consists of irregularly distributed beds of sand, gravel, sandy clay, and clay. The sandy components are medium- to coarse-grained quartz sand with cobbles and boulders near the base. Most beds are lenticular and change rapidly in character over short distances. The finer grained materials consist of varicolored silts and clays and brown to dark gray lignitic silty clay. This formation lies unconformably on the Port Deposit Gneiss which is a moderately to strongly deformed intrusive complex composed of gneissic biotite quartz diorite, hornblende-biotite quartz diorite, and biotite granodiorite. These rocks are reportedly foliated and some strongly sheared.

Lithologic Cross Sections A-A’ and B-B’ (Figures 5 and 6 in Appendix A) illustrate the subsurface conditions in the area of the release. Section A-A’ depicts a south to north transect from near the northern property boundary (B-11) through the dispenser island to B-23 which is near the store building on the southern portion of the Site. Section B-B’ depicts an east to west transect from near the eastern property boundary (B-19), along the dispenser canopy’s northern boundary and through the UST field to B-17 which is in the central portion of the Site.

As shown on both cross-sections, soil types from ground surface to about 25 feet below ground surface (bgs), are dominated by alternating layers of coarse and fine grained soils. As described on the various boring and well logs, the fine grained soils were typically noted as clay dominated, with fewer occurrences of silt dominated matrices. The sand component of the coarse grained soils is predominantly fine to medium grained with some coarse grained sand in conjunction with the appearance of gravel. There are small interbeds and lenses of gravel in the coarse and fine grained layers. These range in thickness from one inch to several inches.

The soil was observed to be wet in some of the borings at depths as shallow as 6 feet bgs. In these borings, it was the coarse grained soil layer which was observed to be wet. Typically, the depth of the first encounter of saturated soil was 12 to 14 feet bgs. A groundwater gauging event was performed on December 15, 2011. Depth to groundwater ranged from 6.86 feet bgs in MW-13 to 14.64 feet bgs in MW-15. These groundwater depths were compared to top of casing elevations with an arbitrary datum of 100 feet. Groundwater elevations in the wells ranged from 84.81 feet in MW-12 to 91.49 feet in MW-16. A groundwater gradient map (December 15, 2011) is provided as Figure 7 in Appendix A. Groundwater flow is shown to be towards the southwest. There appears to be groundwater mounding in the vicinity of MW-7 and MW-16 which may be associated with the sanitary sewer line and/or Site building foundation drainage influences. The hydraulic gradient (change in head per unit distance (*dh/dl*)) between MW-5 and MW-2 was 0.0026 feet per foot during this monitoring event.

Two potable wells are located in the direct vicinity of the release area; off-site potable well CE-88-0994 is located at 10 Montgomery Drive and is within 100 feet of the eastern boundary of the LPH plume and on-site potable well CE-94-3354 is within 150 feet from the southwestern boundary of the LPH plume. The off-site potable well is hydraulically up gradient of the release area and the on-site well is hydraulically down gradient of the release area. According to State of Maryland Well Completion Report form, the on-site potable well is 350 feet deep and cased from 0 to 63 feet bgs. The off-site potable well is 360 feet deep and cased from 0 to 60 feet bgs. According to a review of the driller's lithology for the on-site well, rock, described as "medium hard grey", was encountered at a depth of 60 feet bgs. Between the ground surface and 26 feet bgs the log indicates several different colors of clay (red, brown and tan). From 26 feet to 60 feet bgs, the log notes sand and gravel/sand. Other off-site, down gradient potable wells are located in the Site vicinity but none are closer than 275 feet from the release area. Lithologic logging of the three onsite rock wells indicated the following: sand and gravel with some clay lenses between the surface and 15 to 30 feet bgs; silty sandy clay between 15 and 45 feet bgs; and, appearance of bedrock (undifferentiated gneiss) at depths ranging from 40 to 45 feet. The potable well locations and construction characteristics are illustrated on Figure 3 in Appendix A.

2.2 Liquid-Phase Hydrocarbons

Historically, LPH has been detected in the following wells: MW-3 at thicknesses ranging from a sheen to 1.75 feet; RW-1 at thicknesses ranging from a sheen to 0.08 feet; RW-2 at thicknesses ranging from 0.00 to 0.30 feet; RW-3 at thicknesses ranging from a sheen to 0.13 feet; RW-4 at thicknesses ranging from a sheen to 0.25 feet; and RW-6 at thicknesses ranging from a sheen to 0.01 feet. In addition LPH sheen has been observed in MW-6, MW-7, MW-8, RW-5, RW-7, RW-8, RW-9, RW-10, RW-11, RW-12, and RW-13. All of the other wells did not contain LPH during any of the gauging events.

Based on this data it is suspected that LPH impact consists of an approximately 13,000 square foot, oblong-shaped plume which extends in a southeast to northwest direction from south of the dispenser islands (in the vicinity of MW-7) to the eastern portion of the UST field; and in an east-west direction from the eastern end of the dispenser islands to the central portion of the dispenser islands. Figure 8 in Appendix A, presents an LPH Distribution Map which illustrates the maximum LPH thicknesses during all of the gauging events and the suspected limits of LPH.

2.3 Dissolved-Phase Hydrocarbons

Based on the groundwater quality data dissolved phase hydrocarbon (DPH) impact from the release is estimated to consist of an oval-shaped plume encompassing the eastern and central portions of the Site. Lab results from samples taken from wells up gradient (MW-6 and MW-15) were below detection limits (BDL) for all volatile organic compounds (VOCs). The northern (side gradient) extent of the DPH plume has been substantially delineated as determined by MW-4 and MW-5 (BDL for total benzene, toluene, ethylbenzene and xylenes (total BTEX)). The southern (side gradient) extent of the DPH plume has been substantially delineated as determined by MW-11 and MW-16 (BDL for total BTEX). The western and northwestern down gradient extent of the DPH plume has been delineated as determined by MW-1R, MW-2, MW-11, MW-13, MW-14 (BDL for total BTEX). The down gradient extent of the dissolved phase plume to the southwest, while not expected to extend significantly across the site border, has not been fully delineated in areas around MW-10 and MW-12. The results of the most recent groundwater sample laboratory analyses (December 15, 2011) are summarized on the Groundwater Quality Map included as Figure 9 in Appendix A.

2.4 Adsorbed-Phase Hydrocarbons

Based on the soil quality data absorbed phase hydrocarbon (APH) or residual phase impact distribution is similar to the LPH distribution which extends in a southeast to northwest direction from south of the eastern portion of the dispenser islands to the eastern portion of the UST field; and in an east-west direction from the eastern end of the dispenser islands to the central portion of the dispenser islands. As determined by a review of the boring logs (odor, staining and elevated PID readings), the vertical extent of the significant APH impact is predominantly between 5- and 12-feet bgs. The results of the soil sample laboratory analyses are summarized on the Soil Quality Map, included as Figure 10 in Appendix A.

2.5 Summary

As shown in the cross-sections, lenses and layers of coarse grained soil in the LPH plume area have been identified between 1 foot bgs and approximately 7 feet bgs. This layer is competent and laterally extensive underneath the fuel dispensers and is primarily found between 5 and 7 feet bgs in that area. This layer consists of fine to medium grained sand which lies above a layer of dense (stiff) finer grained material (silty clay to sandy clay). During UST system dispenser line removal and boring activities this shallow coarse grained material was found to be grossly impacted and is thought to be a significant migration pathway for LPH in side and down gradient directions. During boring activities conducted around the suspect release area, the bulk of the elevated photoionization device (PID) readings (greater than 100 parts per million (ppm)) and laboratory analytical results were detected within the 7 to 10 feet bgs coarse grained soil layer. These elevated PID response zones are illustrated on the cross-sections.

As expected, the coarse grained soils have a greater capacity for fluid and vapor flow. This was demonstrated by the relatively high water and vapor extraction flow rates realized during the pilot studies. To some extent the layered lithology also was found to influence fluid drawdown characteristics during extraction conditions (e.g., in one pilot study the drawdown was the same in two wells located at different distances). Based on this it is expected that during VE/GE activities the coarse grained soil layers will contribute the vast majority of flow to the recovery total.

3.0 RISK DETERMINATION SUMMARY

3.1 Introduction

The MDE OCP produced the MEAT for LUSTs document (2003) to provide guidance in the event of a release of a hazardous substance from regulated UST systems. According to the MEAT document, the OCP requires the potential risk be measured at every facility that has a reported release in order to establish cleanup goals and to determine if remediation is necessary. The OCP evaluates risk by a "Seven Risk Factor" process. The seven factors that require consideration include LPH, Current and Future Use of Impacted Groundwater, Migration of Contamination, Human Exposure, Environmental Ecological Exposure, Impact to Utilities and Other Buried Services, and Other Sensitive Receptors. The following sections of this report state each of the seven risk factors, and presents AEC's evaluation of each factor as it pertains to the Site.

3.2 Liquid Phase Hydrocarbons

"*LPH refers to a regulated substance that is present as a non-aqueous phase liquid. When LPH is found on-site, the liquid product must be removed to the maximum extent possible. OCP has determined this to be sheen. (MEAT for LUSTs, 2003).*"

Historically, LPH has been detected in the following monitoring and recovery wells: MW-3 at thicknesses ranging from a sheen to 1.75 feet; RW-1 at thicknesses ranging from a sheen to 0.08 feet; RW-2 at thicknesses ranging from 0.00 to 0.30 feet; RW-3 at thicknesses ranging from a sheen to 0.13 feet; RW-4 at thicknesses ranging from a sheen to 0.25 feet; and RW-6 at thicknesses ranging from a sheen to 0.01 feet. In addition LPH sheen has been observed in MW-6, MW-7, MW-8, RW-5, RW-7, RW-8, RW-9, RW-10, RW-11, RW-12, and RW-13.

LPH was also detected in the temporary piezometers with the following characteristics: B-2 at thicknesses ranging from 0.00 to 0.81 feet; B-6 at thicknesses ranging from a sheen to 1.20 feet; B-9 at thicknesses ranging from 0.00 to 1.40 feet; B-10 at thicknesses ranging from 0.04 to 1.29 feet; B-13 at thicknesses ranging from 0.01 feet to 0.55 feet; and, B-22 at thicknesses ranging from a sheen to 6.91 feet. In addition LPH sheen was observed in B-1, B-8 and B-15.

Based on this data it is suspected that LPH impact consists of an approximately 6,500-square foot, oblong-shaped plume which extends in a southeast to northwest direction from south of the eastern portion of the dispenser islands to the eastern portion of the UST field; and in an east-west direction from the eastern end of the dispenser islands to the central portion of the dispenser islands. Figure 8 in Appendix A, presents an LPH Distribution Map which illustrates the maximum LPH thicknesses during all of the gauging events and the suspected limits of LPH.

There are generally two phases of LPH within the soil material's pore space. These are mobile phase LPH and residual phase LPH. LPH is mobile when LPH saturation is greater than the residual saturation and the LPH is hydraulically connected in the pore space. This condition has the potential to allow LPH flow under a hydraulic gradient. Residual LPH is non-mobile and is approximately the amount of LPH that would be retained after gravity drainage of the pore space. This material cannot be easily moved hydraulically. Based on the current distribution of measurable LPH, the following wells (and associated areas) have demonstrated the existence of mobile LPH: RW-1, 2, 3, 4, and 7 and MW-3. Aggressive vac-truck EFR recovery during the early phases of the project removed mobile LPH from some areas of the remediation zone. These areas are expected to still contain residual phase mass.

3.3 Current and Future Use of Impacted Groundwater

"If the groundwater impacted by the release is used for direct consumption within a half mile of the site or the site is located within an approved wellhead protection zone, a site assessment and CAP must be designed. Other uses of groundwater that would warrant remediation include industrial, agricultural, and surface water augmentation. If known, future use of the groundwater must be taken into consideration. If site-specific future use is unsure, regional trends must be considered. Generally, if future use is not clear, a more conservative approach to cleanup is applied (MEAT for LUSTs, 2003)."

A receptor survey addendum was completed for the Site and vicinity in August 2011. Several potable wells are located in the vicinity of the petroleum release area. The table below shows the well completion characteristics such as total depth and casing depth as described in the various MDE well completion reports. The well completion information for 487 Mechanics Valley Road was verbally relayed to AEC by the MDE. No permit or well completion information has been found for 513 Mechanics Valley Road. Based on visual observation, water from the potable well at 505 Mechanics Valley Road also services the business at 513 Mechanics Valley Road via a garden hose between the two structures.

Address	Well Depth (ft)	Casing Depth (ft)	Sand/Gravel Interval (ft)	Depth to Bedrock (ft)	Approximate Distance to Release Area (ft)
463 Mechanic Valley Road	400	60	10-30	53	740
475 Mechanic Valley Road	400	64	30-45	60	570
487 Mechanic Valley Road	25	No data	No data	No data	420
493 Mechanic Valley Road	165	55	3-45	50	450
500 Mechanic Valley Road	350	63	26-60	60	130
505 Mechanic Valley Road	147	40	0-10	38	350
513 Mechanic Valley Road	No data	No data	No data	No data	No Data
10 Montgomery Drive	360	60	26-60	55	70

Based on the well construction information all but one of the wells (487 Mechanic Valley Road) uses the Port Deposit Gneiss as a water source. The 487 Mechanic Valley Road well is reportedly hand dug and draws water from the surficial material. As a result this well may be particularly susceptible to impact from the release. The remaining down gradient wells are also at risk for being impacted by the release. All but one of the wells (10 Montgomery Drive) are located down gradient of the release area. Regardless, due to the close proximity of the 10 Montgomery Drive well to the release area, this well is considered subject to possible impact from the release. The well locations (street addresses) are illustrated on Figure 3 in Appendix A.

3.4 Migration of Contamination

"The ability of contamination to migrate off-site or to migrate to a receptor is a critical measure. If it can be demonstrated that the contamination is stationary and site conditions restrict the potential for migration, the need for cleanup may be reduced (MEAT for LUSTs, 2003)."

Based on groundwater results from samples taken on December 15, 2011 from the monitoring well and tank pit well networks, the plume of DPH constituents is delineated within the monitoring well network in all directions. Lab results from samples taken from wells up gradient (MW-6 and MW-15) were BDL for all VOCs. Results from samples taken to the north and south of the petroleum impacted area which are parallel with groundwater flow (MW-4, MW-5, MW-11, and MW-16) were also BDL for all VOCs. Results from samples taken from wells down gradient to the west and northwest of the petroleum impacted area (MW-1R, MW-2, MW-13, and MW-14) were BDL for all VOCs. Results from samples taken from wells downgradient to the southwest of the petroleum impacted area (MW-10 and MW-12) were nominally above the detection limits for all VOCs.

3.5 Human Exposure

"Any exposure to the public warrants site corrective action. There are several exposure pathways that must be considered. These pathways include but are not limited to inhalation, ingestion, and dermal contact (MEAT for LUSTs, 2003)."

Direct dermal contact, inhalation, and/or the ingestion of petroleum impacted groundwater are possible as on- and off-Site potable wells exist in the area. Carbon point of entry treatment (POET) systems were installed at the 505 and 513 Mechanics Valley Road properties on Tuesday, July 5, 2011. These systems consist of a sediment pre-filter, three coconut shell carbon filters, and associated plumbing materials to make the systems operational. Based on a review of historical information for the 513 Mechanics Valley Road property these wells have been impacted by a historical release associated with the 513 property. Surface drainage at the Site is generally to the west towards North East Creek, a tributary of the North East River, located approximately 1,400 feet west of the Site at its closest point. The tributary of the North East River is not expected to be impacted by the Site's release.

Dermal contact and/or ingestion of impacted soil is unlikely as the entire Site area is paved with asphalt, gravel or concrete and soil impact is greatest at or near the water table which ranges from approximately 7 to 14 feet bgs. With the exception of construction excavation work, no complete dermal contact, inhalation, and/or ingestion of impacted soil exposure pathway is anticipated.

Vapor inhalation risk to off-Site structures is not thought to be a concern based on the lack of significant dissolved phase VOCs down gradient of the Site. Vapor inhalation risk to the Site building has not been assessed. However, vapor inhalation risk to the Site building is possible based on the identification of LPH and elevated DPH levels within proximity to the northeastern side of the structure.

3.6 Environmental Ecological Exposure

"The need to protect the natural resources of the State is mandated by Maryland law. If there is exposure to animal or plant life from the petroleum release or the degradation of a natural resource, corrective action is warranted (MEAT for LUSTs, 2003)."

AEC did not observe any signs of staining or vegetative stress in the grass-covered areas surrounding the Site or off-site properties. The most proximal natural surface body of water to the Site, North East Creek, a tributary of the North East River, located approximately 1,400 feet west of the Site at its closest point, is not expected to be impacted by the Site's release. AEC does not consider this release to represent a threat to animals or plant life in the vicinity of the Site.

3.7 Impact to Utilities and Other Buried Services

"The responsible party must correct adverse effects to utilities. Utility materials have been known to degrade from contact with petroleum products. Utilities may also act as conduits that lead to the migration of contamination. Migration along utilities may cause vapor impacts or other issues at nearby structures (MEAT for LUSTs, 2003)."

Electric service is provided to the Site by Delmarva Power. Water is supplied by a potable well (Permit No. CE-94-3354) located to the west of the Site building. Storm water flows to a management facility located on the northwest portion of the Site and is channeled into the Maryland State Highway Administration (SHA) storm water system along Pulaski Highway. Municipal sewer service is provided to the Site and vicinity by the Cecil County Department of Public Works. The sanitary sewer line that services the Site runs from the middle of Montgomery Drive to the northeastern portion of the Site building. The Montgomery Drive manhole depth is 7.53 feet bgs. One sanitary cleanout is located along this line. The depth of this cleanout is 5.15 feet bgs. Additionally, a grease interceptor and two associated cleanouts are located immediately north of the Site building. The depth of the bottom of the grease interceptor is 6.12 feet bgs. The grease interceptor is connected to the sanitary sewer line. A Site Utilities Map is included as Figure 11 in Appendix A.

Depth to groundwater at the Site in the vicinity of most of the subsurface utilities is approximately 11 to 13 feet bgs. Depth to groundwater in MW-16 up gradient of the sanitary sewer service is approximately 7 to 7.5 feet bgs. The sanitary sewer service invert is approximately 5 to 6 feet bgs. The shallower water table in this area may be related to either lithology creating a perched condition or leakage from the sewer line. Based on this data, utility trenches on the Site are not expected to be affected by the petroleum impact.

3.8 Other Sensitive Receptors

"Sensitive receptors such as surface water, historic structures, and subways are an indication that a site may warrant corrective action (MEAT for LUSTs, 2003)."

Natural surface bodies of water, historic structures, and subways are not located at the Site; as such, these receptors are not a concern. Additional sensitive receptors in the vicinity of the Site location were not observed during the site assessment. Based on the lack of receptors in the site vicinity that the UST release could possibly have affected, the release does not appear to pose a risk to other sensitive receptors.

3.9 Summary

Based on the results from the subsurface investigations and monitoring efforts, and the evaluation of the seven risk factors, AEC has established that risk exists for the following MDE Risk Factors:

- Liquid Phase Hydrocarbons
- Current and Future Use of Impacted Groundwater
- Migration of Contamination
- Human Exposure

AEC has not identified any risk associated with these remaining MDE Risk Factors:

- Environmental Ecological Exposure
- Impact to Utilities and Other Buried Services
- Other Sensitive Receptors

The existence of LPH will necessitate the removal of this material. The existence of DPH in context of the on- and off-Site potable wells will necessitate the removal of this material. The proposed clean-up technology presented below will also address DPH and APH impact as part of the LPH recovery efforts. Once the LPH is removed in the source area it may be necessary to perform secondary remediation to address DPH and recalcitrant APH (residual phase). If the secondary remediation is necessary, pilot studies will be conducted and this CAP will be amended.

4.0 DUAL PHASE DESIGN PILOT STUDY SUMMARY

In January 2012 extensive pilot studies consisting of a constant rate aquifer pumping test, a modified step drawdown test and a dual phase VE/GE recovery test were performed. According to the results of these pilot studies, the performance parameters for the dual phase VE/GE approach are the following: ROI – 25 feet (based on distance vs. vacuum graphs); individual recovery well flow rate – 3 gpm (based on dual phase extraction test); individual recovery well drawdown - 5 feet below static groundwater (based on step drawdown and dual phase extraction tests); and, individual recovery well air flow rate - 50 cfm (average flow rate during dual phase extraction test).

During these pilot studies the pump intake was set approximately five feet below the static water level. This depth was selected to simulate the lowest drawdown reasonable with respect to the petroleum smear zone. The pilot studies' sustainable, vacuum enhanced flow rate of 3 gpm pumping from 5 feet below static water level was adequate to provide a capture zone size similar to the previous EFR design as presented in the Draft CAP (July 2011). This flow rate is less than the operational EFR flow rate of 6 gpm. The sustainable flow rate for the constant rate test (1 gpm) when compared to the selected flow rate for the dual phase test (3 gpm) indicated that the addition of a vacuum source significantly increases water flow potential of the aquifer.

The previous EFR data collected on July 27, 2011 indicated that at the conclusion of step 1 the average recovery rate was 4 gpm and at step 2 the average recovery rate was 6.77 gpm. At 4 gpm the vacuum was 0.26 inch-H_2O at a monitoring point 20 feet from the extraction well. The January 2012 pilot study data indicates a higher vacuum range (0.61 to 1.01) at approximately the same distance (21 to 23 feet) with a marginally lower flow rate (3 gpm). The previous EFR data indicated that at 4 gpm the drawdown was 0.35 feet at a monitoring point 20 feet from the extraction well. The latest data indicates a slightly higher drawdown range (0.43 to 0.52) at approximately the same distance (21 to 23 feet) with a marginally lower flow rate (3 gpm). These measurements indicate that the higher vacuum during the recent pilot study increased the drawdown and vacuum using a reduced water flow rate with respect to the previous EFR pilot study.

Based on the data collected to date, AEC has estimated that the minimum flow rate necessary to gain hydraulic control in the remediation zone is between 1 and 3 gpm (the constant rate flow estimate and the sustainable dual phase flow rate). The maximum flow rate is 5 to 6 gpm, which has been shown in the EFR pilot studies to substantially dewater the area. The optimal flow rate (or pump intake depth) for maximum recovery of LPH will change throughout the seasons. During wet weather seasons the flow rate will need to be increased (and/or the pump raised) and during dry seasons the flow rate will need to be decreased (and/or the pump lowered). For the early stages of the remedial life cycle it is expected that a higher flow rate will be necessary to provide hydraulic control. As the dewatering of the area reaches a static condition the required flow rate will be reduced for the same degree of hydraulic control.

The recent pilot study has indicated that an effective vacuum influence of 0.1-inch H_2O may be expected at a distance of approximately 25 feet from the recovery wells. In order to provide a safety factor the operational ROI will be 20 feet. Using multiple recovery points with partially overlapping capture zones it is expected that between 2-feet to 5-feet of groundwater drawdown will be realized in the target remediation zone.

The remediation system will be designed to treat recovered groundwater at a rate of 50 gpm and vapors at a rate of 600 cfm. Pilot studies have indicated that a recovery well flow rate of 3 gpm with 50 cfm at 10-inch hg is adequate for effective dual phase operation. The proposed number of recovery wells is eleven which equates to system flow rates of 33 gpm water and 550 cfm vapor. These rates are within the capacity of the design basis summary system flow rates. Figure 12 in Appendix A presents the recovery well distribution with capture zones illustrated.

5.0 REMEDIATION ACTIVITIES AND SYSTEM DESIGN

5.1 Remediation Plan Summary

The remediation approach proposed in this CAP is based upon data collected from the dual phase system design pilot studies performed in January 2012, as well as site characterization investigations, review of historical well gauging/sampling data, and previously ascertained EFR performance characteristics.

Based on the presence of LPH, in-situ chemical oxidation (ISCO), in-situ bioremediation, and air-sparging will not be effective means of remediation at this time. Based upon feasibility and the past effectiveness of the vac-truck EFR work, the recommended remedial approach consists of using VE/GE technology to substantially remediate both soil and groundwater. Once the LPH is removed and dissolved phase levels in the source area are reduced it may be necessary to perform secondary remediation. This may entail using one of the technologies mentioned above. If the secondary remediation is necessary, pilot studies will be conducted and this CAP will be amended.

The results of the EFR pilot study performed from the recovery points indicate that VE/GE would effectively remove LPH, DPH and APH from the subsurface. By mitigating the hydrocarbon presence and achieving hydraulic control over the remediation zone, the future impact to down gradient receptors should be reduced. Secondarily, the significant vacuum influence observed during the January 2012 EFR pilot studies, as well as the recorded air flow and expected hydrocarbon mass recovery rates, indicate that the application of VE should: directly withdraw residual VPH and APH from the soil pore spaces; potentially accelerate aerobic degradation by delivering oxygen into the vadose and smear zones thereby stimulating indigenous microbiological hydrocarbon degradation in these zones; and, potentially mitigate DPH in groundwater through volatilization where the groundwater is not directly recovered.

5.2 Target Remediation Zone and Cleanup Criteria

The VE/GE system will address LPH, DPH and APH impacted soil within the defined remediation zone illustrated on Figure 12 in Appendix A. The boundaries of this zone were developed using the monitoring and temporary piezometers which currently and historically contained LPH. The extent of the remediation zone footprint dimensions is approximately 6,500-square feet. To establish hydraulic control of the remediation zone in relation to the capture zone dimensions, the following existing wells will be used: RW-1, 2 ,3 ,4, 6, 8, 9, 10, 11, 12 and MW-7. These wells are identified on Figure 12 in Appendix A. Additional EFR wells may be installed if cleanup criteria are not achieved.

The cleanup criteria address both LPH and DPH. The LPH cleanup criteria is removal to a sheen or less than 0.01 feet. Numerical DPH cleanup criteria have not yet been developed. The current cleanup criteria is DPH reduction to asymptotic levels. At that time the DPH criteria will be reevaluated for the implementation of the water polishing effort.

5.3 Remediation System Design Summary

The proposed remediation system is designed to recover APH (residual phase) from subsurface soils and remove DPH and LPH from extracted groundwater via vertical recovery wells. By depressing the groundwater table, additional soils will be exposed to soil VE. By using VE/GE, both liquid and vapor phase recovery should be maximized. The remediation system will be designed to treat recovered groundwater at a rate of 50 gpm and vapors at a rate of 600 cfm. Pilot studies have indicated that a recovery well flow rates of 3 gpm water and 50 cfm vapor is adequate for effective VE/GE operation. The proposed number of recovery wells is eleven which equates to a system flow rate of 33 gpm and 550 cfm which is within the capacity of the system design flow rates.

System equipment will be stationed to the east of the Site building near the southeastern corner of the Site property (see Figure 13 in Appendix A). The system control panel and electrical panel will be mounted on the outside of the system building. The interior of the system building will house a positive displacement vacuum blower for vapor removal, phase separation tank (moisture separator), an air compressor associated with the pneumatic submersible pumps for liquid removal, an integrated oil-water separator and air-stripper for LPH and DPH removal, one fluid transfer pump, two bag filter housings, two activated carbon canisters connected in series for final groundwater polishing, and a flow totalizer to record total volume of groundwater treated. The equipment and wiring in the treatment room is rated for explosive environments. The exterior of the equipment compound will contain a catalytic oxidation unit for vapor treatment, and activated carbon canisters connected in series for air stripper off-gas treatment.

Total fluids and soil vapors will be extracted from the eleven vertical recovery wells using the submersible pumps and vacuum blower. Extracted vapors will pass through a moisture separator for separation of recovered liquid and vapor phases. Separated vapors will be directed to the catalytic oxidation unit for treatment. The separated knock out and GE liquids will be directed to an oil-water separator/air stripper for groundwater and LPH separation. The LPH will be directed to a storage reservoir in the separator for collection, and the stripped water will be directed through the bag filters and carbon vessels connected in series for final polishing prior to discharge.

Should the air pressure from the stripper blower fall below a set-point (i.e. the blower is not operating), or should a high liquid level condition occur, an electrical relay into the system control panel will read an alarm condition and will shut off power to the system. The transfer pump is controlled with a high level alarm switch and a level differential control switch placed within the air stripper sump. When the water level in the air stripper sump reaches a set level, the level differential control switch becomes activated and signals the control panel to actuate the transfer pump. The air stream from the vacuum blower will be routed for treatment by a catalytic oxidation unit for off-gas control. A fail safe control device will be installed within the catalytic oxidation unit so that should an operating fault occur within the oxidation unit, the system control panel will disable the recovery and treatment process. The air stripper off-gases will be discharged through granular activated carbon (GAC) vessels. Items concerning discharge streams and allowable emissions are discussed under the permitting section of this CAP. A piping and instrumentation diagram (P&ID) is presented as Figure 14 in Appendix A.

5.4 Equipment Information and Specifications

The following section provides information about each major component of the remedial system. Equipment summaries are supplied that detail the equipment functions, operations, and the suggested supplier and/or manufacturer information. Equipment manufacturer and model numbers are supplied only as reference. Equipment of equal operations and capacities manufactured by others may be substituted.

5.4.1 System Control Panel & Logic Components

The control panel contains the logic and drive components for the remedial equipment. The control panel will control operation of the transfer pump, the vacuum blower, and the air stripper blower and the compressor. Each piece of equipment will be equipped with thermal protection. Logic components will be required as follows:

1) Transfer pump on/off liquid differential float switches will be installed within the knock-out tank and oil-water separator/air stripper sump. The transfer pump will be able to be controlled by a hand/off/auto switch at the control panel.

2) High level alarm floats will be installed within the knock-out tank, oil-water separator/air stripper sump. When a high alarm condition occurs, the control panel will disable operations to the air compressor, vacuum blower (if knock-out tank alarm) and the transfer pump.

3) The air stripper will be equipped by the manufacturer with either a low air flow switch and/or a low pressure switch. When an alarm condition signifying the air stripper air flow conditions are not being met, the control panel will disable the air compressor and transfer pumps.

4) The common line serving the liquid phase carbon vessel series will be equipped with a high pressure switch. The set point of the high pressure switch will be dependent upon the design pressure allowed by the carbon vessels installed. When a high pressure condition occurs at the carbon treatment, the control panel will disable the system.

5) The catalytic oxidation unit will be provided with an independent control panel. The independent control panel for the oxidation unit will contain alarm output terminals signifying low/high air flow conditions and operating temperature faults. Wiring from the oxidation unit to the control panel will be installed so that the system control panel may disable the vacuum blower should the oxidation unit shut down.

The controls will also include a telemetry system with 8 analog inputs and 4 digital outputs. The system will have an integrated data logger and a surge suppression system. The telemetry controls will be capable of remote startup and shutdown operations and real time operations monitoring.

