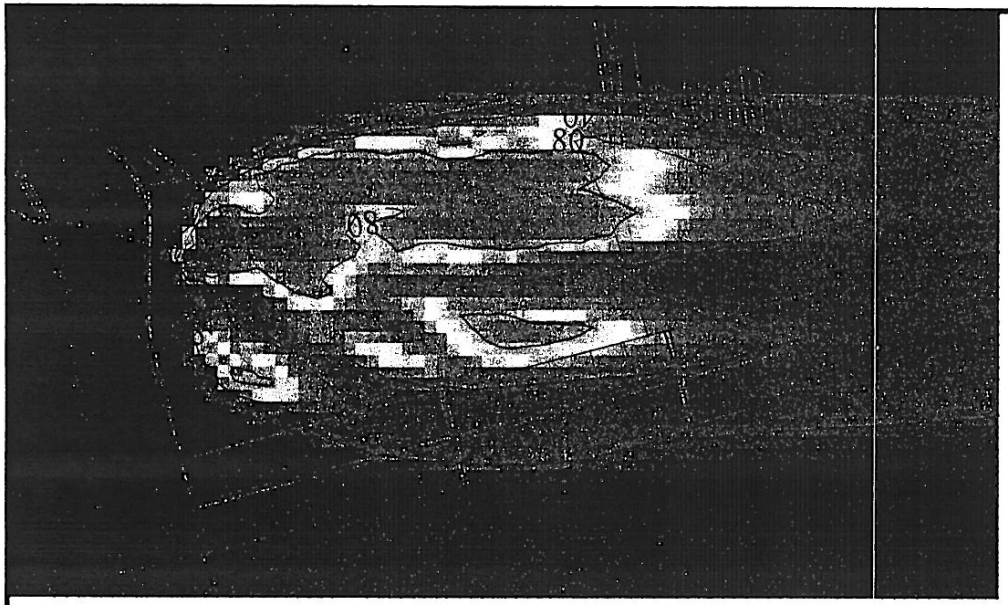
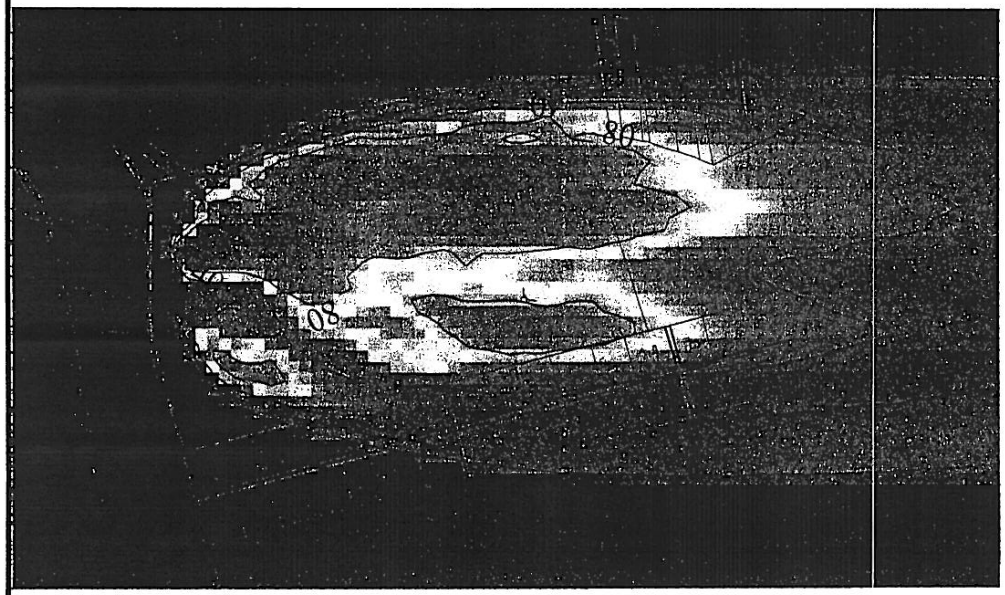


Storage Coefficient of 0.15



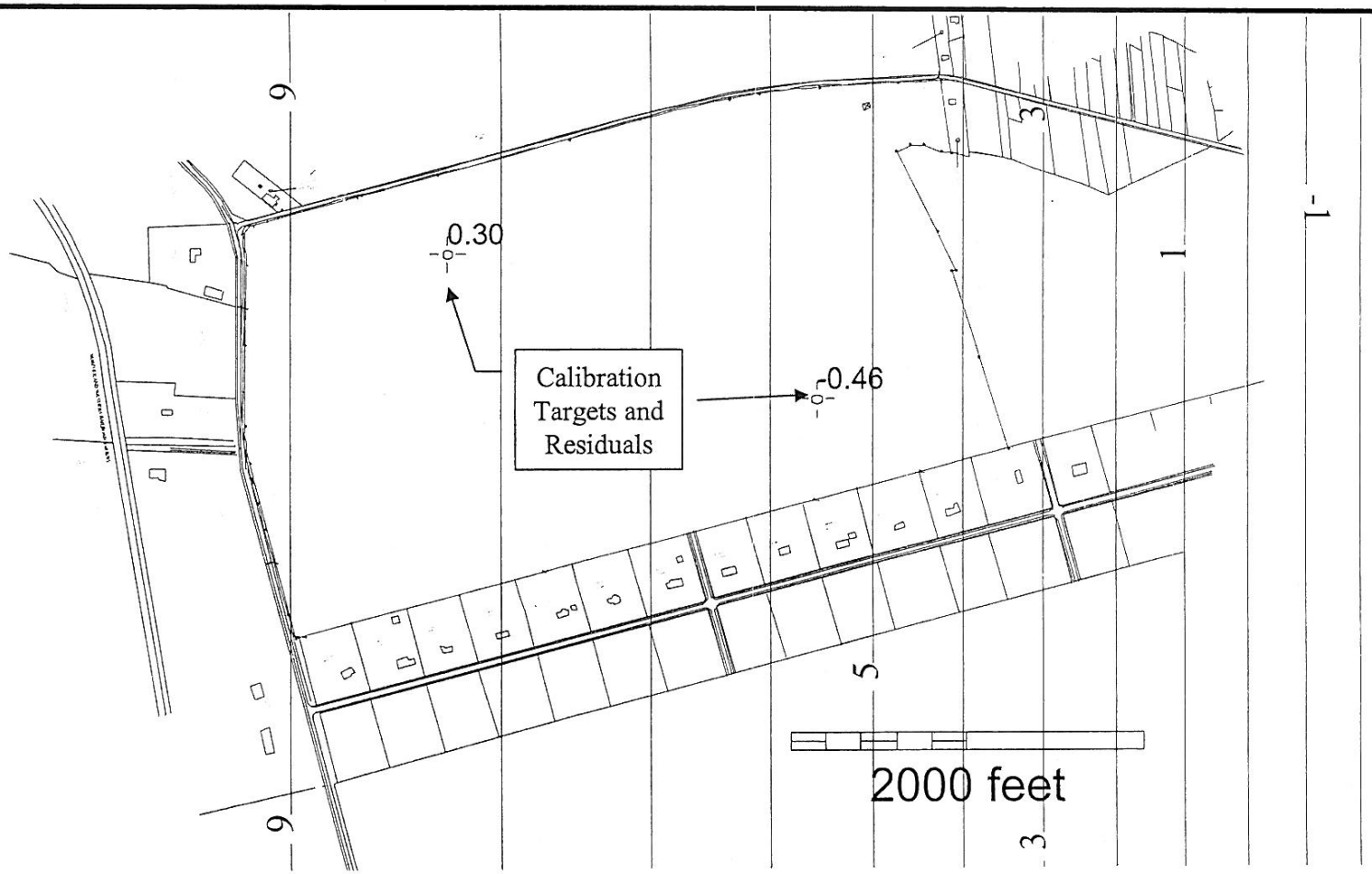
Storage Coefficient of 0.30

Contours are of percent of the initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-5
30-Year Preliminary Simulation
Sensitivity of Storage Coefficient Value

URS



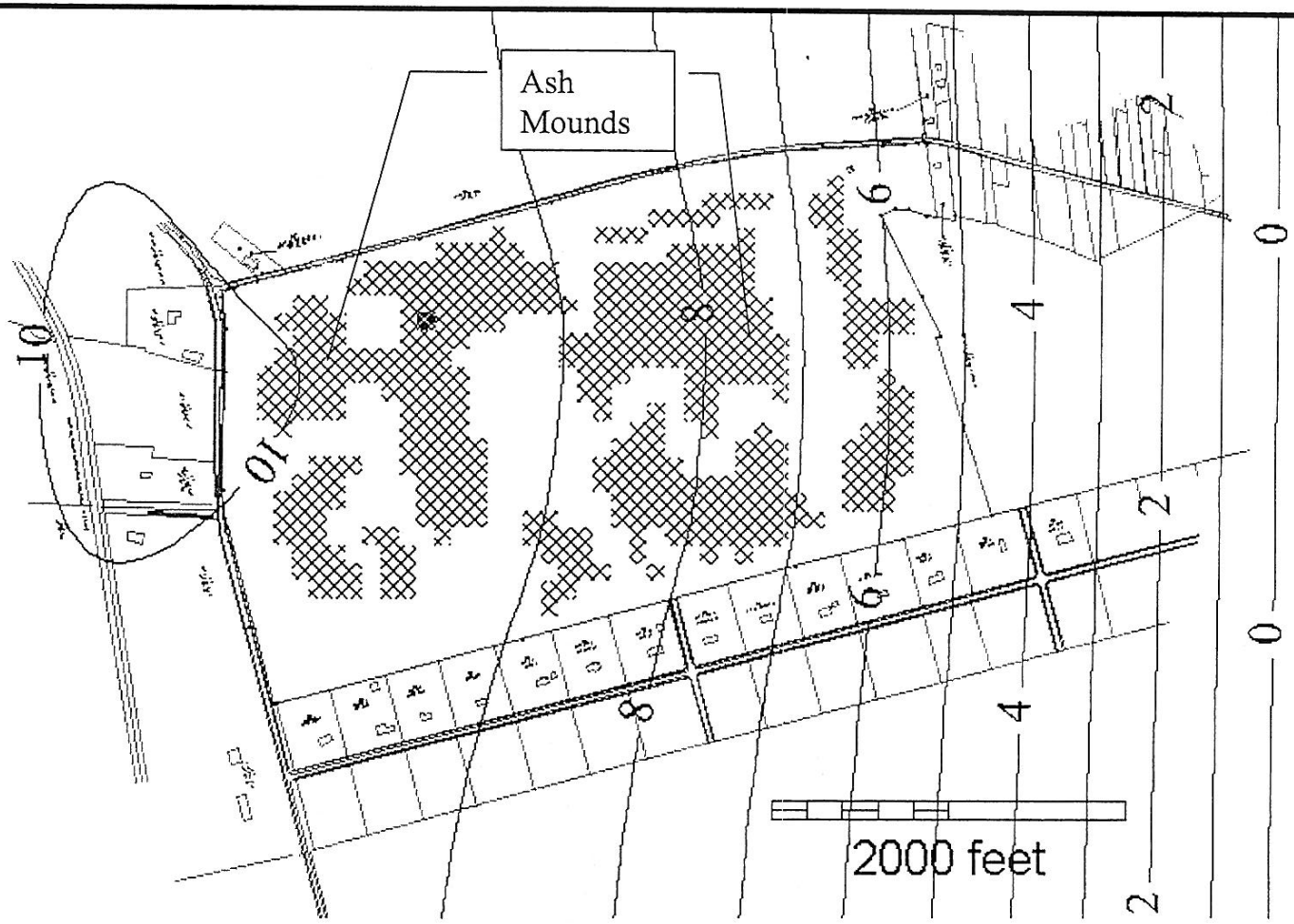
Contours are of simulated groundwater surface in feet above an arbitrary elevation.

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-6
MODFLOW Simulated Groundwater Surface and Calibration Residual

URS

20331



Contours are of simulated groundwater surface in feet above an arbitrary elevation.

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-7
MODFLOW Simulated Ash Placement in Mounds - Groundwater Surface

URS

20332

Contours are of percent initial leachate concentration

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Chesapeake Energy Center
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Figure 3-8
50-Year Preliminary Arsenic Simulation
Percent Initial Leachate Concentration

URS

Contours are of percent initial leachate concentration

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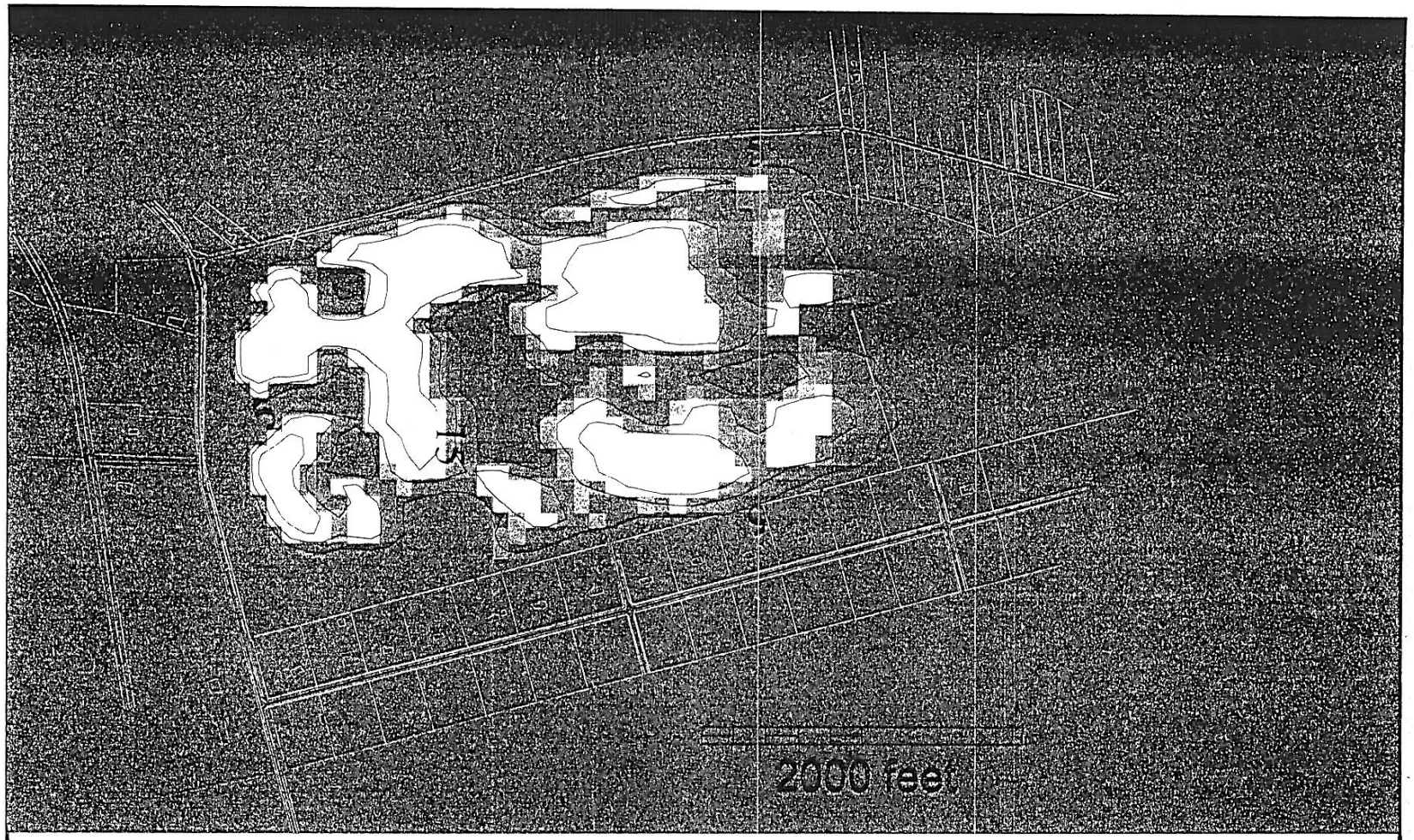
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-9
100-Year Preliminary Arsenic Simulation
Percent Initial Leachate Concentration

URS



Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-10
150-Year Preliminary Arsenic Simulation
Percent Initial Leachate Concentration

URS

Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-11
250-Year Preliminary Arsenic Simulation
Percent Initial Leachate Concentration

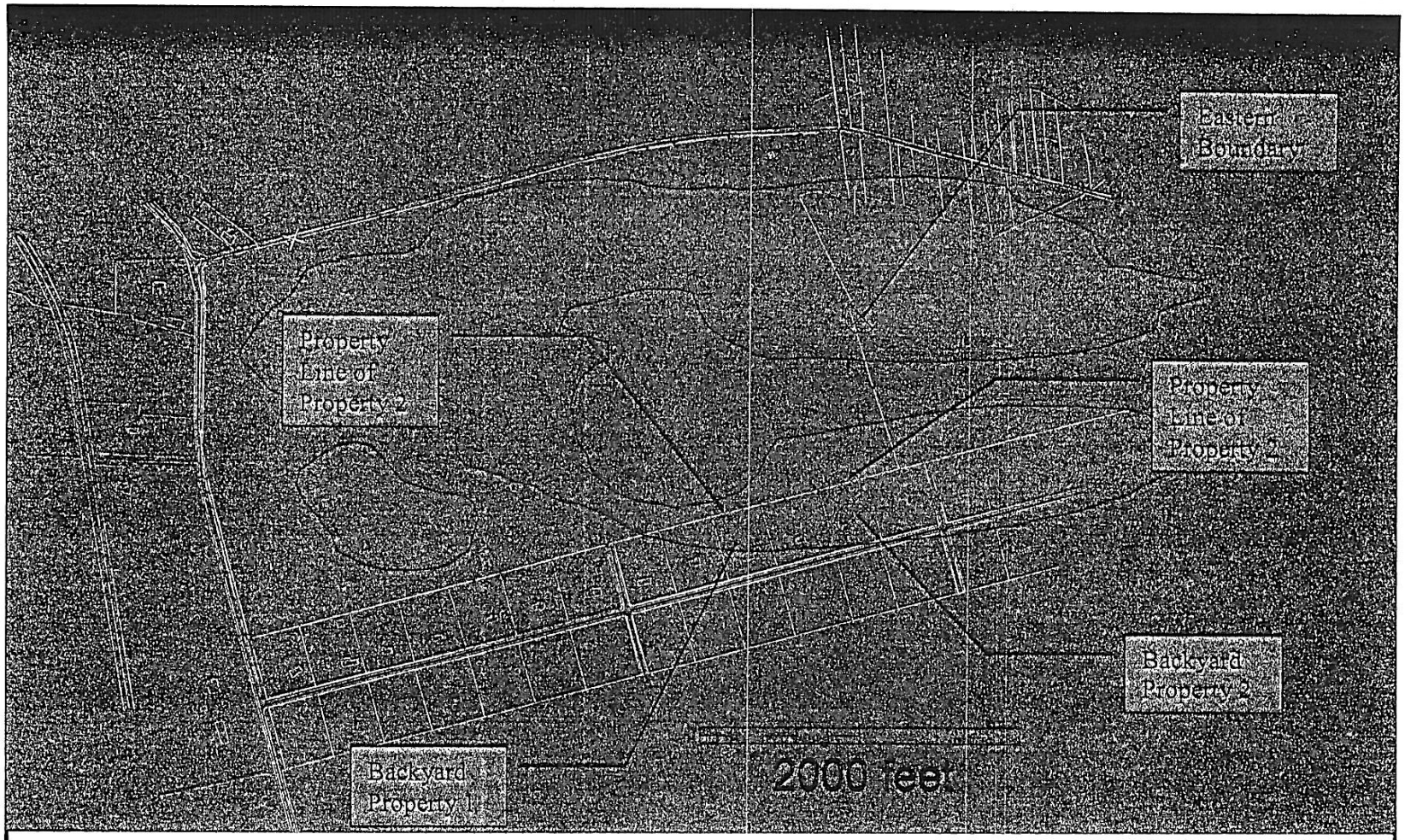
URS

Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-12
500-Year Preliminary Arsenic Simulation
Percent Initial Leachate Concentration

URS



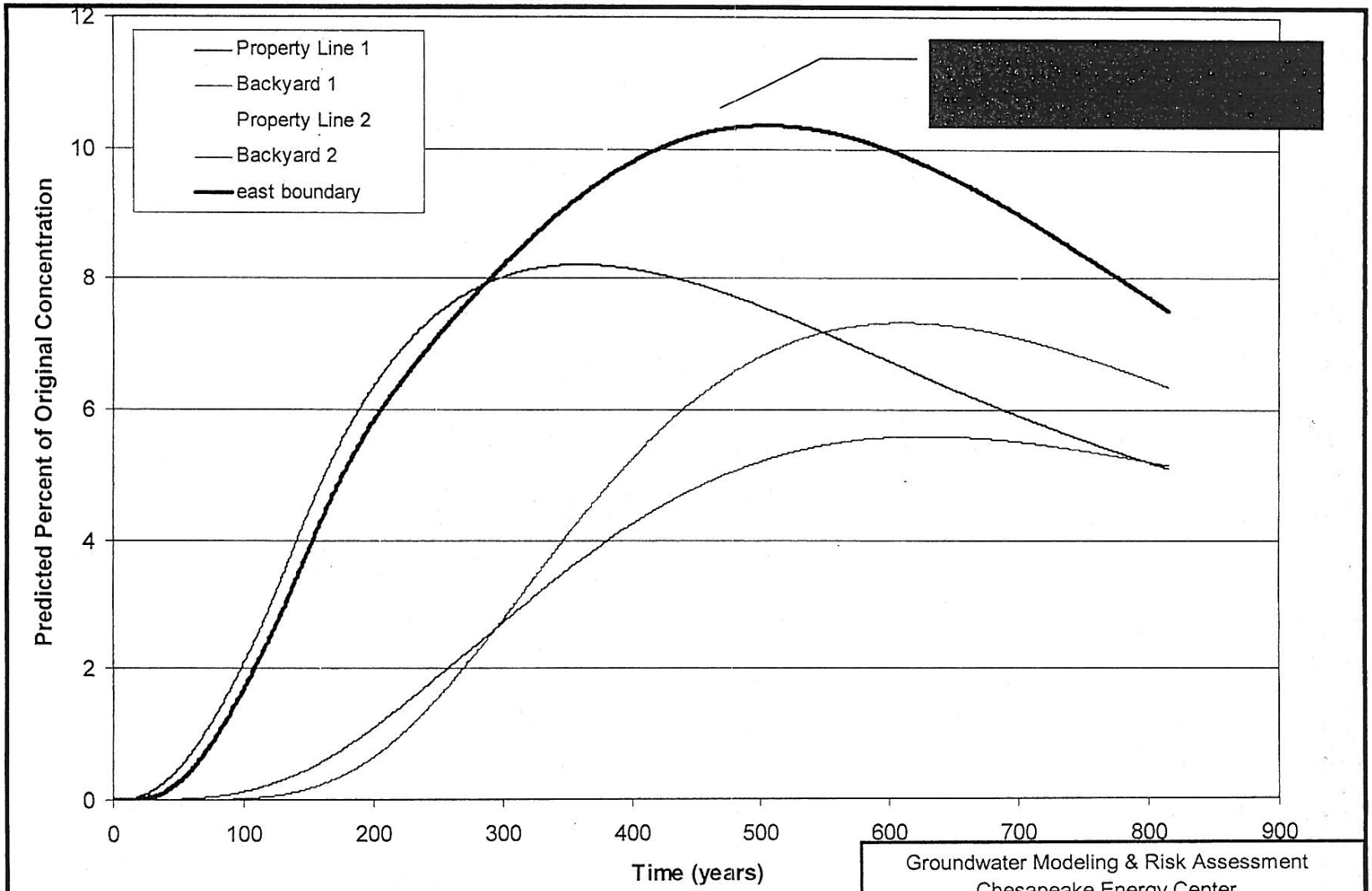
Break-through curves for the above locations are shown on Figure 3-14.

Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-13
750-Year Preliminary Arsenic Simulation
Percent Initial Leachate Concentration

URS

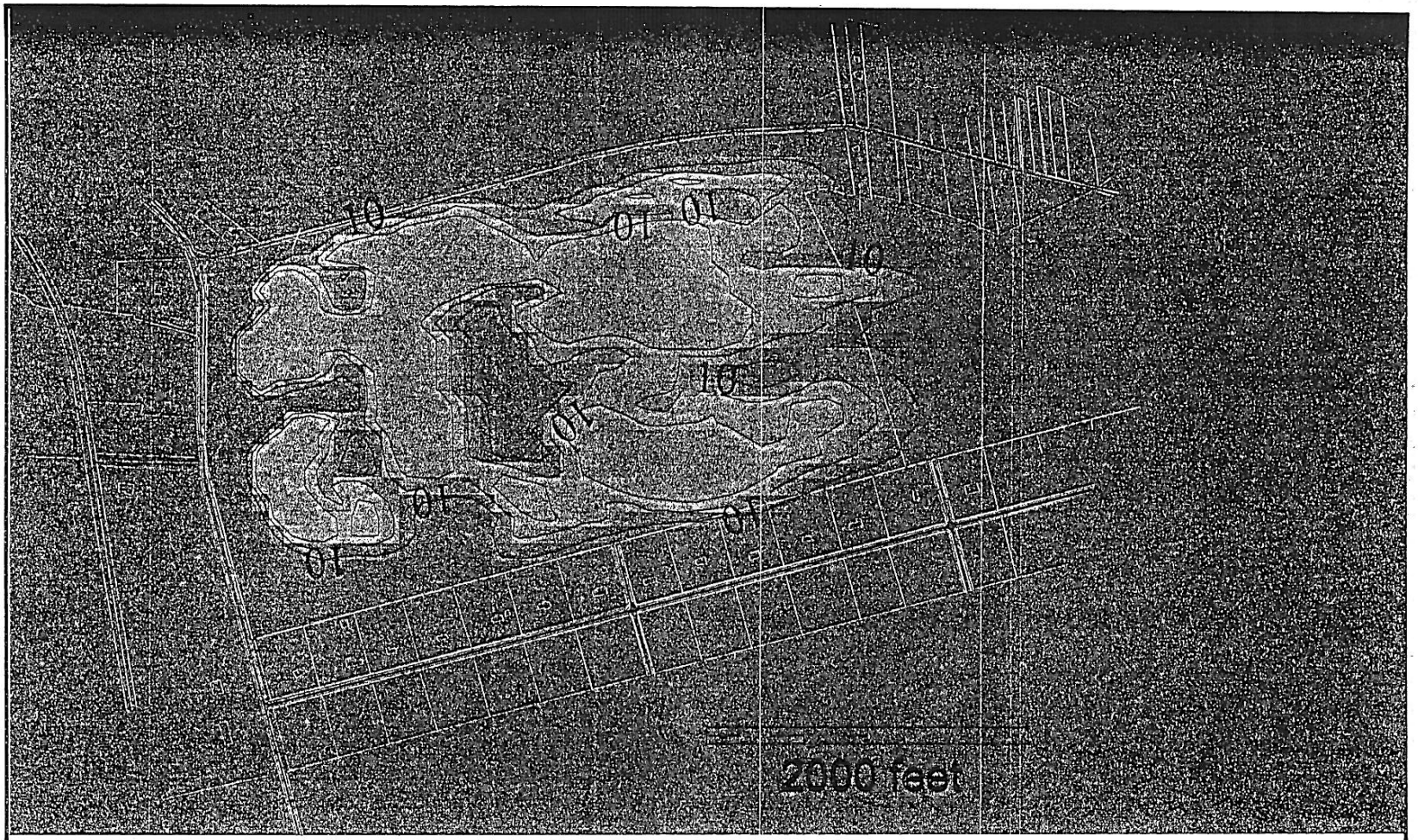


Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-14
Breakthrough Curve of Percent Initial Leachate Concentration of Arsenic

URS

20339



Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-15
50-Year Preliminary Selenium Simulation
Percent Initial Leachate Concentration

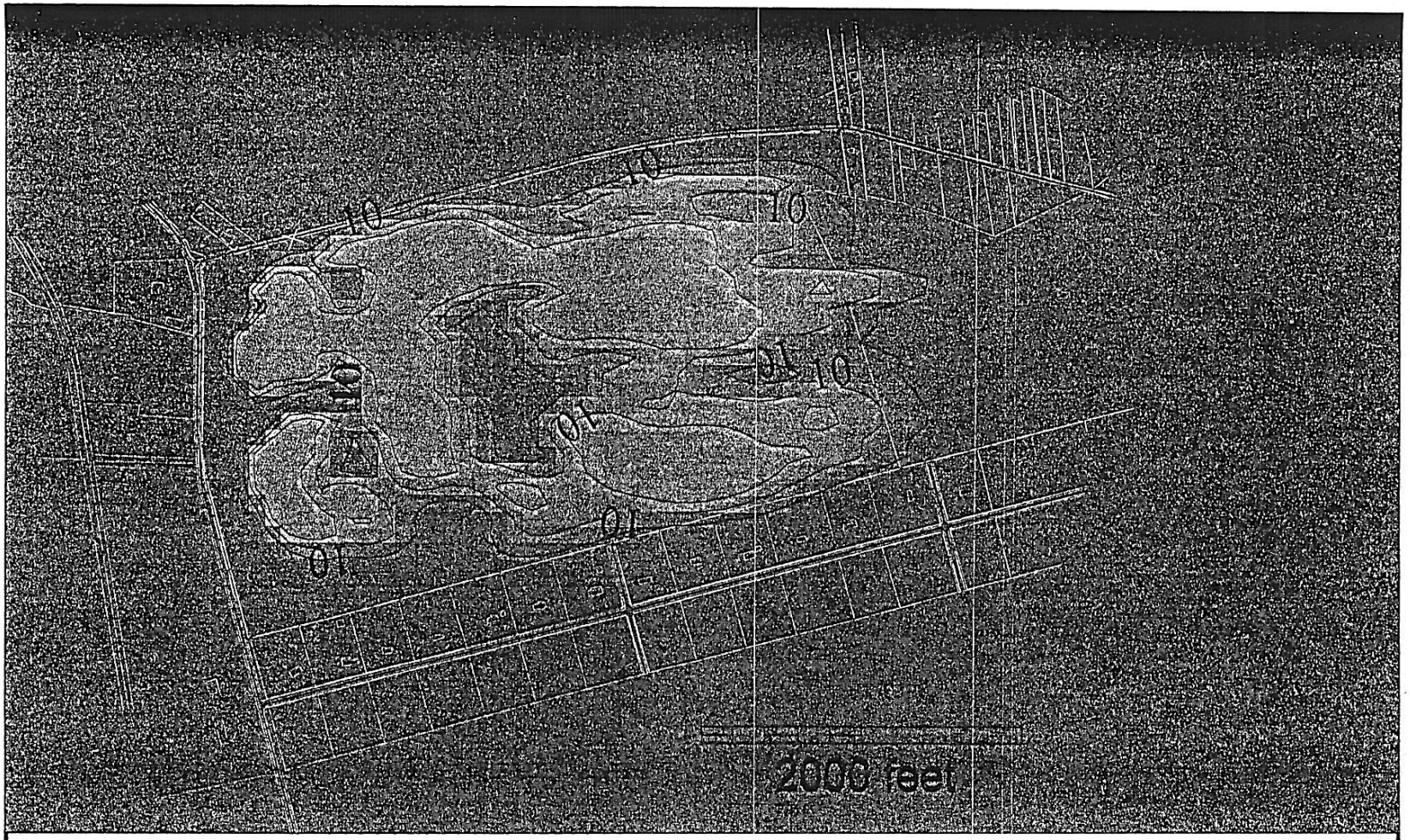
URS

Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-16
100-Year Preliminary Selenium Simulation
Percent Initial Leachate Concentration

URS

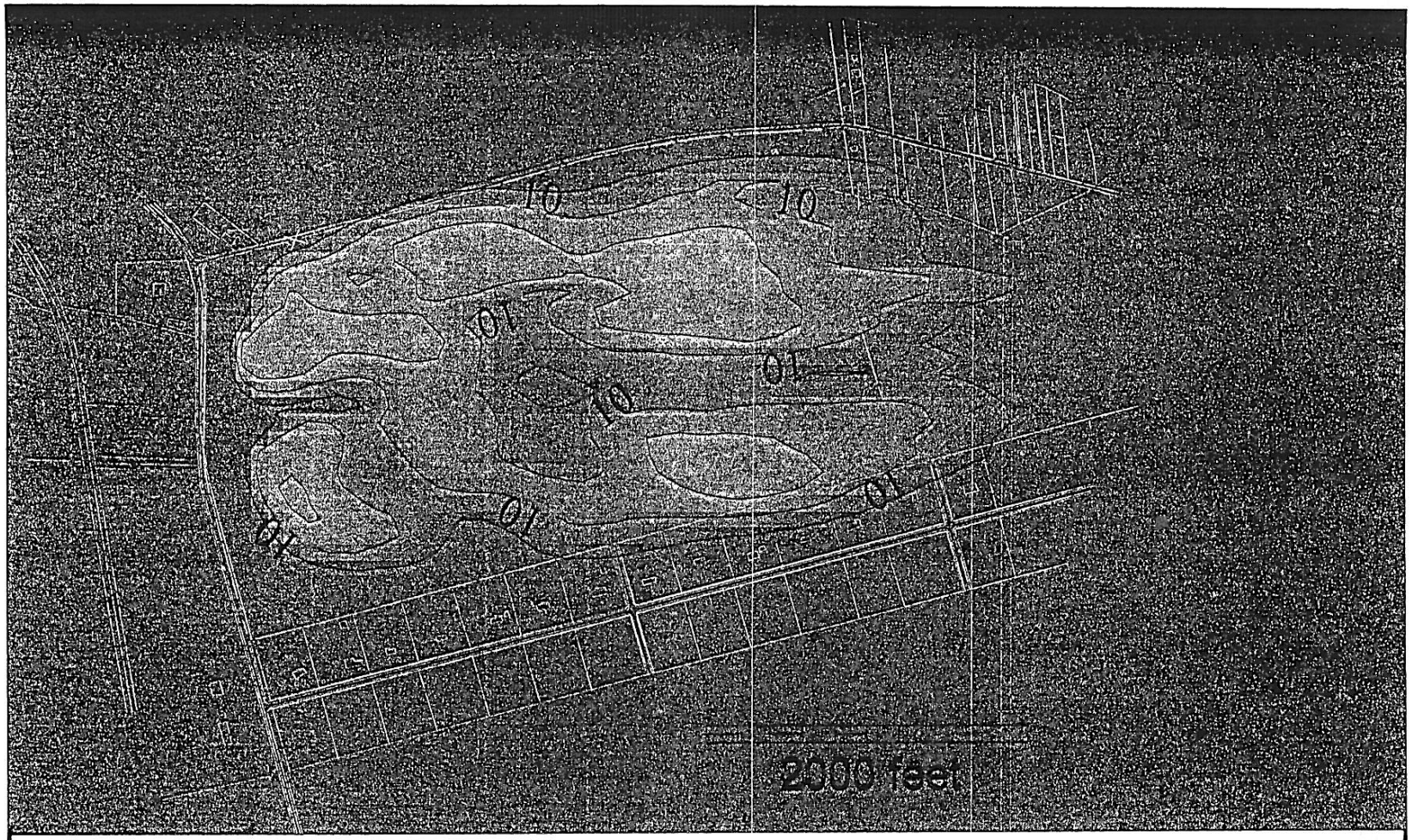


Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-17
150-Year Preliminary Selenium Simulation
Percent Initial Leachate Concentration

URS

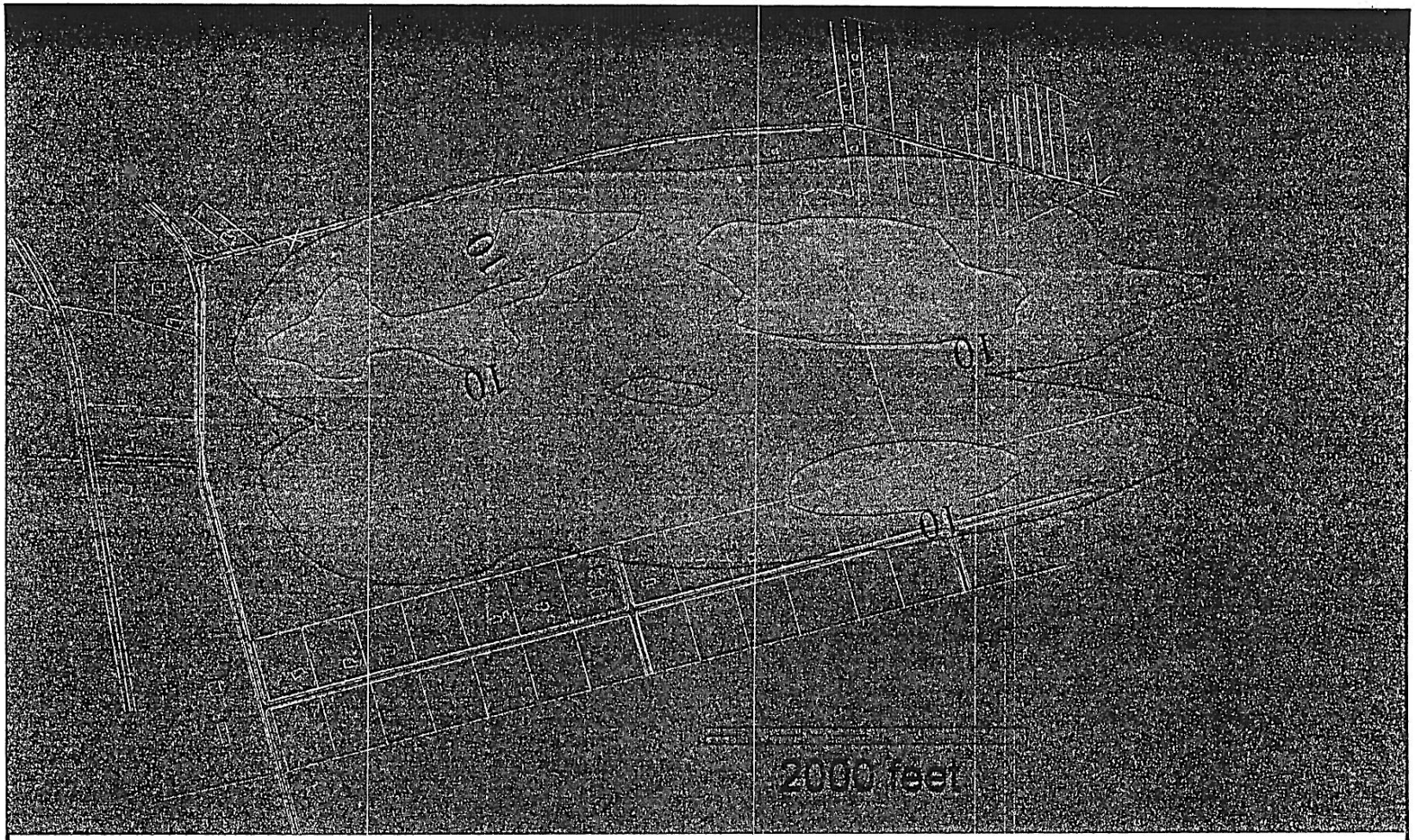


Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-18
250-Year Preliminary Selenium Simulation
Percent Initial Leachate Concentration

URS

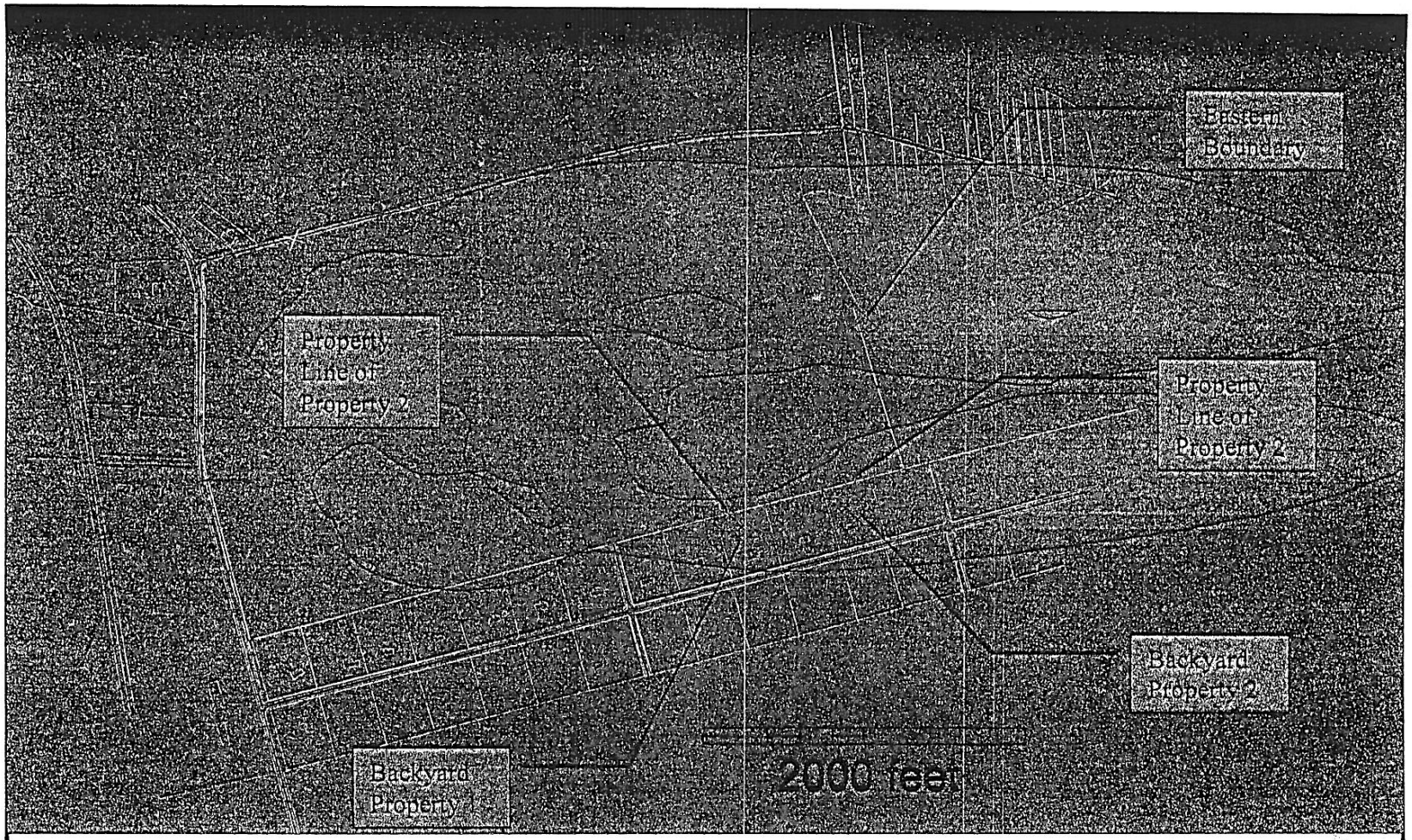


Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-19
500-Year Preliminary Selenium Simulation
Percent Initial Leachate Concentration

URS



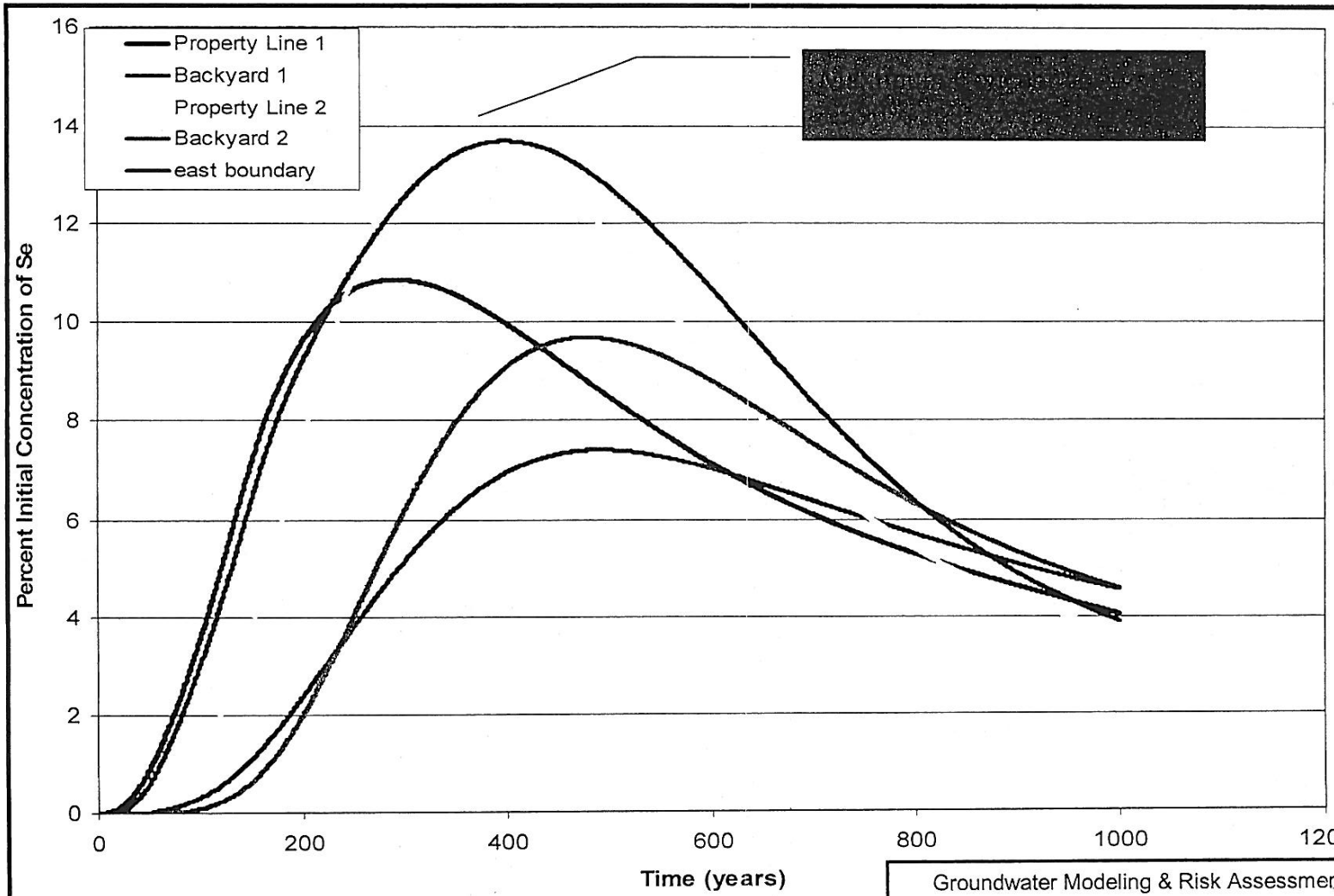
Break-through curves for the above locations are shown on the next figure.

