POTENTIAL TRANSPORT OF URANIUM FROM SUBSURFACE SOILS IN CELL 1 TO THE POINT OF INTEREST

FORMER SYLVANIA ELECTRIC PRODUCTS INCORPORATED FACILITY

HICKSVILLE, NEW YORK

SITE NUMBER V 00089-1

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This Potential Transport of Uranium from Subsurface Soils in Cell 1 to the Point of Interest Report has been reviewed by URS Corporation – New York, and I am in agreement with the conclusions.

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This Potential Transport of Uranium from Subsurface Soils in Cell 1 to the Point of Interest Report has been reviewed by Professional Radiation Consulting, Inc. (PRCI), and I am in agreement with the conclusions.

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This Potential Transport of Uranium from Subsurface Soils in Cell 1 to the Point of Interest Report has been reviewed by Envirocon, Inc. and I am in agreement with the conclusions.

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EXECUTIVE SUMMARY

Under the New York State Department of Environmental Conservation (NYSDEC) Voluntary Cleanup Program, GTE Operations Support Incorporated (GTEOSI) conducted soil investigations and completed Phase 1 of a soil remediation program at the Former Sylvania Electric Products Incorporated (Sylvania) Facility, Hicksville, New York Site (the Site). During these remediation activities, soils above the cleanup level of 100 picoCuries per gram (pCi/g) of total uranium were excavated and replaced with clean fill. In certain portions (cells) of the Site, residual soils remain in limited areas at depths below the engineered excavation limits, but above the water table, with low levels of uranium (i.e., total uranium). Although these levels are generally below the soil cleanup levels, GTEOSI asked URS and Envirocon to conduct a preliminary study to evaluate whether these residual levels would, if mobilized by percolating rainwater, exceed the U.S. Environmental Protection Agency (USEPA) maximum contaminant level (MCL) for total uranium in drinking water after eventual transport to a Site boundary. This Report discusses the methodology and results of this study related to the levels of uranium in residual soils in Cell 1.

After a review of several numerical and analytical models (Appendix C), the MULTIMED model (USEPA, 1996a) was selected to simulate the ground water transport of uranium. This model has the capability to account for dispersion in three dimensions, retardation, source depletion, and dilution due to recharge by infiltration along the path of ground water transport. It assumes that a dominant direction of ground water transport can be identified along with the dimensions of the contaminated area and the concentration of uranium in infiltrating rainwater desorbed from contaminated soils entering the water table. A separate desorption model, which is based on linear equilibrium conditions between concentrations in the liquid and solid phases, was used to estimate the concentration entering the water table.

Detailed soil analytical data for the Site were collected and are available for the uranium isotope, U-238. Therefore, uranium-238 (U-238) is used as an indicator for the transport of uranium. The U-238 concentration in soils used as input for the desorption model was selected from the set of subcells with the highest weighted average concentration in Cell 1, specifically the series V subcells with an estimated weighted average concentration of 17.88 pCi/g (see Figure 1). This estimated weighted average concentration is substantially higher than the estimated weighted average U-238 concentrations in the adjacent subcells (subcell series U and W).

Simulations for U-238 transport using the MULTIMED model were conducted using reasonably conservative assumptions and model input parameters supported by available Site-specific data and commonly accepted literature values. Site-specific values were used for partition coefficient (K_d), hydraulic conductivity (K), porosity (φ), and bulk density (ρ_b). The partition coefficient values were obtained from laboratory analysis of soil samples collected at varying depths from several locations around the Site. The values of the other three parameters (K, φ, and ρ_b) were obtained from laboratory analysis of several samples taken from a bore hole drilled in the vicinity of Cell 1. Other parameters derived from Site-specific information include source dimensions, U-238 concentration in residual soils, direction of dominant ground water flow, and hydraulic gradient. The parameters that are based on literature values include infiltration, dispersivities, and effective aquifer thickness.

A baseline scenario was simulated using a vertical plane rectangular patch source configuration and assuming that the area occupied by series V subcells in Cell 1 remains unpaved or undeveloped. This baseline scenario indicated a maximum U-238 concentration of approximately 7.25 picoCuries per liter (pCi/L) of U-238 in ground water at the southern Site boundary. This predicted concentration of 7.25 pCi/L is below the lower limit of the range of MCL for U-238 (i.e., 10 to 22.5 pCi/L).

Because it is likely that the area occupied by Series V subcells in Cell 1 may be developed in future and paved or covered with buildings, an additional simulation was performed to examine the effect of this condition. In this simulation, infiltration through the residual soils containing uranium is significantly reduced. The result of this simulation indicates much smaller concentration of U-238 at the southern Site boundary (see Appendix E).

Because there is considerable variation in measured U-238 concentrations in the data collected and the concentrations at different locations and depths include different and indeterminate degrees of dilution due to mixing with ambient ground water flow, reliable data for the calibration or "benchmarking" of a uranium transport model are not available. However, predicted U-238 concentration for the aforementioned baseline scenario is similar to the observed concentrations in downgradient monitoring wells and profiles. This suggests that the adopted model parameters are reasonable.

The results of this study indicate that future concentrations of U-238 or total uranium in ground water at the southern Site boundary associated with the uranium concentrations in residual soils in Cell 1 are below MCLs for drinking water.

1.0 INTRODUCTION

1.1 BACKGROUND

This report documents the method and results of ground water transport modeling at the Site. While the former Site is currently subdivided into three lots known as 140, 100 and 70 Cantiague Rock Road, it was a single site when operated by Sylvania in the 1950s and 1960s. Beginning in 1952, Sylvania used the Site to fulfill contracts with the U.S. Atomic Energy Commission (AEC) and the AEC's prime contractors for the production of nuclear fuel elements and components comprised of thorium, natural and enriched uranium, and aluminum alloys. Residual soil contamination created by operations conducted in support of these contracts includes uranium (U-238, U-235, and U-234).

Previous concurrence between NYSDEC and GTEOSI under Voluntary Cleanup Agreement (VCA), Site V-00089-1, Index W1-0903-01-12, established a cleanup level of 100 pCi/g of total uranium for soils at the Site. In this report, the words total uranium and uranium are used interchangeably and refer to all uranium isotopes. The above cleanup level was selected because it provides appropriate safety from the radiological and toxicological hazards of uranium for future users of the property if the remediated Site were released without restriction. To comply with the Agreement, most of the soils with uranium concentrations above the cleanup level were excavated and replaced with clean fill. However, residual soils remain with small amounts of uranium (i.e. generally below cleanup levels) in limited areas at depths below the engineered excavation limits in Cell 1.

Rather than performing a chemical analysis for total uranium during remediation, the State authorized analysis for specific isotopes at the Site. This approved methodology was adopted because of the ease and sensitivity of the radiometric method and because it provided the ability to analyze for enriched uranium. Since information on uranium contamination in residual soils is available in terms of U-238 concentrations, the U-238 isotope is used as an indicator of the transport of uranium in this study (see Appendix A).

The percentage distribution of the isotopes of uranium in Cell 1, on an activity basis, is as follows: U-238 $\approx$ 49%; U-234 $\approx$ 49%; and U-235 (and other isotopes) $\approx$ 2%. Therefore, the concentration of total uranium in soils in Cell 1 is assumed to be two times the measured concentration for U-238 and the results of the transport analysis (for U-238) conducted in this preliminary study were adjusted by a factor of two to reflect the approximate concentration of total uranium.

For Site management and excavation control, the area of interest was divided into cells, and soil removal and replacement were conducted on a cell-by-cell basis. To further facilitate remediation and monitoring of contamination in residual soils, each cell was divided into series of smaller subcells. Cell 1 is divided into three series of subcells, U, V and W. The subcells within Cell 1 include U04 to U07 in series U, V04 to V07 in series V, and W04 to W07 in series W. Residual soils in series V subcells in Cell 1 were found to contain relatively higher concentrations of U-238 compared to subcells in series U and W (Figure 1).

Identified concentrations of U-238 in residual soils, below the engineered excavation limits to a depth of approximately 64 feet (ft) below ground surface (bgs) vary from 3.5 pCi/g in subcell

W07 to 40.31 pCi/g in subcell V06. The investigative soil borings were stopped approximately 5 to 10 ft above the water table to prevent the introduction of potentially impacted soils or water from the unsaturated soil zone into the ground water environment.

1.2 OBJECTIVE

The objective of this preliminary modeling study is to understand and quantify the risk, if any, due to ground water contamination associated with uranium in residual soils by way of potential migration to ground water and eventual transport to the intersection with a Site boundary (Figures 1 and 2). Potential risk of ground water contamination is evaluated by comparison of predicted ground water contamination at the point of interest with the maximum permissible contaminant level (MCL) of uranium for drinking water established by the USEPA.

1.3 GROUND WATER STANDARDS FOR URANIUM

The USEPA regulates uranium in drinking water under the Safe Drinking Water Act, with MCLs published in Title 40 Code of Federal Regulations (CFR), Part 141. Uranium is a naturally occurring radioactive element and a heavy metal, and the MCL reflects consideration of both the chemical and radiological toxicities. The USEPA MCL for total uranium was set at 30 microgram/liter (μg/L) with an effective date of December 8, 2003 (USEPA, 2000a and 2002). The NYSDEC has adopted this MCL for radioactivity as an appropriate goal for evaluating the impacts of the contaminant on ground water at cleanup sites in New York (6 NYCRR Part 703).

For comparison to the MCL, it is necessary to convert the radiometric or activity measurements (picoCuries or pCi) of specific isotopes to the mass units of the MCL (microgram or μg). In this analysis, the range of conversion factors, 0.67 to 1.5 pCi/μg, recommended by USEPA for total uranium was considered (USEPA, 2002a and 2002b). Applicable to a variable isotopic mix of natural uranium, this range resulted in an equivalent MCL range of 20 to 45 pCi/L for total uranium. Based on the proportions of uranium isotopes on an activity basis measured in the soils in Cell 1 (see Subsection 4.1.1), this range of MCL for total uranium (20 to 45 pCi/L) is expressed as 10 to 22.5 pCi/L for U-238 and 10 to 22.5 pCi/L for U-234 (MCL for U-235 being less than 0.5 pCi/L). Thus, the cleanup target of 30 μg/L of total uranium in drinking water is interpreted as a range of 10 to 22.5 pCi/L of U-238 in ground water in this analysis (see Appendix A).

Data collected from ground water close to the water table and at various depths below the water table at the Site indicated either non-detect or relatively low levels below the range of MCL of U-238 in most monitoring wells and profiles. Exceptions are an unfiltered sample from monitoring well MW-2 collected on March 15, 2003, and field-filtered samples (analyzed in April-June 2005) from two profiles, P-103 and P-107, drilled and sampled in April and May, 2005 (see Section 3).

1.4 REPORT ORGANIZATION

This report is organized in seven sections as described below:

Section 1 (Introduction) describes the Site background, objective of the study, and relevant ground water standard for uranium and U-238.

Section 2 (Model Selection) describes relevant physical processes and the models selected to simulate those processes.

Section 3 (Field Data for Ground Water Depth and U-238 Concentrations) summarizes observed data for depth to ground water, U-238 concentrations, and their relevance to model development.

Section 4 (Estimation of Relevant Model Parameters) includes the process and sources for estimating different model parameters.

Section 5 (Baseline Simulation Scenario) includes description of the baseline scenario and model results for the baseline scenario.

Section 6 (Conclusion) summarizes the results of the study.

Section 7 (References) includes a list of references used in the study.

Relevant details of models evaluated for the study along with a list of relevant references, back-up material for the justification of specific items of information used in the analysis, an additional model simulation assuming paved surface of subcells, and the logs of the boreholes from which soil samples were taken for laboratory analyses are included in the appendices.

2.0 MODEL SELECTION

The physical processes that govern the fate and transport of uranium at the Site and provide the basis for model selection are described in the following subsection.

2.1 PHYSICAL PROCESSES

The rainwater infiltrating through a column of soil with U-238 contamination would dissolve (desorb) a portion of the U-238 adsorbed to the soils and transport it through the unsaturated soil column (known as the vadose zone) down to the water table. At the Site, U-238 in residual soils has been detected at various depths below the engineered excavation limits encountered during the Phase I soil remediation program down to approximately five to ten ft above the water table. The concentrations of U-238 in these residual soils are known. Since soil in the area above the residual soil was removed and replaced with clean soil, detailed modeling of the processes related to transport into the vadose zone has little relevance.

In most field situations, the transport from the vadose zone to the water table would occur under partially saturated conditions. This transport is generally not a steady state process. But, for the sake of simplicity and conservatism, it is assumed in the model that sufficient soil moisture is available and the exchange of contamination from soils to water occurs under equilibrium conditions corresponding to the average concentration in soils in subcells in Cell 1. As such, the infiltrating water continuously receives a portion of the U-238 from the soils. Due to the exchange of U-238 from soil to ground water, the soil concentration would be reduced from year to year. Thus, the vadose soil zone is a continuous source with gradually diminishing concentrations of U-238 available for transport into the saturated zone. In this analysis, however, it is assumed that the source concentration remains constant and does not deplete with time.

The transport of U-238 in the saturated zone is controlled primarily by the amount of contaminant present in the soils at the source; the rate of release from the source; and hydrologic factors such as dispersion (Subsection 4.4), advection (i.e., ground water flow velocity), dilution, and adsorption/desorption (Subsection 4.1.1). A brief description of the relevance of such processes to the present study is included in the following paragraphs.

Chemical Speciation

Chemical speciation is not relevant to this study because transport of U-238 (an isotope of uranium) is used as an indicator of the concentrations of total uranium.

Diffusion

In ground water transport modeling, the contribution of diffusion is usually accounted for by adding the molecular diffusion coefficient for the contaminant of concern to the dispersion coefficients. However, the molecular diffusion coefficient for total uranium may be several orders of magnitude smaller than the dispersion coefficients (see Appendix B). Therefore, the contribution of diffusion is not considered significant and is not incorporated in this study. So far as the dispersion of contaminants is concerned, this is a conservative assumption.

Relevant Processes

In view of the above, relevant processes governing the fate and transport of U-238 from the soils to the ground water environment at the Site include the following (see Figures 1 and 2):

- Transfer of U-238 contamination from soils to water due to desorption with infiltrating rainwater;
- Dilution of U-238 concentrations reaching the water table with ambient ground water flow beneath the cell; and
- Transport of the dissolved concentrations in ground water beneath the cell to the point of interest through the saturated soil zone with dispersion, retardation, radioactive decay, dilution due to ground water recharge, and dilution with ambient ground water flow.

The criteria for model selection and brief descriptions of ground water transport models evaluated to simulate the above processes are described in Appendix C. The specific models adopted for the study are described in Subsection 2.2.

2.2 SELECTED MODELS

The selected models include the main ground water transport model and a suite of supplementary models to estimate some of the input parameters for the transport model.

The descriptions of ground water transport models included in Appendix C suggest that the effort required and accuracy of prediction provided by a sophisticated finite-difference or finite-element model or suite of models may not be commensurate or possible with available Site-specific information and the objective of this analysis. Instead, a less complex and reasonably conservative approach is appropriate.

