

NOTICE

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Table of Contents

	Page
Notice	i
Acknowledgements.....	vi
Agreement of Report Contents	vii
Executive Summary	1
1.0 Introduction and Purpose.....	4
2.0 Background on the Mixed Waste Landfill	5
3.0 Peer Review Process	19
4.0 Fate and Transport	22
5.0 Short-term and Long-term Performance	39
6.0 Evaluation of Human Health and Ecological Risk Screening Assessments.....	48
7.0 Analytical/Radiochemistry and Measurement Errors.....	55
8.0 Findings and Recommendations	64
Appendix A – Biographic Sketches of Peer Panel Members and Facilitators.....	67
Appendix B – Mixed Waste Landfill Inventory of Disposed Materials	72
Appendix C – Notices of Peer Review Public Meetings.....	92
Appendix D – Documents Available to Peer Panel and Public	94
Appendix E – Acronyms and Initialisms	107

List of Tables

	Page
Table 1: Radionuclides Present in the Mixed Waste Landfill and Estimated Curie Levels Over Time	21
Table 2: Results of GoldSim® modeling used to predict borehole tritium sampled data	28
Table 3: Uranium Isotopic Activity Ratio Analysis/Monitoring Radioactive Disintegrations	62
Table 4: Uranium Isotopic Activity Ratio Analysis/ICP-Mass Spectrometry	63

List of Figures

	Page
Figure 1: Location of Kirtland Air Force Base and Sandia National Laboratories	8
Figure 2: Mixed Waste Landfill Trenches and Pits	9
Figure 3: Oblique Areal View of Mixed Waste Landfill, looking Southwest, circa 1987	10
Figure 4: Mixed Waste Landfill, "Classified Waste" Disposal, circa 1974	11
Figure 5: Lovelace Waste in Trench E, looking South, May 1980	12
Figure 6: "Unclassified Waste" Disposal in Trench B, looking South, circa 1974	13
Figure 7: Trench F looking South, circa 1987	14
Figure 8: Trench D looking South, circa 1966	15
Figure 9: Classified Area Tritium Disposal, 1959-1983	16
Figure 10: Phase 2 RFI Soil Boring Locations	17
Figure 11: Monitoring Wells in the Vicinity of the Mixed Waste Landfill	18

List of Figures Continued

	Page
Figure 22: Location and Depth of Maximum Subsurface Tritium Soil Concentrations Measured in pCi/L of Extracted Water (Baskaran, <i>Mixed Waste Landfill Review</i> of July 5, 2000 derived from Sandia National Laboratories Phase 1 and Phase 2 RCRA RFI reports)	47
Figure 23: U-238/U-235 Activity Ratios (95% uncertainty error bars), 3 Analytical Labs	59
Figure 24: U-238/U-235 Activity Ratios (95% uncertainty error bars), ICP-MS Analyses	60
Figure 25: U-238/U-235 Activity Ratios (95% uncertainty error bars), ICP-MS Analyses [plotted at the same vertical scale as Figure 23]	61

Acknowledgements

WERC wishes to thank the following for their contributions: panel members Catherine Aimone-Martin, Michael Campana, Antonio Lara, Eric Nuttall, and Mary Walker; panel facilitators Ron Bhada and Tim Carlson; WERC staff Abbas Ghassemi, Jim Loya, Carolyn Perez, and Deb Thrall; presenters of information on the Sandia National Laboratories Mixed Waste Landfill: John Gould with U.S. Department of Energy; Dick Fate, Tim Goering, and Jerry Peace of Sandia National Laboratories; Will Moats of New Mexico Environment Department, and Douglas Earp from City of Albuquerque. A special thanks to Bruce Baker with Technadyne (Albuquerque) who designed the fate and transport model used in this report.

Agreement of Report Contents

The panel members who performed the peer review of the U.S. Department of Energy, Sandia National Laboratories, Mixed Waste Landfill have read the entirety of this peer review final report dated August 31, 2001, and concur with the contents herein.