5.4.2 Positive Displacement Vapor Extraction System

VE from the vertical wells will be performed using a 25 horse power (HP) positive displacement VE system (Tuthill 5009SL or equal). The vacuum blower will be supplied with a temperature gauge, high temperature switch, inlet filter and inlet silencer, universal series or better discharge silencer and automatic and manual dilution valves with silencer. The knock-out tank will consist of a 200-gallon vertical air/water separator with conductivity probe level switches. The knock-out tank will be supplied with 10-inch diameter clean out ports with vacuum rated quick release lids, clear PVC sight glass piping to check for water carryover, liquid filled vacuum gauge, vacuum assist line, 2-inch drain valves, vacuum relief valves and a dilution valve with filter/silencer. The vacuum blower and knock-out tank are package supplied and skid mounted. The vacuum blower is equipped with a 230/460/3/60 Class I, Group D, explosion proof (XP) motor. The vacuum blower will be capable of providing an air flow rate of 600 cfm with 10 inches Hg applied vacuum. The vacuum blower influent will be connected to a PVC vapor inlet manifold with a 6-inch main with 11, 2-inch points, shut off valve, union and sample port for each well.

5.4.3 Air Compressor

The air compressor consists of a 15 HP rotary vane with continuous run option and a 90 gallon receiver tank. The compressor is supplied with a low oil switch, tank auto drain, ½-inch filter regulator and a ½-inch three way Asco solenoid valve. The air compressor is equipped with a 230/460/3/60 Class I, Group D, XP motor. The compressed air will be distributed to the pumps using a brass manifold.

5.4.4 Recovery Pumps

The recovery pumps consists of QED AP4 Long Top Fill Pneumatic Pumps with a 10 gpm maximum flow rate. Each pump is supplied with down well hoses and support rope, vacuum well seals, ¾-inch brass shut off valves for water flow and ½-inch brass ball valve for compressed air at each well. The pump effluent lines will be connected to a carbon steel manifold with brass valves, a 2-inch main with 11 1-inch points, shut off valve, check valve, sample port, and barb for each groundwater pump.

5.4.5 Oil-Water Separator and Low Profile Air Stripper

The integrated oil-water separator/low profile air stripper is manufactured by MKE Inc. (model SA85 Stripperator). Effluent from the pneumatic pumps flows into the inlet of the oil-water separator through a diffusion baffle. The influent then passes through a cross corrugated coalescing media and product skimming weir. A rotary pipe skimmer collects separated floating product which gravity feeds into the internal storage reservoir.

Separated water flows to an effluent chamber of the separator, and then by gravity to the low profile type air stripper portion of the system which is equipped with a regenerative blower. The chamber fills to a set level before flowing through a sheen baffle and out of the separator. The system is equipped with a high level alarm switch. The flow rate of the integrated oil-water separator-low profile air stripper is rated at 85 gpm. The oil-water separator portion of the system will be vented. Groundwater is evacuated from the air stripper sump by a system transfer pump. The air stripper will be equipped with a low flow pressure switch to shut-down the system in the event of stripper blower malfunction.

5.4.6 Vapor Carbon Polishing

The air stripper blower supplies air to the stripper. The stripper vapor effluent will be routed through four vapor phase carbon vessels set up in two series of vessels in parallel for off gas control. Items concerning discharge streams and allowable emissions are discussed under the permitting section of this CAP. The carbon treatment line will be capable of treating 600 cfm.

5.4.7 Groundwater Filtration and Carbon Polishing

The air stripper transfer pump evacuates treated groundwater collected in the air stripper sump through the bag filters and carbon vessels for final treatment before discharge. The bag filters will be connected in a series of two for sediment and particulate removal prior to entering the carbon vessels. Granular activated carbon vessels will be connected in a series of two for final polishing prior to discharge. The carbon treatment line will be capable of treating 60 gpm.

5.4.8 Catalytic Oxidation Unit

The catalytic oxidation unit will be a MKE Model 800E electric oxidizer. The unit has a design flow rate of 800 cfm. The thermal oxidation unit will have the following options: skid mounted; equipped with an independent control panel with alarm output terminals to be wired to the system control panel; a flame arrestor; and, a minimum stack height of 12 feet above ground surface. The unit will be supplied with an air-water separator (knock-out) tank to minimize condensed fluids from entering the burner.

5.4.9 Remediation System Compound

The remediation equipment will be stored within an 8.5 foot wide by 16 foot long by 9 foot high fully insulated aluminum/steel enclosure. The enclosure will be rated XP. Lockable access ways will be installed on the enclosure. The oxidizer and vapor phase carbon canisters will be stored outside of the enclosure but inside of the compound. A privacy fence will be erected surrounding the remedial compound to prevent access and tampering by unauthorized individuals. The air-stripper and VE stacks will be approximately 10 feet in height after the control devices are taken off line. The intake duct work for some of the onsite buildings' ventilation system is located on the south east corner of the building at a height of approximately 15 feet. This duct work is approximately 50 feet from the system compound. The prevailing wind direction in this area for the winter and fall months is from the north-northwest. During the spring and summer months the direction is from the southeast. Both of these prevailing wind directions are not conducive for system effluent air entering the building's duct work.

5.4.10 Ancillary Items

Other items to be installed with the remediation system include electric service, electrical components, plumbing, and valves. The remediation system will be supplied with an independent 400 amp, three phase electric service/panel and meter. The interior of the enclosure will be equipped with an XP heater and thermostat, an XP ventilation fan, a XP lighting fixture, and XP switches or receptacles for each motor. XP wiring will be within rigid conduit/seal-offs, or as applicable according to local fire codes. All motors/pump equipment will be installed so that the equipment may be easily pulled for servicing (i.e. flexible hanger couplings).

5.4.11 Subsurface Piping &Trenching

Subsurface recovery piping will be installed to eleven recovery wells shown on Figure 13 in Appendix A. Road grade vaults will be installed over each recovery well. The depth of the trenching will be 35 inches. Four-inch schedule 40 PVC recovery piping will be used to connect each well head to the liquid piping manifold in the compound. These pipes will contain the pneumatic pump air supply and water discharge hoses. Two-inch schedule 40 PVC recovery piping will be used to connect each well head to the vapor piping manifold in the compound. Black polyethylene (PE) line system effluent line will be run from the equipment compound to the stormwater basin on the western portion of the site. A certified UST technician will be present during trenching activities immediately adjacent and over fuel system lines.

All underground piping will be emplaced within the trenching with a minimum of 30 inches of cover. All piping connections will be accomplished using primed and glued pressure couplings. The piping will be set in a bed of 10 inches of pea gravel (4 inches below and 6 inches above). Native soils may be backfilled into the trench in 6 to 8-inch lifts and compacted. The remainder of the trench will be completed by placing 3 to 4 inches of stone as sub base and 4 inches of finished asphalt to the surface. Trenching and well vault details are shown on Figure 15 in Appendix A.

7.0 OPERATION, MAINTENANCE AND MONITORING PROGRAM

7.1 Pre-startup Equipment Inspection and Baseline Monitoring

Before beginning the remediation effort, all aboveground equipment and piping will be inspected and tested. An extensive shakedown checklist is included below. Manufacturers' specifications will be included on this list so that performance can be easily checked. Out-of-compliance conditions will be corrected prior to start-up of the system.

Checklist Item
Subsurface
Wells installed and developed as specified
Well head covers in good repair and clearly marked
Well heads assembled correctly
Trenches for subsurface piping installed per specifications
Piping installation
Piping complete (aboveground and subsurface)
Piping flushed and pressure/vacuum tested
Silencers, strainers and filters installed in correct direction
Control and check valves installed and operation verified
Valves accessible (easy to reach/manipulate)
Piping clearly labeled and valves tagged
Pumps and blowers
Vibration dampers installed, heavy equipment bolted in place
Motor and blower coupling alignments are level and true
Pipe supports installed
Pumps and seals intact (no leaks)
Centrifugal pumps primed as needed or plumbed to self-prime
Belts properly tensioned, guards in place
Electrical/controls/instrumentation
Grounding installed/checked
Lighting/hvac and thermostats functional
Lockouts/covers/panels in place
Pressure/vacuum transducers functioning and calibrated
Temperature and pressure gauges installed or portable gauge connections provided
Blower and pump rotation verified
High and low fluid level sensors operating
Disconnects in sight of unit being controlled
PLC, controls/alarms, remote monitoring system and interlocks functional and calibrated
Power connected to on-line monitoring instruments
Operators have been trained (with respect to health & safety and equipment operation)
Groundwater treatment system operating (hydraulically) and groundwater discharge (NPDES) arranged
Flame arrestor on vapor oxidizer installed correctly
Vapor treatment systems functional and vapor discharge (ARMA) arranged
Treatment enclosure ventilation functional

Information on subsurface conditions will be updated just prior to startup of the system to provide a baseline against which the future effects of VE/GE can be compared. The following lists the parameters that will be measured or reevaluated.

Soil Characteristics
Variation in contaminant concentrations (laterally and with depth)
Soil gas pressures in recovery and monitoring wells
Groundwater Characteristics
Groundwater elevations in recovery and monitoring wells
Groundwater elevations in deep wells (for determination of vertical hydraulic gradients)
Groundwater quality (e.g., oxidation/reduction potential (ORP), pH, conductivity, temperature, concentrations of contaminants and dissolved oxygen (DO)) in recovery and monitoring wells
LPH Characteristics
Area of plume and thicknesses across site
Depth of smear zone

7.2 System Start-Up

During system start-up, measurements of both the above-ground equipment parameters and below-ground conditions will be performed. The following is a list of the performance criteria that will be met before the start-up phase is considered complete: 48 (or more) hours of continuous operation of all equipment, reaching steady-state flow or pressure conditions; and, completion of all start-up data collection. If measured conditions vary significantly from the expected range, the reason(s) will be investigated, and explained or corrected. If the reason for the variance cannot be determined or remedied, the system may need to be shut down until corrections can be made. The following lists the measurements and inspections to be taken immediately prior and during system startup.

Checklist item
Procedures and measurements prior to startup
Check that all planned baseline measurements have been collected
Calibrate all dedicated and portable instruments
Set submersible pumps to selected depths
Ensure that air seals are tight at top of wells
Procedures and measurements during startup
Turn on vapor treatment system
Start VE system at low vacuum and gradually increase (record flow rate and vacuums)
Open bleed/dilution valves and all valves controlling flow through vapor recovery/treatment system
Slowly decrease flow through dilution air valve(s)
Confirm operation of level control sensors for pump operation
Start GE system in a stepwise fashion (record flow rate and water levels)
Open valves from recovery wells
Procedures and measurements following startup
Recovery well vacuum and vacuum at blower
Gas and dilution air flow rates and settings
Groundwater drawdown
Groundwater flow rates
LPH accumulation rate in oil/water separator
Blower and pump cycles (programmable logic control should record on and off times)
Fluid levels in recovery wells
Catalytic oxidizer catalyst temperature
Measure gas influent and effluent concentrations with PID
Monitor pressure changes in nearby monitoring wells
Check for emulsion formation in oil/water separator
Adjust pump intake depths to maximize LPH removal

Checklist item
Adjust vacuum at the blower and valves on the manifold to optimize operation in accordance with operating strategy (see Section 7.4)
Collect vapor samples for laboratory analysis
Collect influent and effluent compliance samples as required by permits/regulations

7.3 Operation and Maintenance Procedures

The treatment system will operate on a continual basis with the exception of shutdowns for equipment maintenance and repairs. Routine inspections of the remedial operations will be performed in order to ensure proper operation and to evaluate system effectiveness.

The system will be inspected daily for the first month of operation and weekly thereafter for the second month. The daily and weekly visits will be used to adjust and optimize the system operation. Following the second month of system optimization, monitoring of the Site and the remediation system will be conducted on a monthly basis. During site visits the following activities will be performed.

Task
Vacuum in recovery wells and monitoring wells
Vacuum blower inlet vacuum
Vacuum at each flow measurement point
Vacuum blower outlet pressure
Groundwater drawdown in recovery wells
Volume of groundwater removed
Blower inlet flow rate
Treated effluent flow rate
Bleed/dilution air settings
Temperature at blower discharge
LPH thickness in recovery wells and monitoring wells
LPH accumulation rates
Blower amperage meter readings
Run time of blowers or pumps
Groundwater elevations near recovery wells
Degree of upwelling observed
Vapor contaminant concentrations at blower inlet and/or outlet
Contaminant concentrations in treated effluent (gas and/or water)
Contaminant concentrations at treatment midpoint (if using activated carbon vessels in series)
Contaminant concentrations in extracted groundwater

7.4 VE/GE Operations and Closure Methodology

During the initial stages of VE/GE system operation it is important that water table drawdown be minimized. The VE system may experience a short-lived "flushing-stage" in which high VPH removal rates will be observed. The flushing stage is followed by an exponential decline in hydrocarbon removal rates leading to asymptotic levels stabilized either near zero, or at some low value measurably greater than zero. Significant drawdown of the aquifer will not be attempted until VE hydrocarbon removal rates have declined and begun to stabilize. Once this has occurred, the majority of easily volatilized hydrocarbons will have been removed from the vadose zone, and subsurface air will be under saturated with respect to volatile hydrocarbons. Under these conditions, the VE system will remove hydrocarbons from newly-exposed saturated zone soils as rapidly as possible once the next step drawdown begins.

Following stabilization of VE hydrocarbon removal rates, GE pumps will be lowered in the wells such that the aquifer is drawn down in a stepwise fashion towards the final dewatering target level (5 feet). It is anticipated that the step drawdown will occur in one foot intervals. Aquifer dewatering will start early in the season of the lowest water table elevations (early to mid-summer). During low water table season, natural aquifer discharge to streams exceeds recharge from up gradient groundwater flow and rainfall. The GE system flow rates may be increased at this time so the additional differential in discharge versus recharge will augment the normal rate of water table decline. This will generate a broad water table depression beneath the site which will extend beyond the design ROI of the GE system.

In order to provide hydraulic control of the down gradient extent of the remediation area where the hydrocarbon smear zone is either absent or minimal, more aggressive groundwater depression activities may be conducted. This implies that the two areas (i.e., release area and DPH area) may be addressed using different methodologies such as a more rapid step drawdown in the down gradient, low level DPH area.

<u>Monitoring LPH Removal Rates</u> - A stepwise dewatering approach will be used in order to identify and remove any mobile LPH which may be released through aquifer drawdown. As submerged contaminated soils are dewatered, it is typical for LPH to remobilize and collect in the recovery wells. As a result, accumulated LPH will be removed prior to further water table drawdown to prevent enlarging the vertical dimensions of the existing smear zone. In addition, the system's step drawdown approach will be useful in maintaining control of the LPH plume. Shortly after system start up the first step drawdown will occur which will decrease LPH thicknesses and control the down gradient migration of LPH.

<u>Monitoring VPH Removal Rates</u> - During the initial step drawdown, the VE will be closely monitored to measure the spike in hydrocarbon removal rates as an indirect indication of the distribution of submerged impacted soils. These rates will be monitored using a PID and laboratory analytical results from the samples collected from the catalytic oxidizer. When these rates stabilize another step drawdown will occur.

<u>Monitoring DPH Removal Rates</u> - DPH concentrations will typically decline slowly as an increasing number of pore volumes of water are removed from the aquifer by the GE system. These declines will be monitored using system influent and groundwater data. The final dewatering step will be performed during the low water table season. As a result, system discharge may be minimized during the remainder of the year by setting pump levels higher in the recovery wells.

<u>VE/GE System Operational Closure Criteria</u> - Stepwise dewatering of the aquifer will be continued until: no further spikes are observed in VE hydrocarbon removal rates. If a VE hydrocarbon removal rate spike is observed during the initial step drawdown, the lack of

a hydrocarbon removal rate spike in a subsequent step drawdown is indicative that the majority of soils within the newly exposed vadose zone are not contaminated; target drawdown, LPH removal and reduction of DPH objectives are achieved across the entire release area and the VE hydrocarbon removal rate spike declines; and, maximum drawdown occurs in existing GE wells. VE/GE system performance will be evaluated to determine if the degree to which target drawdown objectives were achieved justifies system closure, or if redesign of the GE system and further operation of the VE/GE system is warranted. Once these criteria are met a secondary in-situ DPH polishing initiative may be advanced.

7.5 Groundwater and Vapor Monitoring Procedures

The following describes the means and methods of performing the previously noted data acquisition tasks. These include groundwater sampling from wells and system sample ports and monitoring various system parameters such as vacuum pressures and vapor quality.

Quarterly groundwater samples will be collected using low-flow sampling procedures in general accordance with USEPA Low-Flow Purging and Sampling of Groundwater Monitoring Well procedures (Bulletin No. QAD023). The low-flow samples will be collected with a Grundfos Redi-Flow submersible pump or equivalent. New PVC tubing and nylon rope will be used at each sampling location. The groundwater quality will be monitored using a Horiba U-22 Multi-meter with a flow-through cell or equivalent. The groundwater quality parameters to be monitored include: pH, conductivity, DO, temperature, and ORP. The sample collection procedure in the deep bedrock wells may be modified from the low-flow approach in consultation with the MDE.

Prior to installation of the low-flow sample gear, groundwater levels within each well associated with the site will be measured using an electronic water level indicator accurate to 0.01 feet (Solinst Model 122 or equivalent). The groundwater levels will be correlated with the well head elevations for use in developing a groundwater gradient map and monitoring drawdown. In addition, system groundwater quality samples will be collected to track influent trends, granular activated carbon efficiency and to meet National Pollutant Discharge Elimination System (NPDES) sample requirements. These samples will be collected from designated ports within the extraction and treatment line.

Sample bottles for VOCs will be filled so that there will be no headspace or air bubbles within the container and placed in a cooler on ice pending laboratory analysis. The analytical laboratory will provide pre-preserved sample containers where appropriate. Sample labels will be firmly attached to the container side, and the following information will be legibly and indelibly written on the labels: facility name; sample identification; sampling date and time; preservatives added; and, sample collector's initials. After the samples are sealed and labeled, they will be packaged for transport to the analytical laboratory.

All groundwater monitoring/recovery wells and tank pit observation wells which do not contain LPH will be analyzed for VOCs including fuel oxygenates per EPA Analytical

Method 8260, as well as total petroleum hydrocarbon (TPH) diesel range organics (DRO) and TPH gasoline range organics (GRO) per USEPA Analytical Method 8015B. This same analytical suite will be used for the system groundwater quality samples.

All well development, sampling and gauging equipment will be disassembled (if appropriate) and properly cleaned and calibrated (if required) prior to use in the field. All portions of the sampling and test equipment that contact the sample will be thoroughly cleaned with a Liquinox (phosphate-free laboratory-grade) bath and rinsed with distilled water before initial use and between each sampling point. In addition, a clean pair of new, disposable nitrile gloves will be worn each time a different well is gauged and sampled.

Vacuum readings (soil gas levels) will be measured in all monitoring and recovery wells prior to startup and select monitoring and recovery wells (all wells within 40 feet of the remediation zone boundary) during normal operations. The vacuum readings will be collected using magnehelic differential vacuum gauges (Dwyer or equivalent) attached to the well heads. Air-flow rates and air quality will be measured at various locations including the vacuum blower influent and effluent ports and the off-gas control unit's (catalytic oxidizer and air stripper) effluent stacks using a hot wire anemometer (Ex Tech Model 407119A or equivalent) and PID (Rae Systems MiniRae 2000 or equivalent), respectively. During the MDE Air and Radiation Management Administration (ARMA) required 14 day pilot study, these measurements will be collected on 14 days within a 30 day period. Tedlar bag samples will also be collected during the pilot study and analyzed by EPA Method TO-15.

7.6 Health and Safety

Prior to initiating field activities, a Health and Safety Plan (HASP) will be prepared to meet the requirements of 29 CFR 1910.120. All work will be conducted in accordance with the HASP. The HASP will include a brief site description, site safety hazards, a description of chemical compounds of concern, site training/medical surveillance requirements, Personnel Protective Equipment (PPE) requirements, air monitoring requirements, decontamination procedures, handling of investigation derived waste (IDW), emergency response, special operations safety requirements, and first aid instructions. Remediation contractors will be required to develop and follow their own HASP during all site activities. It is assumed that Level D or modified Level D personal protection will be sufficient for all field work.

8.0 PERMITS, SUBMITTALS, AND SCHEDULING

8.1 Permitting

Construction and operations activities will be performed in compliance with the appropriate operating permits required by the State of Maryland and Cecil County. Permits will be renewed as necessary, and additional permits will be obtained as required if additional remediation activities are proposed in the future. The following presents the anticipated permit requirements:

System Construction - All applicable building permits will be obtained. Applicable permits may include building permits for the equipment shelter and fence, grading, trenching and sediment control permits, and electrical permits. All work will be performed by properly licensed State of Maryland contractors.

Surface Water Discharge - The groundwater will be treated and discharged to the Site's storm water management facility located on the northwest portion of the Site. A Notice of Intent (NOI) to discharge will be submitted to the MDE in accordance with the MDE's current NPDES modified General Discharge Permit (GDP). Results of NPDES permit required monitoring will be submitted to the MDE in quarterly Discharge Monitoring Reports (DMRs), as required.

Off-gas Vapor Emissions - Vapor emission point sources (catalytic oxidation unit and air stripper off-gas) will be operated in compliance with the MDE ARMA General Permit for SVE and Groundwater Air Strippers. Emissions from each point source will be held below the following permit thresholds: Total VOC at 20 pounds per day (lbs/day) and benzene at 0.02 pounds per hour (lbs/hour).

The vapor emission point sources will be periodically evaluated to determine whether the potential emissions warrant continued off-gas treatment via catalytic oxidation or through vapor phase granular activated carbon units prior to discharge to the atmosphere.

8.2 Submittals

AEC will receive, review and accept all environmental submittals (e.g., bills of lading, disposal manifests, etc) from other contractors. Within 30 days after off-site disposal of impacted, regulated material, the contractors will be required to submit copies of all documentation, including but not limited to, bills of lading, materials shipping records, or waste manifests to AEC.

A construction schedule detailing the remedial action activities and 5-day notification to begin will be forwarded to the MDE prior to beginning the work. Within 30 days of completing the CAP activities for the Site, a CAP Implementation Report shall be prepared and submitted to the MDE for review and approval. At a minimum, the report will include a detailed description of the remedial activities performed; volume of liquids removed; maps depicting sampling locations, groundwater flow before, during, and subsequent to VE/GE activities, analytical testing results; laboratory reports of analysis; and conclusions and recommendations.

Quarterly system performance and confirmation sampling progress reports will be prepared for the Site. Groundwater gradient and groundwater quality maps, and post-treatment graphs showing groundwater concentration changes over time will be prepared for each VOC. Quarterly reports will be submitted to the MDE within 30 days of the receipt of the laboratory analytical results.

8.3 Scheduling

System installation activities associated with this CAP are anticipated to be completed within 165 days after authorization by MDE and the client. The MDE Project Manager will be notified of AEC's field schedule at least five business days prior to the start of implementation. The following is a summary of major project milestones and associated estimated times of completion:

Event	**Schedule (days)**
MDE approves CAP Report	Day X
Complete contractor scheduling	X + 15
Complete baseline testing	X + 20
Complete system installation	X + 120
Complete system startup and shakedown phase	X + 125
Complete post system install testing	X + 150
Complete CAP implementation report	X + 165

.

APPENDIX A

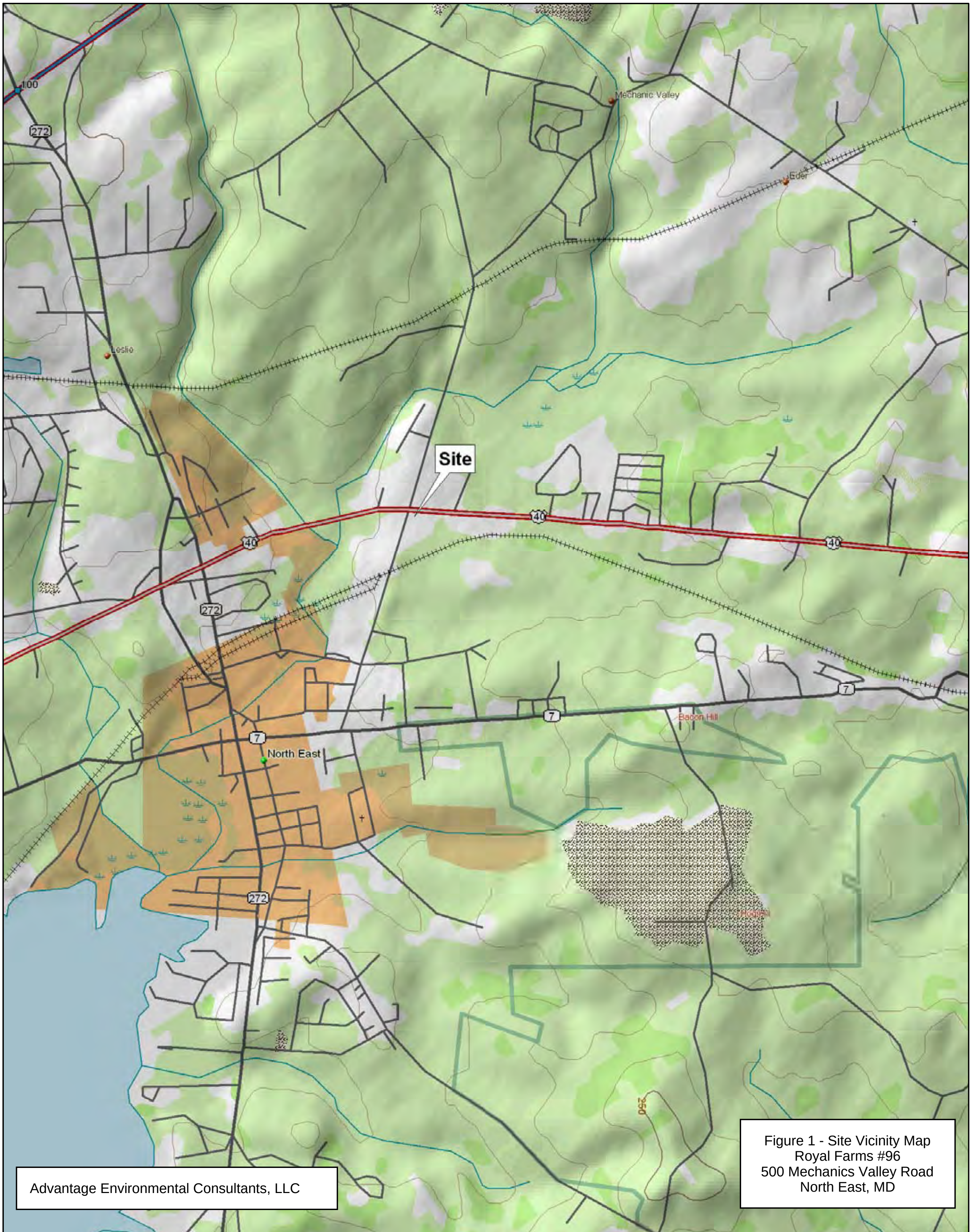

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Figure 1 - Site Vicinity Map
Royal Farms #96
500 Mechanics Valley Road
North East, MD

