UPDATED RESPONSES TO THE U.S. NUCLEAR REGULATORY COMMISSION REQUEST FOR ADDITIONAL INFORMATION ON THE WEST VALLEY DEMONSTRATION PROJECT PHASE 1 DECOMMISSIONING PLAN

RAIs 5C6, 5C7, 5C9, 5C10, 5C12, 5C15, and 5C21

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Prepared by Washington Safety Management Solutions and
Science Applications International Corporation

for the

U.S. Department of Energy

West Valley, New York

As is the Decommissioning Plan itself, these responses are based on the assumption that the preferred alternative in the Revised Draft Environmental Impact Statement for Decommissioning and/or Long-Term Stewardship at the West Valley Demonstration Project and Western New York Nuclear Service Center (the Decommissioning EIS) will be selected in the Record of Decision. If changes to the Decommissioning EIS occur during the course of the National Environmental Policy Act process that affect the Decommissioning Plan, such as changes to the preferred alternative, or if a different approach is selected in the Record of Decision, the Decommissioning Plan and these responses would need to be revised or replaced in their entirety to reflect the changes.

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Acronyms and Abbreviations

CFR	Code of Federal Regulations
DCGL	derived concentration guideline level
$DCGL_{EMC}$	derived concentration guideline level, elevated measurement concentration
$DCGL_W$	derived concentration guideline level, wide
DOE	U.S. Department of Energy
DP	decommissioning plan
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
K_d	distribution coefficient
LTR	License Termination Rule
NRC	Nuclear Regulatory Commission
RAI	*request for additional information*
RESRAD	Residual radioactivity [computer code]
WMA	waste management area
WVDP	West Valley Demonstration Project

Units

cm	centimeter
cm^3	centimeter cubed
g	gram [mass]
kg	kilogram
L	liter
m	meter
millirem	0.001 Roentgen equivalent man
mL	milliliter
mrem	millirem
pCi	10^{-12} curie
y	year

INTRODUCTION

The U.S. Department of Energy (DOE) submitted Revision 0 of the West Valley Demonstration Project (WVDP) Phase 1 Decommissioning Plan to the U.S. Nuclear Regulatory Commission (NRC) for review on December 3, 2008. DOE subsequently submitted Revision 1 of this plan to NRC for review on March 16, 2009. Revision 1 provided additional subsurface soil and groundwater characterization data and the results of additional groundwater modeling, along with several other minor changes.

NRC submitted the Request for Additional Information (RAI) on May 15, 2009 in a letter to Bryan Bower, the Director of the WVDP. This request consisted of 44 separate RAIs on various aspects of the Decommissioning Plan, including dose modeling.

NRC review of the Decommissioning Plan is being performed consistent with the provisions of Public Law 96-368, the WVDP Act of 1980, which provides authority for NRC to consult with DOE informally on matters related to the project. Consistent with the Act, and with a 1981 Memorandum of Understanding between DOE and NRC pertaining to the project, DOE has considered the NRC RAIs and is providing written responses to NRC.

DOE responded to these RAIs in two parts. Responses to the first group of 38 RAIs were provided on August 14, 2009. Responses to the remaining six RAIs were provided on September 16, 2009.

As discussed at the DOE-NRC meeting held on September 2, 2009 and stated in the DOE forwarding letter for the September 16, 2009 submittal, changes to the subsurface soil cleanup goals were necessary to account for diffusion of residual radioactivity from the bottom of the deep excavations. These changes required revisions to the responses to RAI 5C9 and RAI 5C15. The responses to the following additional RAIs were also updated, primarily for the sake of clarity: 5C6, 5C7, 5C10, 5C12, and 5C21.

Like the initial responses, the updated RAI responses are provided in the following format:

NRC RAI number: The NRC RAI number is specified

Subject: DOE added a brief statement of the RAI subject, for clarity.

RAI: A complete copy of the NRC RAI is provided.

Basis: A complete copy of the NRC basis for the RAI is provided.

NRC path forward: A complete copy of the NRC path forward is provided.

DOE response: The DOE response provides requested information and answers NRC questions.

Changes to the plan: Changes to be made are specifically identified with red text and change bars. (The two completely new appendices are not so marked.)

References: References are included where appropriate.

The following calculation packages and the associated electronic files are being provided with this submittal to enable NRC staff to replicate the modeling described in the updated response to RAI 5C9:

- Code Development Verification Package, Rectangular Monolith Finite Difference Solution Groundwater Release Model;
- Calculation Package, Estimates of Human Health Impacts Due to a Subsurface Source in the Vicinity of the Excavation of the Main Plan Process Building; and
- Calculation Package, RESRAD Dose-to-Source Ratios.

As indicated on the cover sheet, if changes to the Decommissioning EIS occur during the course of the National Environmental Policy Act process that affect the Decommissioning Plan, such as changes to the preferred alternative, or if a different approach is selected in the Record of Decision, the Decommissioning Plan and these responses would need to be revised or replaced in their entirety to reflect the changes.

RAI 5C6 (11)

Subject: Show that the cistern scenario is bounding

RAI: DOE did not provide enough information to show that the subsurface DCGL calculations considering a cistern drilling scenario are bounding. (Section 5.1.4, Page 5-14)

Basis: Subsurface DCGLs are calculated assuming a cistern is drilled throughout the thickness of the sand and gravel unit to the top of the Lavery Till.

DOE acknowledges that gully erosion could intrude upon the lagoon areas (see page 5-14). However, DOE did not provide quantitative support for its assumption that erosion from gully formation/advancement, or stream widening could intercept the WMA 2 source areas and produce greater exposures to an offsite or onsite receptor.

Path Forward: DOE should provide the results of a quantitative analysis that supports its assumption that the subsurface DCGLs calculated assuming a cistern driller scenario bound the potential impacts from erosion.

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DOE Response: DOE has performed a quantitative analysis of potential doses to an onsite receptor located in the portion of WMA 2 most susceptible to the impacts of unmitigated erosion based on the erosion modeling performed for the Decommissioning EIS. The results show that the cistern scenario is more limiting than the alternate onsite receptor scenario that was analyzed.

DOE has also performed a quantitative analysis of the potential impacts of unmitigated erosion in the area of the backfilled WMA 2 excavation on a representative offsite receptor. Here too, the results show that the cistern scenario is more limiting than the alternate offsite receptor scenario that was analyzed.

These analyses are described below.

However, additional groundwater modeling using the STOMP code has shown that diffusion of radioactivity from the bottom of the deep excavations must be taken into account in establishing the subsurface soil DCGLs and cleanup goals.

The updated response to RAI 5C9 describes the additional modeling and the reduced DCGLs and cleanup goals that take the results of this analysis into account. This updated response includes a new DP subsection 5.2.6 that describes the modified conceptual model used, the mathematical models used, and the results of the analysis.

The updated response to RAI 5C15 includes revised tables for section 5 of the DP such as Table 5-14 that specifies the cleanup goals to be used in soil and sediment remediation associated with Phase 1 of the decommissioning.

Predicted Erosion

Information in Section 5.1.4 of the DP is drawn from erosion analyses performed for the Decommissioning EIS. As indicated in Section 5.1.4, the studies described in Appendix F to the Decommissioning EIS suggest that the central portion of the north plateau where WMA 1 is located will be generally stable for the next 1000 years, but that the portion of WMA 2 near the Erdman Brook stream valley is much more susceptible to erosion, particularly that associated with development of gullies.

Potential Doses to an Onsite Receptor

The predicted gully erosion would produce narrow, deep steep-sided gullies, conditions where building a home and growing crops would not be practical. Consequently, the resident farmer scenario used in development of the subsurface soil DCGLs would no longer be plausible for this part of WMA 2 under these conditions.

A plausible scenario for these conditions would involve a recreationist spending time hiking in the area, which is assumed to be rent by deep gullies that extend to the bottom of the WMA 2 excavation. Figure 5C6-1 illustrates the basic conceptual model. This scenario was analyzed using RESRAD in the deterministic mode with the following key conceptual model input parameters:

- Unmitigated erosion would produce conditions where the recreationist could be exposed to contamination at the bottom of the WMA 2 excavation in the area of Lagoons 1 and 2 in 200 years;
- One or more gullies are assumed to extend through the contamination zone, which is made up of unweathered Lavery till material one-meter thick at the bottom of the WMA 2 excavation;
- The exposed contamination zone area in the gully walls is assumed to be two meters wide and 100 meters long, a reasonable size to represent the likely geometry of the exposed contamination in the gully (modeling a single source area rather than the two illustrated in Figure 5C6-1 was more practical);
- The recreationist is assumed to be walking at a pace of 0.8 kilometers (0.5 mile) per hour on a path where exposed contamination is present, such as going to the stream to hunt or fish and returning home;
- The recreationist would be exposed to the contamination for a total of 28 hours per year (an outdoor time fraction of 0.0032), based on 112 trips per year to and from the stream.

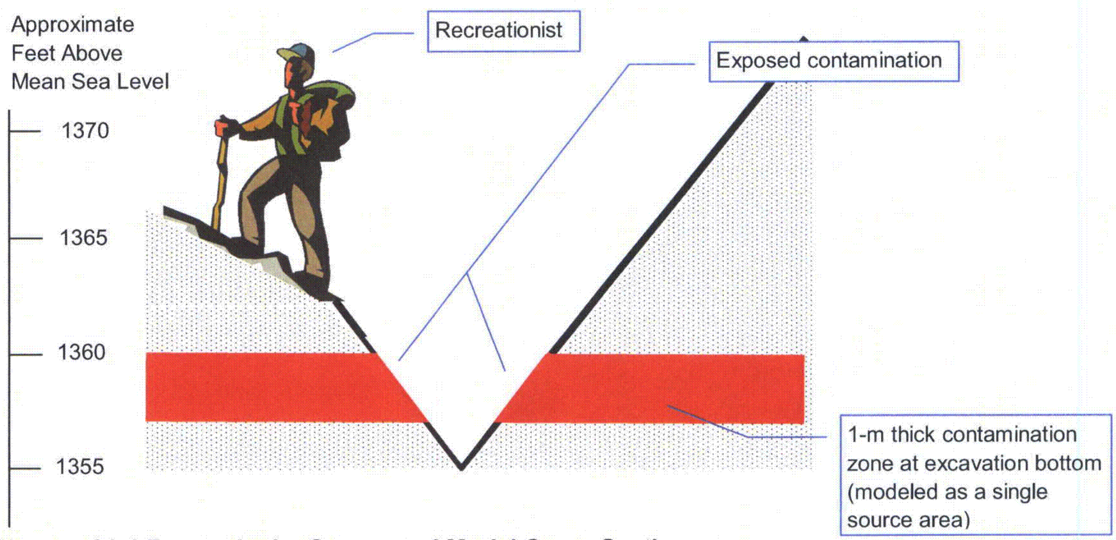

Figure 5C6-1 Recreationist Conceptual Model Cross Section

The modeling of this recreationist scenario produced DCGLs for 25 mrem per year that were more than one order of magnitude greater than the DCGLs produced with the cistern scenario for all 18 radionuclides of interest. These results demonstrate that the cistern scenario is more limiting for an onsite receptor.

Sensitivity analyses of the time to beginning exposure (development of gullies as assumed in the conceptual model) were performed for 100 years and 500 years. These analyses showed that even with an impossibly short period of 100 years to produce the eroded conditions that were analyzed, the DCGLs for the recreationist scenario would still be more than one order of magnitude greater than those for the cistern scenario for all radionuclides. This difference would be even greater using the 500 year time period, as would be expected.

The calculation package describing this analysis and the associated electronic files are being provided to NRC with the RAI responses.

Potential Doses to an Offsite Receptor

The response to RAI 5C4 describes an analysis to determine the values of surface soil DCGLs that would produce 25 mrem per year to an offsite receptor from radioactivity associated with erosion of surface soil. A similar analysis has been performed for residual radioactivity at the bottom of the deep excavation in WMA 2.

The type of erosion described previously in relation to potential doses to an onsite receptor could result in residual radioactivity from the bottom of the backfilled deep excavation in WMA 2 entering Erdman Brook and impacting downstream offsite receptors. To quantitatively estimate such potential impacts, an analysis was performed using methodology used in the Decommissioning EIS for estimating offsite impacts of erosion.

The assumption of erosion by gully intrusion into residual subsurface contamination in WMA 2 is supported by landscape evolution modeling that indicates that the WMA 2 area will be affected by gully erosion over a 10,000-year period as described in the Decommissioning EIS.

In order to evaluate these potential impacts, the largest gully produced in simulations of the landscape evolution model is assumed to intrude into Lagoon 1 (area of 400 m^2) and Lagoon 3 (area of 1,800 m^2). Peak rates of erosion were estimated as 0.012 and 0.0035 m/y for the areas of Lagoons 1 and 3, respectively, based on the erosion modeling done for the Decommissioning EIS. (These peak erosion rates are considered conservative; the next highest erosion rates predicted by this modeling are much less than these values, being on the order of 0.0035 m/y for Lagoon 1 and 0.0012 m/y Lagoon 3.)

Radioactivity in eroded soil is assumed to be transported to surface water used by an offsite receptor. The receptor located on Cattaraugus Creek near the confluence with Buttermilk Creek ingests both the water and fish harvested from the water and uses the water to irrigate a garden.

Drinking water and fish ingestion rates used in the analysis correspond to the 95th percentile of national use and crop and animal product intake values are those recommended in NUREG/CR-5512, Volume 3 (Beyeler, et al. 1999). Doses for the combined pathways due to onsite contamination at a level of one picocurie per gram and the related DCGLs are summarized for key radionuclides in the following tables.

Table 5C6-1. Key Radionuclide Analysis Results for Lagoon 1 Area

Radionuclide	Offsite Receptor Dose (mrem/y for 1 pCi/g)	Onsite DCGL (pCi/g Onsite for 25 mrem/y to Offsite Receptor)	Deterministic DCGL from Cistern Scenario (pCi/g)(1)
C-14	3.0E-06	8.4E+06	5.6E+05
Sr-90	4.2E-06	1.2E+07(1)	4.4E+03(2)
Tc-99	4.1E-07	6.1E+07	1.6E+04
I-129	5.5E-05	4.6E+05	6.5E+02
Cs-137	5.1E-05	9.8E+05(1)	4.4E+02(2)
U-238	5.8E-06	4.3E+06	2.9E+03
Pu-239	7.9E-05	3.2E+05	1.3E+04

NOTE: (1) Revised deterministic $DCGL_W$ values calculated using revised parameters described in the response to RAI 5C12.

(2) With 30-year decay period.

Table 5C6-2. Key Radionuclide Analysis Results for Lagoon 3 Area

Radionuclide	Offsite Receptor Dose (mrem/yr for 1 pCi/g)	Onsite DCGL (pCi/g Onsite for 25 mrem/y to Offsite Receptor)	Deterministic DCGL from Cistern Scenario (pCi/g)(1)
C-14	3.9E-06	6.4E+06	5.6E+05
Sr-90	5.5E-06	9.2E+06(1)	4.4E+03(2)
Tc-99	5.3E-07	4.7E+07	1.6E+04
I-129	7.2E-05	3.5E+05	6.5E+02
Cs-137	6.7E-05	7.4E+05(1)	4.4E+02(2)
U-238	7.6E-06	3.3E+06	2.9E+03
Pu-239	1.0E-04	2.4E+05	1.3E+04

NOTE: (1) Revised deterministic $DCGL_W$ values calculated using revised parameters described in the response to RAI 5C12.

(2) With 30-year decay period.

This analysis produced DCGLs that show the concentrations of each of the 18 radionuclides of interest necessary to produce 25 mrem per year to an offsite receptor. The DCGLs for this scenario were are least one order of magnitude higher than the DCGLs for subsurface soil developed using the base case resident farmer cistern drilling scenario.

This analysis demonstrates that there is a reasonable expectation that the potential dose to an offsite receptor from erosion of radioactivity from the bottom of the deep WMA 2 excavation would be insignificant, even if residual radioactivity concentrations were to approach the DCGLs, which would be a very unlikely circumstance based on available soil data from the unweathered Lavery till. The calculation package for this analysis and the associated electronic files will be provided with the September 2009 RAI responses.

Conclusions

The following conclusions can be drawn from the results of the onsite and offsite dose analyses:

- The subsurface soil DCGLs are protective for onsite receptors, that is, the cistern scenario used to develop the DCGLs is more limiting that the alternate recreationist-hiker scenario analyzed; and
- The subsurface soil DCGLs are also protective for offsite receptors, that is, the cistern scenario used to develop the DCGLs is more limiting that the alternate scenario for an offsite Cattaraugus Creek receptor that was analyzed.

Based on these conclusions, DOE considers that there is a reasonable expectation that remediation of the WMA 2 excavation as planned will ensure that doses to both onsite and offsite receptors will be well below the 25 mrem per year dose limit.

Changes to the Plan:

Change note (2) to Table 5-5 to read as follows:

> This assumption is conservative because it results in no depletion of the source through erosion. The conservative nature of the assumption can be demonstrated by assuming that erosion takes place and evaluating potential doses to a receptor located in a gully where radioactivity has been exposed by erosion. As explained in the discussion of alternate conceptual models below, the receptor in the area of the gully would receive less dose on an annual basis than would the resident farmer due to factors such as spending less time in the contaminated area and receiving exposure through fewer pathways. Consideration of potential doses to an offsite receptor from radioactivity displaced to the stream through erosion indicates that there is a reasonable expectation that offsite doses would not be significant either.

Add the following information to the subsection on page 5-28 labeled **Other Possible Conceptual Models for Subsurface Soil DCGL Development**, coordinating this change with the changes to this subsection identified in the responses to RAI 5C5 and RAI 5C8.

> Another alternative scenario was evaluated to determine the potential impact of long-term erosion in WMA 2. This analysis estimated the potential doses to an offsite receptor from radioactivity that could be released from the bottom of the remediated WMA 2 excavation due to formation of a gully that eventually cut through the bottom of the backfilled excavation.
>
> In this analysis, radioactivity in eroded soil from the bottom of the WMA 2 backfilled excavation was assumed to be transported in surface water to a receptor located on Cattaraugus Creek near the confluence with Buttermilk Creek who ingested both the water and fish harvested from the water and used the water to irrigate a garden. Both the area of Lagoon 1 and the area of Lagoon 3 were considered using conservative erosion rates. The results showed that doses to this receptor would be insignificant compared to the onsite receptor doses estimated in the base case model.

Reference:

Beyeler, et al. 1999, *Residual Radioactivity from Decommissioning, Parameter Analysis*, NUREG/CR-5512, Vol 3, Draft Report for Comment. Beyeler, W. E., W. A. Hareland, F. A. Duran, T. J. Brown, E. Kalinina, D. P. Gallegos, and P. A. Davis, Sandia National Laboratories, Albuquerque, New Mexico, October 1999.

RAI 5C7 (12)

Subject: Show cistern scenario bounding

RAI: The approach to developing subsurface DCGLs may not be limiting for all types of contamination sources found and scenarios expected at the WVDP. Two aspects should be more fully assessed: 1) the potential for groundwater contamination by buried sources; and 2) erosion of cover material thereby converting a subsurface source into a surface source and making an excavation scenario applicable. (Section 5.2.1, Page 5-26):

Basis: The approach of using a scenario where a cistern well is installed and a resident is exposed to the contaminated cuttings may be limiting for some types and distributions of contamination, but may not be limiting for certain sources. For example, the old sewage plant drainage was significantly contaminated and covered with three feet of soil. While the old sewage plant drainage is not considered part of the scope of Phase 1 (see Figure 1-5), if contamination is located in a thin lens but in a hydrologically active or previously hydrologically active area to be remediated as part of Phase 1, the dilution and partitioning with soil afforded in the cistern disruption scenario may be larger and result in higher DCGLs than would be developed from exposure to contaminated groundwater or an excavation scenario that would become applicable if the cover was eroded.

Path Forward: Provide the technical basis that the approach to developing subsurface DCGLs is limiting when groundwater transport and erosion processes are considered. Part of the technical basis could be assurance that the subsurface DCGLs will exclusively be used to guide remediation of excavated areas in WMA 1 and 2, adequate characterization will be conducted to ensure any unremediated areas are not impacted, and that erosion is not expected to uncover residual WMA 1 and 2 contamination following remediation over the 1000 year compliance period. If erosion could lead to applicability of an excavation scenario within the 1000 year compliance period (i.e., if erosion could lead to depletion of the cover materials to a thickness of 3 m or less), then an excavation scenario should also be evaluated. Erosion processes may be limited to those that result in landform evolution consistent with the expected future land use scenario.

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DOE Response: Additional evaluation has confirmed that the approach used to develop subsurface soil DCGLs is limiting insofar as erosion processes are concerned. However, additional groundwater modeling using the STOMP code has shown that diffusion of radioactivity from the bottom of the deep excavations must be taken into account in establishing the subsurface soil DCGLs and cleanup goals.

The updated response to RAI 5C9 describes the additional modeling and the reduced DCGLs and cleanup goals that take the results of this analysis into account. This updated response included a new DP subsection 5.2.6 that describes the modified conceptual model used, the mathematical models used, and the results of the analysis.

The updated response to RAI 5C15 includes revised tables for section 5 of the DP such as Table 5-14 that specifies the cleanup goals to be used in soil and sediment remediation associated with Phase 1 of the decommissioning.

Limitations on Applicability of Subsurface Soil DCGLs

The subsurface soil DCGLs (that is, the cleanup goals of Table 5-14) apply only to the bottoms and lower sides of the two large excavations to be dug to remove facilities in WMA 1 and WMA 2, as indicated on page 5-4 and in other places in the DP. They will not be used in connection with remediation of any other areas. Changes will be made to the DP to reinforce this point for the sake of clarity.

Potential for Groundwater Contamination by Upgradient Sources

The radiological status of groundwater on the project premises is discussed in Section 4.2.8 of the DP. Figure 4-12 shows routinely monitored groundwater monitoring locations and indicates that the three locations just west of WMA 1 show no radiological constituents in excess of background. These results indicate a low potential for contamination of the remediated WMA 1 excavation from upgradient sources.

The response to RAI 7C1 explains that the conceptual schedule in Figure 7-15 is being changed to provide for installation of the WMA 1 hydraulic barrier before starting the WMA 2 excavation. This sequence will reduce groundwater infiltration in the WMA 2 excavation and prevent contamination from WMA 1 being transported by groundwater into the WMA 2 excavation.

Consideration has also been given to the potential for buried contamination in the old sewage treatment plant drainage impacting either the WMA 1 or WMA 2 excavated areas. The amount of buried contamination in this area is expected to be small based on information provided in Section 2.3.2 of the DP, and since this area is not hydraulically upgradient of WMA 1 or WMA 2, the potential for any impact on those areas by groundwater transport is low.

In summary, available data suggest that there is no significant potential for groundwater contamination from upgradient sources impacting either WMA 1 or WMA 2.

