

ADVANTAGE ENVIRONMENTAL CONSULTANTS, LLC

Surfactant Flush Pilot Study Work Plan

**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
Baltimore, Maryland 21230-1719

And

Royal Farms / Two Farms, Inc.
3611 Roland Avenue
Baltimore, Maryland 21211

Prepared by:

Advantage Environmental Consultants, LLC (AEC)
8610 Washington Boulevard, Suite 217
Jessup, MD 20794
Phone – (301)-776-0500
Fax – (301)-776-1123

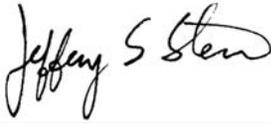
August 9, 2011

ADVANTAGE ENVIRONMENTAL CONSULTANTS, LLC

Surfactant Flush Pilot Study Work Plan



Prepared by: Thomas E. Ruszin III
Title: Staff Scientist
Date: August 9, 2011



Reviewed by: Jeffery S. Stein, P.G.
Title: Principal
Date: August 9, 2011

TABLE OF CONTENTS

1.0	INTRODUCTION	1
1.1	Project Overview	1
1.2	Site Description and Background.....	1
2.0	SITE CONDITIONS	4
2.1	Geology and Hydrology	4
2.2	Liquid Phase Hydrocarbons	5
2.3	Dissolved-Phase Hydrocarbons.....	5
2.4	Adsorbed-Phase Hydrocarbons.....	5
2.5	Summary	6
3.0	PILOT STUDY PROCEDURES.....	7
3.1	Introduction	7
3.2	Pilot Study Location Selection	7
3.3	Extraction Well Installation.....	8
3.4	Pilot Study Design Basis Summary.....	9
3.5	Pilot Study Injection Procedures	10
3.6	Pilot Study Extraction Procedures	11
3.7	Waste Management Procedures	12
4.0	PERFORMANCE MONITORING PROGRAM.....	13
4.1	Pilot Study Monitoring Plan	13
4.2	Soil Monitoring Plan	13
4.3	Groundwater Monitoring Plan	14
4.4	Summary of Pilot Study Monitoring Plan	15
4.5	Evaluation Criteria.....	16
5.0	SCHEDULING	17
6.0	REPORTING	18

APPENDICES

Appendix A Figures

Appendix B MSDS

Figures

Figure 1	Site Vicinity Map
Figure 2	Site Features Map
Figure 3	Site Area Map
Figure 4	Boring/Temporary Piezometer Map
Figure 5	Lithologic Cross Section A-A'
Figure 6	Lithologic Cross Section B-B'
Figure 7	Groundwater Gradient Map
Figure 8	LPH Distribution Map
Figure 9	Groundwater Quality Map
Figure 10	Soil Quality Map
Figure 11	Proposed Remediation Zone Map

1.0 INTRODUCTION

1.1 Project Overview

Advantage Environmental Consultants, LLC (AEC) has prepared this Surfactant Flush Pilot Study Work Plan for the Royal Farms Store No. 96 located at 500 Mechanics Valley Road in North East, Maryland. The Work Plan was prepared as a companion to the document titled Corrective Action Plan (CAP) Addendum, prepared by AEC and dated August 3, 2011.

It was determined in the CAP Addendum that the high permeability of the coarse grained soils below the Site presents a challenging environment for the enhanced fluid recovery (EFR) remedy. The combined water flow rate necessary for providing hydraulic control and meeting the primary remedial objective (e.g., liquid phase hydrocarbon (LPH) removal to a sheen) will necessitate the use of relatively large capacity process equipment. The EFR remedy offers a viable approach to reaching the target cleanup goals in groundwater, but the time period to perform this task may extend over multiple years. The report concluded that the EFR remedy is technically feasible but other approaches to LPH removal may offer significantly reduced time frames for completion of this task.

The subsurface investigation data indicates the bulk of the LPH has migrated and resides within the shallow coarse grained soil layers situated between 1 and 15 feet below ground surface (bgs). EFR pilot studies have shown that these coarse grained soil layers are highly transmissive for fluid and vapor flow. As such it has been determined that a surfactant flush approach will be effective in reducing the volume of LPH in the release area.

The primary objective of the work plan is to evaluate the effectiveness of surfactant flushing assisted by EFR extraction for LPH removal. This approach will augment current groundwater remediation efforts by promoting increased solubility and mobility of the residual and mobile LPH within the release area. This work plan will describe the surfactant injection/extraction means and methods, and pre- and post-flushing groundwater monitoring activities.

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. The Site is currently undergoing an underground storage tank (UST) system upgrade. The Site formerly operated three double-walled, fiberglass wrapped composite steel USTs which distributed fuel to 22 product dispensers (two diesel and 20 gasoline). The system consisted of the following: a 20,000 gallon unleaded regular UST, a 12,000 gallon super unleaded UST, and a 12,000 gallon diesel UST. These USTs were removed from the ground on August 3 and 4th, 2011. 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 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 Maryland Department of the Environment (MDE) Oil Control Program (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. The exact cause of the release is still being investigated. Upon determination of the cause of the release a report will be prepared and submitted to the MDE. Based on LPH plume configuration and visual observations during UST system piping removal, the source of the release is probably between dispensers 3-4 and 7-8 (see Figure 2 in Appendix A).

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. The initial borings were advanced around MW-3 and the subsequent borings arrayed outward from MW-3. Also conducted as part of the investigation was the collection and analysis of groundwater samples from potable drinking water wells located in the Site vicinity. A map illustrating the soil boring/temporary piezometer locations is included as 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 the CAP lacked some final design parameters associated with the feasibility of the technology and process/treatment equipment sizing, it recommended that a 4- to 8-hour pilot study be conducted using a liquid ring pump (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 and five groundwater monitoring wells between July 14 and 19, 2011. The wells were completed to depths ranging from 24 to 26 feet bgs. The groundwater quality from the wells was recently tested but these results are pending. 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. The report concluded that the EFR remedy is technically feasible but other approaches to LPH removal may offer significantly reduced time frames for completion of this task.

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 then sealed 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 and July 19, 2011, they were added to the EFR program via a piping manifold. The vac-truck EFR operation is conducted daily for four hours.

2.0 SITE CONDITIONS

2.1 Geology and Hydrology

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 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 1-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 August 3, 2011. Depth to groundwater ranged from 10.60 feet bgs in MW-1 to 14.60 feet bgs in MW-6. These groundwater depths were compared to top of casing elevations with an arbitrary datum of 100 feet. Groundwater elevations in the wells ranged from 83.87 feet in MW-2 to 84.44 feet in MW-5. A groundwater gradient map is provided as Figure 7 in Appendix A. Groundwater flow is shown to be towards the southwest. There appears to be some slight groundwater mounding in the vicinity of MW-7 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 0.003 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 construction characteristics are unknown. 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. Both of these well locations are illustrated in Figure 2 in Appendix A. Other off-site, down gradient potable wells are located in the Site vicinity but none are closer than 275 feet from the release area.

2.2 Liquid Phase Hydrocarbons

Historically, LPH has been detected in the following wells: 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; B-22 at thicknesses ranging from a sheen to 6.91 feet; MW-3 at thicknesses ranging from 0.01 to 1.75 feet; RW-1 at thicknesses ranging from 0.00 to 0.09 feet; RW-2 at thicknesses ranging from a sheen to 0.30 feet; and, RW-4 at thicknesses ranging from a sheen to 0.18 feet. In addition LPH sheen has been observed in B-1, B-8, B-15 and RW-3. All of the other temporary piezometers and 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 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.

2.3 Dissolved-Phase Hydrocarbons

Based on the groundwater quality data Dissolved Phase Hydrocarbon (DPH) impact from the recent release is estimated to consist of an oval-shaped plume encompassing the eastern and central portions of the Site. The down gradient extent of the DPH plume is delineated by wells MW-1 and MW-2 which both were below detection limits (BDL) for volatile organic compounds (VOCs). The northern (side gradient) extent of the DPH plume has been substantially delineated as determined by piezometers B-11 (76.9 micrograms per liter ($\mu\text{g/L}$) total benzene, toluene, ethylbenzene and xylenes (BTEX) and B-12 (BDL for total BTEX). The southern (side gradient) extent of the DPH plume has not yet been fully delineated but is thought to not extend further than boring B-24 (no groundwater sample but soil analysis results were BDL for all VOCs). The up gradient extent of the DPH plume, while not expected to extend significantly away from the source area, has also not been fully delineated in areas immediately east of the dispenser islands. The results of the most recent groundwater sample laboratory analyses 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) 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 has been identified between the 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 EFR 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 injection/extraction activities the coarse grained soil layers will contribute the vast majority of flow to the recovery total.

3.0 PILOT STUDY PROCEDURES

3.1 Introduction

Based on the hydrogeologic features of the surrounding formation, and distribution of the LPH impact, AEC has developed a surfactant flush pilot study program which will address mobile and residual LPH within the release area. The following describes the sequence of events, and provides a detailed discussion of the means and methods involved in the surfactant flush and extraction activities.

The sequence of events during the surfactant flush pilot study activities will be as follows:

1. Install and develop extraction wells;
2. Install Direct Push (DP) boring for collection and analysis of base-line soil samples;
3. Collect and analyze groundwater samples from select extraction and monitoring wells;
4. Inject surfactant solution into the remediation zone via DP methods;
5. Perform EFR activities on extraction wells while conducting a second round of focused surfactant injection; and,
6. Conduct performance monitoring on select extraction and monitoring wells.

3.2 Pilot Study Location Selection

The proposed footprint of the pilot study area is 80 feet by 80 feet and is located on the northeast quadrant of the LPH impacted area. The actual LPH impacted zone within the pilot study area is 45 by 45 feet or 2,025 square feet. This area is characterized by multiple temporary piezometers and recovery wells which currently contain LPH. Specifically, as of the August 3, 2011 gauging event, the following wells contained LPH: B-6 (0.61 feet), B-9 (0.74 feet), B-10 (0.06 feet), RW-2 (sheen), and RW-4 (0.12 feet). This area is located on the hydraulically upgradient end of the LPH plume and side gradient of the suspect source area (northeastern dispenser islands).

Nine injection points placed on a 20 foot grid pattern will be used to inject surfactant amended water into the shallow, coarse grained soil layers. Specifically, the target injection intervals are currently identified as the permeable sand layers located between 1-7 feet bgs and 11-15 feet bgs. Twenty primary and nine secondary extraction wells will be used to recover the injected water. The primary extraction wells will be placed on a 20 foot grid pattern and the secondary extraction wells, located in a circular configuration around the primary extraction wells, will be placed on a 50 foot grid pattern. Some of the existing recovery and monitoring wells (RW-1 through RW-6 and MW-6) will also be used for the extraction activities. Four of the twenty primary extraction wells will be installed to a shallow depth (i.e., only intercept the 1-7 feet bgs coarse grained soil layer). The proposed pilot study treatment zone boundary is illustrated on Figure 11 in Appendix A.

3.3 Extraction Well Installation

Extraction well borings will be advanced using hollow stem auger (HSA) methods. Soil samples will be obtained using a split-spoon sampler and Standard Penetration Testing (SPT) procedures. The sampling interval for the borings will be on 5-foot centers from the surface to the termination depth of the boring. A Field Geologist will log the geologic conditions of the borings and field screen soil cores for VOCs using a photoionization detector (PID). Additional split-spoon samples may be taken at other locations at the discretion of the Field Geologist.

Various configurations of extraction wells will be installed for this pilot study. Proposed extraction well locations are depicted on Figure 11 in Appendix A. All of the extraction wells will be constructed using 4-inch diameter poly-vinyl chloride (PVC) slotted screen and riser. The following offers a description of the various types of extraction wells and their function.

Primary Extraction Wells – Thirteen wells terminated at depths between 14 and 18 feet bgs. In order to optimize water recovery from the injection activities, the termination depth of the extraction wells will be above the top of the saturated course grained soil layer which resides at 15 to 20 feet bgs. By not extracting water from this lower unit, recovery from the surfactant flush activities will be optimized.