Catherine Aimone-Martin August 31, 2001
Catherine Aimone-Martin Date

Michael C. Campana August 31, 2001
Michael Campana Date

Mary Walker Aug 31, 2001
Mary Walker Date

Antonio Lara 31 Aug 2001
Antonio Lara Date

Eric Nuttall Aug 31, 2001
Eric Nuttall Date

8. A key issue that arose in the review of MWL reports, sampling data, and outside reviews was an argument that the U-238/U-235 activity ratios were less than 21.76 in ground water samples and hence suggested non-natural or anthropogenic (man caused) sources of uranium existed beyond the MWL. Evaluation of laboratory data indicates that past analytical measurements were highly variable, above and below the assumed natural value, and the precision was poor. A recent round of analytical testing provided a method of measuring isotopic activity ratios using mass spectrometry and the precision was very tight. The method strongly suggests that the uranium isotopic activity ratios are those of the natural abundance of the element and thus one can conclude that the MWL has not leached uranium into the groundwater.

Recommendations

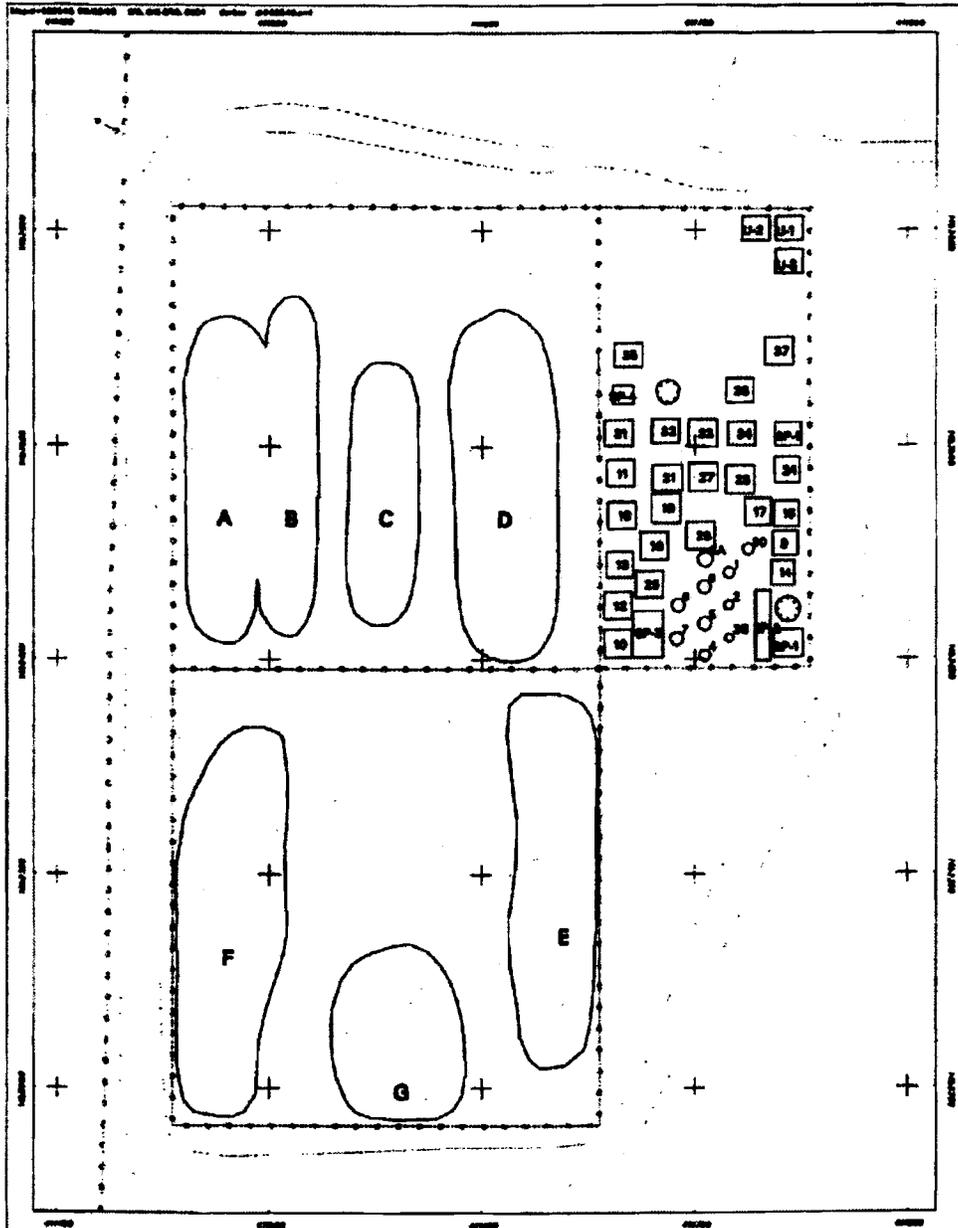
- A. Sandia National Laboratories should proceed with a comprehensive report that evaluates the options of excavating the MWL in the near future, placing a cover on the MWL with retrieval at some future time, a permanent cover with no retrieval, maintaining current conditions, and possibly other alternatives. This study should clearly articulate the risks, costs, and impacts associated with the different alternatives and the different points in time that actions may take place.
- B. Since tritium is the one contaminant detected in soil sampling that clearly originated from the landfill, some additional explanation of the assumptions used in the risk assessment is needed for clarity, such as: for an industrial worker or for a resident how much soil is estimated to be ingested? How much inhalation occurs? It would also be useful to include a table that lists exposure levels (i.e. soil ingestion, inhalation, dermal exposure, and plant uptake).
- C. To provide adequate communication to the public, Sandia National Laboratories should provide an explanatory executive summary for the human health risk assessment and the environmental risk assessment documents. This information should describe the basic risk assessment processes that were used, the identified contaminants of concern, the uncertainties associated with them, and the basic conclusions reached from these processes. This information may already exist in the public information efforts previously conducted by Sandia, however, it is lacking from the risk assessment documents made available to the public.
- D. Although a recent round of analytical testing using mass spectrometry strongly suggests that the uranium isotopic activity ratios are those of the natural abundance of the element, a different laboratory should confirm this finding using similar analytical methods on a future round of groundwater sampling/testing.
- E. It is recommended that Sandia National Laboratories compile all of the relevant information related to the MWL in one document series and make it accessible to the public. Much of this information is currently available in two public reading rooms in Albuquerque that are maintained by Sandia.