Characterization

The characterization program to be defined in the Characterization Sample and Analysis Plan, coupled with the Phase 1 final status surveys, will verify that unremediated areas are not impacted. The response to RAI 7C1 describes mitigative measures to be taken to minimize potential impacts of contaminated excavated soil on areas that will not undergo remediation during the Phase 1 decommissioning activities.

As explained in the response to RAI 9C1, DOE will solicit NRC input on the Characterization Sample and Analysis Plan objectives and provide the final draft plan to NRC for review.

Potential Erosion Impacts and Excavation Scenario

As explained in the response to RAI 5C4, the predicted sheet and rill erosion rate for the central portion of the north plateau where WMA 1 is located is small, so the excavation scenario associated with constructing a basement for a home in that area would not be applicable. However, unchecked long-term erosion could lead to deep gullies in the area of Lagoons 1, 2, and 3 that could possibly reach the bottom of the backfilled deep excavation. Growing crops or building a home in an area with such gullies would not be plausible. Consequently, the excavation scenario associated with constructing a basement for a home in that area would not be realistic. The recreationist-hiker exposure scenario discussed in connection with RAI 5C4 would be much more plausible. The response to RAI 5C6 provides the results of an analysis of this scenario.

Changes to the Plan:

More information about the limitations of the subsurface soil DCGLs is being added to the plan as follows:

On page ES-18, add the following footnote to Table ES-2, with the footnote tagged to the Subsurface Soil heading:

(3) The subsurface soil cleanup goals apply only to the bottom of the large WMA 1 and WMA 2 excavations and to the sides of these excavation three feet or more below the surface.

On page 5-49, add the same footnote to Table 5-14. In this case, the footnote will be number (5).

Make the following additional change on page 5-49:

Basis for Cleanup Goals for Subsurface Soil

DOE has established the subsurface soil cleanup goals at 50 percent of subsurface soil DCGLs calculated in the limited site-wide dose assessments for 22.5 mrem per year (Table 5-12). The cleanup goals for subsurface soil would therefore equate to 11.25 mrem per year. DOE is taking this approach to provide additional assurance that remediation of the WMA 1 and WMA 2 excavated areas would support all potential options for Phase 2 of the proposed decommissioning. As indicated previously, these cleanup goals apply only to the bottom of the large WMA 1 and WMA 2 excavations and to the sides of these excavations three feet or more below the surface.

RAI 5C9 (14)

Subject: Consideration of subsurface contamination

RAI: DOE has not provided sufficient information to justify lack of consideration of subsurface contamination at the bottom of WMA 1 and 2 excavations when deriving subsurface soil DCGLs. Additional data collected on the extent of Lavery Till contamination as remediation proceeds may show greater extent of contamination than originally assumed, additional transport pathways not considered in the subsurface DCGL calculations (e.g., contamination of Lavery Till Sand or along H-piles in the Lavery Till), or greater accessibility of contamination at depth than what is expected. (Section 5.2.1, Page 5-23)

Basis: DOE presented several qualitative arguments (page 5-41) to justify lack of consideration of subsurface contamination at depth after contaminated subsurface soils are excavated from WMA 1 and 2. While some of the qualitative arguments regarding the relative inaccessibility of contamination in the Lavery Till to a potential receptor are compelling, additional data and calculations are needed to fully support the arguments presented. Because only one scenario is evaluated in deriving subsurface DCGLs (i.e., construction of a cistern), this scenario must be demonstrably conservative when considering other scenarios that may be just as, or more, likely. The amount of contamination assumed to be brought to the surface from construction of a cistern is relatively small and dilute[1] and may not be limiting for those radionuclides where water-dependent pathways may dominate the dose (e.g., existing contamination present in the saturated zone may be drawn from a well leading to water-dependent exposure pathways).

Additional information may be needed to support the hydrogeological conceptual model for contamination assumed to be present underneath WMA 1 and 2 used to derive subsurface DCGLs. Previous geologic interpretations showed contamination of a significant portion of the Lavery Till and Lavery Till Sand underneath the Main Plant Process building that could lead to pathways of exposure not considered in the current analysis. DOE should indicate how it plans to manage the risk associated with significantly greater contamination levels at depth along H-piles or within the Lavery Till then were assumed in the DCGL calculations.

Additional calculations or modeling should be performed to support the assumption regarding the expected lower relative risk of residual contamination at depth versus the risk associated with contamination assumed to be brought to the surface due to a cistern drilling scenario. This would include a quantitative evaluation of the potential for Lavery Till contamination to be transported to the Kent Recessional Sequence (KRS). DOE should present information on the relative risk of the cistern versus a ground/surface water transport scenario. DOE should also quantitatively evaluate the impact of pumping and the presence of hydraulic barriers on the potential migration of contamination from the top of the Lavery Till to a well located in the sand and gravel unit and present the relative risks associated with a cistern versus groundwater well scenario.

DOE should clarify how the residual risk from contaminated soil located just below 1 m (e.g., on the sides of the excavations) is appropriately accounted for when comparing residual concentrations to subsurface DCGLs which assume the contamination is mixed with clean soil at a ratio of one to ten (i.e., dilution factor of ten). DOE indicates in a footnote on page 5-4 that contamination on the sides of the excavation up- and cross-gradient from the source area is not

[1] Only one tenth of the soil column is assumed to be contaminated resulting from assumptions regarding the thickness of contamination in the Lavery Till at the bottom of the excavation and the amount of clean soil used to back-fill the excavation.

expected to be contaminated. This expectation should be confirmed in the field or enough data collected to evaluate the impact of contamination at intermediate depths on the dose calculations.

Path Forward: DOE could provide additional information such as borehole logs for those locations where the top of the Lavery Till was significantly lowered and the Lavery Till Sand eliminated underneath the process building in the vicinity of the source of the North Plateau groundwater plume. Additional cross-sections overlaying recent concentration data over reinterpreted geology underneath the process building would also provide additional confidence in the revised hydrogeological conceptual model.

DOE should provide additional details on how in-process or final status survey data will be collected at the bottom of excavations. A procedure should be in place to provide adequate assurance that the thickness of contamination at depth is less than assumed in the DCGL calculations and is present within the impermeable Lavery Till as assumed in the DCGL calculations. If the thickness of contamination is significantly greater than assumed and/or is present in more permeable sediments (e.g., Lavery Till Sand), then sufficient data should be collected to perform additional dose modeling to adequately assess risk. If DOE amends the DP to allow use of surrogate DCGLs to demonstrate compliance with LTR criteria at the bottom of the WMA 1 and 2 excavations, DOE should provide supporting information such as radioisotopic ratios within the Lavery Till used to derive the surrogate DCGLs. DOE should also indicate how it intends to update surrogate DCGLs based on collection of additional data obtained during in-process or final status surveys, if necessary.

As discussed in a preceding comment, it is recommended that DOE provide results of calculations or perform additional modeling (e.g., multi-dimensional groundwater modeling using STOMP) to show the impacts of (i) a pumping well, and (ii) hydraulic barriers on the flow field in the immediate vicinity of WMA 1 and 2 excavations and potential transport of contaminants from the Lavery Till to a the drinking water well located in the sand and gravel. DOE should also evaluate the potential risk associated with transport of contamination from the Lavery Till to the KRS or to surface water. This information could be used to provide additional support that the potential contributions from subsurface contamination to the overall risk from the site from other pathways of exposure (i.e., drilling scenario) are insignificant.

DOE should explain how contamination present on excavation sides will be remediated to ensure that unrestricted use criteria will be met.

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DOE Response: DOE has given additional consideration to subsurface contamination at the bottom of the WMA 1 and WMA 2 excavations from the standpoint of additional groundwater modeling, available data on residual radioactivity in the area of these excavations, the potential for transport of residual contamination to the KRS, the potential for transport of this contamination to groundwater which is then used for drinking water and irrigation, and the potential for drawing this contamination into the hypothetical well postulated in the base-case conceptual model for development of subsurface soil DCGLs. These matters and related matters identified as issues of interest in the NRC path forward are discussed below. Note that most of the subsurface soil cleanup goals were reduced after taking into account the impacts of continuing releases of residual radioactivity from the bottom of the deep excavations by diffusion.

Process Building Area Geology

The Lavery till sand is not located beneath the Process Building nor within the north plateau groundwater plume and previous interpretations of the extent of this unit have not suggested its location beneath the Process Building. Re-examination of borehole logs from the north plateau in 2007 resulted in a re-evaluation of the areal extent of the Lavery till sand. Copies of the borehole logs that were used to revise the extent of the Lavery till sand are attached. Table 5C9-1 (which appears at the end of the text) summarizes the revisions to the geologic interpretation of the boring logs used to delineate the extent of the Lavery till sand as described in Figure 3-64 of the DP.

From 1991 to 2007 the Lavery till sand was inferred to be present to the west, south, and southeast of the Process Building in a location that was hydraulically upgradient and cross-gradient to the north plateau groundwater plume (Figure 5C9-1). Earlier interpretations of the borehole logs considered a prominent clay-rich geologic horizon up to several feet in thickness as part of the unweathered Lavery till and the underlying sandy unit as the Lavery till sand.

Following the completion of the 1993 soil boring program to support the RCRA Facility Investigation, evaluation of the 1993 borehole data indicated that the sand and gravel unit was composed of two distinct subunits, the thick-bedded unit and the underlying slack water sequence which are separated by the prominent clay-rich geologic horizon mentioned earlier.

In 2007 it was noted that the elevation of the original Lavery till sand west and southwest of the Process Building was much shallower in elevation that the Lavery till sand to the southeast of the Process Building. It was determined that this western and southwestern portion was more consistent with the elevation of the slack water sequence of the sand and gravel unit and it was reclassified as part of the slack water sequence. As a result the areal extent of the Lavery till sand was substantially reduced and it is now located southeast of the Process Building away from the north plateau groundwater plume as shown in Figure 3-64 of the DP, which is reproduced here as Figure 5C9-2.

Soil samples have not been collected from the Lavery till sand. However, groundwater monitoring of Lavery till sand wells WNW0202, WNW0204, WNW0206, and WNW0208 does not suggest the presence of radioactive contamination in this unit.

Radioactivity in Subsurface Soil in the Areas of the Deep Excavations

To place the information that follows into context, it is useful to review available characterization data on radioactivity in subsurface soil in the areas of the deep excavations and planned additional characterization of those areas.

Limited soil sampling data currently exists for the Lavery till at the bottom of the WMA 1 and WMA 2 excavations as discussed in Section 4.2. Geoprobe® investigations in 1994, 1998, and 2008 collected soil samples from the upper several feet of the Lavery till at seven locations beneath the Main Plant Process Building and the results are summarized in Table C-4 of Appendix C. Low levels of radioactivity were detected in these samples with a maximum Sr-90 concentration of 59 pCi/g. Deeper soil samples were not collected from the Lavery till during these investigations as sampling was terminated shortly after reaching the Lavery till in accordance with the sampling and analysis plan for this project.

It is not known whether the radioactivity in the shallow Lavery till soil samples is an artifact of the Geoprobe® sampling method or the result of migration from contaminated groundwater from the source area of the north plateau groundwater plume (Hemann and Steiner 1999). Less data are available from WMA 2 as the only Lavery till sample was collected from borehole BH-5 in the vicinity of WMA 1. A representative cross-section showing the geology and recent Sr-90 concentration data beneath the Process Building is presented in Figure 4-8 of the DP.

Additional subsurface soil data will be collected from the Lavery till in WMA 1 and WMA 2 during the Phase 1 soil and sediment characterization program that will be defined in the Characterization Sample and Analysis Plan. This characterization program will provide additional information on the nature and extent of contamination within the project premises and guide the final design of the large excavations in WMA 1 and WMA 2. If this characterization data indicates that contamination at depth is greater than assumed in the subsurface soil DCGL calculations, this factor will be taken into account in the preliminary dose assessments and in plans for remediation of soil in the deep excavations.

In-Process and Phase 1 Final Status Surveys

Samples of Lavery till will also be collected from the bottom of the WMA 1 and WMA 2 excavations during the in-process surveys and final status surveys as described in the responses to RAIs 9C3 and 9C4. In-process surveys will be performed when the WMA 1 and WMA 2 excavations reach a depth of approximately one foot (30 cm) into the Lavery till and will include gamma scans and the collection of biased soil samples six inches (15 cm) in depth in the Lavery till to evaluate whether the subsurface soil cleanup criteria have been met at the bottom of the WMA 1 and WMA 2 excavations. Systematic composite samples from the Lavery till will also be collected from the upper one meter of soil at the bottom of the WMA 1 and WMA 2 excavations during the final status surveys to document that the subsurface soil cleanup criteria have been achieved.

Risk Associated With Transport of Lavery Till Contamination to the KRS

The extent of contamination along the foundation pilings beneath the Main Plant Process Building is currently unknown. As discussed in the response to RAI 4C2, as part of the in-process and final status surveys subsurface soil samples will be collected around representative Process Building foundation pilings located within the area impacted by the north plateau groundwater plume once the Process Building and the sand and gravel overlying the Lavery till have been removed. These samples will be taken in close proximity to the pilings several feet below the surface of the unweathered Lavery till as specified in the Characterization Sample and Analysis Plan and the Phase 1 Final Status Survey Plan to evaluate whether contamination has migrated downward around the pilings towards the KRS. If contamination exceeding the subsurface soil cleanup criteria is detected along the foundation pilings, additional soil will be removed until the soil cleanup criteria is achieved.

Risk Associated With Transport of Residual Lavery Till Contamination to Surface Waters

The risk associated with transport of residual contamination from the Lavery till to surface waters and to groundwater in the backfilled WMA 1 and WMA 2 excavations has been evaluated. Erosion modeling indicates that erosion will not impact the residual contamination in the Lavery till beneath WMA 1. The transport of residual contamination in the Lavery till from WMA 2 as a result of unmitigated gully erosion via surface waters to a downstream receptor on Cattaraugus Creek was evaluated and found to be less limiting than the resident farmer scenario as described in the response to RAI 5C6.

Radionuclide Ratios and the Use of Surrogate Radionuclides

Soil data collected during the soil characterization program will be used to identify radionuclide ratios within the Lavery till from the WMA 1 and WMA 2 excavations that may be used to develop surrogate DCGLs to demonstrate compliance with the subsurface soil cleanup goals. Based on available data, it is doubtful that these ratios will be consistent enough to permit use of an easy-to-measure surrogate radionuclide to identify the concentrations of Sr-90, which available data suggest will be the dominant radionuclide at the bottom of the deep excavations.

Impacts of Residual Radioactivity at the Bottoms of the Deep Excavations

The response to RAI 5C3 describes the results of additional groundwater modeling using the STOMP code and other models used in the EIS to evaluate the potential impacts of changes in flow fields associated with installation of the hydraulic barriers on the DCGLs. As explained in the response to that RAI, this impact is expected to be negligible.

The potential impact of movement of residual contamination from the upper layer of the Lavery till into groundwater of the backfilled excavations has been evaluated using a combination of flow modeling performed using the three-dimensional near field STOMP model of the north plateau and transport and dose modeling using the FEIS finite difference rectangular source model. The STOMP modeling determined the influence of pumping of a well on the direction and magnitude of groundwater flow at the backfill soil-Lavery till interface and established the magnitude and direction of flow of groundwater towards and around the well in the volume above the contaminated till.

The base-case conceptual model that had been used for development of the subsurface soil DCGLs using RESRAD was modified to provide for a multi-source approach. Two potential sources were considered. First, a plug of Lavery till with residual contamination from the excavation bottom is brought to the surface during installation of the cistern and spread over the entire surface of the hypothetical garden. In addition, the remaining contaminated Lavery till is considered a subsurface source that produces a continuing release of contamination from the Lavery till at the excavation bottom into the clean backfill, where residual radioactivity moves upward by diffusion and contaminates the aquifer resulting in additional doses. Both the residential gardener scenario and the resident farmer scenario were evaluated.

A more detailed description of this modeling, including an illustration of the modified conceptual model, is provided below in the form of a new Section 5.2.6 that is to be added to Section 5 of the DP in Revision 2.

Table 5C9-2 compares the subsurface soil DCGLs that take into account continuing releases from the bottoms of the remediated deep excavations with subsurface soil DCGLs calculated using the other conceptual models. This table also shows the changes necessary to the subsurface soil cleanup goals to take these releases into account.

Table 5C9-2. Subsurface Soil DCGL Comparison and Revised Subsurface Soil Cleanup Goals (pCi/g)[1]

Nuclide	Multi-Source Analysis DCGL	Cistern Well Driller DCGL	Recreationist Hiker DCGL	Lagoon 3 Erosion DCGL	Natural Gas Well Driller DCGL	DCGL for Basic Deterministic Models[2]	Probabilistic Peak-of-the-Mean DCGL	Revised Cleanup Goal[3]	Old Cleanup Goal[4]
Am-241	**6.3E+03**	1.7E+04	2.7E+05	2.9E+05	1.4E+05	7.1E+03	6.8E+03	2.8E+03	2.9E+03
C-14	**9.9E+02**	2.3E+09	3.3E+08	6.4E+06	4.9E+09	3.7E+05	7.2E+05	4.5E+02	1.9E+05
Cm-243	3.6E+03	1.1E+04	5.0E+04	1.8E+05	1.2E+05	1.2E+03	**1.1E+03**	5.0E+02	5.1E+02
Cm-244	3.4E+04	3.3E+04	1.0E+09	3.9E+05	2.6E+05	2.3E+04	**2.2E+04**	9.9E+03	8.8E+03
Cs-137[5]	2.8E+03	6.7E+03	9.8E+05	7.4E+05	9.2E+04	4.4E+02	**3.0E+02**	1.4E+02	2.0E+02
I-129	**7.5E+00**	8.0E+05	1.9E+06	3.5E+05	9.2E+06	5.2E+01	6.7E+02	3.4E+00	1.9E+02
Np-237	**1.0E+00**	6.6E+03	2.7E+04	5.9E+05	6.6E+04	4.3E+00	9.3E+01	4.5E-01	1.7E+01
Pu-238	**1.3E+04**	2.0E+04	1.5E+06	2.7E+05	1.6E+05	1.5E+04	1.4E+04	5.9E+03	5.5E+03
Pu-239	**3.1E+03**	1.9E+04	2.8E+05	2.4E+05	1.5E+05	1.3E+04	1.2E+04	1.4E+03	5.0E+03
Pu-240	**3.4E+03**	1.9E+04	2.8E+05	2.4E+05	1.5E+05	1.3E+04	1.2E+04	1.5E+03	5.0E+03
Pu-241	5.5E+05	5.5E+05	1.7E+07	1.2E+07	4.5E+06	**2.4E+05**	2.5E+05	1.1E+05	9.8E+04
Sr-90[5]	**2.8E+02**	8.7E+05	1.6E+08	9.2E+06	1.1E+07	3.2E+03	3.4E+03	1.3E+02	1.4E+03
Tc-99	**5.9E+02**	7.9E+07	2.2E+08	4.7E+07	9.4E+08	1.1E+04	1.4E+04	2.7E+02	5.0E+03
U-232	8.8E+01	1.6E+03	2.8E+04	4.5E+05	1.6E+04	1.0E+02	**7.4E+01**	3.3E+01	5.3E+01
U-233	2.7E+02	6.2E+04	1.3E+06	2.9E+06	4.9E+05	**1.9E+02**	9.9E+03	8.6E+01	7.5E+02
U-234	2.8E+02	6.4E+04	1.4E+06	3.1E+06	5.0E+05	**2.0E+02**	1.3E+04	9.0E+01	7.7E+02
U-235	2.9E+02	1.2E+04	4.2E+04	3.2E+06	1.4E+05	**2.1E+02**	9.3E+02	9.5E+01	4.3E+02
U-238	3.0E+02	3.7E+04	1.9E+05	3.3E+06	3.6E+05	**2.1E+02**	4.6E+03	9.5E+01	8.2E+02

NOTES: (1) Values show in boldface are the lowest of the DCGL sets.

(2) The lower value of the deterministic resident farmer and residential gardener DCGLs.

(3) The cleanup goals are generated by the process described in Section 5.4.1 of the DP, and are based on adjusting DCGLs to an acceptable dose of 22.5 mrem/y, with a further reduction of 50 percent to account for uncertainty in the DCGLs.

(4) From Table 5-14 of the DP, Revision 1.

(5) These values take into account 30 years decay.

Table 5C9-2 shows that in nine cases, the DCGLs developed using other conceptual models are lower than the DCGLs developed by the multi-source model that accounts for continuing releases from the bottom of the deep excavations:

- The peak-of-the-mean probabilistic DCGLs, which did not take into account continuing releases from the bottoms of the excavation, are lower for Cm-243, Cm-244, Cs-137 and U-232; and
- The limiting DCGLs from the deterministic resident farmer and residential gardener conceptual models, which did not take into account continuing releases from the bottom of the excavations, were lower for Pu-241, U-233, U-234, U-235, and U-238.

This situation can be attributed to conceptual model differences such as different contamination zone geometry. As discussed in this response and the responses to RAI 5C6 and RAI 5C15, a number of different scenarios were evaluated in developing the subsurface DCGLs; for all of the radionuclides, the lowest DCGLs are being used as the basis for the subsurface soil cleanup goals. This matter is addressed in the changes being made to Section 5 as described below.

Table 5C9-2 also shows that the revised cleanup goals are lower than the old cleanup goals in Revision 0 and Revision 1 of the DP in all but three cases: Cm-244, Pu-238, and Pu-241.

Remediation of Excavation Sides

Contamination present on the sides of the deep excavation will be remediated to ensure that unrestricted release criteria are met as specified in Section 7 of the DP.

Section 7 states on page 7-25 that remedial action surveys would be performed during the course of the work and soil on the bottom and sides of the excavation with radioactivity concentrations exceeding the cleanup goals would be removed and disposed of offsite as radioactive waste. The related footnote states that it is unlikely that the sides of the excavation that are not hydraulically downgradient will be contaminated. This footnote also states that in any case, the extent of soil remediation on the sides of the excavation would be limited by the excavation boundaries.

The Final Status Survey Conceptual Framework included in the response to RAI 9C4 describes how Phase 1 final status surveys will be performed on the sides of the deep excavations to document that the cleanup criteria are achieved.