Secondary Extraction Wells – Three wells terminated at depths of 25 feet bgs. The termination depth of these extraction wells will be within the lower course grained soil layer which begins at 15 to 20 feet bgs. By extracting water from both course grained soil layers, of which the lower one is thought to contribute substantial water flow, hydraulic control of the pilot study area will be achieved.

Shallow Extraction Wells – Four wells terminated at depths of 7 to 10 feet bgs. The termination depth of the extraction wells will be near the bottom of the upper saturated course grained soil layer which resides at 7 to 10 feet bgs. These wells will be pulse-vacuumed to optimize the lateral migration of the surfactant amended water injected within the shallow course grained soil layer.

The riser length for the extraction wells will be five feet. A sand filter pack will be placed to 2-foot above the top of the screen, and a 1-foot thick bentonite seal will be placed above the sand by dropping bentonite pellets into the annular space and hydrating in place. The remainder of the annular space above the bentonite seal will be grouted to the surface and a flush-mounted, bolt-down, steel manhole set in concrete will be installed at the surface. The poly-vinyl chloride (PVC) well head will be secured with a locking cap.

The wells will be developed using surge block and aggressive vacuum extraction techniques within one week of installation. At least five well volumes of water will be removed from each well as part of the development process. If a well is evacuated dry, the well will be emptied of water five times over a period not to exceed two hours. All development water will be containerized and disposed of off-site via a vacuum truck.

Prior to arriving at the Site and between each soil boring, all hand augers, core barrels, cutting shoes, probe rods, tips, sleeves, pushrods, and samplers will be washed using a water rinse. Fuel, lubricants, and other similar substances will be handled in a manner consistent with accepted safety procedures and standard operating practices. Public utility clearances will be obtained prior to the initiation of the sampling program. This will entail contacting Miss Utility at least 72 hours prior to drilling activities. All drilling work will be performed by a State of Maryland-licensed well driller and appropriate well permits will be obtained from Cecil County.

Groundwater levels within each monitoring well will be measured using an electronic oil-water interface probe accurate to 0.01-feet. The electronic water level meter will be cleaned (Liquinox and water rinse) prior to use in each well.

3.4 Pilot Study Design Basis Summary

Based on previous project experience regarding estimating fluid injection quantities from lithologic data (i.e., assigning an effective or mobile porosity), and surfactant manufacturers’ recommendations, it was possible to calculate the estimated quantity of surfactant amended water necessary to conduct the pilot study. This information was coupled with other site specific parameter estimates to develop the pilot study design. A summary of these parameters is presented in the table below.

Design Parameters	Pilot Study Area Summary
Treatment Area	4,225 square feet (65 feet by 65 feet is actual injection footprint)
Thickness of Contaminated Zone	Two course grained zones (1-7 feet bgs and 11-15 feet bgs)
Treatment Interval Lithology	Layered sand with some gravel intervals
Assumed Mobile Porosity	5 %
Injection Locations	9 (actual number to be based on field performance)
Total Volume	15,800-gallons
Gallons Reagent Per Location	1,755-gallons
Surfactant Dose	3 %
Injection Approach	5-foot injection tool at 4 simultaneous locations
Assumed Average Injection Rate / Pressure Per Location	4- to 5-gpm / <25-PSI

The surfactant will be mixed with water into a 3 percent solution and injected into the subsurface target area. A blue or red biodegradable water dye tracer will be added to the solution per the manufacturers’ specifications. A Material Safety Data Sheet (MSDS) for the dye product is included in Attachment B.

The selected surfactant will be VeruSOL-3 (or equivalent) manufactured by VeruTEK Technologies. VeruSOL-3 is a mixture of cosolvents, citrus-based compounds, and plant oil-based non-ionic compounds. These components are either Generally

Recognized as Safe (GRAS) by the United States Food and Drug Administration (USFDA) or are approved as indirect food additives and for dermal contact, such as cosmetics. VeruSOL-3 has the capacity to bring hydrocarbons into an oil-in-water micro-emulsion which increases the effective solubility of the petroleum hydrocarbons in water and helps reduce the inter-facial tension between the hydrocarbon and water molecules. The increased effective solubility and reduced inter-facial tension will promote formation of an aqueous solution between the LPH and the groundwater, augmenting hydrocarbon recovery via the extraction well network. A MSDS for this product is included in Attachment B.

The extraction well layout was developed using EFR pilot study data. Based on the pilot study vacuum influence data, a radius of influence (ROI) of 25 feet was developed. This ROI represents the anticipated distance from an extraction point where at least 0.1-inch H₂O is applied. The 0.1-inch H₂O vacuum has been determined through extensive studies to be a reasonable value concerning effective ROI for EFR and soil vapor extraction. The primary extraction wells, located within and immediately surrounding the injection points, are configured on a 20-foot spacing (10-foot ROI) which is conservative with regard to the above stated ROI. The secondary extraction wells will be configured on 50-foot spacing (25-foot ROI).

3.5 Pilot Study Injection Procedures

The injection process will be performed by Vironex Environmental Field Services of Bowie, Maryland, under the responsible oversight of AEC. The injection system will include a mixing tank, a pump, pressure gauges, flow meters, valves and chemical transfer hose. Temporary injection points will be advanced using a Geoprobe DP drilling rig.

The surfactant amended water will be pumped from the mixing tank through an injection tool. After the target mass has been delivered to each injection interval, the injection tool will be advanced downwards to inject across the next treatment depth interval. Based on the target lithology it may be possible to inject up to four locations simultaneously using five-foot long injection tools placed in each location. If necessary, a temporary bentonite seal will be placed around the top of the injection tool to minimize the potential seepage around the top of the injection tool. Injections will be performed from the outer edges of the treatment area, towards the center of the treatment area to further prevent displacement of LPH outside the treatment area.

During the injection process the DP rig will be used to collect several core samples within the treatment zone and in-between two injection points. The soil cores will be visually inspected for dyed surfactant staining (red or blue discoloration) which will be indicative of surfactant contact with soil. If necessary, based on the visual inspection of the soil cores, the injection point spacing will be adjusted in the field.

Injection pressures and flow rates may be adjusted based on field observations. Injection will be stopped if fluids surface during the injection, and surfaced fluids will be cleaned up with water, absorbent, or a shop vacuum as needed. After injection, the

injection point will be abandoned by backfilling the boring with a bentonite grout. Injection process data will be collected during injection to monitor treatment effectiveness and optimize the injection activities. Data will include the injected mass, injection flow rate, injection pressure, injection volume, water levels in nearby monitoring wells, and any surfacing or other abnormal conditions.

The surfactant amended water will be allowed to remain in the subsurface for approximately 12 hours before the extraction event is conducted to remove the solution, as described below.

3.6 Pilot Study Extraction Procedures

Approximately 12 hours after the completion of the surfactant injection activities the extraction phase of the work will commence. As discussed below, a second, focused surfactant injection event will be simultaneously conducted.

A pre-fabricated stinger tube connected to vacuum hose will be inserted in each extraction well. The stinger tube will be connected to the well head using a vapor tight rubber boot which will allow vertical adjustment of the stinger tube intake. The stinger tube and vacuum hose will be constructed of 1-inch diameter petroleum compatible material. Each of these hose assemblies will be connected via a cam-lock fitting to a pre-fabricated manifold setup. Each hose assembly connecting to the manifold will have a ball-valve and sight-tube. Each sight-tube will be coupled to a 2-inch diameter PVC Tee. The tees will be connected to form the trunk line. The trunk line will be fitted with a cam-lock fitting to allow connection of the vac-truck influent hose.

Each extraction well will be operated independently and adjusted during operation as needed. The stinger tube assembly will skim LPH from the surface of the ground water interface. LPH is lifted off the surface of the ground water interface by the vacuum and transported up and along the piping by entrained flow. The following sequence of extraction well operation is anticipated: shallow extraction wells followed by primary extraction wells followed by secondary extraction wells. This sequence will be repeated multiple times until the event is completed.

It is anticipated that the extraction event will take between 12 and 24 hours. During the extraction event the effluent water will be observed for both LPH and traces of dyed surfactant amended water. This will be accomplished using the individual extraction well sight tubes and regular monitoring of well water using a clear bailer. The extraction event will be terminated two hours following the last observance of either LPH or dyed surfactant amended water and a minimum of 12 hours. Liquids generated as part of the extraction activities will be handled as discussed below.

During extraction activities a second, focused surfactant injection event will be conducted. This effort will use the four injection points located on the southwest portion of the pilot study area (i.e., the four extraction points located in the LPH plume). The target delivery zone will be the shallow course grained soil layer situated between 1 and 7 feet bgs. This activity will inject the four locations simultaneously using five-foot long

injection tools placed in each location. This activity will be performed no longer than 8 hours. The same means and methods discussed above for the initial injection effort will be followed for this activity.

3.7 Waste Management Procedures

Several types of waste materials may be generated as a result of remediation activities. These may include VOC-impacted soils generated during drilling operations and petroleum-impacted water/LPH generated during vacuum recovery operations. Disposal of each type of material is discussed in the following sections. All waste materials manifests will be signed by the owner or his authorized agent as the generator of the waste or its designated agent.

The primary soil contaminants that are expected to be encountered consist of petroleum-related products. The impacted soils will be transported to the disposal facility. All trucking companies used to transport the impacted soil will be certified, licensed, and insured to transport this waste in the State of Maryland and any other States through which the wastes will travel or where wastes will ultimately be disposed. AEC will retain copies of all bills of lading, manifests, receipts and/or waivers that were signed prior to transport. Copies of these documents will be included in the Work Plan Implementation Report.

Any VOC-impacted water and LPH encountered during recovery activities will be collected and containerized in a vacuum truck. The contained fluids will be properly characterized and transported off-site for final disposal or treatment at facility permitted to accept impacted water originating from the State of Maryland. All trucking companies used to transport the impacted soil will be certified, licensed, and insured to transport hazardous waste in the State of Maryland and any other States through which the wastes will travel or where wastes will ultimately be disposed/treated. AEC will retain copies of all bills of lading, manifests, receipts and/or waivers that were signed prior to transport. Copies of these documents will be included in the Work Plan Implementation Report.

4.0 PERFORMANCE MONITORING PROGRAM

4.1 Pilot Study Monitoring Plan

Monitoring will be performed prior to the pilot study to assess conditions and provide a baseline to compare to post-treatment conditions. Site monitoring will also be performed during and after the pilot study to assess the performance of surfactant injection for feasibility and scale-up design. The following sections provide a discussion of the soil and groundwater monitoring program which will occur as part of the pilot study.

4.2 Soil Monitoring Plan

Prior to the surfactant injection, AEC will collect soil samples from one boring installed with a DP rig within the pilot study treatment zone. Figure 11 in Appendix A illustrates the location of this boring. The boring will be completed to approximately 18 feet bgs which is near the bottom of the pilot study treatment zone. Six soil samples will be collected in the boring. These samples will be collected at 3-feet bgs, 6-feet bgs, 9-feet bgs, 12-feet bgs, 15-feet bgs and 18-feet bgs. To complete the borings the Geoprobe will hydraulically drive a rod into the ground. When the target soil sampling depth is reached, a soil sampler will be attached to the end of the rod. The soil sampler consists of a two-inch diameter tube containing a four-foot acetate sleeve liner. By advancing this sampler into the soil, soil will be forced into the opening of the sampling tube and a sample is obtained. All samples will be collected and prepared using USEPA Method 5035 via Terra-core sampling. The Terra-core sampler will be inserted directly into the soil core using a reusable T-handle. Once the sampler is filled with the soil material, it will be transferred to pre-preserved containers and the airtight sealing cap will be attached.