The comparative evaluation of different modeling approaches included in Appendix C indicates that the MULTIMED model (USEPA, 1996a) captures the essential processes associated with the transport of U-238 or total uranium and is expected to predict reasonably conservative concentrations at a specified downgradient location. Therefore, this model is selected for a preliminary and conservative analysis of the fate and transport of U-238.

The MULTIMED model (like most other models) requires supplementary models to estimate the source concentration for ground water transport and retardation factor. Brief descriptions of the MULTIMED model and supplementary models used to estimate initial concentration at the ground water source and retardation factor are included in Subsection 2.3.

2.3 DESCRIPTION OF SELECTED MODELS

Brief descriptions of the models selected for this analysis are included in the following subsections.

2.3.1 Transport Model

As indicated in Subsection 2.2, the transport model selected for this study is the MULTIMED model (USEPA, 1996a). The capabilities of the MULTIMED model are described in

Appendix D. In particular, this model can simulate dilution due to recharge by infiltration along the path of ground water transport. This simulation option assumes that the recharge and resulting dilution are uniformly distributed throughout the effective thickness of the aquifer.

In the case of the Site, the area with potentially contaminated soils was divided into several cells. Each cell was divided into several series of subcells and soil concentrations were measured at different spatial locations in each subcell. In this analysis, the series of subcells with maximum soil concentrations of U-238 is used to estimate the concentration in the infiltrating water entering the water table. U-238 concentration in the soil in each subcell is assumed to be uniformly distributed within the width of the subcell nearly perpendicular to the direction of dominant ground water flow. Contaminant concentrations in the soils in the vadose zone at the source are discussed in Subsection 4.6.

Due to desorption by infiltrating water, a portion of the contamination in residual soils in the vadose zone reaches the water table. After its entry into the saturated zone, this dissolved contamination mixes and moves with ambient ground water along the bottom of the contributing subcells. During this transport, it undergoes some dilution due to mixing with ambient ground water and reaches the vertical cross section of the aquifer at the downgradient edge of the contributing subcells. The soils in the area downgradient of the above-mentioned contributing subcells are relatively clean in the model and at the Site. Thus, infiltrating rainwater entering the water table through the vadose zone downgradient of the edge of the contributing subcells is relatively clean and is referred to as recharge (see Figure 2).

Within the abovementioned vertical cross section at the downgradient edge of the contributing subcells, the diluted contamination is distributed down to a depth, designated as the mixing zone depth. This vertical cross section in the saturated zone with its width equal to the width of the subcells and its depth equal to the mixing zone depth constitutes a vertical plane (designated as rectangular patch) source for ground water transport in the model domain.

The rectangular patch source is a vertical plane of finite width and depth located in the saturated zone at the downgradient edge of the relevant series of subcells in Cell 1 (see Figure 2). The concentration in ground water at every point along the vertical plane at the source is the same and does not undergo reduction with time. The effect of source depletion should be progressive reduction in the concentrations at the point of interest with time. Since modeling with the rectangular patch source does not provide for source reduction, the predicted concentration is overly conservative, remaining at a constant level and extending impacts unrealistically into the future.

2.3.2 Desorption Model

The desorption model is used to estimate the concentration of infiltrating water entering the water table beneath the series of subcells with residual contamination in soils in the vadose zone. It is based on the following linear equilibrium model (USEPA, 1988; ANL, 2001):

Eq. (1) $$C = S / K_{du}$$

where, C = equilibrium concentration in water (pCi/ml);
S = mass (or activity in pCi/g) adsorbed per unit mass of soil; and

K_{du} = partition/distribution coefficient (for the unsaturated zone) in milliliters per gram (ml/g).

This model assumes that the mass (or activity) adsorbed per unit mass of the soils (pCi/g) is in equilibrium with the liquid phase concentration (pCi/ml), and the relationship between concentrations in the solid (pCi/g) and liquid (pCi/ml) phases is linear. The parameter K_{du} is assumed to lump the effects of most partitioning processes (e.g., soil texture, soil grain size, soil classification, pH of ground water, and organic carbon content of the soil) into one value. The parameter K_d or K_{du} is discussed in more detail in Subsection 4.1.1.

Using the linear equilibrium model (Eq. 1), the following expression is developed to estimate the concentration in infiltrating water corresponding to the average concentration in the soil column in contributing subcells above the water table (IPCB, 2004):

Eq. (2) $$C_i = (C_s \rho_b) / (\varphi_w + \rho_b K_{du})$$

where, C_i = concentration in infiltrating water in the vadose zone (pCi/ml) entering the water table beneath the subcells;
C_s = average concentration in soils in the contributing subcells (pCi/g);
ρ_b = bulk density of soils in grams per cubic centimeter (g/cc); and
φ_w = water-filled porosity in the unsaturated soil zone (unitless).

Eq. 2 is designated as the desorption model. The concentration in infiltrating water, C_i, is used as input to the MULTIMED model. In this model, the ground water source for downgradient transport is a vertical plane located within the saturated zone at the downgradient edge of the subcells with U-238 in residual soils. With the concentration in infiltrating water reaching the water table as input, the MULTIMED model computes the concentration, C_0, at the ground water source after initial mixing of ambient ground water beneath the subcells with residual contamination in soils.

2.3.3 Retardation Factor

One of the effects of the partition/distribution coefficient on contaminants is to retard the rate (velocity) of transport in ground water. The retardation factor, R (unitless), used as input in the transport model, is computed as follows (USEPA, 1996a):

Eq. (3) $$R = 1 + (\rho_b K_d / \varphi)$$

where ρ_b = bulk density of soils in grams per cubic centimeter (g/cc);
φ = effective porosity in the saturated zone (unitless); and
K_d = partition/distribution coefficient for the saturated zone (ml/g).

Any other consistent set of units may also be used for the variables in Eq. 1-3.

3.0 FIELD DATA FOR GROUND WATER DEPTH AND U-238 CONCENTRATIONS

3.1 DEPTH TO GROUND WATER

Ground surface elevations from Cell 1 to the point of interest on the southern Site boundary vary from approximately 145.28 ft to 142.96 ft. In the vicinity of the Site, the water table was observed between 72 and 74 ft bgs.

3.2 CONCENTRATIONS OF U-238

Field data for U-238 concentrations are available for 112 ground water samples from 12 monitoring wells and 45 ground water profiles. Most of the measured values of U-238 concentrations in ground water were either non-detect or below the MCL. The data from those samples collected in 2002 and 2003 that exceeded 1.0 pCi/L are abstracted in Table 3-1. In addition, data based on analysis of field-filtered samples from three recent profiles are also included (e-mail communications with MPI, June-July, 2005) (see Figure 3). The term 'field-filtered sample' included in footnotes b and c to Table 3-1 indicates that the particulate matter in the ground water sample was filtered out before analyzing the filtrate for U-238 concentration.

Table 3-1. Observed U-238 Concentrations in Select Monitoring Wells and Profiles

Profile or Monitoring Well	Approx. Location (See Figure 3)	Depth (bgs) (ft)	Date of Sampling	U-238 Concentration (pCi/L)
P-2[a]	On the 140 Property, subcell W10, approximately 113 ft east of the 100 Building	98.8	October-December, 2002	1.27 (+ or – 0.44)
P-6[a]	On the 100 Property, subcell P23, approximately 90 ft south of the southeast corner of the 100 Building	82.8	October-December, 2002	2.43 (+ or – 0.78)
P-28[b]	On the Golf Course Driving Range, subcell 22A, approximately 63 ft east of the 100 Property	87.02	May 3, 2003	1.03 (+ or – 0.38)
P-35[a]	On the 70 Property, subcell W73, approximately 85 ft north of the 70 Building	87.2	July 9, 2003	1.43 (+ or – 0.48)
MW-01[a]	On the 70 Property, border of subcells F22 and F23, approximately 58 ft north of the 70 Building	58-78 (screened interval)	March 15, 2003	2.22 (+ or – 0.72)
MW-02[a]	On the 70 Property, subcell I22, approximately 56 ft north of the 70 Building	59-79 (screened interval)	March 15, 2003	38.3 (+ or – 8.1)
MW-12[a]	On the 70 Property, subcell R32, approximately 13 ft northwest of southeast corner of the 70 Property	120-130 (screened interval)	March 15, 2003	1.76 (+ or – 0.60)
P-103[c]	On the 100 Property, subcell G21, approximately 50 ft south of the 100 Building	74	April 19, 2005	26.5 (+ or – 2.9)
		84.5	April 19, 2005	3.34 (+ or – 0.62)
P-107[c]	Located on the 140 Property, appears to straddle subcells R08 and U08, approximately 73 ft east of the 140 Building	74.30	May 16, 2005	96 (+ or – 11)
		84.30	May 16, 2005	56.3 (+ or – 5.8)
		94.30	May 17, 2005	6.1 (+ or – 1.6)
		104.30	May 17, 2005	11.6 (+ or – 2.2)
P-108[c]	Located on the 100 Property, subcell W18, 100 ft east of the 100 Building and downgradient of Cells 1, 2, 6, and 3	84.15	May 02, 2005	0.75 (+ or – 0.28)

[a] Based on analysis of an unfiltered sample.
[b] Based on analysis of a field-filtered sample.
[c] Based on analysis of a field-filtered sample as per MPI (e-mail communications, June-July, 2005).

As noted in Table 3-1, the maximum concentrations of U-238 detected were between 10 to 20 ft below the water table. All concentrations measured below 100 ft bgs (30 ft or more below the water table) are below or close to the lower limit of the MCL for U-238 (10 to 22.5 pCi/L).

The data collected and listed in Table 3-1 indicate that there is significant variation in measured concentrations in different monitoring wells and profiles, and it is difficult to identify specific concentrations which may be used for model calibration. Additional limitations associated with this data include the following:

- The uranium found in soils existed in thin zones and not large source areas. The locations and dimensions (i.e., length, width, depth) of the uranium-impacted soils and the specific concentrations of uranium therein, which may be the source of ground water concentrations shown in Table 3-1, are not known.

- It is difficult to estimate the durations of the transport of uranium through the unsaturated and saturated soil zones from the source or sources to the respective profile or monitoring well indicated in Table 3-1.

- The concentrations in ground water at the respective sources and the corresponding mixing zone and effective aquifer depths applicable to the concentrations shown in Table 3-1 are difficult to identify.

- The orientations of the ground water flow paths to various profiles and monitoring wells and other transport parameters applicable to the transport process are also not known. This is further complicated by the fact that various sources of ground water recharge and extraction operated in the Site vicinity and historically have changed over time. These changes have locally impacted ground water flow rates and directions and resulted in the concentrations shown in Table 3-1.

Because of the above-mentioned limitations, the data included in Table 3-1 are not used for model calibration, per se. Instead, they are used for a qualitative assessment of the model parameters and model results presented in this study.

4.0 ESTIMATION OF RELEVANT MODEL PARAMETERS

The adopted model input parameters include Site-specific parameters based on field measurements, laboratory analysis of soil samples from boreholes in the vicinity, and information available in the literature.

4.1 SITE-SPECIFIC SOIL CHARACTERISTICS

Soil samples from various locations and depths have been analyzed to estimate specific values of relevant parameters. The results of the analysis for soils in the vicinity of the Site are summarized in the following subsections.

4.1.1 Solid/Liquid Phase Partition or Distribution Coefficient

Definition

The partition or distribution coefficient (K_{du} for unsaturated or vadose zone and K_d for saturated zone) is a soil parameter which is used to assess the degree to which a chemical species will be distributed in the solid and liquid phases. It provides an indication of how rapidly an ion can move relative to the rate of ground water movement under the geochemical conditions tested (ASTM, 1990). In simpler terms, K_d is defined as the concentration of a species of interest in the solid phase divided by the concentration of that species in the liquid phase, at steady-state (Brookhaven National Laboratory, 1999). In this analysis, the parameter K_{du} or K_d quantifies certain sorption (adsorption/desorption) processes relevant to the transport of uranium from the soils at the Site to the point of interest.

The soils in the unsaturated zone at the Site generally consist of poorly graded or gravelly sands with little or no fines which have a group symbol of SP according to the Unified Soil Classification System (USCS) (see Appendix F). Soils in the saturated zone at the Site generally consist of poorly graded or gravelly sands with little or no fines (USCS group symbol SP) with mixtures of silty sands (USCS group symbol SM). The average reported value of K_{du} or K_d for uranium for sandy soils is 35 ml/g, and generally higher average values are reported for finer materials (USEPA, 1999).

Site-specific Sampling

Usually, K_{du} or K_d values used for ground water transport modeling are obtained from literature or laboratory analysis of soil samples from a studied area. The K_{du} or K_d values for total uranium (or U-238) used for this analysis were obtained from laboratory analysis of soil samples collected from several locations, at various depths around the Site using the ASTM batch equilibrium method, ASTM D4319-83 as interpreted by Severn Trent Laboratories in their Standard Operating Procedure *K_d Leaching Procedure,* revision April 19, 2004 (see locations KD1, KD2, and KD4, Figure 3).

The K_{du} or K_d values measured in laboratory analysis pertain to total uranium. However, detailed field information regarding uranium found in residual soils relates to U-238. As such, the U-238 transport analysis assumes that the values of K_{du} or K_d estimated for total uranium are applicable to U-238 as well (see Appendix A).

Results of Laboratory Analysis

Generally, the same values of K_{du} and K_d are assumed to be applicable to both unsaturated and saturated soils. Laboratory analysis for K_{du} and K_d for soil samples from different depths at and adjacent to the Site indicated that there is appreciable variation with depth. In particular, the values for the saturated zone were lower than the values for the vadose zone.

In Cell 1, contaminated soils have been excavated and replaced with clean fill down to an average depth of approximately 21 ft bgs. Laboratory analysis of six samples from various locations in the unsaturated zone from depths ranging from 30 to 42 ft bgs indicate an average Site-specific value of 5.45 ml/g for K_{du} for uranium. The range of K_{du} values for these six values from the unsaturated zone was 2.98 to 7.72 ml/g.

Laboratory analysis of seven soil samples from various locations in the saturated zone in the Site vicinity from a depth range of 70 to 110 ft bgs indicated an average value of 0.89 ml/g for K_d. The range of K_d values for these seven values from the saturated zone was 0.52 to 1.01 ml/g.

Computations for the baseline case for Cell 1 were made using the average values of $K_{du} = 5.45$ and $K_d = 0.89$ ml/g for the unsaturated and saturated zones, respectively.

Implication of Site-specific K_{du} or K_d Values

A review of Site-specific K_{du} and K_d values indicates that they are generally lower than the average values reported in the literature for similar soils (i.e., sands) (USEPA, 1999).

The low (compared to literature values) Site-specific K_{du} or K_d values for uranium result in the following notable consequences so far as the transport of uranium is concerned:

- A higher equilibrium concentration of the contaminant in pore water in the subcells (see Eq. 1, Subsection 2.3.2);
- A higher concentration in infiltrating rainwater entering the water table (see Eq. 2, Subsection 2.3.2); and
- Lower retardation of the contaminant of interest (i.e., faster rate of movement of dissolved uranium with ground water) (see Eq. 3, Subsection 2.3.3).