Table 5C9-1. Borehole Log Geologic Picks Used to Re-Evaluate the Extent of the Lavery Till Sand in the North Plateau

Borehole	Original Geologic Unit	Original Top Elevation (ft)	Original Bottom Elevation (ft)	Revised Geologic Unit	Revised Top Elevation (ft)	Revised Bottom Elevation (ft)
302	S&G	0	16	S&G-TBU	0	17
	WLT	16	17	S&G-CLAY	17	23
	ULT	17	23			
	LTS	23	28	S&G-SWS	23	28
	ULT	28	>32	ULT	28	>32
402	S&G	0	14.5	S&G-TBU	0	15
	WLT	14.5	15	S&G-CLAY	15	24
	ULT	15	24			
	LTS	24	28.75	S&G-SWS	24	28.75
	ULT	28.75	>36	ULT	28.75	>36
404	S&G	0	14.75	S&G-TBU	0	14.7
	WLT	14.75	15.25	S&G-CLAY	14.7	24
	ULT	15.25	24			
	LTS	24	32	S&G-SWS	24	32
	ULT	32	>36.5	ULT	32	>36.5
410	S&G	0	14.75	S&G-TBU	0	14.7
	WLT	14.75	15.25	S&G-CLAY	14.7	24
	ULT	15.25	24			
	LTS	24	25	S&G-SWS	24	32
	ULT	25	62	ULT	32	62
	KRS	62	82	KRS	62	82
	BR	82	>82	BR	82	>82
11B	S&G	0	14.5	S&G-TBU	0	15
	WLT	14.5	15	S&G-CLAY	15	24
	ULT	15	24			
	LTS	24	28.75	S&G-SWS	24	28.75
	ULT	28.75	46	ULT	28.75	46
	KRS	46	66	KRS	46	66
	KT	66	>66	KT	66	>66
62DMB-16	S&G	0	26	F	0	3
				S&G-TBU	3	26
	ULT	26	27	S&G-CLAY	26	27
	LTS	27	40	S&G-SWS	27	40
	ULT	40	>40	ULT	40	>40
62DMB-17	S&G	0	17	F	0	3
				S&G-TBU	3	17
	ULT	17	25	S&G-CLAY	17	25
	LTS	25	31	S&G-SWS	25	31

Table 5C9-1. Borehole Log Geologic Picks Used to Re-Evaluate the Extent of the Lavery Till Sand in the North Plateau

Borehole	Original Geologic Unit	Original Top Elevation (ft)	Original Bottom Elevation (ft)	Revised Geologic Unit	Revised Top Elevation (ft)	Revised Bottom Elevation (ft)
	ULT	31	>42	ULT	31	>42
62PAH-71	S&G	0	17	S&G-TBU	0	17
	ULT	17	23	S&G-CLAY	17	23
	LTS	23	28	S&G-SWS	23	28
	ULT	28	>36.5	ULT	28	>36.5
63DMB-24	S&G	0	12	S&G-TBU	0	12
	ULT	12	20.5	S&G-CLAY	12	20.5
	LTS	20.5	25	S&G-SWS	20.5	25
	ULT	25	>42	ULT	25	>42
63DMB-25	S&G	0	18	S&G-TBU	0	17.5
	ULT	18	20	S&G-CLAY	17.5	20
	LTS	20	23	S&G-SWS	20	23
	ULT	23	52	ULT	23	52
	KRS	52	77	KRS	52	77
	BR	77	>77	BR	77	>77
70DMB-26	S&G	0	20	S&G-TBU	0	20
	ULT	20	24	S&G-CLAY	20	24
	LTS	24	32	S&G-SWS	24	32
	ULT	32	58	ULT	32	58
	KRS	58	>77	KRS	58	>77
70DMB-27	S&G	0	20	S&G-TBU	0	20
	ULT	20	24	S&G-CLAY	20	24
	LTS	24	28	S&G-SWS	24	28
	ULT	28	50	ULT	28	50
	KRS	50	>76	KRS	50	>76
74DMB-33	S&G	0	15	S&G-TBU	0	15
	ULT	15	43	ULT	15	68
	LTS	43	68			
	BR	68	>68	BR	68	>68
74DMB-39	S&G	0	15	S&G-TBU	0	15
	ULT	15	20	S&G-CLAY	15	20
	LTS	20	29	S&G-SWS	20	29
	ULT	29	53	ULT	29	53
	KRS	53	70	KRS	53	70

Table 5C9-1. Borehole Log Geologic Picks Used to Re-Evaluate the Extent of the Lavery Till Sand in the North Plateau

Borehole	Original Geologic Unit	Original Top Elevation (ft)	Original Bottom Elevation (ft)	Revised Geologic Unit	Revised Top Elevation (ft)	Revised Bottom Elevation (ft)
	BR	70	>70	BR	70	>70
74DMB-40	S&G	0	25	F	0	3
				S&G-TBU	3	25
	ULT	25	31	S&G-CLAY	25	30.5
	LTS	31	34	S&G-SWS	30.5	34
	ULT	34	63	ULT	34	63
	KRS	63	94	KRS	63	94
	KT	94	113	KT	94	113
	ORS	113	128	ORS	113	128
	BR	128	>128	BR	128	>128
UR-1	F	0	5	F	0	5
	S&G	5	23.5	S&G-TBU	5	23.5
	ULT	23.5	27	S&G-CLAY	23.5	27
	LTS	27	35.5	S&G-SWS	27	35.5
	ULT	35.5	>42	ULT	35.5	>42
UR-2	F	0	5	F	0	5
	S&G	5	23.5	S&G-TBU	5	23.5
	ULT	23.5	28	S&G-CLAY	23.5	28
	LTS	28	35.8	S&G-SWS	28	35.8
	ULT	35.8	>37	ULT	35.8	>37
UR-3	F	0	5	F	0	5
	S&G	5	20	S&G-TBU	5	20
	ULT	20	30.3	S&G-CLAY	20	30.3
	LTS	30.3	36	S&G-SWS	30.3	36
	ULT	36	>39	ULT	36	>39

LEGEND: BR - Bedrock
Clay – Clay Unit
F- Fill
KRS – Kent Recessional Sequence
KT – Kent till
LTS – Lavery till sand
ORS – Olean Recessional Sequence
S&G – Sand and Gravel Unit; subdivided into:
SWS –Slack Water Sequence
TBU – Thick-bedded Unit
ULT – Unweathered Lavery till
WLT – Weathered Lavery till

Figure 5C9-1. Pre-2007 Inferred Areal Extent of the Lavery Till Sand in the North Plateau

Figure 5C9-2 – Current Inferred Areal Extent of the Lavery Till Sand in the North Plateau

References:

Hemann and Steiner 1999, *1998 Geoprobe Investigation of the Core Area of the North Plateau Groundwater Plume*, WVDP-346, Revision 0. Hemann, M.R. and R.E. Steiner, II, West Valley Nuclear Services Company, June 11, 1999.

Changes to the Plan:

Section 3.5.2, Lavery Till-Sand Unit on page 3-48 will be modified as follows:

The Lavery till-sand unit is a lenticular shaped, silty, sand layer that is locally present within the Lavery till in the north plateau of the Center, immediately southeast of the Process Building. It is thought to be either a pro-glacial sand deposit or a reworked kame deposit.

The till-sand is limited in areal extent, occurring on the north plateau in an east-west band approximately 750 feet wide. It lies within the upper 20 feet of the Lavery till (Figure 3-6) and is up to seven feet in thickness.

Re-examination of borehole logs from the north plateau in 2007 resulted in a re-evaluation of the areal extent of the Lavery till sand. From 1991 to 2007 the Lavery till sand was inferred to be present to the west, south, and southeast of the Process Building in a location that was hydraulically upgradient and cross-gradient to the north plateau groundwater plume. Earlier interpretations of the borehole logs considered a prominent clay-rich geologic horizon up to several feet in thickness as part of the unweathered Lavery till and the underlying sandy unit as the Lavery till sand.

Following the completion of the 1993 soil boring program to support the RCRA Facility Investigation, the 1993 borehole data indicated that the sand and gravel unit was composed of two distinct subunits, the thick-bedded unit and the underlying slack water sequence which are separated by the prominent clay-rich geologic horizon mentioned earlier. In 2007 it was noted that the elevation of the original Lavery till sand west and southwest of the Process Building was much shallower in elevation that the Lavery till sand to the southeast of the Process Building. It was determined that this western and southwestern portion was more consistent with the elevation of the slack water sequence of the sand and gravel unit and it was reclassified as part of the slack water sequence. As a result the areal extent of the Lavery till sand was substantially reduced and it is now located southeast of the Process Building away from the north plateau groundwater plume as shown in Figure 3-64.

Changes to Section 5 are as follows:

New introductory information will be added following the unnumbered subsection heading "Subsurface Soil Conceptual Model" on page 5-23, as follows:

Evaluation of Various Subsurface Soil Conceptual Models

The analyses described in Revision 0 and Revision 1 to this plan made use of the base-case conceptual model for subsurface soil DCGL development described below and illustrated in Figure 5-8. Minor changes were made to this conceptual model in Revision 2 that produced DCGLs that were slightly higher for most radionuclides.

Addition analyses were also performed to determine whether this conceptual model, which makes use of the resident farmer scenario, represented the bounding case for potential future doses from the remediated deep excavations. These additional analyses, which are described below, involved:

- Evaluating the potential acute dose to the hypothetical individual drilling the well (the two meter diameter cistern) used in the original base case model,
- Evaluating potential acute dose to a hypothetical individual who might drill a natural gas well in the area of one of the deep excavations,
- Evaluating potential doses to a recreational hiker in the area of the lagoons in WMA 2 assuming that unchecked erosion would eventually produce deep gullies in this area,
- Evaluating potential doses to an offsite receptor from residual radioactivity at the bottom of the deep excavation in WMA 2 that might be released to Erdman Brook if deep gullies were to eventually cut into this area, and
- Evaluating a residential gardener scenario.

Of these five alternate conceptual models, one, the residential gardener model, was found to be more limiting for some radionuclides that the original base-case resident farmer scenario.

To help determine whether the input parameters used in the original base-case model were sufficiently conservative, a comprehensive probabilistic uncertainty analysis was performed (similar analyses were also performed for surface soil and streambed sediment DCGL development). Section 5.2.5 describes this analysis. The resulting peak-of-the-mean DCGLs were somewhat lower for most radionuclides than the DCGLs produced by the deterministic resident farmer and residential gardener scenarios.

Another analysis was performed to evaluate whether continuing release of residual radioactivity from the bottom of the deep excavations would influence potential future doses from the remediated deep excavations. Section 5.2.6 describes this analysis. The original base-case conceptual model was modified to add a secondary source of radioactivity from residual contamination at the bottom of the deep excavation that moves upward by diffusion and is drawn into the hypothetical well, resulting in additional dose to the resident primarily from the drinking water pathway.

This multi-source model was analyzed using the resident farmer scenario and also the residential gardener scenario, the latter with three different upper contamination zone geometries to evaluate the sensitivity of the model to the contamination zone area and thickness. The results showed that this model was more limiting for nine of the 18 radionuclides of interest than the other conceptual models that were evaluated.

Consideration of the results of all of this subsurface soil dose modeling led to the decision to use the lowest DCGLs among all of the modeling results as the basis for the subsurface soil cleanup goals in the interest of conservatism.

A new Section 5.2.6 will be added as follows:

5.2.6 Subsurface Soil DCGL Multi-Source Analysis

As noted in Section 5.2.1, the original base-case conceptual model used in developing the subsurface soil DCGLs recognizes one source of contamination – the Lavery till from the bottom of one of the deep excavations that is brought to the surface during construction of the hypothetical cistern. This model does not consider potential impacts to groundwater in the backfilled excavation from continuing release of remaining residual radioactivity at the bottom of the deep excavations.

To address this limitation, analyses were performed that take into account the impacts of releases of this other residual radioactivity on both a hypothetical residential gardener and a resident farmer with a modified model that accounts for a surface and a subsurface source of radiation. Figure 5-10 illustrates the modified conceptual model used in these analyses.

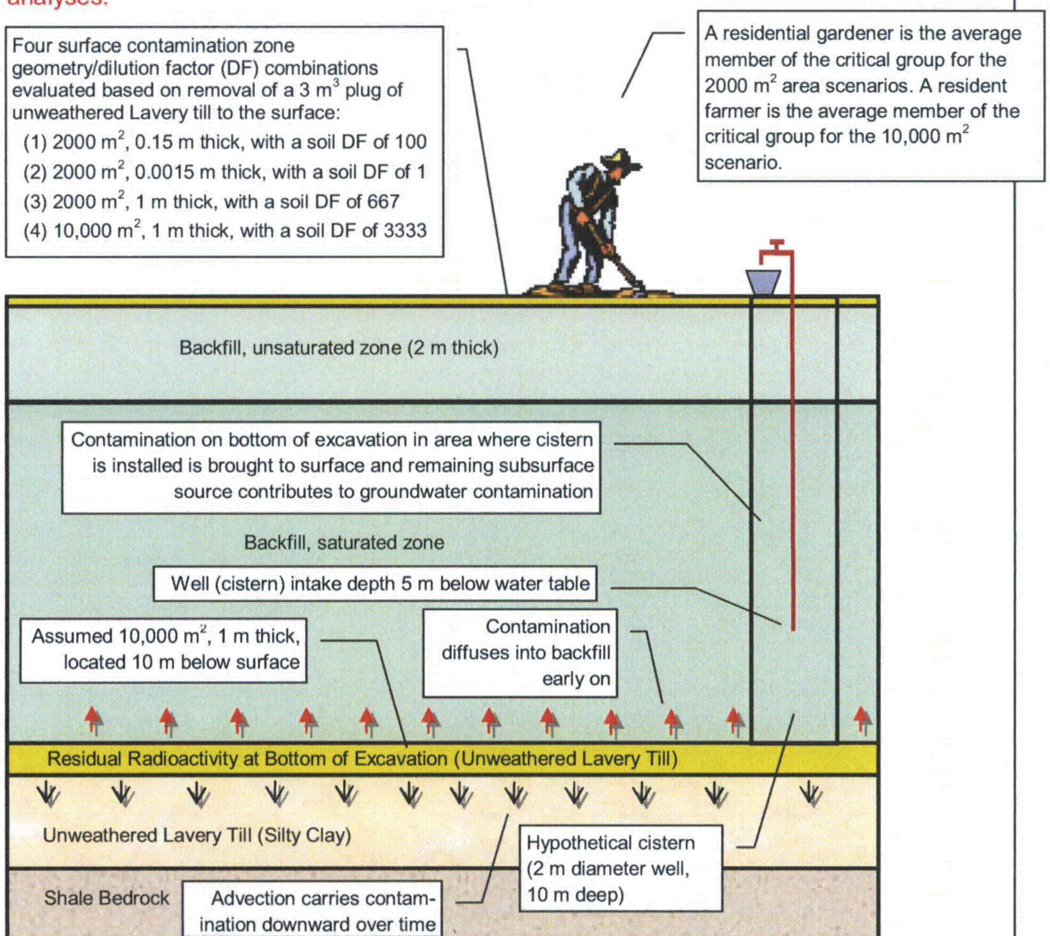


Figure 5-10. Modified Conceptual Model for Subsurface Soil DCGL Development

With this model, the subsurface soil DCGLs are based on exposure to residual radioactivity associated with the bottom of the deep excavation in the unweathered Lavery till, with (1) soil from this area assumed to be relocated to the surface during installation of a cistern and (2) with the remaining contaminated Lavery till in the excavation bottom serving as a continuing source of contaminants to groundwater. These sources and the exposure pathways considered are described below.

Excavation Bottom Treated as Two Sources of Contamination

The excavation bottom is treated as two distinct sources: (1) a plug of contaminated soil from the excavation bottom that is brought to the surface during installation of the cistern and spread over the entire surface of the hypothetical garden, and (2) the remaining contaminated Lavery till at the excavation bottom from which residual radioactivity moves upward by diffusion and enters groundwater being drawn into the well. Both the residential gardener scenario and the resident farmer scenario were considered as indicated in Figure 5-10.

The surface source that results from the contribution of contamination in soil being removed from the bottom of the excavation and brought to the surface and the contribution of contamination in irrigation water has the following characteristics:

- It is assumed that the contaminated material is evenly spread across the entire hypothetical garden and mixed in the soil to varying depths (the surface contamination zone),
- Exposure occurs from direct exposure and soil pathways associated with contaminated soil brought to the ground surface, and
- Exposure occurs from groundwater pathways as contaminated water is drawn into the well and used as irrigation water resulting in plant contamination and animal contamination where these plants are used as feed. As a result, the resident is exposed to radioactivity from the plants being consumed and, in the case of the resident farmer scenario, from meat and milk produced from cattle that have been raised on the contaminated feedstock.

The subsurface source remaining at the bottom of the excavation is assumed to have the following characteristics:

- The diffusive movement of contamination from the excavation bottom (the subsurface contamination zone) begins immediately after the excavation is backfilled and results in contaminating the aquifer,
- Contaminated groundwater entering the well is a source to soil in the surface contamination zone because well water is used to irrigate the garden, and
- Drinking water exposure occurs from contaminated well water being used as a source of drinking water.

Table 5-11b shows the exposure pathways evaluated.

Table 5-11b. Exposure Pathways for Modified Subsurface Soil DCGL Model

Exposure Pathways	Residential Gardener	Resident Farmer
External gamma radiation from contaminated soil	Yes	Yes
Inhalation of airborne radioactivity from re-suspended contaminated soil	Yes	Yes

Table 5-11b. Exposure Pathways for Modified Subsurface Soil DCGL Model

Exposure Pathways	Residential Gardener	Resident Farmer
Plant ingestion (produce impacted by contaminated soil and groundwater contaminated by primary and secondary sources)	Yes	Yes
Meat ingestion (beef impacted by contaminated soil and groundwater contaminated by primary and secondary sources)	No	Yes
Milk ingestion (impacted by contaminated soil and groundwater contaminated by primary and secondary sources)	No	Yes
Aquatic food ingestion	No	No
Ingestion of drinking water (from groundwater contaminated by primary and secondary sources)	Yes	Yes
Soil ingestion	Yes	Yes
Radon inhalation	No	No

Details of the modeling including values of input parameters such as distribution coefficients appear in the calculation package (Price 2009).

Mathematical Models

Calculation of the combined dose utilized information from the three-dimensional near field STOMP finite difference model of the north plateau for groundwater transport, a model that estimated the drinking water dose associated with contamination from the subsurface source diffusing into the aquifer, and RESRAD dose to source ratios associated with unit soil concentrations to determine the total dose from all pathways. The calculations were implemented with a FORTRAN language computer program that estimates time dependent human health impacts.[2]

The model performs mass balance calculations and develops concentrations over time for three distinct areas (1) the remaining subsurface source, (2) the backfilled saturated zone, and (3) the surface which has been contaminated with material excavated from the subsurface source and radionuclides in irrigation water.

In order to identify controlling scenarios, the area of the contaminated zone at the surface and the degree of mixing into the soil of the garden were varied.

The STOMP model was executed with parameter values for the contaminated area and well pumping rates that corresponded with assumptions used in the RESRAD model for the exposure scenarios under consideration. A contaminated area of 10,000 m^2 and pumping rate of 5720 m^3/y were used to evaluate the resident farmer, and a contaminated area of 2,000 m^2 and well pumping rate of 1140 m^3/y were used to evaluate the residential gardener scenario. The residential gardener scenario assumed several source

[2] These analyses were deterministic analyses. Consideration was given to performing probabilistic analyses instead. However, the complexity of the multi-source model made a probabilistic analysis impractical.

configurations within the contaminated area for the three m^3 of contaminated Lavery till assumed to be excavated to the surface:

- Contamination is spread over the surface in a thin layer (1.5 mm thick) of undiluted till,
- Contamination is spread over the surface and then tilled into the soil to a depth of 15 cm, and
- Contamination is spread over the surface and then tilled into the soil to a depth of 1 m.

The source configuration determined to be most limiting for each radionuclide was used as the basis for the development of the subsurface DCGLs.

Results

Table 5-11c shows the results of the analyses compared to DGCLs developed using other conceptual models.

Table 5-11c. Subsurface Soil DCGL Comparison (pCi/g)

Nuclide	Multi-Source	Cistern Well Driller	Recreat. Hiker	Lagoon 3 Erosion	Natural Gas Well Driller	Basic Deterministic Models(1)	Probabilistic Peak of the-Mean
Am-241	6.3E+03	1.7E+04	2.7E+05	2.9E+05	1.4E+05	7.1E+03	6.8E+03
C-14	9.9E+02	2.3E+09	3.3E+08	6.4E+06	4.9E+09	3.7E+05	7.2E+05
Cm-243	3.6E+03	1.1E+04	5.0E+04	1.8E+05	1.2E+05	1.2E+03	1.1E+03
Cm-244	3.4E+04	3.3E+04	1.0E+09	3.9E+05	2.6E+05	2.3E+04	2.2E+04
Cs-137(2)	2.8E+03	6.7E+03	9.8E+05	7.4E+05	9.2E+04	4.4E+02	3.0E+02
I-129	7.5E+00	8.0E+05	1.9E+06	3.5E+05	9.2E+06	5.2E+01	6.7E+02
Np-237	1.0E+00	6.6E+03	2.7E+04	5.9E+05	6.6E+04	4.3E+00	9.3E+01
Pu-238	1.3E+04	2.0E+04	1.5E+06	2.7E+05	1.6E+05	1.5E+04	1.4E+04
Pu-239	3.1E+03	1.9E+04	2.8E+05	2.4E+05	1.5E+05	1.3E+04	1.2E+04
Pu-240	3.4E+03	1.9E+04	2.8E+05	2.4E+05	1.5E+05	1.3E+04	1.2E+04
Pu-241	5.5E+05	5.5E+05	1.7E+07	1.2E+07	4.5E+06	2.4E+05	2.5E+05
Sr-90(2)	2.8E+02	8.7E+05	1.6E+08	9.2E+06	1.1E+07	3.2E+03	3.4E+03
Tc-99	5.9E+02	7.9E+07	2.2E+08	4.7E+07	9.4E+08	1.1E+04	1.4E+04
U-232	8.8E+01	1.6E+03	2.8E+04	4.5E+05	1.6E+04	1.0E+02	7.4E+01
U-233	2.7E+02	6.2E+04	1.3E+06	2.9E+06	4.9E+05	1.9E+02	9.9E+03
U-234	2.8E+02	6.4E+04	1.4E+06	3.1E+06	5.0E+05	2.0E+02	1.3E+04
U-235	2.9E+02	1.2E+04	4.2E+04	3.2E+06	1.4E+05	2.1E+02	9.3E+02
U-238	3.0E+02	3.7E+04	1.9E+05	3.3E+06	3.6E+05	2.1E+02	4.6E+03

NOTES: (1) The lower value of the deterministic resident farmer and residential gardener DCGLs.
(2) These values take into account 30 years decay.

In nine cases, the DCGLs developed using other conceptual models are lower than the DCGLs developed by the multi-source model that accounts for continuing releases from the bottom of the deep excavations:

- The peak-of-the-mean probabilistic DCGLs, which did not take into account continuing releases from the bottom of the deep excavations, are lower for Cm-243, Cm-244, Cs-137, and U-232; and
- The limiting deterministic DCGL from the deterministic resident farmer and residential gardener conceptual models, which did not take into account continuing releases from the bottom of the excavations, was lower for Pu-241, U-233, U-234, U-235, and U-238.

This situation can be attributed to conceptual model differences such as different contamination zone geometry.