The analytical laboratory will provide the Terra-core sample containers where appropriate. The containers will be labeled, and stored in a cooler chilled to four degrees Celsius. Samples will be analyzed for BTEX and Total Petroleum Hydrocarbons Gasoline Range Organics (TPH GRO) by United States Environmental Protection Agency (USEPA) Analytical Method 8260 and 8015B, respectively by Maryland Spectral Services, Inc. of Baltimore, Maryland under chain-of-custody documentation. The remaining soil in the acetate sleeve will be screened for VOCs using a PID and to log the lithology of the borehole. The VOC analytical results will be correlated to the existing data and used to provide additional data to assess the effectiveness of the pilot study.

During the injection process the DP rig will be used to collect several core samples within the treatment zone and in-between two injection points. The soil cores will be visually inspected for dye staining which will be indicative of surfactant contact with soil. This inspection will be instrumental in determining the radius of influence and distribution potential of an injection point.

Approximately one week after the surfactant injection/extraction event is completed AEC will collect additional soil samples with a DP rig within the pilot study area. The boring will be advanced and the samples collected within one-foot and at the same

depth intervals as the pre-injection samples. The same means and methods discussed above for the pre-injection soil sample collection effort will be followed for the post-injection soil sampling program. The VOC analytical results will be correlated to the existing data and the pre-injection data, and used to assess the effectiveness of the pilot study.

4.3 Groundwater Monitoring Plan

Prior to the surfactant injection, AEC will collect groundwater samples from the 16 newly installed extraction wells. It is anticipated that some of the primary extraction wells may not consistently contain groundwater as they will not be screened in the lower coarse grained soil layer. It should be noted that the existing monitoring and recovery wells are currently on a monthly sampling schedule. Groundwater quality data from these routine sampling events will be used for the pre-injection baseline data. Figure 11 in Appendix A illustrates these testing locations. In the event that LPH are identified within a well, the thickness of the LPH will be measured to the nearest 0.01-foot. No groundwater sample will be collected from wells where LPH is identified.

The extraction wells will be sampled 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, turbidity, dissolved oxygen (DO), temperature, and oxidation-reduction potential (ORP). The data collected prior to the commencement of the pilot study will be compared to pilot study and post-pilot study data to evaluate the injection program's hydraulic effects.

The containers will be labeled, and stored in a cooler chilled to four degrees Celsius. Samples will be analyzed for BTEX and TPH GRO by USEPA Analytical Method 8260 and 8015B, respectively by Maryland Spectral Services, Inc. of Baltimore, Maryland under chain-of-custody documentation. The VOC and other groundwater quality analytical results will be correlated to the existing data and used to provide additional data to assess the effectiveness of the pilot study.

Approximately one week after the surfactant injection/extraction event is completed AEC will collect additional groundwater samples from the extraction wells and monitoring/recovery well network. The same means and methods discussed above for the pre-injection groundwater sample collection effort will be followed for the post-injection groundwater sampling program. The VOC and other groundwater quality analytical results will be correlated to the existing data and the pre-injection data, and used to assess the effectiveness of the pilot study with respect to LPH thickness reduction and the determination of the hydraulic properties of the injection and extraction events.

In addition, monitoring wells MW-1, MW-2, MW-4, MW-5, MW-6 and MW-8 will be subject to weekly monitoring for BTEX and GRO during the pilot test period and for one month following the completion of the surfactant pilot test to evaluate potential effects beyond the pilot test area. Samples will be submitted to Maryland Spectral Services, Inc. of Baltimore, Maryland under chain-of-custody documentation.

Water level measurements will be collected from all temporary piezometers, monitoring wells, recovery wells, and extraction wells associated with the Site prior to starting the pilot study, during the pilot study (daily for four weeks following the last extraction event), and following the completion of the pilot study. In addition, a dedicated disposable bailer will be used to collect and inspect the water for dyed surfactant staining (blue or red discoloration) which will be indicative of surfactant contact with groundwater (every four hours during the injection activities and daily for one week following the last extraction event). The data collected during these water level monitoring events will be used to evaluate the injection program’s hydraulic effects.

All 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 an Alconox (phosphate-free laboratory-grade) bath and triple rinse of distilled water before initial use and between each sampling point. This equipment will include the water level probe and cable, low flow submersible pump and cable, flow-thru cell and instrumentation. New sections of polyvinyl chloride tubing and nylon rope will be used for the submersible pump at each sample location. In addition, a clean pair of new, disposable nitrile gloves will be worn each time a different well is gauged and sampled.

4.4 Summary of Pilot Study Monitoring Plan

The table below summarizes the monitoring activities (parameters and frequency) which will occur as part of the pilot study.

Media	Pre-Injection	During-Injection	Post-Injection
Soil	BTEX and TPH GRO by fixed laboratory analysis (6 samples) and PID field scan.	Dyed surfactant by visual observation (following completion of injection).	BTEX and TPH GRO by fixed laboratory analysis (6 samples) and field scan. Dyed surfactant by visual observation.
Groundwater	BTEX and TPH GRO by fixed laboratory analysis. pH, conductivity, turbidity, DO, temperature and ORP by field scan (during sample collection). Water level gauging (prior to sample collection).	Dyed surfactant by visual observation (every four hours during the injection and extraction activities, and daily until the last extraction event is completed). Water level gauging (daily until the last extraction event is completed).	BTEX and TPH GRO by fixed laboratory analysis. Dyed surfactant by visual observation (daily for one week following the last extraction event). pH, conductivity, turbidity, DO, temperature and ORP by field scan (during sample collection). Water level gauging (prior to sample collection and daily for 4 weeks).

4.5 Evaluation Criteria

The success of the pilot study will be measured by the sustained absence of measurable LPH in all of the extraction, recovery and monitoring wells in the pilot study test cell. Also of interest are the expected water and soil BTEX and TPH GRO concentration changes. This data will be plotted against time to evaluate the application of surfactant to the pilot study area and its effect on stripping LPH from the soil matrix. Initial marked or trending increases in dissolved hydrocarbon concentrations followed by declining concentrations to below baseline levels will be indicative of effective utilization of the surfactant flush approach.

5.0 SCHEDULING

All field and reporting activities associated with this work plan are anticipated to be completed within 70 days after authorization by the MDE and the client. The MDE will be notified of AEC’s field schedule at least five business days prior to the start of work plan implementation. The following is a summary of major project milestones and associated estimated times of completion:

Event	Approximate Schedule (days)
MDE approves Work Plan	Day X
Complete Installation and Development of Extraction wells	X + 20
Complete Pre-injection Sampling/Testing	X + 25
Conduct Surfactant Injection/Extraction	X + 26 through 30
Complete Post-injection Sampling/Testing	X + 40
Data Analysis/Reporting	X + 60
Completion of Work Plan Implementation Report Peer Review	X + 65
Submit Work Plan Implementation Report to MDE	X + 70
MDE approves Work Plan Implementation Report	Day Y
Submit Final CAP to MDE	Y + 30

The CAP development schedule will be contingent on the successful application results of the surfactant flush technology. If this technology is deemed to be ineffective for Site wide remediation, the schedule will need to be revised.

6.0 REPORTING

A report will be prepared that describes the entire work plan implementation. Specifically, the report will include:

- A summary of pilot study results (include tables that summarize analytical results).
- A complete description of the pilot study, including all data necessary to understand the project in its entirety including all pilot study methods and procedures.
- A discussion of key decision points encountered and resolved during the course of the pilot study.
- Graphical displays such as isopleths, cross-sections, plume contour maps (showing concentration levels, isoconcentration contours), and Site maps (showing sample and injection locations, etc.) that describe the report results.
- An analysis of current and existing soil and groundwater data to illustrate temporal changes for both water chemistry and piezometric data.

An analysis of the effectiveness of the pilot study and a discussion of a scaled-up design for total Site remediation.

APPENDIX A

FIGURES

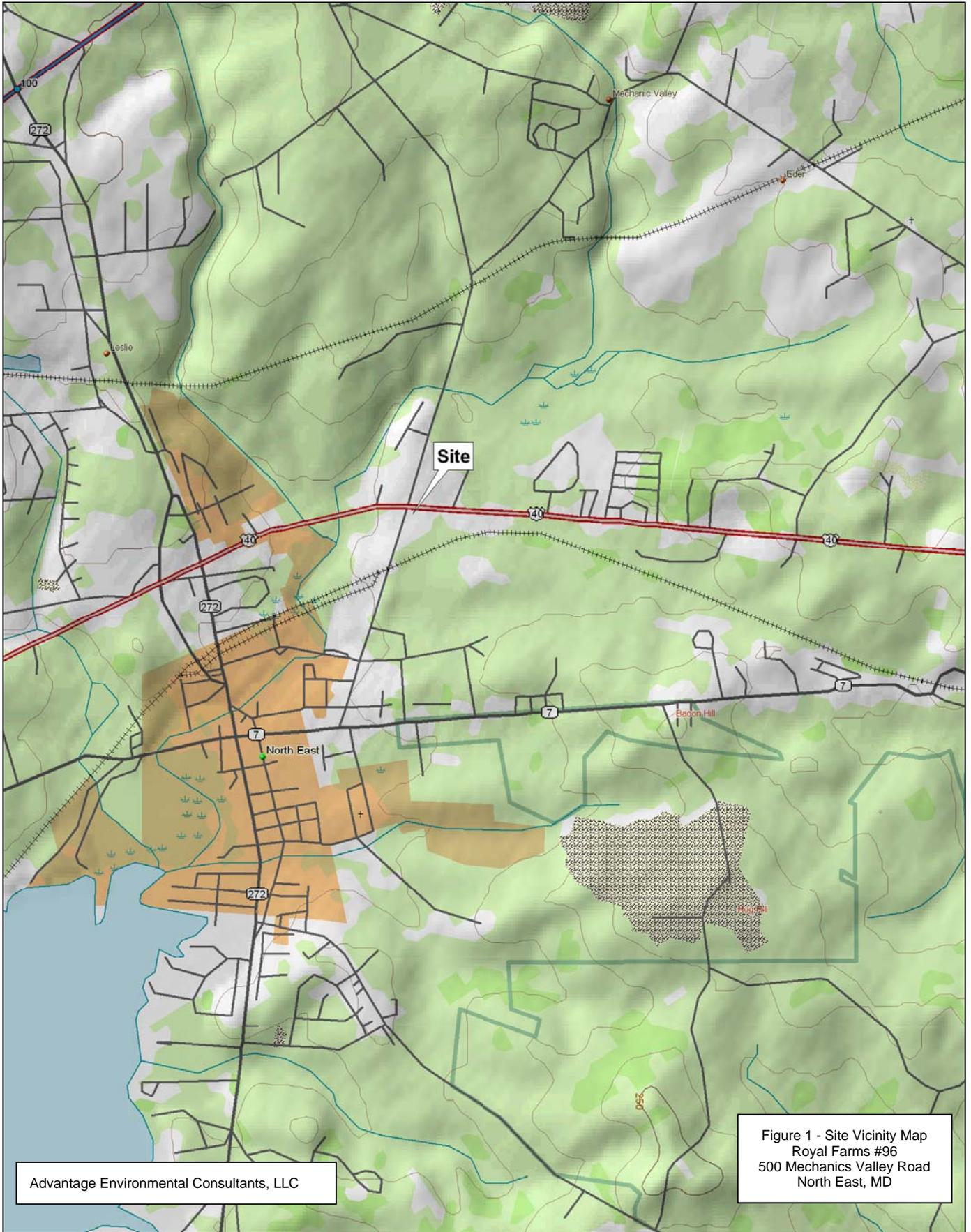
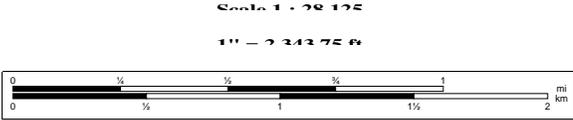


Figure 1 - Site Vicinity Map
 Royal Farms #96
 500 Mechanics Valley Road
 North East, MD