Contours are of percent initial leachate concentration

Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-20
750-Year Preliminary Selenium Simulation
Percent Initial Leachate Concentration

URS



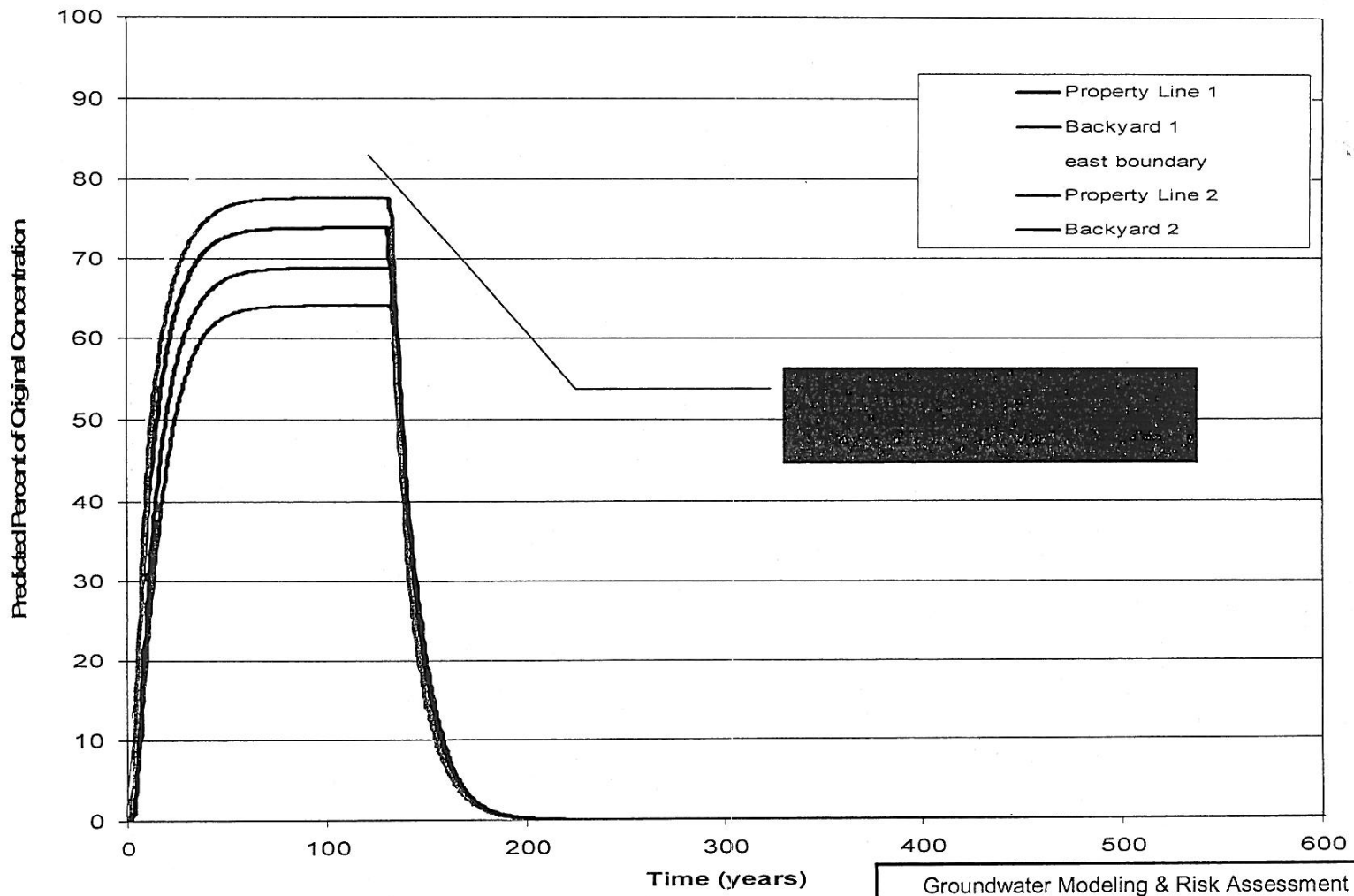
Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-21
Breakthrough Curve of Percent Initial Leachate Concentration of Selenium

URS

Contours are of percent initial leachate concentration

20346

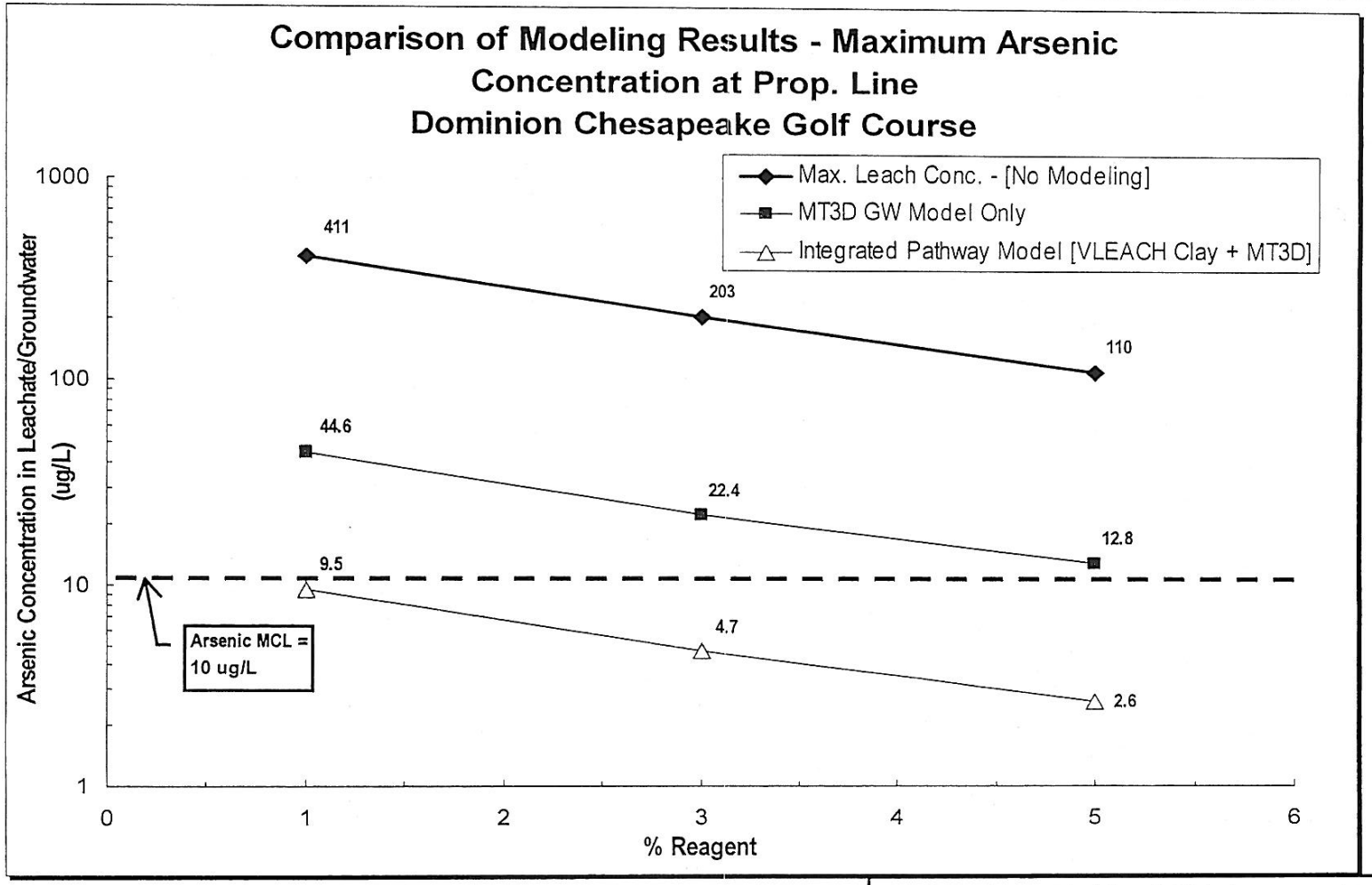


Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-22
Breakthrough Curve of Percent Initial Leachate Concentration w/Kd=0, 130 yr Source

URS

20347

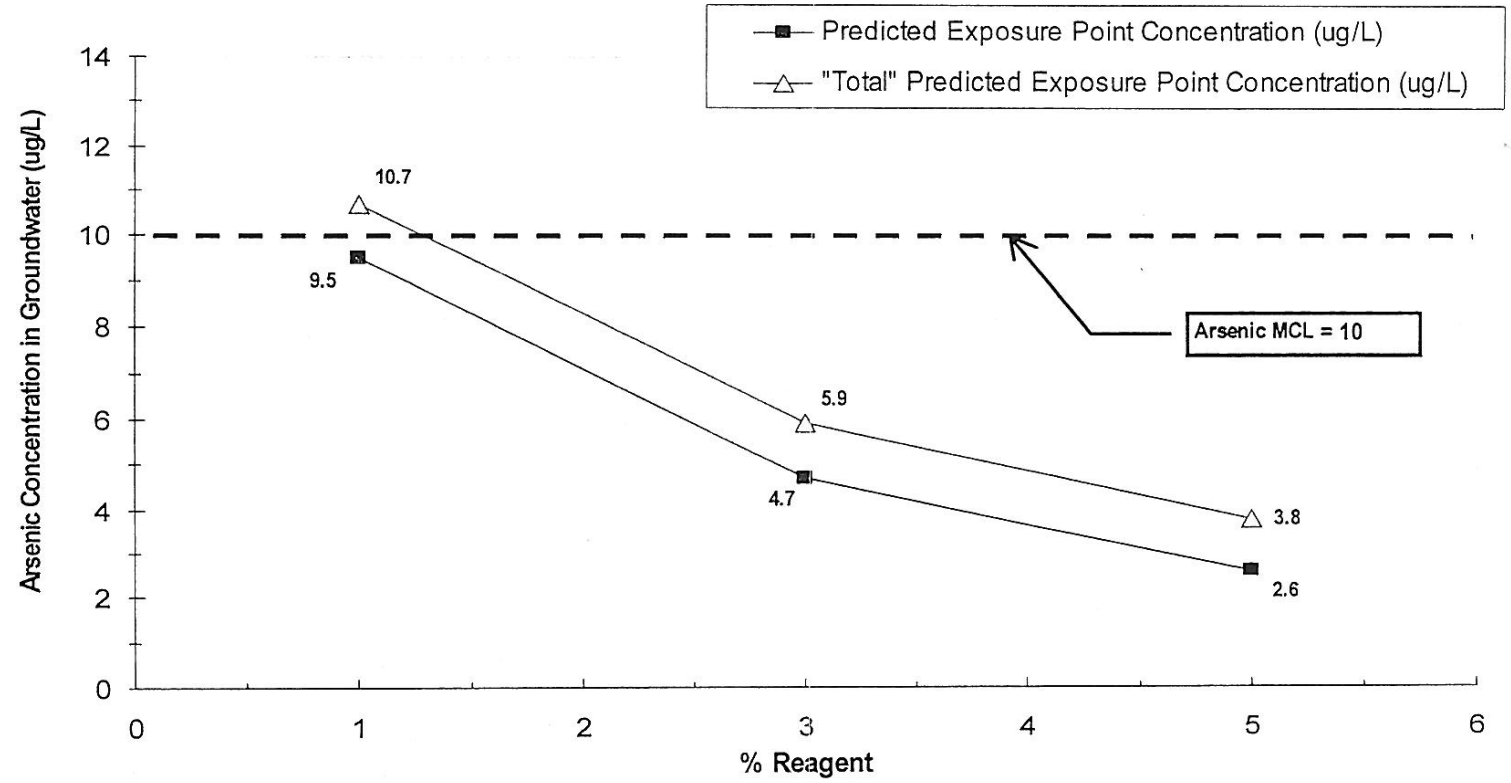


Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 3-23

URS

20348

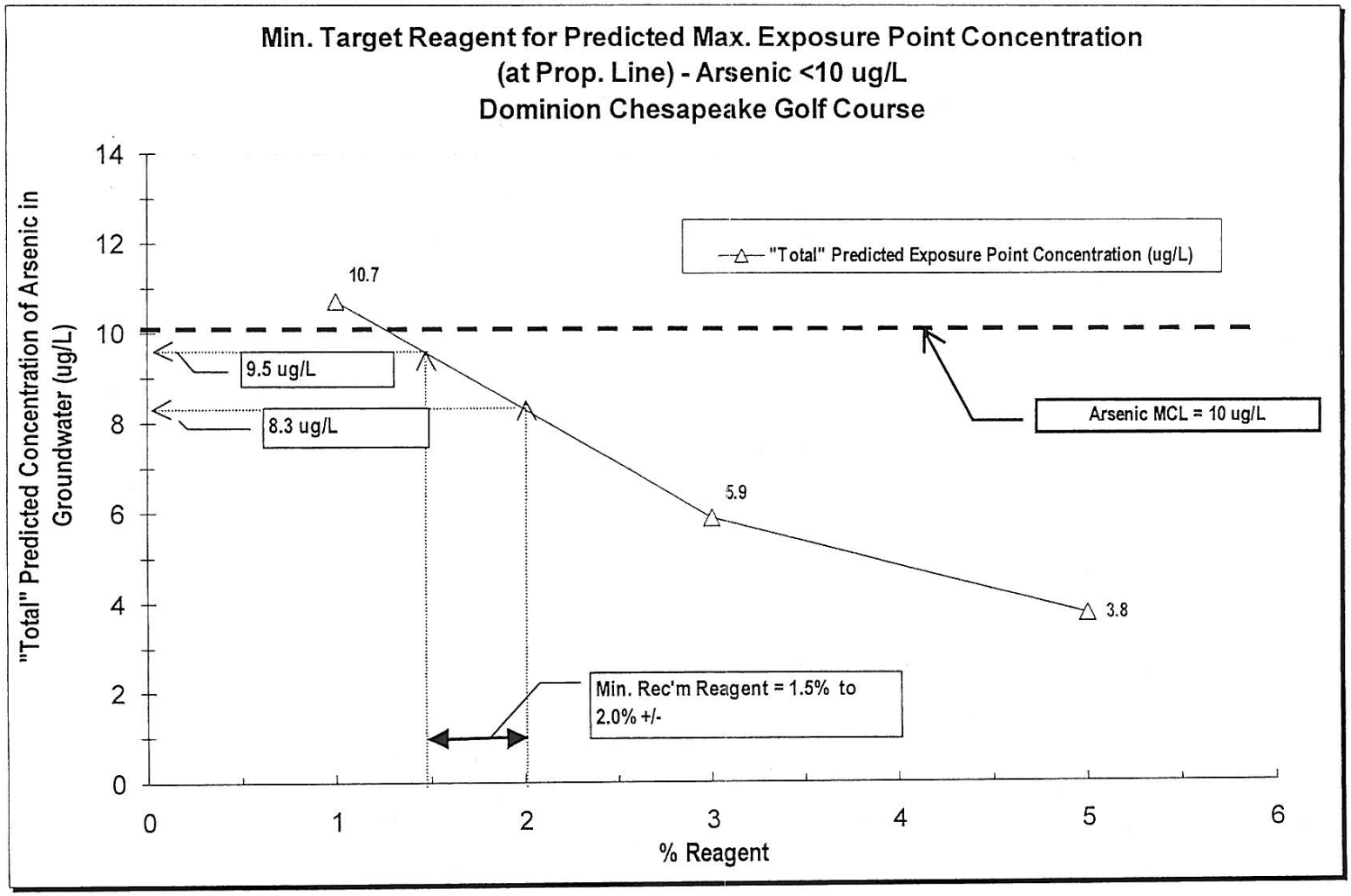


Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 4-1

URS

20349



Groundwater Modeling & Risk Assessment
Chesapeake Energy Center
Proposed Golf Course Project

Figure 5-1

URS

20350

20351

GAI CONSULTANTS

Report

PREDICTED IMPACTS TO GROUND WATER RESULTING FROM THE BENEFICIAL USE OF AMMONIA-CONTAINING FLY ASH ETHERIDGE GREENS GOLF COURSE PROJECT CHESAPEAKE, VIRGINIA

Submitted To: Dominion Virginia Power
Glen Allen, Virginia

Project 2002-466-10

May 2003

Visit GAI's Web Site at www.gaiconsultants.com

20352

DOMINION VIRGINIA POWER
GLEN ALLEN, VIRGINIA

PREDICTED IMPACTS TO GROUND WATER RESULTING FROM THE BENEFICIAL USE OF AMMONIA-CONTAINING FLY ASH ETHERIDGE GREENS GOLF COURSE PROJECT CHESAPEAKE, VIRGINIA

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PROJECT 2002-466-10

MAY 2003

20353

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INTRODUCTION

Dominion Virginia Power (Dominion) currently provides ash generated at the Dominion Chesapeake Energy Center (CEC) to be used beneficially as fill at the Etheridge Greens Golf Course (Site) which is located in the City of Chesapeake, Virginia (Figure 1). It is anticipated that a Selective Catalytic Reduction (SCR) and/or Selective Non-Catalytic Reduction (SNCR) system will be installed and placed on line at the CEC sometime in the early part of 2003. As a result of adding the SCR/SNCR system, Dominion anticipates that the ammonia concentration on the fly ash delivered to the beneficial use site will increase from the pre-SCR/SNCR concentration of essentially zero milligrams per kilogram (mg/kg) to a post-SCR/SNCR concentration of 5 to 10 mg/kg. It is estimated that the fly ash will initially contain 50 to 200 mg/kg of ammonia at CEC. Dominion estimates that a significant portion of the ammonia will be lost to the atmosphere prior to the fly ash being hauled to the Site.

Dominion retained GAI Consultants, Inc. (GAI) to predict, by contaminant transport modeling, how the ammonia associated with the post-SCR/SNCR-generated ash may impact the ground water in the vicinity of the Site. GAI also evaluated potential health and safety impacts to workers that come in contact with and/or are involved with the transportation, preparation, or placement of the ammonia-containing fly ash.

BACKGROUND INFORMATION

Dominion previously retained URS to perform an evaluation of the potential impacts to ground water at the golf course as a result of the beneficial use of fly ash. Dominion provided GAI with a portion of the Client review report that was generated by URS (URS 2001) as a result of this investigation. Specifically, GAI was provided with Section 3, pages 3-6 through 3-20, Figure 1, Figure 3-7, Figure 3, and Appendix A (URS Boring Logs and Well Construction Diagrams) of the client review report that is dated December 19, 2001. Predicted metals concentrations contained in the report provided to GAI were blacked out as part of Dominion's confidentiality program.

Major components of the URS investigation included computer modeling to determine water infiltration rates, unsaturated zone contaminant transport modeling, and ground water flow and transport modeling. Contaminants considered during the URS investigation included metals such as arsenic, selenium, and chromium. GAI used pertinent information from the URS study in this investigation. Pertinent information includes:

- recharge rate for the unsaturated zone - 43 centimeters per year (cm/yr);
- soil porosity - 38 percent;
- soil bulk density - 1.65 kilograms per liter (kg/L);
- aquifer type - Unconfined;
- aquifer effective porosity (storativity) - 15 to 30 percent;
- aquifer hydraulic conductivity - 0.000085 to 0.027 centimeters per second (cm/s);

- aquifer hydraulic gradient - 0.0016 to 0.00035 feet per feet; and
- depth to ground water - three to seven feet below existing ground surface.

The above-listed data along with additional data that is described in subsequent sections of this report were used to predict potential impacts to ground water at the Site. Specifically, ammonia transport in the unsaturated zone and in the saturated zone was evaluated as part of the transport modeling portion of this investigation.

FATE OF AMMONIA IN THE ENVIRONMENT

The majority of the ammonia associated with the SCR/SNCR-generated fly ash is expected to exist as ammonium salts, predominately ammonium sulfate and bisulfate (ammonium sulfates), that are physically absorbed on the fly ash. When water comes in contact with the ammonium sulfates, they are expected to dissolve, resulting in an increase in the aqueous concentration of nitrogen-containing compounds.

Ammonia in aqueous solutions can be transformed/removed in a number of pathways. At elevated pH values (i.e., higher than 9), ammonia gas will readily be lost from solution [GAI (2000) and Bittner, et al. (2001)], thus removing a significant amount of nitrogen from the aqueous environment. The rate of ammonia gas loss from water to the atmosphere is primarily controlled by pH, temperature, and wind speed. An increase in any one of these three variables generally translates to an increase in ammonia loss to the atmosphere. The beneficially used fly ash will be mixed with cement kiln dust and lime kiln dust which is anticipated to achieve a pH for the fly ash/kiln dust mixture ranging from 11 to 12 standard pH units. Assuming that there is ample water available during the mixing process to allow for the dissolution of the ammonium sulfates, it is expected that much of the ammonia (total nitrogen) will be lost to the atmosphere during this process.

Any ammonia remaining adsorbed on the fly ash or dissolved in the pore water of the fly ash/cement kiln dust mixture will be available for transport in the environment. The dominant form of nitrogen in oxidizing ground water is nitrate (Freeze and Cherry, 1979). Because the systems considered in this investigation are relatively shallow, it is assumed that the soil pore water and the ground water are oxidizing, and the dominant

form of dissolved nitrogen is nitrate. That is, all ammonia (nitrogen) that is dissolved from the ash by soil pore water exists in the form of nitrate.