Change the preliminary dose estimates in Section 5.4.4 as follows:

5.4.4 Preliminary Dose Assessment

Preliminary dose assessments have been performed for the remediated WMA 1 and WMA 2 excavations. These assessments made use of the maximum measured radioactivity concentration in the Lavery till for each radionuclide as summarized in Table 5-1, and the results of modeling to develop DCGLs for 25 mrem per year and the multi-source analysis results as shown in Table 5-11c. The results were as follow:

WMA 1, a maximum of approximately 8 mrem a year

WMA 2, a maximum of approximately 0.2 mrem a year

Given the limited data available, these results must be viewed as order-of-magnitude estimates. However, they do suggest that actual potential doses from the two remediated areas are likely to be substantially below 25 mrem per year. Note that the primary dose driver for these estimates is Sr-90, which accounts for approximately 67 percent of the estimated dose for the WMA 1 excavation and approximately 58 percent of the estimate for the WMA 2 excavation.

Note that changes to incorporate the revised subsurface soil cleanup goals into Table 5-14 are described in the updated response to RAI 5C15.

Add the following reference to Section 5.5:

Price 2009, *West Valley EIS/DPlan Calculation Package, Estimates of Human Health Impacts Due to a Sub-surface Source in the Vicinity of the Excavation of the Main Plant Process Building*, Calculation DPlan-SAIC-JDP-003. Price, J., Science Applications International Corporation, Germantown, Maryland, October 2009.

Attachment

(1) Recent WMA 1 Boring Logs

SHEET 1 OF: 1 DATE STARTED: 12/11/89 DATE FINISHED: 12/12/89 DRILLER: Empire Soils Inv. Hamburg, New York INSPECTOR: JTB	# BORING LOG DAMES & MOORE	HOLE/WELL NO.: 0302 SURFACE ELEVATION: 1,416.22 NORTHING 892,564.84 EASTING 480,547.64

PROJECT: WVDP DOE/RCRA wells
JOB NUMBER: 10805-410-023

LOCATION: SW OF CSS
SSWMU Locale: 3

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0 / 6	BLOWS ON SAMPLER 6 / 12	BLOWS ON SAMPLER 12 / 18	BLOWS ON SAMPLER 18 / 24	DESCRIPTION / NOTES
	24/10	SS-1	6	6	12	24	Moist, brown, SILT, some fine to medium subangular gravel, little sand, trace clay, orange and green mottling. (GM)
	24/19	SS-2	12	14	19	15	
5	24/19	SS-3	9	13	10	16	Moist, light to dark, brown, silty SAND and fine to coarse GRAVEL, trace clay. (GM)
	24/15	SS-4	9	13	11	18	Saturated, brown. (GM)
	24/10	SS-5	8	11	11	15	
10	24/12	SS-6	6	16	18	12	Some silt. (GM/ML)
	24/11	SS-7	6	8	12	20	Saturated, brown, silty SAND and fine to coarse GRAVEL, little subangular shale fragments. (GP/ML)
15	24/16	SS-8	29	20	21	22	Saturated, light brown with red and orange mottling. (GP/ML)
	24/15	SS-9	6	9	17	19	Saturated, brown, SILT, little fine sand, trace clay and fine subangular gravel. Weathered till. (ML)
	24/22	SS-10	4	6	8	10	Wet, gray SILT, some clay, trace fine sand and fine to medium subangular gravel. Unweathered. (CL)
20	24/24	SS-11	5	11	6	6	Some to little sand. (CL) Wet, gray, SILT, little clay, little fine to medium sand and gravel, brown-red mottling. (CL)
	24/22	SS-12	4	6	25	18	Saturated, brown-orange, fine to coarse SAND and fine to coarse subangular GRAVEL, trace clay. (SP)
25	24/17	SS-13	3	8	11	11	
	24/22	SS-14	4	8	7	11	Little silt and clay. (SP/SM)
	24/17	SS-15	3	6	10	12	Saturated, brown-gray, sandy SILT, little clay, trace fine to medium gravel. Unweathered. (ML/CL)
30	24/21	SS-16	3	6	8	13	Saturated, dark gray, SILT, some clay, trace fine sand, trace fine to medium subangular gravel. (CL)
35							Augered to 30.0 ft. Sampled to 32.0 ft. The water level was measured at 17.1 ft. b.g.s.- While the bottom of the augers were 30.0 ft. b.g.s.. No radiation detected above background by R/S.

CLASSIFICATION: VISUAL (Modified Burmister),USCS

METHOD OF SAMPLING: ASTM D1586-84

SHEET 1 OF: 1	# BORING LOG	HOLE/WELL NO.:	0402
DATE STARTED: 11/9/89		SURFACE ELEVATION:	1,416.96
DATE FINISHED: 11/10/89			
DRILLER: Empire Soils Inv. Hamburg, New York	DAMES & MOORE	NORTHING	892,668.86
INSPECTOR: FJC		EASTING	480,504.59
PROJECT: WVDP DOE/RCRA wells		LOCATION:	EAST OF TRAILER J
JOB NUMBER: 10805-410-023		SSWMU Locale:	4

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0 / 6, 12 / 18	BLOWS ON SAMPLER 6 / 12, 18 / 24	LITHOLOGY	DESCRIPTION / NOTES
						Medium brown, silty GRAVEL and SAND. (GP)
5						Medium brown, SAND and GRAVEL, some silt. (SM)
10						
15						Medium brown, clayey SILT, trace gravel and sand. (ML)
						Moist, medium brown to dark gray, SILT, some clay, trace gravel, trace fine sand. (ML)
	24/24	SS-1	5 10	8 12		Dark gray, SILT, some clay, trace gravel. (ML)
20	24/22	SS-2	1 7	4 10		
	24/23	SS-3	2 16	7 23		
25	24/20	SS-4	4 7	4 14		Dark gray, fine SAND, trace silt. (SP) Dark gray, GRAVEL and SAND, trace silt. (GP) Dark gray, fine SAND, some silt, little gravel. (SP)
	24/9	SS-5	10 20	27 20		
	24/18	SS-6	16 32	10 37		Dark gray, SILT and CLAY, trace gravel. (ML/CL) Dark gray, SAND, little silt. (SM) Dark gray, SILT and CLAY, trace gravel. (ML/CL)
30	24/23	SS-7	2 12	6 18		
	24/24	SS-8	2 7	6 7		
35	24/20	SS-9	2 11	8 20		
						Augered to 34 ft. / Sampled from 18 to 36 ft.. The water level was measured at 28.25 ft. b.g.s.- While the bottom of the augers were 30.0 ft. b.g.s.. No radiation detected above background by R/S.

CLASSIFICATION: VISUAL (Modified Burmister),USCS

METHOD OF SAMPLING: ASTM D1586-84

See 0401 for sampling 0-18 feet

BORING LOG

DAMES & MOORE

SHEET 1 OF: 3
DATE STARTED: 11/10/89
DATE FINISHED: 11/29/89
DRILLER: Empire Soils Inv. Hamburg, New York
INSPECTOR: JTB

HOLE/WELL NO.: 0410
SURFACE ELEVATION: 1,417.15
NORTHING 892,834.68
EASTING 480,426.42

PROJECT: WVDP DOE/RCRA wells
JOB NUMBER: 10805-410-023

LOCATION: SOUTHWEST OF CTS
SSWMU Locale: 4

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0/6, 12/18	BLOWS ON SAMPLER 6/12, 18/24
20	24/21	SS-1	7 17	14 21
	24/24	SS-2	8 15	12 20
25	24/23	SS-3	6 10	8 14
	24/23	SS-4	4 7	5 10
	24/24	SS-5	6 13	6 18
30	24/23	SS-6	13 18	16 25
	24/15	SS-7	16 11	10 12
35	24/3	SS-8	13 26	16 21
	24/19	SS-9	7 11	7 13
	24/14	SS-10	12 9	10 14

DESCRIPTION / NOTES

Approx. depth (ft)	Description / Notes
0–2	Damp, brown to red, SILT, trace fine sand and clay, trace angular gravel, some orange mottling. (ML)
4–5	Wet to saturated, brown, SILT and fine to coarse GRAVEL, trace fine to medium sand, orange mottling. (GM)
12–13	Wet, brown, SILT and fine to medium angular GRAVEL, trace fine to medium sand, trace clay, mottled. (GM)
14.5–15.5	Damp, brown, SILT, trace sand, oxidized. (ML)
16–17	Damp, gray, SILT, little fine to medium angular to subangular gravel, trace clay, unweathered. (ML)
18–19	Wet, gray, SILT and CLAY, trace angular to subangular gravel. (ML)
21–22	Saturated, gray, silty CLAY, trace fine sand and gravel. (CL)
24	Wet, gray, fine SAND, some silt, trace clay. (SM)
25–26	Saturated, gray, CLAY, little silt, little very fine sand, trace gravel. (CL)
27	Wet, gray, fine SAND and SILT, little clay at 26.0 ft. b.g.s.
30–31	Saturated, gray, fine SAND and SILT, trace gravel and clay. (SM)
32–33	Wet, gray, SILT, little fine sand, trace clay, trace fine to medium subangular gravel. (ML)
38–39	Wet, gray, SILT, little clay, trace fine sand, trace fine gravel. (CL)

CLASSIFICATION: VISUAL (Modified Burmister),USCS

METHOD OF SAMPLING: ASTM D1586-84
SEE 0403 FOR ADDITIONAL SAMPLING

SHEET 2 OF: 3	BORING LOG	HOLE/WELL NO.:	0410
DATE STARTED: 11/10/89		SURFACE ELEVATION:	1,417.15
DATE FINISHED: 11/29/89			
DRILLER: Empire Soils Inv. Hamburg, New York	DAMES & MOORE	NORTHING	892,834.68
INSPECTOR: JTB		EASTING	480,426.42
PROJECT: WVDP DOE/RCRA wells		LOCATION:	SOUTHWEST OF CTS
JOB NUMBER: 10805-410-023		SSWMU Locale:	4

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0/6, 12/18	BLOWS ON SAMPLER 6/12, 18/24	LITHOLOGY	DESCRIPTION / NOTES
	24/14	SS-11	WOR 15	WOR 19		Saturated, gray, silty CLAY, trace fine gravel. (CL)
	24/18	SS-12	7 20	11 30		
45	24/12	SS-13	10 38	23 39		Moist to wet, gray, SILT, little fine to medium gravel, trace fine sand, trace clay. (ML)
	24/11	SS-14	12 44	21 50		Moist, brown, SILT, little fine to coarse gravel and clay , trace fine sand. (ML)
	24/23	SS-15	WOR3 26	24 30		Moist, brownish-gray, SILT, some fine to coarse gravel, trace clay. (ML/CL)
50	24/24	SS-16	8 23	15 30		Moist, gray, SILT, little fine to medium subangular gravel. (ML)
	24/23	SS-17	8 20	17 21		
55	24/0	SS-18	12 22	18 31		
	24/24	SS-19	10 17	13 22		
60	24/24	SS-20	11 20	17 22		
	24/24	SS-21	WOR 11	WOR 17		Saturated, gray, silty CLAY, trace fine to medium gravel. (CL)
	24/18	SS-22	25 50	28 42		Damp, green, fine SAND, trace angular gravel (shale), little silt. (SP)
65	24/19	SS-23	10 36	50 19		
	24/20	SS-24	14 69	13 27		Wet, medium brown, SILT, some clay, trace fine to medium gravel. (ML)
70	24/21	SS-25	6 18	15 21		Moist to wet, gray, SILT, little clay, trace gravel, trace sand. (ML)
	24/13	SS-26	WOR6 11	7 18		
	24/24	SS-27	6 11	7 15		
75	24/24	SS-28	8 12	9 16		Moist to wet,brownish-gray, SILT, little clay, trace sand, bluelsh-gray mottling. (ML)
	24/17	SS-29	14 49	22 107		Moist, brown to green, silty SAND. (SM) Moist, gray, SILT and fine to coarse subangular GRAVEL, little fine to medium sand. (ML/GM)
	24/17	SS-30	25 34	33 30		

CLASSIFICATION: VISUAL (Modified Burmister),USCS

METHOD OF SAMPLING: ASTM D1586-84
SEE 0403 FOR ADDITIONAL SAMPLING

SHEET 3 OF: 3	BORING LOG	HOLE/WELL NO.:	0410
DATE STARTED: 11/10/89		SURFACE ELEVATION:	1,417.15
DATE FINISHED: 11/29/89			
DRILLER: Empire Soils Inv. Hamburg, New York	DAMES & MOORE	NORTHING	892,834.68
INSPECTOR: JTB		EASTING	480,426.42
PROJECT: WVDP DOE/RCRA wells		LOCATION:	SOUTHWEST OF CTS
JOB NUMBER: 10805-410-023		SSWMU Locale:	4

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0 / 6, 12 / 18	BLOWS ON SAMPLER 6 / 12, 18 / 24	LITHOLOGY	DESCRIPTION / NOTES
	24/14	SS-31	9	22		Moist to wet, gray, SHALE and GRAVEL, trace silt, trace sand. (GM)
			28	78		
	24/7	SS-32	200/.3			Moist to wet, gray, SHALE and SILT, little fine sand, thin-bedded, fissile. Shale bedrock.
85	24/0	SS-33	100/.2			
90						
95						
100						
105						
110						
115						

Augered to 83.5 ft..
Sampled to 82.5 ft..
The water level was measured at 7 ft. b.g.s- while the bottom of the augers were 32 ft. b.g.s..
No radiation detected above background by R/S.

CLASSIFICATION: VISUAL (Modified Burmister),USCS

METHOD OF SAMPLING: ASTM D1586-84
SEE 0403 FOR ADDITIONAL SAMPLING

SHEET 1 OF: 2 DATE STARTED: 3/27/90 DATE FINISHED: 3/29/90 DRILLER: Empire Soils Inv. Hamburg, New York INSPECTOR: JTB	# BORING LOG DAMES & MOORE	HOLE/WELL NO.: 0411b SURFACE ELEVATION: 1,416.76 NORTHING 892,657.72 EASTING 480,509.12

PROJECT: WVDP DOE/RCRA wells
JOB NUMBER: 10805-410-023

LOCATION: WEST OF TRAILER J
SSWMU Locale: 4

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0/6, 12/18	BLOWS ON SAMPLER 6/12, 18/24	LITHOLOGY	DESCRIPTION / NOTES
0						Medium brown, silty GRAVEL and SAND. (OL/GP)
5						Medium brown, SAND and GRAVEL, some silt. (SM)
10						
15						Medium brown, clayey SILT, trace gravel, trace sand. (ML) Dark gray, SILT, some clay, trace gravel. (ML)
20						
						Dark gray, SILT, some clay, trace gravel. (ML)
25						Dark gray, fine SAND, trace silt. (SP) Dark gray, GRAVEL and SAND, trace silt. (GP/GM) Dark gray, fine SAND, some silt, little gravel. (SM)
30						Dark gray, SILT and CLAY, trace gravel. (ML/CL) Dark gray, SAND, little silt. (SM) Dark gray, SILT and CLAY, trace gravel. (ML/CL)
35	24/18	SS-1	4 7	5 6		Saturated, gray, SILT, some clay, little fine to medium sand, trace fine to medium subangular to angular gravel, slightly plastic, medium plastic. (ML/CL)
	24/18	SS-2	3 11	8 19		
	24/8	SS-3	7 18	7 24		Saturated, gray, SILT and CLAY, trace fine to medium subangular to angular gravel, medium stiff. (ML/CL)

CLASSIFICATION: VISUAL (Modified Burmister),USCS

METHOD OF SAMPLING: ASTM D1586-84
SEE 0401 & 0402 FOR ADD'L SAMPLING

SHEET 2 OF: 2	BORING LOG	HOLE/WELL NO.: 0411b
DATE STARTED: 3/27/90		SURFACE ELEVATION: 1,416.76
DATE FINISHED: 3/29/90		
DRILLER: Empire Soils Inv. Hamburg, New York	DAMES & MOORE	NORTHING 892,657.72
INSPECTOR: JTB		EASTING 480,509.12
PROJECT: WVDP DOE/RCRA wells		LOCATION: WEST OF TRAILER J
JOB NUMBER: 10805-410-023		SSWMU Locale: 4

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0 / 6, 12 / 18	BLOWS ON SAMPLER 6 / 12, 18 / 24	LITHOLOGY	DESCRIPTION / NOTES
	24/15	SS-4	17	17		Wet, dark gray, SILT, some clay, trace fine to coarse subangular to subrounded gravel, trace fine sand, slightly plastic, dense. (ML/CL)
			23	30		
	24/24	SS-5	20	30		
			35	31		
45	24/24	SS-6	31	30		
			34	38		
	24/18	SS-7	53	100		Saturated, greenish-gray, mostly fine to coarse GRAVEL and fine to medium SAND, trace silt, trace clay. (GM)
				100/.2		
	24/3	SS-8				Saturated, gray, medium to coarse GRAVEL, trace silt, trace clay, trace fine sand. (GM)
50	24/18	SS-9	68	52		Wet, gray, black, greenish, medium SAND. (SM)
			84	59/.4		
	24/10	SS-10	80	100/.3		Moist, greenish, fine to coarse GRAVEL, little silt, trace sand. Dry, medium to coarse GRAVEL, trace fine sand, trace silt, dense, undisturbed till. (GM)
55	24/12	SS-11	39	59		Wet, greenish-gray, silty SAND and fine to medium subangular to subrounded GRAVEL, trace clay. (GM)
			48	36		
	24/18	SS-12	9	21		
			17	23		
	24/12	SS-13	15	15		Saturated, greenish-gray, fine to medium GRAVEL and fine to medium SAND, little silt, trace clay. (GM)
			14	11		
60	24/8	SS-14	12	16		
			20	21		
	24/10	SS-15	26	15		
			21	23		
65	24/6	SS-16	30	31		Saturated, greenish-gray, silty SAND and fine to medium GRAVEL, trace clay, loose. (GM)
			30	38		
	24/12	SS-17	5	9		Moist to wet, gray, SILT and CLAY, trace fine to medium subangular to subrounded gravel, medium stiff. (ML/CL)
			14	17		
	24/18	SS-18	5	7		
			16	15		
70						Augered to 68.0 ft.. Sampled to 70.0 ft.. The water level was measured at 44.8 ft. b.g.s. - while the bottom of the augers were at 68.0 ft. b.g.s.. No radiation was detected above background by R/S.
75						

CLASSIFICATION: VISUAL (Modified Burmister),USCS

METHOD OF SAMPLING: ASTM D1586-84
SEE 0401 & 0402 FOR ADD'L SAMPLING

BORING LOG

Dames & Moore

HOLE/WELL NO.:	UR-1	SHEET 1 OF:	2
DATE STARTED:	9/27/91	SURFACE ELEVATION:	1408.10
DATE FINISHED:	9/30/91	GROUNDWATER DEPTH:	1
DRILLER:	EMPIRE SOILS HAMBURG, NY	MEASUREMENT DATE:	9/30/91
		NORTHING:	892694.05
INSPECTOR:	F. J. COHEN	EASTING:	480857.12
PROJECT:	UR EXPANSION	LOCATION:	WVDP
JOB NUMBER:	10805-509	SWMU Locale:	3

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0/6, 12/18	BLOWS ON SAMPLER 6/12, 18/24	UNIT	LITHOLOGY	DESCRIPTION / NOTES
0–5							Gravelly fill at surface-augered to 5 ft.
5	24/15	SS-1	14 / 18	16 / 12	S/G Unit		Dry to damp medium to light brown SILT, some gray and white medium angular Gravel, some medium to coarse Sand, little clay. Crumbly. Some rust mottling. (GM)
10	24/10	SS-2	12 / 19	13 / 18	S/G Unit		Dry, light brown fine SAND, some medium to coarse subangular gray Gravel. (SP)
15	24/14	SS-3	10 / 15	13 / 15	S/G Unit		Moist light brown to greenish brown fine to coarse, subangular to subrounded GRAVEL, some Sand and Silt. Loose when disturbed. Trace rust mottling. (GM)
20	24/17	SS-4	18 / 10	10 / 11	S/G Unit		
25	24/17	SS-5	23 / 15	12 / 18	UTILL		Moist light brown CLAY, little silt, trace fine to medium sand. Grades to dark gray, some Silt, fine silty sandy layering at 1/8" intervals. (CL)
	24/24	SS-6	10 / 14	14 / 14	Coarse Unit		Wet gray fine to medium SAND. (SP) Grades to moist gray CLAY with silty laminations. (CL) Grades to wet light brown fine SAND, little medium to coarse sand and fine gravel. (SP) Grades to dark brown, medium to coarse SAND. (SP)
30	24/12	SS-7	7 / 3	3 / 4	Coarse Unit		Moist light brown CLAY, little silt, little medium to coarse gravel. (CL) Grades to saturated light brown fine to medium SAND. (SW) Grades to medium to coarse SAND and fine to medium GRAVEL. (SW)
35	24/11	SS-8	5 / 7	7 / 6	UTILL		Damp brown CLAY, little silt. Grades to dark gray. Laminated, with fine silty sandy partings. (CL)
	24/12	SS-9	9 / 14	12 / 13	UTILL		

CLASSIFICATION: VISUAL (MODIFIED BURMISTER), USCS

METHOD OF SAMPLING: ASTM D1586-84

HOLE/WELL NO.: UR-1	# BORING LOG	SHEET 2 OF: 2	
DATE STARTED: 9/27/91		SURFACE ELEVATION: 1408.10	
DATE FINISHED: 9/30/91		GROUNDWATER DEPTH: 13	
DRILLER: EMPIRE SOILS, HAMBURG, NY	Dames & Moore	MEASUREMENT DATE: 9/30/91	
		NORTHING: 892694.05	
INSPECTOR: F. J. COHEN		EASTING: 480857.12	

PROJECT: UR EXPANSION
JOB NUMBER: 10805-509
LOCATION: NVDP
SWMU Locale: 3

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12	UNIT	LITHOLOGY	DESCRIPTION / NOTES
			12/18	18/24			
	24/16	SS-10	14	10			Damp to moist gray-green fine to medium GRAVEL, some Clay and Silt. (GM/GC)
			8	12			Grades to damp dark gray CLAY and SILT, grades to fine sandy silty CLAY. (CL/ML)
45							Augered to 40 ft. Sampled to 42 ft. Water encountered at 5.5 ft. Boring grouted to surface.
50							
55							
60							
65							
70							
75							

CLASSIFICATION: VISUAL (MODIFIED BURMISTER), USCS METHOD OF SAMPLING: ASTM D1586-8

BORING LOG

Dames & Moore

HOLE/WELL NO.:	UR-2	SHEET 1 OF:	1
DATE STARTED:	10/01/91	SURFACE ELEVATION:	1407.99
DATE FINISHED:	10/02/91	GROUNDWATER DEPTH:	13.2
DRILLER:	EMPIRE SOILS HAMBURG, NY	MEASUREMENT DATE:	10/02/91
		NORTHING:	892674.56
INSPECTOR:	J.T.B. & F.J.C.	EASTING:	480826.50
PROJECT:	UR EXPANSION	LOCATION:	WVDP
JOB NUMBER:	10805-509	SWMU Locale:	3

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0/6 – 12/18	BLOWS ON SAMPLER 6/12 – 18/24	UNIT	LITHOLOGY	DESCRIPTION / NOTES
0–5							Gravelly fill at surface-augered to 5'.
5	24/16	SS-1	13 / 15	13 / 16	S/G UNIT		Wet grayish-brown very fine SAND and fine to medium subangular GRAVEL, little silt, loose. (SP) Grades to damp light brown-yellow very fine sandy SILT and fine to medium subangular GRAVEL, trace clay, firm to friable, oxidized, mottled, non-plastic. (Rock in end of spoon) (GM)
10	24/12	SS-2	20 / 11	10 / 9	S/G UNIT		Grades to moist. (GM)
15	24/15	SS-3	16 / 9	12 / 8	S/G UNIT		Moist coarse angular GRAVEL, some brown Silt and Clay, little coarse sand. (GM)
20	24/0	SS-4	6 / 3	5 / 7	S/G UNIT		
	24/3	SS-5	WOR / -	- / -	S/G UNIT		Grades to wet, some medium to coarse black, brown, gray Sand, little clay. (GW)
25	24/19	SS-6	6 / 9	7 / 10	UTILL		Moist gray CLAY, little silt and fine to medium sand, trace gravel. Grades to brown, layering at 1/8" intervals, some silty partings. (CL)
30	24/11	SS-7	6 / 6	7 / 5	Coarse Unit		5" Wet fine to coarse subangular SAND and medium to coarse black, pink, gray GRAVEL, some clay, little silt. (SW)
					Coarse Unit		Wet brown-gray SILT, some medium angular Gravel. (GM) Grades to wet gray-green fine to medium SAND, some medium to coarse subangular Gravel, little clay. (SW)
35	24/14	SS-8	20 / 10	17 / 9			Grades to moist gray CLAY, little silt, little medium gravel and sand. (CL)
							Augered to 37 ft.- Grouted to surface.