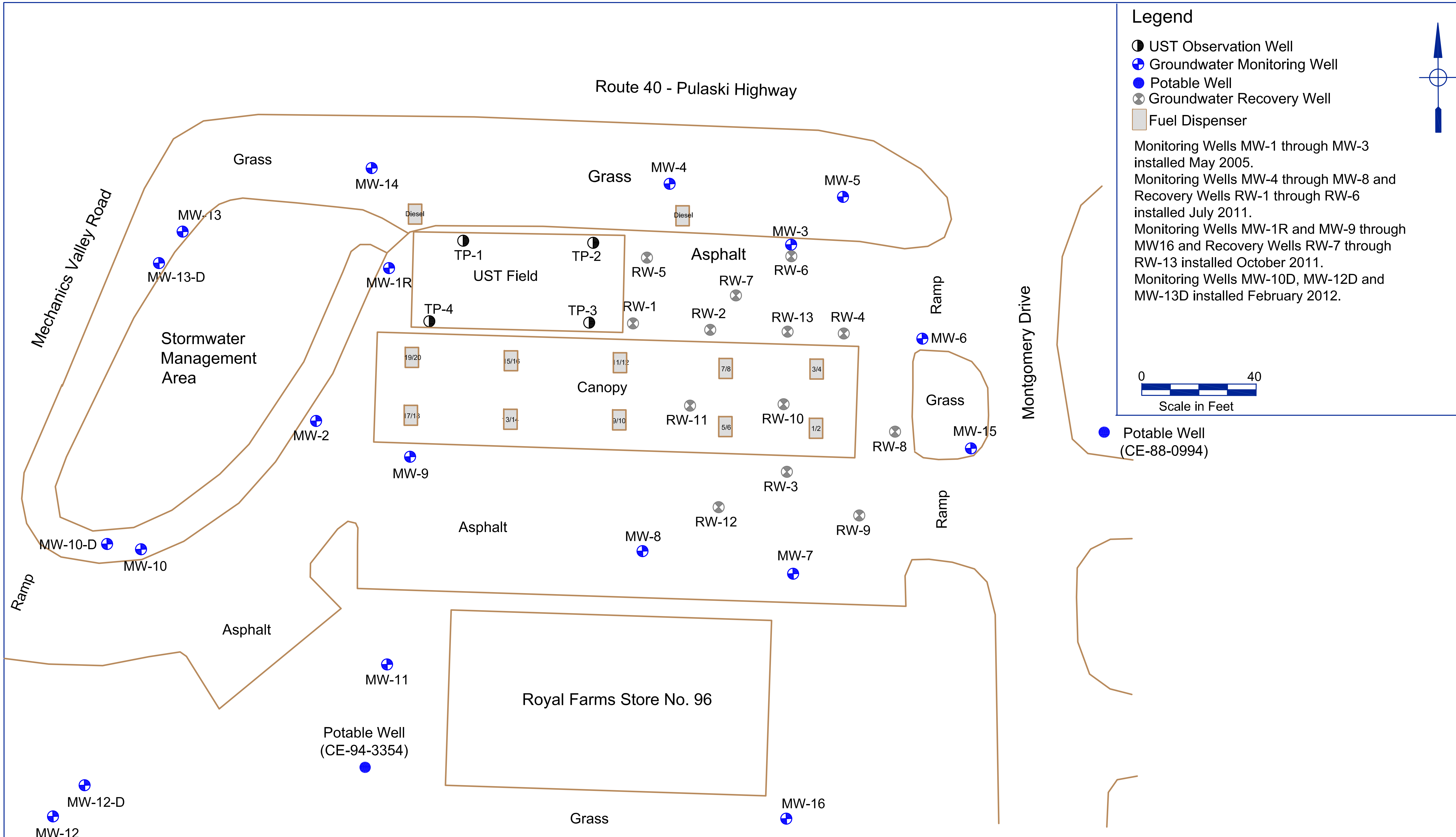
Zoom Level: 12-7 Datum: WGS84

Scale 1 : 28,125

1" = 2,343.75 ft

0 ¼ ½ ¾ 1 mi
0 ½ 1 1½ 2 km

TN
MN
11.7°W



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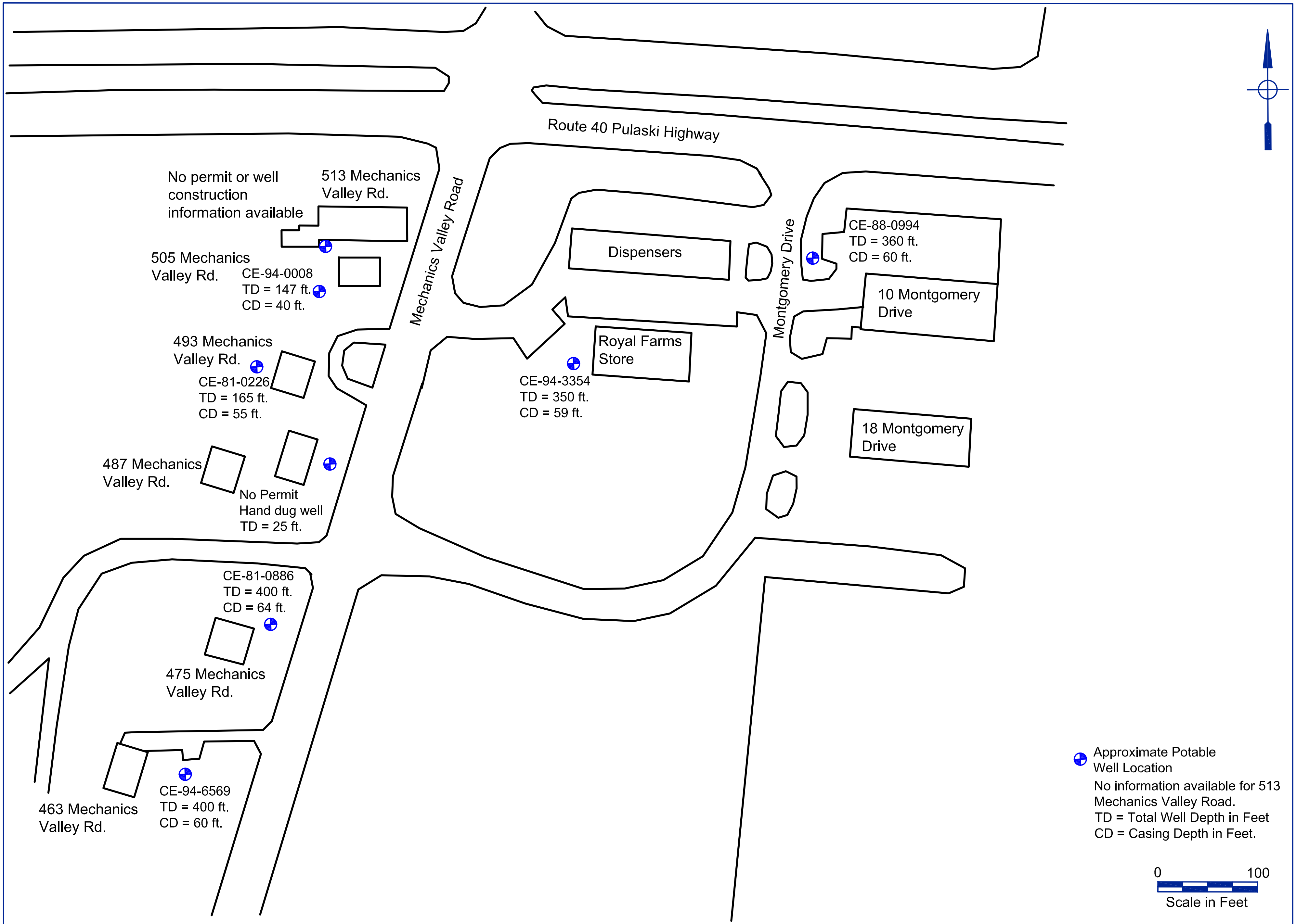
Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 1-10-12
File: Site Features	Revision No.: 2

Figure 2 - Site Features Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



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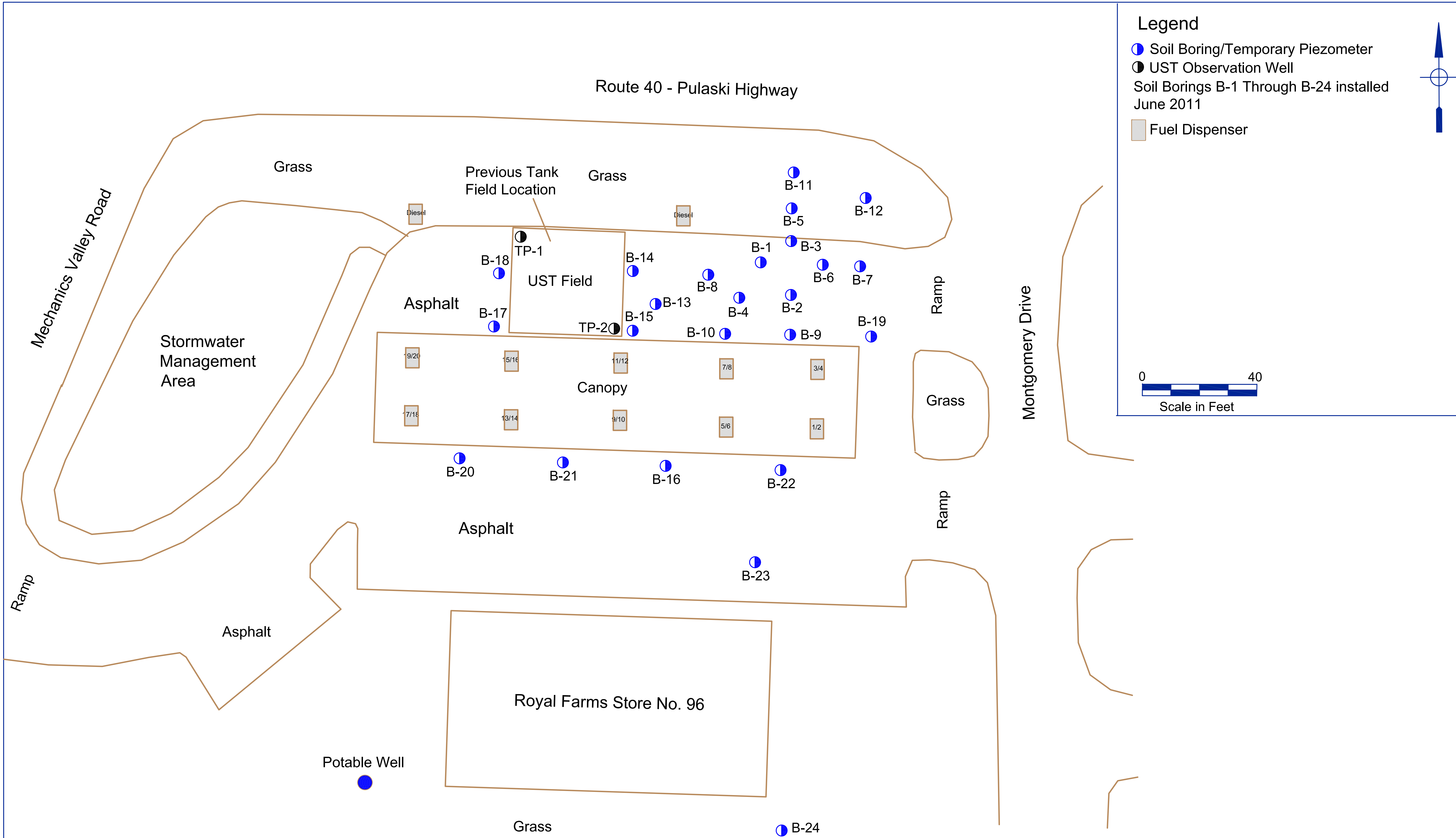
Project No.: 05-056	Drawn by: JSS	Figure 3 - Site Area Map Royal Farms No. 96 500 Mechanics Valley Road North East, MD
Task No.: RF96	Date:1-10-11	
File: Site Area	Revision No.: 2	



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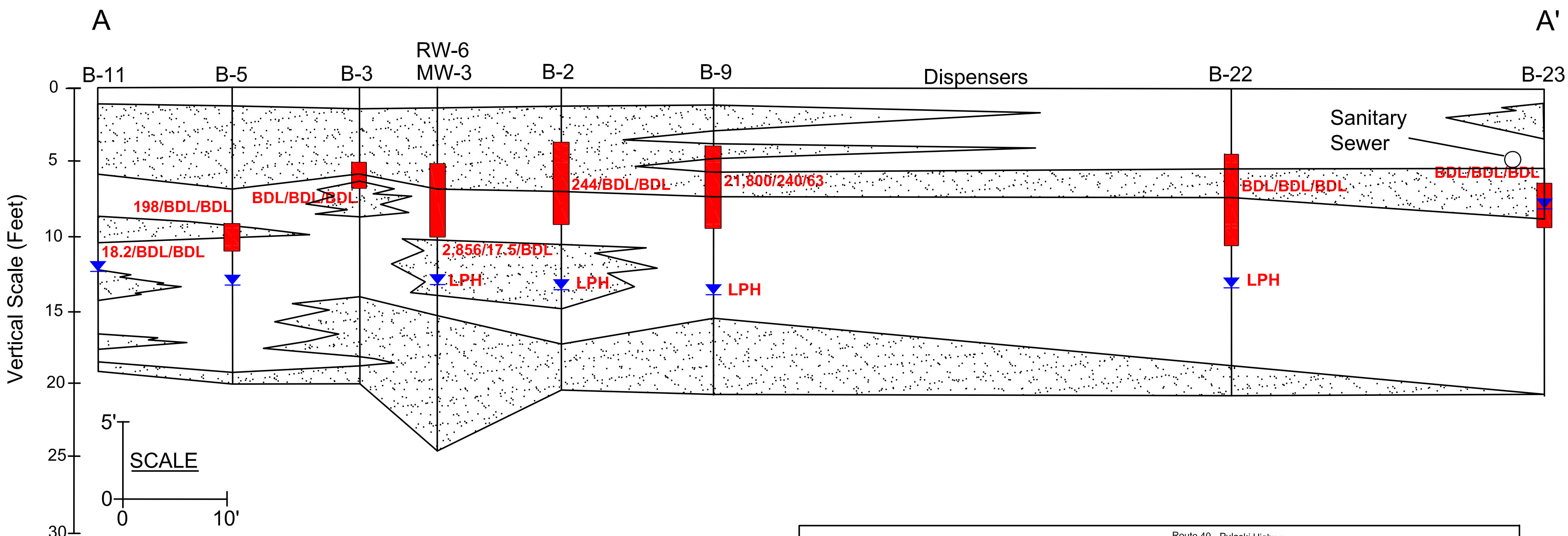
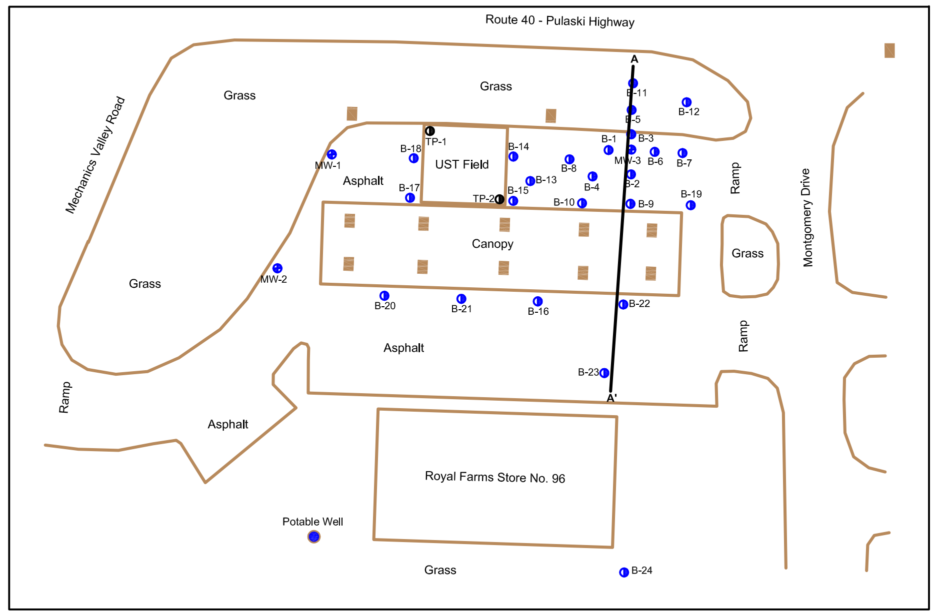
	Task No.: RF96	Date: 6-27-11
	File:	Revision No.: 1

Figure 4 - Boring/Temporary Piezometer Location Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD





Legend

Soil Samples Collected 6-16-11 through 6-21-11

2340/1.2/30 = Total BTEX/TPH GRO/TPH DRO concentration.

Total BTEX in micrograms per kilogram (ug/kg)

TPH GRO and DRO in milligrams per kilogram (mg/kg)

Samples Analyzed by EPA Method 8260 (BTEX) and 8015 (TPH)

BDL = Below Detection Limits

LPH = Liquid Phase Hydrocarbon

predominately coarse grained material (sand/gravel)

predominately fine grained material (silt/clay)

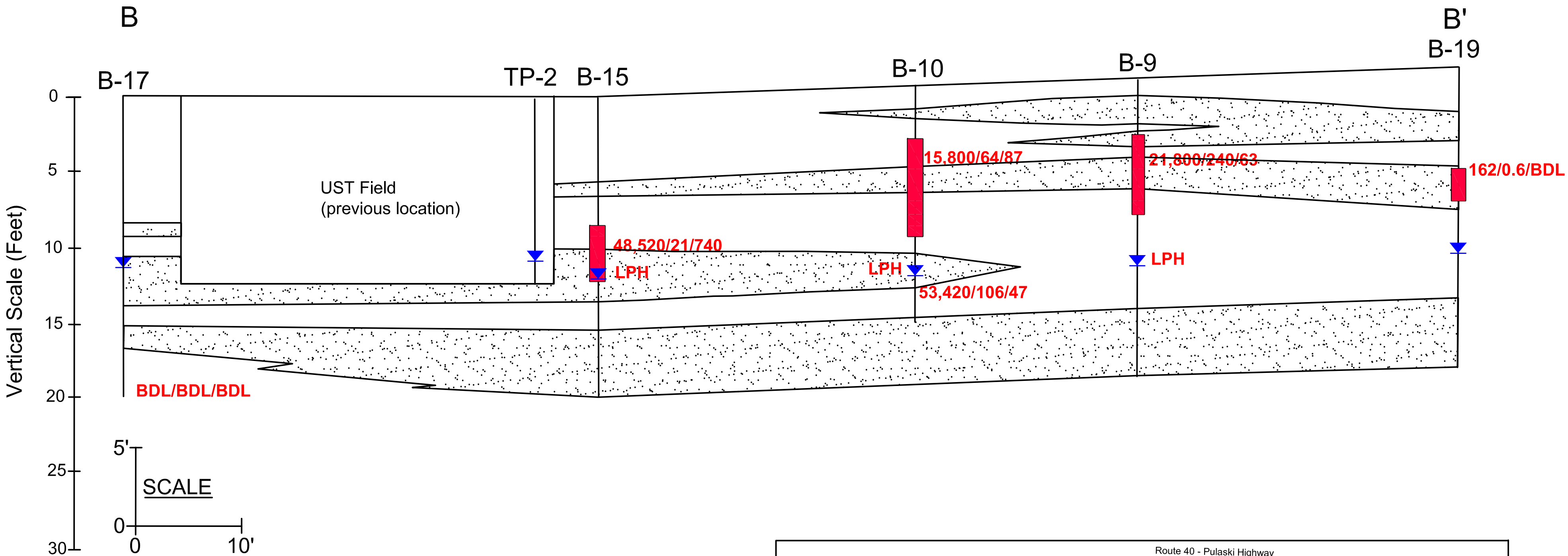
B=Boring/Temporary Piezometer

MW=Monitoring Well

Water Level 6-29-2011

Zone of PID readings above 100 parts per million (ppm)

Advantage Environmental Consultants, LLC 8610 Washington Boulavard, Suite 217 Jessup, Maryland 20794 301-776-0500	Drawn by: JSS Date: 6-29-11	Checked by: JSS Revision: First	Figure 5 - Lithologic Cross Section A-A' Royal Farms No. 96 500 Mechanics Valley Road North East, Maryland



Legend

Soil Samples Collected 6-16-11 through 6-21-11
2340/1.2/30 = Total BTEX/TPH GRO/TPH DRO concentration.
Total BTEX in micrograms per kilogram (ug/kg)
TPH GRO and DRO in milligrams per kilogram (mg/kg)
Samples Analyzed by EPA Method 8260 (BTEX) and 8015 (TPH)
BDL = Below Detection Limits
LPH = Liquid Phase Hydrocarbon

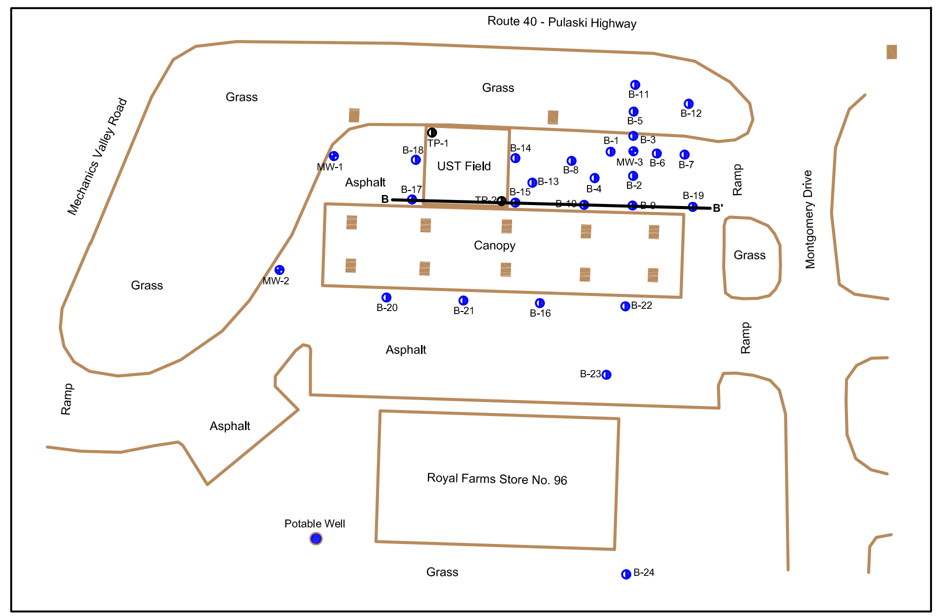
predominately coarse grained material (sand/gravel)

predominately fine grained material (silt/clay)

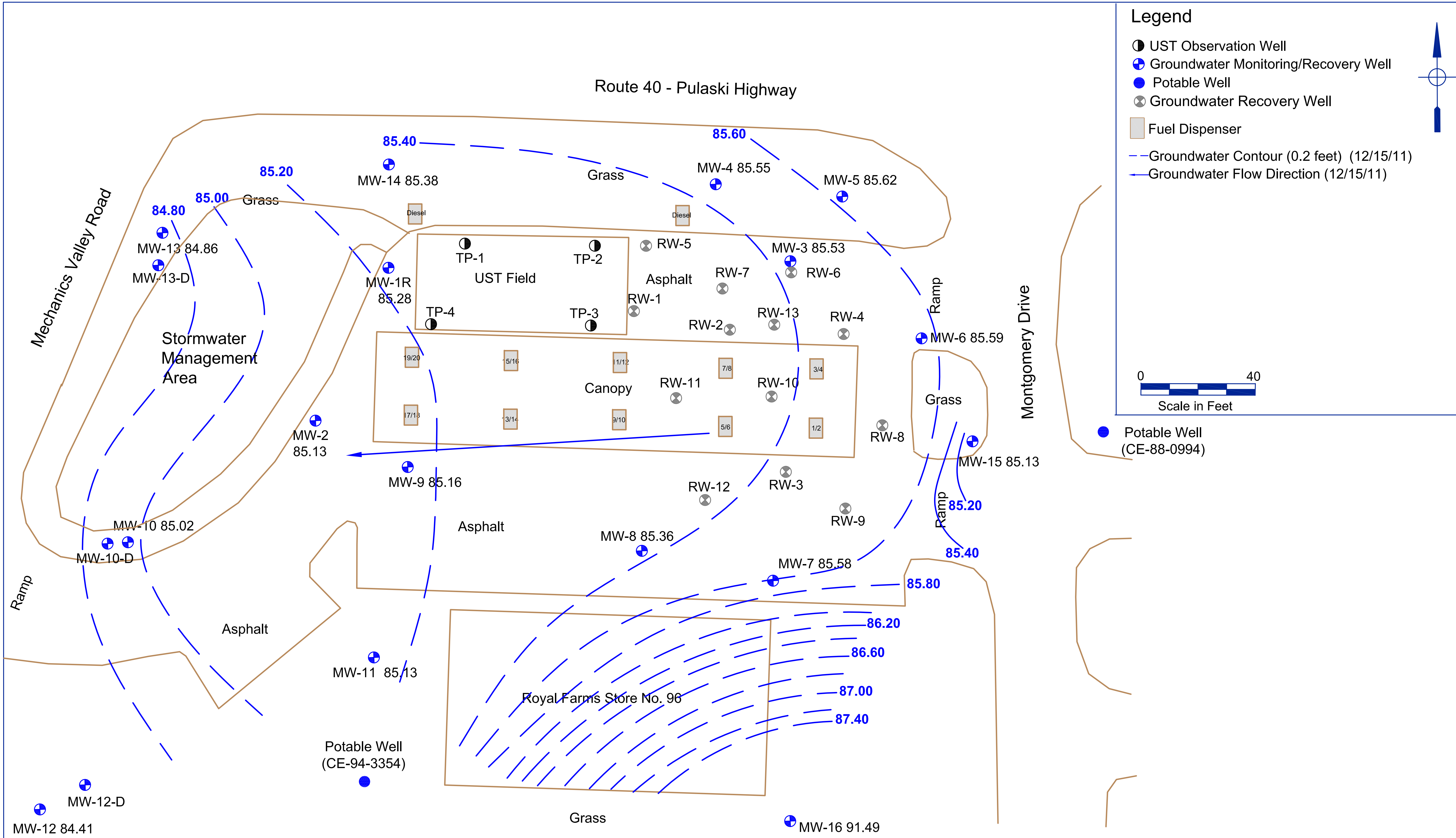
B=Boring/Temporary Piezometer
TP=Tank Pit Observation Well

Water Level 6-29-2011

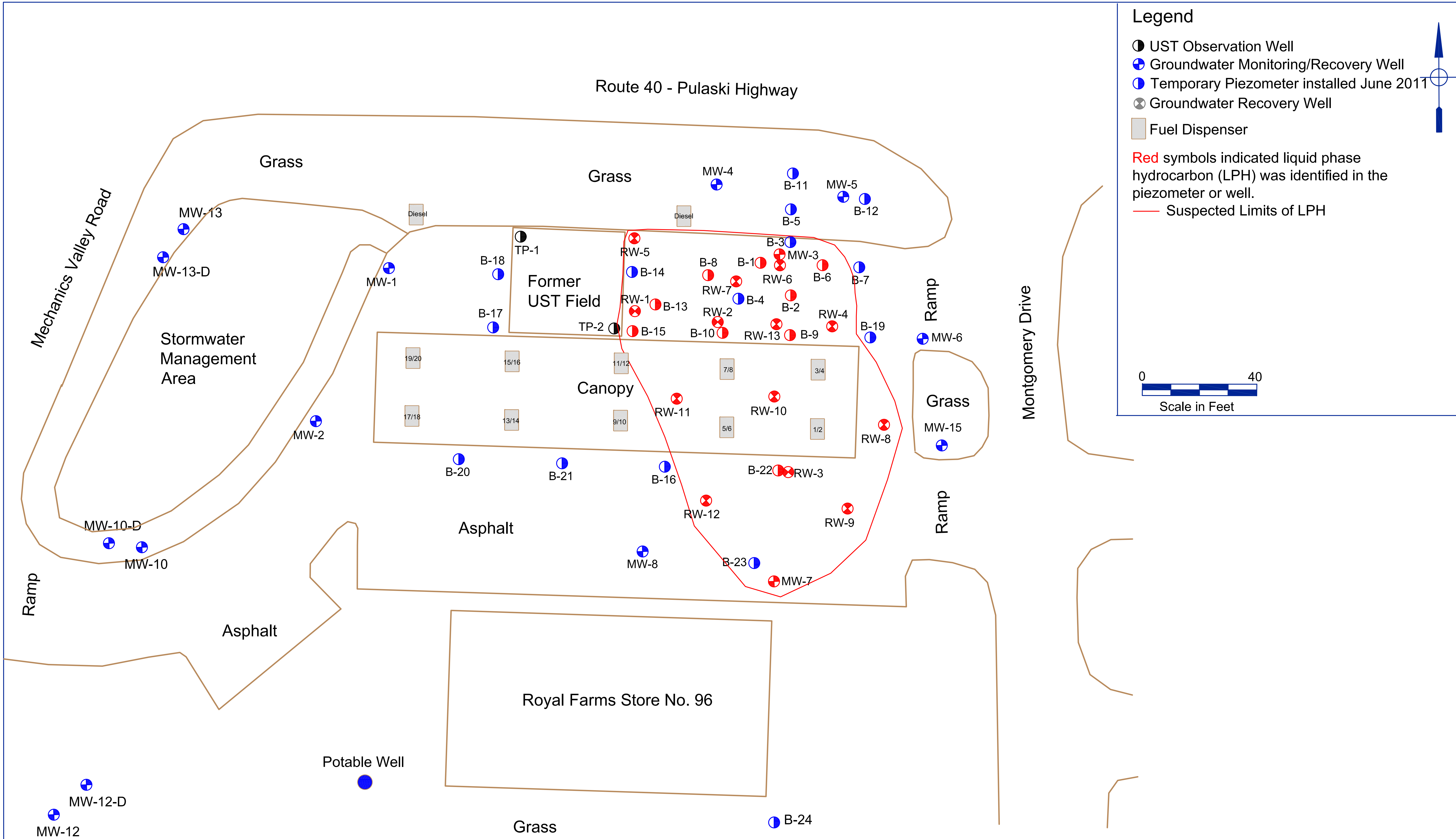
Zone of PID readings above 100 parts per million (ppm)



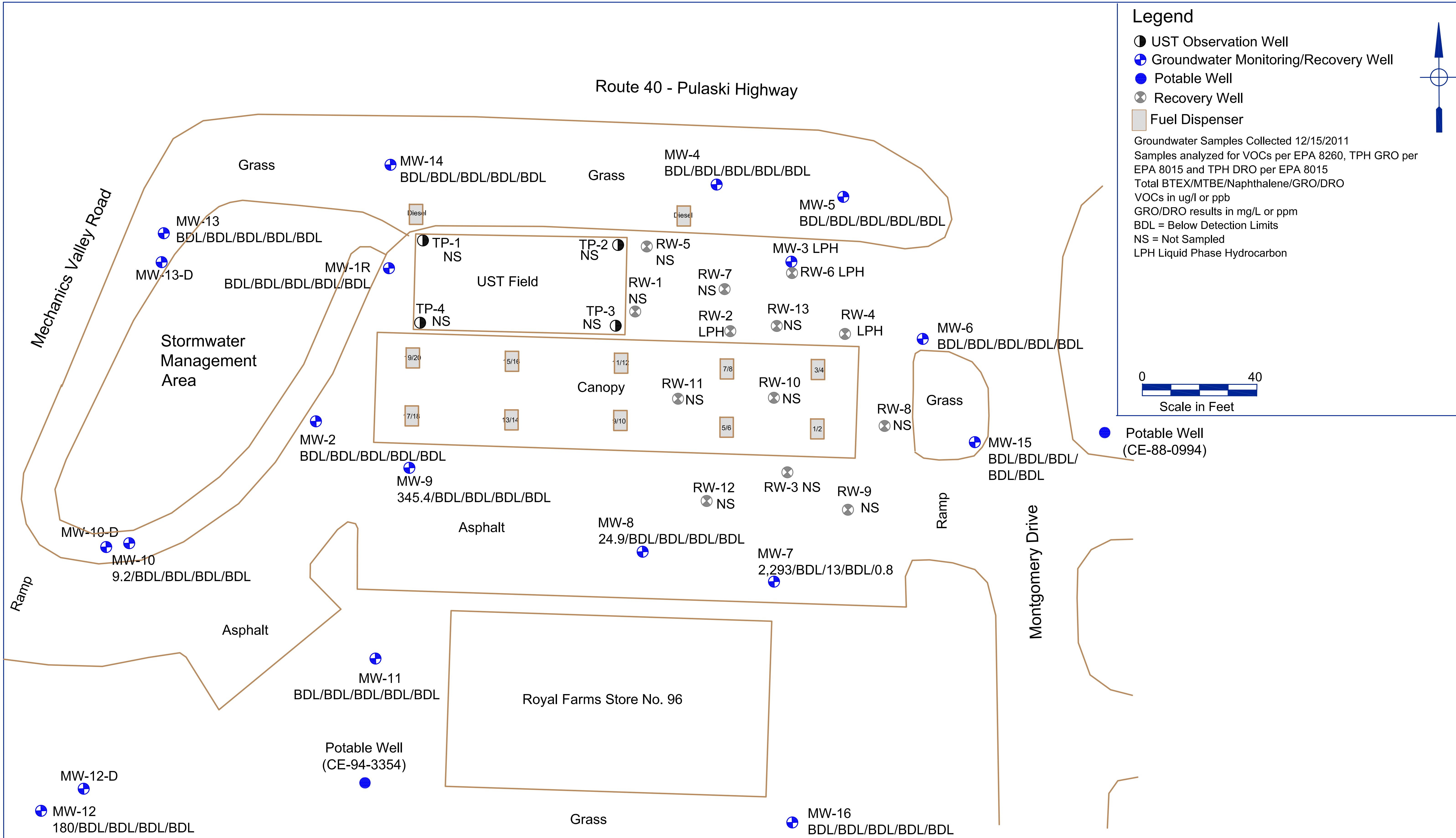
Advantage Environmental Consultants, LLC 8610 Washington Boulavard, Suite 217 Jessup, Maryland 20794 301-776-0500	Drawn by: JSS	Checked by: JSS	Figure 6 - Lithologic Cross Section B-B' Royal Farms No. 96 500 Mechanics Valley Road North East, Maryland
	Date: 6-29-11	Revision: First	