4.1.2 Organic Content

Since Site-specific K_d or K_{du} values have been determined, organic carbon content is not required to estimate K_d or K_{du} values for this analysis

4.1.3 Hydraulic Conductivity

Laboratory analysis of three soil samples from depths of 25 to 64 ft bgs collected from Boring KD4 (Figure 3) indicated a Site-specific geometric mean hydraulic conductivity of 1.64×10^{-2} cm/sec (i.e., 46.50 ft/day or 5171.9 m/yr). This value is used for the baseline scenario. The three test results varied from 1.15×10^{-2} to 2.22×10^{-2} cm/sec (32.6 to 62.93 ft/day or 3626.6 to 7001 m/yr). Reported values of the hydraulic conductivity of the Magothy Formation range from 27 ft/day to 150 ft/day (see Subsection 4.5). The average value of 5171.9 m/yr (46.50 ft/day) is used for the baseline scenario simulated in this study.

4.1.4 Porosity

The three soil samples from Boring KD4 (depths of 25 to 64 ft bgs) were analyzed in the laboratory for dry unit weight and specific gravity. The porosity of the soils is estimated using the measured values of dry unit weight and specific gravity. The estimated values of porosity for the three samples vary from 0.386 to 0.413 with an average value of 0.39 for soils in the vicinity of Cell 1. For unconsolidated sediments coarser than silt size, effective porosity can be less than total porosity by approximately 2% to 5%. Typical values of effective porosity for fine to coarse sands reported in the literature vary from 0.10 to 0.35 (USEPA, 2000). The reported mean values of specific yield (which is generally equal to the effective porosity) for fine to coarse sands are between 0.30 and 0.33 (USEPA, 1985).

In view of the above, the effective soil porosity under saturated conditions (φ) is taken to be 0.30.

Default soil porosity under unsaturated soil conditions may vary from 0.15 at the ground surface to 0.30 for subsurface conditions and from 0.18 for sand to 0.20 for gravel (IPCB, 2005). Use of an empirical equation included in Tiered Approach to Corrective Action Objectives (TACO) (IPCB, 2004) suggests values in the range of approximately 0.16 to 0.19.

In view of the above, a value of 0.18 is adopted for porosity under unsaturated soil conditions (φ_w). Minor variations in the adopted value of porosity under unsaturated conditions (e.g., in the approximate range from 0.17 to 0.20) are not expected to have significant effect on the results of this analysis.

4.1.5 Bulk Density

Based on the results of the aforementioned laboratory tests of the three soil samples for dry unit weight, the bulk density of soils in the vicinity of Cell 1 is estimated to vary from 1.55 to 1.63 grams per cubic centimeter (g/cc) with an average of 1.60 g/cc. The average value of 1.60 g/cc is used in this analysis.

4.2 RADIOACTIVE DECAY

In most environmental transport models, the term decay is defined by the first-order decay coefficient which is a function of the half life of the constituent. U-238 has a relatively long half life of 4.47E+09 years resulting in little decrease in U-238 concentrations due to natural decay during the time period of interest in this study (www.ornl.gov/sci/isotopes). The other natural isotopes of uranium also have relatively long half lives (i.e., half life of U-234 = 2.46E+05 years and half life of U-235 = 7.04E+08 years). The longer half life (i.e., half life of U-238) with the corresponding lower decay coefficient of 0.155E-09 year^{-1}, is used in this study to analyze the transport of U-238.

4.3 HYDRAULIC GRADIENT

The selected ground water transport model simulates the propagation of concentration along a specified direction of ground water flow, i.e., along a vertical profile of the aquifer, with distinct localized hydraulic gradient. By definition, this localized hydraulic gradient (unitless) for ground water in unconfined situations is the slope of the water table between two points of interest or between points closest to the two points of interest on the above-mentioned vertical profile.

The dominant on-Site ground water flow direction and localized hydraulic gradient were identified from available field data. While the general regional ground water flow direction in the vicinity of the Site is towards the south, discrete areas within the Site have localized variation. This localized variation is important for ground water transport modeling within the relatively short transport distance considered in this study (see Figure 1).

For Cell 1, the source in ground water is assumed to be located at the downgradient edge of subcell V07 (see Subsection 4.6). Thus, the localized hydraulic gradient applicable to the transport of dissolved uranium from subcells in series V in Cell 1 to the point of interest is estimated by the difference in ground water levels in the monitoring wells closest to the downgradient edge of subcell series V of Cell 1 and the point of interest.

To estimate the localized hydraulic gradient, ground water elevations were used from three on-Site monitoring wells for two monitoring events. The localized hydraulic gradient was taken to be the average of values computed from ground water elevations measured during the December 2002 (URS Corporation, unpublished data) and March 2003 sampling events for monitoring wells MW-07, MW-11, and MW-09. Monitoring well MW-07 is located downgradient of Cell 1 and Cell 6 and MW-09 and MW-11 are located further downgradient near the southern Site boundary (see Figure 3). These three monitoring wells were selected because they define the plane representing the water table in the area between Cell 1 and the southern Site boundary.

Three different approaches were used to estimate the average hydraulic gradient using observed ground water elevations for the aforementioned monitoring wells, MW-07, MW-09, and MW-11 (see Appendix G).The estimated average hydraulic gradients using the three approaches are 0.00049, 0.00054, and 0.00056, respectively. To be conservative, the highest value of 0.00056 is used in this study.

The length of the transport distance from the downgradient edge of subcell V07 to its intersection with the southern Site boundary is estimated to be 574 ft (175 m).

4.4 DISPERSIVITY

The spreading of a contaminant dissolved in ground water beyond the region it is expected to occupy due to average flow alone is called dispersion. It is quantified by a factor called the dispersion coefficient. The dispersion coefficient is a function of a soil property known as dispersivity and the velocity of ground water through soil pores.

There is large variation in values of dispersivities reported in the literature (e.g., Maidment, 2003; USEPA, 1985). Based on commonly used practice, the longitudinal (α_x), transverse (α_y), and vertical (α_z) dispersivities for this analysis are estimated using the following equations

(USEPA, 1996a; IPCB, 2004; ASTM , 1995), i.e.,

Eq. (9) $(\alpha_x) = 0.1\ x$

Eq. (10) $(\alpha_y) = (\alpha_x)/3$ and

Eq. (11) $(\alpha_z) = 0.056\ (\alpha_x)$,

where x = the length of the ground water flow path (m).

These equations are based on a review of a range of values reported in the literature, are generally accepted for screening level (which are normally considered to be conservative and preliminary) analyses, and are included in several commonly used industry guides (e.g., IPCB, 2004; ASTM, 1995). In addition, they are included as 'other commonly used relationships' in several other models (e.g., USEPA, 1996b; USEPA, 2000b).

4.5 EFFECTIVE AVERAGE AQUIFER THICKNESS

Three major aquifers exist beneath the Site (i.e., Upper Glacial at the top underlain in order by the Magothy, and Lloyd Aquifers). These aquifers are interconnected to various degrees and the combined depth is fairly large (i.e., more than 600 ft) (Isbister, 1966). Recent Site-specific ground water investigations indicate that the Upper Glacial deposits in the vicinity extend to approximately 75 ft bgs. The water table was observed between 71 to 74 ft bgs, which is near the contact between the Upper Glacial and Magothy Aquifer. Thus, the saturated thickness of interest for this study is primarily within the Magothy Aquifer. The Magothy Aquifer was encountered during recent area investigations from approximately 75 ft bgs to as deep as 532 ft bgs (noted by Malcolm Pirnie during the ground water investigation in 2004-2005).

During ground water investigations, silt and clay lenses were encountered beneath and downgradient of the Site. This may limit the effective aquifer thickness available for contaminant transport. Also, the vertical dispersivity of the medium is relatively low (see Sub Section 4.4 and Table 5-1). These factors are expected to limit the depth of the zone of effective U-238 transport and effective thickness of the aquifer relevant to the transport of U-238 with ground water.

A review of the data for profiles downgradient or south and southwest of Cell 1 (i.e., P-103 and P-108) included in Table 3-1 indicates relatively low concentrations of U-238 at a depth of 84.5 ft bgs (or approximately 10 ft below the water table). In addition, there is significant reduction in U-238 concentrations with depth in Profile P-107 which is also located downgradient of Cell 1. This suggests that a relatively small portion of the total aquifer depth may be effective along the path of any appreciable transport of U-238 from Cell 1.

In view of the above, a relatively small effective aquifer thickness of 30 ft (i.e., extending to approximately 102 to 104 ft bgs) is used. The mixing zone depth corresponding to this effective aquifer thickness is internally calculated in the MULTIMED model using an analytical equation (IPCB, 2004; and USEPA, 1996a).

4.6 U-238 CONTAMINATION IN RESIDUAL SOILS AT SOURCE

The characteristics of the U-238 contamination at the source in soils in series V subcells in Cell 1 are described in the following subsections.

4.6.1 U-238 Concentration in Soils at Source

Measured concentrations of U-238 are available in the residual soils to a depth of approximately 64 ft bgs at various spatial locations in several borings in Cell 1. Because of different spatial locations of the borings, several values are available at each depth.

Cell 1 is divided into three series (rows) of subcells, U, V, and W (Figure 1). Each series of subcells constitutes a linear segment for U-238 or total uranium transport to the point of interest. The contamination originating from soils at different depths in a particular vertical column or subcell is likely to appear as mixed dissolved concentration at the bottom of the column near the water table. This mixed dissolved concentration from all such vertical columns or subcells would be transported downgradient with ambient ground water flow along the length of the series parallel to the direction of ground water flow. Ultimately, this mixed concentration from all columns or subcells in a series would appear at the downgradient edge of the contaminated subcells. The effect of mixing during ground water transport along the length of the subcells is internally computed in the MULTIMED model. Thus, the source concentration of dissolved U-238 or total uranium in ground water in the saturated zone appearing at the downgradient edge of a series of subcells would correspond to the average of depth-wise, width-wise, and length-wise soil concentrations in that series.

Cell 1 includes four subcells in each of series U, V, and W (see Figure 3). The weighted average soil concentration of U-238 in subcells in series V (i.e., subcells V04 to V07) in Cell 1 is higher than the weighted average of U-238 in subcells in series U (i.e., subcells U04 to U07) or subcells in series W (i.e., subcells W04 to W07) (see Figures 1 and 3 and Appendix H). To be conservative, the highest weighted average concentration in soils, located in subcells V04, V05, V06, and V07 in series V, is assumed to be the overall average concentration in soils at source in Cell 1.

The weighted average concentration of U-238 in subcells V04 to V07 in series V in Cell 1 is estimated from measured concentrations in soils at various depths within residual soils in areas occupied by these subcells. The computations are made using the EVS software (C Tech Development Corporation, 2005). The EVS software uses a three-dimensional interpolation algorithm to estimate concentrations at various points within the specified model domain based on relative proximity of each point from the surrounding points where measured values are available. The resulting grid or contours are used to estimate the volume or mass of soils and mass of contaminants represented by each point on the grid or between specified contours. This information is used to estimate the weighted average concentration in the specified model domain (e.g., an individual subcell).

Using the results of the EVS model for each subcell, the weighted average concentration of U-238 in the soil mass at the source (i.e., subcellsV04 to V07) is estimated. These computations are made using the following equation:

Eq. (12) $$X = [\sum w_i x_i] / [\sum w_i]$$

where X = weighted average concentration of U-238 (pCi/g) in subcells V04 to V07;
i = index identifying an individual subcell (e.g., V04, V05, etc.);

w_i = mass of soil (g) in subcell i;

x_i = weighted average concentration (pCi/g) within subcell i as estimated by the EVS software; and

$\sum$ indicates summation over all subcells from V04 to V07.

The information used to estimate the weighted average concentration of U-238 in the soils at the source is included in Table 4-1.

Table 4-1. Weighted Average Concentrations of U-238 in Soils at Source, Cell 1

Subcell	Average thickness of residual soils in subcell[a] (ft)	Mass of residual soils[a] (kg)	Weighted average U-238 concentration in subcell[a] (pCi/g)
V04	59.82	1176800	8.55
V05	55.58	1077200	23.43
V06	56.31	1101100	29.62
V07	56.35	1081100	10.54
Weighted average U-238 concentration in the four subcells (Eq. 12) = 17.88 pCi/g			

[a] EVS model output (see Appendix H)

The average of the thicknesses of residual soils with U-238 contamination at the source shown in Table 4-1 is approximately 57 ft and the estimated weighted average concentration of U-238 is 17.88 pCi/g. The corresponding source concentration of total uranium in soils at the source is taken to be twice the value for U-238 (i.e., a concentration of 35.76 pCi/g of total uranium in soils at the source).

The desorption model (Subsection 2.3.2, Eq. 2) is used to estimate the concentration of U-238 entering the water table beneath subcell series V corresponding to the afore-mentioned concentration (i.e., 17.88 pCi/g) in soils at the source (see Figure 2).

4.6.2 Length and Width of U-238-impacted Soils at Source

Cell 1 is nearly rectangular in plan (see Figure 3). The total length of subcells V04 to V07 in Cell 1 along the direction of ground water flow is 94 ft (28.6 m). This is the length along which desorbed U-238 enters the water table at the concentration, C_i, estimated by the desorption model (Eq. 2). The width of series V subcells (i.e., V04 to V07), nearly perpendicular to the direction of dominant ground water flow, is 20 ft (6.1 m). This is the width along which desorbed U-238 enters the water table.

Upon entry into the saturated zone, the desorbed U-238 undergoes mixing with ambient ground water as it moves along the length of the contaminated soils (subcells V04 to V07) at source. It is assumed that there is little lateral dispersion along this length. Therefore, the width of the contaminated water that reaches the downgradient edge of the contaminated soils at source remains the same as the width of the subcells. The initial dilution along this length of transport and the mixing depth, H, at the downgradient edge of this length are internally computed by the MULTIMED model. Due to mixing during this transport, the concentration changes from C_i to C_0. It is the above-mentioned width, mixing depth, and concentration in ground water, C_0, at the downgradient edge of the subcells that constitute the physical dimensions and ground water concentration for the vertical plane source in the saturated zone used for ground water transport simulation in the MULTIMED model (see Figure 2).

4.7 PRECIPITATION, RECHARGE, AND INFILTRATION

In the MULTIMED model, the term infiltration is used to define the portion of precipitation that percolates through the soil at the source and enters the water table. With greater infiltration, more contaminant is mobilized from the soil into the ground water. Recharge is defined as the portion of precipitation that percolates from the ground surface along the path of ground water transport and enters the water table as relatively fresh water (i.e., water that is not impacted by the contamination at the source). Greater recharge means more dilution of contaminant along the path of ground water transport. Infiltration or recharge is estimated as precipitation minus surface runoff and other losses applicable to the source area or domain of ground water transport. They are expressed as the volume of water percolating per unit time per unit area of surface (i.e., m^3/yr per square meter, or more commonly, m/yr, or cm/yr).