Soil consists of numerous negatively charged mineral and organic particles. A measure of the total negative charge in a particular soil is referred to as the cation exchange capacity. As a result of the cation exchange capacity, most soils have the ability to absorb positively charged particles or ions (Gerwing and Gelderman, 1997). Nitrate, however, is a negatively charged ion (anion), and therefore, has no affinity for the negatively charged soil particles. As a consequence, nitrate dissolved in water moves through a porous media without retardation [Meints and Vitosh (1990), Freeze and Cherry (1979)]. For this reason, nitrate is considered a conservative parameter in the subsurface. That is, nitrate is not retarded in a subsurface environment, and it is assumed to move at the same rate at which water moves in the subsurface.

TRANSPORT MODELING

Unsaturated Zone Transport Modeling

Source Concentration

As stated previously, Dominion estimates that the beneficially used fly ash will have an ammonia concentration that ranges from 5 mg/kg to 10 mg/kg at the Site. GAI has evaluated potential environmental impacts using the upper concentration (10 mg/kg) within this range as the source concentration. As noted previously, it is assumed that all ammonia dissolved in water and available for transport in the subsurface will be in the form of nitrate. The equivalent nitrate concentration to 10 mg/kg ammonia is 8.3 mg/kg as N. This concentration, 8.3 mg/kg nitrate as N, is used as the source concentration.

Method

Transport modeling in the unsaturated zone was conducted to predict the ammonia (dissolved nitrogen) concentration at the water table resulting from the beneficial use of ammonia-containing fly ash. A model developed by the Pennsylvania Department of Environmental Protection (PaDEP), BUFFER1 (PaDEP, 2002a) was used for this task. BUFFER1 computes contaminant transport based on depletion or mass balance of the contaminant as it moves through the contaminated soil and the underlying uncontaminated soils. The following assumptions apply to this model:

- the unsaturated soils are homogeneous and isotropic;
- flow of water vertically through the unsaturated zone is uniform;
- contaminant movement occurs only in the vertical direction;

- contaminant concentrations are not so high that they affect the flow of water in the unsaturated zone;
- multiple contaminants act independently of each other; and
- for any species in soil, the relationship between the concentration "sorbed" and the aqueous concentration remains linear irrespective of concentration.

BUFFER1 requires the input parameters that are specified in Table 1. Based on the text in the URS report, it is estimated that the ammonia-containing fly ash will be placed at a thickness of approximately five feet and the base of the ammonia-containing fly ash will be approximately five feet above the water table. Source concentrations were discussed previously. Other required input parameters, with the exception of the apparent partition coefficient, are physical parameters which require no explanation. The apparent partition coefficient is the ratio of total contaminant concentration to leachable contaminant concentration. The apparent partition coefficient is a value that is proportional to the degree to which processes such as adsorption retard the migration of a particular contaminant. Because nitrate is a conservative parameter, an apparent partition coefficient of one was used in the BUFFER1 model. Use of an apparent partition coefficient of one results in the pore water and the soil having the same concentration within the source area throughout the simulation.

Results

Output from BUFFER1.xls using a nitrate source concentration of 8.3 mg/kg is provided in Appendix A. A graph showing predicted nitrate concentrations in soil pore water over time is provided as Figure 2. The results show that at a depth of five feet

below the base of the beneficially used fly ash, the aqueous concentration of nitrate in the soil pore water will reach a maximum concentration of approximately 6 mg/L as N. This maximum concentration occurs approximately 9 years after the fly ash is placed at the Site. Results also show that nitrate concentrations will be above background concentrations (assumed to be 1 mg/kg) in shallow ground water for a period of approximately 17 years at the Site.

Saturated Zone Transport Modeling

Method

An analytical contaminant transport model was used to predict nitrate transport in the saturated zone and also to predict resulting nitrate concentrations at the property boundary downgradient of the Site. Based on the 2001 URS report, ground water at the Site flows from the northwest to the southeast, and the distance from the placed fly ash to the property boundary that marks a property occupied by a residence (nearest receptor) is generally 450 feet or more. A Site plan showing approximate limits of fill areas, approximate ground water flow directions, and the property boundary is provided as Figure 3. This location (the downgradient property boundary) is referred to as the potential receptor and this distance (450 feet) is referred to as the target distance throughout the remainder of this document. This evaluation was conducted using QUICK DOMENICO.xls, which is available from the PaDEP (2002b). Quick Domenico is based on the analytical solution for multidimensional transport of a decaying species in ground water. This analytical solution to contaminant transport was developed by Domenico (1981), and it assumes that the aquifer is homogeneous and isotropic and also assumes that the source concentration is constant and continuous.

Required Input Parameters

Quick Domenico requires the input parameters that are specified in Table 2. The input values presented in Table 2 were used to develop the predicted nitrate concentrations that are described below. The predicted nitrate concentrations are based on input parameters that are thought to represent average conditions at the Site. The source concentration used in QUICK DOMENICO equaled the predicted soil pore water concentration at a depth of five feet below the base of the beneficially used fly ash from the BUFFER1 model. The geometry of the source was estimated based on the expected placement of the fly ash. Dispersivity values were estimated based on the information provided in Domenico and Schwartz (1990). For organic compounds that are not biodegradable or at sites where biodegradation is not occurring, a Lambda value of zero is used. For nitrate, which is a conservative inorganic parameter, a value of zero was used for Lambda. The physical properties of the aquifer (hydraulic conductivity, hydraulic gradient, porosity, and soil bulk density) were estimated based on the information contained in the URS report. The organic partition coefficient and the fraction of organic matter in the aquifer were set to zero and 0.005, respectively, so that the model considered no retardation of nitrate.

Forward Modeling

Forward modeling is the process of solving the inverse of the problem normally evaluated by modeling. The normal problem, described above, consists of predicting downgradient concentrations in ground water based on specified input parameters and a constant source concentration. The forward modeling problem determines what source concentration is required to result in a specified ground water concentration at a

specified time and location downgradient of the source. For this investigation, the forward modeling problem evaluated the minimum source concentration required to produce a ground water concentration greater than the maximum contaminant level (MCL) of 10 mg/L nitrate as nitrogen at the target distance and at a time of 17 years. The MCL has been promulgated by the United States Environmental Protection Agency (USEPA, 2002) and it is the highest level of nitrate as allowed in drinking water by the USEPA.

Sensitivity Analysis

The sensitivity of the model to major input parameters was evaluated by performing a sensitivity analysis. The sensitivity analysis was conducted by varying the input parameters by 20 percent, either up or down so that the resulting predicted nitrate concentration increased, and determining how this variation impacted the predicted nitrate concentrations at a specified time and at a specified location.

Results

Output from QUICK DOMENICO is provided in Appendix B and predicted nitrate concentrations at the receptor location are summarized in Table 3. Predicted nitrate concentrations were compared to the MCL for nitrate as N of 10 mg/L. The predicted concentrations presented herein are for locations directly downgradient of the source at the water table, and are based on the assumption that background nitrate concentrations in ground water are zero. The predicted nitrate concentrations do not account for above-background nitrate concentrations that originate upgradient of the model domain. The output results provided in Appendix B are given for various locations downgradient of the source.

Transport Modeling Results

Simulation results indicate that nitrate concentrations at the receptor will begin to increase above background concentrations (assumed to be less than 1.0 mg/L as N) approximately 11 years after the dissolved nitrogen reaches the water table. Predicted concentrations at the receptor 17 years after the source reaches the water table (which corresponds to the predicted time the soil pore water will be elevated above background concentrations versus distance downgradient of the source) are provided on Figure 4. At 17 years after the source reaches the water table, nitrate concentrations at the target distance are predicted to equal 3.6 mg/L. Simulation results indicate that nitrate concentrations reach a maximum, equilibrium concentration of 4.2 mg/L (Table 3) and will not exceed the MCL at the target distance and at locations downgradient of the target distance.

Forward Modeling Results

The results of the forward modeling exercise are provided in Appendix C. The results show that an aqueous nitrate as N source concentration of 21.6 mg/L is required to produce Nitrate as N concentrations greater than or equal to the MCL of 10 mg/L at a time of 17 years at the target location. A time of 17 years was selected because the unsaturated zone modeling results indicate that the pore water beneath the source area will have a concentration of Nitrate as N above background concentrations for a period of 17 years. Forward modeling using the BUFFER1 model indicates that a source concentration of 31 mg/kg Nitrate nitrogen is required to produce a soil pore water concentration of

21.6 mg/L at the water table (Appendix C). A nitrate as N source concentration of 31 mg/kg is equivalent to an ammonia concentration of approximately 38 mg/kg ammonia as N on the beneficially used fly ash. This source concentration, 38 mg/kg ammonia as N, is called the threshold concentration. Therefore, based on the forward modeling, it is concluded that source ammonia concentration of 38 mg/kg as N or less on the beneficially used fly ash will result in concentrations of 10 mg/L or less (less than the MCL) at the target distance of a 450 feet and a time of 17 years. Also source concentrations above the threshold concentration are predicted to result in nitrate concentrations in ground water at the target distance above the MCL.

Sensitivity Analysis Results

Results of the sensitivity analysis are summarized in Table 4 and the output generated by QUICK DOMENICO for the sensitivity analysis are provided in Appendix D. Based on the sensitivity analysis results, the model is very sensitive to the physical aquifer properties:

- hydraulic conductivity;
- hydraulic gradient; and
- porosity.

Because the model is sensitive to these input parameters, and because there is a range of values for these input parameters, the model was run using the maximum values shown in Table 2 for the three aquifer parameters mentioned. The resulting conservative-case predicted nitrate concentrations are shown in Table 3. Based on the conservative-case predicted concentration, at

the potential receptor location the nitrate in ground water reaches a maximum concentration of 4.2 mg/L within four years of the source reaching the water table. These results also indicate that, based on the input parameters specified herein, the nitrate concentrations in ground water will not exceed the MCL at the target location.

POTENTIAL HEALTH AND SAFETY ISSUES

Introduction

There are particular health and safety risks associated with ammonia-containing ash for personnel who will work this mixture during the transfer and distribution of the product. Fly ash containing well-absorbed ammonia as ammonium sulfate presents relatively minor risks for personnel exposure because of its stability; however, ammonia that is not well absorbed into the fly ash presents concerns related to off-gassing. As stated previously, loss of ammonia to the atmosphere from solution occurs readily at pH values above 9 standard pH units. Because the fly ash will be mixed with cement kiln dust to achieve an expected final pH of 11 to 12 standard pH units prior to placement, workers may be exposed to ammonia gas during mixing, transportation, and placement activities. Also, local residents may be exposed to ammonia gas that is transported by wind. Health concerns may become apparent when there is overexposure to ammonia largely through inhalation or direct skin contact. Ammonia serves as a severe irritant to the eyes, respiratory tract, and skin. Although not expected at the Pug Mill or at the Site, at concentrations above 300 parts per million (ppm) it may cause serious or fatal conditions evolving from severe bleeding within the respiratory tract and pulmonary function changes. Direct skin contact in large concentrations can cause skin burns and contact to the eyes may cause corneal damage and blindness.

Task Related Exposures

Individual exposures may be of concern during mixing and/or bulk transfer to mechanical devices or spreaders used for final distribution of the material at the golf course. It is mainly during these tasks that initial monitoring/screening may be

necessary to quantify the levels of ammonia present in the work zone. Additionally, depending on the proximity of the mechanical means of distribution (mixer, spreader, etc.) to the operator and other workers, exposures may also exist during final distribution as individuals pass through previously distributed areas where potential off-gassing may be occurring as part of the end-process. Secondary risks exist to a far lesser degree for silica and other carcinogenic minerals as well as particulates in the form of dusts containing heavy metals such as arsenic, beryllium, lead, nickel, or possibly cadmium, again primarily during transfer activities.

Regulatory Limits and Irritant Levels for Ammonia

The Occupational Safety and Health Administration (OSHA) has established a 50 ppm limit for ammonia as their eight-hour time-weighted average (TWA). The National Institute of Safety and Health (NIOSH) has established a Recommended Exposure Limit (REL) for ammonia of 25 ppm as their TWA and a Short-Term Exposure Limit (STEL) of 35 ppm (a value not to be exceeded for any one 15-minute period). The American Conference of Governmental Industrial Hygienists (ACGIH) has established a Threshold Limit Value (TLV) for ammonia of 25 ppm, which serves as their TLV, and a STEL of 35 ppm. All of these values relate in some ways to irritant levels or limits for the eyes, nose, and throat. Most people will react below these exposure levels or at the lower portion of these limits. Individuals will show early signs of general discomfort, tearing of eyes, irritation of the throat, and nasal passages. Again these reactions may occur at the lower ranges of the limits provided above. These early warning signs trigger the need for sampling or monitoring of the limits to gain a better understanding of the personal exposures during various work tasks.

Monitoring and Controls Methods

For workers, any irritation to the eyes, nasal passages, throat or respiratory tract should be well observed and communicated early on. Initial screening should be conducted using grab samples (colorimetric tubes) to develop a general baseline for exposure to ammonia during various tasks, especially those that present greater risks for exposure. In conjunction with this method of initial assessment, passive dosimetry may be used to establish an eight-hour TWA for workers. A baseline for exposure should be established and documented regardless of any worker symptoms that may be present during start-up activities with the beneficially used fly ash. Additional sampling methods should be employed if baseline exposures approach 50 percent of the most conservatively established limits for worker protection.

The use of basic Personal Protective Equipment (PPE) is recommended during mixing, handling, and distribution of the beneficially used fly ash. At least early on, the use of goggles is also recommended during all activities, particularly if dust is being generated in close proximity to the workers face, eyes, or breathing zone. If transfers are well controlled and dust generation is minimal, wrap around eye protection may replace the goggles as the level of protection offered. In addition, the use of impervious gloves is suggested during operations such as those that involve mixing or transfer of the materials or when there is the possibility for direct skin contact. Twelve-mil or greater nitrile, neoprene, or other non-latex impervious gloves are recommended in this case. Long sleeve shirts and pants should also be worn to further limit direct skin contact.

The use of particulate-filtering respirators (N, R, or P-95 filtering facepieces or elastomeric-facepieces equipped with similarly rated filters) should be considered until the dust generating characteristics of the material and application can be field-evaluated. Should irritation from ammonia vapors be observed, elastomeric facepiece respirators equipped with combination ammonia vapor/particulate filters are recommended. If half-face elastomeric respirators are used for this application, the use of non-vented ("gas-tight") goggles is suggested. These control methods may initially be required only during transfer of the fly ash. If exposures in excess of regulatory limits for either ammonia and/or other fly-ash components are identified, ways to limit exposure by improving the methods of transfer through various engineering controls (using, shrouds, funnels, or hoppers) should be evaluated.

SUMMARY

This analysis was conducted to predict how the beneficial use of ammonia-containing fly ash at a golf course under construction in the City of Chesapeake, Virginia, may impact ground water. The ammonia concentration of the beneficially used fly ash is unknown but it is expected to range from 5 mg/kg to 10 mg/kg at the time of placement. Prior to being placed, the fly ash will be mixed with cement kiln dust and water at CEC with the resulting mixture having a pH between 11 and 12 standard pH units. At pH values above 9, ammonia is readily lost to the atmosphere from solution. Therefore, prior to being placed, it is likely that a large portion of the SCR/SNCR ammonia absorbed in the fly ash will be lost to the atmosphere during mixing, transportation, and placement of the fly ash.

The ammonia associated with the beneficially used fly ash is expected to dissolve in water and perhaps leach into ground water where it will exist in the form of nitrate. Unsaturated zone and saturated zone transport modeling were conducted using an ammonia source concentration of 10 mg/kg to predict nitrate concentrations in the shallow aquifer at a receptor location that is 450 feet downgradient of the beneficial use Site.

Simulations indicate that nitrate will leach from the source area (the beneficial use site) for approximately 17 years. The concentration of nitrate in the soil pore water will reach a maximum concentration of 6 mg/L approximately 9 years after the fill is beneficially used at the Site. Nitrate that reaches the water table will migrate in the downgradient direction without retardation and will reach a maximum concentration of approximately 4 mg/L and will not exceed the MCL at the target distance.

Forward modeling results indicate that a source concentration of 38 mg/kg of ammonia on the beneficially used fly ash is the threshold source concentration. That is, source concentrations of ammonia of 38 mg/kg or less are not predicted to lead to nitrate concentrations in ground water at the target location above the MCL of 10 mg/L. Also, ammonia source concentrations of more than 38 mg/kg are predicted to cause nitrate concentrations in ground water at the target location that exceed the MCL.

Worker exposure to ammonia originating from the fly ash presents potential health and safety risks. This risk may be substantial because loss of ammonia to the atmosphere from solution is likely to occur when the fly ash is mixed with cement kiln dust to a final pH of 11 to 12 standard pH units. Exposure to ammonia may cause skin, eye, and respiratory tract irritation at low to moderate concentrations, and may cause a series of fatal conditions at higher concentrations. Monitoring is recommended at the workplace at the startup of the project to establish baseline exposure concentrations for the workers. Workers that mix, handle, or come in contact with the ammonia-containing ash should wear personal protective clothing until baseline exposure limits are established and a project-specific health and safety plan can be prepared and implemented.

DISCLAIMER

The services, data, and opinions of GAI performed for and expressed in this report are for the sole and exclusive use of Dominion and may not be relied upon by any other party without the express written consent of GAI. In performing this investigation, GAI has striven to conform to generally accepted principles and practices of other consultants conducting similar investigations in the same geographic area. The evaluation is limited to the specific project, property, and dates described in this report, and its findings should not be relied upon by any third party to represent conditions at other properties or at later dates. The scope of this work was mutually devised by GAI and Dominion and no activity may be assumed to be included in this investigation unless such activity is expressly considered in this report.

A model is a simplified representation of a complex physical and chemical system. Simplifying assumptions are required when conceptualizing a model problem. Modeling results inherently have uncertainty associated with them due to the underlying assumptions, numerical accuracy of the model and the uncertainty associated with the data used to perform the model simulation. Modeling results should not be interpreted as numerical absolutes but as order-of magnitude indicators of probable occurrence.

The findings of the evaluation are probabilities based on GAI's professional judgment of the Site's conditions as discernible from the limited, and often indirect, information provided by others and obtained or interpolated by GAI using the methods specified. GAI does not warranty the accuracy or completeness of information provided or developed by others and assumes no responsibility for documenting conditions detectable with methods or the techniques not specified herein. GAI's opinion regarding

the Site conditions is not a warranty that all areas within the Site and beneath the Site are of the same quality of those observed, sampled, or predicted. If additional data concerning this Site becomes available, such information should be provided to GAI so that our findings may be reviewed and modified a necessary

Respectfully submitted,
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200246610rpt-jeb/cwi116

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TABLES

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Table 1

REQUIRED INPUT PARAMETERS FOR BUFFER1

Required Input Parameter	Estimated Value	Source of Estimated Value
Recharge Rate for the Unsaturated Zone (cm/yr)	43	URS report
Soil Bulk Density (g/cc)	1.65	URS report
Water Filled Soil Porosity (fraction)	0.38	URS report
Apparent Partition Coefficient (mL/g)	1	Freeze and Cherry, 1979
Depth Increment of Model Domain (feet)	0.5	Estimated based on anticipated geometry of fill
Nitrate Source Concentration in Fly Ash (mg/kg as N dry weight)	8.3	Estimated based on anticipated ammonia slip of SCR/SNCR system

Table 2

REQUIRED INPUT PARAMETERS FOR QUICK DOMENICO

Required Input Parameter	Estimated Value	Source of Estimated Value
Source Concentration (mg/L)	6	BUFFER1 output expressed as N concentration
Distance to Location of Concern	450	Estimated based on anticipated Site geometry
Longitudinal Dispersivity (feet)	35	Domenico and Schwartz, 1990
Transverse Dispersivity (feet)	0.35	QUICK DOMENICO help Documentation
Vertical Dispersivity (feet)	0.001	QUICK DOMENICO help Documentation
Lambda (1/day)	0.0	QUICK DOMENICO help Documentation
Source Width (feet)	1000	Estimated based on anticipated Site geometry
Source Thickness (feet)	0.2 to 2, use 1	Assumed water table fluctuation
Hydraulic Conductivity (feet/day)	7.3 to 76.5, use 19.5	Average of nine values listed in the URS report
Hydraulic Gradient (feet/foot)	0.00035 to 0.0016, use 0.001	Average of maximum and minimum measured from Site plan in URS report
Porosity (decimal fraction)	0.15 to 0.30, use average of 0.23	URS report
Soil Bulk Density (g/cm^3)	1.65	URS report
Organic Carbon Partition Coefficient (mg/L)	0	QUICK DOMENICO help Documentation resulting Retardation Coefficient of 1
Fraction of Organic Carbon (decimal fraction)	0.005	QUICK DOMENICO help Documentation resulting Retardation Coefficient of 1

Table 3

SUMMARY OF QUICK DOMENICO RESULTS

Time (Years)	Predicted Nitrate[1] Concentration at 450 feet (mg/L as N)	Conservative-Case Estimate[2] Predicted Nitrate Concentration at 450 Feet (mg/L as N)
1	< 1	< 1
2	< 1	3.2
3	< 1	4.1
4	< 1	4.2
5	< 1	4.2
10	< 1	4.2
11	1	4.2
12	1.3	4.2
17	2.8	4.2
20	3.4	4.2
40	4.2	4.2
80	4.2	-
160	4.2	-

Notes:

1 Source concentration and input parameters that are thought to represent average conditions at the Site.

2 Conservative-case estimate based on sensitive input parameters within the range of known values that produce conservative results.