Advantage Environmental Consultants, LLC 8610 Washington Blvd. Suite 217 Jessup, MD 20794 Phone 301-776-0500 Fax 301-776-1123	Project No.: 05-056	Drawn by: JDW	Figure 4 - Groundwater Gradient Map Royal Farms No. 96 500 Mechanics Valley Road North East, MD
	Task No.: RF96	Date: 1-10-12	
	File: Site Features	Revision No.: 3	



Advantage Environmental Consultants, LLC 8610 Washington Blvd. Suite 217 Jessup, MD 20794 Phone 301-776-0500 Fax 301-776-1123	Project No.: 05-056	Drawn by: JSS	Figure 8 - Liquid Phase Hydrocarbon Distribution Map Royal Farms No. 96 500 Mechanics Valley Road North East, MD
	Task No.: RF96	Date: 1-21-12	
	File: Remed Zone	Revision No.: 2	



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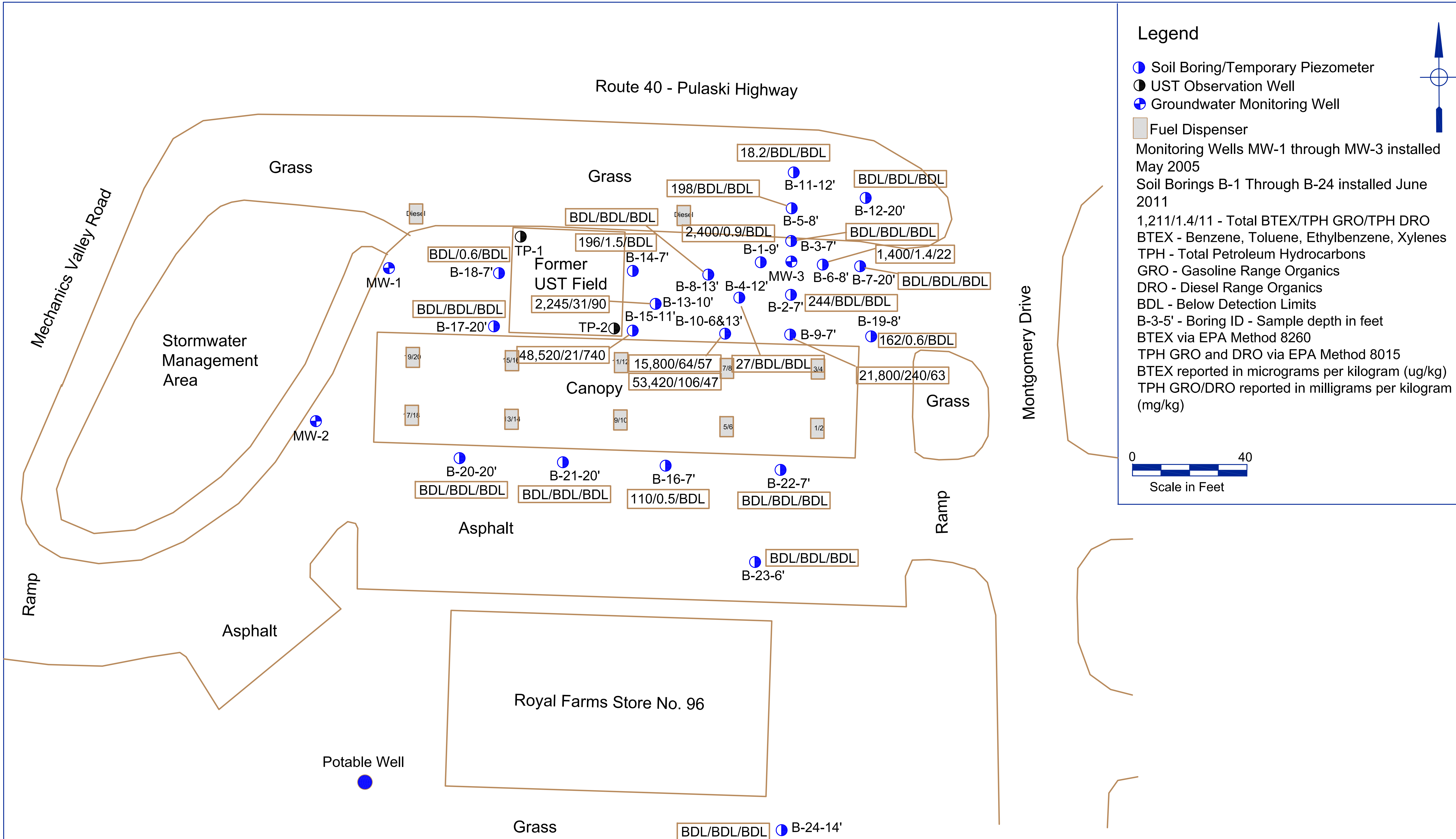
Project No.: 05-056	Drawn by: JDW
Task No.: RF96	Date: 1-10-12
File: Site Features	Revision No.: 3

Figure 9 - Groundwater Quality Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



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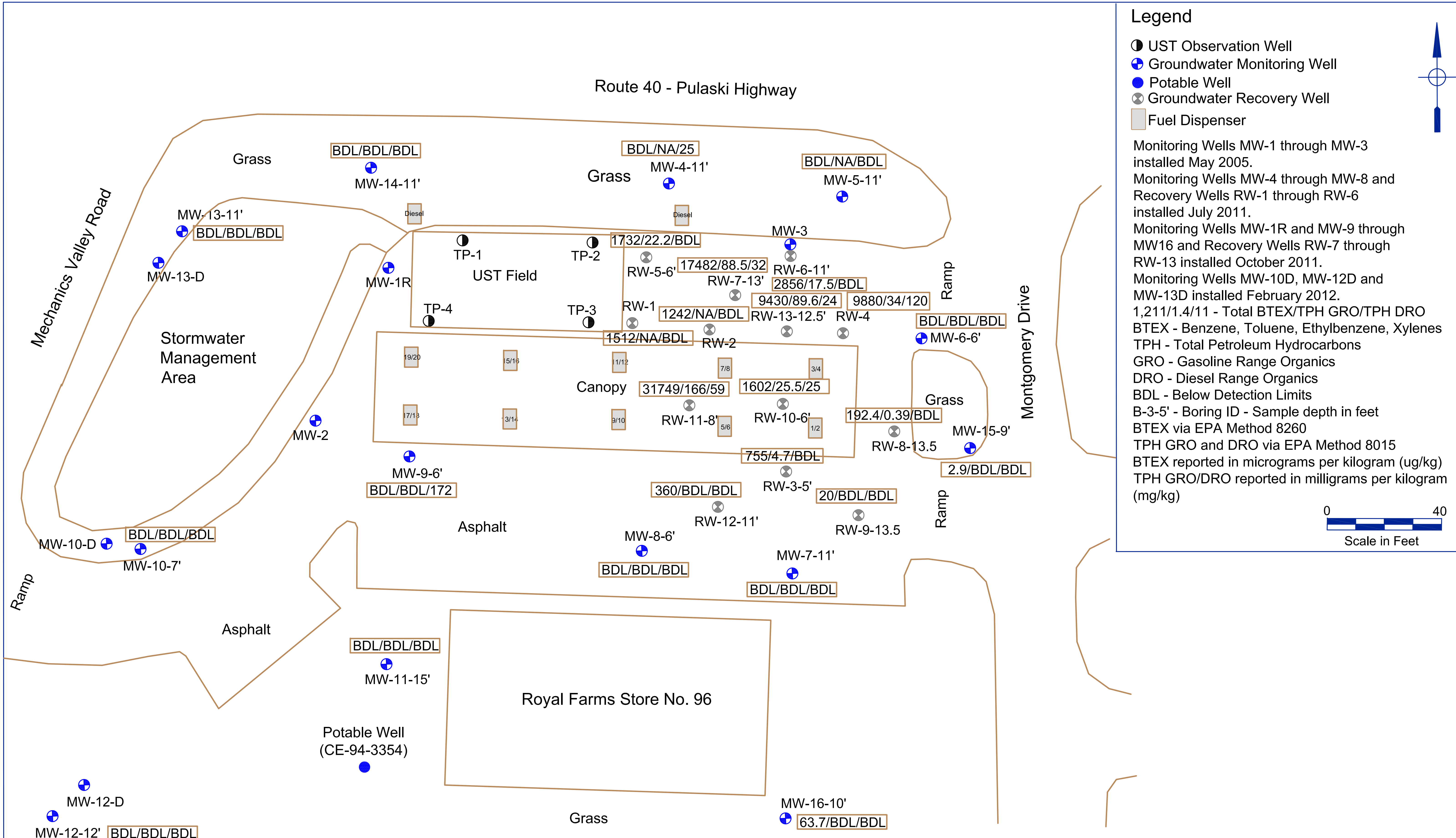
Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 6-27-11
File: Soil Qual	Revision No.: 1

Figure 10A - Soil Quality Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



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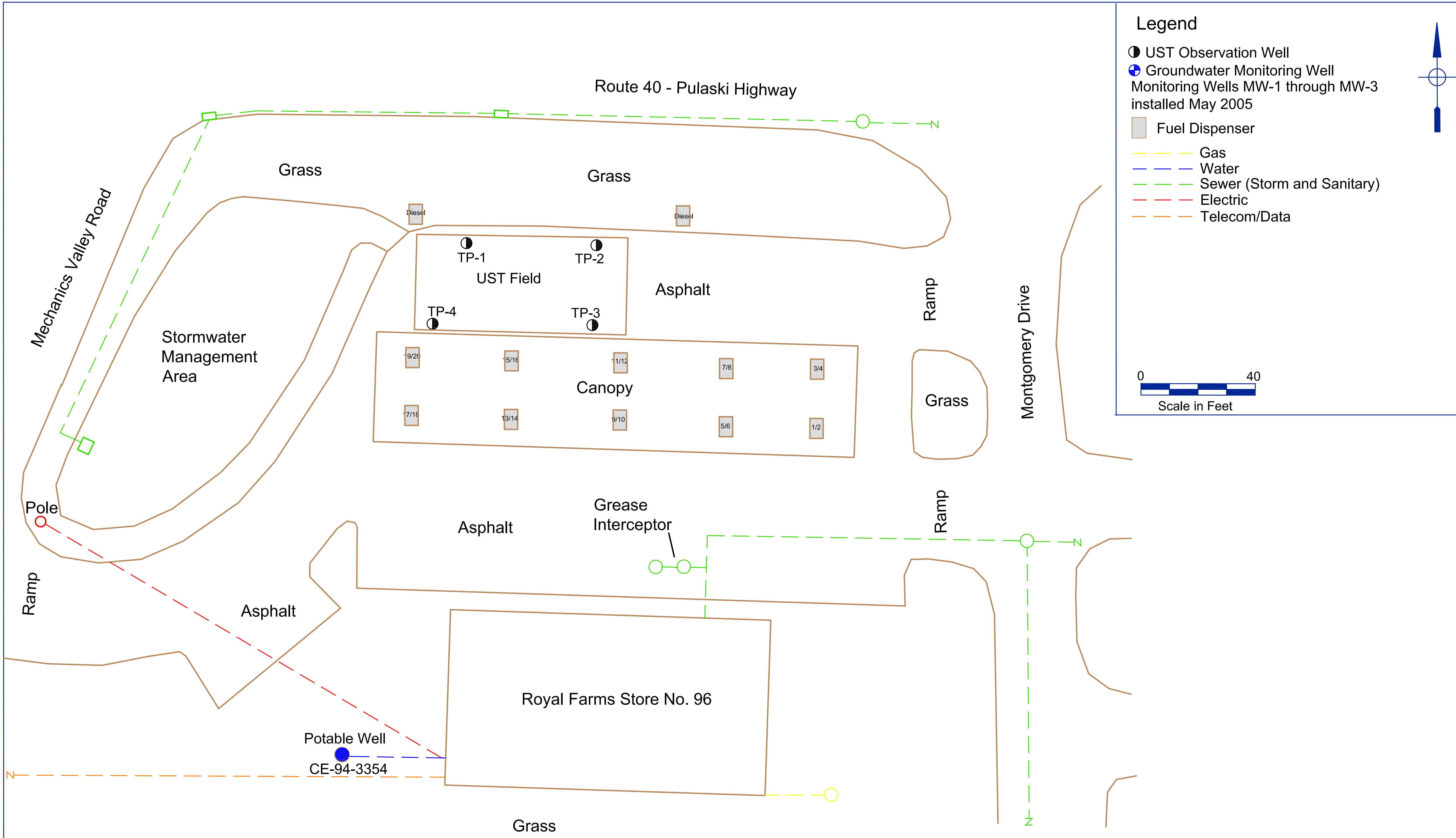
Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 1-10-12
File: Site Features	Revision No.: 2

Figure 10B - Soil Quality Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



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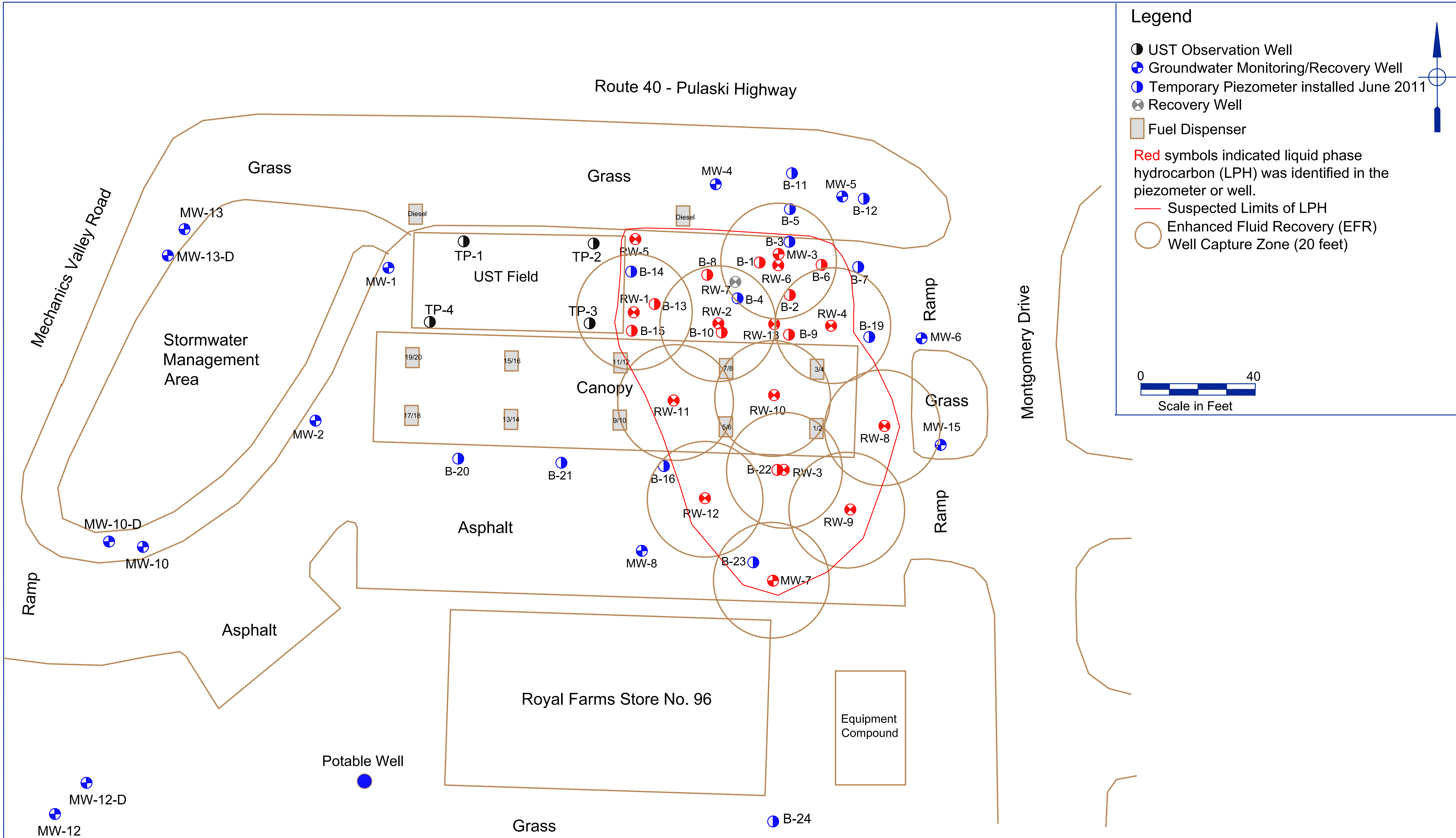
Project No.: 05-056	Drawn by: JSS	Figure 11 - Site Utilities Map Royal Farms No. 96 500 Mechanics Valley Road North East, MD
Task No.: RF96	Date: 6-22-11	
File: Site Features	Revision No.: 1	



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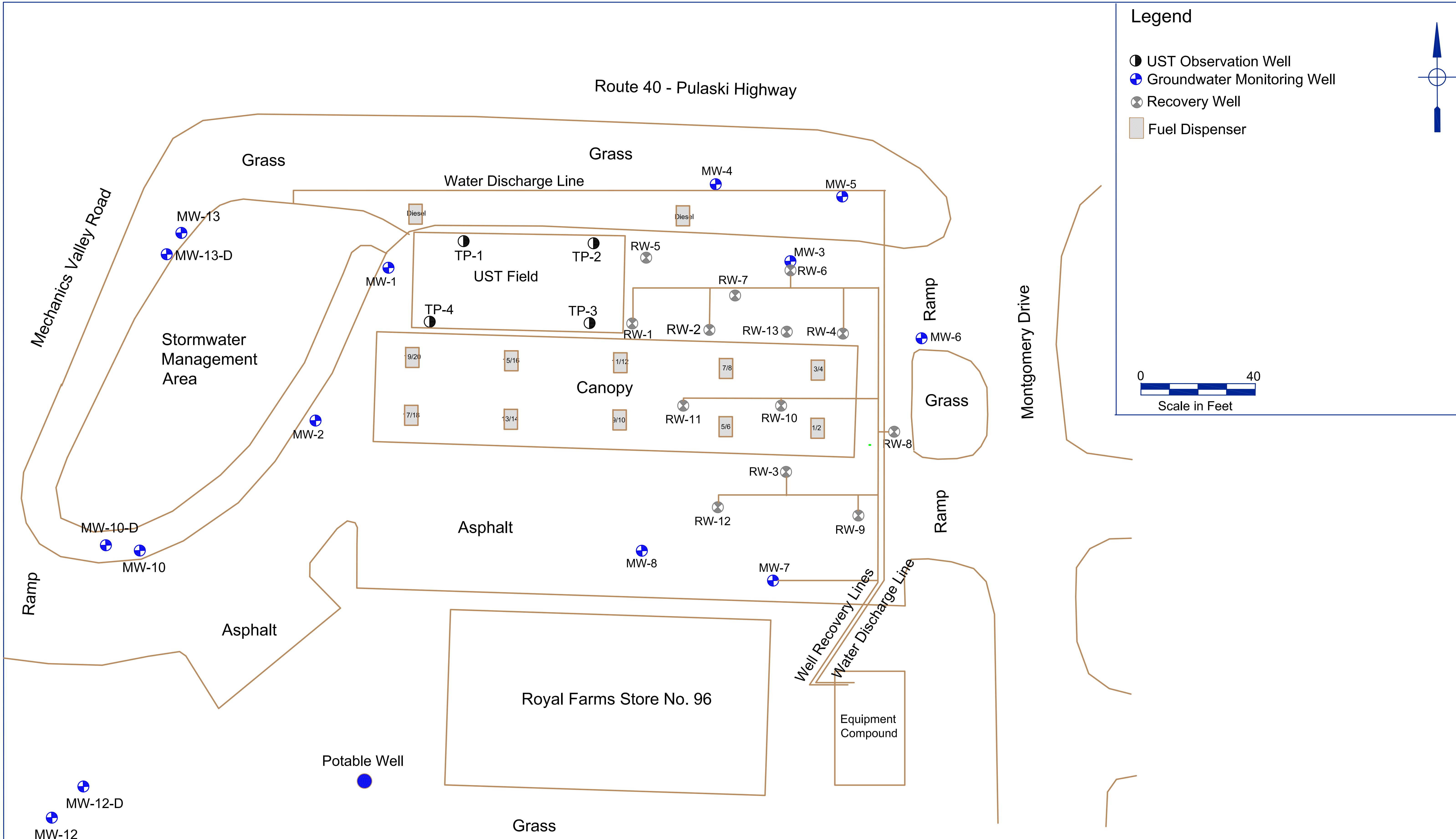
Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 1-21-12
File: Remed Zone	Revision No.: 2

Figure 12 - Proposed Remediation Zone Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



Project No.: 05-056	Drawn by: JSS	Figure 13 - Proposed Trench Configuration Map Royal Farms No. 96 500 Mechanics Valley Road North East, MD
Task No.: RF96	Date: 8-2-11	
File: Line Map	Revision No.: 1	

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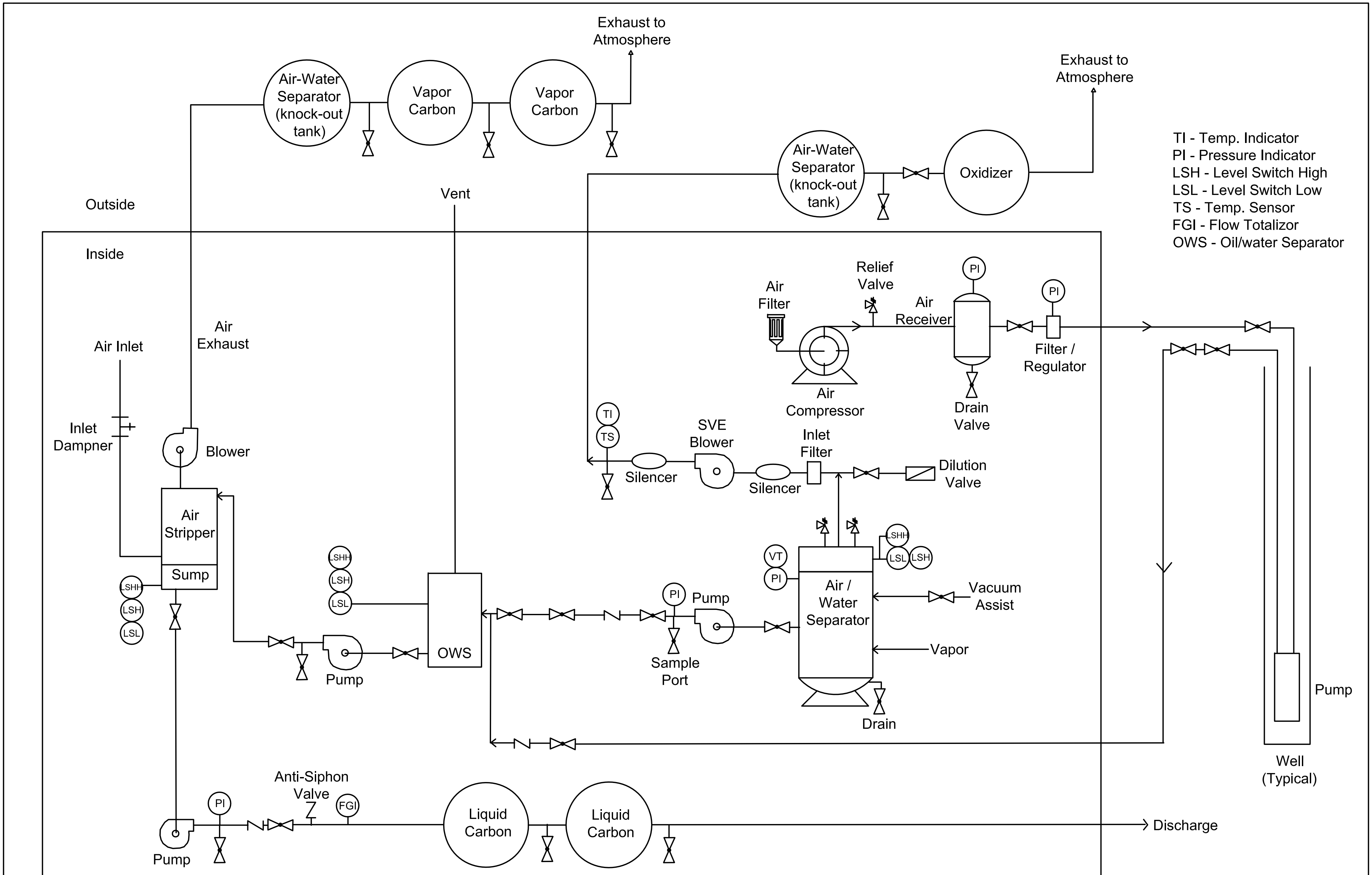

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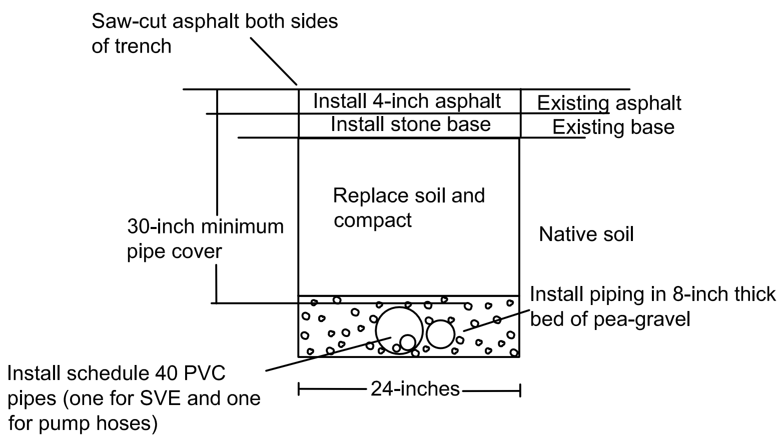
301-776-0500

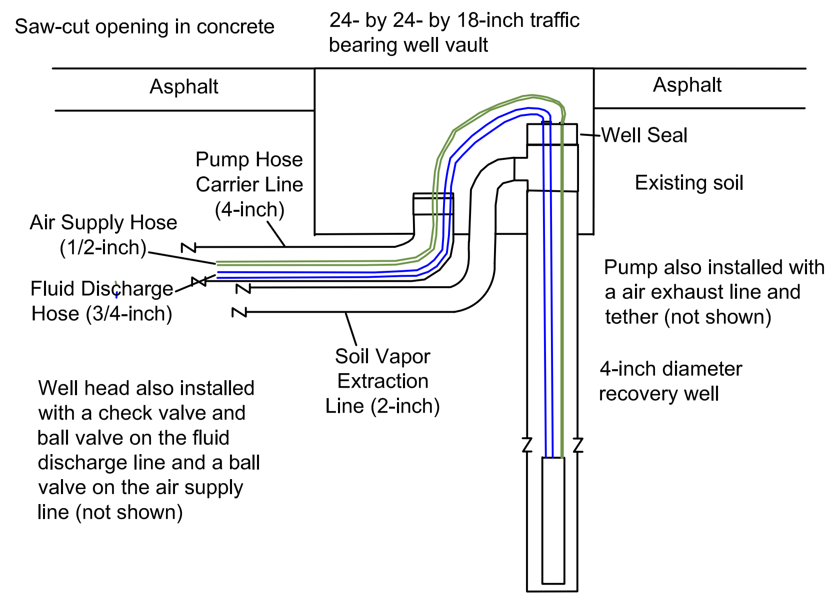
Drawn by: JSS	Checked by: JSS
Date: 9-13-11	Revision: First

Figure 14 - Process & Instrumentation Diagram
Royal Farms No. 96
500 Mechanics Valley Road
North East, Maryland

Trench Section (Typical)



Well Head Set Up (Typical)



Advantage Environmental Consultants, LLC 8610 Washington Boulavard, Suite 217 Jessup, Maryland 20794 301-776-0500	Drawn by: JSS	Checked by: JSS	Figure 15 - Vault and Trench Details Royal Farms No. 96 500 Mechanics Valley Road North East, Maryland
	Date: 9-13-11	Revision: First	

APPENDIX B

Design Basis Summary
Dual Phase Recovery System
Gasoline Fueling Station – Royal Farms #96
500 Mechanics Valley Road
North East, Cecil County, Maryland 21901
OCP Case No. 2011-0729-CE
MDE Facility No. 13326

Introduction

Based on the July 27, 2011 enhanced fluid recovery (EFR) pilot study findings AEC has developed the following remediation system design criteria: Radius of influence (ROI) - 25 feet; Individual recovery well flow rate – 6 gallons per minute (gpm); Individual recovery well drawdown - 4 feet below static groundwater; and, Individual recovery well air flow rate - 50 cubic feet per minute (cfm). Based on a 10 recovery well use scenario the minimum treatment system equipment sizing criteria will be: 30 gpm water flow rate and 500 cfm air flow rate. Dual phase (vapor and liquid) recovery technology has been selected for use at this site. Dual phase recovery will be implemented using pneumatic submersible pumps for liquid removal and a positive displacement vacuum blower for vapor removal. This technology is similar to EFR in concept and application. The following provides a summary of the equipment to be used for the dual phase application at the site. Also provided are a Process and Instrumentation Diagram and Trench and Well Head Details.

Soil Vapor Extraction System

25 HP Positive displacement vapor extraction system, Tuthill 5009SL or equal
600 ACFM @ 10"Hg. Capacity
Temperature gauge
High temperature switch
Inlet filter and inlet silencer
Universal SD series or better discharge silencer
Universal SD series or better
Belt drive
Automatic and manual dilution valves with silencer

200 Gallon Vertical Air/water Separator

Conductivity probe level switches
10" diameter clean out ports with vacuum rated quick release lids
Clear PVC sight glass piping to liquid ring pump, to check for water carryover
Liquid filled vacuum gauge
Vacuum assist line
2" drain valves
Vacuum relief valves
Dilution valve with filter/silencer
Inlet screen

MK Coalescing Oil/Water Separator System

Model C85 with 85 GPM capacity

Coalescing separator with product skimming weir
Polypropylene coalescing pack with 1/2" spacing for efficient oil removal
Hopper bottom for sludge removal
Effluent chamber with stainless steel float level sensors

MK Low Profile Cascade Air Stripper System
0-150 GPM flow rating
800 CFM air flow rating
3-tray air stripper unit - Model LP150-3
Low profile air stripper with 7.5 hp AMCA Type B spark resistant aluminum blower
Nylon tube aeration air stripper for high mass removal rates with low maintenance
Low, high, and high-high sump conductivity probes
12" clean out hatch
Epoxy coated carbon steel construction
Sump level sight glass
99.8% Removal for BTEX @ 50 GPM, 60°F

Air Stripper Blower Silencer to Reduce Noise Level of the Stripper Blower

1.5 hp Transfer Pump
3450 rpm, TEFC motor
Cast Iron housing with bronze impeller, anti air lock design
Manual "Pump ON" button inside building for sampling

3 hp Transfer Pump (2)
3450 rpm, TEFC motor
Cast Iron housing with bronze impeller, anti air lock design
Manual "Pump ON" button inside building for sampling

Groundwater Inlet Manifold
Carbon steel with brass valves
2" main with (11) 1" points, with shut off valve, check valve, sample port, barb for each groundwater pump.

