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NOV 1 5 2002

Mr. William Von Till
U.S. Nuclear Regulatory Commission
Two White Flint North
11545 Rockville Pike
MS T7J8
Rockville, MD 20852-2747

Subject: Canonsburg Area C Ground Water Concentrations

Dear Mr. Von Till:

Per our conversation on "Canonsburg Area C ground water concentration predictions" among you, Dr. Cooper Wayman, and me, I have enclosed the *Update to the Canonsburg PA UMTRA Ground Water Modeling Analysis.*

The update documents that Area C ground water institutional controls should be removed and not continue to encumber the subject site (Area C). Therefore, the DOE would appreciate concurrence by the NRC in this matter.

Please contact Dr. Cooper Wayman at 970/248-7620 to verify your agreement with our modeling update.

Sincerely,

Donald R. Metzler
Program Manager

Enclosures

cc w/enclosures:
C. Wayman, DOE-GJO
Project File GWCAN 3.3 (DOE)

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**Technical Memorandum**

*Date:* September 30, 2002

*Subject:* Update to the Canonsburg, PA UMTRA Ground Water Modeling Analysis

*To:* David Peterson, Ph.D., S.M. Stoller Corp.

*From:* Robert G. Knowlton, Ph.D., P.E., Framatome ANP DE&S

Introduction

In 1997, the U.S. Department of Energy (DOE) proposed an alternate concentration limit (ACL) remedy for the Uranium Mill Tailings Remedial Action (UMTRA) Project site at Canonsburg, PA (DOE, 2000a). At the time, a probabilistic flow and transport simulator called GANDT was used to assess the fate of the contaminants in local ground water. This analysis provided an estimate of the uncertainty in future behavior of the ground water contaminants. The U.S. Nuclear Regulatory Commission (NRC) concurred with the conclusions that the DOE made regarding the ability of the site to conform to environmental standards using the ACL approach.

The Canonsburg UMTRA Project site is divided into three main areas, Areas A, B, and C. Area C is the focus of this updated modeling effort, inasmuch as DOE wants to sell the property and desires a current understanding of potential contamination at the site.

From 1984 to 1986, the DOE removed radioactively contaminated materials from Area C and disposed of them in a permanent, capped disposal cell in Areas A and B. On the basis of information available through 1997 (DOE, 2000a), the probabilistic flow and transport modeling at the time estimated that the time to clean up at Area C was on the order of 15 years. Since 1997, an additional five (5) years of ground water monitoring data have been collected at the site. These recent data suggest that the main constituent of potential concern, uranium, may be attenuating in the ground water system more quickly than originally predicted. In fact, the uranium concentrations at the point of compliance (POC) well for Area C (monitor well 414) are below the applicable ground water standard of 0.044 mg/L. The purpose of updating the ground water flow and transport model is to honor the last 5 years of uranium concentration data and to predict future behavior of uranium in the aquifer underlying Area C.

Previous Modeling

A description of conditions at the Canonsburg site, as well as an historical perspective of site activities, is provided in the ACL application (DOE, 2000a). A conceptual model of the site's hydrogeology is also included in the ACL application. Using the conceptual model, a numerical model of ground water flow and transport was developed in the mid-1990s to predict future ground water contaminant behavior. The Monte Carlo method (e.g., de Marsily, 1986) was applied to conduct hundreds of simulations with the model so that a range of contaminant plume outcomes could be examined.

The computer code used to construct and implement the numerical model for the 1997 ACL study was Version 1.1 of the Groundwater Analysis and Network Design Tool (Knowlton et al., 1995), or GANDT. GANDT 1.1 has also been used to perform this updated assessment of uranium transport at Area C. The GANDT code has the following capabilities:

- Performs Monte Carlo analyses (i.e., many model runs) to translate uncertainty in the model input parameters into uncertainty in model output;
- Uses Latin Hypercube Sampling (LHS) to efficiently set up the input parameters for the Monte Carlo analysis in order to minimize the number of model runs needed to quantify uncertainties;
- Conditions the model results on observed ground water concentration data (i.e., essentially a built-in calibration method) to honor actual site conditions; and
- Produces statistical results and graphical output to aid in understanding the uncertainties and how they relate to performance objectives.

A more detailed description of the GANDT code and its functionality are presented in the *Ground Water Compliance Action Plan for the Canonsburg, Pennsylvania, UMTRA Project Site* (GCAP) (DOE, 2000b), which also contains the ACL application (DOE, 2000a).

A comprehensive write-up on the numerical model, including input distributions used in the analysis, following American Society for Testing Materials (ASTM) guidelines for model documentation, was presented in the GCAP (DOE, 2000b). Most of the parameters employed in the 1997 analysis were retained in the current application of the numerical model. Some modifications were necessary, however, in order to honor the new data acquired at the site since 1997.

<u>Recent Behavior of the Uranium Plume</u>

Ground water quality data collected from POC monitoring well 414 between 1997 and 2002 suggests that the site may be achieving compliance sooner than expected relative to the 1997 model predictions. Table 1 lists measured concentrations of uranium in ground water for the full period of record at monitor well 414, and Figure 10 depicts these concentrations graphically. It is worth noting that the ground water concentrations for uranium were below the regulatory limit of 0.044 mg/L prior to the removal of the contaminated material from Area C. It appears that, between 1993 and 1995, dissolved uranium concentrations in the well exceeded this limit, with the largest concentration of 0.185 mg/L occurring in late 1995. The presumed cause of these larger concentrations was a delayed response to the mobilization of uranium during site remediation.

It is quite difficult, if not unattainable, to account in the model for the temporary dissolved uranium concentration increases caused by site remediation activities. Because of this difficulty, the updated model discussed in this memorandum has been developed using only post-1997 data for model conditioning.

No additional characterization data other than ground water quality information have been obtained from the site in the last 5 years. To honor the observed concentration behavior over the past several years, with more rapid attenuation than predicted 5 years ago, several model input parameters must be adjusted. Two parameters that are difficult to obtain *in situ* - initial source concentration and the uranium sorption coefficient - have a major impact on the uranium ground water plume. Given that water quality data of late suggest that attenuation of uranium is more rapid than previously predicted, it is likely that the estimated ranges of both the uranium source concentration and its sorption coefficient were too high in the 1997 investigation. Lowering the ranges on both these parameters are expected to cause the predicted uranium plume to show enhanced attenuation. The process of modifying these two data distributions is discussed in the next section.