4.7.1 Precipitation

The average annual precipitation for the period 1951-1980 at Mineola, New York was approximately 1.11 m (Gale Research Company, 1985). Based on 10 years (1994 to 2003) of daily precipitation data for Mineola, New York (with 48 missing daily values) the average annual precipitation is estimated to be 43.7 inches (1.11 m) (nrcc@cornell.edu). Mineola is approximately 7 miles west of Hicksville. This suggests that an annual average precipitation of 1.11 m is reasonable for the Site area.

4.7.2 Recharge

On an average, approximately 25 percent or more of annual precipitation is expected to infiltrate into the ground (Avon and Durbin, 1994; Donovan and Katzer, 2000). The 25 percent value is reported for arid climates. The average annual recharge in the Site vicinity, which is sub-humid to humid, is expected to be larger than 25 percent (e.g., 33 percent to 45 percent) of the average annual precipitation.

Previous studies reported in the literature have used different rates of recharge/infiltration. A report describing the Nassau County Groundwater Model (CDM, 2003) states an overall recharge rate of 51.8 percent of precipitation for the model as a whole. A qualifier is added suggesting that this amount of recharge could be slightly higher than would be expected during a normal year. This suggests that an overall recharge rate in the model domain may be approximately 50 percent of precipitation or 0.56 m/yr for the region. However, in the tabulated values of recharge in the CDM (2003) report, a rate of 80 percent of precipitation is shown for Nassau County. This suggests a recharge rate of approximately 0.89 m/yr for the Site area.

A USGS modeling study for Kings and Queens Counties, Long Island, New York (USGS, 1999) indicates a recharge rate of approximately 23.1 inches/year or 0.59 m/yr for Nassau County.

The estimated, reported, and adopted rates of annual recharge for the Site are abstracted in Table

4-2.

Table 4-2. Estimated, Reported, and Adopted Rates of Annual Recharge

Source	Annual Recharge Rate (m/yr)
Estimated as fraction of annual precipitation (Avon and Durbin, 1994; Donovan and Katzer, 2000)	0.37 to 0.50
CDM (2003)	0.56-0.89
USGS (1999)	0.59
Adopted (along potential path of ground water transport)	0.59

The information presented in the previous paragraphs and abstracted in Table 4-2 suggests that an average recharge rate of 0.59 m/yr may be reasonably conservative for the path of ground water transport from the area occupied by Cell 1 to the point of interest.

Recharge immediately below paved areas or areas occupied by buildings may be significantly lower. However, Nassau County regulations require that a system of leach basins should provide for most of the storm water runoff from a site to discharge into the subsoil even if the area is paved. This results in a greater portion of precipitation entering the ground water regime and greater net recharge.

4.7.3 Infiltration

Infiltration from unpaved source areas is taken to be the same as the recharge described in Subsection 4.7.2 (i.e., 0.59 m/yr).

If the source area occupied by subcells V04 to V07 in Cell 1 were to be paved, then water infiltration through the underlying unsaturated soils and the resulting contamination entering the saturated zone would be significantly reduced. For an estimate of the infiltration rate for paved areas, the Soil Conservation Service (SCS) curve number method is used (USDA, 1986). It is assumed that the entire amount of annual rainfall that does not appear as surface runoff from paved areas is lost as infiltration. The SCS curve number (CN) for paved areas is reported to be 98 (USDA, 1986). Computations using the SCS curve number method, with CN = 98, suggest that the annual infiltration from paved areas corresponding to an annual rainfall of 1.11 m may approximate 0.006 m (USDA, 1986). The infiltration rate at the location of the subcells may be even smaller than this if buildings were to occupy the surface area.

The estimated rates of annual infiltration for the Site are abstracted in Table 4-3.

Table 4-3. Estimated Rates of Annual Infiltration

Surface Condition	Annual Infiltration Rate (m/yr)
Unpaved areas of subcells	0.59
Paved areas of subcells (USDA, 1986)	0.006

5.0 BASELINE SIMULATION SCENARIO

The baseline scenario is modeled using average values of the estimated model parameters and rectangular source configuration in the MULTIMED model. In statistical terms, use of the average model parameters is expected to provide the most plausible results.

The baseline scenario assumes that the area occupied by subcell series V of Cell 1 (i.e., subcells V04 to V07) remains unpaved with an infiltration rate of 0.59 m/yr through the U-238-impacted residual soils.

The path of ground water transport intersects the southern Site boundary approximately 175 m from the downgradient edge of subcell V07 in Cell 1. This intersection with the southern Site boundary is the point of interest for model predictions.

Potential transport of U-238 is simulated using the average values of measured Site-specific parameters. Thus, the input parameters of this case include K_{du} and K_d values of 5.45 and 0.89 ml/g, respectively, for the unsaturated and saturated soil zones; geometric mean value of hydraulic conductivity, i.e., 5171.9 m/yr (46.50 ft/day); average annual recharge rate of 0.59 m/yr along the path of ground water transport; and infiltration rate of 0.59 m/yr for the unpaved surface of subcells V04 to V07 in Cell 1.

Relevant input parameters for this baseline scenario are abstracted in Table 5-1.

Table 5-1. Input Model Parameters for Baseline Scenario

Effective soil porosity (saturated conditions) (φ)	0.30
Water-filled soil porosity (unsaturated conditions) (φ_w)	0.18
Soil bulk density (ρ_b)	1.60 g/cc
Average Hydraulic conductivity (K)	5171.9 m/yr (46.5 ft/day)
Average hydraulic gradient (i)	0.00056
Average recharge rate (along path of ground water transport) (q)	0.59 m/yr (23.2 in/yr) (see Table 4-2)
Average infiltration rate in area occupied by subcells V04 to V07 (I)	0.59 m/yr (23.2 in/yr) (see Table 4-3)
Effective aquifer thickness gradient (B)	9.14 m (30 ft)
Partition/distribution coefficient for unsaturated zone (K_{du}) (Average of measured values)	5.45 ml/g
Partition/distribution coefficient for saturated zone (K_d) (Average of measured values)	0.89 ml/g
Retardation factor in saturated zone (Eq. 3, Subsection 2.3..3) (R)	5.75
Radioactive decay constant for U-238 (λ)	1.55E-10 yr^{-1}
Source depletion coefficient	0.0 yr^{-1}
Distance from downgradient edge of subcell V07 in Cell 1 to downgradient point on southern Site boundary (x)	175 m (570 ft)
Longitudinal dispersivity (α_x)	17.5 m (57 ft)
Transverse dispersivity (α_y)	5.83 m (19 ft)
Vertical dispersivity (α_z)	0.98 m (3.2 ft)
Length of series V subcells (V04 to V07) in Cell 1 (L)	28.6 m (94 ft)
Width of subcells in series V in Cell 1 (W)	6.1 m (20 ft)
Initial concentration of U-238 in soils (C_s)	17.88 pCi/g
Concentration of U-238 in rainwater entering the saturated zone (Eq. 2, Subsection 2.3.2) (Ci)	3,214 pCi/L (or 3.2 pCi/mL)

The rectangular patch source configuration implies that U-238 concentration in soils is uniformly distributed and remains at 17.88 pCi/g within the width of the subcell for all times in the future.

For the baseline scenario, the maximum predicted concentration at the point of interest (i.e., southern Site boundary) is 7.25 pCi/L. This is below the lower limit of the range of MCL for U-238 (i.e., 10 pCi/L). The predicted maximum concentration occurs after approximately 225 years from the start of the transport process and stays at that level thereafter. As noted in Section 2.3.1, because source depletion is not included in the analysis, the concentration at the point of interest remains at the equilibrium (or steady-state) value indefinitely.

6.0 CONCLUSION

Potential transport of U-238 or total uranium from residual soils in Cell 1 at the Former Sylvania Electric Products Incorporated Facility, Hicksville, New York Site has been analyzed using the MULTIMED model. The input data for this preliminary study include values based on commonly used practices, information available in the literature, and measured Site-specific parameters. In particular, values of partition/distribution coefficient are obtained from several soil samples from several locations and depths in the Site vicinity. Geotechnical properties including hydraulic conductivity, porosity, and soil bulk density are estimated from laboratory analysis of several soil samples obtained from Boring KD4, which is close to Cell 1 (see Appendix F and Figure 3).

Residual soils in series V subcells are found to contain the maximum concentration of U-238 in Cell 1. The estimated weighted average concentration of U-238 in residual soils in series V subcells in Cell 1 is 17.88 pCi/g. This concentration is used to estimate the U-238 concentration in infiltrating rainwater entering the saturated zone.

A baseline scenario is simulated using average values of parameters obtained from laboratory analysis of soil samples and a vertical plane rectangular patch source configuration assuming that the area occupied by subcell series V in Cell 1 remains unpaved or undeveloped.

The rectangular patch source implies constant and uniform concentration within the width of the source, which is equal to the width of the subcells. This is consistent with the use of a weighted average soil concentration in subcell series V.

The result of the scenario with rectangular patch source configuration for a condition which postulated that the area occupied by subcell series V in Cell 1 is paved is included in Appendix E.

The results of this study are summarized in Table 6-1 and discussed in the following subsections. Note that the predicted concentrations at the point of interest on the southern Site boundary, are below the lower limit of the estimated range of applicable MCL for U-238 (i.e., 10 to 22.5 pCi/L).

Table 6-1. Result of Ground Water Transport Analysis

Description of Scenario	Estimated Concentrations at Point of Interest
Point of Interest	Southern Site boundary, 175 m from source
BASELINE SCENARIO	
Average soil parameters; unpaved cell surface	
Maximum concentration of U-238 (pCi/L)	7.25
Maximum concentration of total uranium[a] (pCi/L)	14.5
Approximate time to maximum concentration (years)	225
PAVED CELL SURFACE (APPENDIX E)	
Reduced infiltration; more conservative model parameters	
Maximum concentration of U-238 (pCi/L)	0.18
Maximum concentration of total uranium[a] (pCi/L)	0.36
Approximate time to maximum concentration (years)	150

[a] MCL for total uranium is 20 to 45 pCi/L or 30 µg/L (Appendix A).

Simulation with average values of Site-specific parameters with a vertical plane rectangular patch source configuration indicates a maximum U-238 concentration of 7.25 pCi/L in ground water at the southern Site boundary. This concentration is below the lower limit of the range of MCL (i.e., 10 pCi/L) for U-238. Based on this simulation, the corresponding maximum concentration of total uranium in ground water is approximately 14.5 pCi/L. This indicates that future concentration of U-238 or total uranium in ground water at the southern Site boundary associated with the soils containing residual uranium in Cell 1 is below the lower limit of the range of MCL of 10 to 22.5 pCi/L for U-238 and 20 to 45 pCi/L for total uranium.

It is likely that the area occupied by Series V subcells in Cell 1 may be developed in future. To evaluate the effect of paved surface of subcell series V in Cell 1, an additional simulation was conducted assuming more conservative model parameters (see Appendix E). Even with relatively more conservative model parameters, the predicted concentration of U-238 at the southern Site boundary for this case is 0.18 pCi/L. With a paved surface of subcells, infiltration through residual soils with U-238 contamination is significantly reduced resulting in significant reduction in predicted U-238 concentrations at the southern Site boundary.

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APPENDIX A

RADIOMETRIC AND MASS UNITS AND MCLs FOR URANIUM AND U-238

A.1 Use of U-238 as Indicator of Total Uranium Transport

In its natural state, uranium consists of three radioisotopes, U-234, U-235 and U-238, all having uranium chemical properties, but differing in their radioactive characteristics. These radioisotopes each decay through alpha particle emission, but the rates of decay (and emission) for each isotope are quite different, as shown by the half-lives in Table A-1. The half-life influences the relative abundance when comparing the isotope content by activity (radiological properties) rather than by mass fraction (chemical properties).

Table A-1. Relative Abundances of Uranium Isotopes

Isotope	Half-life (years)	Relative Isotopic Abundance (%)			
		Natural Uranium		3% Enriched Uranium	
		By Mass	By Activity	By Mass	By Activity
U-234	246,000	0.0054	49.0	0.03	82.7
U-235	704,000,000	0.711	2.25	2.96	2.84
U-238	4,470,000,000	99.283	48.7	97.01	14.5

Half-life data from *Chart of Nuclides (14th Edition)*, General Electric Co, San Jose, CA, 1989

During the Site investigations, uranium was analyzed for isotope specificity rather than through chemical analysis for total uranium. The State approved this approach because of the ease and sensitivity of the radiometric method as well as the need to rule out (or identify) the presence of enriched uranium. Enriched uranium is natural uranium processed to enhance the U-235 through removal of a small fraction of the U-238. Uranium used at the Hicksville Site is understood to have included both natural and enriched uranium. Historically, the value of enriched uranium imposed special handling procedures, so that enriched uranium was rarely discarded as waste, but recycled to recapture the valuable asset. Consistent with this understanding, very little enriched uranium was found at the Hicksville Site. And, considering relative isotopic abundance by mass, U-238 makes up 99+% of the total uranium found. As such, U-238 is an appropriate marker for tracking or predicting transport of total uranium.

Chemical properties of total uranium (such as the partition or distribution coefficient or K_d) are unaffected by the radioisotope properties. Thus, K_d for the three radioisotopes is essentially the same as the K_d for uranium. While we use the radiometric properties for detection at very sensitive levels, the radiometric properties are transparent to the physical and chemical processes driving the environmental transport.

Environmental transport is fundamentally a physical transfer process influenced by chemical interactions of the contaminant species, independent of radioisotope properties (Sheppard and Thibault, 1990; Yu, et al., 1993). The only radionuclide property with any significant impact on environmental transport is the half-life, in that extremely short-lived radionuclides undergo significant decay during the periods elapsed for environmental transport processes. From Table

A-1 it is seen that all three uranium isotopes have long half-lives, so that the analysis of transport considered at the Hicksville Site is unaffected by uranium decay.

A.2 MCLs for Total Uranium and U-238

The USEPA regulates uranium in drinking water under the Safe Drinking Water Act, with MCLs published in Title 40 CFR Part 141. Uranium is a naturally occurring radioactive element and a heavy metal, and the MCL reflects consideration of both the chemical and radiological toxicities. The USEPA MCL for uranium was set at 30 microgram/liter (μg/L) with an effective date of December 8, 2003 (USEPA 2000). The NYSDEC has adopted the drinking water standard MCL for radioactivity as an appropriate goal for evaluating impacts of this contaminant on ground water at cleanup sites in New York (6 NYCRR Part 703).

Considering relative isotopic abundance by activity, the percentage of each of the U-238 and U-234 isotopes in the soils in Cell 1 is 49%. This is consistent with the information included in Table A-1.