Table 4

SUMMARY OF QUICK DOMENICO SENSITIVITY ANALYSIS

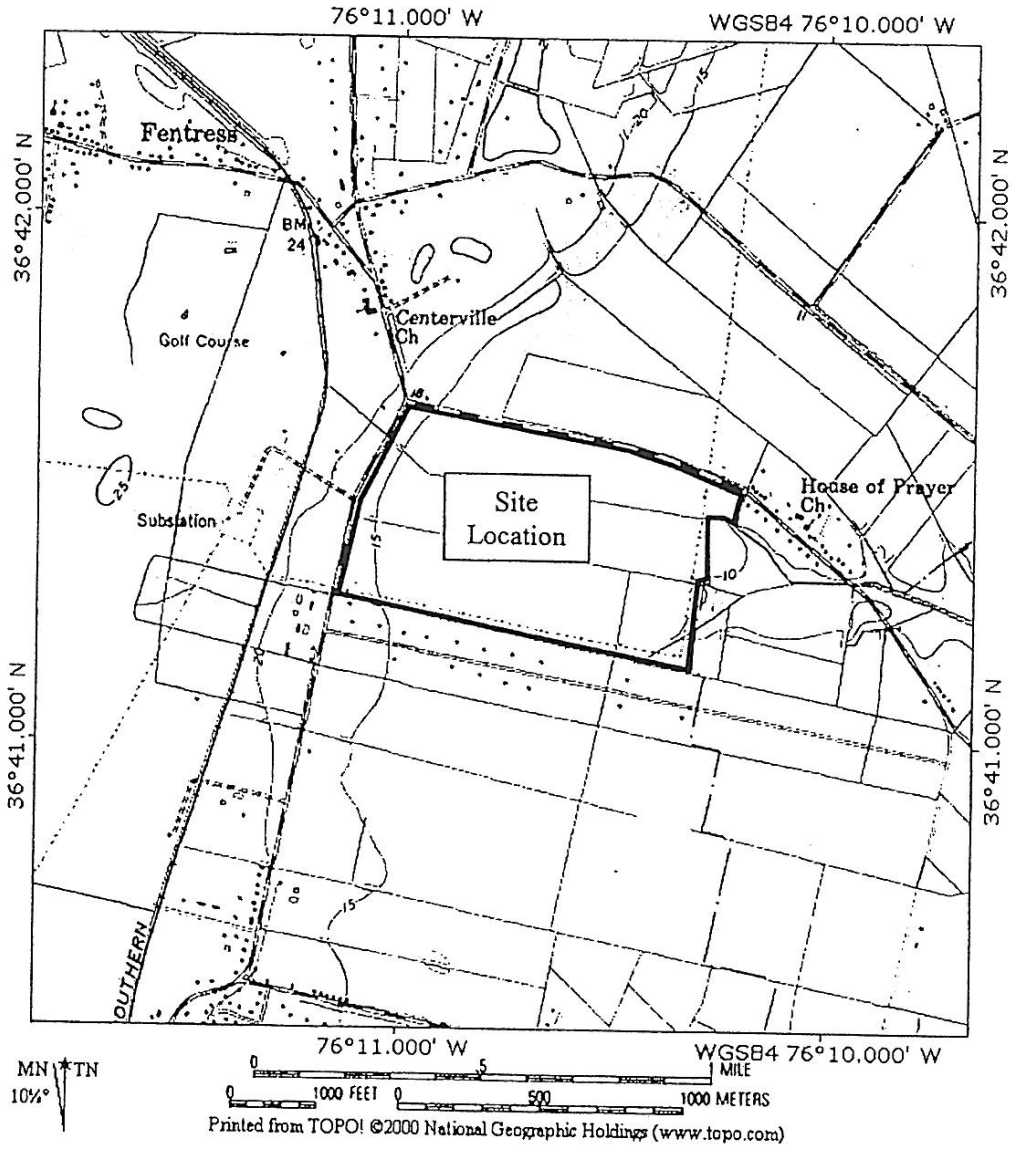
Parameter	Nitrate Concentration at 450 feet at 17 years (mg/L as N)[1]	Percent Change from Baseline Prediction (percentage)
Baseline[2]	2.8	--
Source Concentration	3.3	18
Longitudinal Dispersivity	2.9	4
Transverse Dispersivity	2.8	0
Source Width	2.8	0
Source Thickness	3.1	11
Hydraulic Conductivity	3.4	21
Hydraulic Gradient	3.4	21
Porosity	3.5	25
Soil Bulk Density	2.8	0

Notes:

1 Excluding the baseline concentration, the concentration reported is the result of changing the parameter by 20 percent.

2 The baseline concentration is predicted nitrate concentration provided on Table 3.

FIGURES



Boundaries are approximate.

Reference: USGS 7.5 minute Quadrangle
Fentress, VA. 1982 Revised 1986

Figure 1
Site Location Map
Chesapeake Energy Center
Proposed Golf Course Project
Chesapeake, Virginia

July 2001

URS

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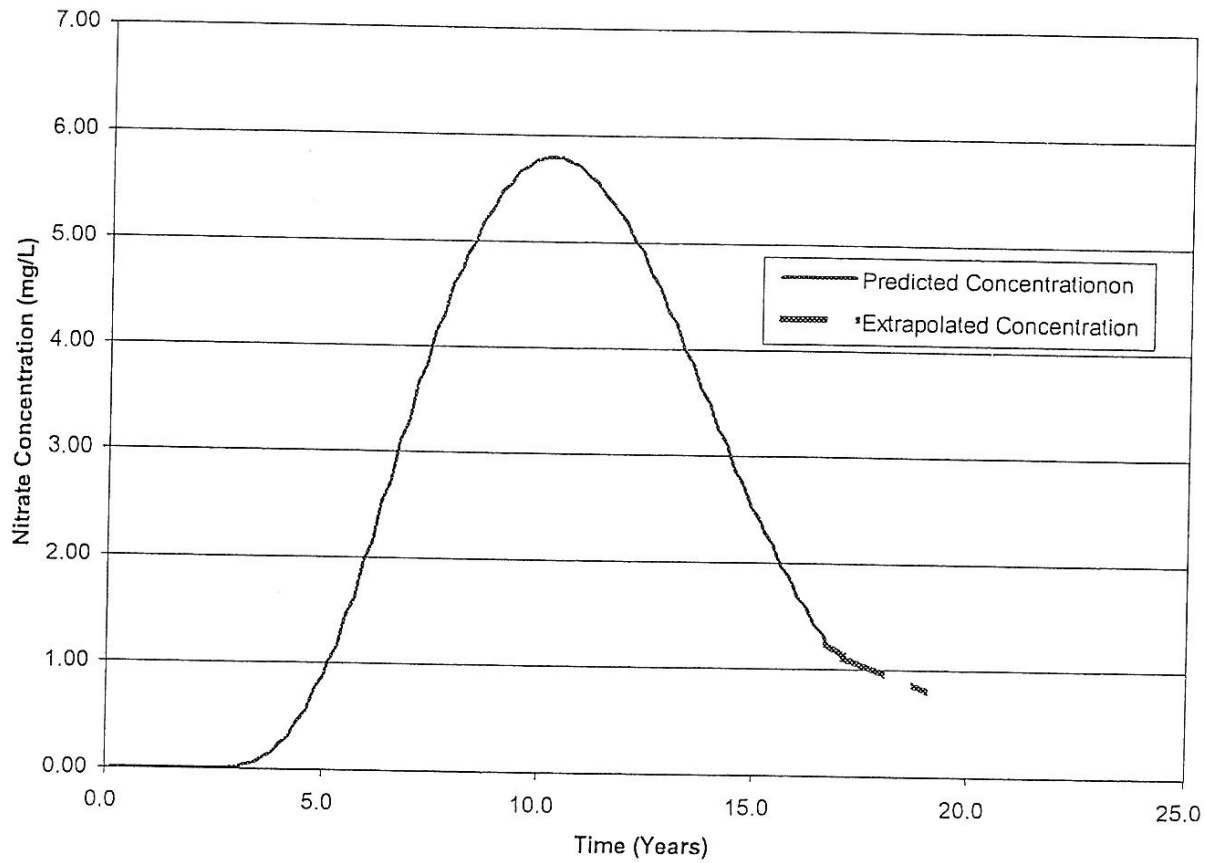
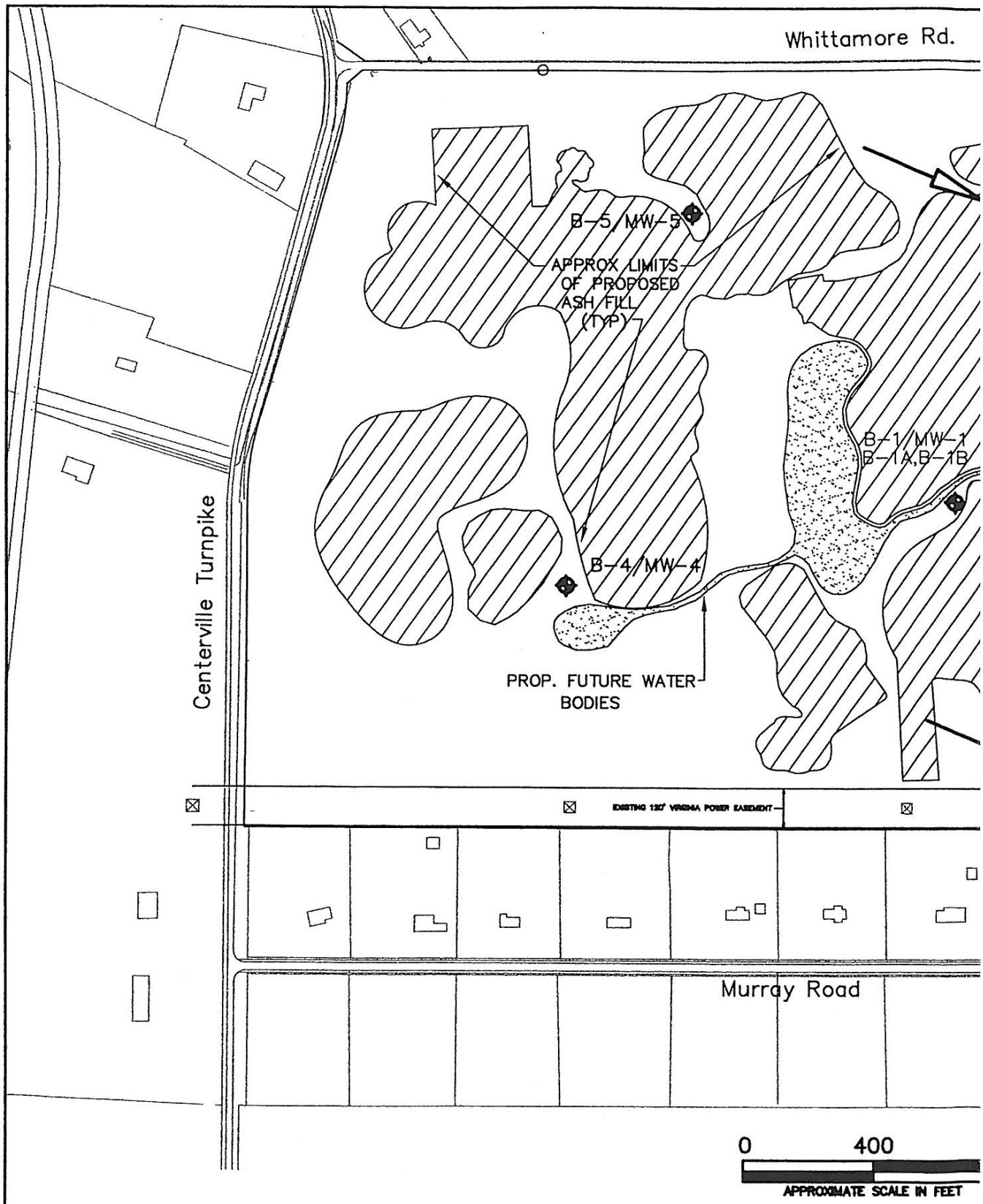
Figure 2. Predicted Soil Pore Water Concentrations using a Nitrate Source Concentration of 8.3 mg/kg at Five Feet Below the Base of the Beneficially Used Fly Ash.





Reference: URS Drawing "Figure 3–Site Location Map Showing Proposed Golf Course and Monitoring Well Locations, Chesapeake, Va." Dated Sept. 2001 and URS Drawing "Figure 3–7 Modflow Simulated Ash Placement Mounds–Ground Water Surface"

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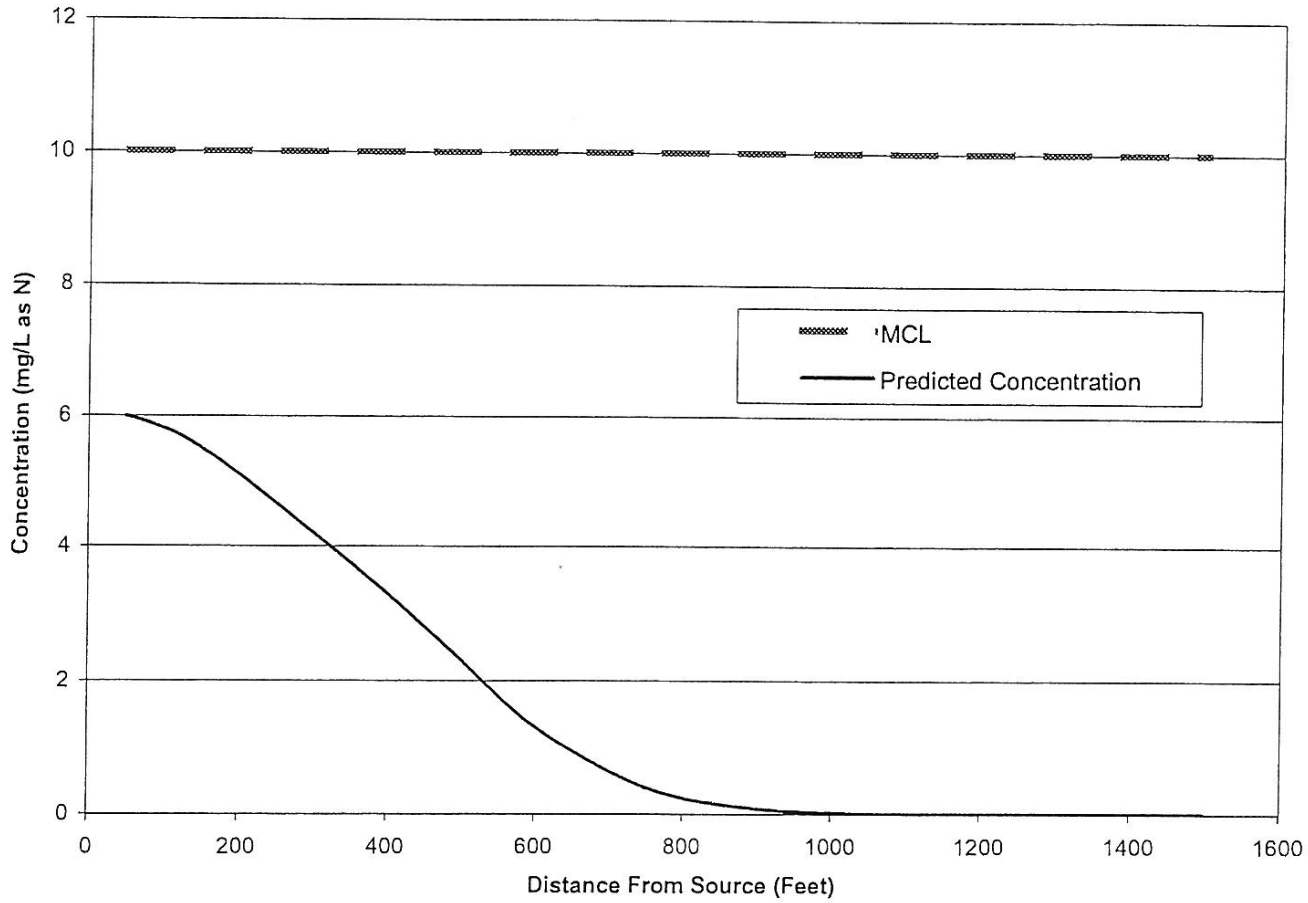
Figure 4. Predicted Nitrate Concentrations in Ground Water with a Nitrate Source Concentration of 6 mg/L at 17 years



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APPENDIX A

TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

PROJECT 2002-466-10

NITRATE CONCENTRATION (MG/L) =	8.30
Recharge rate in cm/year	43.00
Soil bulk density in g/cc	1.65
Water-filled porosity of soil	0.38
Apparent partition coefficient Kapp (ml/g)	1.00
Depth increment in feet	0.50
Time increment in months	1.62

	Time (years)	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.2
	Soil Depth																
	0.5	6.75	5.46	4.43	3.58	2.90	2.35	1.90	1.54	1.25	1.01	0.82	0.66	0.54	0.44	0.35	0.29
	1	6.75	6.75	6.50	6.11	5.63	5.11	4.59	4.08	3.59	3.15	2.74	2.38	2.05	1.76	1.51	1.29
	1.5	6.75	6.75	6.75	6.70	6.59	6.40	6.16	5.86	5.52	5.15	4.77	4.39	4.00	3.63	3.28	2.94
	2	6.75	6.75	6.75	6.75	6.74	6.71	6.65	6.56	6.42	6.25	6.04	5.80	5.53	5.24	4.94	4.62
	2.5	6.75	6.75	6.75	6.75	6.75	6.74	6.74	6.72	6.69	6.64	6.57	6.47	6.34	6.19	6.01	5.80
	3	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.74	6.74	6.73	6.71	6.69	6.64	6.59	6.51	6.41
	3.5	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.74	6.74	6.74	6.73	6.71	6.69	6.65
Original	4	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.74	6.74	6.73	6.73
Ground	4.5	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.74	6.74
Surface at 5	5	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75	6.75
feet	5.5	0.00	1.28	2.32	3.16	3.84	4.40	4.84	5.20	5.50	5.73	5.93	6.08	6.21	6.31	6.39	6.46
	6	0.00	0.00	0.24	0.64	1.12	1.64	2.16	2.67	3.15	3.60	4.00	4.37	4.70	4.98	5.24	5.46
	6.5	0.00	0.00	0.00	0.05	0.16	0.34	0.59	0.89	1.23	1.59	1.97	2.36	2.74	3.11	3.47	3.80
	7	0.00	0.00	0.00	0.00	0.01	0.04	0.10	0.19	0.32	0.49	0.70	0.94	1.21	1.50	1.81	2.13
	7.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.11	0.18	0.28	0.41	0.56	0.74	0.94
	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.06	0.10	0.16	0.24	0.33
	8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.06	0.09
	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
Water Table at	9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 feet	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils)

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APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

	Time (years)	2.3	2.4	2.6	2.7	2.8	3.0	3.1	3.2	3.4	3.5	3.6	3.8	3.9	4.0	4.2	4.3
	Soil Depth																
	0.5	0.23	0.19	0.15	0.12	0.10	0.08	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01
	1	1.10	0.93	0.79	0.67	0.57	0.48	0.40	0.34	0.28	0.24	0.20	0.17	0.14	0.12	0.10	0.08
	1.5	2.63	2.34	2.07	1.83	1.61	1.41	1.23	1.07	0.93	0.81	0.70	0.61	0.52	0.45	0.39	0.33
	2	4.30	3.98	3.67	3.37	3.07	2.79	2.53	2.28	2.05	1.84	1.65	1.47	1.30	1.15	1.02	0.90
	2.5	5.58	5.34	5.08	4.81	4.54	4.26	3.98	3.70	3.43	3.17	2.92	2.68	2.45	2.23	2.03	1.83
	3	6.30	6.16	6.00	5.83	5.64	5.43	5.20	4.97	4.73	4.48	4.24	3.98	3.74	3.49	3.25	3.02
	3.5	6.61	6.55	6.48	6.39	6.28	6.16	6.02	5.86	5.69	5.51	5.32	5.11	4.90	4.68	4.45	4.22
Original Ground Surface at 5 feet	4	6.71	6.69	6.67	6.63	6.58	6.53	6.46	6.37	6.28	6.17	6.04	5.90	5.75	5.59	5.42	5.23
	4.5	6.74	6.73	6.73	6.71	6.70	6.68	6.65	6.61	6.57	6.51	6.44	6.37	6.28	6.18	6.07	5.94
	5	6.75	6.74	6.74	6.74	6.73	6.73	6.72	6.70	6.69	6.66	6.63	6.60	6.55	6.50	6.44	6.37
	5.5	6.52	6.56	6.59	6.62	6.64	6.66	6.67	6.68	6.69	6.69	6.68	6.67	6.66	6.64	6.61	6.58
	6	5.65	5.81	5.95	6.08	6.18	6.27	6.34	6.41	6.46	6.50	6.54	6.56	6.59	6.60	6.61	6.61
	6.5	4.12	4.41	4.68	4.92	5.14	5.34	5.51	5.67	5.81	5.93	6.04	6.14	6.22	6.29	6.35	6.40
	7	2.44	2.76	3.08	3.38	3.67	3.95	4.21	4.46	4.69	4.90	5.10	5.28	5.44	5.59	5.72	5.84
	7.5	1.17	1.41	1.67	1.94	2.21	2.49	2.77	3.04	3.31	3.57	3.83	4.07	4.30	4.52	4.72	4.91
	8	0.45	0.58	0.74	0.92	1.11	1.32	1.54	1.77	2.02	2.26	2.51	2.76	3.01	3.26	3.49	3.73
	8.5	0.14	0.20	0.27	0.36	0.47	0.59	0.73	0.88	1.05	1.24	1.43	1.64	1.85	2.07	2.30	2.52
	9	0.03	0.05	0.08	0.12	0.16	0.22	0.29	0.37	0.47	0.58	0.71	0.84	0.99	1.16	1.33	1.51
	9.5	0.01	0.01	0.02	0.03	0.05	0.07	0.10	0.14	0.18	0.24	0.30	0.38	0.47	0.57	0.68	0.80
Water Table at 10 feet	10	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.06	0.08	0.11	0.15	0.19	0.24	0.31	0.38

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

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APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

PROJECT 2002-466-10

	Time (years)	4.4	4.6	4.7	4.8	5.0	5.1	5.3	5.4	5.5	5.7	5.8	5.9	6.1	6.2	6.3	6.5
	Soil Depth																
	0.5	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00
	1.5	0.28	0.24	0.21	0.18	0.15	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.04	0.03	0.03	0.02
	2	0.79	0.70	0.61	0.53	0.47	0.41	0.35	0.31	0.27	0.23	0.20	0.17	0.15	0.13	0.11	0.09
	2.5	1.66	1.49	1.34	1.20	1.07	0.96	0.85	0.76	0.67	0.59	0.53	0.46	0.41	0.36	0.31	0.28
	3	2.79	2.58	2.37	2.17	1.99	1.82	1.65	1.50	1.36	1.23	1.11	1.00	0.90	0.80	0.72	0.64
	3.5	3.99	3.77	3.54	3.32	3.10	2.89	2.69	2.49	2.30	2.12	1.95	1.79	1.64	1.50	1.37	1.24
Original Ground Surface at 5 feet	4	5.04	4.84	4.64	4.43	4.22	4.00	3.79	3.58	3.37	3.17	2.97	2.78	2.59	2.41	2.24	2.07
	4.5	5.81	5.66	5.51	5.34	5.17	4.99	4.80	4.61	4.41	4.22	4.02	3.82	3.62	3.42	3.23	3.04
	5	6.29	6.20	6.10	5.98	5.86	5.73	5.59	5.44	5.28	5.12	4.94	4.77	4.59	4.40	4.22	4.03
	5.5	6.54	6.49	6.44	6.37	6.30	6.22	6.12	6.02	5.91	5.79	5.66	5.53	5.38	5.23	5.07	4.91
	6	6.60	6.59	6.57	6.55	6.51	6.47	6.42	6.37	6.30	6.23	6.14	6.05	5.95	5.84	5.73	5.60
	6.5	6.44	6.47	6.49	6.51	6.51	6.51	6.51	6.49	6.47	6.44	6.40	6.35	6.29	6.23	6.15	6.07
	7	5.95	6.04	6.12	6.19	6.25	6.30	6.34	6.37	6.40	6.41	6.41	6.41	6.40	6.38	6.35	6.31
	7.5	5.09	5.25	5.40	5.54	5.66	5.77	5.87	5.96	6.04	6.11	6.17	6.21	6.25	6.28	6.30	6.31
	8	3.95	4.17	4.37	4.57	4.75	4.93	5.09	5.24	5.38	5.50	5.62	5.72	5.81	5.90	5.97	6.03
	8.5	2.75	2.98	3.21	3.43	3.65	3.86	4.06	4.25	4.44	4.62	4.79	4.94	5.09	5.23	5.36	5.47
	9	1.71	1.90	2.11	2.32	2.53	2.74	2.95	3.16	3.37	3.57	3.77	3.97	4.15	4.33	4.50	4.66
Water Table at 10 foot	9.5	0.94	1.08	1.24	1.41	1.58	1.76	1.95	2.14	2.33	2.53	2.73	2.93	3.12	3.32	3.51	3.70
	10	0.46	0.55	0.65	0.76	0.88	1.02	1.16	1.31	1.47	1.63	1.80	1.98	2.16	2.34	2.53	2.71