CLASSIFICATION: VISUAL (MODIFIED BURMISTER), USCS METHOD OF SAMPLING: ASTM D1586-84

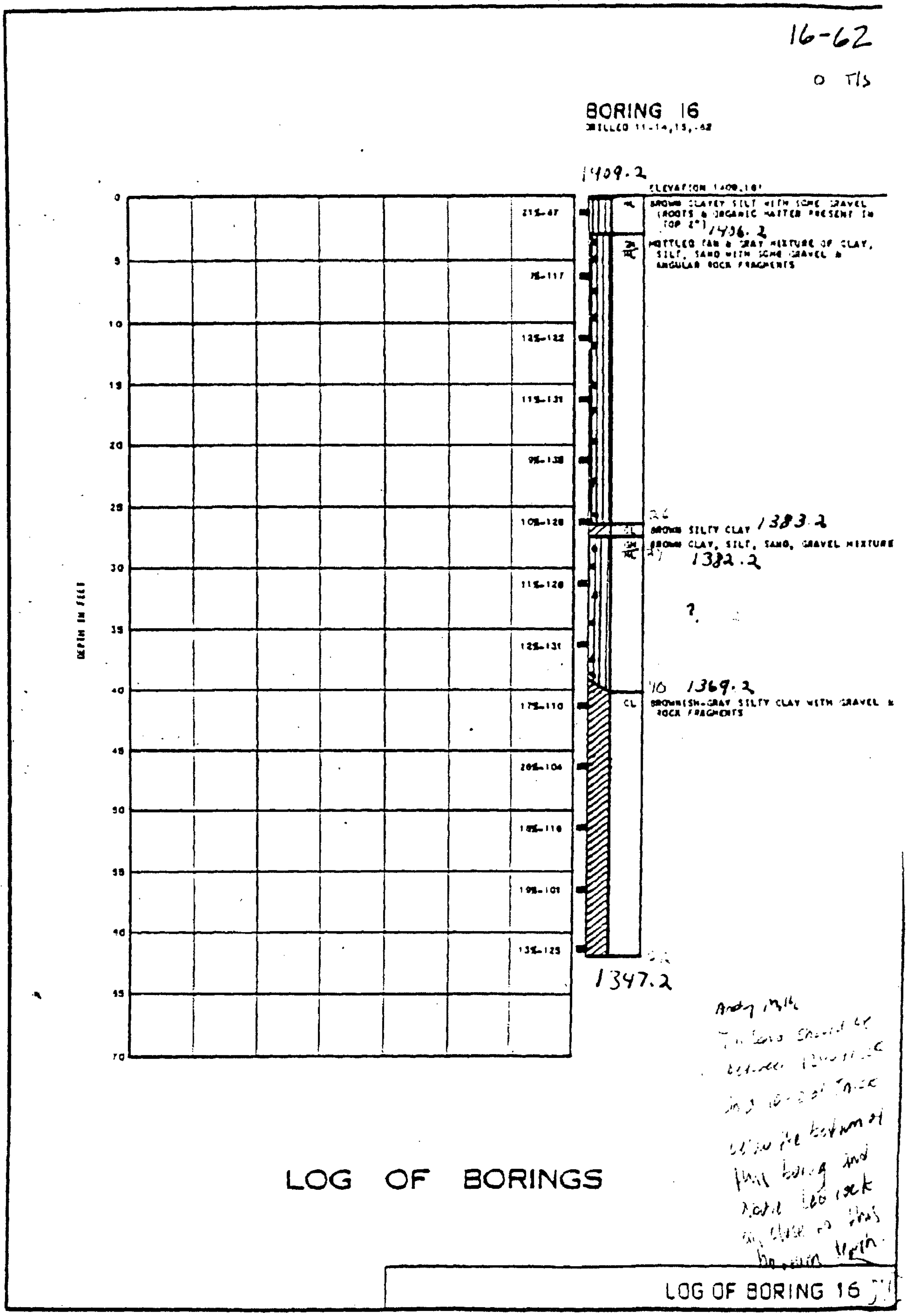
BORING LOG

Dames & Moore

HOLE/WELL NO.:	UR-3	SHEET 1 OF:	2
DATE STARTED:	10/02/91	SURFACE ELEVATION:	1407.77
DATE FINISHED:	10/04/91	GROUNDWATER DEPTH:	20
DRILLER:	EMPIRE SOILS HAMBURG, NY	MEASUREMENT DATE:	10/02/91
		NORTHING:	892684.95
INSPECTOR:	F.J.C.	EASTING:	480807.97
PROJECT:	UR EXPANSION	LOCATION:	NVDP
JOB NUMBER:	10805-509	SWMU Locale:	3

DEPTH IN FEET	INCHES DRIVEN / RECOVERED	SAMPLE TYPE-NO.	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24	UNIT	LITHOLOGY	DESCRIPTION / NOTES
0–5							S/G UNIT		Gravelly fill at surface-augered to 5'.
5	24/18	SS-1	6	9	9	7	S/G UNIT		Dry brown fine to coarse subangular GRAVEL, gray, brown, light brown fine to medium SAND, little brown clay. (GW)
10	24/10	SS-2	12	7	7	8	S/G UNIT		
15	24/12	SS-3	4	6	7	6	S/G UNIT		Grades to wet. (GW)
20	24/9	SS-4	19	12	12	12	TILL		Moist light brown CLAY, some Silt, some medium to coarse sand and fine subangular gravel. (CL)
25	24/16	SS-5	12	8	13	13	TILL		Grades to dark gray. (CL)
30	24/14	SS-6	9	7	4	5	Coarse Unit		Wet brown, gray, black subangular to subrounded GRAVEL and medium to coarse SAND, some Clay, little silt. (GC)
							Coarse Unit		Wet brown fine to medium SAND, some fine Gravel. (SW) Grades to gray-green, some Clay. (SC/GC)
35	24/15	SS-7	25	10	14	9	TILL		Wet gray CLAY, some Silt. (CL) Grades to damp, little fine to medium gravel, trace sand. (CL)
	24/15	SS-8	8	12	22	23	TILL		
									Augered to 39 ft.-Grouted to surface.

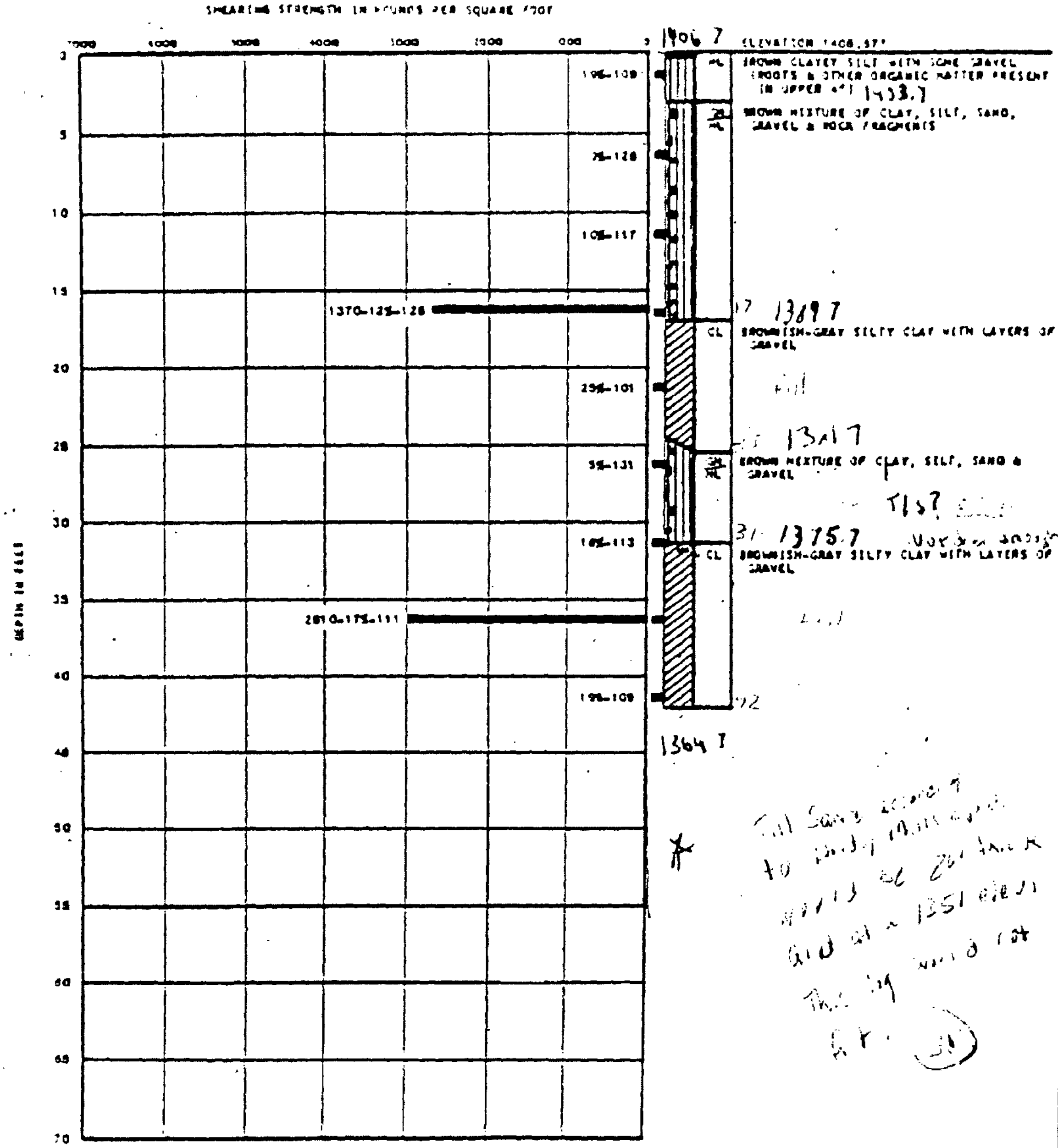
CLASSIFICATION: VISUAL (MODIFIED BURMISTER), USCS METHOD OF SAMPLING: ASTM D1586-84


16-62
BORING 16
DRILLED 11-14,15,-62
1409.2
ELEVATION 1409.16'
BROWN CLAYEY SILT WITH SOME GRAVEL (ROOTS & ORGANIC MATTER PRESENT IN TOP 2")
1406.2
MOTTLED TAN & GRAY MIXTURE OF CLAY, SILT, SAND WITH SOME GRAVEL & ANGULAR ROCK FRAGMENTS
BROWN SILTY CLAY
1383.2
BROWN CLAY, SILT, SAND, GRAVEL MIXTURE
1382.2
1369.2
CL
BROWNISH-GRAY SILTY CLAY WITH GRAVEL & ROCK FRAGMENTS
1347.2
DEPTH IN FEET
LOG OF BORINGS
LOG OF BORING 16

17-62

BORING 17

DRILLED 11-17-62



LOG OF BORINGS

LOG OF BORING 17

62-PAM63 Augered January 3, 1962. Lat 42°26'27", Long 78°37'58". Altitude 1,402.38 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-7 ft	Brown silt, trace to some sand and stone
7-40	Silt, some clay

62-PAM64 Augered January 3, 1962. Lat 42°26'27", Long 78°37'58". Altitude 1,407.13 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-6 ft	No samples taken; bottom of hole 6 ft (See log of PAM63)

62-PAM65 Augered January 4, 1962. Lat 42°26'40", Long 78°37'43". Altitude 1,433.10 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-5 ft	Brown silt, trace of clay and stone
5-16	Gray silt, some clay (soft and plastic)
16-21	Gray silt and angular shale fragments
21	Possible shale bedrock

62-PAM66 Augered January 4, 1962. Lat 42°26'50", Long 78°38'16". Altitude 1,388.76 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-5 ft	Moist brown silt, trace of clay
5-10	Wet gray silt and very fine sand
10-30	Wet gray silt, trace of very fine sand and clay
30-40	Wet gray silt, some clay (soft and plastic)

62-PAM67 Augered January 4, 1962. Lat 42°26'50", Long 78°38'16". Altitude 1,388.67 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-5 ft	Brown silt
5-7	Silt and very fine sand
7-9	Sand

62-PAM68 Augered January 5, 1962. Lat 42°26'41", Long 78°38'46". Altitude 1,395.40 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-10 ft	Moist brown silt, trace of clay
10-45	Moist gray silt, some clay, trace of stone (medium and plastic)

62-PAM69 Augered January 5-9, 1962. Lat 42°26'29", Long 78°39'17". Altitude 1,472.23 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-10	Moist brown silt, trace of clay
10-17	Dry brown silt, trace to some weathered shale
below 17	Probable shale bedrock

62-PAM70 Augered January 9, 1962. Lat 42°27'33", Long 78°39'30". Altitude 1,368.03 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-10	No samples taken; bottom of hole 10 ft (See log of PAM59)

62-PAM71 Augered January 10-11, 1962. Lat 42°27'01", Long 78°39'22". Altitude 1,422.52 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-17 ft	Brown silt, some stone and sand (hard)
17-23	Gray silt, trace of clay and stone (medium and plastic)
23-28	Gray sand and silt
28-36.5	Gray silt, trace to some clay, trace of stone and very fine sand (medium and plastic)

62-PAM72 Augered January 10,,1962. Lat 42°27'01", Long 78°39'22". Altitude 1,422.80 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-10 ft	No samples taken; bottom of hole 10 ft (See log of PAM71)

62-PAM73 Augered January 11, 1962. Lat 42°27'01", Long 78°39'22". Altitude 1,422.80 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-25 ft	No samples taken; bottom of hole 25 ft (See log of PAM71)

62-PAM74 Augered January 12, 1962. Lat 42°26'51", Long 78°39'22". Altitude 1,446.59 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-8 ft	Yellow brown silt, trace of sand and stone (hard)
8-17	Gray brown silt, trace to some weathered shale (very hard)
17-21	Brown silt, trace to some weathered shale and clay (very hard)
below 21	Probable shale bedrock

62-PAM75 Augered January 16, 1962. Lat 42°26'34", Long 78°38'00". Altitude 1,424.95 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

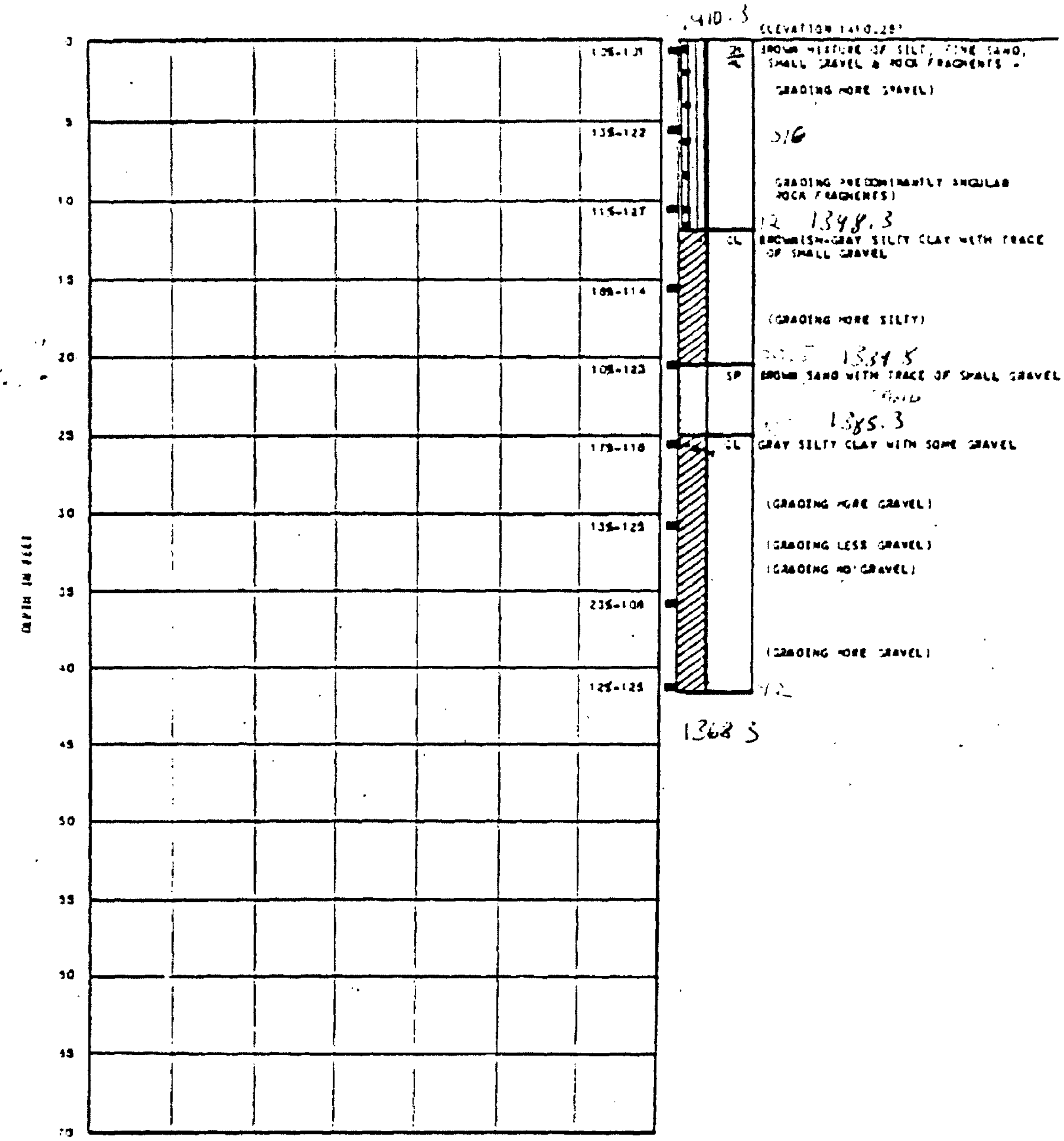
0-12 ft	No samples taken; bottom of hole 12 ft (See log of PAM93)

62-PAM76 Augered January 10, 1962. Lat 42°26'17", Long 78°39'56". Altitude 1,823.00 ft. Log from records of New York State Dept. of Public Works, Bureau of Soil Mechanics.