For comparison to the MCL, it is necessary to convert the radiometric measurements (picoCuries or pCi) of specific isotopes to the units of the MCL (microgram or μg) for total uranium. In the supplementary information published when promulgating the MCL for uranium, USEPA indicated that "the typical conversion factors that are observed in drinking water range between 0.67 up to 1.5 pCi/μg" (USEPA 2000). According to USEPA's uranium activity to mass conversion factor guidelines (USEPA, 2002), "the mass to activity ratio for uranium in a water sample varies depending on the isotopic ratio in that water supply. The nature of radioactivity in drinking water is such that there can be a significant difference in the activity due to the mixtures of isotopes in different water supplies." "The major challenge is to determine which factor is most appropriate to use to calculate an exposure point concentration for compliance monitoring or to use in a human health risk assessment. Ideally the activity to mass ratio should be calculated for each water supply but if this is not possible, there is a health protective approach to evaluate compliance with the regulatory level." This health protective approach includes a conversion factor of 0.67 in Tier I and calculated site-specific value in Tier II.

In light of the fact that there are no public or private drinking water wells within a mile downgradient of the Site, it is not anticipated, and is almost improbable, that ground water at the Site boundaries would be used as a source of public water supply. And, ground water entering the public water supply downgradient of the Site would involve ground water contributed by a much larger extent of the aquifer than the limited area under the Site. However, recognizing that significant mixing and dilution with ambient ground water would occur before ground water downgradient of the Site can be extracted for any use, it is reasonable to consider the upper range of conversion factors in the analysis. But, for the present study to be conservative, the full range of factors are presented to qualitatively assess the impacts of uranium in residual soils at Cell 1 on ground water at the Site boundaries.

Using the recommended range of conversion factors of 0.67 to 1.5 pCi/μg and the total uranium MCL of 30 μg/L, the range of MCL for total uranium in radiometric units can be expressed as 20 to 45 pCi/L.

For the aforementioned abundance activity ratios, the range of MCL of 20 to 45 pCi/L for total uranium can be expressed as 10 to 22.5 pCi/L for U-238 because the ratio of U-238 to total uranium in the soils in Cell 1 is 49%, i.e., approximately one-half.

Thus in this analysis, the cleanup target of 30 μg/L of total uranium in drinking water is interpreted as 10 to 22.5 pCi/L of U-238 in ground water. Modeling results for U-238 in ground water at the point of interest are compared to this range of 10 to 22.5 pCi/L to evaluate compliance.

References- Appendix A

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APPENDIX B
COMPARATIVE EVALUATION OF DIFFUSION AND DISPERSION

B.1 Introduction

The contribution of molecular diffusion is not included in the simulation of ground water transport for U-238 because its contribution is small compared to dispersion (see Subsection 2.1). To clarify the rational for this, a comparison of the coefficients of molecular diffusion and dispersion is presented below.

Diffusion or molecular diffusion is a microscopic and molecular scale process that results from the random thermal induced motion of the solute molecules within the liquid phase. It is independent of the advective motion of ground water. Dispersion or mechanical dispersion occurs predominantly on a macro and megascopic scale and is due to mechanical mixing of the solute. Mechanical mixing is caused by velocity variations within the pores, tortuosity of the porous medium, and variations in sizes of pore channels (USEPA, 1985).

In ground water transport modeling, the contribution of diffusion is usually accounted for by adding the molecular diffusion coefficient for the contaminant of concern to the dispersion coefficients. However, the molecular diffusion coefficient for total uranium may be several orders of magnitude smaller than the dispersion coefficients.

B.2 Diffusion Coefficient

Most chemical species are reported to have molecular diffusion coefficient in liquids on the order of 10^{-9} m^2/s to 10^{-10} m^2/s at 20° C and so the contribution of molecular diffusion is not included in most cases of ground water contaminant transport (Waterloo Hydrogeologic, Inc., 1994).

For most simple aqueous species, the diffusion coefficient, D_d, is approximately 10^{-9} m^2/s (0.0315 m^2/yr) (USEPA, 1999, Volume I, Page 2.35). The diffusion coefficient in soils is less than in free aqueous solutions due to the constrained geometry of the porous media represented by media characteristics such as tortuosity and porosity (USEPA, 1999, Volume I; Baehr, 1987). So, the effective diffusion coefficient for the Site conditions may be smaller than 10^{-9} m^2/s.

Based on an experimental investigation of molecular diffusion of radioisotopes, Duursma (1966; USEPA, 1985) reported molecular diffusion coefficients that ranged between 2x 10^{-10} to 6x 10^{-10} m^2/s (0.006 to 0.019 m^2/yr) for trivalent and monovalent ions (both positive and negative) in fine sand.

While the above values are not specific to the temperature and environmental conditions at the Site, they provide reasonable guidance for use in the analysis. The reasonableness of the above values is, in part, corroborated by the results of experimental and theoretical investigations reported in the literature to estimate self-diffusion of some metals under microgravity (Itami, et al., 2000). According to this report, the diffusion coefficients for lead (Pb), germanium (Ge), tin (Sn), and silicon (Si) vary from approximately 10^{-8} to 10^{-9} m^2/s at much higher ranges of temperatures (e.g., 400° to 1,700° K) than those expected in the field. The diffusion coefficients at lower temperatures are expected to be lower than these values.

B.3 Dispersion Coefficient

For comparison with the above values of diffusion coefficients, estimated values of longitudinal, transverse, and vertical dispersion coefficients for the Site conditions are set forth in Table B-1. The values of parameters used to estimate the dispersion coefficients are also shown in Table B-1 and are taken from Section 4.0.

Table B-1. Estimated Dispersion Coefficients for Cell 1

Hydraulic gradient (i) = 0.00056; effective porosity (φ) = 0.30; longitudinal dispersivity (α_x) = 17.5 m; transverse dispersivity (α_y) = 5.83 m; and vertical dispersivity (α_z) = 0.98 m.

Parameter	Maximum	Average	Minimum
Hydraulic Conductivity (K) (m/yr)	7001.0	5171.9	3626.6
Longitudinal dispersion coefficient[a] (m^2/yr)	228.7	168.9	118.5
Transverse dispersion coefficient[a] (m^2/yr)	76.2	56.3	39.5
Vertical dispersion coefficient[a] (m^2/yr)	12.8	9.5	6.6

[a] Longitudinal dispersion coefficient = $K\ i\ \alpha_x / \varphi$, Transverse dispersion coefficient = $K\ i\ \alpha_y / \varphi$, and Vertical dispersion coefficient = $K\ i\ \alpha_z / \varphi$,

The above values evidence that the dispersion coefficients are approximately 2 to 4 orders of magnitude greater than the expected diffusion coefficient for uranium. Therefore, the contribution of diffusion will go undetected and is not incorporated in the analysis.

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APPENDIX C

EVALUATION OF APPLICABLE GROUND WATER TRANSPORT MODELS

C.1 CRITERIA FOR MODEL SELECTION

The criteria used for selecting an appropriate ground water transport model for the analysis are:

- The model must be relatively simple. It should preferably be available in the public domain and should have a history of use by more than one entity;
- The model should be capable of simulating the relevant physical processes listed in Section 2.1, particularly in a predictive mode;
- The model should use a conservative approach for simulating the above-mentioned processes; and
- The details of the required model input should be commensurate with available site-specific data, current knowledge of site conditions, and expected time-frame of analysis for the transport of dissolved U-238.

C.2 MODELS CONSIDERED

The relevant processes listed in Subsection 2.1 can be modeled using several different approaches. Steady state and non-steady state models (approaches), which may be relevant in this study with appropriate assumptions, are described in the following paragraphs. A non-steady state model predicts contaminant concentrations at different time periods. A steady state model predicts concentrations with no reference to time (i.e., the simulated transport conditions do not vary with time).

a. A **Rapid Assessment Nomograph** developed by USEPA based upon a simple analytical solution of the advective-dispersion equation for ground water transport (USEPA, 1983). This non-steady state model assumes one-dimensional flow, one-dimensional (i.e., longitudinal) dispersion, and a continuous constant concentration point source. It accounts for retardation and biodegradation during transport through saturated soils but does not account for recharge along the flow path, decreasing source concentrations, and dilution due to lateral and vertical dispersion.

b. **USEPA Analytical model** based on an equation included in USEPA (1985). This non-steady-state model assumes one-dimensional flow, one-dimensional (i.e., longitudinal) dispersion, and a diminishing point source. It accounts for retardation and biodegradation during transport through saturated soils but does not account for recharge along the flow path and dilution due to lateral and vertical dispersion.

c. **Model based on the Domenico equations** (e.g., IPCB, 2004; Domenico, 1987; Domenico and Robbins, 1985; and ASTM, 1995). The steady and non-steady state versions of this model assume one-dimensional flow, three-dimensional dispersion, and a continuous vertical plane source with constant concentration. It can account for retardation and biodegradation during transport through saturated soils but does not account for recharge along the flow path nor for reduction in source concentration due to rainwater infiltration.

d. **Natural Attenuation Decision Support System, BIOCHLOR** (USEPA, 2000). This model is based on modified Domenico equations (Domenico, 1987; Domenico and Robbins, 1985) and simulates one-dimensional advection, three-dimensional dispersion, linear adsorption, and biotransformation. Just like the Domenico equations, this model also assumes a fully penetrating, vertical plane source oriented perpendicular to ground water flow. It can account for source reduction but does not account for recharge along the flow path.

e. **Analytical Transient One-, Two-, and Three-Dimensional Model, AT123D** (Yeh, 1981). This model is a collection of analytical solutions for one-, two-, and three-dimensional contaminant transport with advection, dispersion, and source reduction. A uniform flow field with constant velocity is assumed. It is applicable to the transport of radioactive waste, heat, and chemicals from linear, areal, or volumetric sources with instantaneous, finite-time, or continuous release. The model does not account for recharge along the flow path. According to some reviews, numerical errors may occur during calculation of the series summation which means convergence and accuracy may not be guaranteed (e.g., Maidment, 1993).

f. **Multimedia Exposure Assessment Model, MULTIMED** (USEPA, 1996) for saturated and unsaturated zone fate and transport of dissolved chemicals. This model can simulate both steady and non-steady state transport. It assumes one-dimensional flow, three-dimensional dispersion, and can simulate contaminant transport emanating from a continuous or finite-duration, non-decaying patch type or decaying or non-decaying Gaussian source. It accounts for retardation, biodegradation, and recharge along the flow path during transport through saturated soils.

g. **Coupled and uncoupled two- and three-dimensional finite-difference or finite-element flow and transport models.** There are a number of complex and sophisticated models in this category. A few examples include:
  - The MT3D (USEPA, 1992) model coupled with the MODFLOW model (USGS, 2000);
  - USGS MOC model (Konikow and Bredehoeft, 1978; Goode and Konikow, 1989);
  - SEFTRAN model (Geotrans, Inc., 1988);
  - CFEST model (Gupta, et al., 1987);
  - FTWORK model (Faust, et al, 1989);
  - HST3D model (Kipp, 1987);
  - SUTRA model (Voss, 1984; Souza, 1987);
  - SWIFT II model (Reeves et al., 1986); and
  - TARGET model (Sharma et al., 1981).

These models can simulate two- and three-dimensional flow and transport under steady or non-steady state conditions. The model domain boundaries have to be defined based on existing natural and man-made surface and ground water flow and transport conditions in the site vicinity. To minimize boundary effects, the model domain has to include an area much larger than the site area. Appropriate hydraulic head, flow, and concentration conditions have to be provided at these boundaries and verified during calibration. The model domain is divided into variable size discrete elements or cells and layers. Site-specific hydrogeologic and chemical data have to be available or estimated for each of the discrete elements or cells. A relatively large amount of field data is required for model calibration. The larger the number of input parameters, the more difficult it is to obtain adequate and reliable information for them. Therefore, several assumptions may have to be made or default values may have to be used based on the judgment of the user.

C.3 COMPARATIVE EVALUATION

Each model has its own assumptions and limitations and may require adaptations and additional simplifying assumptions to simulate specific site situations. The more sophisticated models (coupled or decoupled two- and three-dimensional flow and transport models) require more data on site-specific parameters for calibration and simulation.

U-238 contamination at different concentrations has been detected at different depths in the ground water profiles and monitoring wells drilled and investigated at the Site. There is considerable variation in measured U-238 concentrations. In addition, the concentrations at different locations and depths include different and indeterminate degrees of dilution due to mixing with ambient ground water flow. Thus, reliable data for the calibration or "benchmarking" of the uranium transport model are not available. Without adequate calibration, the results of the sophisticated models may not have a higher degree of accuracy.

Regardless of model used, one of the significant model input parameters is the concentration of U-238 at the source. This parameter has to be estimated outside the above-mentioned models and will not be affected by the sophistication or simplicity of the selected transport model. In addition, the time horizon for the transport of U-238 is fairly large (approximately several decades to several hundred years or so), so a number of simplifying and conservative assumptions have to be made to evaluate the potential for ground water contamination at the point of interest at some time in the distant future regardless of the model selected. However, when a relatively large number of assumed input parameters are required for a model, there is a possibility that more than one combination of input parameters may provide similar results (or that the model over or under predicts transport). In such cases, without the ability to properly calibrate a model, it may be difficult to distinguish between realistic and spurious results.

Of the models listed in Section B2.0, only MULTIMED (USEPA, 1996) has the capability to simulate dilution due to recharge along the path of ground water transport.

The ground water flow component of the afore-mentioned finite-difference and finite-element models may provide ground water flow (advection) in three directions. Because three-dimensional advection may result in more dilution, using a three-dimensional model may predict relatively lower concentrations reaching the point of interest. Consequently, the predicted concentrations may not be conservative when compared to the case in which ground water flow is assumed to have only one dominant flow direction. This is true for each of the more sophisticated models.

References: See Appendix D References.

APPENDIX D

DESCRIPTION OF MULTIMED MODEL

The Multimedia Exposure Assessment Model (MULTIMED) simulates the movement of contaminants leaching from a waste disposal facility or contaminated soils. The model consists of a number of modules which predict concentrations at a receptor due to transport in both unsaturated and saturated soil zones. The output from the unsaturated zone module may be used to couple the unsaturated zone transport module with the steady-state or transient, semi-analytical saturated zone transport module. The saturated zone transport module includes one-dimensional uniform flow, three-dimensional dispersion, linear adsorption, first-order decay, and dilution due to direct infiltration into the ground water plume. The unsaturated zone module of MULTIMED is not relevant in this analysis because the prior excavation activities removed upper levels of soil and left residual soils relevant to this analysis approximately 5 to 10 ft above the water table.

The fate of contaminants in various media depends on the chemical properties of the contaminants as well as a number of media- and environment-specific parameters. The uncertainty in these parameters can be quantified in MULTIMED using the Monte Carlo simulation technique. To enhance the user-friendly nature of MULTIMED, a preprocessor, PREMED, and a postprocessor, POSTMED, have been developed.

The operation of each module requires specific input, which is organized into data groups. The General Data Group, which is required for all simulations, contains flags and data which describe the scenario being modeled. The input parameters needed for the Saturated Zone Transport Model are arranged in three additional data groups: the Chemical Data Group, the Source Data Group, and the Aquifer Data Group.

The simplifying assumptions required to obtain the analytical solutions for the equations used in MULTIMED limit the complexity of the systems that can be modeled. Accordingly, MULTIMED cannot be used to account for site-specific spatial variability or boundary conditions, landfill shape, multiple aquifers and pumping wells, flow in fractures, or chemical reactions between reactants. As a result, MULTIMED should be used only as a screening level tool when applied to complex sites.