Advantage Environmental Consultants, LLC

DeLORME
 © 2001 DeLorme. Topo USA® 3.0
 Zoom Level: 12-7 Datum: WGS84



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
-  Potable Well



 Scale in Feet

Route 40 - Pulaski Highway

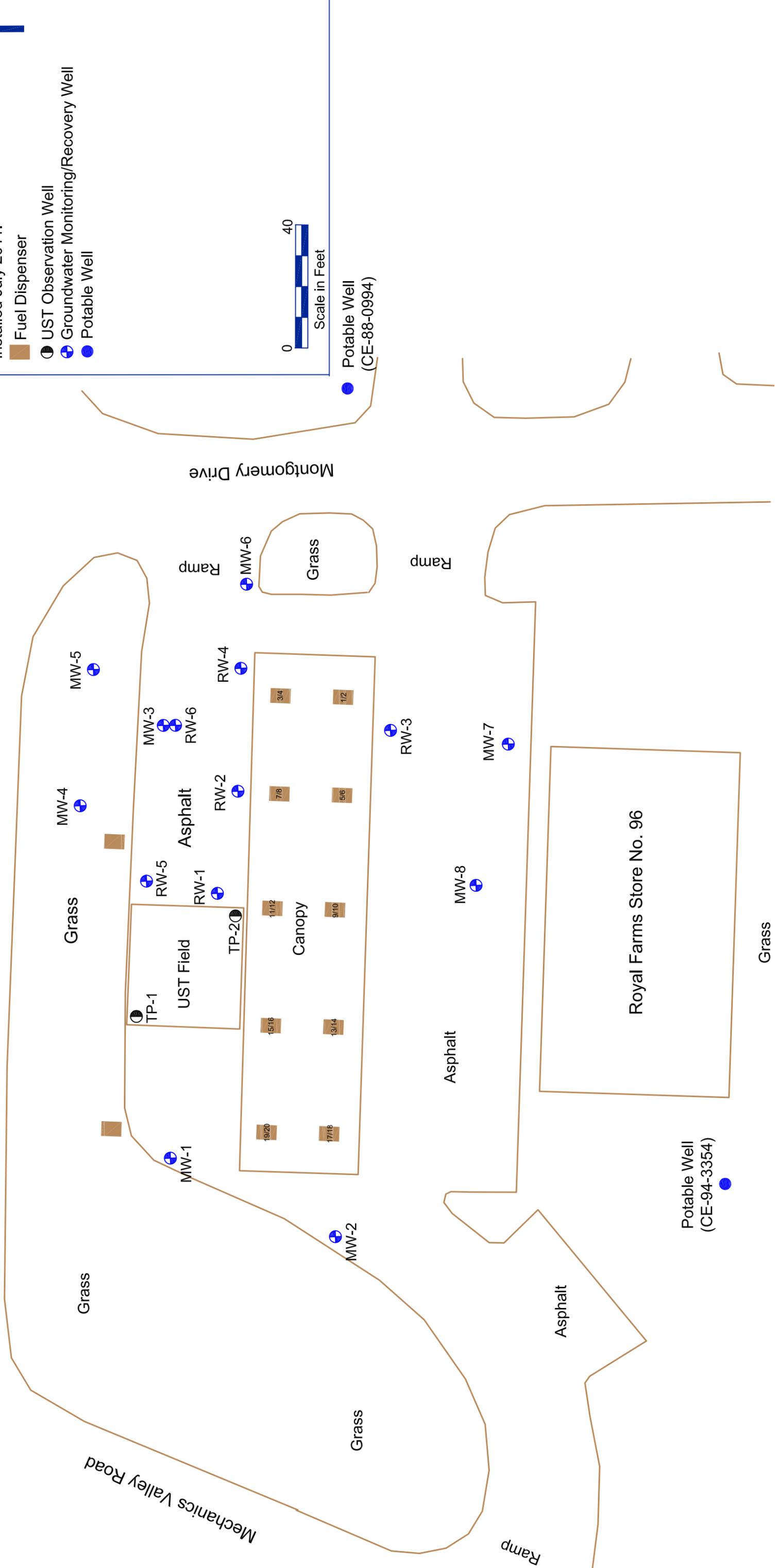


Figure 2 - Site Features Map
 Royal Farms No. 96
 500 Mechanics Valley Road
 North East, MD

Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 8-4-11
File: Site Features	Revision No.: 1

Advantage Environmental Consultants, LLC
 8610 Washington Blvd. Suite 217
 Jessup, MD 20794
 Phone 301-776-0500 Fax 301-776-1123

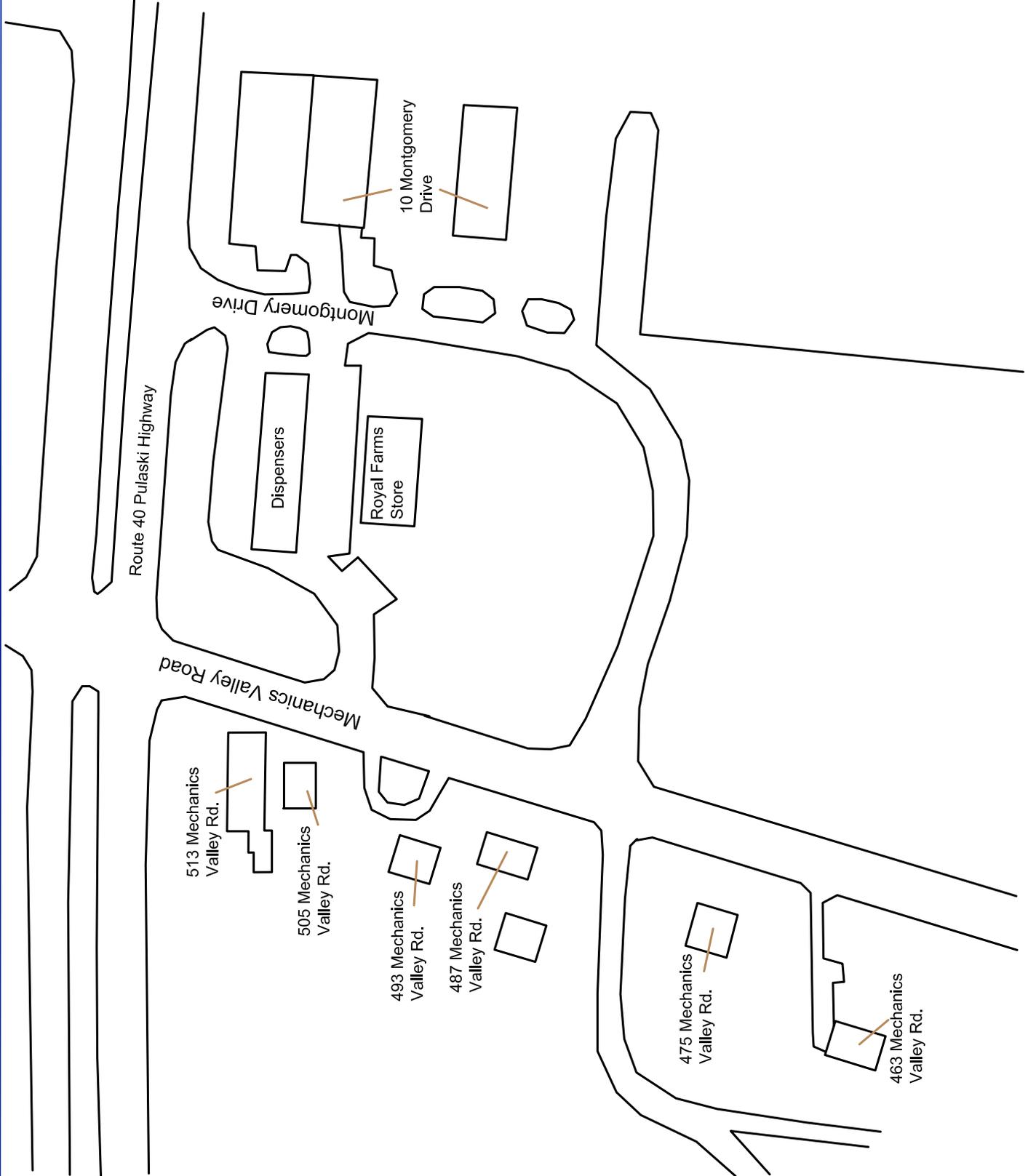
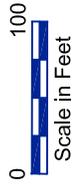


Figure 3 - Site Area Map
 Royal Farms No. 96
 500 Mechanics Valley Road
 North East, MD

Project No.: 05-056	Drawn by: JSS
Task No.: RF96	Date: 7-14-11
File: Site Area	Revision No.: 1

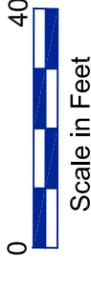
Advantage Environmental Consultants, LLC
 8610 Washington Blvd. Suite 217
 Jessup, MD 20794
 Phone 301-776-0500 Fax 301-776-1123

Legend

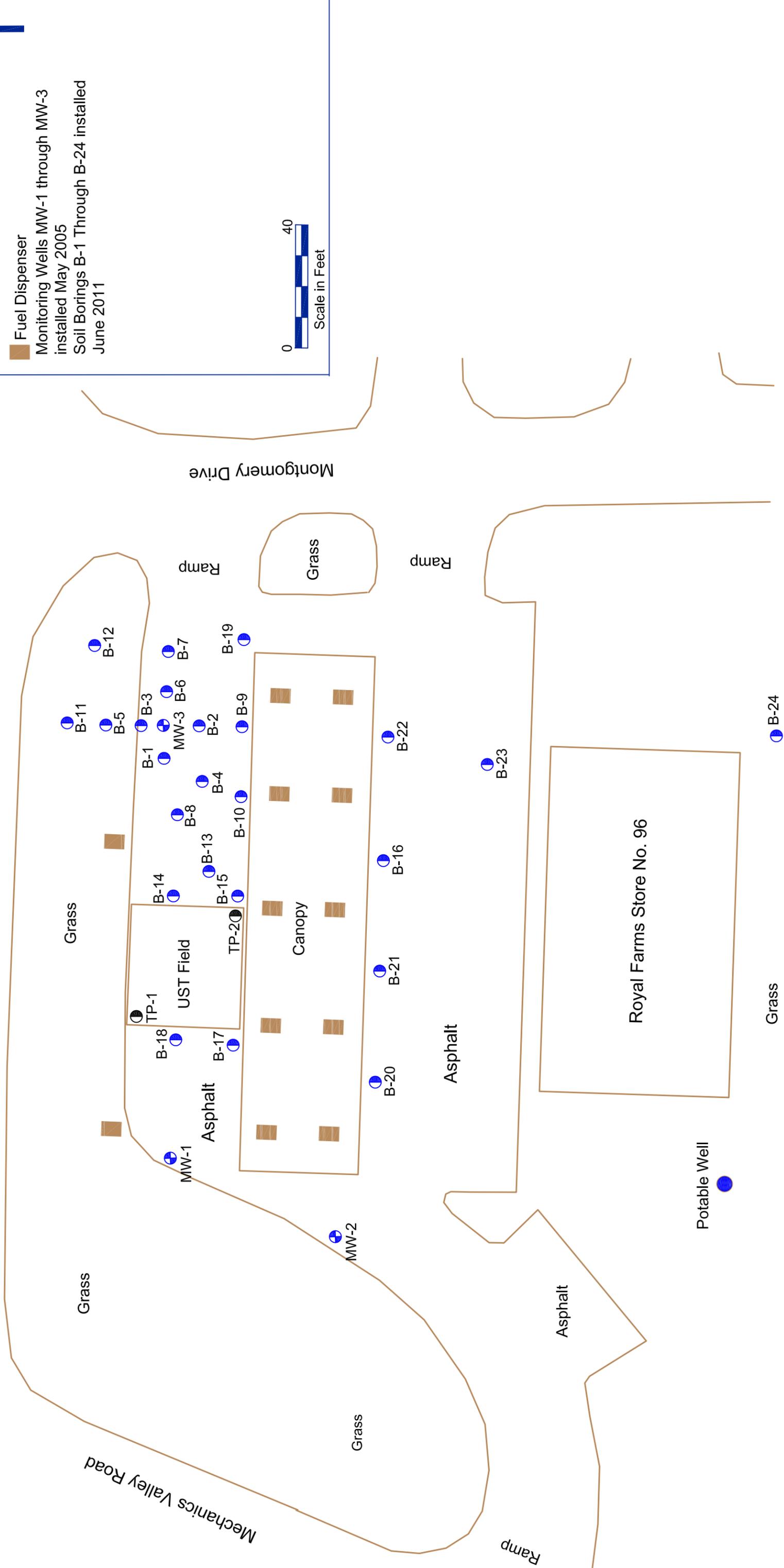
-  Soil Boring/Temporary Piezometer
-  UST Observation Well
-  Groundwater Monitoring Well