0-5 ft	Brown silt, trace of clay and stone
5-9	Gray brown silt, trace of shale fragments (angular) and clay
below 9	Probable shale bedrock

24-63

BORING 24



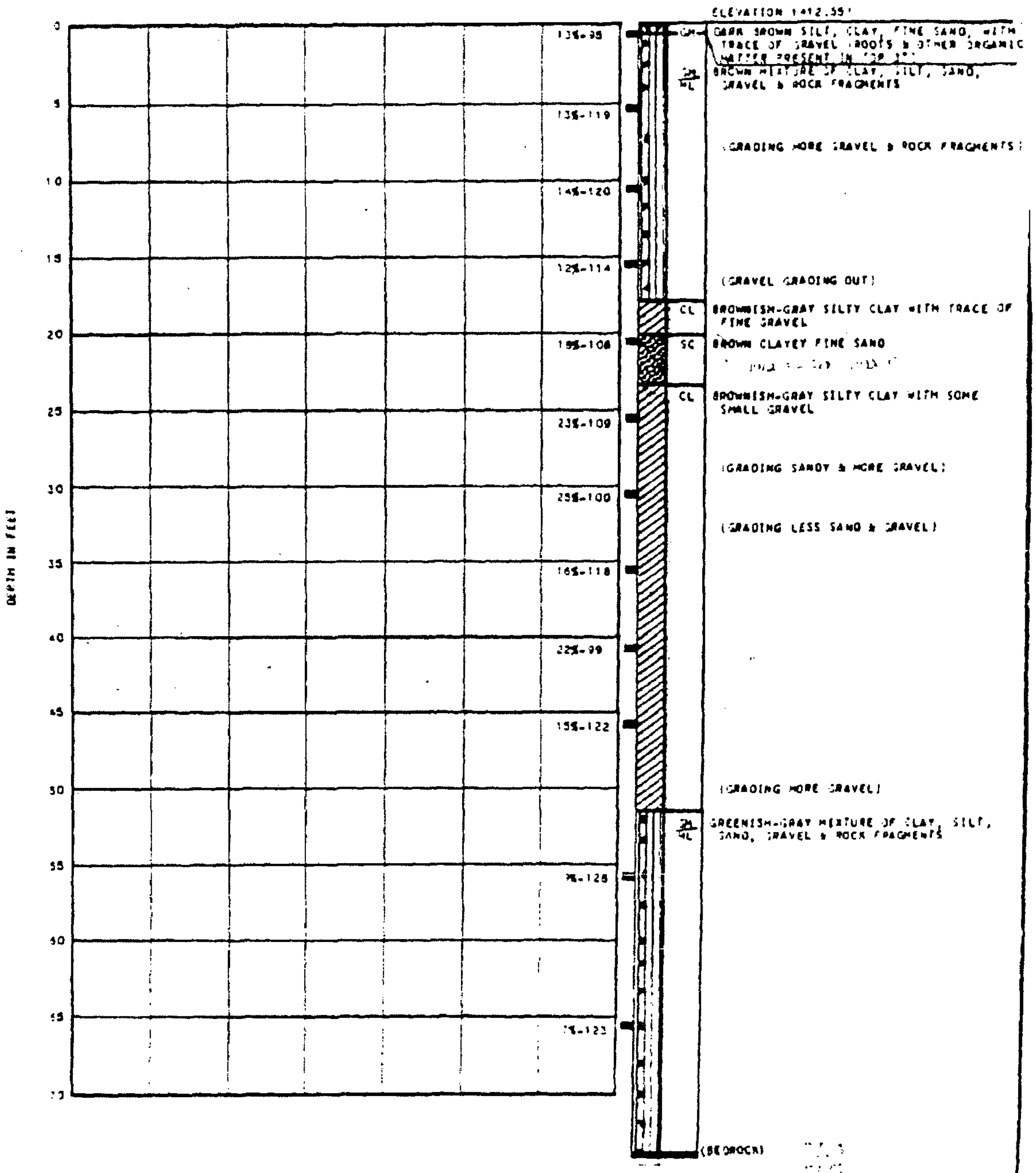
LOG OF BORINGS

LOG OF BORING 24

25-63

BORING 25

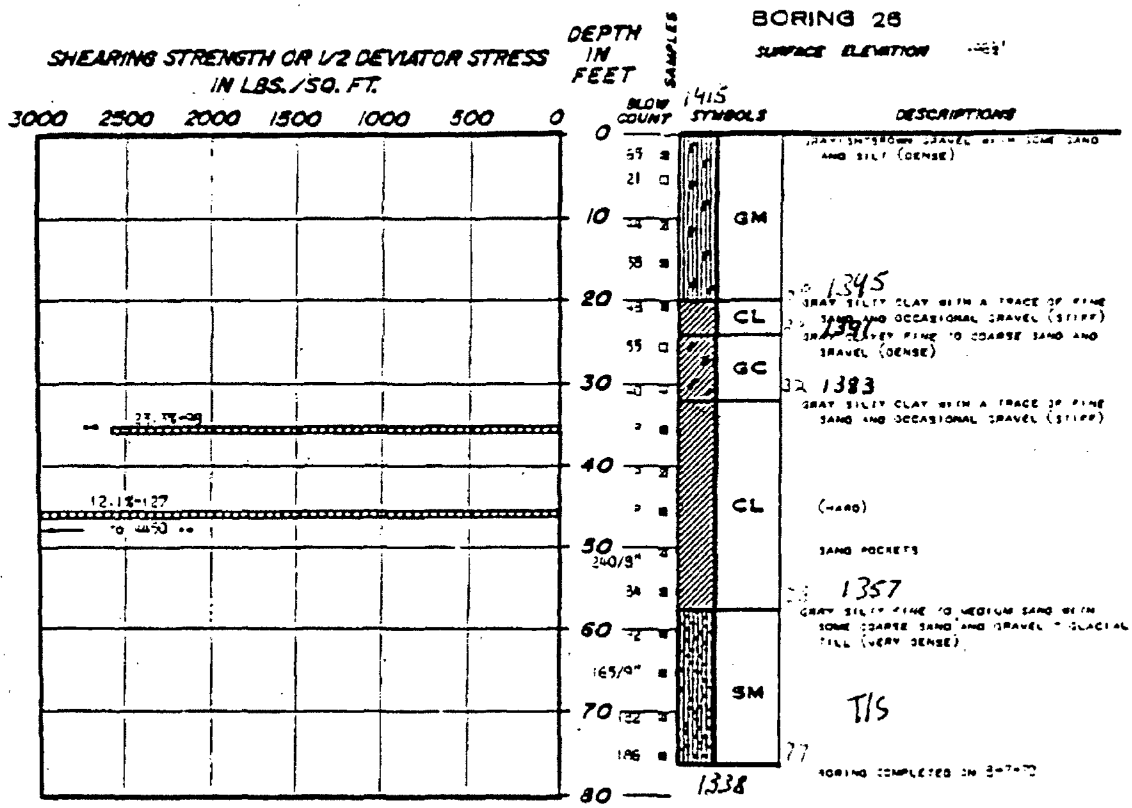
DRILLED 2-3-63



LOG OF BORINGS

LOG OF BORING 25

26 - 70



62+63 to 70+71

NOTES:

THE FIGURES IN THE COLUMN LABELED "BLOW COUNT" REFER TO THE NUMBER OF BLOWS REQUIRED TO DRIVE THE DAMES & MOORE SOIL SAMPLER, OR A STANDARD SPLIT-SPOON SAMPLER, A DISTANCE OF ONE FOOT USING A 300-POUND HAMMER FALLING 24 INCHES. THE DAMES & MOORE SAMPLER IS [illegible] O.D. AND APPROXIMATELY [illegible] I.D. THE STANDARD SPLIT-SPOON SAMPLER IS 2" O.D. AND [illegible] I.D.

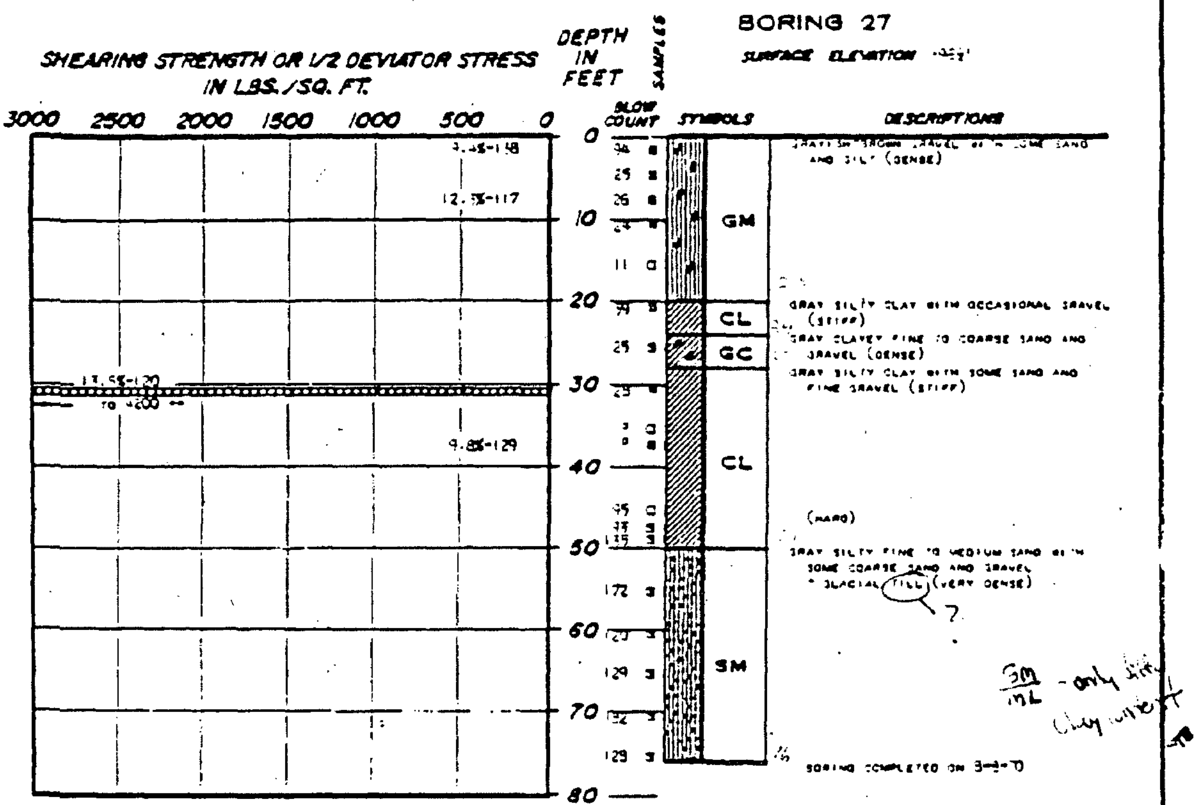
THE LETTER "P" IN THE "BLOW COUNT" COLUMN INDICATES THAT THE SAMPLER WAS ADVANCED BY MEANS OF HYDRAULIC PRESSURE, WITHOUT DRIVING.

ELEVATIONS REFER TO PLANT DATUM.

THE DISCUSSION IN THE TEXT OF THE REPORT IS NECESSARY FOR A PROPER UNDERSTANDING OF THE NATURE OF THE SUBSURFACE MATERIALS.

LOG OF BORING 26

27 - 70



LOG OF BORING

LOG OF BORING 27

33-74
34-74
35-74

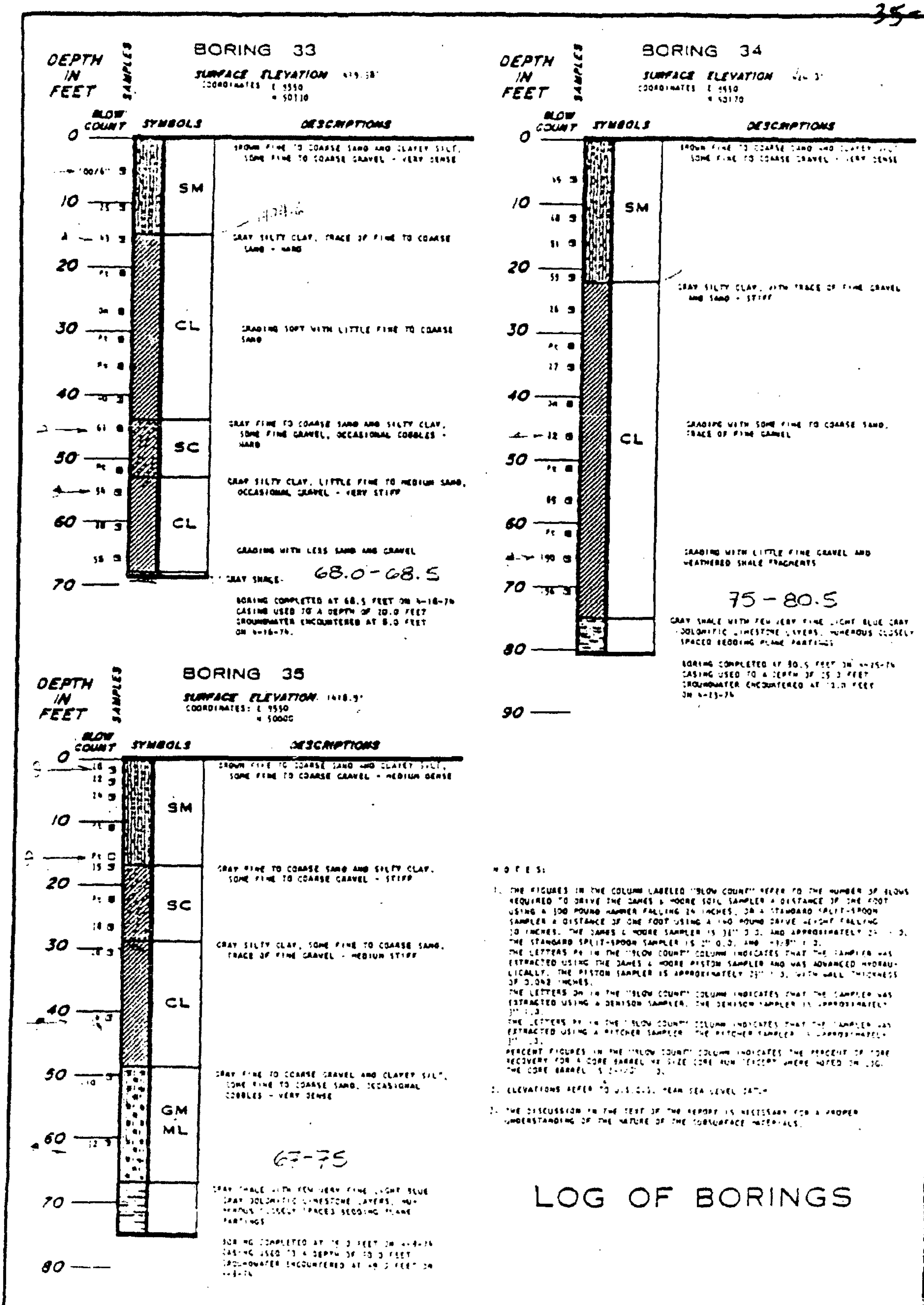
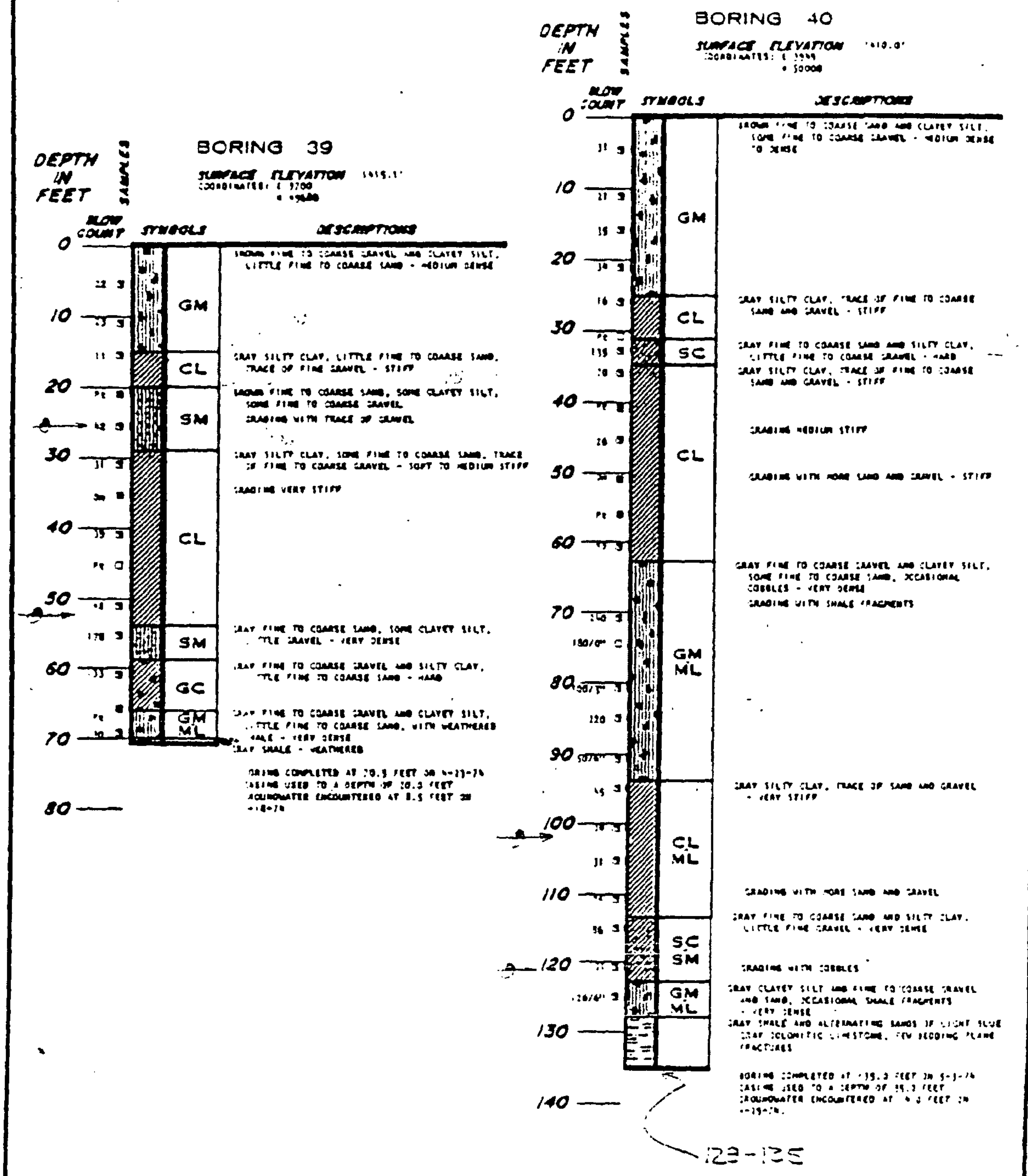


FIGURE A.3.6-B-27 LOG OF BORING 33, 34, & 35



LOG OF BORINGS

FIGURE A.3.6-B-29 LOG OF BORING 39 & 40

RAI 5C10 (15)

Subject: subsurface DCGL model contaminated area

RAI: For certain pathways and radionuclides, the assumption that contamination is distributed over a larger area (e.g., 1000 m^2) rather than 100 m^2 would lead to more restrictive DCGLs. Sensitivity analyses currently do not evaluate the impact of area on the DCGL calculations. (Section 5.2.1, Page 5-27)

Basis: For those radionuclides dominated by certain pathways (e.g., plant and water ingestion), the assumption regarding the area (and thickness) of contamination significantly impacts the DCGL calculations. On a footnote on page 5-26 of the DP, there is some discussion regarding use of a 1000 m^2 area of contamination rather than a 100 m^2 area of contamination; however, sensitivity analysis results do not address larger assumed areas of contamination. Assumptions regarding the distribution of contamination brought up from drilling a cistern should be further evaluated as the DCGL for many radionuclides would be more restrictive if a change in assumption regarding the area of contamination is made.

NRC Path Forward: Suggest calculating DCGLs considering a 100 m^2 and larger areas (e.g., 1000 m^2) of contamination and use the more limiting DCGL for the list of 18 radionuclides evaluated or provide additional justification for why an assumed 100 m^2 area of contamination is reasonable.

****

DOE Response: The assumed 100 m^2 area of the contamination zone is considered to be reasonable. The size of this area in the model is limited by the relatively small volume of material brought to the surface during construction of the hypothetical cistern, which is approximately 30 m^3.

A sensitivity analysis was performed as described below. However, the multi-source conceptual model described in the response to RAI 5C9 has effectively superseded the original base-case conceptual model for subsurface soil DCGL development. Additional information on the multi-source model is provided below.

Sensitivity Analysis Performed

A sensitivity analysis for the combined contamination zone thickness and area has been performed, using areas of 300 square meters and 50 square meters, compared to the 100 square meters base case, which has a thickness of 0.3 meter. (The area and thickness parameters are positively correlated due to the small volume of material brought to the surface.) Table 5C10-1 shows the results.

Table 5C10-1. Contamination Zone Thickness/Area Sensitivity Analysis Results(1)

Nuclide	0.1 m/300 m^2		0.6 m/50 m^2	
	Year of Peak Dose	DCGL Change (%)	Year of Peak Dose	DCGL Change (%)
Am-241	0	-1%	0	16%
C-14	0	86%	0	-33%
Cm-243	0	4%	0	10%
Cm-244	0	3%	0	22%
Cs-137	0	14%	0	9%
I-129	10.4	-58%	10.5	86%
Np-237	22.5	-61%	22.6	87%
Pu-238	0	3%	0	22%
Pu-239	0	3%	0	22%
Pu-240	0	3%	0	22%
Pu-241	60.7	0%	64.5	15%
Sr-90	0	170%	0	0%
Tc-99	2.06	204%	0	-3%
U-232	3.58	70%	6.69	-4%
U-233	327	-64%	327	91%
U-234	327	-65%	327	98%
U-235	0	9%	0	8%
U-238	327	-65%	0	70%

NOTE: (1) The base case is a 0.3 m thickness with an area of 100 m^2.

The results in the table show that:

- The DCGL for Sr-90, the radionuclide expected to dominate contamination at the bottoms of the deep excavations based on available data, increased as the contaminated material was spread over a larger area and remained unchanged when the contaminated area was reduced.
- The DCGLs for the following radionuclides significantly decreased with the smaller thickness/larger area contamination zone geometry: I-129, Np-237, U-233, U-234, and U-238.
- The DCGLs for most radionuclides increased with the larger thickness/smaller area condition, with only C-14 exhibiting a significant decrease.

Note that the influence of the source geometry on the DCGL is mainly due to external exposure and groundwater pathways. The external exposure dose increases with increases in contaminated zone area. The dilution factor increases with increases in contaminated zone area in the subsurface model, due to increased leachate infiltration rates. However, the reduction in source thickness shortens the travel times to the groundwater receptor. The effect of the combination of these factors is radionuclide specific.

The results showing lower DCGLs for C-14, I-129, Np-237, U-233, U-234, and U-238 are being taken into account in revising the cleanup goals for subsurface soil in the deep excavations. This matter is addressed in the response to RAI 5C15, which describes the probabilistic uncertainty analysis undertaken to evaluate degree of conservatism in conceptual model input parameters. Note that the results of alternate scenario analyses, such as the resident gardener scenario discussed in the response to RAI 5C18, are also being taken into account in revising the cleanup goals.

Additional Information on Multi-Source Modeling

Because additional groundwater modeling using the STOMP code showed that diffusion of radioactivity from the bottom of the deep excavations must be taken into account in establishing the subsurface soil DCGLs and cleanup goals, additional analyses were performed using a modified conceptual model. The updated response to RAI 5C9 describes this model, which accounts for continuing release of residual radioactivity from the bottom of the deep excavation as a secondary source of contamination.

The modified conceptual model makes use of larger contamination zone areas of 2000 m^2 for the residential gardener scenario and 10,000 m^2 for the resident farmer scenario.

The updated response to RAI 5C9 provides the reduced DCGLs and cleanup goals that take the results of this analysis into account. This updated response includes a new DP subsection 5.2.6 that describes the modified conceptual model, the mathematical models used, and the results of the analysis.

The updated response to RAI 5C15 includes revised tables for section 5 of the DP such as Table 5-14 that specifies the cleanup goals to be used in soil and sediment remediation associated with Phase 1 of the decommissioning.

Changes to the Plan: The changes to the plan related to the sensitivity analysis involve making the following changes to Section 5:

Changing the second data row of Table 5-10 as indicated below (the remainder of the table is unchanged insofar as this RAI response is concerned).

Table 5-10. Summary of Parameter Sensitivity Analyses – Subsurface Soil DCGLs(1)

Parameter (Base Case)	Run	Change Made	Minimum DCGL Change		Maximum DCGL Change	
			Change	Nuclide(s)	Change	Nuclide(s)
Indoor/Outdoor Fraction (0.66/0.25)	1	-32%	-25%	Cs-137	0.1%	U-234
	2	21%	-1%	U-238	35%	U-232
Contaminated Zone thickness/area (0.3 m/100 m^2)	1	-67%/ +200%	-65%	U-234, U-238	204%	Tc-99
	2	+100%/ -50%	-33%	C-14	98%	U-234

NOTES: (1) Information from the $DCGL_{EMC}$ calculations provides additional information on how reductions in the size of the contamination zone affect the DCGLs. DCGLs generally increased with smaller areas.