Vapor Inlet Manifold
PVC
6" main with (11) 2" points, with shut off valve, union and sample port for each well.

Air Compressor
15 HP rotary vane with continuous run option
90 gallon receiver tank
Air cooled after cooler
Low oil switch
Tank auto drain
1/2" filter regulator
1/2" 3 way Asco solenoid valve

Recovery Pumps - QED AP4 Long Top Fill Pneumatic Pumps (10)
10 GPM maximum flow rate
Down well hoses and support rope per well
Vacuum well seal
3/4" brass shut off at each well for groundwater
1/2" brass ball valve for compressed air at each well

Master Control Panel System
NEMA 3R control panel with blank front cover
Swing out sub panel for gauges, control operators, and switches
IEC Magnetic motor starters, safety switches, H-O-A controls
Control transformer
8 intrinsically safe relays, 8 alarm indicator LED's, 16 output channels
Hard wired relay logic
Exterior GFCI utility outlet
System run-time totalizing hour meter
Blower low pressure alarm
Anti-falsing alarm circuit to prevent nuisance tripping
Three phase voltage and phase monitor
Emergency E-stop LED red indicator light located on swing out sub panel

Telemetry System Model 570
16 analog inputs, expandable to 32
4 digital outputs
24 hour gel cell battery backup
10,000 line data logger
UL listed surge suppression
Manual or automatic control of outputs
8 number dial out list
Programmable dial out intervals
Site telephone with duplex RJ11 jack

Vacuum Transducer
Integrated into telemetry for real time monitoring
4-20mA

System Building
8.5'W x 28'L x 9.5'H aluminum/steel enclosure, fully insulated
Removable sliding wall panels for ease of maintenance
Exterior grade plywood floor, structural steel frame
Includes 100 watt XP interior light, and removable center grate for ease of maintenance
Breaker panel and control panel will be mounted on a vertical steel bracket attached to platform end.
10" structural steel base with 4" steel cross members
Steel corner posts and roof frame

Continuous sheet aluminum roof
2 XP heater with thermostat, 12,000 BTU each

Groundwater Flow Totalizer
Pulse output and flow calibration button

Equipment Electrical Installation
Includes XP wiring, XP seal off connectors, liquid tight flexible conduit
UL listed equipment.

Equipment Mechanical Installation
Includes mounting, piping and connectors
Brass fittings, sample ports, pressure gauges and sight glasses
400 Amp meter base and (2) 200 amp fused disconnects or breakers for the system and oxidizer
Weatherhead with extension pole and bracket support
Electric meter socket base installed

MKE Model 500E Electric Oxidizer with 50% Effective Heat Exchanger
500 CFM capacity 99% destruction efficiency; flame arrestor
Watlow controls
First out detector
Honeywell 2-pen chart recorder
Located outside system enclosure
Includes 200 amp circuit breaker in main panel

Air/water Separator Knock Out Tank
Located prior to oxidizer to minimize condensed liquids from entering burner or vapor phase carbon bed.

VF-400 Vapor Phase Carbon Vessels
Filled with activated carbon for odor control and vapor capture when the oxidizer is off, during remote restart conditions

Air/water Separator Knock Out Tank
Located prior to oxidizer to minimize condensed liquids from entering vapor phase carbon bed for air stripper

500 Gallon Product Holding Tank
UL listed with emergency vents
Stainless steel high-level float switch and intrinsically safe channel in the control panel

Electrical Service Installation
200 amp 3/60/460 volt 3 wire plus ground electrical service to NEMA 3R control panel
Interior electrical will comply with NEC requirements for Class 1, Division 2, Group D Hazardous locations

Motors will be TEFC construction

Nationally Recognized Testing Laboratory (NRTL) Approvals
MET Labs certified manufacturer

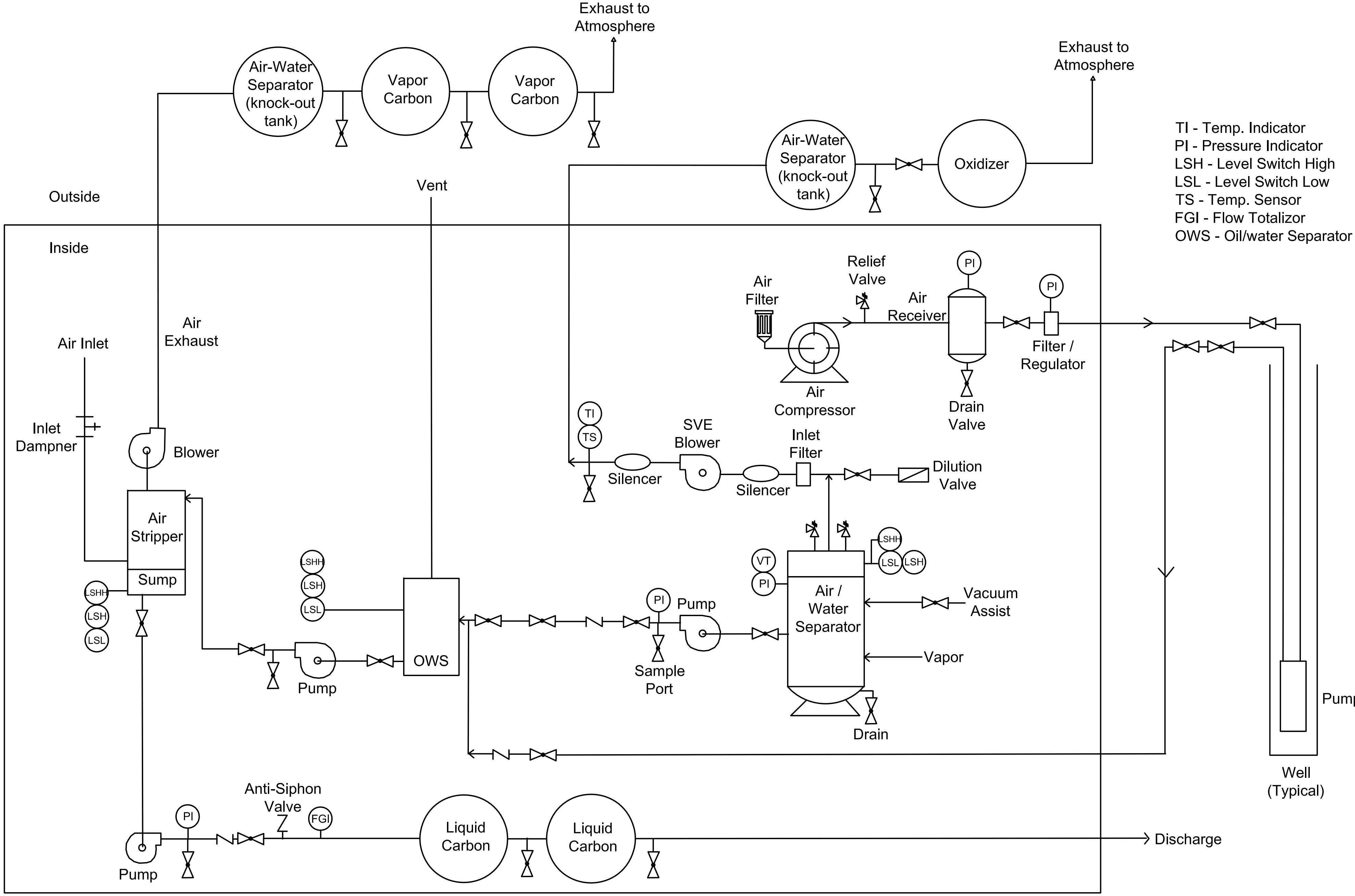
Recovery Well Vaults
2’ by 2’ by 18” side skirt traffic rated well vaults with hydraulic arms

Recovery Well Trenches
Trenches will be saw-cut in asphalt and/or concrete
Trenches will be installed 24” wide and 30” deep
Pipes will be bedded in pea-gravel
Trenches will be backfilled in one foot lifts with crush and run gravel or removed fill
Disturbed areas will be placed back to its original condition i.e. asphalt, concrete, soil

Soil Vapor Extraction System Lines
Recovery wells will have independent SVE lines
Lines will be installed using 2" diameter PVC conduit from treatment building to recovery wells

Recovery Pump Air Line and Discharge Line
Recovery wells will have independent air and discharge lines
Lines will be installed within 4" diameter PVC conduit from treatment building to recovery wells
Air lines to recovery pumps will be 1/2" diameter
Discharge lines from recovery pumps will be 3/4" diameter
Due to the number of 90 degree turns, PVC "sweeps" will be used so that the air/water lines can be easily installed and removed for maintenance

Treated Effluent Discharge Line
Discharged approximately 85 feet to the northeast to the sanitary sewer drain
Effluent line will be 1.5” diameter black PE plastic
Installed three feet below grade



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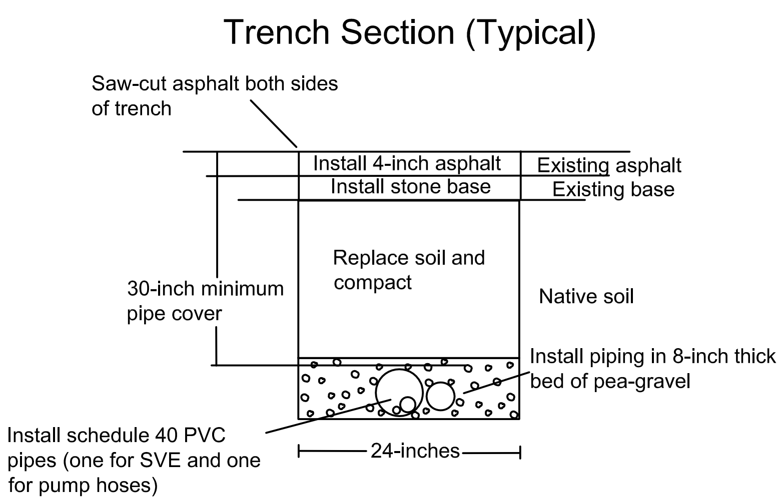
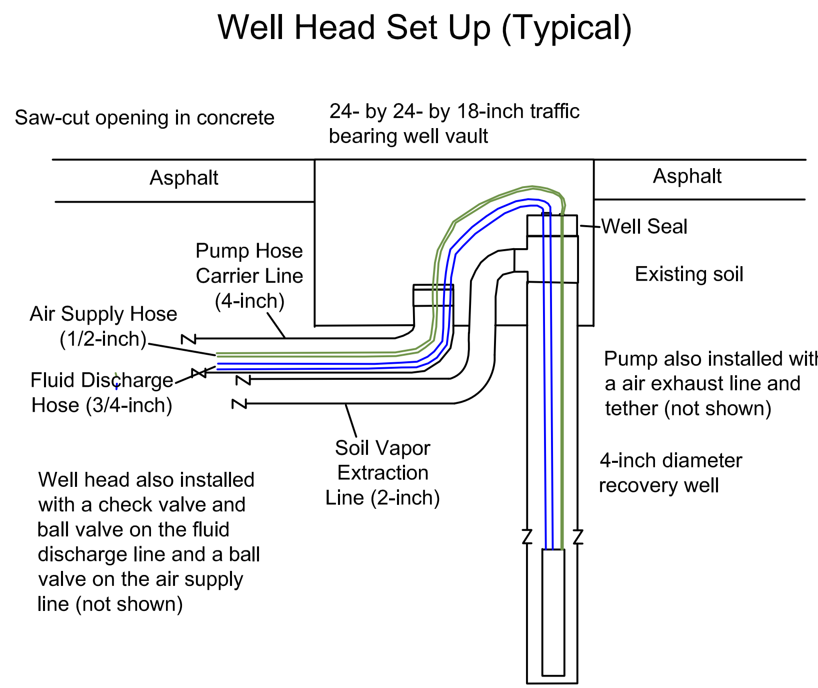
Drawn by: JSS	Checked by: JSS
Date: 9-13-11	Revision: First

Process & Instrumentation Diagram
Royal Farms No. 96
500 Mechanics Valley Road
North East, Maryland





Advantage Environmental Consultants, LLC 8610 Washington Boulavard, Suite 217 Jessup, Maryland 20794 301-776-0500	Drawn by: JSS	Checked by: JSS	Vault and Trench Details Royal Farms No. 96 500 Mechanics Valley Road North East, Maryland
	Date: 9-13-11	Revision: First	

APPENDIX C

***A**DVANTAGE **E**NVIRONMENTAL **C**ONSULTANTS, LLC*

Dual Phase System Design Pilot Study Report

Gasoline Fueling Station – Royal Farms #96
500 Mechanics Valley Road
North East, Cecil County, Maryland 21901

OCP Case No. 2011-0729-CE
MDE Facility No. 13326

AEC Project Number: 05-056 RF096

Prepared for:
Maryland Department of the Environment
Oil Control Program
Montgomery Park
1800 Washington Boulevard
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And

Royal Farms / Two Farms, Inc.
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January 31, 2012

ADVANTAGE ENVIRONMENTAL CONSULTANTS, LLC

Dual Phase System Design Pilot Study Report

Prepared by: Thomas E. Ruszin III
Title: Staff Scientist
Date: January 31, 2012

Reviewed by: Jeffery S. Stein, P.G.
Title: Principal
Date: January 31, 2012

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1.0 INTRODUCTION

Advantage Environmental Consultants, LLC (AEC) has prepared this Dual Phase System Design Pilot Study Report for the Royal Farms Store No. 96 located at 500 Mechanics Valley Road in North East, Maryland. Site Vicinity, Site Features, and Site Area Maps are provided in Appendix A as Figures 1, 2 and 3.

This report was prepared in accordance with Dual Phase System Design Pilot Study Work Plan, dated October 27, 2011. The work plan was prepared as a companion to the document titled Design Basis Summary - Dual Phase Recovery System, prepared by AEC and dated September 13, 2011.

The Dual Phase System Design Pilot Study Work Plan was approved in correspondence from the Maryland Department of the Environment (MDE) dated December 8, 2011. The MDE required these additional pilot tests to confirm that proposed system modifications outlined in the Design Basis Summary will be capable of achieving the previously established radius of influence (ROI). This report includes estimates of the maximum, minimum, and optimal flow rates needed to establish hydraulic control, with consideration to a phased lowering of the pumps over time to establish optimum recovery of the plume.

1.1 Project Overview

Based on abbreviated enhanced fluid recovery (EFR) pilot studies conducted on July 21 and 22, 2011 a Corrective Action Plan (CAP) was prepared and submitted to the MDE on July 25, 2011. The CAP presented the following remediation system design criteria: ROI - 20 feet; individual recovery well flow rate – 3.2 gallons per minute (gpm); individual recovery well drawdown – up to 5 feet below static groundwater; and, individual recovery well air flow rate - 50 cubic feet per minute (cfm). Data collected during the course of the initial pilot study did not provide some necessary final design parameters associated with the feasibility of the technology and process/treatment equipment sizing. As such, the performance of a full scale EFR pilot study was recommended in the CAP.

Based on the full scale EFR pilot study conducted on July 27, 2011, using equipment enabling the necessary design data to be collected, a CAP Addendum (August 3, 2011) was developed. The full scale EFR pilot study indicated the following remediation system design criteria: ROI - 25 feet; individual recovery well flow rate – 4 to 6 gpm; individual recovery well drawdown - 4 feet below static groundwater; and, individual recovery well air flow rate - 50 cfm.

Both the CAP and the CAP Addendum planned on an EFR design using liquid ring pump (LRP) technology. The CAP and CAP Addendum selected the LRP technology based on extraction at eight recovery wells. Based on a technical meeting with the MDE, an expansion of the recovery system to a range of 10 to 13 wells was required. As a result of the increased system flow rates from the additional wells, the standard LRP equipment would be reaching its maximum design capabilities. As such, a Design Basis Summary was created that introduced the dual phase approach using integrated vapor extraction/groundwater extraction (VE/GE) technology. The VE/GE will be implemented using pneumatic submersible pumps for liquid removal and a positive displacement vacuum blower for vapor removal. This technology is similar to LRP induced EFR but offers the capability for increased flow rates.

1.2 Project Objectives

The primary objective of the dual phase system design pilot studies is to confirm that the proposed system modifications outlined in the Design Basis Summary are capable of achieving the previously established ROI (25 feet). In order to accomplish this task the following studies were performed: constant rate aquifer pumping test and modified step drawdown and dual phase recovery tests. A brief description of the pilot study activities is presented below.

A constant-rate aquifer pumping test was conducted at select recovery and monitoring wells to estimate aquifer parameters (hydraulic conductivity and coefficient of transmissivity) and the effective radius of influence (capture zone) of each well under a constant pumping rate. Recovery measurements were also obtained for similar time intervals as the drawdown measurements.

The modified step drawdown test entailed pumping the recovery well at successively higher flow rates for equal, or nearly equal, time steps. The step drawdown testing was used to evaluate an optimal flow rate for the dual phase recovery test discussed below. Using the results of the step drawdown testing, a specific flow rate was used for the dual phase recovery test. The dual phase recovery test was used to determine if equivalent water and air flows as the design basis summary (4 to 6 gpm water flow and 50 cfm air flow) produce a similar radius of influence as the recent EFR test.

2.0 PILOT STUDY PROCEDURES

2.1 Pilot Study Location Selection

The location of the pilot study is on the northeast quadrant of the Site. This area has been characterized by multiple temporary piezometers, monitoring and recovery wells. This area is located within the Liquid Phase Hydrocarbon (LPH) plume and adjacent to the suspect source area (northeastern dispenser islands). Figure 4 in Appendix A illustrates the historical extent of LPH.

2.2 Pilot Study 1 – Constant Rate Pumping Test

The following is the operating procedure for the aquifer pumping test conducted at the Site on January 13, 2012. The pilot study used extraction equipment that was capable of producing approximately equivalent water flows as the design basis summary description (i.e., 4 to 6 gpm). The pilot study groundwater extraction pump was capable of up to 10 gpm flows.

2.2.1 Procedure

The constant rate test is the standard method for determining the aquifer parameters of hydraulic conductivity and transmissivity. The resultant drawdown data was plotted verses time and distance to develop these aquifer parameters. RW-13 was used as the recovery well. Water levels in monitoring wells RW-2, RW-4, RW-6, RW-7 and RW-10 were recorded using pressure transducers. Water levels in wells RW-1, RW-3, MW-5, and MW-6 were recorded using a water level meter. Based on the previous EFR pilot study it was expected that equilibrium conditions could be reached in approximately 4 hours. The constant rate pumping test was performed for a period of 4 hours and 38 minutes.

The following procedures were used to perform the pumping test:

- An initial round of water levels was collected within each monitoring well using an oil-water interface probe accurate to 0.01-feet.
- The beginning of data collection was programmed to begin several minutes before the start of the test. The transducers were programmed to use drawdown mode relative to the static water level and to obtain 30-second arithmetic data during the pumping and recovery tests. The transducers installed in the monitoring wells were programmed to obtain 30-second arithmetic data during the pumping test. In order to obtain more frequent initial data the transducer in the recovery well was programmed to collect logarithmic data.
- The pressure transducers were installed in the recovery well and select monitoring wells and the elevation of each transducer recorded. The pressure transducer data logger data was verified throughout the test with manual (tape) water-level measurements.

- A pneumatic pump (QED pneumatic AP-4 Auto Pump) was installed in the recovery well. The pump intake was set at approximately 5 feet below static water levels.
- An initial test was performed in order to determine optimal flow rate. The flow rate was verified with a 5-gallon bucket and stopwatch. The flow rate was controlled using a valve on the pump setup.
- Flow rate measurements were performed as accurately and timely as necessary to allow a constant flow rate to be maintained during the course of the test. The flow rate was verified using a five-gallon bucket and stopwatch.
- The fluids were piped to a 275-gallon poly tank. During the study the evacuated water was removed from the holding tank via a vac-truck and appropriately disposed of as hydrocarbon-impacted liquids.

2.2.2 Recovery Phase

Transducers installed in monitoring wells were programmed to obtain 30-second arithmetic data during the recovery test. The transducer installed in the recovery well was programmed to obtain logarithmic data in order to obtain more frequent initial data.

2.3 Pilot Study 2 – Modified Step Drawdown and Dual Phase Recovery Tests

The following is the operating procedure for a modified step drawdown and dual phase recovery tests conducted at the Site on January 12 and 16, 2012, respectively.

2.3.1 Procedure for Modified Step Drawdown Test

The procedure entailed pumping and vacuuming the test well at successively higher water flow rates for equal, or nearly equal, time steps. The flow rate in gpm and pumping well drawdown was recorded at the end of each step. Increases in flow rate were evenly spaced (i.e., 2, 3, 4 gpm). The pilot study was conducted in steps of 90 minutes (Step 1), 90 minutes (Step 2) and 98 minutes (Step 3) for a total of 278 minutes. RW-13 was used as the recovery well. Water levels in wells RW-2, RW-4, RW-6, RW-7 and RW-10 were recorded using pressure transducers. The same procedures were used above along with the procedures outlined below.

- The recovery well head was fitted with a 4-inch diameter PVC riser. The pressure transducer cable, pump air supply hose and pump discharge hose were installed through a well sanitary seal placed on top of the riser. The 2-inch diameter VE piping was connected to the riser using a PVC tee below the sanitary seal. The vacuum source (Rietschle VLR 250 Vacuum Pump, 7.5 HP) was fitted with an ambient relief valve and a flow control valve.
- Vacuum readings were measured in the observation and recovery wells. The vacuum readings were collected using magnehelic differential vacuum gauges attached to the well heads. Air-flow rates and air quality were measured at the effluent stack using a hot wire anemometer and photo-ionization device (PID), respectively. Measurements occurred at an approximate frequency of one every five minutes for the first thirty minutes of the pilot study. Measurements were collected less frequently as the pilot study progressed. AEC

noted the total volume of liquid extracted and the average recovery rate during the pilot study.

2.3.2 Procedure for Dual Phase Recovery Test

Using the results of the step drawdown test, a flow rate of 3 gpm was used for the dual phase recovery test. This test was conducted for a period of 404 minutes. The recovery well was RW-13. Water and vacuum levels in wells RW-2, RW-4, RW-6, RW-7 and RW-10 were recorded using pressure transducers and differential pressure gauges. Water and vacuum levels in wells MW-6, RW-1 and RW-11 were recorded using a water level meter and differential pressure gauges. The same procedures used in the modified step drawdown task were used for this study.

2.4 Waste Management Procedures

The hydrocarbon impacted water and LPH encountered during testing activities was collected and containerized in a vacuum truck. The contained fluids were properly characterized and transported off-site for final disposal or treatment at facility permitted to accept impacted water originating from the State of Maryland. AEC retained copies of all manifests and receipts that were signed prior to transport. Copies of these documents are included in Appendix B.

3.0 PILOT STUDY RESULTS

3.1 Pilot Study 1 – Constant Rate Pumping Test

The data obtained from the constant rate pumping test was analyzed using the aquifer testing program AQTESOLV for Windows, v4.50. The methods included Cooper-Jacob (1946) and Theis (1935). The recovery phase data was analyzed using Theis (1935).

Drawdown Analysis

As shown on Graphs 1 and 2 included in Appendix C, during pumping of RW-13, water elevations in observation wells RW-4, RW-6, RW-7 and RW-10 decreased below static water levels. An initial decrease in water elevation was also observed in RW-2; however, an increase in water level began at this location approximately 38 minutes into the test. The majority of the drawdown occurred within 50 minutes of the start of the test. This data is presented in Table 1 in Appendix D. A summary of drawdown observations is presented in the following table.

Constant Rate Pumping Test
Pilot Study Data Summary
Royal Farms 96-500 Mechanics Valley Road, North East, Maryland

Monitoring Well	Distance From Pumping Well (ft.)	Drawdown at Completion of Test (ft.)
RW-13 (Pumping Well)	0	6.41
RW-4	21	0.27
RW-7	21	0.28
RW-6	23	0.18
RW-2	27	0.09*
RW-10	28	0.27

*Maximum drawdown for MW-2 was observed approximately 38 minutes after the start of the constant rate pumping test.

Analysis of pumping test data using the Cooper-Jacob (1946) and Theis (1935) methods resulted in K values of 0.001 feet/second (ft/sec). Based on the observed drawdown in RW-10, located approximately 28 feet from the pumping well, the radius of influence is at least 28 feet for the extraction well RW-13 operating with a discharge rate of 1 gpm. A groundwater gradient map and cross sections of the drawdown illustrating the effects of the pumping test are included as Figures 5 and 6 in Appendix A. A distance verses drawdown plot (Graph 3) is provided in Appendix C.

Recovery Analysis

Logarithmic groundwater level recovery measurements were collected at RW-13 immediately following the completion of the pumping test. Recovery data was also collected from RW-2, RW-4, RW-6, RW-7 and RW-10 at 30-second intervals. The groundwater level in RW-13 returned to 98 percent of the static water level within 12 minutes of the pumping test completion. This may have been partially influenced by the release of water from the pump and/or hose into the well. The data obtained from the RW-13 recovery testing was analyzed using the aquifer testing program AQTESOLV for Windows, v4.50. Theis (1935) was the selected analysis method. The AQTESOLV output showed that the hydraulic conductivity at RW-13 is 0.004 ft/sec. A summary of aquifer parameters developed during the various testing efforts is presented below.

Constant Rate Pumping Test
Pilot Study Data Summary
Royal Farms 96-500 Mechanics Valley Road, North East, Maryland

Analysis Method	K (ft/min)	Transmissivity (ft^2 / sec)	V (ft/ day)
Theis – Pumping	0.07	0.01	
Theis - Recovery	0.24	0.04	
Cooper-Jacob - Pumping	0.06	0.01	
Average	0.12	0.02	11.36
Average w/o Recovery	0.06	0.01	0.288

The average hydraulic conductivity using all three methods is 0.12 ft/min. The average hydraulic conductivity using just the pumping methods is 0.06 ft/min. The average hydraulic conductivity value range is consistent with the encountered lithology (i.e. sand) as compared to ranges of hydraulic conductivity values in the literature (Freeze and Cherry, 1979). Data generated as part of the AQTESOLV analysis is presented in Appendix E.

Based on the results of the pumping and recovery tests, the groundwater flow velocity is estimated to be 0.288 feet/day. Flow velocity was computed using Darcy's law, which is described as: $V = K(dh/dl)/n$. K is the hydraulic conductivity (86.4 ft/day), dh/dl is the groundwater gradient between RW-6 and RW-1 on January 13, 2012 (0.001 feet per foot); n is the effective porosity (30 percent). The porosity value (sand) was estimated from the literature (Freeze and Cherry, 1979).

A capture zone consists of the up-gradient and down-gradient areas that will drain into a pumping well. The dimensions of the capture zone from a pumping well in a homogeneous water-bearing unit with a fully penetrating pumping well are a function of the water-bearing unit thickness, discharge rate, and flow velocity. The only values that require calculation are the width of inflow zone and the distance to the stagnation point, which is located down-gradient of the pumping well.

The distance to the stagnation point is derived by equating the flow velocity under static groundwater conditions to the velocity of groundwater moving toward the pumping well. The width of the inflow zone, up-gradient of the pumping well, is an estimate of the maximum width of the groundwater capture zone. Using capture zone equations as shown on the work sheet presented in Appendix E, the distance to stagnation point and width of the inflow zone were determined to be 10.6 feet and 66.6 feet, respectively. These dimensions are consistent with the pumping conditions gradient map (Figure 5) with respect to the general size of the ROI on the map and the estimated capture zone.

3.2 Pilot Study 2 – Modified Step Drawdown and Dual Phase Recovery Tests

3.2.1 Modified Step Drawdown Test

The purpose of the modified step drawdown test was to determine an optimal flow rate for the dual phase recovery test. As shown on Graphs 4 and 5 included in Appendix C, during pumping of RW-13, water elevations in observation wells RW-2, RW-4, RW-6, RW-7 and RW-10 decreased below static water levels. The majority of the drawdown occurred within 50 minutes of the start of the test (during step 1) at a flow rate of 2 gpm. A slight drawdown trend was observed during step 2 at a flow rate of 3 gpm. Water levels were generally stable for step 3 at a flow rate of 4 gpm. This data is presented in Table 2 in Appendix D. Observed drawdown for each of the observation wells is summarized in the following table.

Modified Step Drawdown Test – Summary of Drawdown Response
Pilot Study Data Summary
Royal Farms 96-500 Mechanics Valley Road, North East, Maryland

Monitoring Well	Distance From Pumping Well	Drawdown at Completion of Step 1 (2 gpm)	Drawdown at Completion of Step 2 (3 gpm)	Drawdown at Completion of Step 3 (4 gpm)
RW-13 (Pumping Well)	0	*	*	*
RW-4	21	0.36	0.45	0.42
RW-7	21	0.40	0.50	0.49
RW-6	23	0.32	0.41	0.38
RW-2	27	0.34	0.43	0.43
RW-10	28	0.41	0.52	0.53

*Adequate drawdown measurements in RW-13 were not collected during this test due to water turbulence caused by the vacuum pump. All measurements in feet.

During the RW-13 pilot study the following wells were monitored for vacuum: RW-2, RW-4, RW-6, RW-7 and RW-10. The vacuum readings were collected using magnehelic differential vacuum gauges attached to the well heads. Vacuum pump vapor discharge stack effluent air flow and quality were measured using a Dwyer Series 470 Thermal Anemometer and a MiniRAE 2000 portable PID. Groundwater flow was estimated for each step using a five-gallon bucket and stop watch.

The modified step drawdown test was conducted with a vacuum of 129-inch H_2O (approximately 9.5-inch Hg) applied to extraction well RW-13. The initial vacuum applied to the well remained stable throughout the duration of the study. Vacuum influence readings were recorded at regular intervals from the vacuum monitoring points throughout the study.

Field observations indicated that the vacuum influences in the monitoring wells generally stabilized approximately 32 minutes after step 1 began and remained stable through the completion of step 2 (146 minutes). In general, the highest average vacuum readings were observed during step 2 at a flow rate of 3 gpm. Recorded vacuum influence occurred in all of the monitored wells. The vacuum readings were similar in RW-6 and RW-7 located 23 and 21 feet from RW-13, respectively. Vacuum influence versus distance for the modified step drawdown test is presented in Graphs 6, 7 and 8 in Appendix C. As the graphs illustrate, an effective vacuum influence of 0.1-inch H_2O may be expected at a distance of approximately 25 feet from the recovery wells with 129-inch H_2O vacuum applied. This data is presented in Table 3 and 4 in Appendix D. A summary of vacuum observations is presented in the following table.

Modified Step Drawdown Test – Summary of Vacuum Response
Pilot Study Data Summary
Royal Farms 96-500 Mechanics Valley Road, North East, Maryland

Step	RW-13	RW-4	RW-7	RW-6	RW-2	RW-10
Average (Step 1)	129	1.29	2.43	2.34	0.73	0.04
Average (Step 2)	129	1.65	2.81	2.83	0.73	0.10
Average (Step 3)	129	1.66	2.69	2.43	0.71	0.11
Distance from RW-13	0	21	21	23	27	28

All measurements in inches H_2O.