MULTIMED was developed primarily for, and has seen extensive application in, predicting leachate movement from a Subtitle D (hazardous waste) landfill. This type of application, however, only utilizes a subset of MULTIMED's full capabilities. When MULTIMED has been used in conjunction with a separate source model, such as HELP (USEPA, 1995), it has been applied to a much larger range of scenarios. Such scenarios may include development and comparison of the effects of different facility designs or conditions on ground water quality to address questions related to appropriate cleanup levels for contaminated soils.

The MULTIMED model has undergone a series of tests to verify the correctness of the model. Discussion of these tests and related model application considerations are included in the model documentation (USEPA, 1996). The model can simulate steady and non-steady state transport of conservative or decaying substances emanating from a rectangular (patch type) or Gaussian source with specified leach rates. The source may be a constant concentration source or a decaying source.

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APPENDIX E

U-238 TRANSPORT ASSUMING PAVED CELL SURFACE

E.1 Introduction

It is likely that the area occupied by subcell series V in Cell 1 may be paved or occupied by buildings at some point in future. If the area occupied by subcell series V in Cell 1 is paved, it would significantly reduce infiltration of rainwater through the residual soils containing U-238. Thus the quantity and rate of desorption of U-238 from the residual soils would also be reduced. As a result, the volumetric rate and concentration of U-238 entering the water table would be significantly reduced.

To illustrate the effect of paved surface of subcell series V in Cell 1, an additional scenario is simulated with relatively more conservative values of model parameters. This scenario is designated as Scenario E-1. The result of this postulated case is presented in this Appendix.

E.2 Model Parameters

The model parameters for Scenario E-1 are shown in Table E-1. The K_{du} value is assumed to be the lowest of the six samples mentioned in Subsection 4.1.1 for the unsaturated zone and the K_d value is taken to be the lowest of the seven samples for the saturated zone. In addition, the hydraulic conductivity is assumed to be the highest of the three samples mentioned in Subsection 4.1.3. The infiltration for paved surfaces is taken to be 0.006 m/yr (see Subsection 4.7.3).

Table E-1. Input Model Parameters for Scenario E-1- Paved Surface of Subcells

Effective soil porosity (saturated conditions) (φ)	0.30
Water-filled soil porosity (unsaturated conditions) (φ_w)	0.18
Soil bulk density (ρ_b)	1.60 g/cc
Hydraulic conductivity (Maximum of measured values) (K)	7,001 m/yr (62.9 ft/day)
Average hydraulic gradient (i)	0.00056
Average recharge rate (along path of ground water transport) (q)	0.59 m/yr (23.2 in/yr) (see Table 4-2)
Average infiltration rate (in the paved area occupied by subcells V04 to V07 in Cell 1) (I)	0.006 m/yr (0.24 in/yr) (see Table 4-3)
Effective aquifer thickness (B)	9.14 m (30 ft)
Distribution coefficient for unsaturated zone (K_{du}) (Minimum of relevant measured values)	2.98 ml/g
Distribution coefficient for saturated zone (K_d) (Minimum of relevant measured values)	0.52 ml/g
Retardation factor in saturated zone (Eq. 3, Subsection 2.3.3) (R)	3.77
Radioactive decay constant for U-238 (λ)	1.55E-10 yr^{-1}
Source depletion coefficient	0.0 yr^{-1}
Distance from downgradient edge of subcell V07 in Cell 1 to downgradient point on southern Site boundary (x)	175 m (570 ft)
Longitudinal dispersivity (α_x)	17.5 m (57 ft)
Transverse dispersivity (α_y)	5.83 m (19 ft)
Vertical dispersivity (α_z)	0.98 m (3.2 ft)
Length of series V subcells (V04 to V07) in Cell 1 (L)	28.6 m (94 ft)
Width of subcells in series V in Cell 1 (W)	6.1 m (20 ft)
Initial concentration of U-238 in soils (C_s)	17.88 pCi/g
Concentration of U-238 in leachate entering the saturated zone (Eq. 2, Subsection 2.3.2) (C_i)	5,782 pCi/L (or 5.8 pCi/mL)

E.3 Result of Simulation with Paved Subcells

The predicted maximum U-238 concentrations at the southern Site boundary for the relatively more conservative model parameters included in Table E-1 is 0.18 pCi/L if the area occupied by subcell series V in Cell 1 is paved. The maximum concentration for Scenario E-1 occurs after 150 years from the initiation of the transport process.

If the area occupied by series V subcells in Cell 1 is occupied by buildings, then rainwater infiltration, desorption of U-238 from soils in the vadose zone, and vertical transport of U-238 to the saturated zone would be reduced to a minimum. In this case predicted concentration of U-238 in ground water reaching the southern Site boundary would be even smaller than the above value of 0.18 pCi/L.

APPENDIX F

BORING LOGS

APPENDIX G

HYDRAULIC GRADIENT AND LENGTH OF FLOW PATH

G.1 Introduction

The MULTIMED model is based on one-dimensional ground water flow and predicts the propagation of concentration along a vertical profile of the aquifer downgradient from the source. This profile follows a straight line along the uni-directional flow path specified as input to the model. The localized hydraulic gradient of ground water along the above-mentioned vertical profile in unconfined situations is the slope of the water table between two selected points or between points closest to these two points on this vertical profile. Thus, the localized hydraulic gradient applicable to the transport of dissolved uranium from subcell series V of Cell 1 to the point of interest has to be estimated by the difference in ground water levels in the monitoring wells closest to the downgradient edge of subcell series V of Cell 1 and the point of interest.

The dominant on-Site localized ground water flow direction and localized hydraulic gradient were identified from available field data. While the regional ground water flow direction in the vicinity of the Site is to the south, discrete small areas may have localized variation. This localized variation is relevant for ground water transport modeling within the short transport distance considered in this study (USEPA, 1985, Page 346).

To estimate the localized hydraulic gradient between Cell 1 and the southern Site boundary, ground water elevations were used from three on-Site monitoring wells (MW-07, MW-11, and MW-09) for two monitoring events (December 2002 and March 2003). The localized hydraulic gradient was taken to be the average of values computed for the above two monitoring events. MW-07 is located downgradient of Cell 1 and MW-09 and MW-11 are located further downgradient near the southern Site boundary (see Figure 3). These three monitoring wells were selected because they define the plane representing the water table in the area between Cell 1 or Cell 6 and the southern Site boundary (USEPA, 1998; IPCB, 2004).

Relevant data for monitoring wells MW-07, MW-11, and MW-09 are included in Table G-1.

Table G-1. Relevant Data for Selected on-Site Monitoring Wells

Monitoring Well	Screen Interval (ft)	Relative Coordinates[a] (ft)		Ground Water Elevation (ft)	
		x	y	March 2003	December 2002
MW-09	72-82	0	0	68.80	67.90
MW-11	71-81	110	0	68.84	67.91
MW-07	69.5-79.5	330.46	317.11	68.98	68.16

[a]Based on distances scaled from Site map (1 inch = 80 ft). (MW-09 to MW-11 = 110 ft; MW-09 to MW-07 = 458 ft; and MW-11 to MW-07 = 390 ft).

G.2 Estimation of Localized Hydraulic Gradient

Three different approaches were used to estimate the localized hydraulic gradient using ground water elevation data for the three monitoring wells included in Table G-1.

G.2.1 Hydraulic Gradient Estimation Using Average Ground Water Elevations

In this approach hydraulic gradient is estimated between monitoring well MW-07 and the point between monitoring wells MW-9 and MW-11 where ground water elevation is equal to the average of ground water elevations in these two wells. The distance of this point from MW-07 is approximately 420 ft.

The estimated hydraulic gradients for the March 2003 and December 2002 ground water elevations are 0.00038 and 0.00061, respectively. This gives an average hydraulic gradient of 0.00049 toward the southern Site boundary.

G.2.2 Hydraulic Gradient based on Potentiometric Contours

In this case ground water contours were sketched for each of the two monitoring events (March 2003 and December 2002). The estimated average ground water gradients from these contours for March 2003 and December 2002 are 0.00054 and 0.00068, respectively. This gives an average hydraulic gradient of 0.00054.

G.2.3 Estimation of Slope of Water Table

This approach uses a matrix solver to develop the equation of a plane through the measured ground water elevations in the three monitoring wells in March 2003 and December 2002, respectively. Each plane represents the plane of water table in the vicinity for that particular monitoring event (March 2003 and December 2002). The slope of this plane with respect to the horizontal plane gives the hydraulic gradient (Devlin, 2002).

According to this method, the estimated hydraulic gradients for the March 2003 and December 2002 ground water elevations are 0.00041 and 0.00071, respectively. This gives an average hydraulic gradient of 0.00056 toward the southern Site boundary.

G.3 Adopted Localized Hydraulic Gradient and Length of Flow Path

So far as the transport of U-238 is concerned, the three estimates of hydraulic gradient included in Subsections G.2.1, G.2.2, and G.2.3 are not significantly different. The highest value of 0.00056 is adopted for ground water transport modeling.

Scaling from a Site map (scale 1 inch = 80 ft), the length of the flow path from the downgradient edge of subcell V07 to the southern Site boundary along the direction of the above hydraulic gradient is approximated to be 574 ft (175 m).

Reference - Appendix G

Devlin, J.F., 2002. A Spreadsheet Method of Estimating Best-Fit Hydraulic Gradients Using Head Data from Multiple Wells, Ground Water, Vol. 41, No. 3, 316-320.

Illinois Pollution Control Board (IPCB), 2004. Tiered Approach to Corrective Action Objectives.

U.S. Environmental Protection Agency (USEPA), 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water-Part II, EPA/600/6-85/002b, September 1985, Environmental Research Laboratory, Athens, GA.

U.S. Environmental Protection Agency (USEPA), 1998. USEPA Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water 1998, EPA/600/R-98/128, September 1998, Office of Research and Development, Washington, D.C.

APPENDIX H

VOLUME AND MASS CALCULATIONS FOR RESIDUAL SOILS IN CELL 1

Calculations constrained to the area below the excavation level and above the water table for each subcell
Cell 1 includes subcells U04 - U07, V04 - V07, and W04 - W07
All input sample data is from the on-Site gamma spectroscopy service.
Water table is approximated at 71 ft bgs, and is assumed constant throughout Cell 1
* All values were calculated at the 0 (zero) isolevel for U-238
U-238 mass calculation is based on a specific activity of 3.3601 E-7 Ci/g

Subcell	Excavation Depth (ft)	Surface Elevation (ft)	Excavation Elevation (ft)	Soil Volume* (cubic ft)	Soil Mass* (kilograms)	U-238 Mass* (kilograms)	Average U-238* (pCi/g)	Center of Mass* (Elevation in ft MSL)
U04	13.65	145.63	131.98	25,403	1,162,800	21.63	6.24	101.8
V04	14.88	145.70	130.82	25,710	1,176,800	29.97	8.55	102.1
W04	12.76	145.46	132.70	25,912	1,186,100	28.60	8.09	100.1
U05	23.32	145.17	121.85	20,796	951,900	57.61	20.31	96.4
V05	18.68	145.26	126.58	23,534	1,077,200	75.20	23.43	98.8
W05	14.60	145.76	131.16	25,684	1,175,600	34.40	9.82	104.2
U06	40.13	145.01	104.88	14,174	648,770	33.82	17.49	87.8
V06	17.40	144.71	127.31	24,057	1,101,100	97.18	29.62	96.2
W06	18.03	145.76	127.73	24,125	1,104,300	36.55	11.11	96.5
U07	39.48	145.05	105.57	14,214	650,610	27.29	14.08	89.2
V07	17.27	144.62	127.35	23,619	1,081,100	33.95	10.54	94.9
W07	18.43	145.28	126.85	23,497	1,075,500	19.46	6.07	96.2