 Fuel Dispenser

Monitoring Wells MW-1 through MW-3 installed May 2005
 Soil Borings B-1 Through B-24 installed June 2011



Route 40 - Pulaski Highway



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:

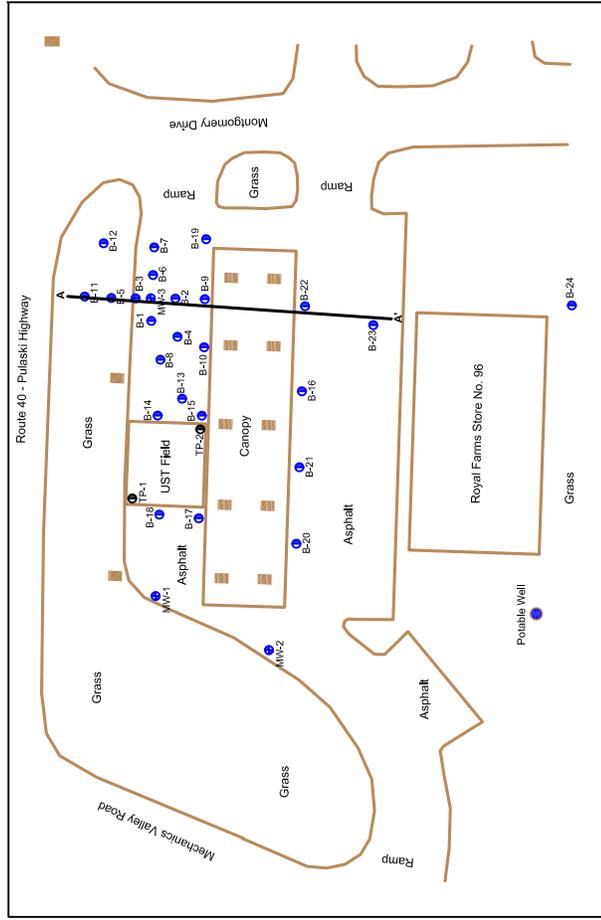
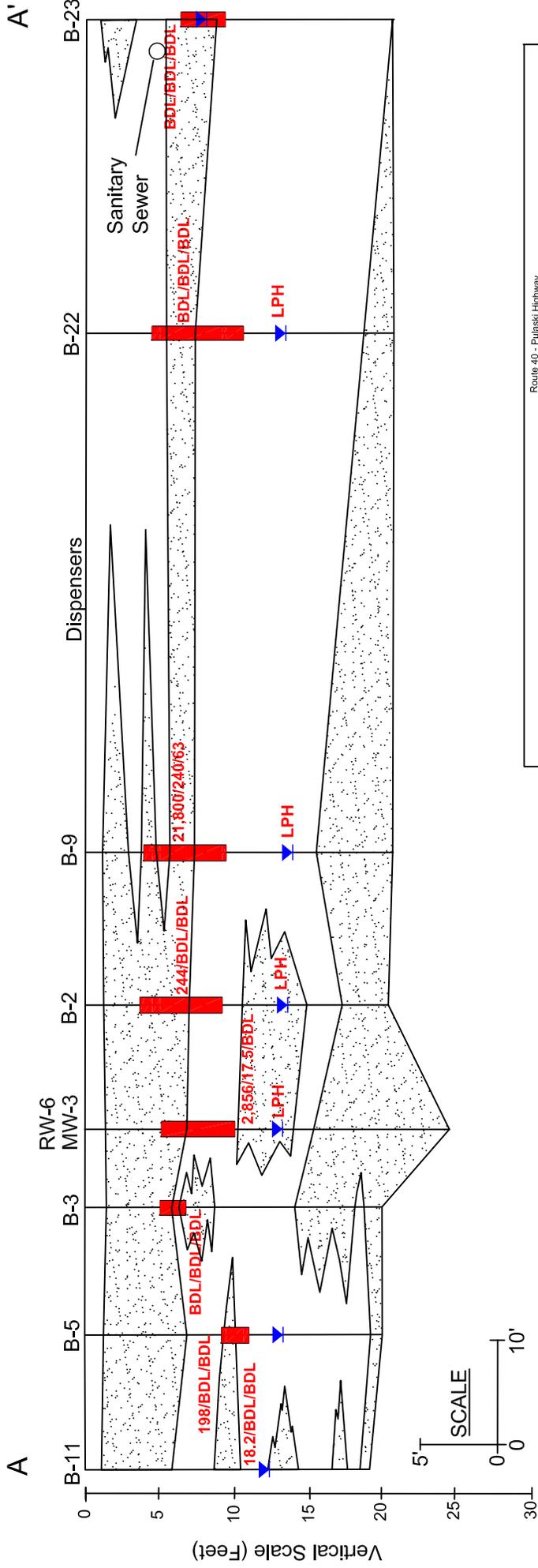
Drawn by: JSS

Date: 6-27-11

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)

Figure 5 - Lithologic Cross Section A-A'

Royal Farms No. 96
500 Mechanics Valley Road
North East, Maryland

Checked by:
JSS

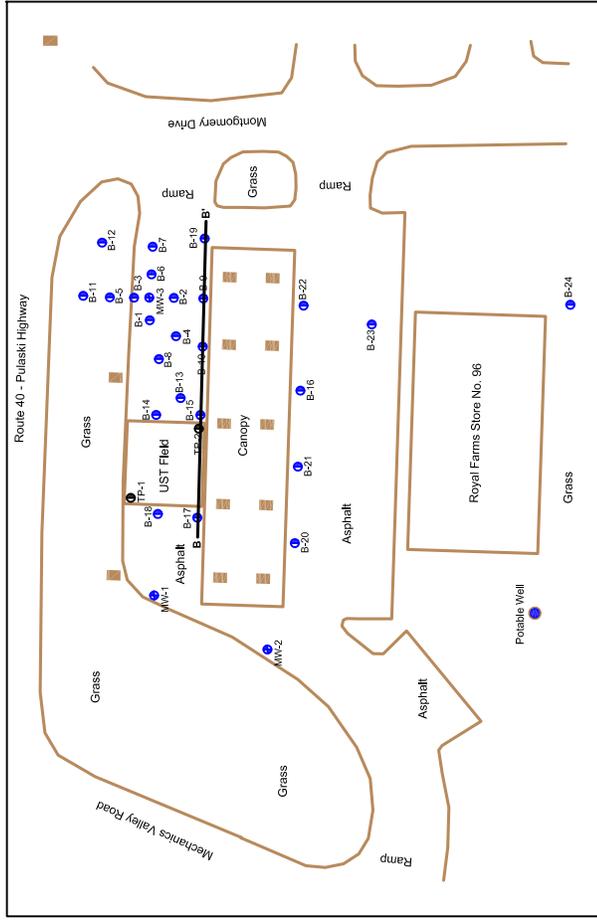
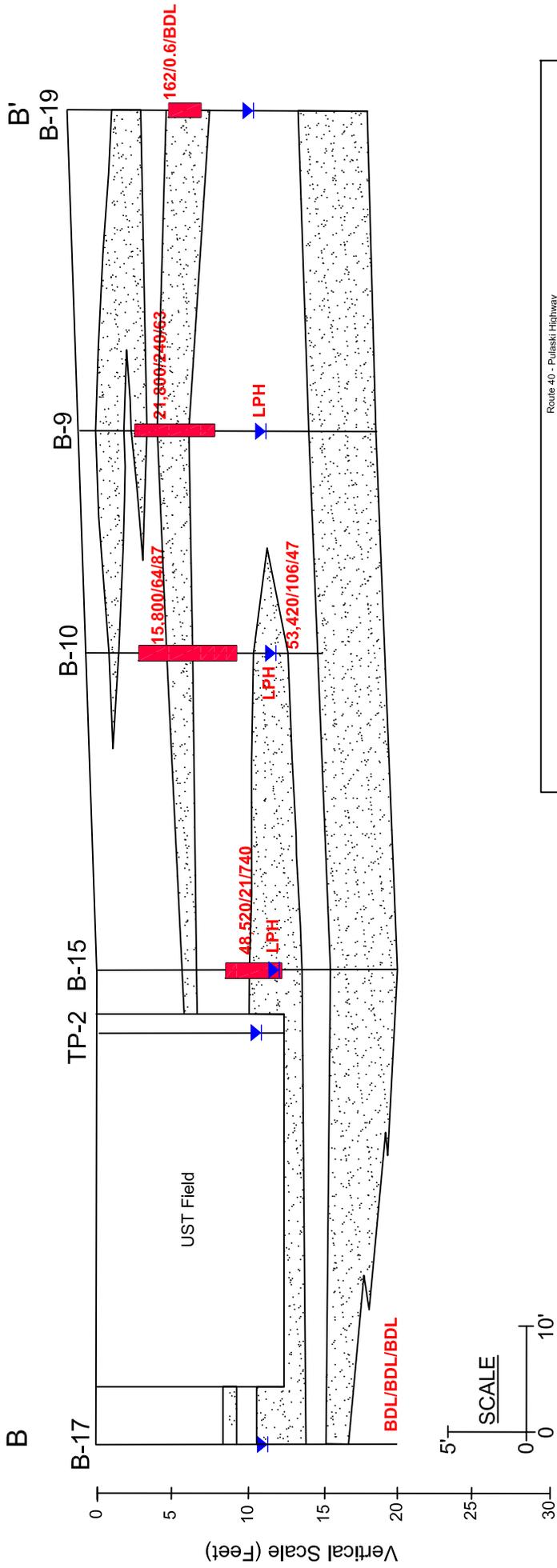
Drawn by:
JSS

Revision:
First

Date:
6-29-11

Advantage Environmental Consultants, LLC

8610 Washington Boulevard, Suite 217
 Jessup, Maryland 20794
 301-776-0500



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 Boulevard, Suite 217

Jessup, Maryland 20794

301-776-0500

Figure 6 - Lithologic Cross Section B-B'

Royal Farms No. 96

500 Mechanics Valley Road

North East, Maryland

Checked by:
JSS

Drawn by:
JSS

Revision:
First

Date:
6-29-11

Legend

- UST Observation Well
- Groundwater Monitoring Well
- Potable Well

■ Fuel Dispenser

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.

85.07 - Groundwater elevation measured on 8/3/11. Values shown in red have been corrected using a Liquid Phase Hydrocarbon density of 0.7 grams per milliliter.

All measurements in feet.
NG - Not gauged.