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20393

APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

	Time (years)	6.6	6.7	6.9	7.0	7.1	7.3	7.4	7.5	7.7	7.8	7.9	8.1	8.2	8.4	8.5	8.6
	Soil Depth																
	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.5	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
	2.5	0.24	0.21	0.18	0.16	0.14	0.12	0.11	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03
	3	0.57	0.51	0.45	0.40	0.36	0.31	0.28	0.24	0.22	0.19	0.17	0.15	0.13	0.11	0.10	0.09
	3.5	1.13	1.02	0.93	0.84	0.75	0.68	0.61	0.55	0.49	0.44	0.39	0.35	0.31	0.27	0.24	0.22
Original	4	1.91	1.76	1.62	1.49	1.37	1.25	1.14	1.04	0.95	0.86	0.78	0.70	0.64	0.57	0.52	0.47
Ground	4.5	2.86	2.68	2.50	2.34	2.18	2.02	1.88	1.74	1.60	1.48	1.36	1.25	1.15	1.05	0.96	0.88
Surface at 5 feet	5	3.84	3.66	3.47	3.29	3.11	2.93	2.76	2.59	2.43	2.27	2.12	1.98	1.84	1.71	1.58	1.46
	5.5	4.74	4.57	4.40	4.22	4.04	3.87	3.69	3.51	3.34	3.16	2.99	2.83	2.67	2.51	2.36	2.21
	6	5.47	5.33	5.19	5.04	4.88	4.72	4.56	4.39	4.23	4.06	3.89	3.72	3.55	3.38	3.21	3.05
	6.5	5.98	5.89	5.78	5.67	5.55	5.42	5.29	5.15	5.01	4.86	4.71	4.55	4.39	4.23	4.07	3.91
	7	6.27	6.21	6.15	6.08	6.00	5.92	5.82	5.72	5.61	5.50	5.38	5.25	5.12	4.98	4.84	4.69
	7.5	6.31	6.30	6.28	6.26	6.22	6.18	6.13	6.07	6.01	5.93	5.85	5.76	5.66	5.56	5.45	5.33
	8	6.08	6.13	6.16	6.18	6.20	6.20	6.20	6.19	6.16	6.13	6.10	6.05	5.99	5.93	5.86	5.78
	8.5	5.58	5.68	5.76	5.84	5.90	5.96	6.01	6.04	6.07	6.09	6.10	6.10	6.09	6.07	6.04	6.01
	9	4.82	4.96	5.10	5.22	5.34	5.45	5.54	5.63	5.71	5.78	5.84	5.89	5.93	5.96	5.98	5.99
	9.5	3.88	4.06	4.23	4.40	4.55	4.70	4.85	4.98	5.10	5.22	5.32	5.42	5.51	5.59	5.66	5.72
Water Table at 10 foot	10	2.90	3.09	3.27	3.46	3.63	3.81	3.98	4.14	4.30	4.45	4.60	4.74	4.87	4.99	5.10	5.21

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20394

APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

PROJECT 2002-466-10

Time (years)	8.8	8.9	9.0	9.2	9.3	9.4	9.6	9.7	9.8	10.0	10.1	10.2	10.4	10.5	10.6	10.8
Soil Depth																
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
3	0.07	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01
3.5	0.19	0.17	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03
Original Ground Surface at 5 feet 4	0.42	0.37	0.34	0.30	0.27	0.24	0.21	0.19	0.17	0.15	0.13	0.12	0.10	0.09	0.08	0.07
4.5	0.80	0.73	0.66	0.60	0.54	0.49	0.44	0.40	0.36	0.32	0.29	0.26	0.23	0.21	0.19	0.17
5	1.35	1.25	1.15	1.05	0.97	0.89	0.81	0.74	0.68	0.62	0.56	0.51	0.46	0.42	0.38	0.34
5.5	2.07	1.93	1.80	1.68	1.56	1.45	1.34	1.24	1.14	1.05	0.97	0.89	0.82	0.75	0.69	0.63
6	2.89	2.73	2.58	2.43	2.29	2.15	2.02	1.89	1.76	1.65	1.53	1.43	1.33	1.23	1.14	1.05
6.5	3.74	3.58	3.42	3.26	3.10	2.95	2.80	2.65	2.50	2.36	2.23	2.10	1.97	1.85	1.73	1.62
7	4.54	4.39	4.24	4.08	3.93	3.77	3.61	3.46	3.30	3.15	3.00	2.85	2.71	2.57	2.43	2.30
7.5	5.21	5.08	4.95	4.81	4.68	4.53	4.39	4.24	4.09	3.94	3.79	3.64	3.49	3.34	3.20	3.05
8	5.70	5.60	5.50	5.40	5.29	5.17	5.05	4.92	4.79	4.66	4.52	4.38	4.24	4.10	3.96	3.81
8.5	5.97	5.91	5.85	5.79	5.71	5.63	5.55	5.45	5.35	5.25	5.13	5.02	4.90	4.77	4.65	4.51
9	5.99	5.99	5.97	5.95	5.92	5.88	5.83	5.78	5.72	5.65	5.57	5.49	5.40	5.30	5.20	5.10
Water Table at 10 feet 9.5	5.77	5.81	5.85	5.87	5.89	5.89	5.89	5.88	5.86	5.83	5.80	5.76	5.70	5.65	5.58	5.51
10	5.31	5.40	5.47	5.55	5.61	5.66	5.70	5.74	5.77	5.78	5.79	5.79	5.79	5.77	5.75	5.72

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20395

APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

PROJECT 2002-466-10

Time (years)	10.9	11.0	11.2	11.3	11.4	11.6	11.7	11.9	12.0	12.1	12.3	12.4	12.5	12.7	12.8	12.9
Soil Depth																
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
4	0.06	0.06	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
4.5	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.03	0.03	0.02
5	0.31	0.28	0.25	0.22	0.20	0.18	0.16	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.07	0.06
5.5	0.57	0.52	0.48	0.43	0.39	0.36	0.32	0.29	0.27	0.24	0.22	0.19	0.18	0.16	0.14	0.13
6	0.97	0.90	0.83	0.76	0.70	0.64	0.59	0.54	0.49	0.45	0.41	0.37	0.34	0.31	0.28	0.25
6.5	1.51	1.41	1.31	1.22	1.13	1.05	0.97	0.90	0.83	0.76	0.70	0.65	0.60	0.55	0.50	0.46
7	2.17	2.04	1.92	1.81	1.69	1.59	1.48	1.39	1.29	1.21	1.12	1.04	0.97	0.90	0.83	0.77
7.5	2.91	2.77	2.63	2.50	2.36	2.24	2.11	1.99	1.88	1.77	1.66	1.56	1.46	1.37	1.28	1.19
8	3.67	3.52	3.38	3.24	3.10	2.96	2.82	2.69	2.55	2.43	2.30	2.18	2.06	1.95	1.84	1.73
8.5	4.38	4.25	4.11	3.97	3.83	3.69	3.55	3.41	3.27	3.14	3.00	2.87	2.74	2.61	2.48	2.36
9	4.99	4.87	4.75	4.63	4.50	4.38	4.25	4.11	3.98	3.85	3.71	3.58	3.44	3.31	3.17	3.04
9.5	5.43	5.35	5.26	5.16	5.06	4.95	4.84	4.73	4.61	4.49	4.37	4.24	4.12	3.99	3.86	3.73
10	5.68	5.63	5.58	5.52	5.45	5.37	5.29	5.21	5.12	5.02	4.92	4.82	4.71	4.60	4.48	4.36

Original Ground Surface at 5 feet

Water Table at 10 feet

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20396

APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

	Time (years)	13.1	13.2	13.3	13.5	13.6	13.7	13.9	14.0	14.1	14.3	14.4	14.5	14.7	14.8	14.9	15.1
	Soil Depth																
	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Original Ground Surface at 5 feet	4	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4.5	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
	5	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
	5.5	0.11	0.10	0.09	0.08	0.07	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.03	0.02	0.02
	6	0.23	0.21	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.05
	6.5	0.42	0.38	0.35	0.32	0.29	0.26	0.24	0.22	0.20	0.18	0.16	0.15	0.13	0.12	0.11	0.10
	7	0.71	0.65	0.60	0.55	0.51	0.47	0.43	0.39	0.36	0.33	0.30	0.27	0.25	0.23	0.21	0.19
	7.5	1.11	1.03	0.96	0.89	0.83	0.77	0.71	0.66	0.61	0.56	0.52	0.48	0.44	0.40	0.37	0.34
	8	1.63	1.53	1.44	1.35	1.26	1.18	1.10	1.03	0.96	0.89	0.83	0.77	0.71	0.66	0.61	0.56
	8.5	2.24	2.12	2.01	1.90	1.80	1.69	1.60	1.50	1.41	1.32	1.24	1.16	1.09	1.02	0.95	0.88
	9	2.91	2.79	2.66	2.54	2.42	2.30	2.18	2.07	1.96	1.86	1.76	1.66	1.56	1.47	1.39	1.30
Water Table at 10 feet	9.5	3.60	3.47	3.34	3.21	3.08	2.95	2.83	2.71	2.59	2.47	2.35	2.24	2.13	2.02	1.92	1.82
	10	4.24	4.12	4.00	3.87	3.75	3.62	3.49	3.37	3.24	3.12	2.99	2.87	2.75	2.63	2.52	2.40

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20397

APPENDIX A
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE RESULTS - BUFFER1 OUTPUT

	Time (years)	15.2	15.4	15.5	15.6	15.8	15.9	16.0	16.2	16.3	16.4	16.6	16.7
	Soil Depth												
	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Original Ground Surface at 5 feet	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	5.5	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
	6	0.04	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01
	6.5	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.03
	7	0.17	0.15	0.14	0.13	0.11	0.10	0.09	0.08	0.08	0.07	0.06	0.06
	7.5	0.31	0.28	0.26	0.24	0.22	0.20	0.18	0.16	0.15	0.13	0.12	0.11
	8	0.52	0.48	0.44	0.41	0.38	0.35	0.32	0.29	0.27	0.24	0.22	0.20
	8.5	0.82	0.77	0.71	0.66	0.61	0.57	0.53	0.49	0.45	0.41	0.38	0.35
	9	1.22	1.15	1.08	1.01	0.94	0.88	0.82	0.76	0.71	0.66	0.61	0.57
	9.5	1.72	1.62	1.53	1.45	1.36	1.28	1.21	1.13	1.06	1.00	0.93	0.87
Water Table at 10 feet	10	2.29	2.18	2.08	1.97	1.87	1.78	1.68	1.59	1.50	1.42	1.34	1.26

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20398

APPENDIX B

GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

20399

APPENDIX B
DOMINION VIRGINIA POWER - 5 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project: Dominion Virginia Power - Etheridge Ridge Golf Course
Date: 11/20/2002 Prepared by: JEB GAI Consultants, Inc.
Contaminant: Nitrate

PA DEPARTMENT
OF ENVIRONMENTAL PROTECTION
QUICK_DOMENICO.XLS
SPREADSHEET APPLICATION OF
"AN ANALYTICAL MODEL FOR
MULTIDIMENSIONAL TRANSPORT OF A
DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation

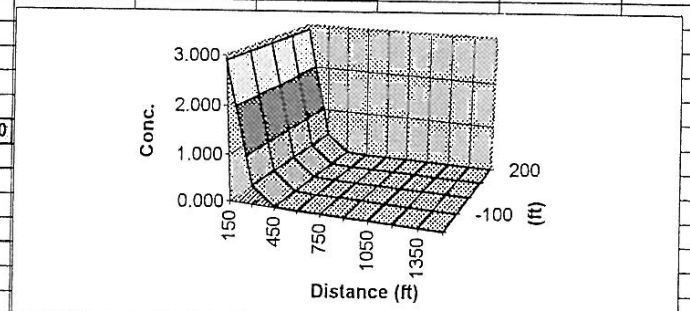
SOURCE CONC (MG/L)	X DISTANCE TO LOCATION OF CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609

	y(ft)	z(ft)	Time (days)
450	0	0	1825

Projected Conc. at 450 0 0
at 1825 days
0.010 mg/l

AREAL MODEL CALCULATION DOMAIN
Length (ft) 1500
Width (ft) 200



	150	300	450	600	750	900	1050	1200	1350	1500
200	2.898	0.392	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
100	2.898	0.392	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0	2.898	0.392	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-100	2.898	0.392	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-200	2.898	0.392	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000

20400

APPENDIX B
DOMINION VIRGINIA POWER - 10 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm^3)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	3650				
Projected Conc. at		450	0	0			
at	3650	days					
0.722	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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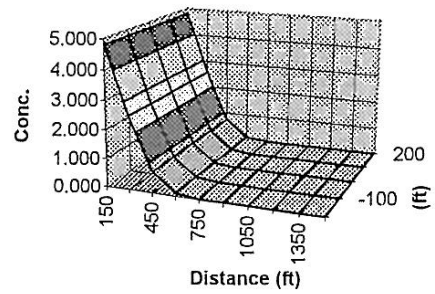
DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	4.814	2.533	0.722	0.093	0.005	0.000	0.000	0.000	0.000	0.000
100	4.814	2.533	0.722	0.093	0.005	0.000	0.000	0.000	0.000	0.000
0	4.814	2.533	0.722	0.093	0.005	0.000	0.000	0.000	0.000	0.000
-100	4.814	2.533	0.722	0.093	0.005	0.000	0.000	0.000	0.000	0.000
-200	4.814	2.533	0.722	0.093	0.005	0.000	0.000	0.000	0.000	0.000

20401

APPENDIX B
DOMINION VIRGINIA POWER - 11 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE	DISTANCE T	Ax	Ay	Az	LAMBDA	SOURCE	SOURCE
CONC	LOCATION O	(ft)	(ft)	(ft)		WIDTH	THICKNESS
(MG/L)	CONCERN (ft)			>=.001	day-1	(ft)	(ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic	Hydraulic		Soil Bulk		Frac.	Retard-	V
Cond	Gradient	Porosity	Density	KOC	Org. Carb.	ation	(=K*i/n*R)
(ft/day)	(ft/ft)	(dec. frac.)	(g/cm³)			(R)	(ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	4015				
Projected Conc. at		450	0	0			
at	4015	days					
1.015	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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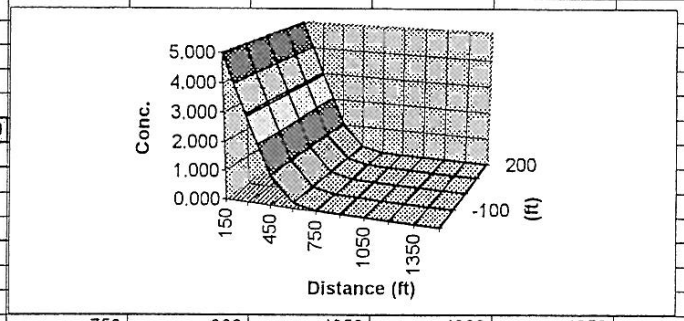
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	4.985	2.907	1.015	0.177	0.014	0.000	0.000	0.000	0.000	0.000
100	4.985	2.907	1.015	0.177	0.014	0.000	0.000	0.000	0.000	0.000
0	4.985	2.907	1.015	0.177	0.014	0.000	0.000	0.000	0.000	0.000
-100	4.985	2.907	1.015	0.177	0.014	0.000	0.000	0.000	0.000	0.000
-200	4.985	2.907	1.015	0.177	0.014	0.000	0.000	0.000	0.000	0.000

20402

APPENDIX B
DOMINION VIRGINIA POWER - 12 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	4380				
Projected Conc. at		450	0	0			
at	4380	days					
1.329	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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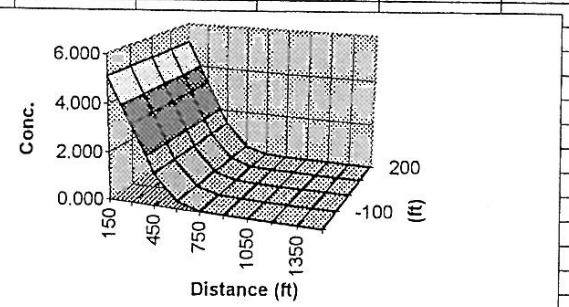
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.118	3.234	1.329	0.299	0.033	0.002	0.000	0.000	0.000	0.000
100	5.118	3.234	1.329	0.299	0.033	0.002	0.000	0.000	0.000	0.000
0	5.118	3.234	1.329	0.299	0.033	0.002	0.000	0.000	0.000	0.000
-100	5.118	3.234	1.329	0.299	0.033	0.002	0.000	0.000	0.000	0.000
-200	5.118	3.234	1.329	0.299	0.033	0.002	0.000	0.000	0.000	0.000

20403

APPENDIX B
DOMINION VIRGINIA POWER - 17 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project: Dominion Virginia Power - Etheridge Ridge Golf Course
Date: 11/20/2002 Prepared by: JEB GAI Consultants, Inc.
Contaminant: Nitrate

PA DEPARTMENT
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P.A. Domenico (1987)
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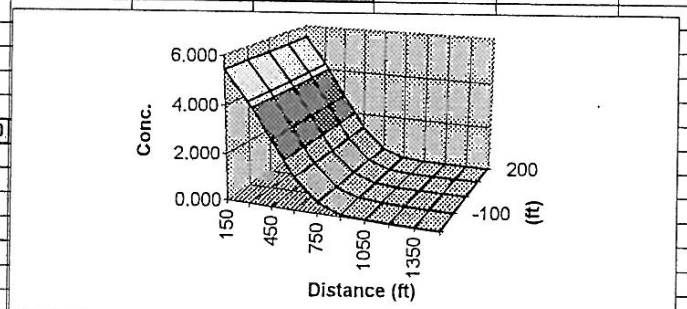
SOURCE CONC (MG/L)	X DISTANCE TO LOCATION OF CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609

y(ft)	z(ft)	Time (days)
450	0	0	6205

Projected Conc. at 450 0 0
at 6205 days
2.779 mg/l

AREAL MODEL CALCULATION DOMAIN
Length (ft) 1500
Width (ft) 200



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
0	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000

20404

APPENDIX B
DOMINION VIRGINIA POWER - 20 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	7300				
Projected Conc. at		450	0	0			
at	7300	days					
3.363	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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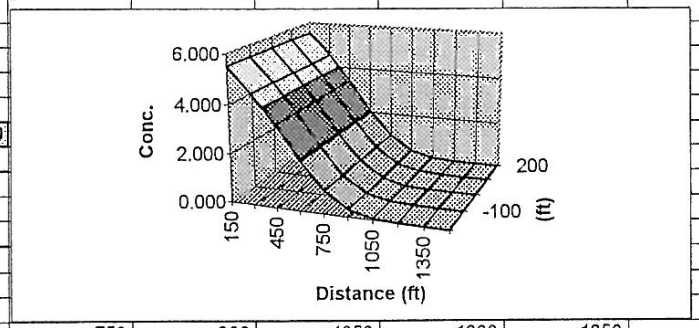

	150	300	450	600	750	900	1050	1200	1350	1500
200	5.525	4.517	3.363	2.055	0.929	0.289	0.059	0.008	0.001	0.000
100	5.525	4.517	3.363	2.055	0.929	0.289	0.059	0.008	0.001	0.000
0	5.525	4.517	3.363	2.055	0.929	0.289	0.059	0.008	0.001	0.000
-100	5.525	4.517	3.363	2.055	0.929	0.289	0.059	0.008	0.001	0.000
-200	5.525	4.517	3.363	2.055	0.929	0.289	0.059	0.008	0.001	0.000

APPENDIX B
DOMINION VIRGINIA POWER - 26 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.55	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	9490				
Projected Conc. at		450	0	0			
at	9490	days					
3.962	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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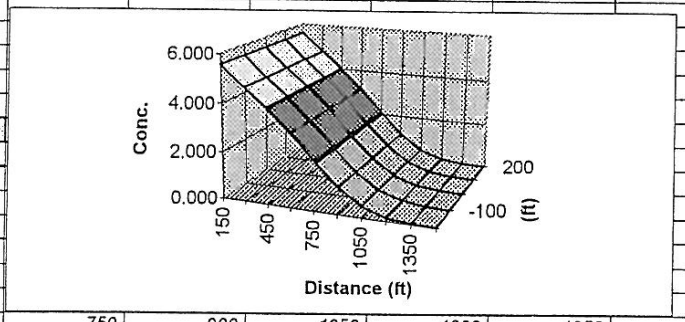
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.576	4.739	3.962	3.087	2.077	1.122	0.461	0.138	0.030	0.004
100	5.576	4.739	3.962	3.087	2.077	1.122	0.461	0.138	0.030	0.004
0	5.576	4.739	3.962	3.087	2.077	1.122	0.461	0.138	0.030	0.004
-100	5.576	4.739	3.962	3.087	2.077	1.122	0.461	0.138	0.030	0.004
-200	5.576	4.739	3.962	3.087	2.077	1.122	0.461	0.138	0.030	0.004

20406

APPENDIX B
DOMINION VIRGINIA POWER - 27 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	9855				
Projected Conc. at		450	0	0			
at	9855	days					
4.013	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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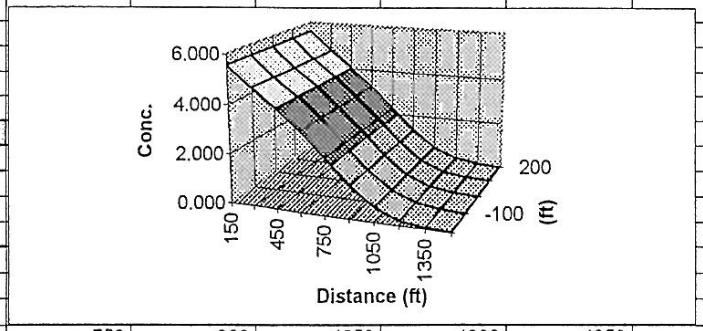
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.580	4.755	4.013	3.200	2.243	1.289	0.574	0.190	0.046	0.008
100	5.580	4.755	4.013	3.200	2.243	1.289	0.574	0.190	0.046	0.008
0	5.580	4.755	4.013	3.200	2.243	1.289	0.574	0.190	0.046	0.008
-100	5.580	4.755	4.013	3.200	2.243	1.289	0.574	0.190	0.046	0.008
-200	5.580	4.755	4.013	3.200	2.243	1.289	0.574	0.190	0.046	0.008