## Updated Model

As mentioned above, the GANDT model has the capability to condition model results on observed water quality data. This process essentially constitutes a built-in calibration procedure for multiple Monte Carlo simulations made with the model. There are some limitations to the process, however, that are worth noting. Namely, GANDT only allows the user to condition model results at one output time. Therefore, a time series of data cannot be explicitly used in conditioning model results. When the conditioning methodology is applied, the GANDT code is capable of predicting water quality behavior past the time of conditioning, but not prior to it. Thus, if the model user is interested in observing model results prior to the time of conditioning, he must cull out individual model simulations and subsequently re-run them in a deterministic manner.

As previously mentioned, conditioning in the updated modeling was limited to the past 5 years of water quality data. This meant that uranium concentrations from only a single well – well 414 – could be considered for this purpose. Of the 5 years of available data, the uranium concentration measured in 2001 was from a newly constructed borehole, 414a, which was installed to replace the original monitor well 414. The 414a sample indicated that uranium was non-detectable. Thus the measured uranium concentration in 2000 at the original well was used for the conditioning of model results.

Conditioning within the GANDT 1.1 code is accomplished using the following process. First, the model user specifies the wells to be used as conditioning points in the model. The target ground water concentrations for conditioning at the selected wells are then input to the model. Next, the user invokes the Monte Carlo method by developing estimates of probabilistic descriptors for each uncertain parameter in the simulation.

Efficient Latin Hypercube Sampling (LHS) algorithms are used for this purpose, and a large number of model runs are made with the resulting sets of uncertain parameters. The GANDT model then queries the results of each model run and performs an analysis of the root mean square error (RMSE) between observed and comparable modeled concentrations. The user is subsequently informed as to how many model runs meet the RMSE acceptance criterion, and the model may then be used to simulate additional years beyond the conditioning time.

The target year selected for model conditioning was 2000, when the concentration at well 414 was measured at 0.0265 mg/L. One thousand (1000) simulations were made with the GANDT model using an RMSE criterion of 0.0065 mg/L. Of the 1000 simulations initially performed, 108 runs met this criterion.

To achieve the conditioning results just mentioned, it was necessary to use ranges of values for both the Area C source term concentration for uranium and its saturated zone sorption coefficient that were different than the ranges used in the 1997 analyses. The distribution for uranium source term concentration was changed from a uniform distribution with a range of 0.0005 to 0.001 mg/g to a uniform distribution with a range of 0.0002 to 0.0007 mg/g. The distribution for saturated zone sorption coefficient was changed from a uniform distribution with a range of 0.3 to 0.6 $cm^3/g$ to a uniform distribution with a range of 0.2 to 0.45 $cm^3/g$.

<u>Model Results</u>

Upon completion of the Monte Carlo runs, results from the 108 simulations that met the prescribed conditioning criterion were analyzed both statistically and graphically. One type of analysis shows the distribution of the average predicted uranium concentration in ground water at several times, as illustrated in Figures 1 through 6 for years between 2000 and 2020. Each distribution represents the expected case for uranium concentration in ground water. These model results indicate that the uranium is expected to completely flush from the aquifer by the year 2020.

It is useful to also examine predicted probabilities of exceeding the ground water standard for uranium (0.044 mg/L), both in space and time. Figures 7 through 9 show such probability plots for the years 2000, 2002, and 2005. After 2005, the probability of exceeding the 0.044 mg/L standard is negligible.

Figure 10 shows a plot of the predicted average concentration (or expected value) of uranium in monitor well 414 through time, and also indicates the range of computed uranium concentrations at this well during several key years. As previously mentioned, observed uranium concentrations at well 414 since 1986, the first year it was sampled, are also displayed. A comparison of the predicted and simulated values indicates that the model performs reasonably well in matching observed concentrations from 2000 to the present. Figure 10 also clearly shows that dissolved uranium concentrations at well 414, both observed and computed, are currently below the regulatory standard for ground water (0.044 mg/L). The model predicts that uranium concentrations will drop below detection limits by about the year 2015.

It is of some interest to compare observed and computed uranium concentrations for years prior to the time of conditioning (2000). Unfortunately, GANDT 1.1 is unable to condition model results on observed concentrations in one year and subsequently produce probabilistic results for earlier years. However, this difficulty can be partly overcome by choosing a particular realization from the suite of Monte Carlo parameter sets and then re-running that simulation in a deterministic mode using alternative output times. This approach is useful, for instance, if the user is interested in seeing how the model runs that produced minimum and maximum computed concentrations at the time of conditioning simulate plume behavior in previous years.

Analysis of the 108 conditioned simulations showed that model run 75 produced the minimum predicted uranium concentration in 2000, and run number 37 produced the maximum value. A deterministic simulation was performed using the parameter values from run number 75 and several output times prior to 2000 to provide an estimate of model behavior for the minimum value case. A similar deterministic run was performed for the maximum value case using the parameter input set from run number 37. Figure 11 shows the results of these two deterministic model runs for the years 1986 through 2000, as well as the years after 2000. The plots shown in this figure are of interest because they show computed concentrations for the years 1995-1999 to be of the same general magnitude as observed concentrations during this period; however, model-generated concentrations in the years leading up to 1995 are considerably larger than their observed counterparts. Such comparisons indicate the effect that man-induced concentration increases attributable to remediation activity can have on modeling analyses. It is possible that, had the Canonsburg site not been disturbed by remedial activities, probabilistic modeling analyses might have produced different sets of model input parameters. However, the general decline in observed uranium concentrations during the 1990s and the early 2000s would have also likely led to an expectation that dissolved uranium would flush from Area C of the Canonsburg site in the next 5 to 7 years.

Conclusions

Five years have elapsed since a probabilistic modeling analysis of Area C at the Canonsburg, PA UMTRA Project site demonstrated that an ACL remedy is appropriate for the site. Annual monitoring at point of compliance (POC) well 414 in Area C between 1997 and 2000, and at well 414a in 2001, has shown that the uranium concentration in ground water is attenuating more quickly than originally predicted. In an effort to better understand the local ground water system, the site model of ground water flow and transport was updated to honor the more recent data. Current data show that concentrations of uranium at wells 414 and 414a are below the ground water standard of 0.044 mg/L. Updating the model to simulate these data indicate that the probability of uranium concentration exceeding this standard after 2005 is negligible. The updated model also indicates that uranium levels in ground water will be below 0.001 mg/L by about the year 2020.

References

de Marsily, G., 1986, *Quantitative Hydrogeology*, Academic Press, Inc., 440 p.