Add the following new third bullet point in the discussion of the sensitivity analysis results on page 5-39:

- The DCGLs for the following radionuclides significantly decreased with the smaller thickness/larger area contamination zone geometry: I-129, Np-237, U-233, U-234, and U-238.
- The DCGLs for most radionuclides increased with the larger thickness/smaller area contamination zone geometry, with only C-14 exhibiting a significant decrease.

RAI 5C12 (17)

Subject: Inhalation pathway in streambed sediment model

RAI: The streambed sediment DCGL development does not include the inhalation of airborne radioactivity from resuspended contaminated sediment because of the assumed moisture content and limited resuspension. However, this argument may not consider the dynamic aspects of sediment deposition, stream water levels, and soil moisture content. (Section 5.2.1, Page 5-29)

Basis: In general, streambed sediments will have relatively high moisture content and would experience limited resuspension. However, mobilization of contaminants from source areas may increase during storm events and result in deposition of the contaminants in areas that are above the normal water levels, such as a flood plain. Moisture content of these environments will be very dynamic, ranging from saturated to quite dry depending on the frequency the location experiences high water.

Path Forward: Provide an evaluation of the importance of the inhalation pathway relative to the other pathways that have been included in the streambed sediment DCGL development. The evaluation should consider the natural inherent variability in deposition processes and sediment moisture contents.

****

DOE Response:

NOTE

Changes from the previous version of this response submitted to NRC on 8/14/09 have been to recognize the multi-source model for subsurface soil DCGL development, which takes into account release of residual radioactivity by diffusion from the bottoms of the deep excavations. The code verification package and calculation packages that document the multi-source analysis will become Attachment 3 to Appendix C.

Note that changes from the 8/14/09 version of this response in Appendix C that are shown in blue will be shown in red in Revision 2 of the plan.

The inhalation pathway has been incorporated into the deterministic model for streambed sediment DCGL development without regard to considerations of moisture content, in the interest of conservatism. This change had no significant impact on the DCGLs, as shown below. The probabilistic uncertainty analysis described in the response to RAI 5C15 also includes the inhalation pathway in the streambed sediment model.

Note that the response to RAI 5C11 discusses the streambed conceptual model and natural inherent variability in deposition processes, including changes in water level.

Table 5C12-1 compares the streambed sediment DCGLs included in Revision 1 to the DP with the deterministic DCGLs with the inhalation pathway active. Note that several other parameter changes were also made as discussed below.

Table 5C12-1. Streambed Sediment DCGL Comparison

Nuclide	$DCGL_W$ Values from Table 5-8 of Revision 1 (pCi/g)	$DCGL_W$ Values With Inhalation Pathway Active (pCi/g)
Am-241	1.6E+04	1.6E+04
C-14	3.4E+03	3.4E+03
Cm-243	3.6E+03	3.6E+03
Cm-244	4.7E+04	4.8E+04
Cs-137(1)	1.3E+03	1.3E+03
I-129	3.7E+03	3.7E+03
Np-237	5.4E+02	5.2E+02
Pu-238	2.0E+04	2.0E+04
Pu-239	1.8E+04	1.8E+04
Pu-240	1.8E+04	1.8E+04
Pu-241	5.2E+05	5.1E+05
Sr-90(1)	9.5E+03	9.5E+03
Tc-99	2.2E+06	2.2E+06
U-232	2.7E+02	2.6E+02
U-233	5.8E+04	5.7E+04
U-234	6.1E+04	6.0E+04
U-235	2.9E+03	2.9E+03
U-238	1.3E+04	1.2E+04

NOTE: (1) Reflects 30 years decay.

The other parameter changes are identified in the revised Appendix C, which follows. Many of the parameter changes were made for consistency with dose modeling in the Decommissioning EIS. Note that Appendix C is included in its entirety for the sake of completeness, even though only limited portions were changed from Revision 1. The text in blue in Appendix C signifies changes made in Revision 1. The Revision 2 changes are shown in red with change bars in the right margin as with the other RAI responses.

Changes to the Plan: The value for strontium in the sand and gravel layer in Table 3-20 will be changed from 6.16 to 4.5 mL/g (cm^3/g).

Table 5-8 will be changed to reflect the slightly revised $DCGL_W$ values as indicated in the updated response to RAI 5C21.

The revised Appendix C that follows will be incorporated into the plan.

APPENDIX C

DETAILS OF DCGL DEVELOPMENT AND THE INTEGRATED DOSE ASSESSMENT

PURPOSE OF THIS APPENDIX

The purpose of this appendix is to provide supporting information related to development of derived concentration guideline levels (DCGLs) and the limited integrated dose assessment performed to ensure that cleanup criteria for surface soil, subsurface soil, and streambed sediment used in Phase 1 of the proposed decommissioning would support any decommissioning approach that may be selected for Phase 2.

INFORMATION IN THIS APPENDIX

This appendix provides the following information:

- Table C-1 in Section 1 provides a complete list of RESRAD input parameters, except for distribution coefficients, and the bases for these parameters.
- Table C-2 in Section 1 provides a list of distribution coefficients and their bases.
- Table C-3 in Section 1 provides the exposure pathways considered in the analysis.
- Table C-4 in Section 1 provides data on measured radionuclide concentrations in the Lavery till in the area of the large excavations in Waste Management Area 1 and Waste Management Area 2.
- Section 2 describes the information that comprises Attachment 1, which supports the calculation of DCGL and Cleanup Goal values presented in Section 5 of the Decommissioning Plan.
- Attachment 1 provides electronic RESRAD input and output files for the three base cases (surface soil, subsurface soil, and streambed sediment), the limited integrated dose analysis, and the input parameter sensitivity analyses performed, along with the associated Microsoft Excel spreadsheets.
- Attachment 2 provides an additional electronic file (a Microsoft Excel spreadsheet) used in the preliminary dose assessments.
- Attachment 3 provides the basis for development of the multi-source DCGLs, which consider the bottoms of the deep excavations as a continuing source of contamination to groundwater.

RELATIONSHIP TO OTHER PLAN SECTIONS

This appendix provides supporting information for Section 5. Information provided in Section 5 and in Section 1 on the project background will help place the information in this appendix into context.

1.0 Tabulated Data

Table C-1 identifies input parameters used in the RESRAD models, except for the distribution coefficients, which are included in Table C-2. Input parameters are provided for the three source exposure scenarios: surface soil (SS), subsurface soil (SB), and stream bank sediment (SD). The RESRAD input parameters presented in Table C-1 were selected as discussed in Section 5.

Distribution coefficients (K_d) are presented in Table C-2 for chemical elements of the 18 radionuclides and their decay progeny for each of the three analyses (SS, SB and SD) for each of the modeled media (contaminated zone, unsaturated zone and saturated zone) used in RESRAD. The conceptual models assume the sand and gravel unit is representative of the three RESRAD zones, except that in the SB and SD analyses, the contaminated zone is assumed to be represented by the Lavery till. The table includes the RESRAD default value, the specific value input into the RESRAD model for $DCGL_W$ calculations, either measured site-specific or reference values (as identified in Note 1 to table C-2), and the range of values used in the sensitivity analysis. The K_d values were selected to represent the central tendency of the site-specific data or were based on specific soil strata characteristics where available. Variability/uncertainty in the K_d values was addressed through the sensitivity analysis.

The exposure pathways presented in Table C-3 were based on the critical groups identified for each of the source media. The resident farmer was the critical receptor for soil exposure and the recreationist was identified as the critical receptor for stream bank sediment exposure. Alternate receptors were considered as discussed in Section 5, including acute dose from subsurface material to a well driller during cistern installation, dose from subsurface material during installation of a natural gas well, and dose from surface and subsurface material to a resident gardener. Additionally, a separate multi-source evaluation was conducted to assess the impact of the bottoms of the deep excavations as a continuing source to groundwater (see Attachment 3).

The data in Table C-4 are the basis for the maximum radionuclide concentration data in Table 5-1. These data comprise the available characterization data for radionuclides in the Lavery till within the footprints of the large excavations for the Process Building-Vitrification area and the Low-Level Waste Treatment Facility area that are described in Section 7.

Preliminary dose assessments have been performed for the remediated WMA 1 and WMA 2 excavations. These assessments made use of the maximum measured radioactivity concentration in the Lavery till for each radionuclide as summarized in Table C-4, and the maximum detection level concentration for non-detected radionuclides. (It should be noted that the minimum detection levels for non-detected radionuclides may range several orders of magnitude. Use of the maximum detection level concentration for non-detected radionuclides results in added conservatism in the reported preliminary dose assessment. The results are based on the most limiting exposure scenario (see Section 5) and include consideration of the bottoms of the deep excavations as a continuing source to groundwater. The dose estimates were:

WMA 1, a maximum of approximately 8 mrem a year

WMA 2, a maximum of approximately 0.2 mrem a year

Given the limited data available, these results must be viewed as order-of-magnitude estimates. However, they do suggest that actual potential doses from the two remediated areas are likely to be substantially below 25 mrem per year. Table C-4B in Attachment 2 shows how these doses were estimated.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Area of contaminated zone (m^2)	1.00E+04	1.00E+04	SS	Assumed area of 10,000 m^2 for subsistence farmer scenario; garden is 2,000 m^2.
	1.00E+04	1.00E+02	SB	Assumed area of 100 m^2 for excavated contaminated cistern cuttings scenario. Alternative configurations were considered in the sensitivity analysis.
	1.00E+04	1.00E+03	SD	Assumed 1000 m^2 area along stream bank (3 m wide by ~330 m length).
Thickness of contaminated zone (m)	2.00E+00	1.00E+00	SS, SD	Assumed surface soil contaminated zone thickness.
	2.00E+00	3.00E-01	SB	Assumed thickness of contaminated cistern cuttings spread on surface over a 100 m^2 area. Alternative configurations were considered in the sensitivity analysis.
Length parallel to aquifer flow (m)	1.00E+02	1.65E+02	SS	Selected to achieve site specific groundwater dilution factor of 0.2, based on DEIS groundwater model correlation. Only applicable for non-dispersion model.
Time since placement of material (y)	0.00E+00	0.00E+00	All	Only non-zero if K_d values are not available. (Site-specific K_ds are available).
Cover depth (m)	0.00E+00	0.00E+00	All	No cover considered.
Density of cover material (g/cm^3)	0.00E+00	not used	All	No cover considered.
Cover depth erosion rate (m/y)	0.00E+00	not used	All	No cover considered.
Density of contaminated zone (g/cm^3)	1.50E+00	1.70E+00	All	WVNSCO 1993a and WVNSCO 1993c.
Contaminated zone erosion rate (m/y)	1.00E-03	0.00E+00	All	Assumed for no source depletion.
Contaminated zone total porosity	4.00E-01	3.60E-01	All	WVNSCO 1993c.
Contaminated zone field capacity	2.00E-01	2.00E-01	All	WVNSCO 1993c.
Contaminated zone hydraulic conductivity (m/y)	1.00E+01	1.40E+02	All	Average for Sand and Gravel Thick Bedded Unit (4.43E-03 cm/s from Table 3-19) divided by 10 to provide vertical conductivity that accounts for potential anisotropy (DEIS Appendix E, Table E-3).
Contaminated zone b parameter	5.30E+00	1.40E+00	All	Yu, et al. 2000, Att. C table 3.5-1, mean for loamy sand (ln(mean)=0.305).
Average annual wind speed (m/sec)	2.00E+00	2.60E+00	All	WVNSCO 1993d.
Humidity in air (g/m^3)	8.00E+00	not used	All	Applicable for tritium exposures only.
Evapotranspiration coefficient	5.00E-01	7.80E-01	All	Evapotranspiration and runoff coefficients selected to achieve infiltration rate of 0.26 m/y.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Precipitation (m/y)	1.00E+00	1.16E+00	All	WVNSCO 1993d.
Irrigation (m/y)	2.00E-01	4.70E-01	SS, SB	Beyeler, et al. 1999.
	2.00E-01	0.00E+00	SD	Not applicable for non-farming scenario.
Irrigation mode	overhead	overhead	All	Site-specific.
Runoff coefficient	2.00E-01	4.10E-01	All	Runoff and evapotranspiration coefficients selected to achieve infiltration rate of 0.26 m/y.
Watershed area for nearby stream or pond (m^2)	1.00E+06	1.37E+07	All	Based on drainage area of site of 13.7 km^2 or ~5.2 mi^2 for Buttermilk Creek.
Accuracy for water/soil computations	1.00E-03	1.00E-03	All	Default assumed.
Saturated zone density (g/cm^3)	1.50E+00	1.70E+00	All	WVNSCO 1993a and WVNSCO 1993c.
Saturated zone total porosity	4.00E-01	3.60E-01	All	WVNSCO 1993c.
Saturated zone effective porosity	2.00E-01	2.50E-01	All	WVNSCO 1993c.
Saturated zone field capacity	2.00E-01	2.00E-01	All	WVNSCO 1993c.
Saturated zone hydraulic conductivity (m/y)	1.00E+02	1.40E+03	All	Average for Sand and Gravel Thick Bedded Unit (4.43E-03 cm/s from Table 3-19)
Saturated zone hydraulic gradient	2.00E-02	3.00E-02	All	WVNSCO 1993b.
Saturated zone b parameter	5.30E+00	1.40E+00	All	Yu, et al. 2000, Att. C table 3.5-1, mean for loamy sand (ln(mean)=0.305).
Water table drop rate (m/y)	1.00E-03	0.00E+00	All	Site Specific.
Well pump intake depth (m below water table)	1.00E+01	5.00E+00	SS	Assumption based on site hydrogeology and site-specific groundwater dilution factor. Only applicable to non-dispersion model.
Model: Non-dispersion (ND) or Mass-Balance (MB)	ND	ND	SS	Applicable to areas >1,000 m2 (Yu, et.al. 2001, p.E-18)
	MB	MB	SB, SD	Applicable to areas <1,000 m2 (Yu, et. al. 2001, pE-18)
Well pumping rate (m^3/y)	2.50E+02	5.72E+03	SS, SB	Based on 2.9 m^3/y drinking water (2 L/d per 4 people for 365 days), 329 m^3/y household water (225 L/d per 4 people for 365 day), 385 m^3/y livestock watering (5 beef cattle at 50 L/d, 5 milk cows 160 L/d) and 5,000 m^3/y for irrigation of 10,000 m^2 (at rate of 0.5 m/y) from Yu, et al. 2000, Attachment C, Section 3.10.
	2.50E+02	0.00E+00	SD	Not applicable for non-farming scenario.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Number of unsaturated zone strata	1.00E+00	1.00E+00	All	Assumed.
Unsaturated zone thickness (m)	4.00E+00	2.00E+00	SS, SB	Site specific.
	4.00E+00	0.00E+00	SD	Assumed saturated for stream bank.
Unsaturated zone soil density (g/cm^3)	1.50E+00	1.70E+00	SS, SB	WVNSCO 1993a and WVNSCO 1993c.
Unsaturated zone total porosity	4.00E-01	3.60E-01	SS, SB	WVNSCO 1993c.
Unsaturated zone effective porosity	2.00E-01	2.50E-01	SS, SB	WVNSCO 1993c.
Unsaturated zone field capacity	2.00E-01	2.00E-01	SS, SB	WVNSCO 1993c.
Unsaturated zone hydraulic conductivity (m/y)	1.00E+01	1.40E+02	SS, SB	Average for Sand and Gravel Thick Bedded Unit (4.43E-03 cm/s from Table 3-19) divided by 10 to provide vertical conductivity that accounts for potential anisotropy (DEIS Appendix E, Table E-3).
Unsaturated zone b parameter	5.30E+00	1.40E+00	SS, SB	Yu, et al. 2000, Att. C table 3.5-1, mean for loamy sand (ln(mean)=0.305).
Distribution coefficients – radionuclides				
Contaminated zone (mL/g)	varies	Site specific	All	See Table C-2 for distribution coefficients.
Unsaturated zone 1 (mL/g)	varies	Site specific	All	See Table C-2 for distribution coefficients.
Saturated zone (mL/g)	varies	Site specific	All	See Table C-2 for distribution coefficients.
Plant Transfer Factor	varies	Chemical-specific	All	Default values assumed.
Fish Transfer Factor	Varies	Chemical-specific	SD	Default values assumed.
Leach rate (1/y)	varies	not used	All	Using site-specific Kd values instead of assigning leach rate.
Solubility constant	varies	not used	All	Using site-specific Kd values instead of assigning solubility constant.
Inhalation rate (m^3/y)	8.40E+03	8.40E+03	All	Beyeler, et al. 1999.
Mass loading for inhalation (g/m^3)	1.00E-04	1.48E-05	All	Beyeler, et al. 1999. Based on relative time fractions and mean dust loadings. Assumes 288 hours of active farming per year.
Exposure duration (y)	3.00E+01	1.00E+00	All	Yearly dose estimates calculated.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Filtration factor, inhalation	4.00E-01	1.00E+00	SS, SB	Beyeler, et. al. 1999.
Shielding factor, external gamma	7.00E-01	2.73E-01	SS, SB	Yu, et al. 2000, Att. C Figure 7.10-1, mean of distribution approximates a frame house with slab or basement.
Fraction of time spent indoors	5.00E-01	6.60E-01	SS, SB	Yu, et al. 2000, Att. C Figure 7.6-2, value represents ~50th percentile of distribution.
	5.00E-01	0.00E+00	SD	Assumed.
Fraction of time spent outdoors	2.50E-01	2.50E-01	SS, SB	RESRAD default value used.
	2.50E-01	1.20E-02	SD	Based on 104 hours/year (2 hours/day, 2 day/week, 26 weeks/y) spent on the stream bank over 8760 residence hours per year (24 hr/day, 365 days/y)
Shape factor flag, external gamma	1.00E+00	1.00E+00	SS, SB	RESRAD default.
Fruits, vegetables and grain consumption (kg/y)	1.60E+02	1.12E+02	SS, SB	Beyeler, et al. 1999.
Leafy vegetable consumption (kg/y)	1.40E+01	2.10E+01	SS, SB	Beyeler, et al. 1999.
Milk consumption (L/y)	9.20E+01	2.33E+02	SS, SB	Beyeler, et al. 1999.
Meat and poultry consumption (kg/y)	6.30E+01	6.50E+01	All	Beyeler, et al. 1999.
Fish consumption (kg/y)	5.40E+00	9.00E+00	SD	Exposure Factors Handbook (EPA, 1999). The value represents the 95th percentile of fish consumption by recreational anglers
Other seafood consumption (kg/y)	9.00E-01	0.00E+00	SD	Assumes only fish consumed from the stream
Soil ingestion rate (g/y)	3.65E+01	1.83E+01	All	Yu, et al. 2000, Att C. Figure 5.6-1, value represents mean of distribution for resident farmer (50 mg/d).
Drinking water intake (L/y)	5.10E+02	7.30E+02	SS, SB	Beyeler, et al. 1999.
	5.10E+02	1.00E+00	SD	Based on 104 hour/year exposure and 10 mL/hr for wading scenario (http://www.epa.gov/Region4/waste/ots/healtbul.htm)
Contamination fraction of drinking water	1.0	1.0	All	Assumed. For streambed sediment, this is 100% of incidental ingestion.
Contamination fraction of household water	1.0	1.0	SS, SB	Assumed.
Contamination fraction of livestock water	1.0	1.0	SS, SB	Assumed.
Contamination fraction of groundwater	1.0	0	SD	All water ingested is from surface water.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Contamination fraction of irrigation water	1.0	1.0	SS, SB	Assumed.
Contamination fraction of aquatic food	1.0	1.0	SD	Assumed.
Contamination fraction of plant food	-1	1.0	SS, SB	Assumes all ingestion is from the contaminated source.
Contamination fraction of meat	-1	1.0	All	Assumes all ingestion is from the contaminated source.
Contamination fraction of milk	-1	1.0	SS, SB	Assumes all ingestion is from the contaminated source.
Livestock fodder intake for meat (kg/day)	6.80E+01	2.73E+01	SS, SB	Beyeler, et al. 1999.
	6.80E+01	2.25E+00	SD	Assumption for deer.
Livestock fodder intake for milk (kg/day)	5.50E+01	6.42E+01	SS, SB	Beyeler, et al. 1999.
Livestock water intake for meat (L/day)	5.00E+01	5.00E+01	All	Beyeler, et al. 1999, assumed for venison exposure to sediment source.
Livestock water intake for milk (L/day)	1.60E+02	1.60E+02	SS, SB	RESRAD default value used.
Livestock soil intake (kg/day)	5.00E-01	5.00E-01	All	RESRAD default, assumed for venison exposure to sediment source.
Mass loading for foliar deposition (g/m^3)	1.00E-04	4.00E-04	SS, SB	Beyeler, et al. 1999.
Depth of soil mixing layer (m)	1.50E-01	1.50E-01	SS, SB	Beyeler, et al. 1999.
Depth of roots (m)	9.00E-01	9.00E-01	All	RESRAD default, represents crops with short growing seasons.
Drinking water fraction from ground water	1.0	1.0	All	Assumed.
Household water fraction from ground water	1.0	1.0	SS, SB	Assumed.
Livestock water fraction from ground water	1.0	1.0	SS, SB	Assumed.
Irrigation fraction from ground water	1.0	1.0	SS, SB	Assumed.
Wet weight crop yield for non-leafy (kg/m^2)	7.00E-01	1.75E+00	SS, SB	Yu, et al. 2000, Att. C Figure 6.5-1 value is mean of distribution.
Wet weight crop yield for leafy (kg/m^2)	1.50E+00	1.50E+00	SS, SB	RESRAD default.
Wet weight crop yield for fodder (kg/m^2)	1.10E+00	1.10E+00	SS, SB	RESRAD default.
Growing season for non-leafy (years)	1.70E-01	1.70E-01	SS, SB	RESRAD default.
Growing season for leafy (years)	2.50E-01	2.50E-01	SS, SB	RESRAD default.
Growing season for fodder (years)	8.00E-02	8.00E-02	SS, SB	RESRAD default.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Translocation factor for non-leafy	1.00E-01	1.00E-01	SS, SB	RESRAD default.
Translocation factor for leafy	1.00E+00	1.00E+00	SS, SB	RESRAD default.
Translocation factor for fodder	1.00E+00	1.00E+00	SS, SB	RESRAD default.
Dry foliar interception fraction for non-leafy	2.50E-01	2.50E-01	SS, SB	RESRAD default.
Dry foliar interception fraction for leafy	2.50E-01	2.50E-01	SS, SB	RESRAD default.
Dry foliar interception fraction for fodder	2.50E-01	2.50E-01	SS, SB	RESRAD default.
Wet foliar interception fraction for non-leafy	2.50E-01	2.50E-01	SS, SB	RESRAD default.
Wet foliar interception fraction for leafy	2.50E-01	6.70E-01	SS, SB	Yu, et al. 2000, Att. C Figure 6.7-1 represent the most likely value.
Wet foliar interception fraction for fodder	2.50E-01	2.50E-01	SS, SB	RESRAD default.
Weathering removal constant (1/y)	2.00E+01	1.80E+01	SS, SB	Yu, et al. 2000, Att. C Figure 6.6-1 represent the most likely value
Carbon-14-related exposure parameters				
C-12 concentration in water (g/cc)	2.00E-05	2.00E-05	All	RESRAD default.
C-12 concentration in soil (g/g)	3.00E-02	3.00E-02	All	RESRAD default.
Fraction of vegetable carbon from soil	2.00E-02	2.00E-02	All	RESRAD default.
Fraction of vegetable carbon from air	9.80E-01	9.80E-01	All	RESRAD default.
C-14 evasion layer thickness in soil (m)	3.00E-01	3.00E-01	All	RESRAD default.
C-14 evasion flux rate from soil (1/sec)	7.00E-07	7.00E-07	All	RESRAD default.
C-12 evasion flux rate from soil (1/sec)	1.00E-10	1.00E-10	All	RESRAD default.
Fraction of grain in beef cattle feed	0.8	0.8	All	RESRAD default.
Fraction of grain in milk cow feed	0.2	0.2	All	RESRAD default.
Storage times of contaminated foodstuff (days)				
Fruits, non-leafy vegetables, and grain	1.40E+01	1.40E+01	SS, SB	RESRAD default.
Leafy vegetables	1.00E+00	1.00E+00	SS, SB	RESRAD default.
Milk	1.00E+00	1.00E+00	SS, SB	RESRAD default.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Meat	2.00E+01	2.00E+01	SS, SB	RESRAD default.
Fish	7.00E+00	7.00E+00	SD	RESRAD default.
Crustacea and mollusks	7.00E+00	7.00E+00	Not used	RESRAD default.
Well water	1.00E+00	1.00E+00	SS, SB	RESRAD default.
Surface water	1.00E+00	1.00E+00	SS, SB	RESRAD default.
Livestock fodder	4.50E+01	4.50E+01	SS, SB	RESRAD default
Radon-related exposure parameters				
Thickness of building foundation (m)	1.50E-01	not used	All	Applicable for Radon exposures only
Bulk density of building foundation (g/cc)	2.40E+00	not used	All	Applicable for Radon exposures only.
Total porosity of cover material	4.00E-01	not used	All	Applicable for Radon exposures only.
Total porosity of building foundation	1.00E-01	not used	All	Applicable for Radon exposures only.
Volumetric water constant of the cover material	5.00E-02	not used	All	Applicable for Radon exposures only.
Volumetric water constant of the foundation	3.00E-02	not used	All	Applicable for Radon exposures only.
Diffusion coefficient for radon gas (m^2/sec)				
in cover material	2.00E-06	not used	All	Applicable for Radon exposures only.
in foundation material	3.00E-07	not used	All	Applicable for Radon exposures only.
in contaminated zone soil	2.00E-06	not used	All	Applicable for Radon exposures only.
Radon vertical dimension of mixing (m)	2.00E+00	not used	All	Applicable for Radon exposures only.
Average building air exchange rate (1/hr)	5.00E-01	not used	All	Applicable for Radon exposures only.
Height of building or room (m)	2.50E+00	not used	All	Applicable for Radon exposures only.
Building indoor area factor	0.00E+00	not used	All	Applicable for Radon exposures only.
Building depth below ground surface (m)	-1	not used	All	Applicable for Radon exposures only.
Emanating power of Rn-222 gas	2.50E-01	not used	All	Applicable for Radon exposures only.