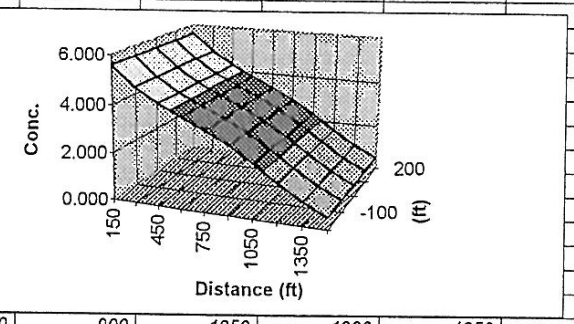
20407

APPENDIX B
DOMINION VIRGINIA POWER - 40 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	14600				
Projected Conc. at		450	0	0			
at	14600	days					
4.233	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
OF ENVIRONMENTAL PROTECTION
QUICK_DOMENICO.XLS
SPREADSHEET APPLICATION OF
"AN ANALYTICAL MODEL FOR
MULTIDIMENSIONAL TRANSPORT OF A
DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.592	4.816	4.233	3.774	3.343	2.854	2.258	1.592	0.964	0.488
100	5.592	4.816	4.233	3.774	3.343	2.854	2.258	1.592	0.964	0.488
0	5.592	4.816	4.233	3.774	3.343	2.854	2.258	1.592	0.964	0.488
-100	5.592	4.816	4.233	3.774	3.343	2.854	2.258	1.592	0.964	0.488
-200	5.592	4.816	4.233	3.774	3.343	2.854	2.258	1.592	0.964	0.488

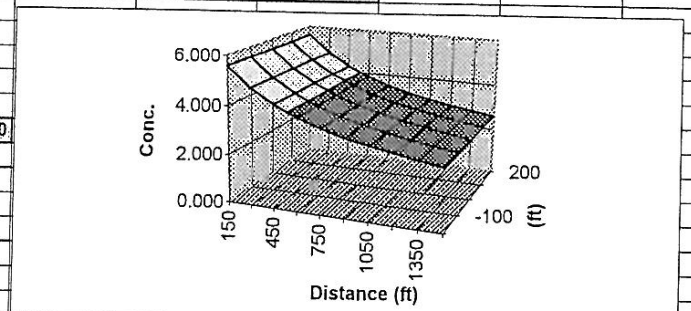
20408

APPENDIX B
DOMINION VIRGINIA POWER - 80 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.0847826609
	y(ft)	z(ft)	Time (days)				
450	0	0	29200				
Projected Conc. at		450	0	0			
at	29200 days						
4.249 mg/l							
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
OF ENVIRONMENTAL PROTECTION
QUICK_DOMENICO.XLS
SPREADSHEET APPLICATION OF
"AN ANALYTICAL MODEL FOR
MULTIDIMENSIONAL TRANSPORT OF A
DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.593	4.820	4.249	3.832	3.515	3.263	3.058	2.885	2.734	2.593
100	5.593	4.820	4.249	3.832	3.515	3.263	3.058	2.885	2.734	2.593
0	5.593	4.820	4.249	3.832	3.515	3.263	3.058	2.885	2.734	2.593
-100	5.593	4.820	4.249	3.832	3.515	3.263	3.058	2.885	2.734	2.593
-200	5.593	4.820	4.249	3.832	3.515	3.263	3.058	2.885	2.734	2.593

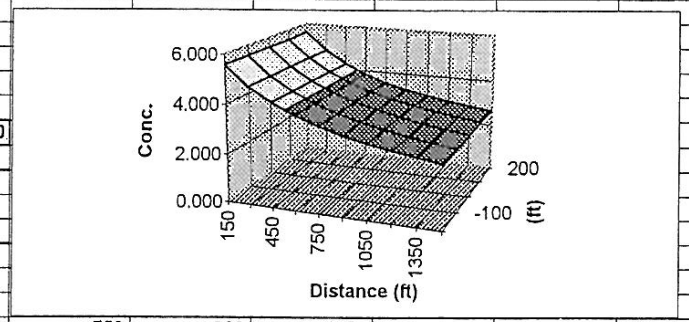
20409

APPENDIX B
DOMINION VIRGINIA POWER - 160 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	58400				
Projected Conc. at		450	0	0			
at	58400	days					
4.249	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
OF ENVIRONMENTAL PROTECTION
QUICK_DOMENICO.XLS
SPREADSHEET APPLICATION OF
"AN ANALYTICAL MODEL FOR
MULTIDIMENSIONAL TRANSPORT OF A
DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.593	4.820	4.249	3.832	3.515	3.264	3.059	2.888	2.743	2.618
100	5.593	4.820	4.249	3.832	3.515	3.264	3.059	2.888	2.743	2.618
0	5.593	4.820	4.249	3.832	3.515	3.264	3.059	2.888	2.743	2.618
-100	5.593	4.820	4.249	3.832	3.515	3.264	3.059	2.888	2.743	2.618
-200	5.593	4.820	4.249	3.832	3.515	3.264	3.059	2.888	2.743	2.618

20410

APPENDIX C

FORWARD MODELING RESULTS

20411

PROJECT 2002-466-10

APPENDIX C
DOMINION VIRGINIA POWERE - 17 YEARS
GROUND WATER TRANSPORT RESULTS - QUICK DOMENICO OUTPUT
FORWARD MODELING RESULTS

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project: Dominion Virginia Power - Etheridge Greens Golf Course

Date: 11/20/2002 Prepared by JEB GAI Consultants, Inc

Contaminan Nitrate

PA DEPARTMENT OF ENVIRONMENTAL PROTECTION QUICK_DOMENICO.XLS SPREADSHEET APPLICATION OF "AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES" P.A. Domenico (1987) Modified to Include Retardation

SOURCE CONC (MG/L)	X DISTANCE LOCATION CONCERN	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
21.6	450	35	0.35	0.001	0	1000	1

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.0847826

	y(ft)	z(ft)	Time (days)
450	0	0	6205

Projected Conc. at 450 0 0

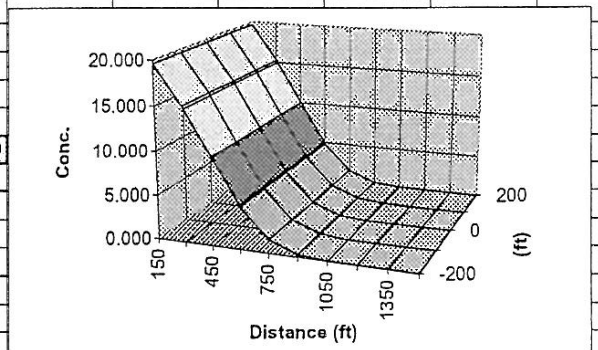
at 6205 days

10.005 mg/l

AREAL MODEL CALCULATION DOMAIN

Length (ft 1500

Width (ft) 200



	150	300	450	600	750	900	1050	1200	1350	1500
200	19.630	15.280	10.005	4.829	1.539	0.302	0.035	0.002	0.000	0.000
100	19.630	15.280	10.005	4.829	1.539	0.302	0.035	0.002	0.000	0.000
0	19.630	15.280	10.005	4.829	1.539	0.302	0.035	0.002	0.000	0.000
-100	19.630	15.280	10.005	4.829	1.539	0.302	0.035	0.002	0.000	0.000
-200	19.630	15.280	10.005	4.829	1.539	0.302	0.035	0.002	0.000	0.000

20412

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

NITRATE CONCENTRATION (MG/L) =	31.00
Recharge rate in cm/year	43.00
Soil bulk density in g/cc	1.65
Water-filled porosity of soil	0.38
Apparent partition coefficient Kapp (ml/g)	1.00
Depth increment in feet	0.50
Time increment in months	1.62

Time (years)	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.8	1.9	2.0	2.2
Soil Depth																
0.5	25.20	20.41	16.53	13.39	10.84	8.78	7.11	5.76	4.66	3.78	3.06	2.48	2.01	1.63	1.32	1.07
1	25.20	25.20	24.29	22.81	21.02	19.08	17.13	15.22	13.42	11.76	10.24	8.87	7.66	6.58	5.64	4.82
1.5	25.20	25.20	25.20	25.02	24.60	23.92	23.00	21.88	20.62	19.25	17.83	16.38	14.96	13.57	12.24	10.99
2	25.20	25.20	25.20	25.20	25.16	25.06	24.84	24.49	24.00	23.35	22.57	21.67	20.67	19.58	18.44	17.26
2.5	25.20	25.20	25.20	25.20	25.20	25.19	25.17	25.10	24.99	24.80	24.52	24.15	23.68	23.11	22.44	21.68
3	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.19	25.17	25.14	25.07	24.97	24.81	24.60	24.32	23.96
3.5	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.19	25.18	25.16	25.12	25.07	24.98	24.85
4	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.19	25.19	25.17	25.15	25.12
4.5	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.19	25.19	25.18
5	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20	25.20
5.5	0.00	4.79	8.67	11.81	14.36	16.42	18.09	19.44	20.53	21.42	22.14	22.72	23.19	23.57	23.88	24.13
6	0.00	0.00	0.91	2.39	4.18	6.11	8.07	9.98	11.77	13.44	14.96	16.32	17.54	18.61	19.56	20.38
6.5	0.00	0.00	0.00	0.17	0.59	1.28	2.19	3.31	4.58	5.95	7.37	8.81	10.24	11.63	12.96	14.21
7	0.00	0.00	0.00	0.00	0.03	0.14	0.36	0.71	1.20	1.84	2.62	3.53	4.53	5.62	6.76	7.94
7.5	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.09	0.21	0.40	0.67	1.04	1.52	2.09	2.76	3.52
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.06	0.12	0.23	0.38	0.60	0.88	1.24
8.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.07	0.13	0.22	0.35
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.08
9.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Original Ground Surface at 5 feet

Water Table at 10 feet

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils)

20413

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

PROJECT 2002-466-10

Time (years)	2.3	2.4	2.6	2.7	2.8	3.0	3.1	3.2	3.4	3.5	3.6	3.8	3.9	4.0	4.2	4.3
Soil Depth																
0.5	0.86	0.70	0.57	0.46	0.37	0.30	0.24	0.20	0.16	0.13	0.10	0.08	0.07	0.06	0.05	0.04
1	4.11	3.49	2.96	2.50	2.12	1.78	1.50	1.26	1.06	0.89	0.74	0.62	0.52	0.43	0.36	0.30
1.5	9.81	8.73	7.73	6.83	6.00	5.26	4.60	4.01	3.49	3.03	2.62	2.26	1.95	1.68	1.44	1.24
2	16.07	14.88	13.71	12.57	11.48	10.44	9.46	8.53	7.67	6.88	6.15	5.48	4.87	4.31	3.81	3.36
2.5	20.84	19.93	18.97	17.97	16.94	15.91	14.87	13.84	12.83	11.85	10.90	10.00	9.14	8.33	7.56	6.85
3	23.52	23.01	22.43	21.77	21.05	20.27	19.44	18.57	17.67	16.75	15.82	14.88	13.95	13.04	12.14	11.27
3.5	24.68	24.46	24.19	23.85	23.46	23.00	22.48	21.90	21.27	20.58	19.85	19.09	18.29	17.46	16.62	15.77
4	25.07	25.00	24.89	24.76	24.59	24.37	24.11	23.80	23.44	23.03	22.56	22.05	21.48	20.88	20.23	19.54
4.5	25.17	25.15	25.12	25.08	25.02	24.94	24.83	24.69	24.52	24.32	24.07	23.78	23.45	23.08	22.66	22.20
5	25.19	25.19	25.18	25.17	25.15	25.13	25.09	25.04	24.98	24.89	24.78	24.65	24.48	24.29	24.06	23.79
5.5	24.33	24.50	24.63	24.73	24.82	24.88	24.93	24.96	24.97	24.97	24.96	24.92	24.87	24.80	24.70	24.58
6	21.09	21.71	22.24	22.69	23.08	23.41	23.69	23.93	24.12	24.28	24.42	24.52	24.60	24.65	24.68	24.68
6.5	15.38	16.47	17.46	18.37	19.19	19.93	20.59	21.18	21.70	22.16	22.57	22.92	23.22	23.48	23.70	23.89
7	9.13	10.32	11.49	12.62	13.72	14.76	15.74	16.66	17.52	18.32	19.05	19.72	20.33	20.88	21.37	21.82
7.5	4.36	5.27	6.23	7.23	8.25	9.29	10.33	11.36	12.37	13.35	14.29	15.20	16.06	16.87	17.63	18.34
8	1.67	2.18	2.77	3.43	4.15	4.93	5.76	6.63	7.53	8.45	9.38	10.31	11.24	12.16	13.05	13.92
8.5	0.52	0.74	1.01	1.35	1.74	2.20	2.72	3.30	3.93	4.61	5.34	6.11	6.91	7.73	8.57	9.43
9	0.13	0.20	0.30	0.44	0.61	0.83	1.09	1.40	1.76	2.17	2.63	3.15	3.71	4.32	4.97	5.65
9.5	0.03	0.04	0.07	0.12	0.18	0.26	0.37	0.50	0.67	0.88	1.13	1.41	1.74	2.12	2.54	3.00
10	0.00	0.01	0.02	0.03	0.04	0.07	0.11	0.16	0.22	0.31	0.42	0.55	0.72	0.91	1.14	1.41

Original Ground Surface at 5 feet

Water Table at 10 feet

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20414

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

PROJECT 2002-466-10

	Time (years)	4.4	4.6	4.7	4.8	5.0	5.1	5.3	5.4	5.5	5.7	5.8	5.9	6.1	6.2	6.3	6.5
	Soil Depth																
	0.5	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.25	0.21	0.17	0.14	0.12	0.10	0.08	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.02
	1.5	1.06	0.91	0.77	0.66	0.56	0.48	0.41	0.34	0.29	0.25	0.21	0.18	0.15	0.13	0.11	0.09
	2	2.96	2.60	2.28	1.99	1.74	1.51	1.32	1.14	0.99	0.86	0.74	0.64	0.55	0.48	0.41	0.35
	2.5	6.19	5.57	5.01	4.49	4.01	3.58	3.19	2.83	2.51	2.22	1.96	1.73	1.52	1.34	1.18	1.03
	3	10.43	9.62	8.85	8.12	7.43	6.78	6.17	5.61	5.08	4.59	4.14	3.73	3.35	3.00	2.68	2.40
	3.5	14.92	14.06	13.22	12.39	11.58	10.79	10.03	9.30	8.59	7.93	7.29	6.69	6.13	5.60	5.11	4.65
Original	4	18.83	18.08	17.32	16.54	15.75	14.96	14.17	13.38	12.60	11.84	11.10	10.37	9.67	9.00	8.35	7.74
Ground	4.5	21.69	21.15	20.57	19.95	19.30	18.63	17.93	17.21	16.48	15.75	15.00	14.26	13.52	12.79	12.07	11.36
Surface at 5 feet	5	23.49	23.15	22.77	22.35	21.89	21.40	20.87	20.31	19.72	19.11	18.47	17.81	17.13	16.45	15.75	15.05
	5.5	24.43	24.25	24.04	23.80	23.52	23.21	22.87	22.49	22.07	21.63	21.15	20.64	20.10	19.54	18.95	18.34
	6	24.66	24.62	24.55	24.45	24.33	24.17	23.99	23.78	23.53	23.26	22.95	22.60	22.23	21.83	21.39	20.93
	6.5	24.04	24.16	24.25	24.30	24.33	24.33	24.30	24.24	24.15	24.04	23.89	23.71	23.50	23.26	22.99	22.68
	7	22.21	22.56	22.86	23.13	23.35	23.54	23.69	23.80	23.89	23.94	23.96	23.94	23.90	23.82	23.71	23.58
	7.5	19.00	19.61	20.17	20.68	21.15	21.57	21.94	22.27	22.56	22.82	23.03	23.20	23.35	23.45	23.52	23.56
	8	14.76	15.57	16.34	17.07	17.75	18.40	19.00	19.56	20.08	20.55	20.98	21.37	21.72	22.03	22.30	22.53
	8.5	10.28	11.13	11.98	12.81	13.62	14.40	15.16	15.89	16.59	17.25	17.88	18.47	19.02	19.53	20.01	20.44
	9	6.37	7.11	7.88	8.66	9.45	10.24	11.03	11.82	12.59	13.35	14.09	14.81	15.51	16.18	16.81	17.42
Water Table at	9.5	3.50	4.05	4.63	5.25	5.90	6.57	7.27	7.98	8.71	9.45	10.19	10.93	11.67	12.40	13.12	13.82
10 feet	10	1.71	2.05	2.43	2.85	3.30	3.80	4.32	4.88	5.47	6.09	6.73	7.39	8.06	8.75	9.44	10.14

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20415

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

Time (years)	6.6	6.7	6.9	7.0	7.1	7.3	7.4	7.5	7.7	7.8	7.9	8.1	8.2	8.4	8.5	8.6
Soil Depth																
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.5	0.08	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01
2	0.30	0.26	0.22	0.19	0.16	0.14	0.12	0.10	0.09	0.07	0.06	0.05	0.04	0.04	0.03	0.03
2.5	0.90	0.79	0.69	0.60	0.52	0.45	0.39	0.34	0.29	0.26	0.22	0.19	0.16	0.14	0.12	0.10
3	2.14	1.90	1.69	1.50	1.33	1.17	1.04	0.91	0.81	0.71	0.62	0.55	0.48	0.42	0.37	0.32
3.5	4.22	3.82	3.46	3.12	2.81	2.53	2.27	2.04	1.82	1.63	1.46	1.30	1.15	1.03	0.91	0.81
4	7.15	6.59	6.06	5.57	5.10	4.67	4.26	3.88	3.53	3.21	2.91	2.63	2.38	2.15	1.93	1.74
4.5	10.67	10.00	9.35	8.73	8.13	7.55	7.00	6.48	5.99	5.52	5.08	4.67	4.28	3.92	3.58	3.27
5	14.35	13.65	12.96	12.27	11.60	10.94	10.30	9.67	9.06	8.48	7.92	7.38	6.86	6.37	5.91	5.46
5.5	17.72	17.08	16.43	15.77	15.10	14.44	13.77	13.11	12.46	11.81	11.18	10.56	9.95	9.37	8.80	8.25
6	20.44	19.92	19.38	18.82	18.24	17.64	17.03	16.41	15.78	15.15	14.52	13.88	13.25	12.62	12.00	11.39
6.5	22.35	21.98	21.59	21.17	20.72	20.25	19.75	19.24	18.70	18.15	17.58	16.99	16.40	15.80	15.20	14.59
7	23.41	23.21	22.97	22.71	22.42	22.10	21.75	21.37	20.96	20.53	20.08	19.60	19.11	18.59	18.06	17.52
7.5	23.56	23.53	23.47	23.38	23.25	23.09	22.90	22.68	22.43	22.15	21.84	21.51	21.15	20.76	20.35	19.91
8	22.73	22.88	23.01	23.10	23.15	23.17	23.15	23.11	23.02	22.91	22.77	22.59	22.39	22.15	21.89	21.59
8.5	20.84	21.20	21.52	21.80	22.05	22.26	22.43	22.57	22.67	22.74	22.77	22.77	22.74	22.67	22.57	22.44
9	18.00	18.54	19.04	19.51	19.95	20.35	20.71	21.04	21.33	21.58	21.80	21.99	22.14	22.25	22.33	22.38
9.5	14.50	15.17	15.81	16.42	17.01	17.57	18.10	18.59	19.06	19.49	19.89	20.25	20.58	20.88	21.14	21.36
10	10.84	11.54	12.23	12.91	13.58	14.23	14.86	15.48	16.07	16.64	17.18	17.70	18.18	18.64	19.06	19.46

Original Ground Surface at 5 feet

Water Table at 10 feet

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20416

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

	Time (years)	8.8	8.9	9.0	9.2	9.3	9.4	9.6	9.7	9.8	10.0	10.1	10.2	10.4	10.5	10.6	10.8
	Soil Depth																
	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
	2.5	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
	3	0.28	0.24	0.21	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03
	3.5	0.71	0.63	0.56	0.49	0.43	0.38	0.34	0.29	0.26	0.23	0.20	0.17	0.15	0.13	0.12	0.10
Original	4	1.56	1.40	1.25	1.12	1.00	0.89	0.80	0.71	0.63	0.56	0.50	0.44	0.39	0.34	0.30	0.27
Ground	4.5	2.98	2.71	2.46	2.23	2.02	1.83	1.65	1.49	1.34	1.20	1.08	0.97	0.87	0.78	0.70	0.62
Surface at 5 feet	5	5.05	4.65	4.28	3.94	3.61	3.31	3.03	2.77	2.52	2.30	2.09	1.90	1.72	1.56	1.41	1.27
	5.5	7.72	7.21	6.72	6.26	5.82	5.40	5.00	4.63	4.27	3.94	3.63	3.34	3.06	2.81	2.57	2.35
	6	10.80	10.21	9.64	9.09	8.55	8.03	7.53	7.05	6.59	6.15	5.73	5.33	4.95	4.59	4.25	3.93
	6.5	13.98	13.38	12.78	12.18	11.59	11.01	10.45	9.89	9.35	8.83	8.32	7.83	7.35	6.89	6.46	6.04
	7	16.96	16.40	15.82	15.24	14.66	14.08	13.49	12.92	12.34	11.77	11.21	10.66	10.12	9.60	9.08	8.58
	7.5	19.46	18.98	18.49	17.98	17.46	16.93	16.39	15.84	15.28	14.72	14.16	13.60	13.04	12.49	11.94	11.39
	8	21.27	20.93	20.56	20.17	19.75	19.32	18.86	18.39	17.91	17.41	16.90	16.38	15.85	15.32	14.78	14.24
	8.5	22.28	22.09	21.87	21.62	21.34	21.04	20.71	20.36	19.99	19.59	19.18	18.74	18.29	17.83	17.35	16.86
	9	22.39	22.37	22.31	22.23	22.11	21.97	21.79	21.59	21.35	21.09	20.81	20.50	20.16	19.81	19.43	19.04
Water Table at	9.5	21.56	21.71	21.84	21.93	21.99	22.01	22.00	21.96	21.89	21.79	21.66	21.49	21.30	21.09	20.84	20.58
10 feet	10	19.82	20.15	20.45	20.71	20.94	21.14	21.31	21.44	21.54	21.61	21.64	21.64	21.61	21.56	21.47	21.35