Department of Energy (DOE), 2000a, *Application for Alternate Concentration Limits for the Canonsburg, Pennsylvania, UMTRA Project Site*, UMTRA Ground Water Project, U.S. Department of Energy, Grand Junction Office, Grand Junction, CO, Document Number U0035800, February 2000.

Department of Energy (DOE), 2000b, *Ground Water Compliance Action Plan for the Canonsburg, Pennsylvania, UMTRA Project Site*, UMTRA Ground Water Project, U.S. Department of Energy, Grand Junction Office, Grand Junction, CO, Document Number U0035901, February 2000.

Knowlton, R.G., D.M. Peterson, D. Metzler, D.D. Walker, B. Rutherford, J. White, J. Massman, D. McCorquodale, K. Belcourt, and E. Klavetter, 1995, *Monitor Well Network Design With a Decision Analysis Tool*, Proceedings of the ER95 Conference, sponsored by the U.S. Department of Energy, Denver, Colorado.

Table 1 – Observed Ground Water Quality Data for Uranium for Monitor Well 414

| Sampling Date | Uranium Concentration (mg/l) | Lab/Data Qualifiers | Detection Limit (mg/l) |
|---|---|---|---|
| 8/5/1986 | 0.0221 | | 0.003 |
| 11/5/1986 | 0.0206 | F | 0.003 |
| 1/23/1987 | 0.0133 | F | 0.003 |
| 5/29/1987 | 0.0134 | | 0.003 |
| 12/9/1987 | 0.017 | | 0.003 |
| 6/23/1988 | 0.0103 | F | 0.003 |
| 12/8/1988 | 0.023 | | 0.003 |
| 5/25/1989 | 0.0153 | F | 0.003 |
| 1/4/1990 | 0.02 | F | 0.003 |
| 8/1/1990 | 0.014 | F | 0.001 |
| 8/1/1991 | 0.02 | F | 0.001 |
| 1/15/1992 | 0.021 | F | 0.001 |
| 8/6/1992 | 0.012 | F | 0.001 |
| 10/28/1993 | 0.04 | | 0.001 |
| 10/28/1993 | 0.036 | | 0.001 |
| 10/29/1994 | 0.056 | | 0.001 |
| 10/29/1994 | 0.056 | | 0.001 |
| 11/18/1995 | 0.185 | F | 0.001 |
| 12/5/1996 | 0.0317 | | - |
| 11/11/1997 | 0.0814 | L | - |
| 10/10/1998 | 0.0441 | L | - |
| 9/25/1999 | 0.0187 | L | - |
| 10/3/2000 | 0.0265 | L | 0.0001 |
| 10/30/2001 | 0.0019* | UL | 0.0001 |

Lab/Data Qualifiers:
F – Low flow sampling method used
L – Less than 3 well-bore volumes purged prior to sampling
U – Parameter analyzed for but was not detected

Note - * New well, 414A, drilled and sampled for this event, replacing original well 414

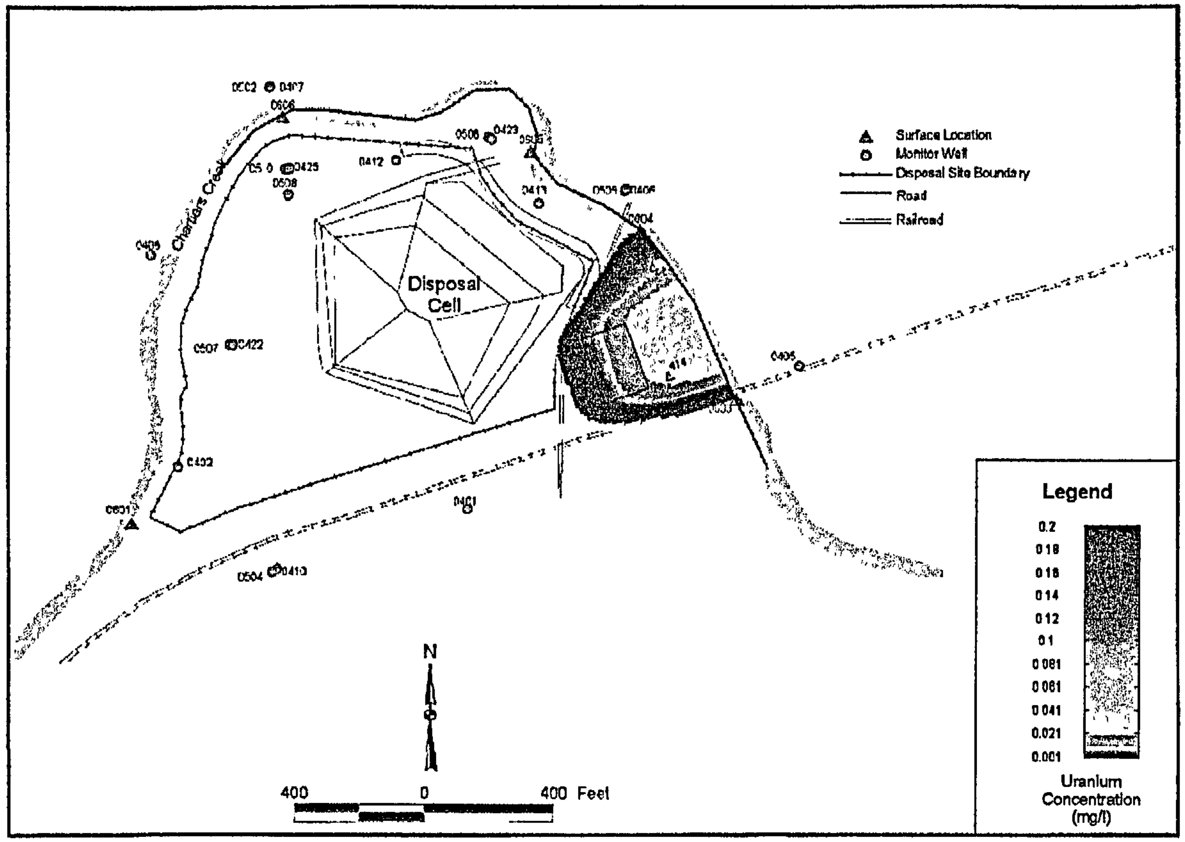


Figure 1 – Predicted Average Uranium Concentration Distribution in Ground Water at the UMTRA Canonsburg, PA Site at the Conditioning Time - 2000