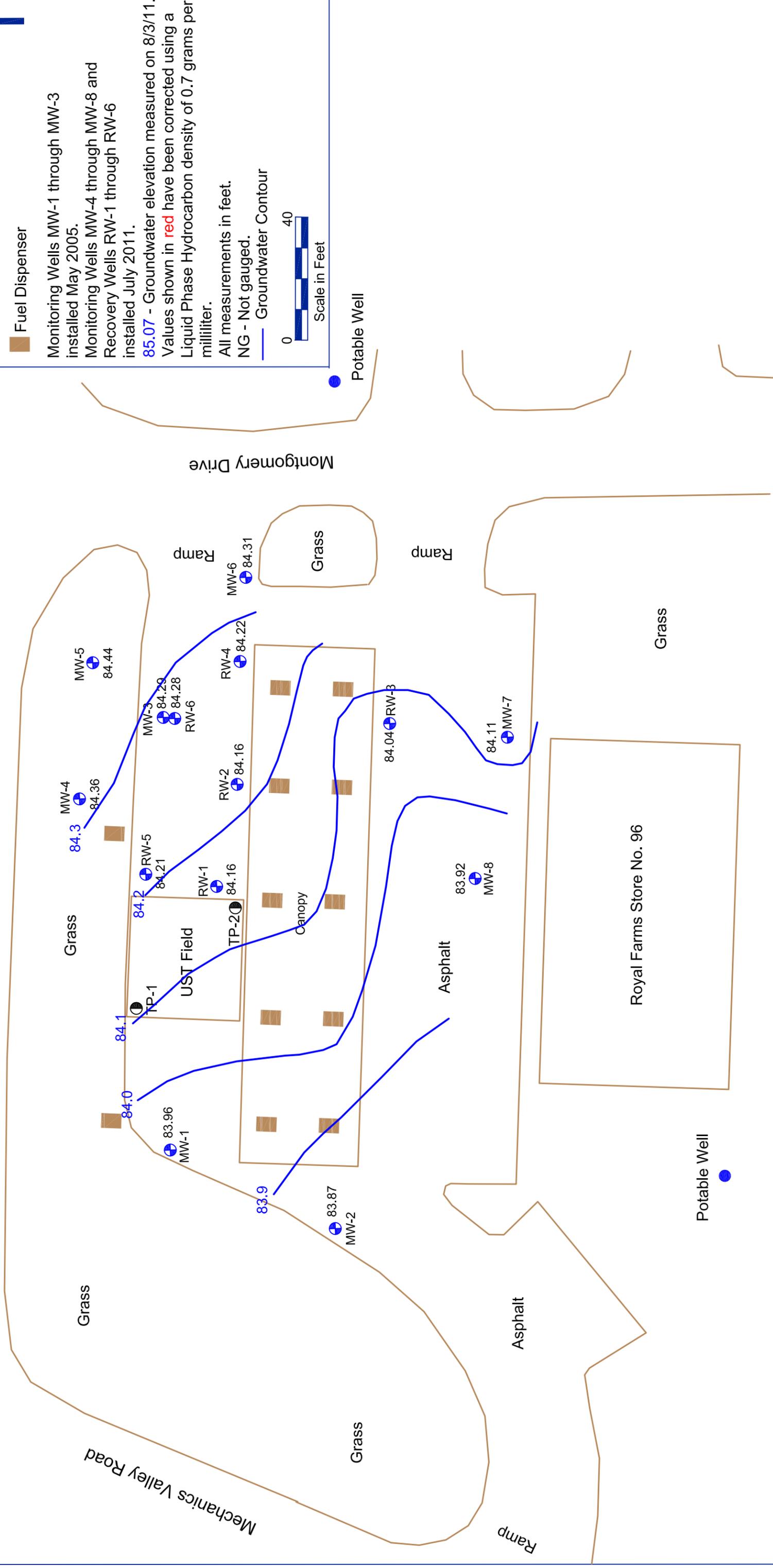
— Groundwater Contour



Scale in Feet



Route 40 - Pulaski Highway



Advantage Environmental Consultants, LLC

8610 Washington Blvd. Suite 217
Jessup, MD 20794
Phone 301-776-0500 Fax 301-776-1123

Drawn by: JSS

Date: 8-5-11

Revision No.: 1

Project No.: 05-056

Task No.: RF96

File: GW Grad

Figure 7 - Groundwater Gradient Map

Royal Farms No. 96
500 Mechanics Valley Road
North East, MD



Legend

- Soil Boring/Temporary Piezometer
- UST Observation Well
- Groundwater Monitoring Well
- Fuel Dispenser

Monitoring Wells MW-1 through MW-3 installed May 2005

Soil Borings B-1 Through B-24 installed June 2011

Total BTEX/TPH GRO/TPH DRO

BTEX - Benzene, Toluene, Ethylbenzene, Xylenes

TPH - Total Petroleum Hydrocarbons

GRO - Gasoline Range Organics

DRO - Diesel Range Organics

BDL - Below Detection Limits

LPH - Liquid Phase Hydrocarbon

NS - Not Sampled

BTEX via EPA Method 8260

TPH GRO and DRO via EPA Method 8015

BTEX reported in micrograms per liter (ug/l)

TPH GRO/DRO reported in milligrams per liter (mg/l)

Piezometer Samples collected 6-22-11 thru 6-24-11

MW-1 and 2 samples collected 6-8-11



Route 40 - Pulaski Highway

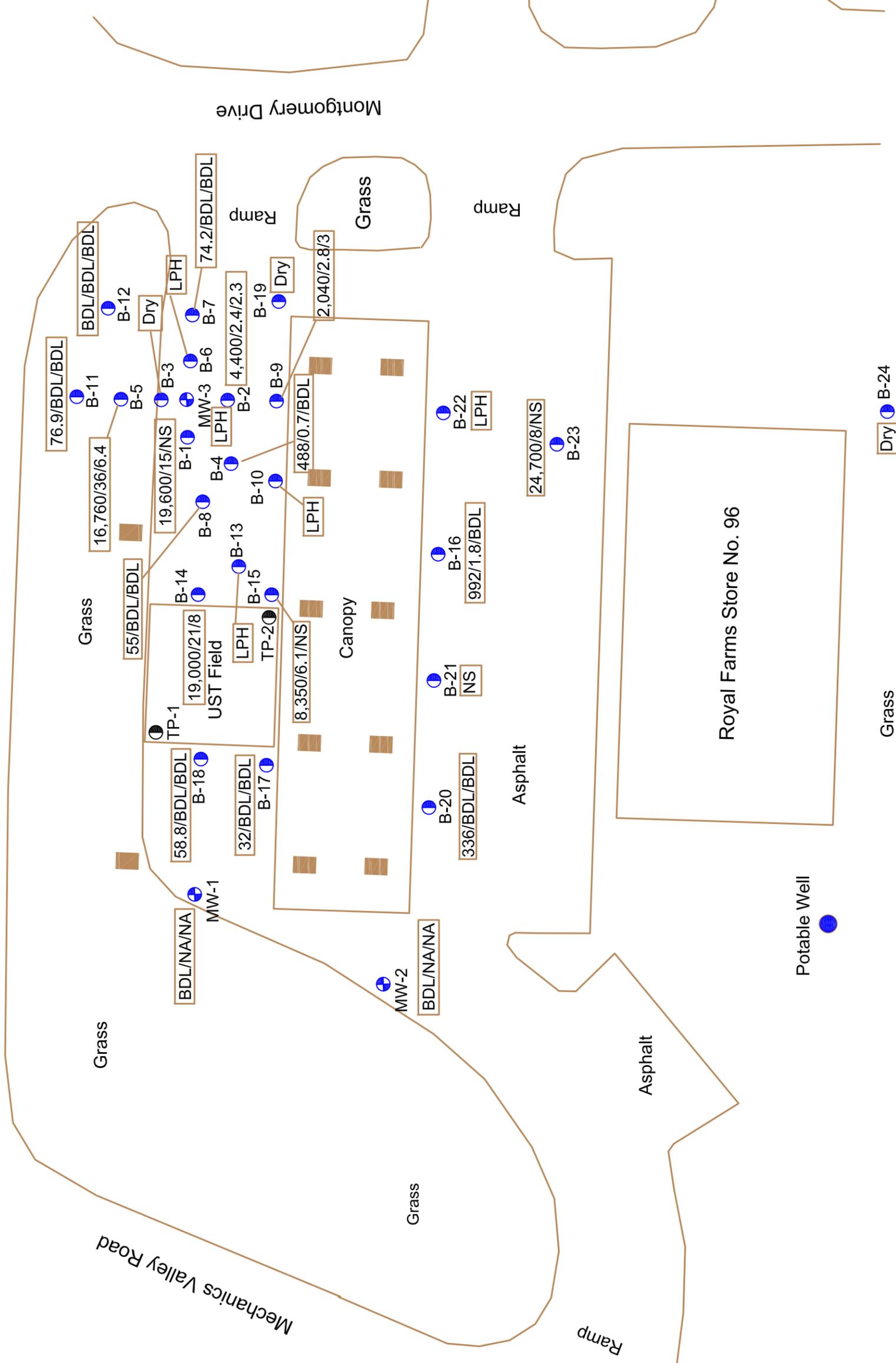


Figure 9 - Groundwater Quality Map

Royal Farms No. 96
500 Mechanics Valley Road
North East, MD

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

Advantage Environmental Consultants, LLC
8610 Washington Blvd. Suite 217
Jessup, MD 20794
Phone 301-776-0500 Fax 301-776-1123

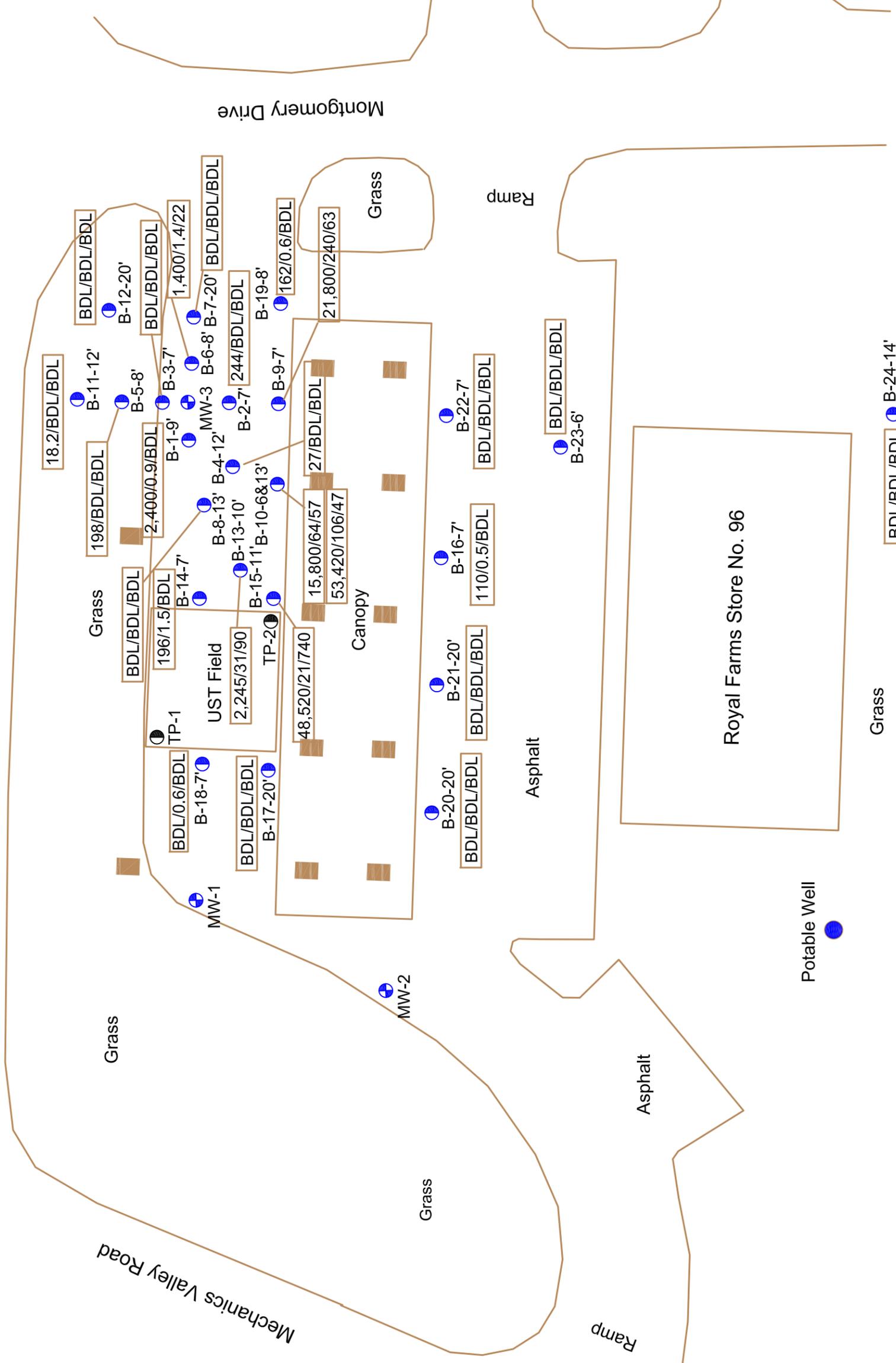


Legend

-  Soil Boring/Temporary Piezometer
 -  UST Observation Well
 -  Groundwater Monitoring Well
 -  Fuel Dispenser
- Monitoring Wells MW-1 through MW-3 installed May 2005
- Soil Borings B-1 Through B-24 installed June 2011
- 1,211/1,4/11 - Total BTEX/TPH GRO/TPH DRO
- BTEX - Benzene, Toluene, Ethylbenzene, Xylenes
- TPH - Total Petroleum Hydrocarbons
- GRO - Gasoline Range Organics
- DRO - Diesel Range Organics
- BDL - Below Detection Limits
- B-3-5' - Boring ID - Sample depth in feet
- BTEX via EPA Method 8260
- TPH GRO and DRO via EPA Method 8015
- BTEX reported in micrograms per kilogram (ug/kg)
- TPH GRO/DRO reported in milligrams per kilogram (mg/kg)