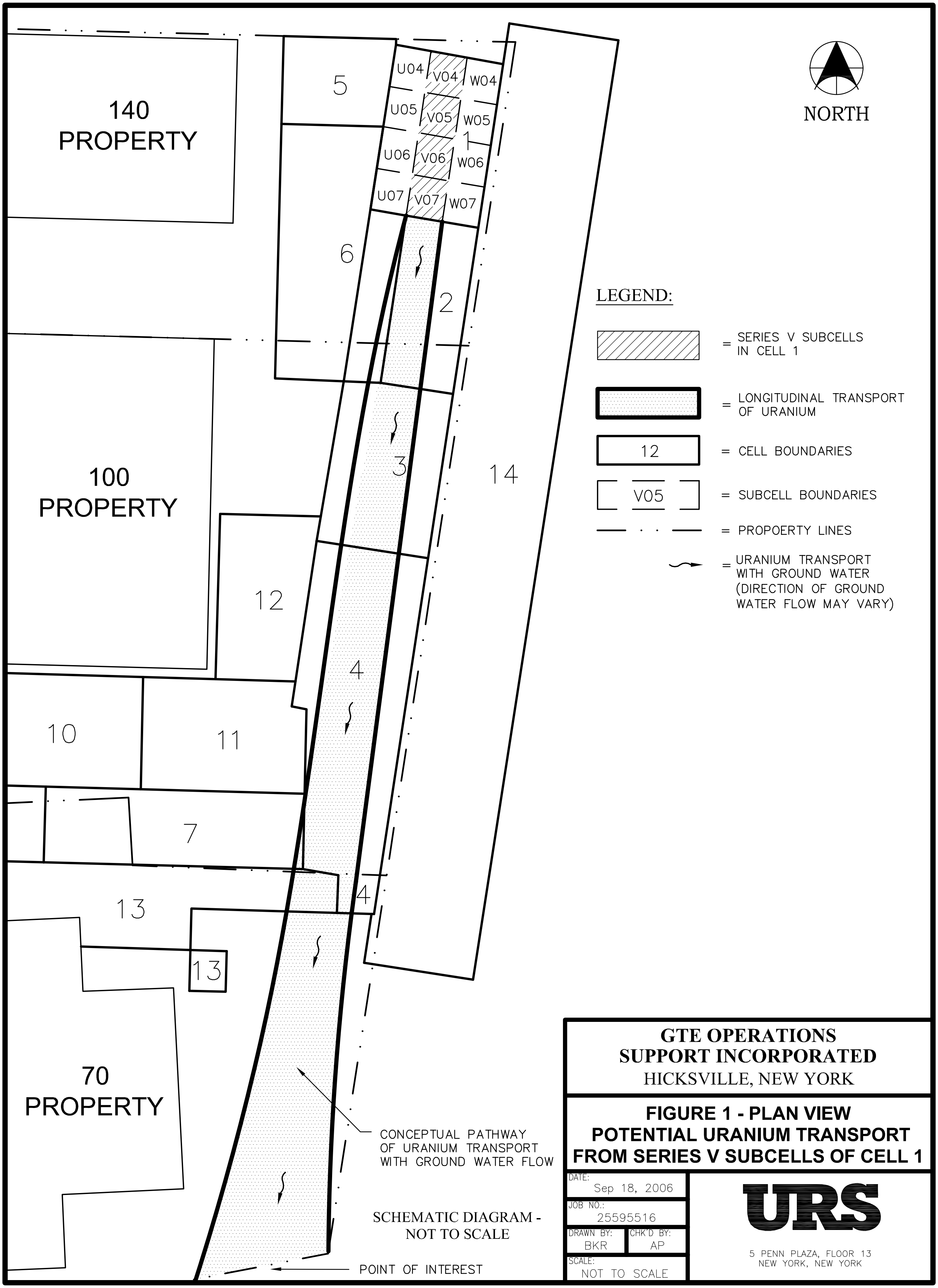

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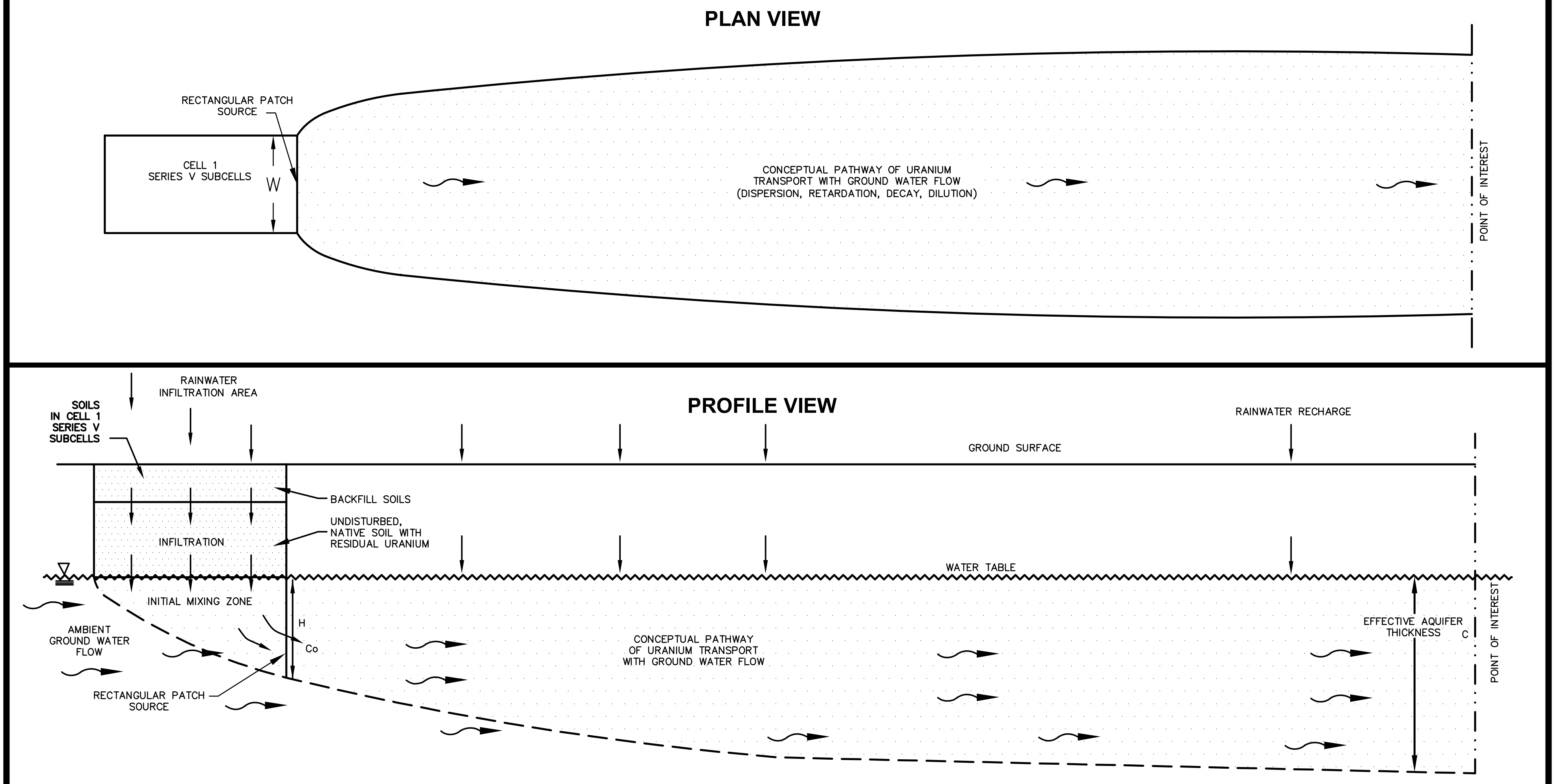
FIGURE 1 - PLAN VIEW
POTENTIAL URANIUM TRANSPORT
FROM SERIES V SUBCELLS OF CELL 1

DATE: Sep 18, 2006
JOB NO.: 25595516
DRAWN BY: BKR
CHK'D BY: AP
SCALE: NOT TO SCALE

URS
5 PENN PLAZA, FLOOR 13
NEW YORK, NEW YORK

Q:\GTE Hicksville, NY\Figures\Autocad Drawings\25595516 - GTE OPERATIONS NY\Cell 01 - V04-V07 Uranium Transport (3).dwg



NOTES:

Co = POTENTIAL URANIUM CONCENTRATION IN GROUND WATER AT SOURCE

C = POTENTIAL URANIUM CONCENTRATION AT POINT OF INTEREST

H = MIXING ZONE DEPTH

W = WIDTH OF SOURCE

SCHEMATIC DIAGRAM -
NOT TO SCALE

GTE OPERATIONS
SUPPORT INCORPORATED
HICKSVILLE, NEW YORK

**FIGURE 2 - CROSS-SECTIONAL VIEW
POTENTIAL URANIUM TRANSPORT
FROM SERIES V SUBCELLS OF CELL 1**

DATE: OCT. 6, 2006
JOB NO.: 25595516
DRAWN BY: BKR
CHK'D BY: AP
SCALE: NOT TO SCALE

URS
5 PENN PLAZA, FLOOR 13
NEW YORK, NEW YORK

Q:\GTE Hicksville, NY\Figures\Autocad Drawings\25595516 - GTE OPERATIONS NY\Cell 01 - V04-V07 Uranium Transport (2).dwg

\\Server\Public\Destiny_Data\GIS\GIS_NY\mxdfiles\all_site_KD1_2_4.mxd

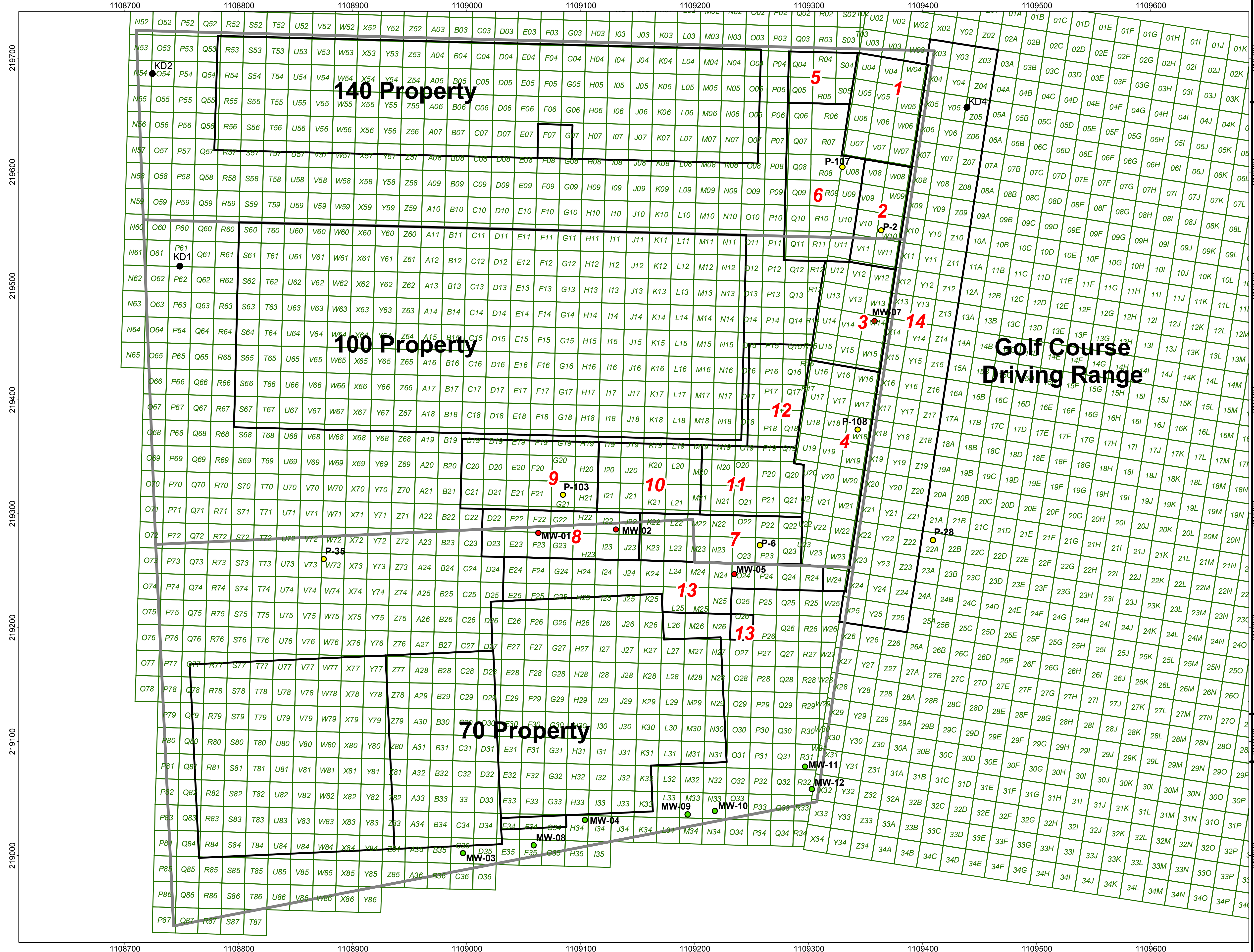


Figure 3
Location of Referenced Monitoring Wells, Profiles, and Borings

Legend

- 🟢 Monitoring Wells (Existing)
- 🔴 Monitoring Wells (Abandoned)
- 🟡 Profile Locations
- ● KD1, KD2, KD4 Boring Locations
- ― Building
- ― Property Line
- ▭ Subcell Boundary
- ▭ Cell Boundaries

N

Feet

0 25 50

Projection Information
State Plane Projection
Long Island Zone
North American Datum 1983
Feet

NYSDEC V00089-1

URS27010-039

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October 6, 2006

Appendix F – Boring Logs

This appendix provides the boring log for the Potential Uranium Transport Report. Boring logs are provided in sequential order, KD1 through KD4. Boring KD1 was advanced using hollow-stem auger drilling rig; Boring KD2 and KD4 were advanced using hollow-stem augers to 69 feet below ground surface, then casing was advanced with a 300-pound hammer to the bottom of the boring. The borings were backfilled with clean fill upon completion.

The main lithologic name with the appropriate group symbol is described at the top of each stratum. The main lithologic group is in capital letters and bold font. Minor variations within the soil stratum are called out at the approximate elevation in which they occur, and the main lithologic group is not repeated nor any variations above the one identified.

Fill is defined as non-native material (evidenced by color, texture, structure, or miscellaneous debris), other than the material GTEOSI used to backfill excavations, which is noted as ‘backfill’ in the logs.

MAJOR DIVISIONS			GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	⁘	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
			⁘	GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▥	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
			▨	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	CLEAN SAND (LITTLE OR NO FINES)	⁚	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
			⁙	SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▥	SM	SILTY SANDS, SAND-SILT MIXTURES
			▨	SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			▨	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			▥	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			▨	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			≋	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

SOIL CLASSIFICATION CHART

MATERIAL SIZE	PARTICLE SIZE			
	LOWER LIMIT		UPPER LIMIT	
	MILLIMETERS	SIEVE SIZE*	MILLIMETERS	SIEVE SIZE*
SAND				
FINE	.074	#200*	0.42	#40*
MEDIUM	0.42	#40*	2.00	#10*
COARSE	2.00	#10*	4.76	#4*
GRAVEL				
FINE	4.76	#4*	19.1	3/4"•
COARSE	19.1	3/4"•	76.2	3"•
COBBLES	76.2	3"•	304.8	12•
BOULDERS	304.8	12•	914.4	36"

*U.S. STANDARD •CLEAR SQUARE OPENINGS

GRADATION CHART

Notes:

1. Dual symbols are used to indicate borderline classifications or intermixed strata.

2. Soil descriptions and classification are based on field observations, not on laboratory testing of soil physical properties.

3. When used on the boring logs, the following terms are used to describe the consistency of cohesive soils and the relative compactness of cohesionless soils:

Cohesive Soils	Cohesionless Soils
Very Soft	*Very Loose*
Soft	*Loose*
Medium Stiff	*Medium Dense*
Stiff	*Dense*
Very Stiff	*Very Dense*
Hard	

4. When used on the boring logs, the following terms indicate the volume percentage of the minor soil components estimated in the field based on visual observations:
trace: 1 to 10% *little: 10 to 20%* *some: 20 to 35%* *and: 35 to 50%.*

5. Moisture Content:
Dry: Absence of moisture, dusty, dry to the touch
Moist: Damp but no visible water
Wet: Visible free water, usually soil is below the water table

UNIFIED SOIL CLASSIFICATION SYSTEM AND KEY TO LOG OF BORINGS

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD1
Date Drilled: 8/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Carrie Olsen

URS
5 Penn Plaza
13th Floor
New York, NY 10001

Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
		▩						Asphalt Surface elevation at 144.9', first sample at 20'	
1		▩						**FILL**, dark brown, fine to medium sand, trace fine gravel and cobbles, dry (lithology observed from auger cuttings to 20' bgs)	
2		▩							
3		▩						(Fill depth interpreted from adjacent borings)	
4		░						Brown, fine to medium **SAND**, trace coarse sand, fine to coarse gravel and cobbles	
5		░							
6	SP	░							
7		░							
8		░							
9		░							
10		░						Cobble layer	
11		░							
12		░							
13		░							

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program
Client: GTEOSI, Hicksville, NY
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Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Carrie Olsen

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New York, NY 10001

Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								Brown, fine to medium **SAND**, trace coarse sand, fine to coarse gravel and cobbles	
14									
15									
16									
	SP								
17									
18									
19									
20								Light brown, fine to coarse **SAND** and fine to coarse **GRAVEL**, medium dense, dry	
21			21	12	0.0	10.3			
22	GW							Dense	
							Kd		
23			30	18	0.0	10.3			
								Tan, fine to medium **SAND**, trace fine gravel, dense, dry Medium dense	
24									NA = Not available (rad data not recorded)
25	SP		21	18	0.0	NA		Medium to coarse sand, some fine to coarse gravel	
26									

Log of Boring: KD1
Date Drilled: 8/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Carrie Olsen

Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
27	SW		41	24	0.0	9.0		Light brown, fine to coarse **SAND**, some gravel, dense, moist	
28	SP							Light brown, fine to medium **SAND**, trace fine gravel, dense, moist	
29	SW		26	20	0.0	8.5		Light brown, fine to coarse **SAND**, trace fine to coarse gravel, medium dense, moist	
30	SP							Brown, fine to medium **SAND**, trace fine gravel, medium dense, moist Trace coarse sand	
31			26	21	0.0	10.8	Kd		
32									
33			35	24	0.0	10.8		Light brown to tan, fine sand, trace medium to coarse sand and fine gravel to 34', dense, moist	
34								Medium dense	
35			23	24	0.0	9.0			
36	SW							Light brown, fine to coarse **SAND**, trace fine gravel, medium dense, moist	
37	GP		36	22	0.0	9.3		Tan, fine to coarse sandy, **GRAVEL,** moist	
	SW							Light brown to tan, fine to coarse **SAND**, trace fine gravel, dense, moist	
38	SP							Tan with reddish mottles, fine **SAND**, trace medium sand and fine gravel, dense, moist	
39			31	24	1.4	9.1			

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program
Client: GTEOSI, Hicksville, NY
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Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								Tan with reddish mottle, fine **SAND**, dense, moist Tan, trace clay	
40								Tan to light brown, occasional gravel, medium dense	
41			28	24	0.8	9.0	Kd	Dark brown, clay grades out Tan, occasional fine gravel	
42	SP							Trace gravel	
43			26	24	1.7	9.0			
44								Trace clay Light brown, some clay, medium dense	
45			18	24	0.7	9.1		Light brown, fine sandy, **CLAY**, moist, very stiff	
46	CL							Silty, soft, moist to wet	
47			2	24	0.5	10.1			
48	SC							Light brown, clayey, fine **SAND**, moist, very loose	
49			38	24	6.2	8.1		Light brown to tan, fine to medium **SAND**, trace fine gravel, dense, moist	
50	SP							Trace coarse sand and fine to coarse gravel Trace medium sand, dense, moist	
51			43	24	7.3	9.5	Kd		
52									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program
Client: GTEOSI, Hicksville, NY
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Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
		▨						Light brown, fine to medium **SAND**, trace fine to coarse gravel, dense, moist	
53			48	24	10.2	9.0		1" orange sandy clay	
54								Tan to light tan, medium sand grades out, medium dense	
55			21	24	2.5	9.0			
56									
57			20	24	1.6	9.0			
58	SP								
59			20	24	0.5	9.0			
60									
61			22	24	1.3	9.4	Kd		
62									
63			23	24	1.2	9.1			
64								Dense	
65			31	24	0.0	10.7			

Project No.: NYSDEC: V-00089-1; URS: 27010-039
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Client: GTEOSI, Hicksville, NY
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Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								Tan to light tan, fine **SAND**, dense, moist	
66	CL							Trace bright orange, 1/2" clay seam	
67			37	24	0.5	9.1			
68								Medium dense	
69	SP		26	24	0.9	9.0			
70								Dense	
71			33	24	0.0	9.4	Kd		
72									
73			52	24	0.0	9.1		inferred groundwater level	
74	▼							No recovery, wet	
75			5	0	-	-			
76				0					
77									NA = Not available (rad data not recorded)
78			18	14	0.0	NA			

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD1
Date Drilled: 8/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
	SP	▨						Tan, fine to medium **SAND**, trace coarse sand and silt, wet	NA = Not available (PID and rad data not recorded)
79				0				No recovery	
80 81	SP	▨	11	20	0.0	NA	Kd	Tan, fine to medium **SAND**, trace coarse sand and silt, medium dense, wet	
82 83		▨	23	22	NA	NA			
84 85		▨	16	10	NA	NA			
86								No samples collected	
87 88	SP	▨	135	12	NA	NA		Tan, fine to medium **SAND**, trace coarse sand and silt, very dense, wet	
89								No samples collected	
90 91	SP	▨	79	22	NA	NA		Tan, fine to medium **SAND**, trace coarse sand and silt, very dense, wet	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD1
Date Drilled: 8/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
92	SP	▨						Tan, fine to medium **SAND**, trace coarse sand and silt, very dense, wet	NA = Not available (PID and rad data not recorded)
93								No samples collected	
94			63	10	NA	NA		No lithology data recorded	
95 96 97 98 99								No samples collected	
100 101			14	0	-	-		No recovery	
102 103 104								No samples collected	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD1
Date Drilled: 8/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								No samples collected	
105									
106									
107									
108									
109									
110									
111									
112									
113									
114									
115									
116									
117									

Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
118–122								No samples collected	
122–124			65	0	-	-		No recovery	
124	EOB							NOTES: 1. Boring completed to a depth of 124' on 8/31/04 2. Groundwater estimated at 74' bgs during drilling 3. Continuous sampling was discontinued from 94.5-120' bgs (flowing sand in auger) 4. Boring backfilled to surface with clean soil on 9/3/04 5. Kd samples included off-Site nickel, off-Site uranium, off-Site thorium, on-Site VOCs, and a sample for the GTE attorneys	
125									
126									
127									
128									
129									
130									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								Asphalt Surface elevation at 145.8', first sample at 20' below reference	
1								**FILL**, brown, fine sand, some medium sand, trace coarse sand, fine to coarse gravel, and asphalt debris, dry (lithology observed from auger cuttings to 20' bgs)	
2									
3									
4								(Fill depth interpreted from adjacent borings)	
5								Brown, fine **SAND**, some medium sand, trace coarse sand, fine to coarse gravel, dry	
6									
7									
8	SP								
9									
10									
11									
12									
13									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								Brown, fine **SAND**, some medium sand, trace coarse sand, fine to coarse gravel, dry	
14									
15									
16	SP								
17									
18									
19									
20								Brown, fine to coarse **SAND**, trace fine gravel, medium dense, dry	
21			11	18	0.2	11.1	Kd		
22	SW								
23			25	32	-	-			
24								Light brown, some to trace gravel	
	SP		19	18	-	-	GT	Poorly graded **SAND**	
25	SW						Kd	Light brown, fine to coarse **SAND**, some to trace fine gravel, medium dense, dry	
26									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
27 28 29								No samples collected	
30 31	SP	░	28	18	0.0	10.4	Kd	Light brown, fine to medium **SAND**, some coarse sand and fine gravel, medium dense, dry Gravel and coarse sand grade out from 31.7-32'	
32 33 34 35 36 37 38 39								No samples collected	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								No samples collected	
40 41	SP	░	20	19	0.5	10.3	Kd	Light brown, fine to medium **SAND**, some coarse sand and fine gravel, medium dense, dry Coarse gravel/cobbles at 40.75' Fine sand, some medium sand, trace fine gravel, medium dense, moist	
42 43								No samples collected	
44	SP	░	14	17	-	-	Kd	Light brown, fine **SAND**, some medium sand, trace fine gravel, medium dense, moist	
45	SM	▥						Light brown, silty, fine **SAND**, medium dense, moist	
46 47		▥	21	19	-	-	GT	Light brown to tan	
48 49								No samples collected	
50 51	SP	░	27	22	0.4	10.5	Kd	Brown, fine to medium **SAND**, trace coarse sand and fine gravel, medium dense, moist Tan, fine sand, coarse sand and gravel grade out, occasional clay balls	
52									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
53 54 55 56 57 58 59								No samples collected	
60 61	SP	░	20	13	0.2	10.4		Tan, fine **SAND**, intermittent clay, medium dense, moist	
62 63 64 65								No samples collected	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								No samples collected	
66									
67									
68									
69		▨						Tan, fine **SAND**, medium dense, moist	
70		▨	27	24	0.6	NA	Kd		
71	SP	▨						Tan to light brown, fine to medium sand, trace silt, dense, moist	
72		▨	46	24	-	-	GT		
73								No samples collected inferred groundwater level	
74	▼								
75									
76									
77									
78									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
79–80			69	0	-	-		No recovery	
81–82								No samples collected	
83–84			46	0	-	-		No recovery	
85–87								No samples collected	
88–89			-	0	-	-		No recovery (piston sample attempt)	
90–91								No samples collected	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
92 93								No samples collected	
94								No recovery	
95 96 97	SM		43 53	<2 12	0.0 0.0	- -	GT	Light brown, silty, fine to medium **SAND**, some coarse sand, wet	
98								No samples collected	
99 100 101	SM		76	4	0.0	-		Light brown, silty, fine to medium **SAND**, some coarse sand, wet	
102								No samples collected	
103 104			93	0	-	-		No recovery	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
105 106								No recovery	
107 108								No samples collected	
109 110	SM		51	8	0.0	-		Light brown, silty, fine to medium **SAND**, some coarse sand and fine gravel, wet	
111 112								No samples collected	
113 114 115 116 117	SM		47	12	0.0	-	Kd	Light brown, silty, fine to coarse **SAND**, wet	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD2
Date Drilled: 9/20/04
Sampler Type: 3-inch split spoon driven by 300-lb hammer / Shelby tube / piston sampler
Logged By: Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
118	SM	▦	51	11	0.0	-	Kd	Light brown, silty, fine to coarse **SAND**, wet	
119	EOB							NOTES: 1. Boring completed to 118.9' bgs on 9/23/04 2. Groundwater estimated at 74' bgs during drilling 3. Casing and hollow stem auger removed and boring backfilled with clean soil on 09/24/04 4. Kd samples include off-Site nickel, off-Site uranium, off-site thorium, on-Site VOCs, and GTE attorney samples 5. GT, geotechnical samples; samples analyzed for particle size distribution, hydraulic conductivity, total organic carbon, specific gravity, and percent moisture. The sample at 94.5-98.7' bgs was analyzed for particle size distribution and percent moisture.	
120									
121									
122									
123									
124									
125									
126									
127									
128									
129									
130									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
16 17 18 19								**BACKFILL** Soil previously excavated to 20' bgs and backfilled Surface elevation at 142', first sample at 20'	
20 21	SW		14	14	0.0	-		Dark tan, fine to coarse **SAND**, some fine to coarse gravel, medium dense, moist	
22	SP							Tan, fine to medium **SAND**, medium dense, moist	
23	SW		25	22	0.1	-	Kd	Tan, fine to coarse **SAND**, medium dense, moist	Lithological observations and field readings limited on geotechnical samples due to their being encased almost entirely in sample tubes. USCS classification of geotechnical samples are based on laboratory results.
24 25	SP		10	20	-	-	GT	Tan, fine to medium **SAND**, medium dense, moist	
26 27 28								No samples collected	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
29								No samples collected	
30	SP	▨						Tan, fine to medium **SAND**, medium dense, moist Brown, some fine gravel, trace silt	
31	SW	░	12	18	0.1	-	Kd	Tan, fine to coarse **SAND**, trace fine gravel, medium dense, moist	
32 33 34 35 36 37 38 39								No samples collected	
40 41	SP	▨	18	18	16.9	-	Kd	Tan, fine to medium **SAND**, medium dense, moist	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
42	SP	▨					Kd	Tan, fine to medium **SAND**, medium dense, moist	
43		▨	23	22	-	-	GT		
44 45 46 47 48 49								No samples collected	
50 51	SP	▨	19	19	0.0	-	Kd	Tan, fine to medium **SAND**, medium dense, moist	
52 53 54								No samples collected	

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								No samples collected	
55									
56									
57									
58									
59									
60		▨						Tan, fine to medium **SAND**, cobbles at 60', moist	NA = Not available (blow counts and/or recovery not recorded)
61		▨	NA	16	0.0	-	Kd		
62	SP	▨							
63	SP/SM	▨	NA	NA	-	-	GT		The water table depth was measured inside the auger, and is thus higher than the actual water table depth within the formation. The water table at the time of drilling lay below 71 ft bgs, as the sample collected from 69 to 71 ft was moist, not wet.
64								No samples collected	
65									
66	▼							inferred groundwater level after boring completion	
67									

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								No samples collected	
68									
69		▨						Tan, fine to medium **SAND**, trace fine gravel	Borehole advanced from 69 ft to 113 ft bgs using 4-in diameter casing driven by a 300-lb hammer.
70	SP	▨	25	24	0.0	-	Kd		
71								No samples collected	
72									
73									
74									
75									
76									
77									
78									
79								No recovery	
80			88	0	-	-			

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
								No recovery	
81			130					No samples collected	
82			203						
83								No recovery	
84									
85			*						* Blow counts >100 per ft for casing from 85.25 to 89.25 ft bgs.
86								No samples collected	
87									
88									
89									
90									
91									
92									
93		▨							

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
94 95	SP		*63	8	0.0	-	GT	Light brown, fine to medium **SAND**, some silt, wet	The permeability test was not conducted at the 93-96' bgs sample
96 97 98			*66	12	0.0	-	Kd		*These 3 spoons were each over-driven 1'; the blow counts given are for the 6-18" interva lwithin the larger 3' interval.
99 100 101			75	0	-	-		No recovery	
102 103 104			*54	0	-	-			
105 106	SM		**48	4	0.0	-	GT	Light brown, silty, fine **SAND**, some medium sand, wet	**This spoon was over-driven 9"; the blow counts are for the 6-18" interval within the larger 3' interval.

Project No.: NYSDEC: V-00089-1; URS: 27010-039
Project: Kd Drilling Program/Lithological Drilling Program
Client: GTEOSI, Hicksville, NY
Log of Boring: KD4
Date Drilled: 9/24/04
Sampler Type: 3-inch/2-inch split spoon driven by 300-lb/140-lb hammer
Logged By: Aimee Clark, Carrie Olsen

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Depth (feet)	USCS Letter Symbol	USCS Lithologic Symbol	Blows/Foot (center ft only)	Recovery (in per 2-ft interval)	PID Sample Screen (ppm)	NaI 3x3 (kcpm)	Sample Type	Description	Remarks
107	SM						GT	Light brown, silty, fine **SAND**, some medium sand, wet	The permeability test was not conducted at the 104.5-107.3 bgs sample
108			NA					No recovery	
109	SW CL		***	12	0.0	-	Kd	Light brown, fine to coarse **SAND**, trace silt and fine gravel, clay/silt seam at 109.75', wet	***Spoon was rotated into formation in an attempt to increase sample recovery. However, after spoon was rotated down in depth 1 ft, the spoon was sheared off the rods. The sheard spoon was recovered, and the 1-ft interval pf material inside it was used for Kd testing.
110			NA					No recovery	
111 112	SM		NA	8	0.0	-		Light brown, silty, fine to coarse **SAND**, trace fine gravel, wet	
113			NA					No recovery	
114 115			NA	0	-	-			
116 117 118 119									

NOTES:
1. Boring completed to 115.5' bgs on 9/30/04
2. Groundwater depth estimated at 74' bgs during drilling
3. Boring backfilled with clean soil on 9/30/04
4. Kd samples included off-Site nickel, off-Site uranium, off-Site thorium, on-Site VOCs, and a sample for the GTE attorneys
5. GT, geotechnical samples; samples analyzed for particle size distribution, hydraulic conductivity, total organic content, specific gravity, and percent moisture.