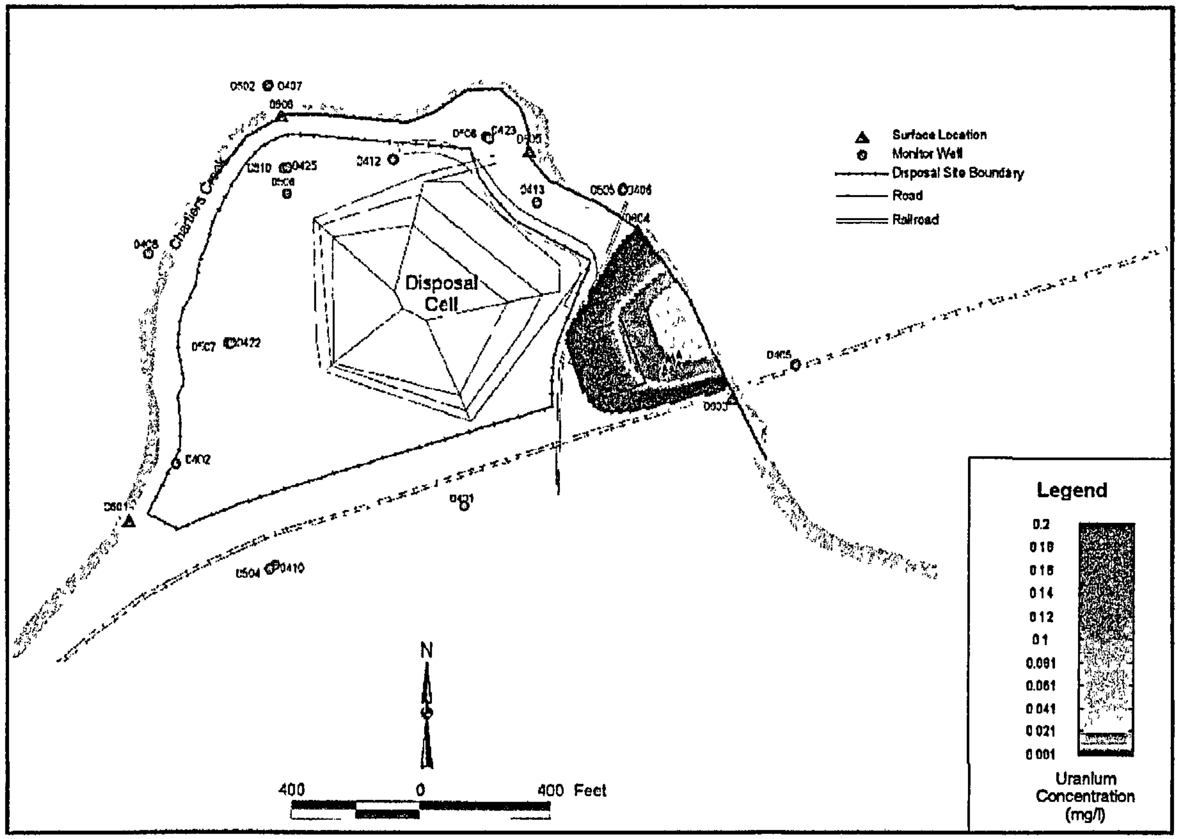


Figure 2 – Predicted Average Uranium Concentration Distribution in Ground Water at the UMTRA Canonsburg, PA Site 2 Years After Conditioning Time - 2002

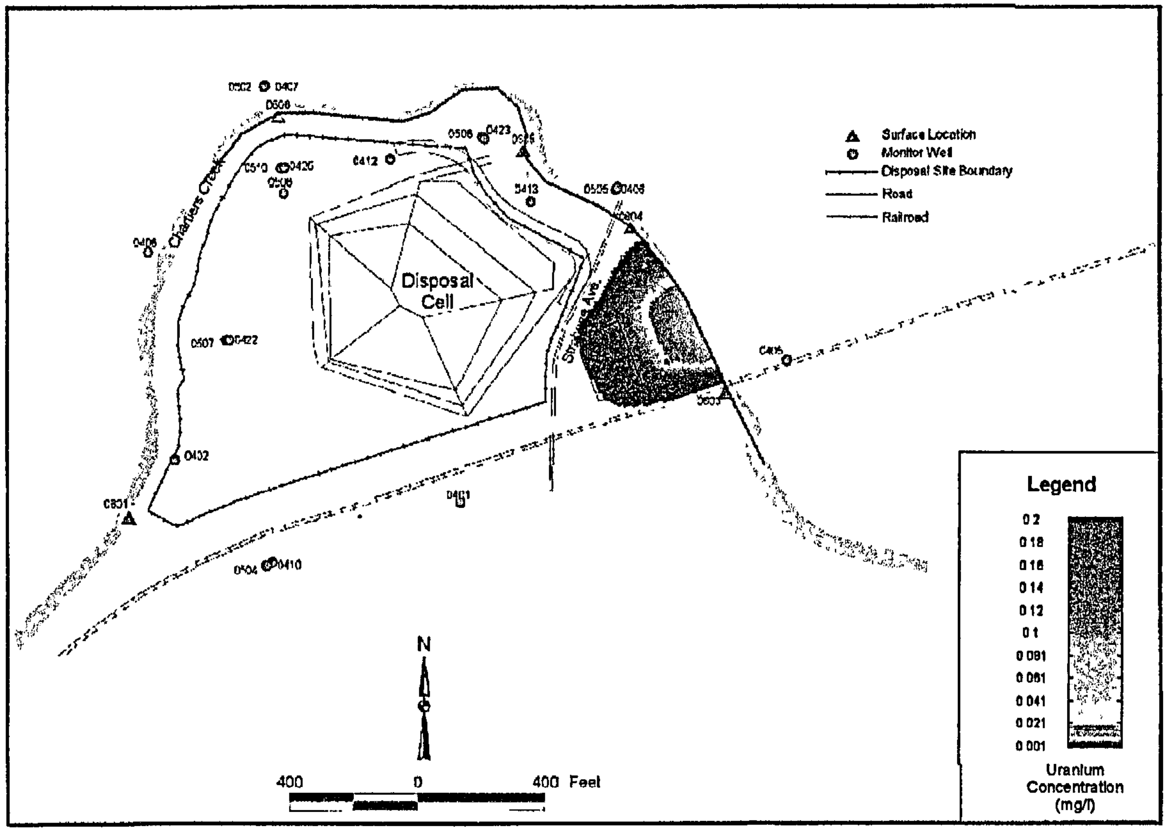


Figure 3 – Predicted Average Uranium Concentration Distribution in Ground Water at the UMTRA Canonsburg, PA Site 5 Years After Conditioning Time - 2005