Route 40 - Pulaski Highway



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: Soil Qual

Figure 10 - Soil Quality Map

Royal Farms No. 96
500 Mechanics Valley Road
North East, MD

Drawn by: JSS

Date: 6-27-11

Revision No.: 1

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
- Existing Groundwater Monitoring/Recovery Well
- Proposed Injection Point
- Proposed Extraction Well
- Proposed Shallow Zone Extraction Well
- Proposed Soil Boring (Pre- and Post-Injection)
- Suspected Limits of Liquid Phase Hydrocarbon (LPH)

Scale in Feet
0 40

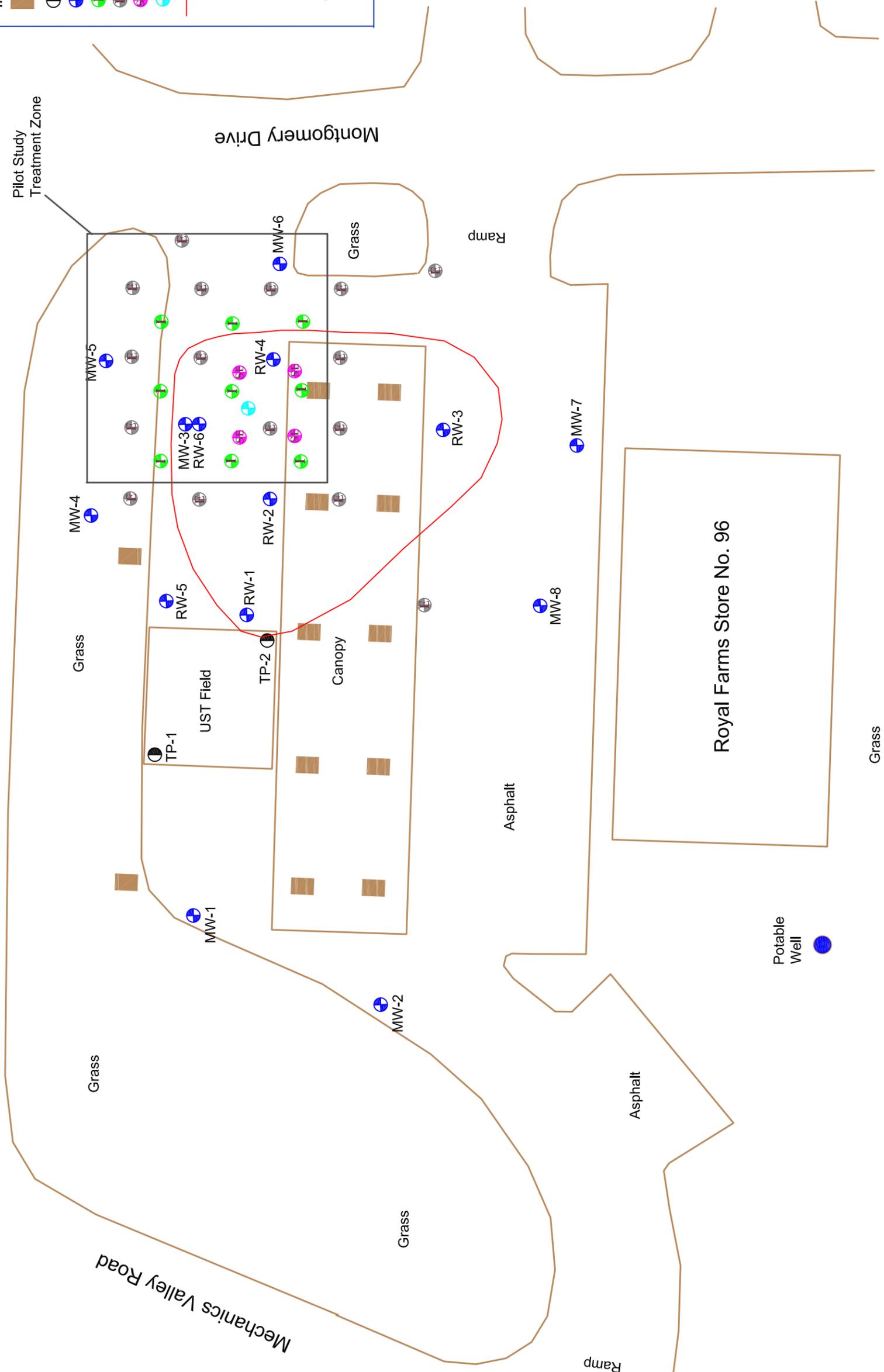


Figure 11 - Proposed Remediation Zone Map

Royal Farms No. 96
 500 Mechanics Valley Road
 North East, MD

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

Advantage Environmental Consultants, LLC
 8610 Washington Blvd. Suite 217
 Jessup, MD 20794
 Phone 301-776-0500 Fax 301-776-1123

APPENDIX B

MSDS

BRIGHT DYES™ MATERIAL SAFETY DATA SHEET
STANDARD BLUE™ DYE TABLET
PAGE 1 OF 3

MSDS PREPARATION INFORMATION

PREPARED BY: T. P. MULDOON
(937) 886-9100
DATE PREPARED: 1/7/11

PRODUCT INFORMATION

MAUNFACTURED BY: KINGSCOTE CHEMICALS
3334 S. TECH BLVD.
MIAMISBURG, OHIO 45342

CHEMICAL NAME MIXTURE
CHEMICAL FORMULA NOT APPLICABLE
CHEMICAL FAMILY WATER SOLUBLE DYE FORM

HAZARDOUS INGREDIENTS

NONE PER 29 CFR 1910.1200

PHYSICAL DATA

PHYSICAL STATE DRY TABLET
ODOR AND APPEARANCE BLUE COLOR WITH NO APPARENT ODOR
SPECIFIC GRAVITY >1
VAPOR DENSITY (mm Hg @ 25 ° C) NOT APPLICABLE
VAPOR DENSITY (AIR =1) NOT APPLICABLE
EVAPORATION RATE (Butyl Acetate = 1) NOT APPLICABLE
BOILING POINT NOT APPLICABLE
FREEZING POINT NOT APPLICABLE
pH NOT APPLICABLE
SOLUBILITY IN WATER HIGHLY SOLUBLE WITH SMALL AMOUNT OF INSOLUBLE
RESIDUE

FIRE HAZARD

CONDITION OF FLAMMABILITY NON-FLAMABLE
MEANS OF EXTINCTION WATER FOG, CARBON DIOXIDE, OR DRY CHEMICAL
FLASH POINT AND METHOD NOT APPLICABLE
UPPER FLAMABLE LIMIT NOT APPLICABLE
LOWER FLAMABLE LIMIT NOT APPLICABLE
AUTO-IGNITION TEMPERATURE NOT APPLICABLE
HAZARDOUS COMBUSTION PRODUCTS BURNING MAY PRODUCE OXIDES OF CARBON NITROGEN
UNUSUAL FIRE HAZARD REMOTE POSSIBILITY OF A DUST EXPLOSION. IF MIXED
WITH AIR IN THE PROPER PROPORTIONS, IT CAN BE
EXPLOSIVE (SIMILAR TO FLOUR OR STARCH).

BRIGHT DYES™ MATERIAL SAFETY DATA SHEET
STANDARD BLUE™ DYE TABLET
PAGE 2 OF 3

EXPLOSION HAZARD

SENSITIVITY TO STATIC DISCHARGE REMOTE POSSIBILITY OF A DUST EXPLOSION. IF MIXED WITH AIR IN THE PROPER PROPORTIONS, IT CAN BE EXPLOSIVE (SIMILAR TO FLOUR OR STARCH).

SENSITIVITY TO MECHANICAL IMPACT NOT APPLICABLE

REACTIVITY DATA

PRODUCT STABILITY STABLE

PRODUCT INCOMPATIBILITY AVOID BROMINE TRIFLUORIDE, LITHIUM, STRONG ACIDS, BASES AND OXIDIZERS.

CONDITIONS OF REACTIVITY NONE KNOWN

HAZARDOUS DECOMPOSITION PRODUCTS SEE HAZARDOUS COMBUSTION PRODUCTS

TOXICOLOGICAL PROPERTIES

SYMPTOMS OF OVER EXPOSURE FOR EACH POTENTIAL ROUTE OF ENTRY:

INHALLATION, ACUTE MAY CAUSE IRRITATION IF DUST IS INHALED.

INHALATION, CHRONIC NONE KNOWN

SKIN CONTACT MAY BE IRRITATING TO THE SKIN. WILL CAUSE STAINING OF THE SKIN ON CONTACT.

EYE CONTACT MAY CAUSE IRRITATION

INGESTION URINE MAY BE A BLUE COLOR UNTIL THE DYE HAS BEEN WASHED THROUGH THE SYSTEM.

EFFECTS OF ACUTE EXPOSURE DIRECT CONTACT MAY CAUSE IRRITATION TO THE EYES, SKIN, AND RESPIRATORY TRACT.

EFFECTS OF CHRONIC EXPOSURE NONE KNOWN

THRESHOLD OF LIMIT VALUE NOT APPLICABLE

CARCINOGENICITY NOT LISTED AS A KNOWN OR SUSPECTED CARCINOGEN BY IARC, NTP OR OSHA.

TERATOGENICITY NONE KNOWN

TOXICOLOGY SYNERGISTIC PRODUCTS NONE KNOWN

PREVENTATIVE MEASURES

PERSONAL PROTECTIVE EQUIPMENT

GLOVES RUBBER

RESPIRATORY USE NIOSH APPROVED DUST MASK IF DUSTY CONDITIONS EXIST.

CLOTHING PROTECTIVE CLOTHING SHOULD BE WORN WHERE CONTACT IS UNAVOIDABLE.

OTHER HAVE ACCESS TO EMERGENCY EYEWASH.

BRIGHT DYES™ MATERIAL SAFETY DATA SHEET
STANDARD BLUE™ DYE TABLET
PAGE 3 OF 3

PREVENTATIVE MEASURES (CONT.)