PID readings from the vacuum pump vapor stack ranged from 49 to 509 parts per million (ppm) and showed a stable trend in concentration as the study progressed. Air flow readings from the vacuum pump vapor stack averaged 35 cfm and showed a stable trend in flow rate as the study progressed.

3.2.2 Dual Phase Recovery Test

As shown on Graphs 9 and 10 included in Appendix C, during the dual phase recovery test of RW-13, water elevations in observation wells RW-4, RW-6, RW-7, and RW-10 decreased below static water levels. An initial decrease in water elevation was also observed in RW-2; however, an increase in water level began at this location approximately 32 minutes into the test. The majority of the drawdown occurred within 50 minutes of the start of the test. This data is presented in Table 5 in Appendix D. A summary of drawdown observations is presented in the following table.

Dual Phase Recovery Test – Summary of Drawdown Responses
Pilot Study Data Summary
Royal Farms 96-500 Mechanics Valley Road, North East, Maryland

Monitoring Well	Distance From Pumping Well	Drawdown at Completion of Test
RW-13 (Pumping Well)	0	*
RW-4	21	0.44
RW-7	21	0.52
RW-6	23	0.43
RW-2	27	0.13**/+1.34
RW-10	28	0.66

* Drawdown measurements in RW-13 not collected during test due to turbulence caused by blower. **Maximum drawdown in MW-2 at 32 min.

During the RW-13 dual phase recovery test, the following wells were monitored for vacuum: RW-2, RW-4, RW-6, RW-7 and RW-10. The vacuum readings were collected using magnehelic differential vacuum gauges attached to the well heads. Vacuum pump vapor discharge stack effluent air flow and quality were measured using the same equipment referenced above. Groundwater flow was estimated for each step using by gauging with a five-gallon bucket and stop watch.

The dual phase recovery test was initiated with a vacuum of 129-inch H_2O (approximately 9.5-inch Hg) applied to extraction well RW-13. The initial vacuum applied to the well remained stable throughout the duration of the study. Vacuum influence readings were recorded at regular intervals from the vacuum monitoring points throughout the study.

Field observations indicated that the vacuum influences in the observation wells generally stabilized approximately 20 minutes after the start of the dual phase recovery test. The highest average vacuum readings were observed in RW-7 located 27 feet from RW-13. Recorded vacuum influence occurred in all of the monitored wells. This vacuum response is consistent with the findings of the previous EFR pilot study. Vacuum influence versus distance for the dual phase recovery test is plotted in Graph 11 (Appendix C). As the graph demonstrates, an effective vacuum influence of 0.1-inch H2O may be expected at a distance of approximately 25 feet from the recovery wells. An applied vacuum gradient map illustrating vacuum data collected at the end of the dual phase extraction test is included as Figure 8 (Appendix A). This data is presented in Tables 6 and 7 (Appendix D). A summary of vacuum observations is presented in the following table.

Dual Phase Recovery Test - Summary of Vacuum Response
Pilot Study Data Summary
Royal Farms 96-500 Mechanics Valley Road, North East, Maryland

	RW-13	RW-2	RW-4	RW-6	RW-7	RW-10
Average	129	0.61	1.01	0.69	2.31	0.16
Distance from RW-13	0	21	21	23	27	28

All measurements in inches H_2O.

PID readings from the vacuum pump vapor stack ranged from 640 to 675 ppm and showed a stable trend in concentration as the study progressed. Air flow readings from the vacuum pump vapor stack averaged 32 cfm and showed a stable trend in flow rate as the study progressed.

3.3 Pilot Study Conclusions

The full scale EFR pilot study indicated the following remediation system design criteria: ROI - 25 feet; individual recovery well flow rate – 4 to 6 gpm; individual recovery well drawdown - 4 feet below static groundwater; and, individual recovery well air flow rate - 50 cfm. According to the results of the recent pilot studies, the previous EFR design parameters can be duplicated with dual phase technology. The performance parameters for the dual phase approach using the pilot study data are the following:

ROI – 25 feet (based on distance vs. vacuum graphs); individual recovery well flow rate – 3 gpm (based on dual phase extraction test); individual recovery well drawdown - 5 feet below static groundwater (based on step drawdown and dual phase extraction tests); and, individual recovery well air flow rate - 50 cfm (average flow rate during dual phase extraction test). The latest pilot study data supports this position as presented below.

During this pilot study the pump intake was set approximately five feet below the static water level. This depth was selected to simulate the lowest drawdown reasonable with respect to the petroleum smear zone. The pilot studies' sustainable, vacuum enhanced flow rate of 3 gpm pumping from 5 feet below static water level was adequate to provide a capture zone size similar to the previous EFR design. This flow rate is less than the operational EFR flow rate of 6 gpm. The sustainable flow rate for the constant rate test (1 gpm) when compared to the selected flow rate for the dual phase test (3 gpm) indicated that the addition of a vacuum source significantly increases water flow potential of the aquifer.

The previous EFR data indicated that at the conclusion of step 1 the average recovery rate was 4 gpm and at step 2 the average recovery rate was 6.77 gpm. At 4 gpm the vacuum was 0.26 inch-H_2O at a monitoring point 20 feet from the extraction well. The latest pilot study data indicates a higher vacuum range (0.61 to 1.01) at approximately the same distance (21 to 23 feet) with a marginally lower flow rate (3 gpm). The previous EFR data indicated that at 4 gpm the drawdown was 0.35 feet at a monitoring point 20 feet from the extraction well. The latest data indicates a slightly higher drawdown range (0.43 to 0.52) at approximately the same distance (21 to 23 feet) with a marginally lower flow rate (3 gpm). These measurements indicate that the higher independent vacuum blower during the recent pilot study increased the drawdown and vacuum using a reduced water flow rate with respect to the EFR test.

Based on the data collected to date AEC has estimated that the minimum flow rate necessary to gain hydraulic control in the remediation zone is between 1 and 3 gpm (the constant rate flow estimate and the sustainable dual phase flow rate). The maximum flow rate is 5 to 6 gpm, which has been shown in the EFR pilot studies to substantially dewater the area. The optimal flow rate (or pump intake depth) for maximum recovery of LPH will change throughout the seasons. During wet weather seasons the flow rate will need to be increased (and/or the pump raised) and during dry seasons the flow rate will need to be decreased (and/or the pump lowered). For the early stages of the remedial life cycle it is expected that a higher flow rate will be necessary to provide hydraulic control. As the dewatering of the area reaches a static condition the required flow rate will be reduced for the same degree of hydraulic control.

The recent pilot study has indicated that an effective vacuum influence of 0.1-inch H_2O may be expected at a distance of approximately 25 feet from the recovery wells. In order to provide a safety factor the operational ROI will be 20 feet. Using multiple recovery points with partially overlapping capture zones it is expected that between 2-feet to 5-feet of groundwater drawdown will be realized in the target remediation zone.

The remediation system will be designed to treat recovered groundwater at a rate of 50 gpm and vapors at a rate of 600 cfm. Pilot studies have indicated that a recovery well flow rate of 3 gpm with 50 cfm at 10-inch hg is adequate for effective dual phase operation. The proposed number of recovery wells is 11 which equates to system flow rates of 33 gpm water and 550 cfm vapor. These rates are within the capacity of the design basis summary system design flow rates. Figure 9 in Appendix A presents the recovery well distribution with capture zones illustrated.

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APPENDIX A

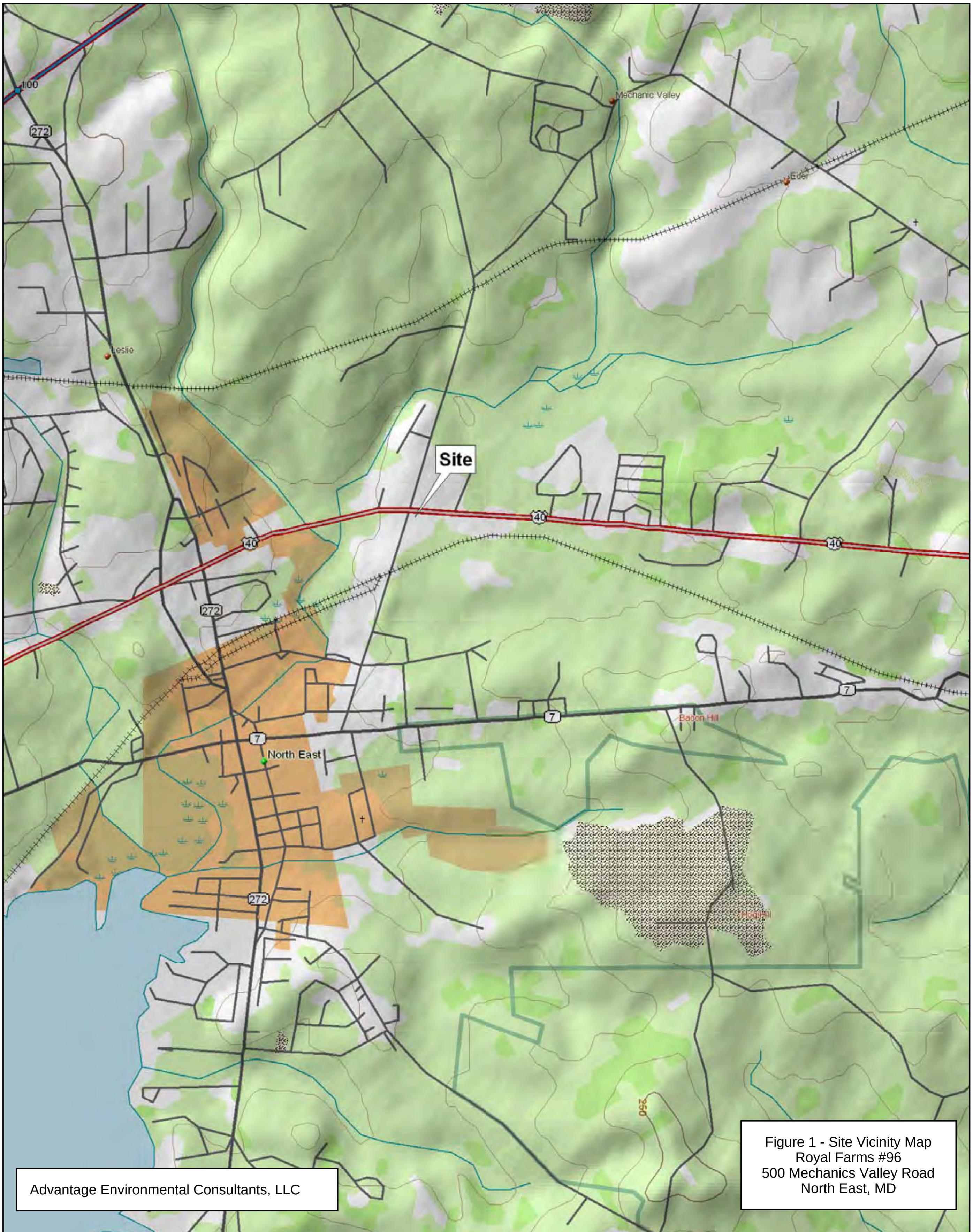


Figure 1 - Site Vicinity Map
Royal Farms #96
500 Mechanics Valley Road
North East, MD

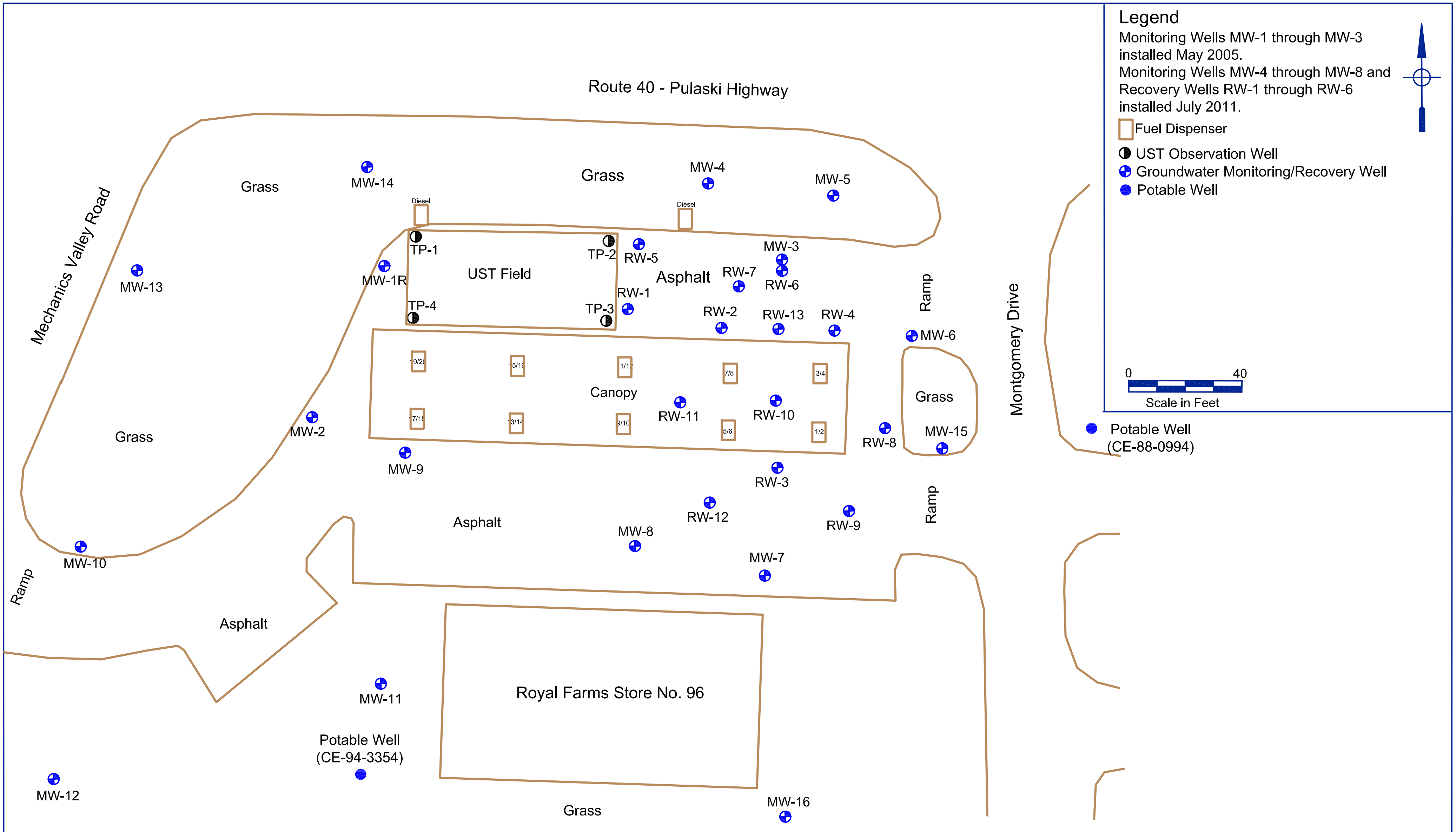
Advantage Environmental Consultants, LLC

Zoom Level: 12-7 Datum: WGS84

Scale 1 : 28,125

1" = 2,343.75 ft

TN
MN
11.7°W



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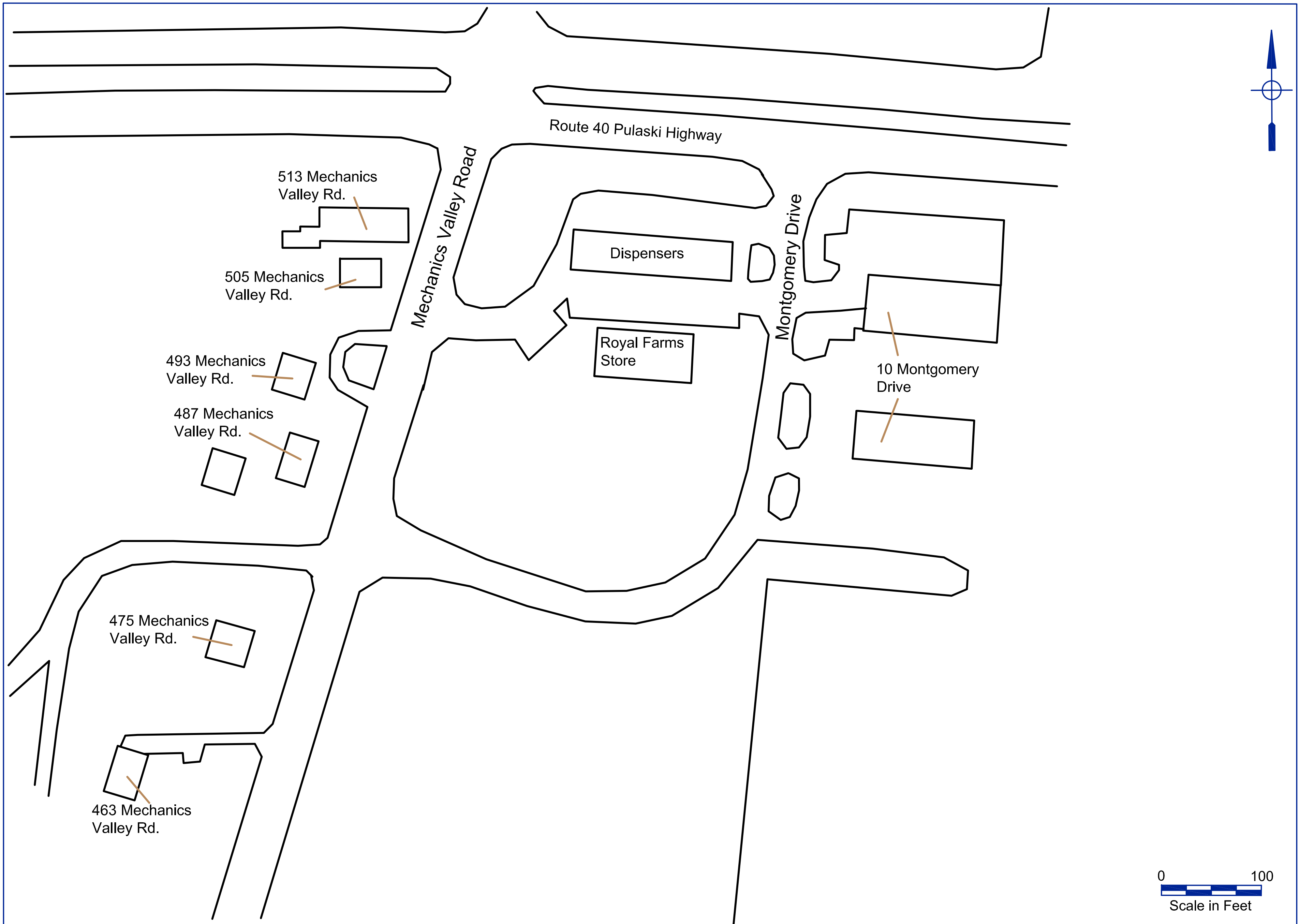
Project No.: 05-056	Drawn by: JSS	Figure 2 - Site Features Map Royal Farms No. 96 500 Mechanics Valley Road North East, MD
Task No.: RF96	Date: 1-23-12	
File: Site Features	Revision No.: 1	



Advantage Environmental Consultants, LLC
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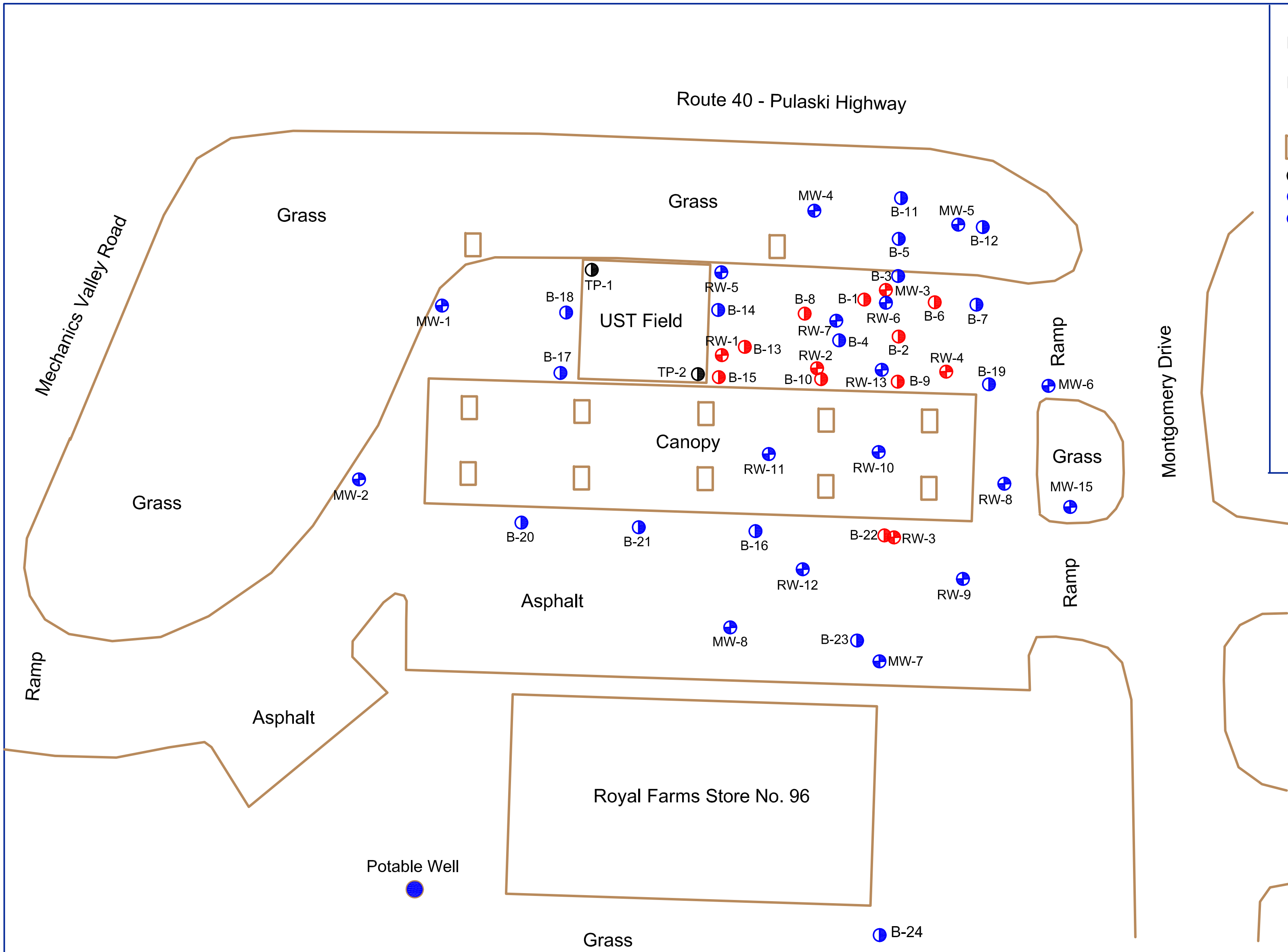
Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date:1-23-12
File: Site Area	Revision No.: 1

Figure 3 - Site Area Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



Legend

Monitoring Wells MW-1 through MW-3 installed May 2005.
Monitoring Wells MW-4 through MW-8 and Recovery Wells RW-1 through RW-6 installed July 2011.

- Fuel Dispenser
- UST Observation Well
- Groundwater Monitoring/Recovery Well
- Temporary Piezometer installed June 2011

Red symbols indicated liquid phase hydrocarbon (LPH) was identified in the piezometer or well.

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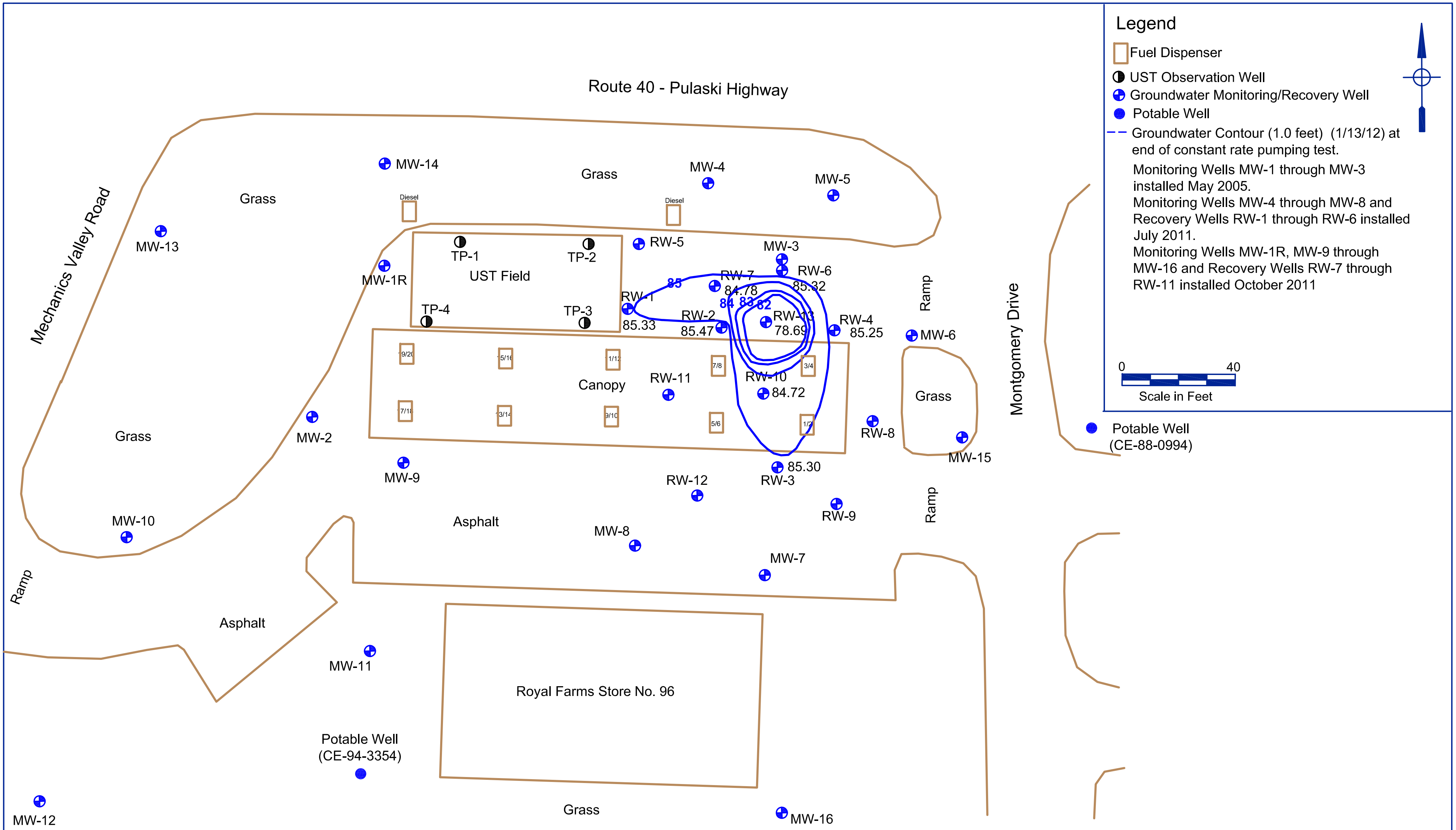
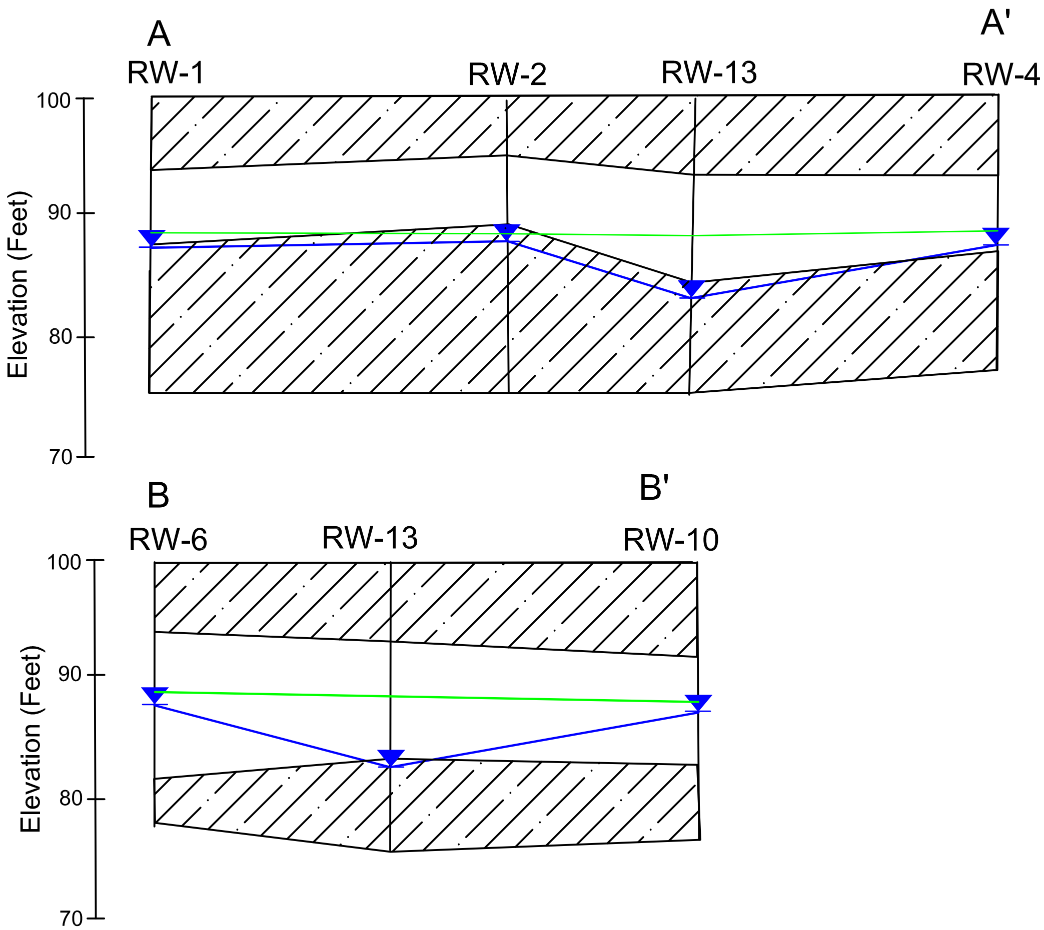
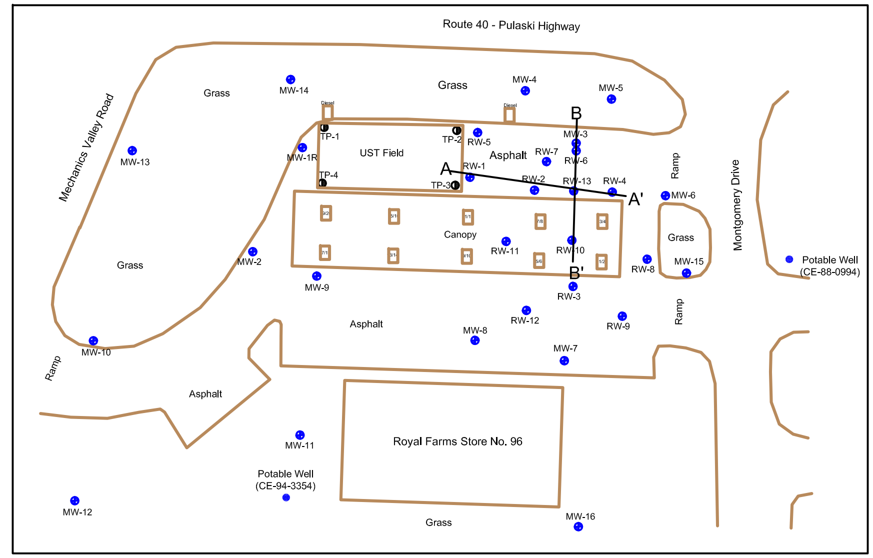
Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 8-2-11
File: Remed Zone	Revision No.: 1