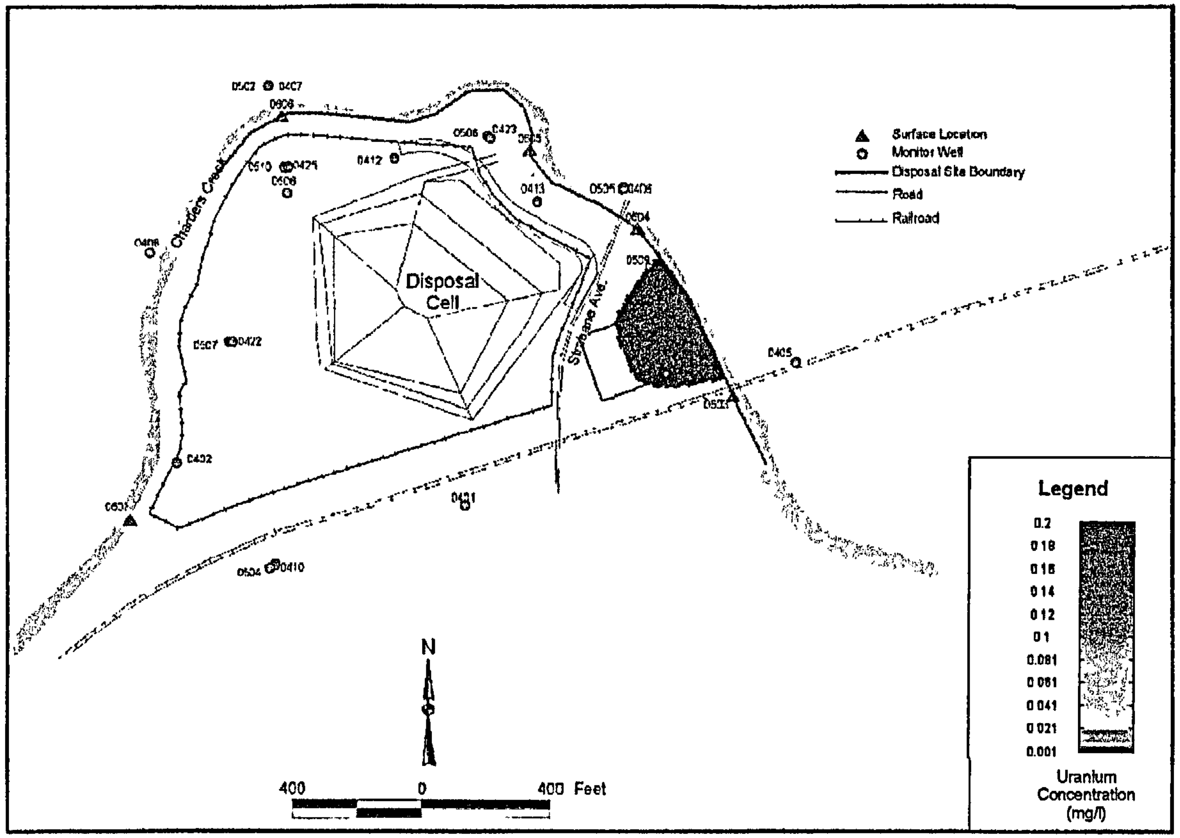


Figure 4 – Predicted Average Uranium Concentration Distribution in Ground Water at the UMTRA Canonsburg, PA Site 10 Years After Conditioning Time - 2010

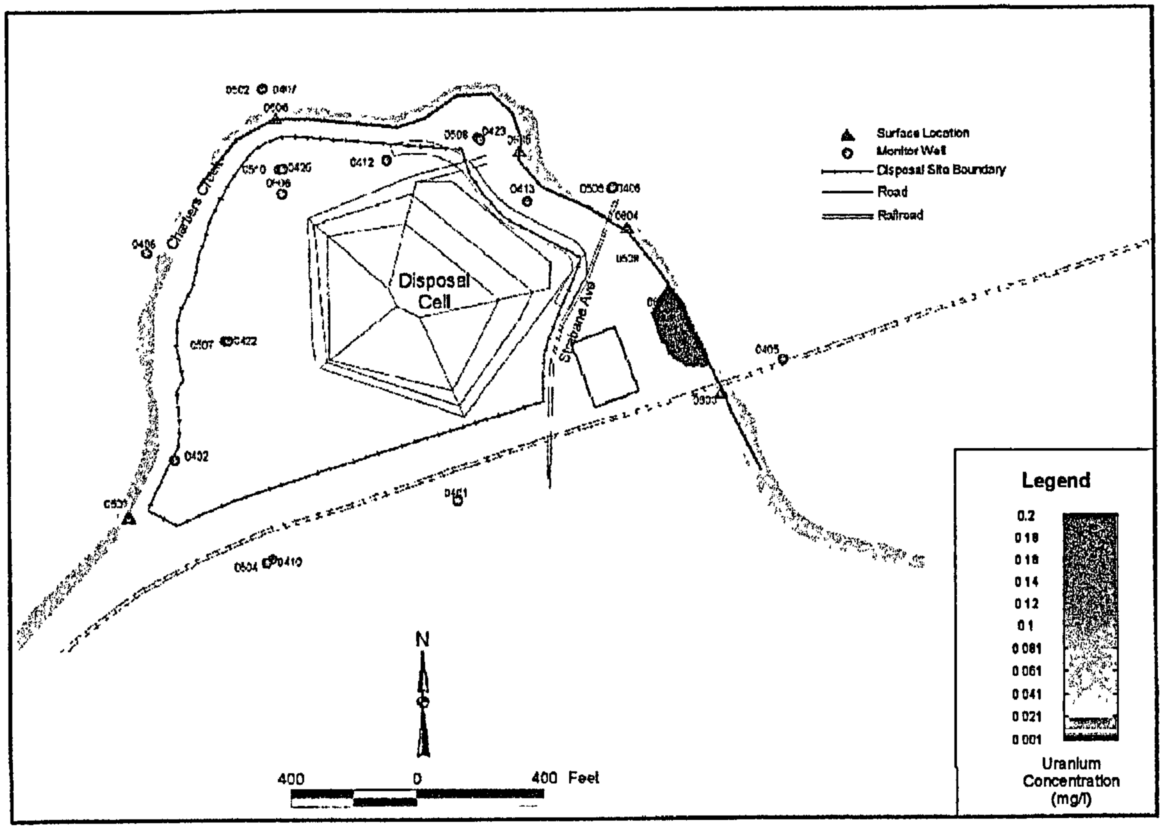


Figure 5 – Predicted Average Uranium Concentration Distribution in Ground Water at the UMTRA Canonsburg, PA Site 15 Years After Conditioning Time - 2015