Table C-1. RESRAD Input Parameters

RESRAD Parameter (Units)	Default	Value	Medium	Comment/Reference
Emanating power of Rn-220 gas	1.50E-01	not used	All	Applicable for Radon exposures only.

LEGEND: SS = surface soil, SB = subsurface soil, SD = streambed sediment.

Table C-2. Soil/Water Distribution Coefficients[(1)]

Radionuclide	RESRAD Default (mL/g)	Surface Soil DCGL Contaminated Zone (mL/g)	Subsurface Soil DCGL Contaminated Zone (mL/g)	Sediment DCGL Contaminated Zone (mL/g)	Unsaturated[(2)] Zone (mL/g)	Saturated[(3)] Zone (mL/g)
Principal Elements						
Americium	20	1900[(4)] (420 - 111,000)	4000[(5)] (420 - 111,000)	4000[(5)] (420 - 111,000)	1900[(4)] (420 - 111,000)	1900[(4)] (420 - 111,000)
Carbon	0	5[(4)] (0.7 - 12)	7[(5)] (0.7 - 12)	7[(5)] (0.7 - 12)	5[(4)] (0.7 - 12)	5[(4)] (0.7 - 12)
Curium[(6)]	calculated	6760 (780 – 22,970)	6760 (780 – 22,970)	6760 (780 – 22,970)	6760 (780 – 22,970)	6760 (780 – 22,970)
Cesium	4600	280[(4)] (48 - 4800)	480[(5)] (48 - 4800)	480[(5)] (48 - 4800)	280[(4)] (48 - 4800)	280[(4)] (48 - 4800)
Iodine	calculated	1[(4)] (0.4 - 3.4)	2[(7)] (0.4 - 3.4)	2[(7)] (0.4 - 3.4)	1[(4)] (0.4 - 3.4)	1[(4)] (0.4 - 3.4)
Neptunium	calculated	2.3[(8)] (0.5 - 5.2)	3[(5)] (0.5 - 5.2)	3[(5)] (0.5 - 5.2)	2.3[(8)] (0.5 - 5.2)	2.3[(8)] (0.5 - 5.2)
Plutonium	2000	2600[(8)] (5 - 27,900)	3000[(5)] (5 - 27,900)	3000[(5)] (5 - 27,900)	2600[(8)] (5 - 27,900)	2600[(8)] (5 - 27,900)
Strontium	30	5[(9)] (1 - 32)	15[(5)] (1 - 32)	15[(5)] (1 - 32)	5[(9)] (1 - 32)	5[(9)] (1 - 32)
Technetium	0	0.1[(4)] (0.01 - 4.1)	4.1[(7)] (1 - 10)	4.1[(7)] (1 - 10)	0.1[(4)] (0.01 - 4.1)	0.1[(4)] (0.01 - 4.1)
Uranium	50	35[(4)] (10 - 350)	10[(9)] (1 - 100)	10[(9)] (1 - 100)	35[(4)] (10 - 350)	35[(4)] (10 - 350)

Table C-2. Soil/Water Distribution Coefficients[(1)]

Radionuclide	RESRAD Default (mL/g)	Surface Soil DCGL Contaminated Zone (mL/g)	Subsurface Soil DCGL Contaminated Zone (mL/g)	Sediment DCGL Contaminated Zone (mL/g)	Unsaturated[(2)] Zone (mL/g)	Saturated[(3)] Zone (mL/g)
Progeny Elements[(10)]						
Actinium	20	1740	1740	1740	1740	1740
Lead	100	2400	2400	2400	2400	2400
Protactinium	50	2040	2040	2040`	2040	2040
Radium	70	3550	3550	3550	3550	3550
Thorium	60,000	5890	5890	5890	5890	5890

NOTES: (1) Sources of K_d values considered included Table 3-20; NUREG-5512 (Beyeler, et al. 1999), Table 6.7; RESRAD User's Guide (Yu, et al. 2001), Tables E-3, E-4; Sheppard, et. al. 2006, and Sheppard and Thibault 1990. Values in parentheses are the bounds used in the sensitivity evaluation, selected considering site-specific and literature values to reflect a reasonable range.

(2) Sediment model assumes no unsaturated zone. Values used for surface and subsurface soil evaluation only.

(3) Values presented here are those used for surface soil DCGLs based on the non-dispersion model.

(4) From Sheppard and Thibault 1990, for sand.

(5) Site specific value for the unweathered Lavery till (see Section 3.7.8, Table 3-20).

(6) Beyeler, et. al. 1999

(7) Site specific value for the Lavery till (see Section 3.7.8, Table 3-20).

(8) Site specific value for the sand and gravel unit (see Section 3.7.8, Table 3-20). The value of 5 mL/g is consistent with the value used in the Decommissioning EIS.

(9) Site specific data (Dames and Moore 1995a, 1995b)

(10) Progeny K_ds were not included in the sensitivity analysis; DEIS values were used in all cases.

Table C-3 Scenario exposure pathways for WVDP DCGL development

Exposure Pathways	Resident Farmer (surface soil and Lavery Till source)	Recreationist (sediment source)
Incidental ingestion of source	●	●
External exposure to source	●	●
Inhalation of airborne source	●	●
Ingestion of groundwater impacted by source	●	X
Ingestion of milk impacted by soil and water sources	●	X
Ingestion of beef impacted by soil and water sources	●	X
Ingestion of produce impacted by soil and water sources	●	X
Incidental ingestion of surface water impacted by source	○	●
Ingestion of fish impacted by source	○	●
Ingestion of venison impacted by sediment and water sources	○	●

LEGEND:

● - Pathway is considered complete and is included in DCGL development.

○ - Pathway is considered potentially complete but unlikely, and is not included in DCGL development.

x - *Pathway is considered incomplete and is not included in DCGL development.*

Table C-4. Radiological Concentrations from Soil Samples Containing Lavery Till in the WMA 1 and WMA 2 Excavation Areas[1]

Location	Nuclide	Result (pCi/g)	Sample Depth Interval (ft)
BH-17 (WMA 6, 1993) Depth to Lavery till - 27 ft	Sr-90	1.1E-01	26-28
	Cs-137	2.6E-02	26-28
	U-232	< 3.2E-03	26-28
	U-233/234	1.6E-01	26-28
	U-235	< 5.8E-03	26-28
	U-235/236	< 6.9E-03	26-28
	U-238	1.1E-01	26-28
	Pu-238	< 4.3E-03	26-28
	Pu-239/240	< 4.3E-03	26-28
	Pu-241	1.3E+00	26-28
	Am-241	< 9.6E-03	26-28
BH-21A (WMA 1, 1993) Depth to Lavery till - 37.5 ft	Sr-90	4.5E+02	36-38
	Cs-137	< 3.0E-02	36-38
	U-232	< 7.4E-03	36-38
	U-233/234	8.6E-02	36-38
	U-235	< 5.1E-03	36-38
	U-235/236	< 7.2E-03	36-38
	U-238	7.1E-02	36-38
	Pu-238	< 4.8E-03	36-38
	Pu-239/240	< 4.8E-03	36-38
	Pu-241	< 1.1E+00	36-38
	Am-241	< 7.2E-03	36-38
GP3098 (WMA 1, 1998) Depth to Lavery till - 37 ft	Sr-90	6.6E+00	36.5-37
	Sr-90	4.2E+00	37-37.5
	Sr-90	6.3E+00	37.5-38
	Sr-90	5.5E+01	38-38.5
	Sr-90	5.9E+01	38.5-39
	Sr-90	3.4E+01	39-39.5
	Sr-90	2.9E+01	39.5-40
GP3008 (WMA 1, 2008) Depth to Lavery till - 37 ft	C-14	< 3.0E-01	37-39
	Sr-90	1.7E+00	37-39
	Tc-99	< 5.5E-01	37-39
	I-129	< 1.1E-01	37-39
	Cs-137	< 2.0E-02	37-39
	U-232	< 2.2E-02	37-39
	U-233/234	9.7E-01	37-39
	U-235/236	1.3E-01	37-39
	U-238	1.1E+00	37-39

Table C-4. Radiological Concentrations from Soil Samples Containing Lavery Till in the WMA 1 and WMA 2 Excavation Areas[(1)]

Location	Nuclide	Result (pCi/g)	Sample Depth Interval (ft)
	Np-237	< 9.8E-03	37-39
	Pu-238	< 1.1E-02	37-39
	Pu-239/240	< 1.2E-02	37-39
	Pu-241	< 4.8E-01	37-39
	Am-241	< 1.2E-02	37-39
	Cm-243/244	< 1.2E-02	37-39
GP7398 (WMA 1, 1998) Depth to Lavery till - 39 ft	Sr-90	1.9E+00	40-40.5
	Sr-90	1.8E+00	40.5-41
	Sr-90	5.2E+00	41-41.5
	Sr-90	8.4E+00	41.5-42
GP7608 (WMA 1, 2008) Depth to Lavery till - 38 ft	C-14	< 3.4E-01	38-40
	Sr-90	1.8E+01	38-40
	Tc-99	< 3.9E-01	38-40
	I-129	< 2.3E-01	38-40
	Cs-137	7.9E+00	38-40
	U-232	< 2.8E-01	38-40
	U-233/234	1.9E+00	38-40
	U-235/236	< 4.2E-01	38-40
	U-238	8.8E-01	38-40
	Np-237	< 3.6E-01	38-40
	Pu-238	< 3.4E-01	38-40
	Pu-239/240	< 3.1E-01	38-40
	Pu-241	< 3.4E+01	38-40
	Am-241	< 2.0E-01	38-40
	Cm-243/244	< 2.2E-01	38-40
GP7808 (WMA 1, 2008) Depth to Lavery till - 37 ft	C-14	< 2.9E-01	37-39
	Sr-90	8.6E+00	37-39
	Tc-99	< 4.4E-01	37-39
	I-129	< 2.3E-01	37-39
	Cs-137	< 2.2E-02	37-39
	U-232	< 1.3E-02	37-39
	U-233/234	8.2E-01	37-39
	U-235/236	9.2E-02	37-39
	U-238	1.1E+00	37-39
	Np-237	< 2.1E-02	37-39
	Pu-238	< 1.1E-02	37-39
	Pu-239/240	< 1.5E-02	37-39
	Pu-241	< 4.9E-01	37-39
	Am-241	< 1.7E-02	37-39
	Cm-243/244	< 1.6E-02	37-39
GP8098 (WMA 1, 1998) Depth to Lavery till - 41 ft	C-14	< 8.6E-02	40-42
	Sr-90	1.3E+01	40-42

Table C-4. Radiological Concentrations from Soil Samples Containing Lavery Till in the WMA 1 and WMA 2 Excavation Areas(1)

Location	Nuclide	Result (pCi/g)	Sample Depth Interval (ft)
	Tc-99	< 2.6E-01	40-42
	I-129	< 2.3E-01	40-42
	Cs-137	< 2.2E-02	40-42
	Pu-241	< 2.1E+00	40-42
GP8008 (WMA 1, 2008) Depth to Lavery till - 40 ft	C-14	< 2.8E-01	39-41
	C-14	< 2.8E-01	41-43
	Sr-90	5.3E+00	39-41
	Sr-90	1.4E+00	41-43
	Tc-99	< 3.4E-01	39-41
	Tc-99	< 3.7E-01	41-43
	I-129	< 1.2E-01	39-41
	I-129	< 1.2E-01	41-43
	Cs-137	< 2.3E-02	39-41
	Cs-137	< 2.8E-02	41-43
	U-232	< 1.0E-02	39-41
	U-232	< 1.3E-02	41-43
	U-233/234	5.2E-01	39-41
	U-233/234	1.1E+00	41-43
	U-235/236	3.9E-02	39-41
	U-235/236	1.1E-01	41-43
	U-238	8.2E-01	39-41
	U-238	1.4E+00	41-43
	Np-237	< 1.1E-02	39-41
	Np-237	< 1.2E-02	41-43
	Pu-238	< 1.5E-02	39-41
	Pu-238	< 1.5E-02	41-43
	Pu-239/240	< 1.6E-02	39-41
	Pu-239/240	< 1.5E-02	41-43
	Pu-241	< 4.4E-01	39-41
	Pu-241	< 5.2E-01	41-43
	Am-241	< 1.2E-02	39-41
	Am-241	< 1.5E-02	41-43
	Cm-243/244	< 1.3E-02	39-41
	Cm-243/244	< 1.6E-02	41-43
GP8308 (WMA 1, 2008) Depth to Lavery till - 41.5 ft	C-14	< 3.5E-01	40-42
	Sr-90	1.5E+00	40-42
	Tc-99	< 3.6E-01	40-42
	I-129	2.4E-01	40-42
	Cs-137	< 2.7E-02	40-42
	U-232	< 2.4E-02	40-42
	U-233/234	9.8E-01	40-42
	U-235/236	2.2E-01	40-42
	U-238	1.1E+00	40-42

Table C-4. Radiological Concentrations from Soil Samples Containing Lavery Till in the WMA 1 and WMA 2 Excavation Areas(1)

Location	Nuclide	Result (pCi/g)	Sample Depth Interval (ft)
	Np-237	< 1.3E-02	40-42
	Pu-238	< 1.1E-02	40-42
	Pu-239/240	< 1.1E-02	40-42
	Pu-241	< 2.7E-01	40-42
	Am-241	< 1.2E-02	40-42
	Cm-243/244	< 1.8E-02	40-42
GP8698 (WMA 1, 1998) Depth to Lavery till - 39 ft	Sr-90	2.2E+00	39-39.5
	Sr-90	1.0E+00	39.5-40
	Sr-90	3.0E+00	40-40.5
	Sr-90	1.0E+01	40.5-41
	Sr-90	4.1E+01	41-41.5
	Sr-90	3.0E+01	41.5-42
GP10008 (WMA 1, 2008) Depth to Lavery till - 37 ft	C-14	< 3.0E-01	37-39
	Sr-90	6.7E+00	37-39
	Tc-99	< 4.0E-01	37-39
	I-129	< 1.4E-01	37-39
	Cs-137	< 2.7E-02	37-39
	U-232	< 1.3E-02	37-39
	U-233/234	7.6E-01	37-39
	U-235/236	7.5E-02	37-39
	U-238	9.5E-01	37-39
	Np-237	< 1.2E-02	37-39
	Pu-238	< 2.2E-02	37-39
	Pu-239/240	< 1.1E-02	37-39
	Pu-241	< 4.3E-01	37-39
	Am-241	< 1.4E-02	37-39
	Cm-243/244	< 2.3E-02	37-39
GP10108 (WMA 1, 2008) Depth to Lavery till - 33 ft	C-14	< 3.1E-01	32-34
	Sr-90	6.3E-01	32-34
	Tc-99	< 5.4E-01	32-34
	I-129	< 9.1E-02	32-34
	Cs-137	< 2.6E-02	32-34
	U-232	< 1.6E-01	32-34
	U-233/234	6.0E-01	32-34
	U-235/236	5.0E-02	32-34
	U-238	7.3E-01	32-34
	Np-237	< 1.0E-02	32-34
	Pu-238	< 9.5E-03	32-34
	Pu-239/240	< 8.8E-03	32-34
	Pu-241	< 4.7E-01	32-34
	Am-241	< 1.1E-02	32-34
	Cm-243/244	< 1.1E-02	32-34

Table C-4. Radiological Concentrations from Soil Samples Containing Lavery Till in the WMA 1 and WMA 2 Excavation Areas(1)

Location	Nuclide	Result (pCi/g)	Sample Depth Interval (ft)
GP10408 (WMA 1, on border of WMA 2) Depth to Lavery till - 24 ft	C-14	< 3.6E-01	24-26
	Sr-90	7.4E+00	24-26
	Tc-99	< 5.1E-01	24-26
	I-129	< 1.1E-01	24-26
	Cs-137	< 5.5E-02	24-26
	U-232	4.1E-02	24-26
	U-233/234	8.8E-01	24-26
	U-235/236	1.4E-01	24-26
	U-238	7.9E-01	24-26
	Np-237	< 6.9E-03	24-26
	Pu-238	< 1.2E-02	24-26
	Pu-239/240	< 1.2E-02	24-26
	Pu-241	< 3.1E-01	24-26
	Am-241	< 1.3E-02	24-26
	Cm-243/244	< 1.4E-02	24-26
BH-05 (WMA 2, 1993), located downgradient of Lagoon 1 Depth to Lavery till - 12 ft	Sr-90	8.5E-01	12-14
	Cs-137	4.5E-01	12-14
	U-232	1.2E-02	12-14
	U-233/234	1.8E-01	12-14
	U-235	< 5.9E-03	12-14
	U-235/236	< 8.3E-03	12-14
	U-238	1.1E-01	12-14
	Pu-238	1.0E-02	12-14
	Pu-239/240	< 5.9E-03	12-14
	Pu-241	< 1.3E+00	12-14
	Am-241	3.0E-02	12-14
BH-07 (WMA 2, 1993) Depth to Lavery till - 13 ft	Sr-90	1.3E-01	12-14
	Cs-137	7.5E-02	12-14
	U-232	< 8.7E-03	12-14
	U-233/234	2.2E-01	12-14
	U-235	< 6.6E-03	12-14
	U-235/236	< 7.6E-03	12-14
	U-238	1.5E-01	12-14
	Pu-238	< 4.7E-03	12-14
	Pu-239/240	< 6.2E-03	12-14
	Pu-241	9.5E-01	12-14
	Am-241	< 5.1E-03	12-14
BH-08 (WMA 2, 1993), located downgradient of Lagoon 1	Sr-90	1.8E+02	10-12
	Cs-137	2.5E+02	10-12

Table C-4. Radiological Concentrations from Soil Samples Containing Lavery Till in the WMA 1 and WMA 2 Excavation Areas[1]

Location	Nuclide	Result (pCi/g)	Sample Depth Interval (ft)
Depth to Lavery till - 11.5 ft	U-232	1.9E+01	10-12
	U-233/234	9.7E+00	10-12
	U-235	3.2E-01	10-12
	U-235/236	5.0E-01	10-12
	U-238	1.3E+01	10-12
	Pu-238	3.9E+00	10-12
	Pu-239/240	7.6E+00	10-12
	Pu-241	2.7E+01	10-12
	Am-241	1.1E+01	10-12
BH-12 (WMA 2, 1993) Depth to Lavery till - 15.5 ft	Sr-90	1.8E-01	14-16
	Cs-137	< 2.2E-02	14-16
	U-232	< 6.0E-03	14-16
	U-233/234	1.1E-01	14-16
	U-235	< 7.0E-03	14-16
	U-235/236	1.3E-02	14-16
	U-238	9.7E-02	14-16
	Pu-238	< 4.9E-03	14-16
	Pu-239/240	< 4.9E-03	14-16
	Pu-241	< 1.0E+00	14-16
	Am-241	< 4.6E-03	14-16
BH-13 (WMA 2, 1993) Depth to Lavery till - 19 ft	Sr-90	1.8E-01	18-20
	Cs-137	2.7E+00	18-20
	U-232	1.6E-02	18-20
	U-233/234	8.5E-02	18-20
	U-235	< 5.1E-03	18-20
	U-235/236	< 8.2E-03	18-20
	U-238	5.3E-02	18-20
	Pu-238	2.4E-02	18-20
	Pu-239/240	2.6E-02	18-20
	Pu-241	< 8.1E-01	18-20
	Am-241	9.5E-02	18-20
BH-14 (WMA 2, 1993) Depth to Lavery till - 15 ft	Sr-90	1.8E+01	14-16
	Cs-137	1.9E+00	14-16
	U-232	2.0E-02	14-16
	U-233/234	1.9E-01	14-16
	U-235	< 7.9E-03	14-16
	U-235/236	< 1.1E-02	14-16