Figure 4 - LPH Distribution Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



Advantage Environmental Consultants, LLC 8610 Washington Blvd. Suite 217 Jessup, MD 20794 Phone 301-776-0500 Fax 301-776-1123	Project No.: 05-056 Task No.: RF96 File: Site Features	Drawn by: JDW Date: 1-10-12 Revision No.: 3	Figure 5 - Groundwater Gradient Map - Pumping Conditions Royal Farms No. 96 500 Mechanics Valley Road North East, MD





Trace of Sections

Legend

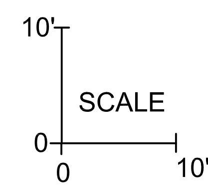
predominately coarse grained material (sand/gravel)

predominately fine grained material (silt/clay)

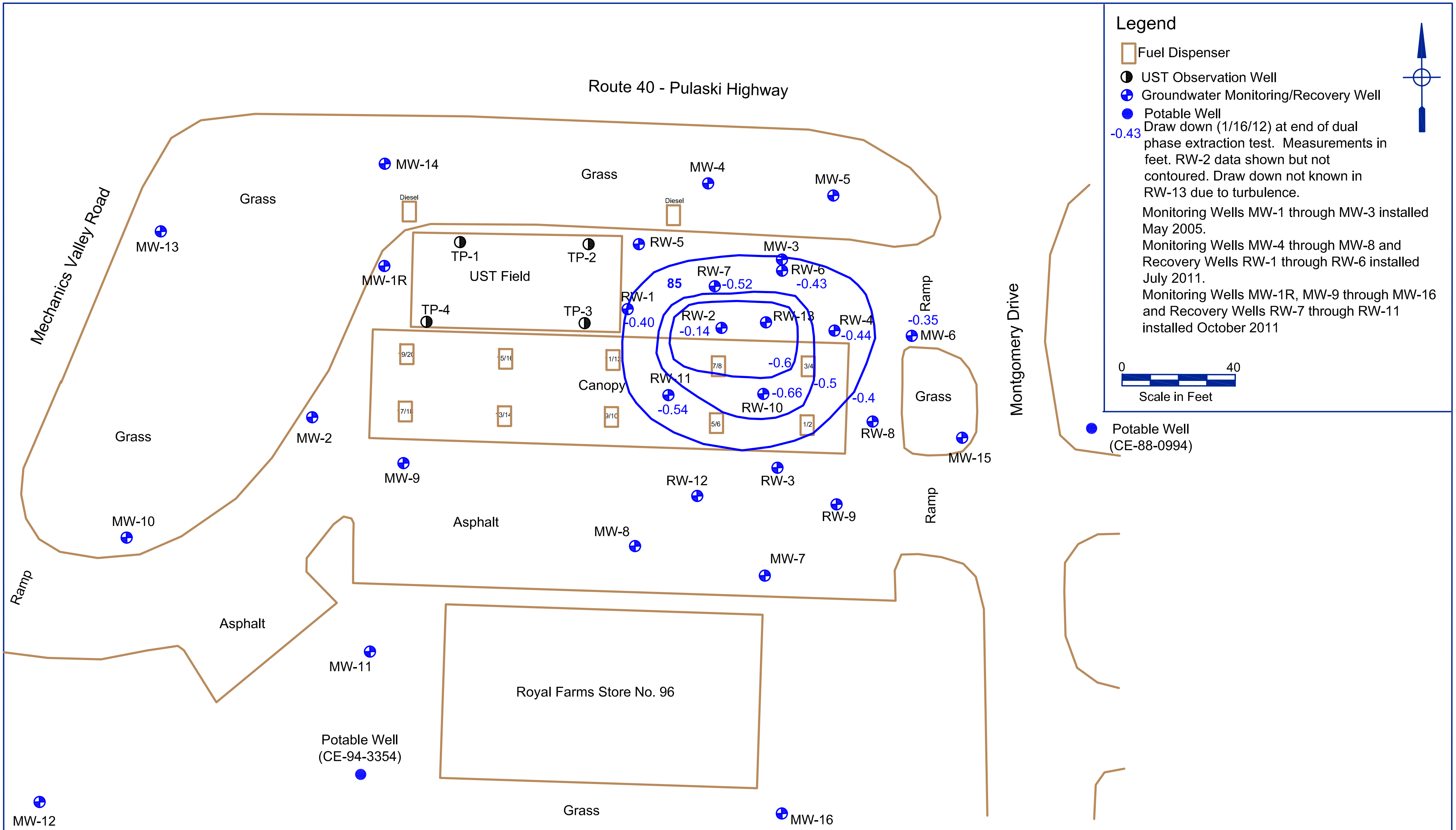
Water level (1-13-2012) taken at end of constant rate pumping test. RW-13 was pumping well.

Water table surface taken at end of constant rate pumping test. RW-13 was pumping well.

Static (pre-test) water table surface (taken on 1-12-12)



Advantage Environmental Consultants, LLC 8610 Washington Boulavard, Suite 217 Jessup, Maryland 20794 301-776-0500	Drawn by: JSS	Checked by: JSS	Figure 6 - Cross Sections - Pumping Conditions at End of Constant Rate Test Royal Farms No. 96 500 Mechanics Valley Road, North East, Maryland
	Date: 1-21-12	Revision: First	



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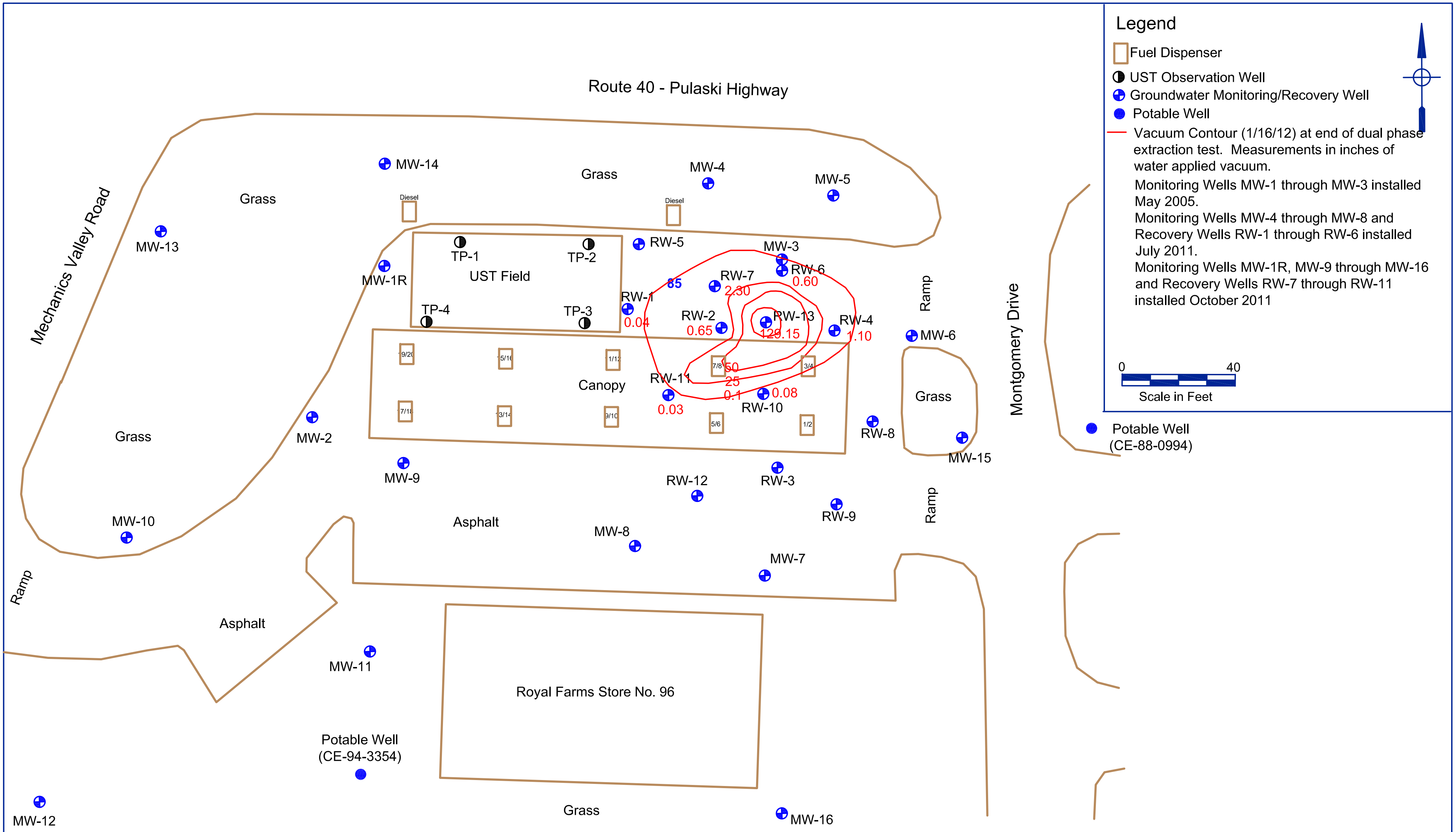
Project No.: 05-056	Drawn by: JDW
Task No.: RF96	Date: 1-10-12
File: Site Features	Revision No.: 3

Figure 7 - EFR Drawdown Contour Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



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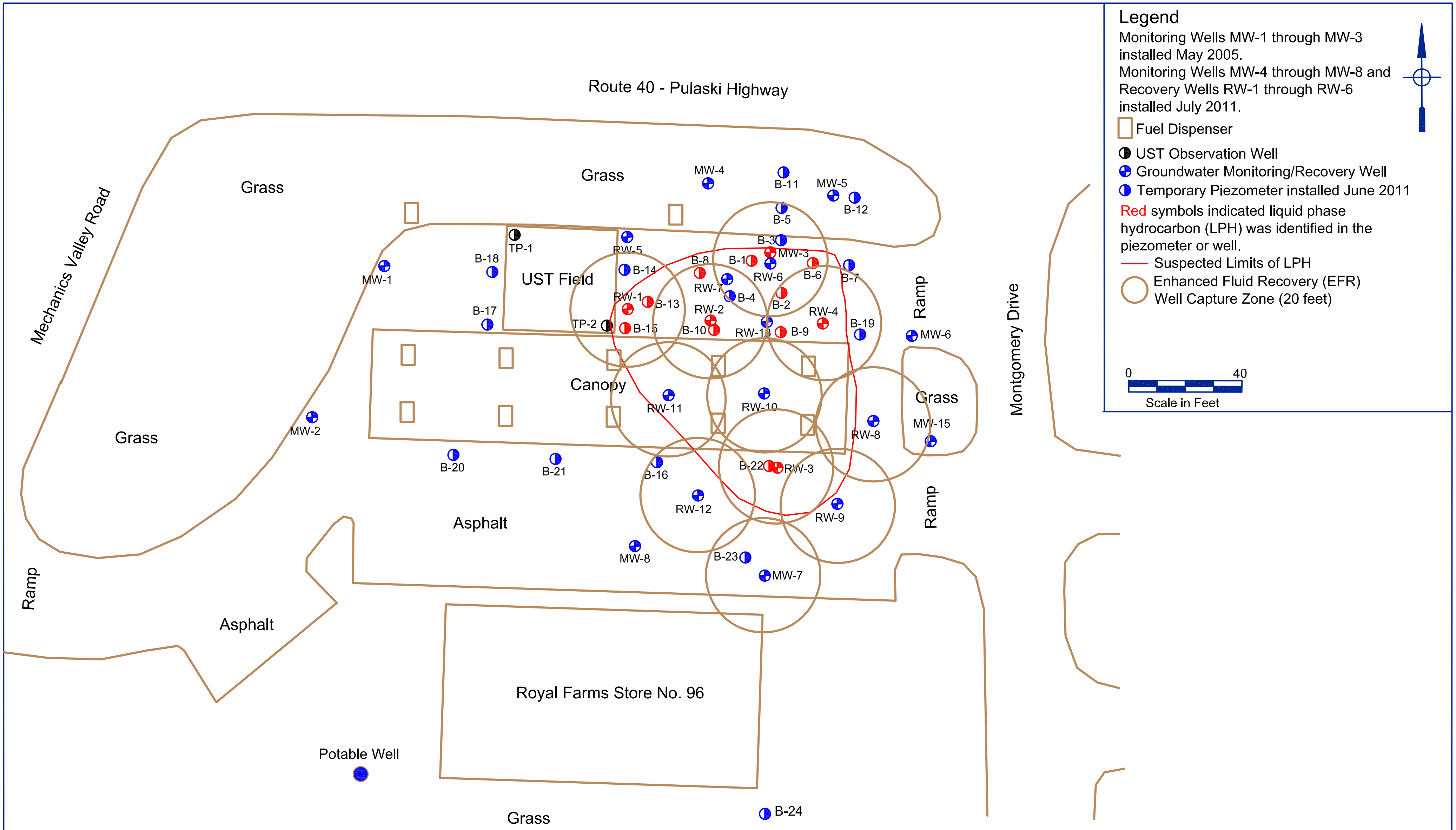
Project No.: 05-056	Drawn by: JDW
Task No.: RF96	Date: 1-10-12
File: Site Features	Revision No.: 3

Figure 8 - Applied Vacuum Gradient Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



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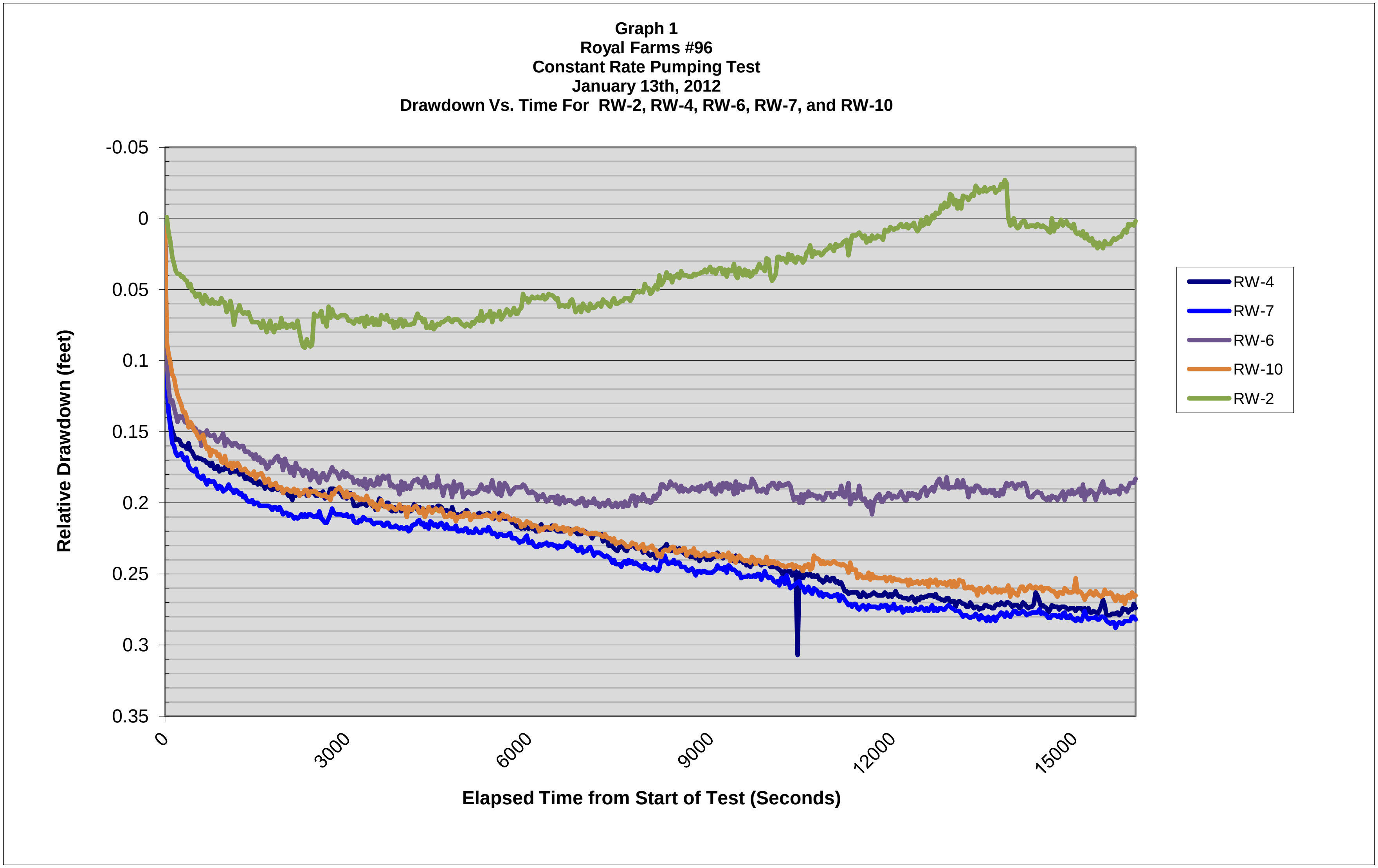
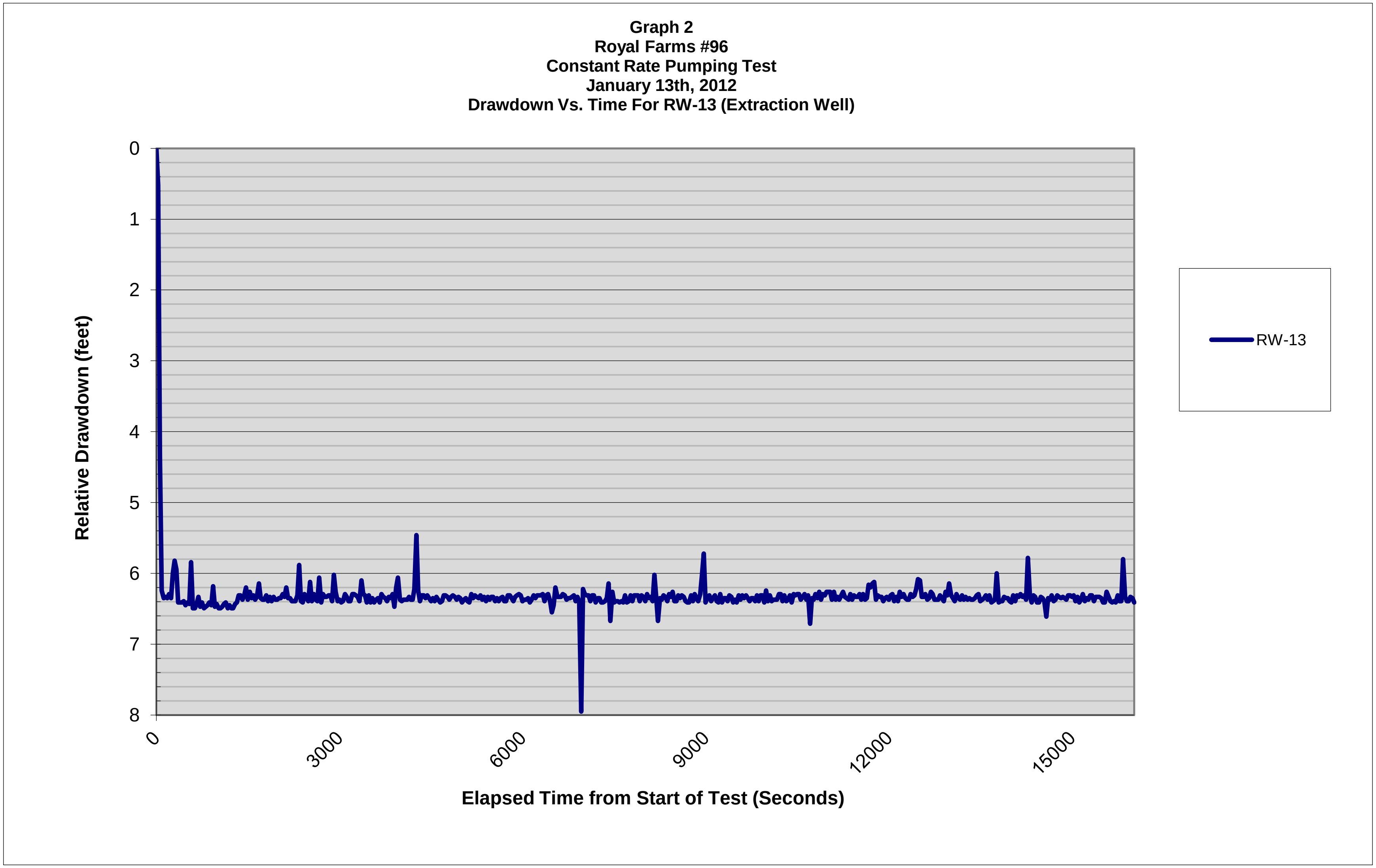
Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 1-21-12
File: Remed Zone	Revision No.: 2

Figure 9 - Proposed Remediation Zone Map
Royal Farms No. 96
500 Mechanics Valley Road
North East, MD

APPENDIX C

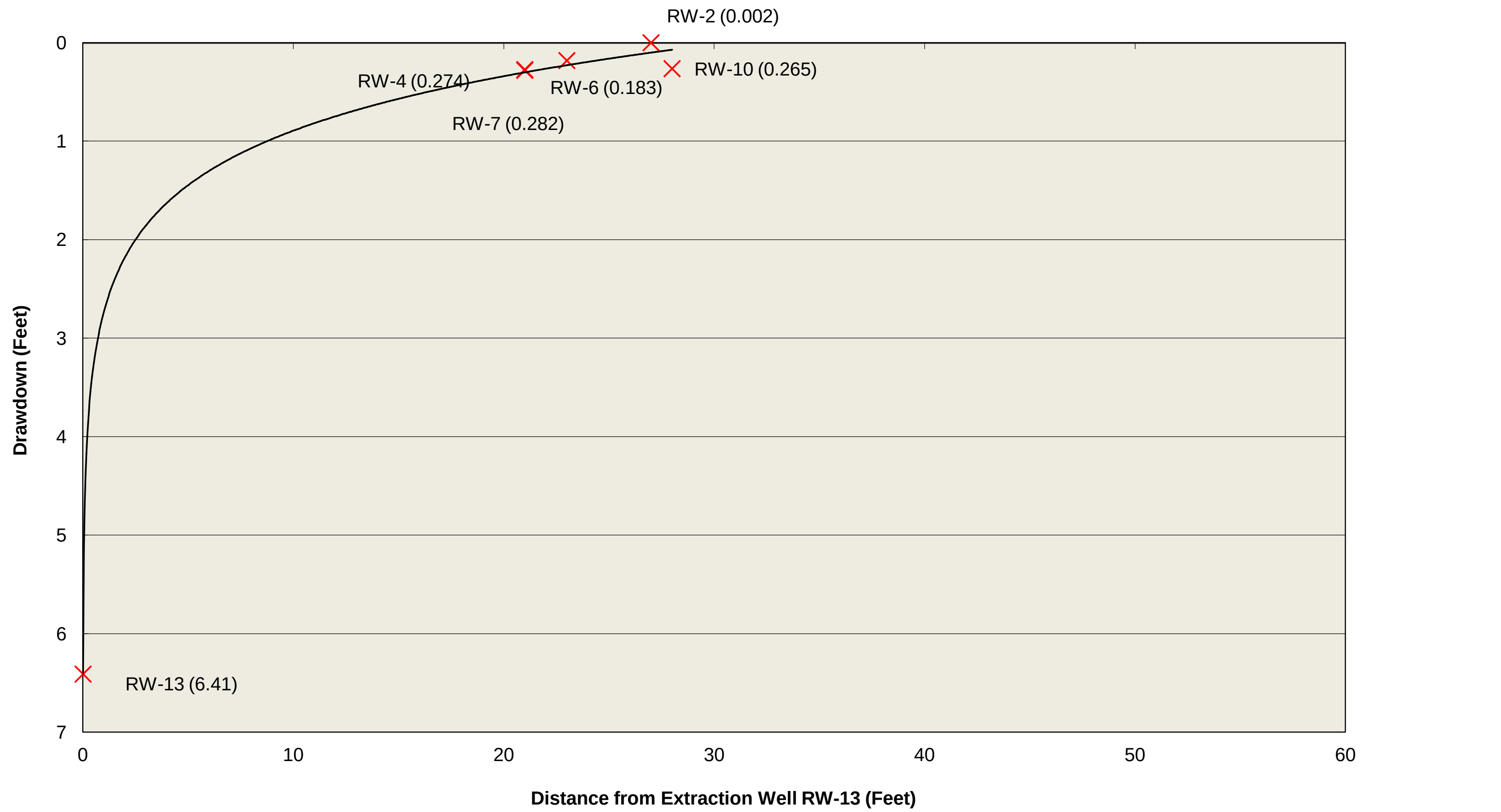


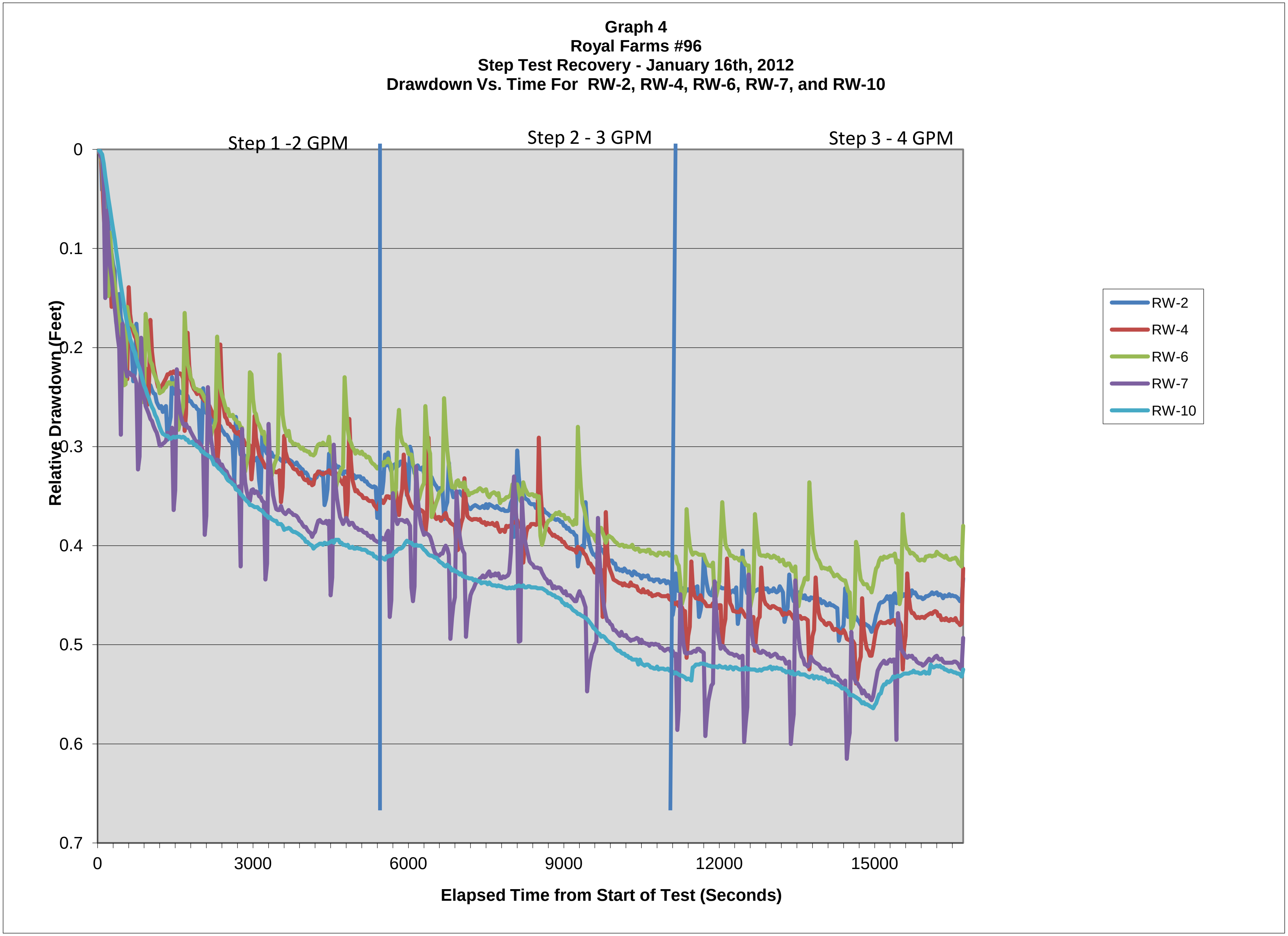
Graph 1
Royal Farms #96
Constant Rate Pumping Test
January 13th, 2012
Drawdown Vs. Time For RW-2, RW-4, RW-6, RW-7, and RW-10
Relative Drawdown (feet)
-0.05
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0
3000
6000
9000
12000
15000
Elapsed Time from Start of Test (Seconds)
RW-4
RW-7
RW-6
RW-10
RW-2