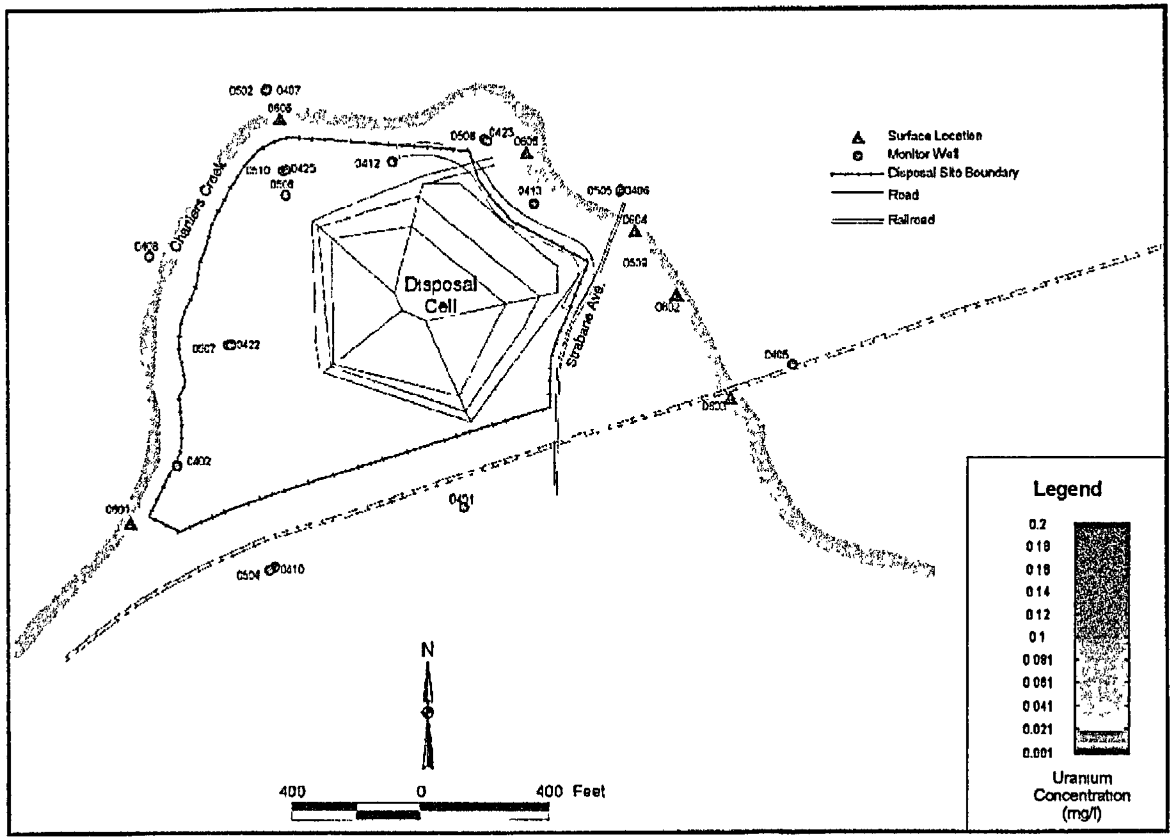


Figure 6 – Predicted Average Uranium Concentration Distribution in Ground Water at the UMTRA Canonsburg, PA Site 20 Years After Conditioning Time - 2020

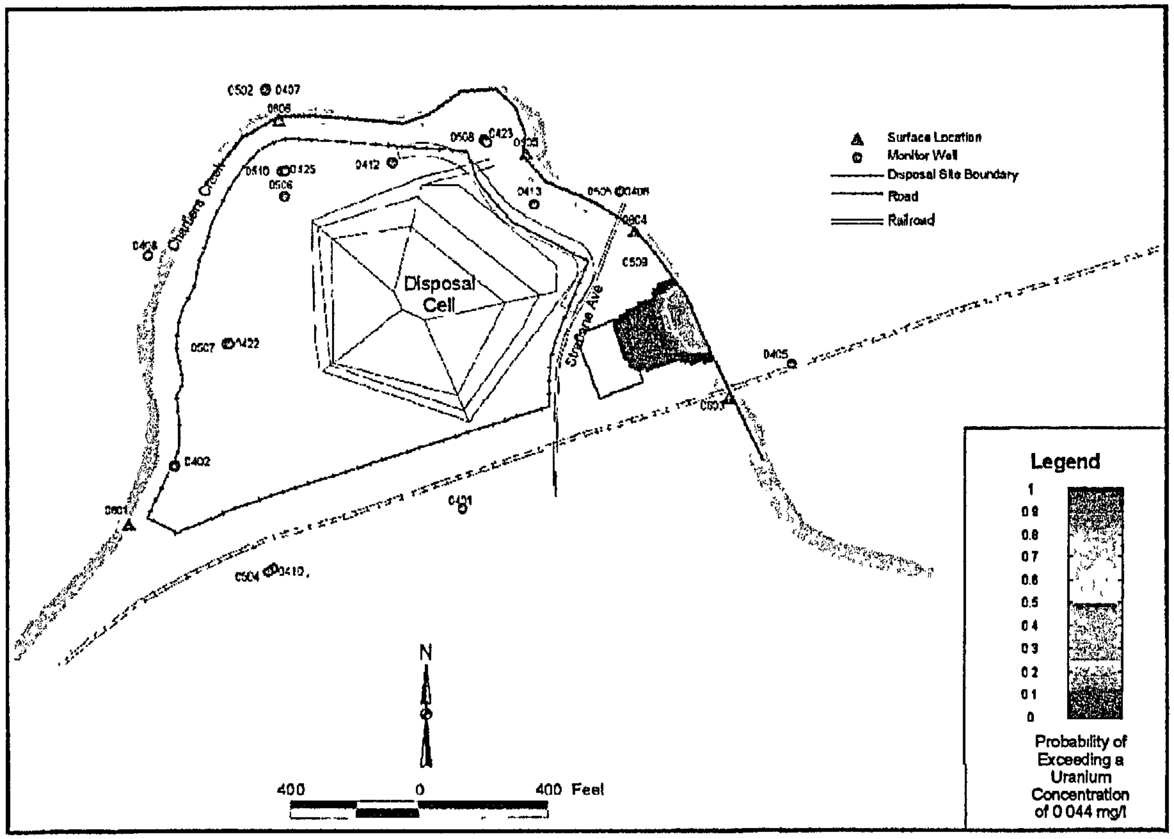


Figure 7 – Predicted Probability Distribution for Exceeding the Uranium Concentration Standard of 0.044 mg/L in Ground Water at the UMTRA Canonsburg, PA Site at the Conditioning Time - 2000