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20417

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

	Time (years)	10.9	11.0	11.2	11.3	11.4	11.6	11.7	11.9	12.0	12.1	12.3	12.4	12.5	12.7	12.8	12.9
	Soil Depth																
	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.5	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	3.5	0.09	0.08	0.07	0.06	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01
Original Ground Surface at 5 feet	4	0.24	0.21	0.18	0.16	0.14	0.12	0.11	0.09	0.08	0.07	0.06	0.06	0.05	0.04	0.04	0.03
	4.5	0.55	0.49	0.44	0.39	0.35	0.31	0.27	0.24	0.21	0.19	0.17	0.15	0.13	0.11	0.10	0.09
	5	1.15	1.04	0.93	0.84	0.75	0.68	0.61	0.54	0.49	0.43	0.39	0.35	0.31	0.27	0.24	0.22
	5.5	2.15	1.96	1.78	1.62	1.47	1.34	1.21	1.10	0.99	0.89	0.81	0.73	0.65	0.59	0.53	0.47
	6	3.63	3.35	3.08	2.84	2.61	2.39	2.19	2.00	1.83	1.67	1.52	1.39	1.26	1.15	1.04	0.94
	6.5	5.64	5.26	4.89	4.55	4.22	3.92	3.63	3.35	3.10	2.86	2.63	2.42	2.22	2.04	1.87	1.71
	7	8.10	7.63	7.18	6.74	6.33	5.93	5.55	5.18	4.83	4.50	4.19	3.89	3.61	3.35	3.10	2.87
	7.5	10.86	10.34	9.82	9.32	8.83	8.35	7.89	7.45	7.02	6.60	6.20	5.82	5.45	5.10	4.77	4.45
	8	13.70	13.16	12.62	12.09	11.56	11.04	10.53	10.03	9.54	9.06	8.59	8.14	7.70	7.27	6.86	6.46
	8.5	16.36	15.86	15.34	14.83	14.31	13.78	13.26	12.74	12.23	11.72	11.21	10.71	10.22	9.74	9.27	8.81
	9	18.62	18.19	17.75	17.29	16.82	16.34	15.86	15.36	14.87	14.36	13.86	13.36	12.85	12.35	11.86	11.37
	9.5	20.28	19.97	19.63	19.27	18.90	18.50	18.09	17.67	17.23	16.78	16.32	15.85	15.38	14.90	14.41	13.93
Water Table at 10 feet	10	21.20	21.03	20.83	20.60	20.35	20.07	19.77	19.45	19.11	18.75	18.38	17.99	17.58	17.16	16.73	16.29

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20418

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

	Time (years)	13.1	13.2	13.3	13.5	13.6	13.7	13.9	14.0	14.1	14.3	14.4	14.5	14.7	14.8	14.9	15.1
	Soil Depth																
	0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.5	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Original Ground Surface at 5 feet	4	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
	4.5	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01
	5	0.19	0.17	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.04	0.04	0.03	0.03
	5.5	0.43	0.38	0.34	0.30	0.27	0.24	0.22	0.19	0.17	0.15	0.14	0.12	0.11	0.09	0.08	0.07
	6	0.85	0.77	0.70	0.63	0.57	0.51	0.46	0.41	0.37	0.33	0.30	0.27	0.24	0.21	0.19	0.17
	6.5	1.57	1.43	1.31	1.19	1.08	0.99	0.90	0.81	0.74	0.67	0.60	0.55	0.49	0.45	0.40	0.36
	7	2.65	2.44	2.25	2.07	1.90	1.75	1.60	1.47	1.34	1.23	1.12	1.02	0.93	0.85	0.77	0.70
	7.5	4.15	3.87	3.59	3.34	3.10	2.87	2.66	2.46	2.27	2.09	1.93	1.77	1.63	1.50	1.38	1.26
	8	6.08	5.71	5.36	5.03	4.70	4.40	4.11	3.83	3.57	3.32	3.09	2.87	2.66	2.47	2.28	2.11
	8.5	8.37	7.93	7.51	7.10	6.71	6.33	5.96	5.61	5.27	4.95	4.64	4.34	4.06	3.80	3.54	3.30
	9	10.88	10.40	9.93	9.47	9.02	8.58	8.15	7.74	7.33	6.94	6.56	6.20	5.84	5.51	5.18	4.87
	9.5	13.44	12.95	12.47	11.99	11.51	11.04	10.57	10.11	9.66	9.22	8.78	8.36	7.95	7.55	7.16	6.78
Water Table at 10 feet	10	15.84	15.39	14.92	14.46	13.99	13.52	13.05	12.57	12.11	11.64	11.18	10.72	10.28	9.83	9.40	8.97

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20419

APPENDIX C
DOMINION VIRGINIA POWER
TRANSPORT IN UNSATURATED ZONE - BUFFER1 OUTPUT
FORWARD MODELING RESULTS

Time (years)	15.2	15.4	15.5	15.6	15.8	15.9	16.0	16.2	16.3	16.4	16.6	16.7
Soil Depth												
0.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Original Ground Surface at 5 feet 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.5	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
5.5	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.02
6	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.04
6.5	0.33	0.29	0.26	0.24	0.21	0.19	0.17	0.15	0.14	0.12	0.11	0.10
7	0.64	0.58	0.52	0.47	0.43	0.39	0.35	0.32	0.28	0.26	0.23	0.21
7.5	1.15	1.06	0.97	0.88	0.80	0.73	0.67	0.61	0.55	0.50	0.45	0.41
8	1.95	1.80	1.66	1.52	1.40	1.29	1.18	1.08	0.99	0.91	0.83	0.76
8.5	3.08	2.86	2.66	2.47	2.29	2.12	1.96	1.81	1.68	1.55	1.43	1.31
9	4.57	4.29	4.02	3.76	3.51	3.28	3.06	2.85	2.65	2.47	2.29	2.13
9.5	6.42	6.07	5.73	5.40	5.09	4.79	4.50	4.23	3.97	3.72	3.48	3.25
Water Table at 10 feet 10	8.56	8.15	7.75	7.37	7.00	6.63	6.28	5.95	5.62	5.31	5.00	4.71

LEGEND

Beneficially-Used Fly Ash

Vadose Zone (Existing Soils

20420

APPENDIX D

SENSITIVITY ANALYSIS

20421

APPENDICX D
DOMINION VIRGINIA POWER - BASELINE - 17 YEARS
SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project: Dominion Virginia Power - Etheridge Ridge Golf Course

Date: 11/20/2002 Prepared by: JEB GAI Consultants, Inc.

Contaminant: Nitrate

SOURCE CONC (MG/L)	X DISTANCE TO LOCATION OF CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*I/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609

y(ft)	z(ft)	Time (days)
450	0	0	6205

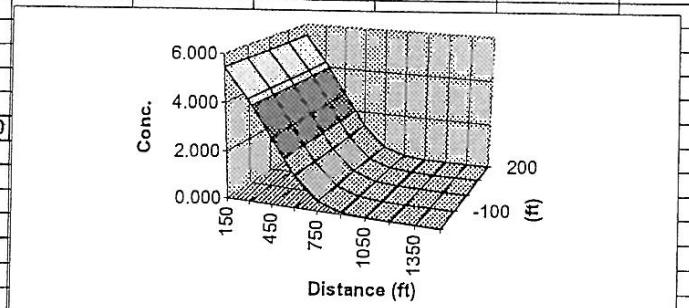
Projected Conc. at 450 0 0

at 6205 days

2.779 mg/l

AREAL MODEL	CALCULATION DOMAIN
Length (ft)	1500
Width (ft)	200

PA DEPARTMENT OF ENVIRONMENTAL PROTECTION
QUICK_DOMENICO.XLS
SPREADSHEET APPLICATION OF
"AN ANALYTICAL MODEL FOR MULTIDIMENSIONAL TRANSPORT OF A DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
0	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000

20422

APPENDICX D
DOMINION VIRGINIA POWER - SOURCE CONCENTRATION SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project: Dominion Virginia Power - Etheridge Ridge Golf Course
Date: 11/20/2002 Prepared by: JEB GAI Consultants, Inc.
Contaminant: Nitrate

PA DEPARTMENT
OF ENVIRONMENTAL PROTECTION
QUICK_DOMENICO.XLS
SPREADSHEET APPLICATION OF
"AN ANALYTICAL MODEL FOR
MULTIDIMENSIONAL TRANSPORT OF A
DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation

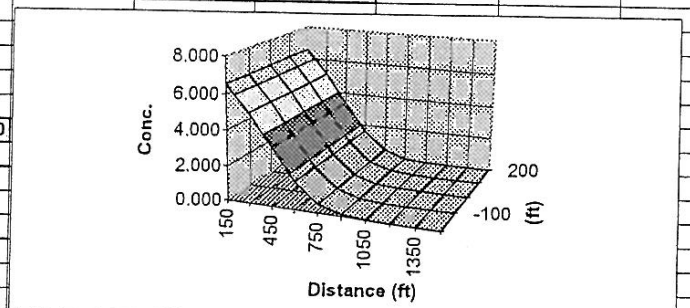
SOURCE CONC (MG/L)	X DISTANCE TO LOCATION OF CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
7.2	450	35	0.35	0.001	0	1000	1

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609

	y(ft)	z(ft)	Time (days)
450	0	0	6205

Projected Conc. at 450 0 0
at 6205 days
3.335 mg/l

AREAL MODEL CALCULATION DOMAIN
Length (ft) 1500
Width (ft) 200



	150	300	450	600	750	900	1050	1200	1350	1500
200	6.543	5.093	3.335	1.610	0.513	0.101	0.012	0.001	0.000	0.000
100	6.543	5.093	3.335	1.610	0.513	0.101	0.012	0.001	0.000	0.000
0	6.543	5.093	3.335	1.610	0.513	0.101	0.012	0.001	0.000	0.000
-100	6.543	5.093	3.335	1.610	0.513	0.101	0.012	0.001	0.000	0.000
-200	6.543	5.093	3.335	1.610	0.513	0.101	0.012	0.001	0.000	0.000

20423

APPENDICX D
DOMINION VIRGINIA POWER - LONGITUDINAL DISPERSIVITY SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE TO LOCATION OF CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	28	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	6205				
Projected Conc. at		450	0	0			
at	6205 days						
2.852 mg/l							
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

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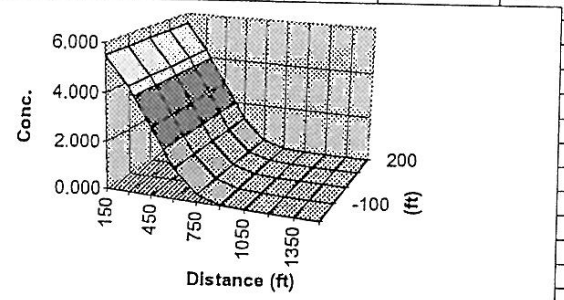
DECAYING CONTAMINANT SPECIES"
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.513	4.367	2.852	1.277	0.337	0.048	0.003	0.000	0.000	0.000
100	5.513	4.367	2.852	1.277	0.337	0.048	0.003	0.000	0.000	0.000
0	5.513	4.367	2.852	1.277	0.337	0.048	0.003	0.000	0.000	0.000
-100	5.513	4.367	2.852	1.277	0.337	0.048	0.003	0.000	0.000	0.000
-200	5.513	4.367	2.852	1.277	0.337	0.048	0.003	0.000	0.000	0.000

20424

APPENDICX D
DOMINION VIRGINIA POWER - TRANSVERSE DISPERSIVITY SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE TO LOCATION OF CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.42	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	6205				
Projected Conc. at		450	0	0			
at	6205	days					
2.779	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

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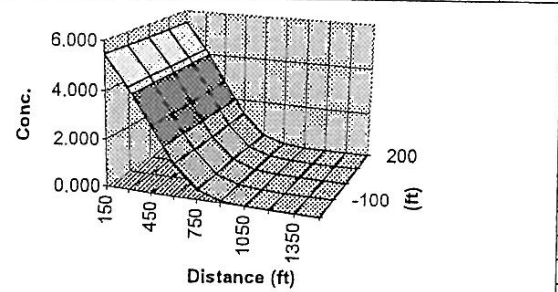
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
0	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000

APPENDICX D
DOMINION VIRGINIA POWER - SOURCE WIDTH SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1200	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	6205				
Projected Conc. at		450	0	0			
at	6205 days						
2.779 mg/l							
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

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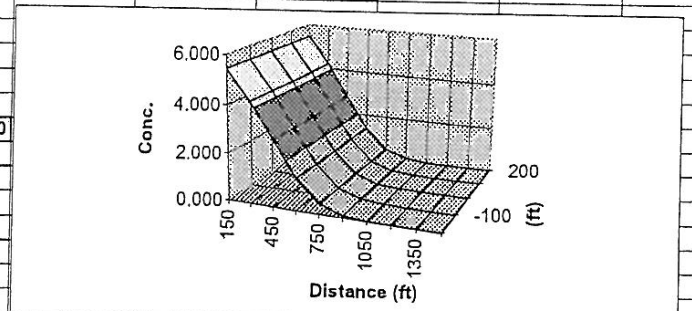
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
0	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000

APPENDICX D
DOMINION VIRGINIA POWER - SOURCE THICKNESS SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project: Dominion Virginia Power - Etheridge Ridge Golf Course

Date: 11/20/2002 Prepared by: JEB GAI Consultants, Inc.

Contaminant: Nitrate

PA DEPARTMENT
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Modified to Include Retardation

X							
SOURCE CONC (MG/L)	DISTANCE TO LOCATION OF CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1.2

Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
1.95E+01	0.001	0.23	1.65	0	5.00E-03	1	0.084782609

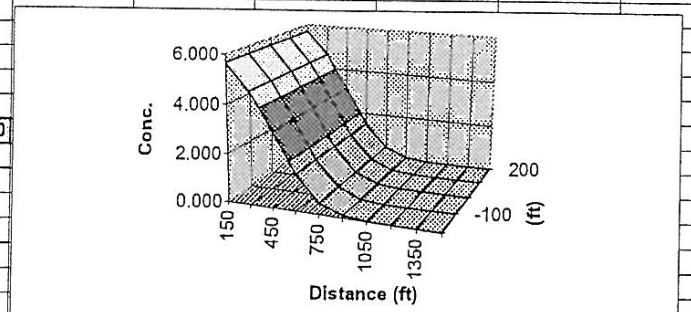
	y(ft)	z(ft)	Time (days)
450	0	0	6205

Projected Conc. at 450 0 0

at 6205 days

3.117 mg/l

AREAL MODEL	CALCULATION DOMAIN
Length (ft)	1500
Width (ft)	200



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.683	4.643	3.117	1.526	0.491	0.097	0.011	0.001	0.000	0.000
100	5.683	4.643	3.117	1.526	0.491	0.097	0.011	0.001	0.000	0.000
0	5.683	4.643	3.117	1.526	0.491	0.097	0.011	0.001	0.000	0.000
-100	5.683	4.643	3.117	1.526	0.491	0.097	0.011	0.001	0.000	0.000
-200	5.683	4.643	3.117	1.526	0.491	0.097	0.011	0.001	0.000	0.000

APPENDICX D
DOMINION VIRGINIA POWER - HYDRAULIC CONDUCTIVITY SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE CONC (MG/L)	DISTANCE T LOCATION O CONCERN (ft)	Ax (ft)	Ay (ft)	Az (ft) >=.001	LAMBDA day-1	SOURCE WIDTH (ft)	SOURCE THICKNESS (ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic Cond (ft/day)	Hydraulic Gradient (ft/ft)	Porosity (dec. frac.)	Soil Bulk Density (g/cm³)	KOC	Frac. Org. Carb.	Retard-ation (R)	V (=K*i/n*R) (ft/day)
2.34E+01	0.001	0.23	1.65	0	5.00E-03	1	0.10173913
	y(ft)	z(ft)	Time (days)				
450	0	0	6205				
Projected Conc. at		450	0	0			
at	6205	days					
3.424	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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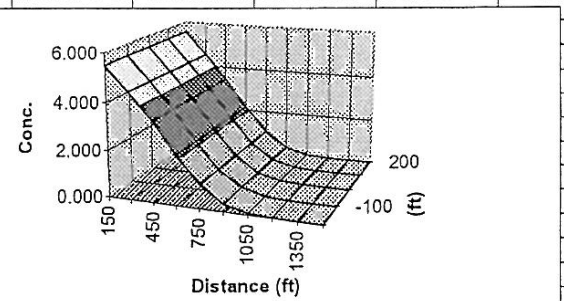

	150	300	450	600	750	900	1050	1200	1350	1500
200	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
100	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
0	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
-100	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
-200	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000

20428

APPENDICX D
DOMINION VIRGINIA POWER - HYDRAULIC GRADIENT SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE	DISTANCE T	Ax	Ay	Az	LAMBDA	SOURCE	SOURCE
CONC	LOCATION O	(ft)	(ft)	(ft)		WIDTH	THICKNESS
(MG/L)	CONCERN (ft)			>=.001	day-1	(ft)	(ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic	Hydraulic		Soil Bulk		Frac.	Retard-	V
Cond	Gradient	Porosity	Density	KOC	Org. Carb.	ation	(=K*I/n*R)
(ft/day)	(ft/ft)	(dec. frac.)	(g/cm³)			(R)	(ft/day)
1.95E+01	0.0012	0.23	1.65	0	5.00E-03	1	0.10173913
	y(ft)	z(ft)	Time (days)				
450	0	0	6205				
Projected Conc. at		450	0	0			
at	6205	days					
3.424	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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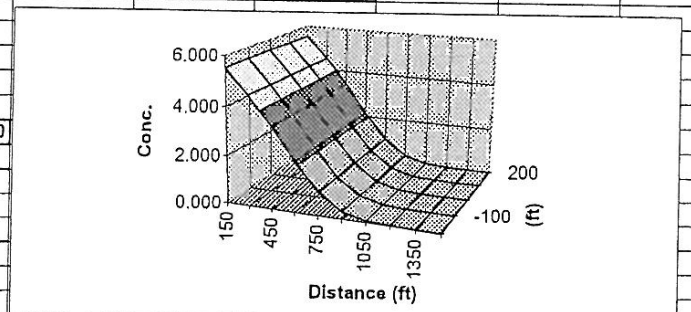

	150	300	450	600	750	900	1050	1200	1350	1500
200	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
100	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
0	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
-100	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000
-200	5.531	4.543	3.424	2.143	1.006	0.328	0.071	0.010	0.001	0.000

20429

APPENDICX D
DOMINION VIRGINIA POWER - POROSITY
SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE	DISTANCE T	Ax	Ay	Az	LAMBDA	SOURCE	SOURCE
CONC	LOCATION O	(ft)	(ft)	(ft)		WIDTH	THICKNESS
(MG/L)	CONCERN (ft)			>=.001	day-1	(ft)	(ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic	Hydraulic		Soil Bulk		Frac.	Retard-	V
Cond	Gradient	Porosity	Density	KOC	Org. Carb.	ation	(=K*i/n*R)
(ft/day)	(ft/ft)	(dec. frac.)	(g/cm³)			(R)	(ft/day)
1.95E+01	0.001	0.184	1.65	0	5.00E-03	1	0.105978261
	y(ft)	z(ft)	Time (days)				
450	0	0	6205				
Projected Conc. at		450	0	0			
at	6205	days					
3.541	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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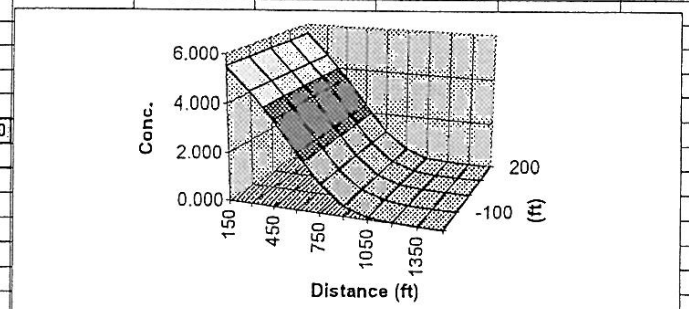

	150	300	450	600	750	900	1050	1200	1350	1500
200	5.542	4.589	3.541	2.322	1.172	0.422	0.103	0.017	0.002	0.000
100	5.542	4.589	3.541	2.322	1.172	0.422	0.103	0.017	0.002	0.000
0	5.542	4.589	3.541	2.322	1.172	0.422	0.103	0.017	0.002	0.000
-100	5.542	4.589	3.541	2.322	1.172	0.422	0.103	0.017	0.002	0.000
-200	5.542	4.589	3.541	2.322	1.172	0.422	0.103	0.017	0.002	0.000

20430

APPENDICX D
DOMINION VIRGINIA POWER - SOIL BULK DENSITY SENSITIVITY ANALYSIS - QUICK DOMENICO OUTPUT

ADVECTIVE TRANSPORT WITH THREE DIMENSIONAL DISPERSION AND 1ST ORDER DECAY and RETARDATION

Project:	Dominion Virginia Power - Etheridge Ridge Golf Course						
Date:	11/20/2002	Prepared by:	JEB GAI Consultants, Inc.				
		Contaminant:	Nitrate				
	X						
SOURCE	DISTANCE T	Ax	Ay	Az	LAMBDA	SOURCE	SOURCE
CONC	LOCATION O	(ft)	(ft)	(ft)		WIDTH	THICKNESS
(MG/L)	CONCERN (ft)			>=.001	day-1	(ft)	(ft)
6	450	35	0.35	0.001	0	1000	1
Hydraulic	Hydraulic		Soil Bulk		Frac.	Retard-	V
Cond	Gradient	Porosity	Density	KOC	Org. Carb.	ation	(=K*i/n*R)
(ft/day)	(ft/ft)	(dec. frac.)	(g/cm³)			(R)	(ft/day)
1.95E+01	0.001	0.23	1.98	0	5.00E-03	1	0.084782609
	y(ft)	z(ft)	Time (days)				
450	0	0	6205				
Projected Conc. at		450	0	0			
at	6205	days					
2.779	mg/l						
	AREAL MODEL	CALCULATION DOMAIN					
	Length (ft)	1500					
	Width (ft)	200					

PA DEPARTMENT
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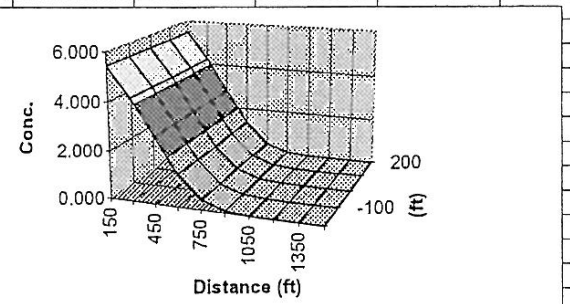
P.A. Domenico (1987)
Modified to Include Retardation



	150	300	450	600	750	900	1050	1200	1350	1500
200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
0	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-100	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000
-200	5.453	4.244	2.779	1.341	0.427	0.084	0.010	0.001	0.000	0.000

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