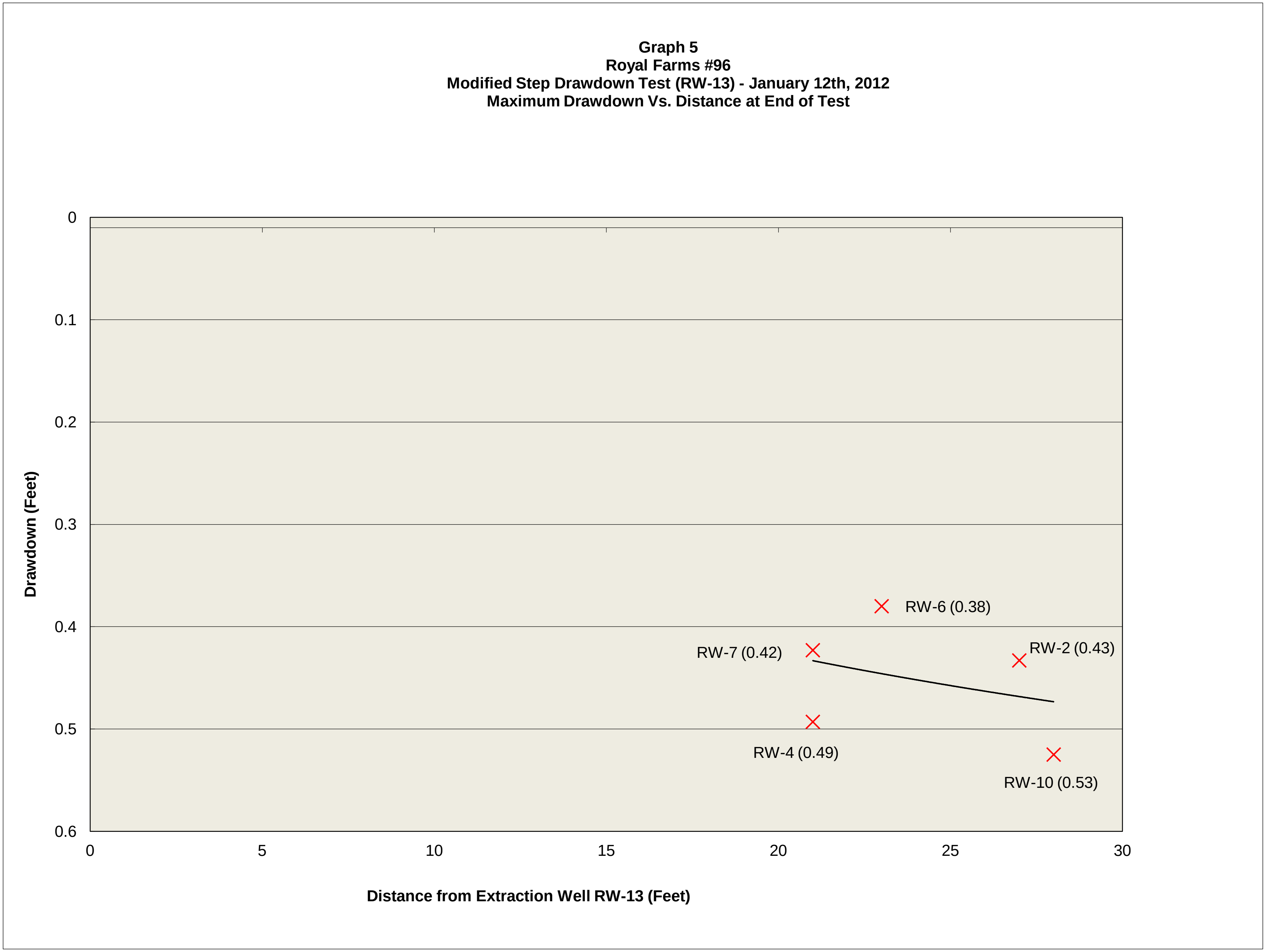
Graph 2
Royal Farms #96
Constant Rate Pumping Test
January 13th, 2012
Drawdown Vs. Time For RW-13 (Extraction Well)
Relative Drawdown (feet)
0
1
2
3
4
5
6
7
8
0
3000
6000
9000
12000
15000
Elapsed Time from Start of Test (Seconds)
RW-13

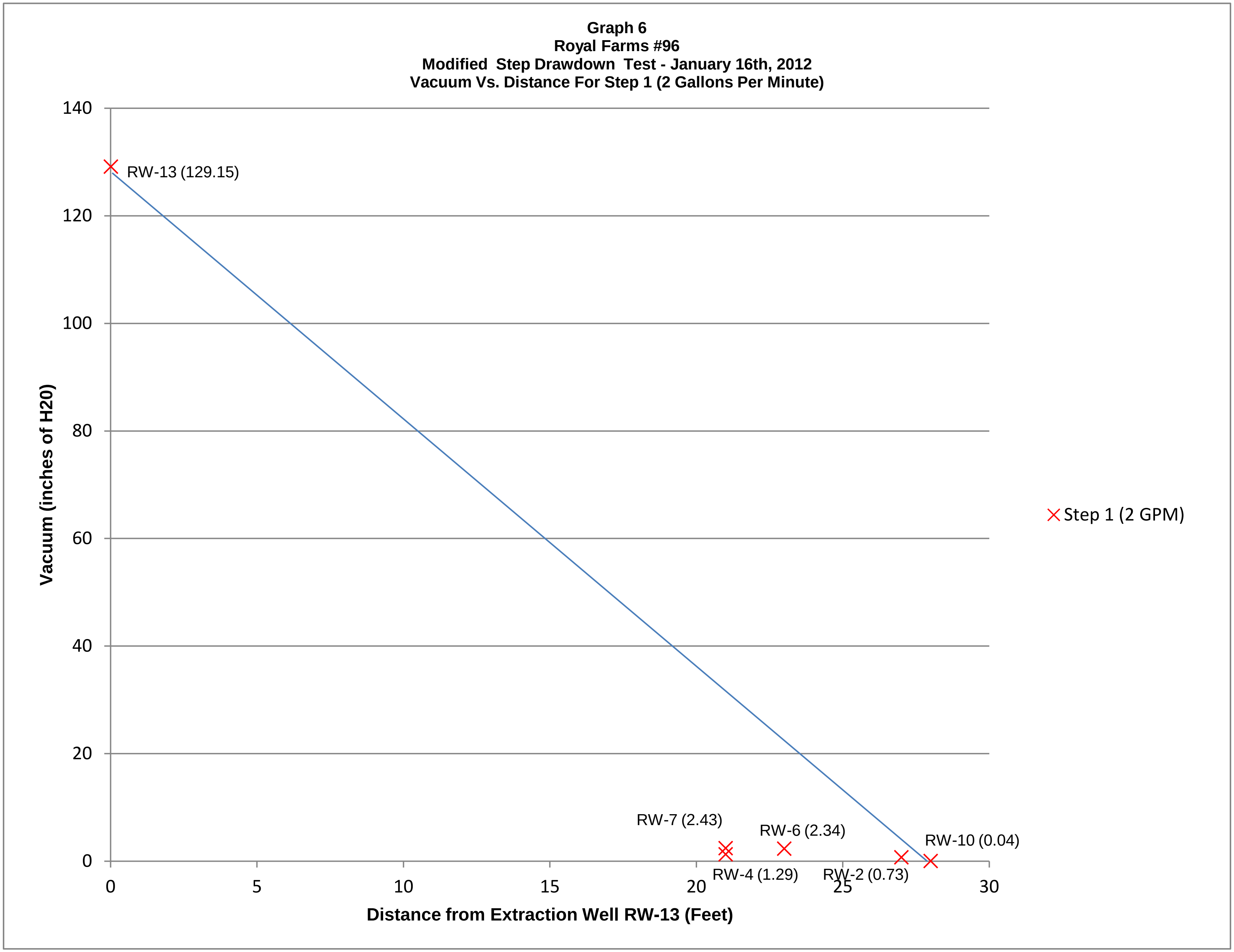
Graph 3
Royal Farms #96
Constant Rate Pumping Test (RW-13)
January 13th, 2012
Drawdown Vs. Distance at End of Test

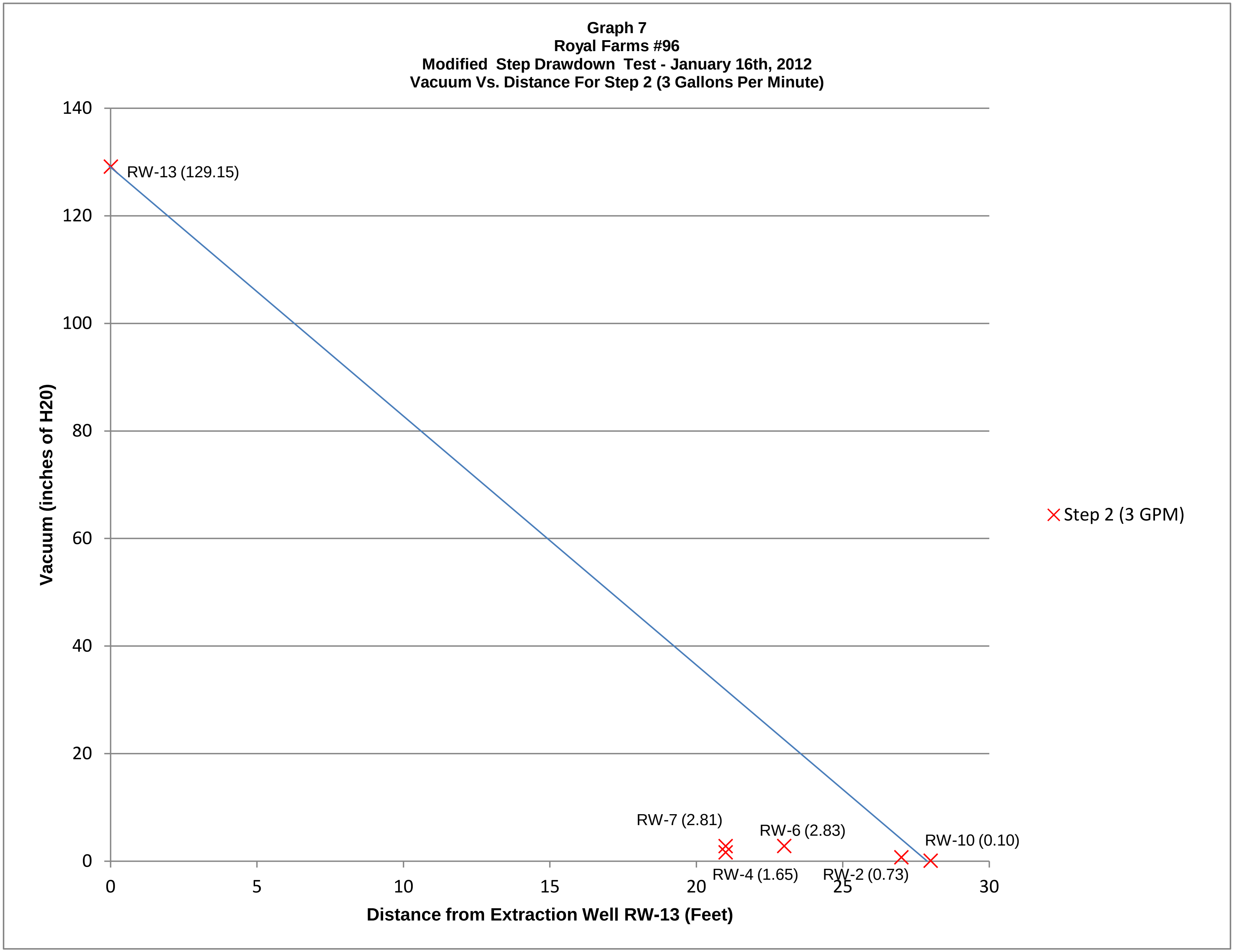


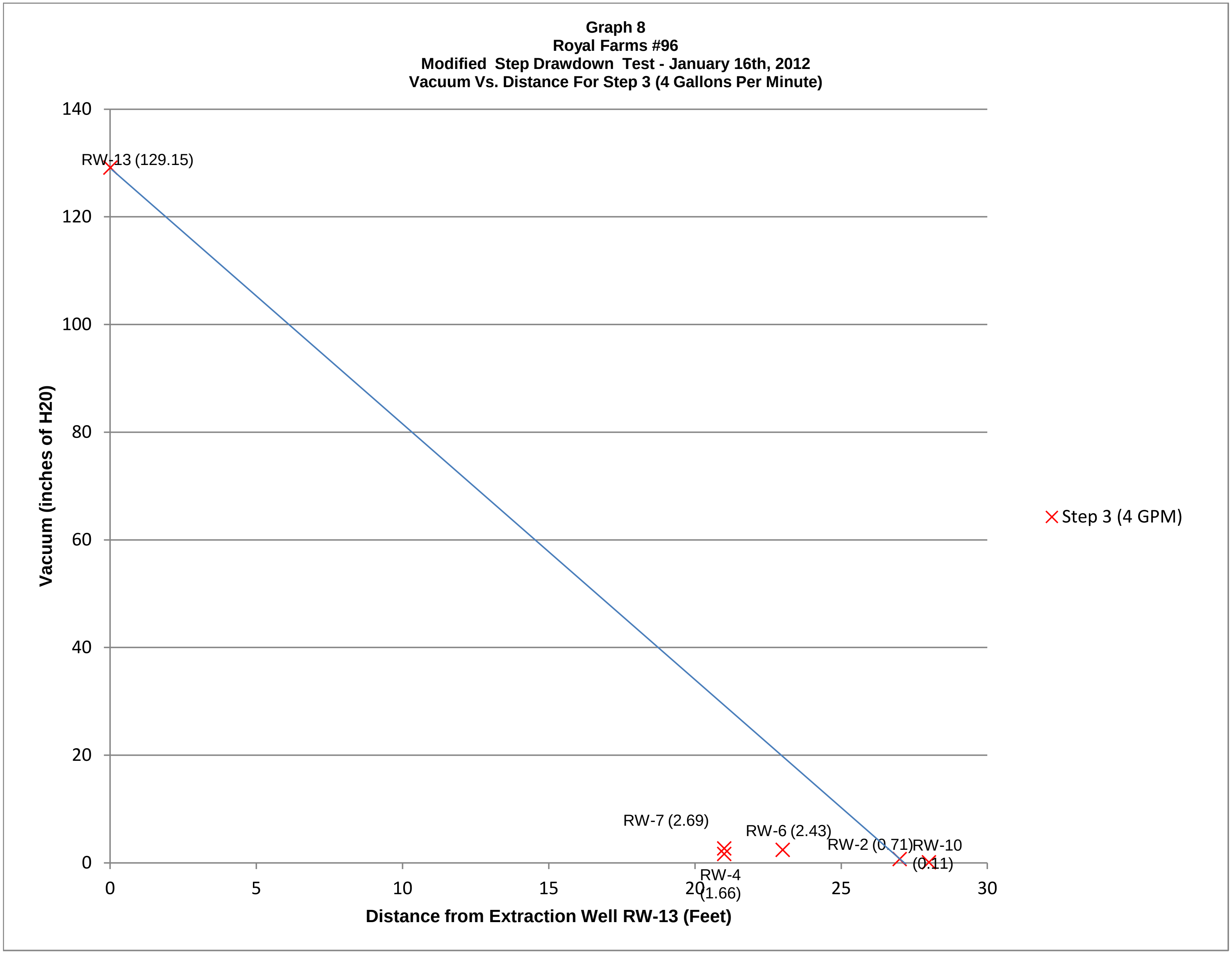


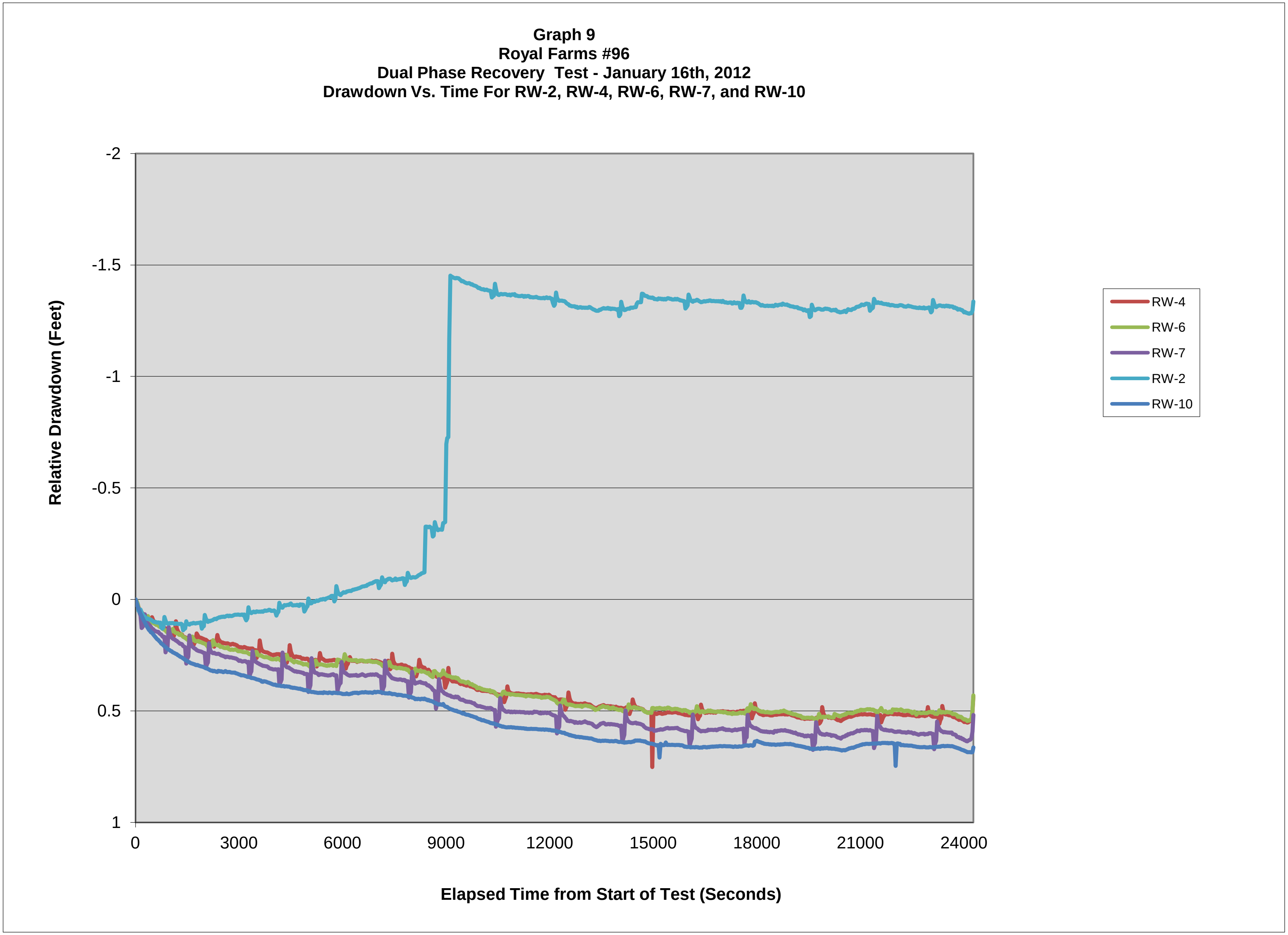
Graph 4
Royal Farms #96
Step Test Recovery - January 16th, 2012
Drawdown Vs. Time For RW-2, RW-4, RW-6, RW-7, and RW-10
Step 1 -2 GPM
Step 2 - 3 GPM
Step 3 - 4 GPM
Relative Drawdown (Feet)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
3000
6000
9000
12000
15000
Elapsed Time from Start of Test (Seconds)
RW-2
RW-4
RW-6
RW-7
RW-10

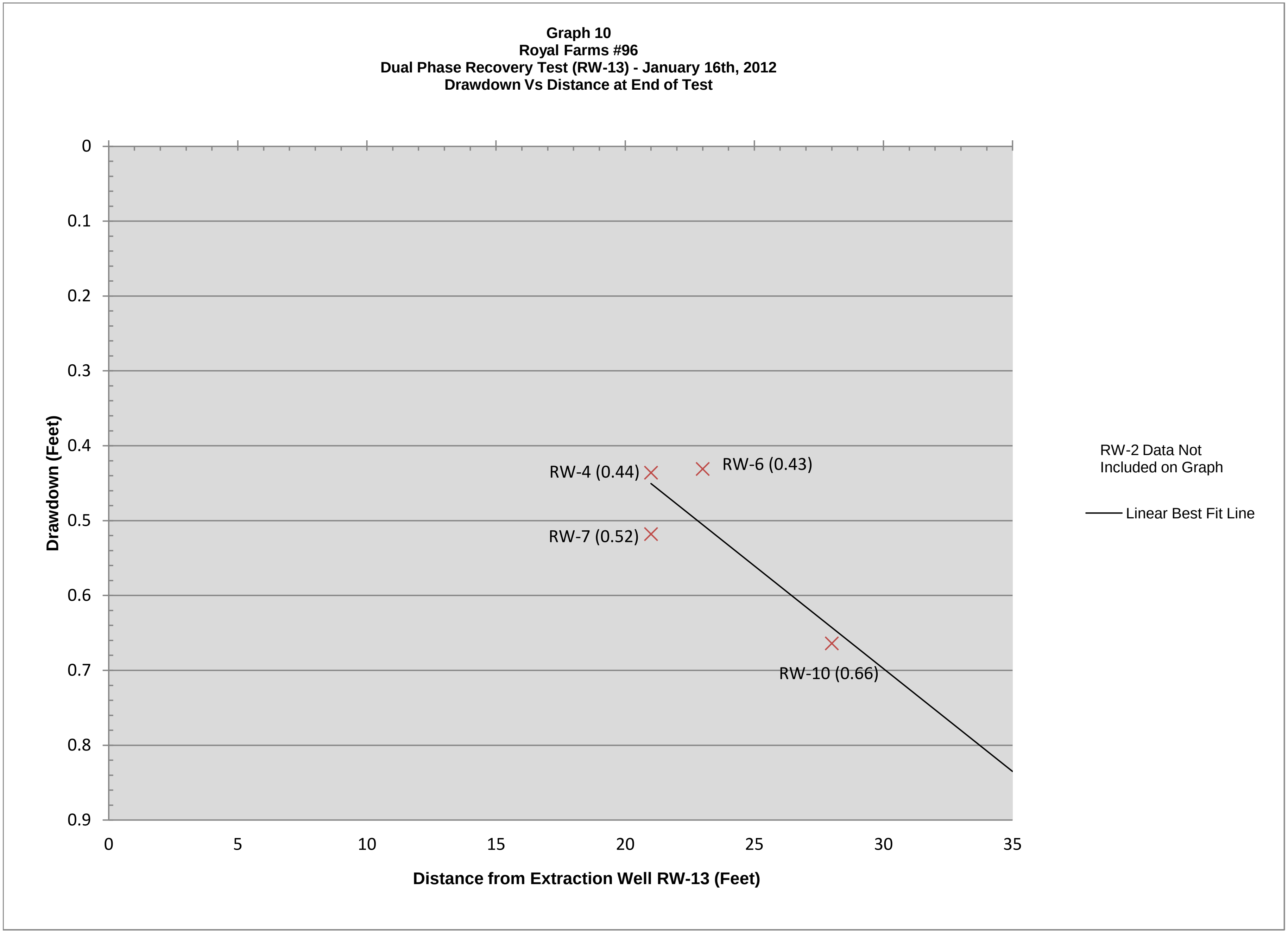

Graph 5
Royal Farms #96
Modified Step Drawdown Test (RW-13) - January 12th, 2012
Maximum Drawdown Vs. Distance at End of Test
Drawdown (Feet)
0
0.1
0.2
0.3
0.4
0.5
0.6
RW-6 (0.38)
RW-7 (0.42)
RW-2 (0.43)
RW-4 (0.49)
RW-10 (0.53)
0
5
10
15
20
25
30
Distance from Extraction Well RW-13 (Feet)

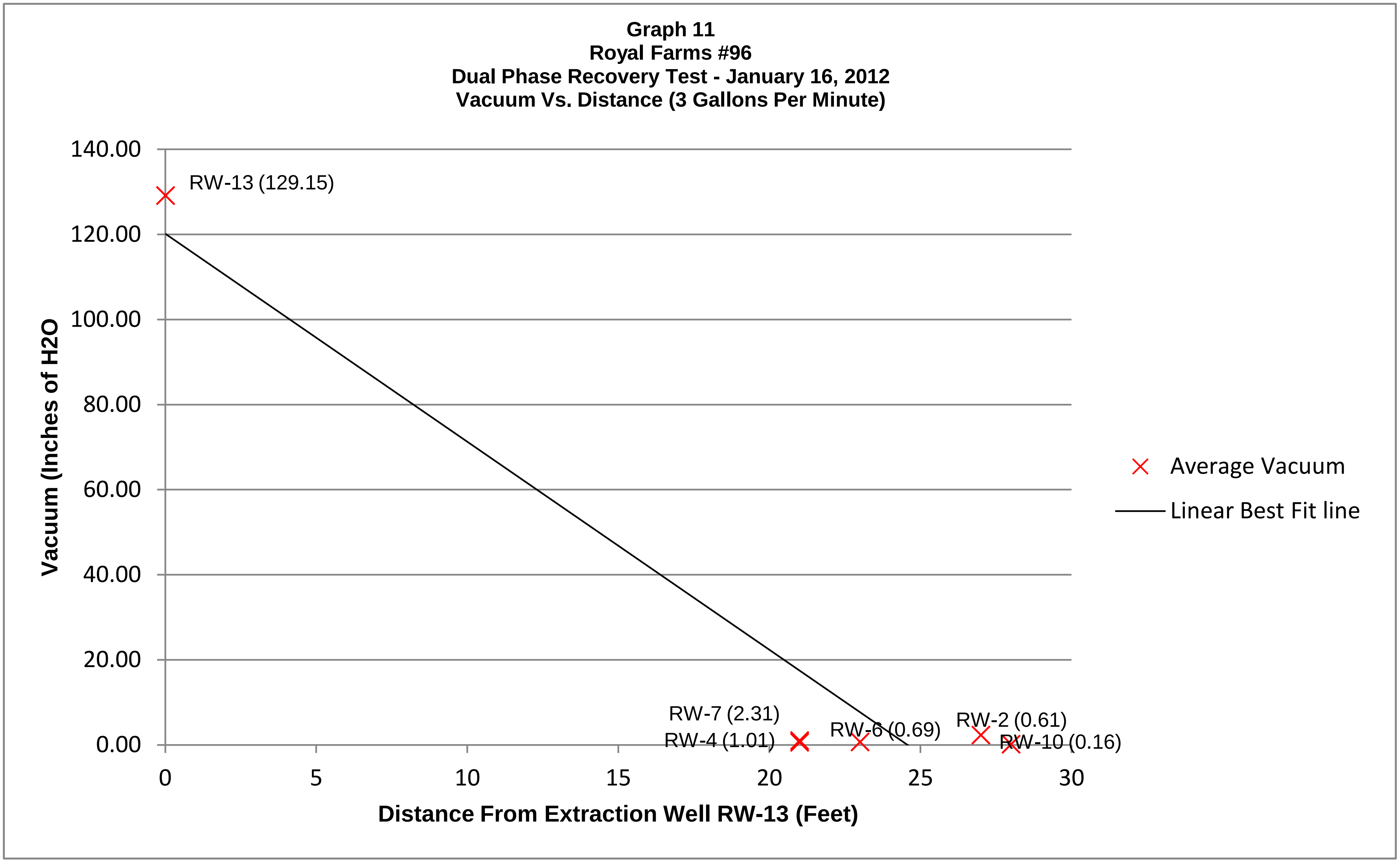

Graph 6
Royal Farms #96
Modified Step Drawdown Test - January 16th, 2012
Vacuum Vs. Distance For Step 1 (2 Gallons Per Minute)
Vacuum (inches of H20)
Distance from Extraction Well RW-13 (Feet)
RW-13 (129.15)
RW-7 (2.43)
RW-6 (2.34)
RW-10 (0.04)
RW-4 (1.29)
RW-2 (0.73)
Step 1 (2 GPM)
0
20
40
60
80
100
120
140
0
5
10
15
20
25
30


Graph 7
Royal Farms #96
Modified Step Drawdown Test - January 16th, 2012
Vacuum Vs. Distance For Step 2 (3 Gallons Per Minute)
Vacuum (inches of H20)
Distance from Extraction Well RW-13 (Feet)
0
20
40
60
80
100
120
140
0
5
10
15
20
25
30
RW-13 (129.15)
RW-7 (2.81)
RW-6 (2.83)
RW-10 (0.10)
RW-4 (1.65)
RW-2 (0.73)
Step 2 (3 GPM)


Graph 8
Royal Farms #96
Modified Step Drawdown Test - January 16th, 2012
Vacuum Vs. Distance For Step 3 (4 Gallons Per Minute)
Vacuum (inches of H20)
Distance from Extraction Well RW-13 (Feet)
RW-13 (129.15)
RW-7 (2.69)
RW-6 (2.43)
RW-2 (0.71)
RW-10 (0.11)
RW-4 (1.66)
Step 3 (4 GPM)
0
20
40
60
80
100
120
140
0
5
10
15
20
25
30


Graph 9
Royal Farms #96
Dual Phase Recovery Test - January 16th, 2012
Drawdown Vs. Time For RW-2, RW-4, RW-6, RW-7, and RW-10
Relative Drawdown (Feet)
-2
-1.5
-1
-0.5
0
0.5
1
0
3000
6000
9000
12000
15000
18000
21000
24000
Elapsed Time from Start of Test (Seconds)
RW-4
RW-6
RW-7
RW-2
RW-10


Graph 10
Royal Farms #96
Dual Phase Recovery Test (RW-13) - January 16th, 2012
Drawdown Vs Distance at End of Test
Drawdown (Feet)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
5
10
15
20
25
30
35
Distance from Extraction Well RW-13 (Feet)
RW-4 (0.44)
RW-6 (0.43)
RW-7 (0.52)
RW-10 (0.66)
RW-2 Data Not
Included on Graph
Linear Best Fit Line


Graph 11
Royal Farms #96
Dual Phase Recovery Test - January 16, 2012
Vacuum Vs. Distance (3 Gallons Per Minute)
Vacuum (Inches of H2O
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
5
10
15
20
25
30
Distance From Extraction Well RW-13 (Feet)
RW-13 (129.15)
RW-7 (2.31)
RW-4 (1.01)
RW-6 (0.69)
RW-2 (0.61)
RW-10 (0.16)
Average Vacuum
Linear Best Fit line

Capture Zone Estimate Work Sheet

Keely (1983) has demonstrated that the capture zone dimensions can be calculated using the following equations:

$$D = Q / 2\pi Vb \quad (1)$$
$$V = (T / b)(1/n)(dh/dl) \quad (2)$$
$$W = 2\pi D \quad (3)$$

Where:

Q = flow rate (192 cf/day)
b = water bearing unit thickness (10.1 ft)
V = flow velocity (0.288 ft/day)
D = distance to stagnation point (ft)
T = transmissivity (864 sf/day)
dh/dl = hydraulic gradient (0.001 ft/)
n = porosity (dimensionless value of 0.3)
W = width of inflow zone (feet)

The porosity value (sand) was estimated from the literature (Table 2.4 Page 37, Freeze and Cherry, Groundwater, 1979). The hydraulic gradient value was determined using the January 13, 2012 groundwater elevation data. The water bearing unit thickness was determined using the water column within the well screen for RW-13. The flow rate was determined using the water extraction rate during RW-13 constant rate recovery test.