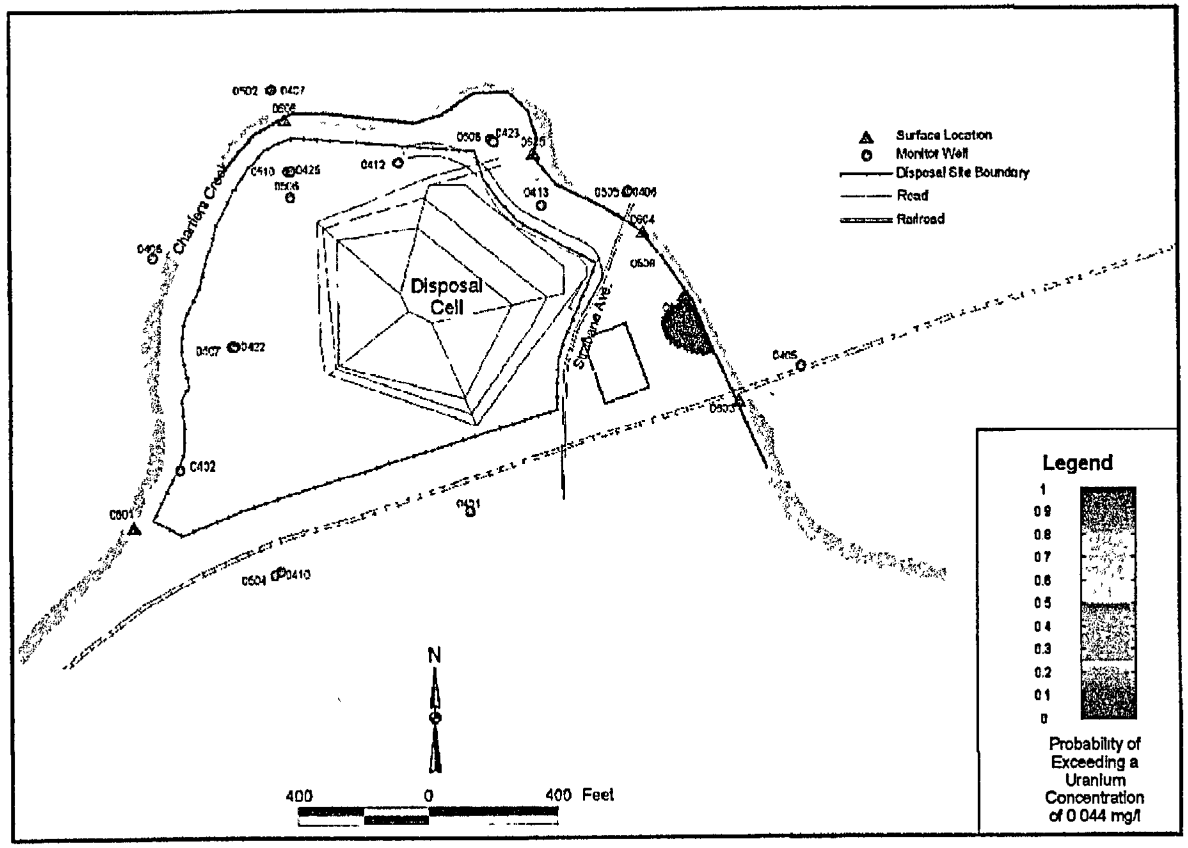


Figure 8 – Predicted Probability Distribution for Exceeding the Uranium Concentration Standard of 0.044 mg/L in Ground Water at the UMTRA Canonsburg, PA Site 2 Years After the Conditioning Time - 2002