ENGINEERING CONTROLS	NOT NECESSARY UNDER NORMAL CONDITIONS, USE LOCAL VENTILATION IF DUSTY CONDITIONS EXIST.
SPILL OR LEAK RESPONSE	SWEEP UP SPILLS AND PLACE IN WASTE DISPOSAL CONTAINER, FLUSH AFFECTED AREA WITH WATER.
WASTE DISPOSAL	INCINERATE OR REMOVE TO A SUITABLE SOLID WASTE DISPOSAL SITE, DISPOSE OF ALL WASTES IN ACCORDANCE WITH FEDERAL, STATE AND LOCAL REGULATIONS.
HANDELING PROCEDURES AND EQUIPMENT	NO SPECIAL REQUIREMENTS.
STORAGE REQUIREMENTS	STORE IN A COOL, DRY PLACE AWAY FROM EXCESSIVE HEAT OR FLAME.
SHIPPING INFORMATION	NO SPECIAL REQUIREMENTS

FIRST AID MEASURES

FIRST AID EMERGENCY PROCEDURES

EYE CONTACT	FLUSH EYES WITH WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION IF IRRITATION PERSISTS.
SKIN CONTACT	WASH SKIN THOROUGHLY WITH SOAP AND WATER. GET MEDICAL ATTENTION IF IRRITATION DEVELOPS.
INHALATION	IF DUST IS INHALED, MOVE TO FRESH AIR. IF BREATHING IS DIFFICULT GIVE OXYGEN AND GET IMMEDIATE MEDICAL ATTENTION.
INGESTION	DRINK PLENTY OF WATER AND INDUCE VOMITING. GET MEDICAL ATTENTION IF LARGE QUANTITIES WERE INGESTED OR IF NAUSEA OCCURS. NEVER GIVE FLUIDS OR INDUCE VOMITING IF THE PERSON IS UNCONSCIOUS OR HAS CONVULSIONS.

SPECIAL NOTICE

ALL INFORMATION, RECOMMENDATIONS AND SUGGESTIONS APPEARING HEREIN CONCERNING THIS PRODUCT ARE BASED UPON DATA OBTAINED FROM MANUFACTURER AND/OR RECOGNIZED TECHNICAL SOURCES; HOWEVER, KINGSCOTE CHEMICALS MAKES NO WARRANTY, REPRESENTATION OR GUARANTEE AS TO THE ACCURACY, SUFFICIENCY OR COMPLETENESS OF THE MATERIAL SET FORTH HEREIN. IT IS THE USER'S RESPONSIBILITY TO DETERMINE THE SAFETY, TOXICITY AND SUITABILITY OF HIS OWN USE, HANDLING, AND DISPOSAL OF THE PRODUCT. ADDITIONAL PRODUCT LITERATURE MAY BE AVAILABLE UPON REQUEST. SINCE ACTUAL USE BY OTHERS IS BEYOND OUR CONTROL, NO WARRANTY, EXPRESS OR IMPLIED, IS MADE BY KINGSCOTE CHEMICALS AS TO THE EFFECTS OF SUCH USE, THE RESULTS TO BE OBTAINED OR THE SAFETY AND TOXICITY OF THE PRODUCT, NOR DOES KINGSCOTE CHEMICALS ASSUME ANY LIABILITY ARISING OUT OF USE BY OTHERS OF THE PRODUCT REFERRED TO HEREIN. THE DATA IN THE MSDS RELATES ONLY TO SPECIFIC MATERIAL DESIGNATED HEREIN AND DOES NOT RELATE TO USE IN COMBINATION WITH ANY OTHER MATERIAL OR IN ANY PROCESS.

END OF MATERIAL SAFETY DATA SHEET

VeruSOL

MATERIAL SAFETY DATA SHEET

Section 1: PRODUCT AND COMPANY IDENTIFICATION

Manufacturer: VeruTEK Technologies, Inc.
Address: 628-2 Hebron Avenue, Suite 505, Glastonbury, CT 06033
Phone Number: (860) 633-4900

Product Name: VeruSOL
Issue Date: June 2006

Section 2: HAZARDS IDENTIFICATION

Emergency Overview

Appearance/Odor: Light yellow, slightly viscous liquid with citrus odor.

Product is Combustible.

Slippery when spilled.

Potential Health Effects: See Section 11 for more information.

Likely Routes of Exposure: Eye contact, skin contact, inhalation.

Eye: Causes moderate to severe irritation.

Skin: May cause slight redness. Prolonged or repeated exposure may cause drying of the skin.

Inhalation: May cause nose, throat, and respiratory tract irritation, coughing, headache.

Ingestion: Not likely to be toxic, but may cause vomiting, headache, or other medical problems.

Medical Conditions Aggravated By Exposure: May irritate the skin of people with pre-existing skin conditions.

This product does not contain any carcinogens or potential carcinogens as listed by OSHA, IARC, or NTP.

OSHA Regulatory Status

This material is combustible, which is defined as having a flash point between 100°F (37.8°C) and 200°F (93.3°C). Combustible materials are hazardous according to the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Section 3: COMPOSITION/INFORMATION ON INGREDIENTS

The specific chemical identity is being withheld as a trade secret.

Section 4: FIRST AID MEASURES

Eye Contact: Remove contact lenses at once. Flush with water for at least 15 minutes. If irritation persists, seek medical attention.

Skin Contact: Wash affected area with copious amounts of soap and water. If irritation develops, seek medical attention.

Inhalation: Move to fresh air. If symptoms persist, seek medical attention.

Ingestion: Seek medical attention immediately. DO NOT induce vomiting. Rinse mouth with water. Offer water to drink. DO NOT administer anything by mouth to an unconscious person.

General: As with any chemical, employees should thoroughly wash hands with soap and water after handling this material.

Section 5: FIRE FIGHTING MEASURES

Suitable Extinguishing Media: Carbon dioxide, foam or dry chemical. Caution: Carbon dioxide will displace air in confined spaces and may create an oxygen deficient atmosphere.

Unsuitable Extinguishing Media: Water.

Products of Combustion: Forms acrid fumes, carbon monoxide, carbon dioxide and oxides of nitrogen.

Protection of Firefighters: Vapors may be irritating to eyes, skin and respiratory tract. Firefighters should wear self-contained breathing apparatus (SCBA) and full fire-fighting turnout gear.

Material Safety Data Sheet
VeruSOL

Section 6: ACCIDENTAL RELEASE MEASURES

Personal Precautions: Use personal protection recommended in Section 8. Product is slippery when spilled. Isolate the hazard area. Deny entry to unnecessary and unprotected personnel.
Environmental Precautions: Keep out of drains, sewers, ditches and waterways.
Methods for Containment: Dike spill area and cap leaking containers as necessary to prevent further spreading of spilled material. Absorb spilled liquid with suitable material.
Methods for Clean Up: Eliminate all ignition sources. Use equipment rated for use around combustible materials. Oil soaked rags may spontaneously combust; place in appropriate disposal container.
Other Information: There are no special reporting requirements for spills of this material.

Section 7: HANDLING AND STORAGE

Handling

Keep away from heat, sparks, and flame. Open container slowly to release pressure caused by temperature variations. Do not allow this material to come in contact with eyes. Avoid prolonged contact with skin. Use in well ventilated areas. Do not breathe vapors. As with any chemical, employees should thoroughly wash hands with soap and water after handling this material.

Storage

Product may be packaged in phenolic-lined, steel containers or fluorinated plastic containers. Store in well ventilated area. Storage temperature should not exceed 110°F (43°C) for extended periods of time. Keep container closed when not in use. Air should be excluded from partially filled containers by displacing with nitrogen or carbon dioxide. Do not cut, drill, grind or weld on or near this container; residual vapors may ignite.

Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

VeruSOL N/E (N/E – Not Established)

Engineering Controls: Provide ventilation. Keep away from sparks and flames.
Eye/Face Protection: Wear safety glasses or goggles.
Skin Protection: Nitrile gloves are recommended. Boots, apron, or bodysuits should be worn as necessary.
Respiratory Protection: Not normally required. If adequate ventilation is unavailable, use NIOSH approved air-purifying respirator with organic vapor cartridge or canister.
General Hygiene Considerations: As with any chemical, wash hands thoroughly after handling. Have eyewash facilities immediately available.

Section 9: PHYSICAL AND CHEMICAL PROPERTIES

Color: Light yellow.
Odor: Citrus odor.
Physical State: Liquid.
Boiling Point: >212°F (>100°C)
Specific Gravity: 0.968 to 0.985 @ 77°F (25°C)
Vapor Pressure: <2mmHg @ 68°F (20°C)
Flash Point: 130°F (54.4°C)
Solubility in Water: Soluble.
Evaporation Rate: Medium to fast.
Volatile Organic Compound (VOC) Content: 10-30% by volume.

Note: These specifications represent a typical sample of this product, but actual values may vary. Certificates of Analysis and Specification Sheets are available upon request.

Section 10: STABILITY AND REACTIVITY

Stability: Stable.
Conditions to Avoid: Keep away from heat, sparks and flames.
Incompatible Materials: None
Hazardous Decomposition Products: None
Possibility of Hazardous Reactions: None

Material Safety Data Sheet

VeruSOL

Section 11: TOXICOLOGICAL INFORMATION

Acute Effects

An ingredient has been shown to have low oral toxicity ($LD_{50} > 5$ g/kg) and low dermal toxicity ($LD_{50} > 5$ g/kg) when tested on rabbits, It also showed low toxicity by inhalation ($RD_{50} > 1$ g/kg) when tested on mice. Product may be a skin and eye irritant. Inhalation may cause irritation of the nose, throat, and respiratory tract.

Chronic Effects

This product is not classified as a carcinogen by OSHA, IARC or NTP. This product has not been shown to produce genetic changes when tested on bacterial or animal cells. This product does not contain known reproductive or developmental toxins. Prolonged or repeated exposure can cause drying or dermatitis of skin. Improper storage and handling may lead to the formation of a possible skin sensitizer.

Section 12: ECOLOGICAL INFORMATION

Ecotoxicity: There is no information available at this time for this product. However, a spill may produce significant toxicity to aquatic organisms and ecosystems. Some studies have shown that certain bacteria and fungi have the ability to degrade terpenes, decreasing their toxicity to fish. When spilled, this product may act as an oil, causing a film, sheen, emulsion or sludge at or beneath the surface of a body of water.

Persistence/Degradability: Product is expected to be readily biodegradable.

Bioaccumulation/Accumulation: No appreciable bioconcentration is expected in the environment.

Mobility in Environment: Product volatilize rapidly.

Section 13: DISPOSAL CONSIDERATIONS

Disposal: Incinerate or dispose of in accordance with Local, State, and Federal Regulations. Taking regulations into consideration, waste may be incinerated or handled through EPA Spill Control Plan via landfill or dilution. Empty containers must be triple-rinsed prior to disposal.

Section 14: TRANSPORT INFORMATION

US DOT Shipping Classification

Hazard Class: 3

Identification No.: UN2319

Packing Group: III

Label/Placard: exception §173.150(f) applies.

TDG Status: Hazardous

IMO Status: Hazardous

IATA Status: Hazardous

The listed transportation classification does not address regulatory variations due to changes in package size, mode of shipment or other regulatory descriptions.

Section 15: REGULATORY INFORMATION

Global Inventories

The components of this product are included in the following inventories:

USA (TSCA)

Canada (DSL)

Australia (AICS)

Korea (KECL)

Philippines (PICCS)

Proposition 65: California Safe Drinking Water and Toxic Enforcement Act of 1986

This product is not known to contain any chemicals currently listed as carcinogens or reproductive toxins under California Proposition 65 at levels which would be subject to the proposition.

Material Safety Data Sheet

VeruSOL

Section 16: OTHER INFORMATION

NFPA 704: National Fire Protection Association

Health – 1 (slight hazard)

Fire – 2 (moderate hazard)

Reactivity – 0 (minimal hazard)

Legend

OSHA – United States Occupational Health and Safety Administration

IARC – International Agency for Research on Cancer

NTP – National Toxicology Program

NIOSH – National Institute for Occupational Safety and Health

EPA – United States Environmental Protection Agency

Caution: The user should conduct his/her own experiments and establish proper procedures and control before attempting use on critical parts.

The information contained herein is based on current knowledge and experience: no responsibility is accepted that the information is sufficient or correct in all cases. Users should consider these data only as a supplement to other information obtained by the user. No warranty is expressed or implied regarding the accuracy of this data, the results to be obtained from the use thereof, or that any such use will not infringe any patent. Users should make independent determinations of suitability and completeness of information from all sources to assure proper use and disposal of these materials, the safety and health of employees and customers, and the protection of the environment. This information is furnished upon the condition the person receiving it shall determine the suitability for the particular purpose. This MSDS is to be used as a guideline for safe work practices and emergency response.