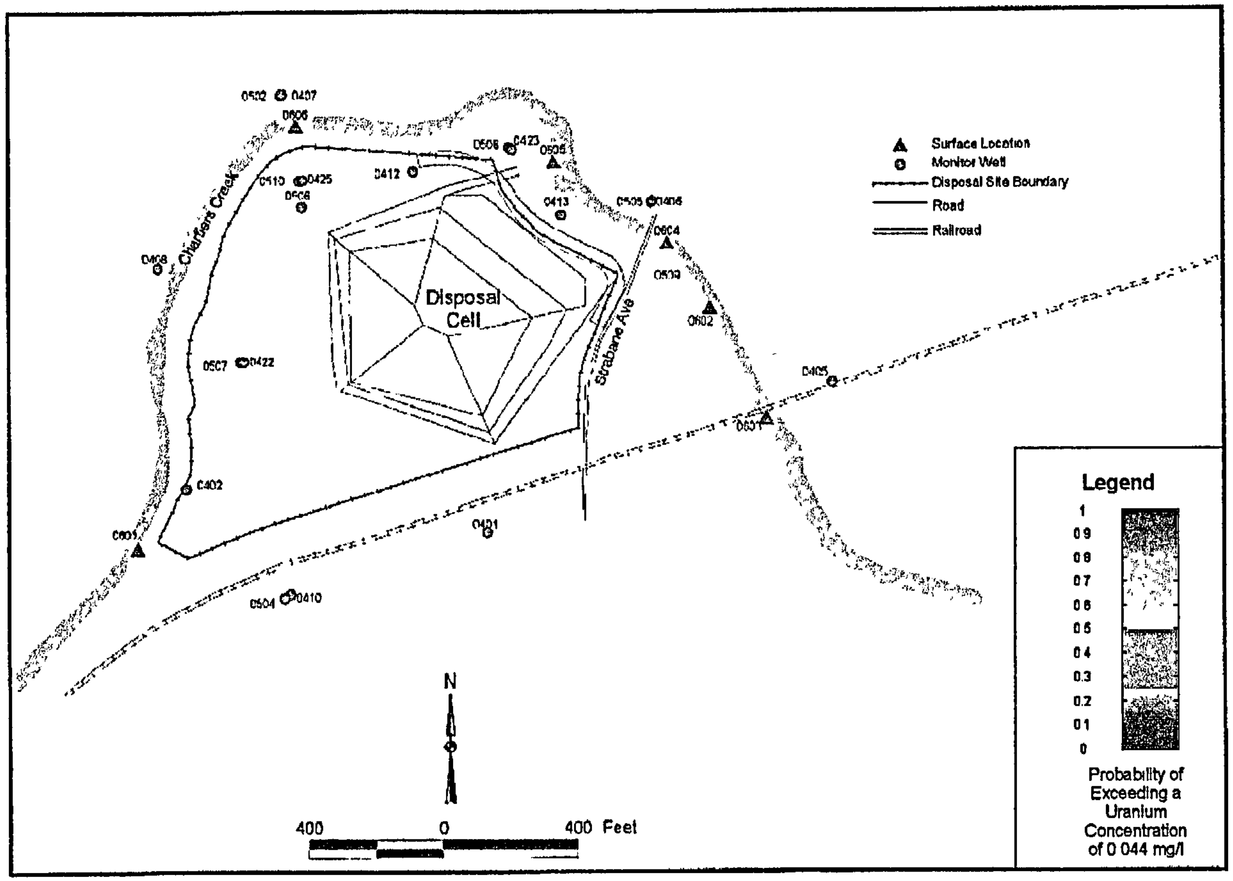


Figure 9 – Predicted Probability Distribution for Exceeding the Uranium Concentration Standard of 0.044 mg/L in Ground Water at the UMTRA Canonsburg, PA Site 5 Years After the Conditioning Time - 2005

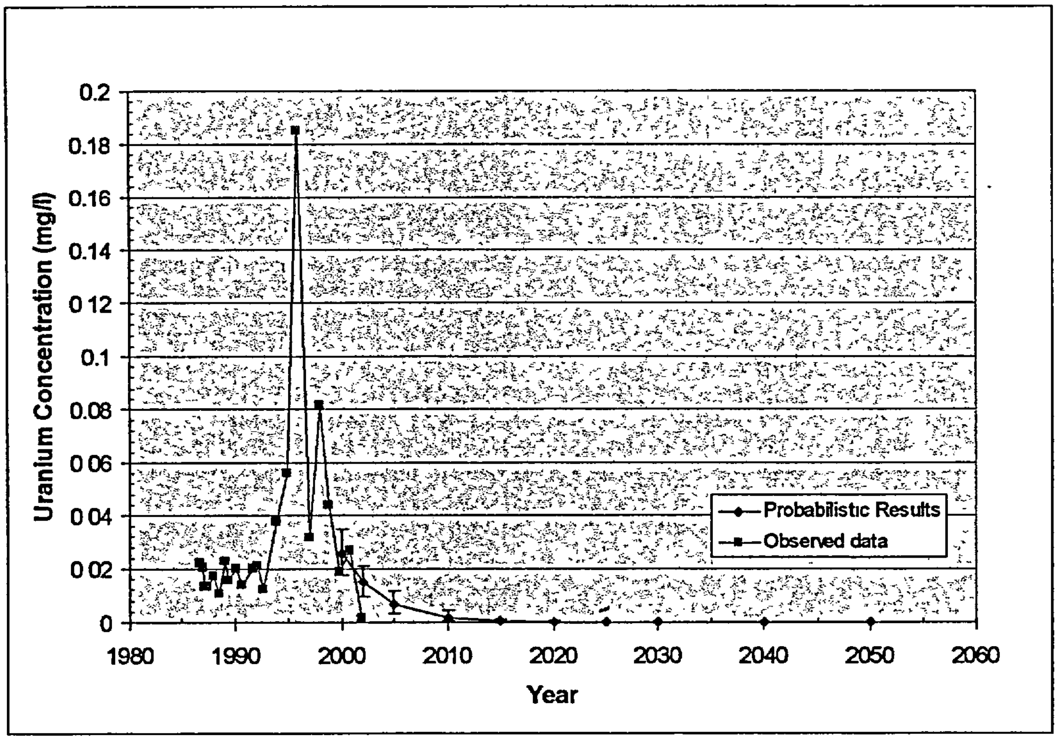


Figure 10 – Predicted and Observed Uranium Concentrations in Ground Water at the UMTRA Canonsburg, PA Site for POC Monitoring Well 414; Error Bars Represent Maximum and Minimum Predicted Concentrations

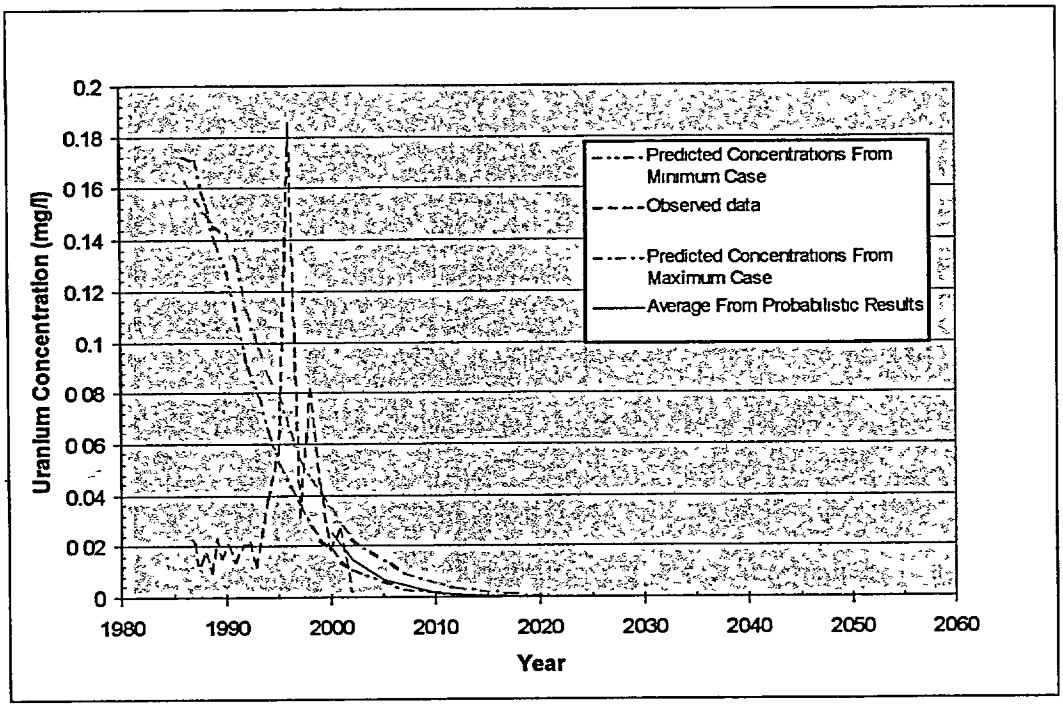


Figure 11 – Predicted and Observed Uranium Concentrations in Ground Water at the UMTRA Canonsburg, PA Site for the POC Monitoring Well 414, Including Deterministic Analyses of the Maximum and Minimum Runs