were disposed at the MWL. Mixed waste is defined as waste that contains both hazardous waste, as defined by the U.S. Environmental Protection Agency (EPA), and radioactive waste. Because hazardous wastes were disposed at the MWL, the State of New Mexico is authorized by the EPA to implement the hazardous waste management provisions of RCRA for treatment, storage, and disposal facilities within the state. Under RCRA, the New Mexico Environment Department regulates the MWL as a Solid Waste Management Unit (SWMU) as a corrective action. DOE orders also provide requirements for landfill closure and cover design, and establish long-term performance requirements for the closed facility.

The MWL consists of two distinct disposal areas: the classified area, occupying 0.6 acres, and the unclassified area, occupying 2.0 acres (Figures 2 and 3). Classified wastes are materials that are considered to have national security value and are not subject to public disclosure and are disposed in Pits 1 through 37, Pits SP-1 through SP-5, and Pits U-1 through U-3. They may include documents, materials, or physical configurations. Wastes in the classified area were disposed in a series of vertical, cylindrical pits. Historic records indicate that early pits were 3 to 5 feet in diameter and 15 feet deep. Later pits were 10 feet in diameter and 25 feet deep. A typical disposal of classified materials is represented in Figure 4. Once pits were filled with waste, they were backfilled with soil then capped with concrete. Wastes in the unclassified area (Trenches A through G) were disposed in a series of parallel, north-south excavated trenches. Records indicate that the trenches were 15 to 25 feet wide, 150 feet to 180 feet long, and 15 to 20 feet deep. Trenches were reportedly backfilled with soil on a quarterly basis and, once filled with waste, capped with originally excavated soils that had been stockpiled locally. Figures 5 through 8 show how wastes were typically disposed in the unclassified area.

Wastes disposed in the classified area pits included depleted, natural, and enriched uranium; thorium; barium; enriched lithium; liquid scintillation vials and beakers; neutron generator tubes and targets; plutonium contaminated wastes; and plutonium contaminated weapons test debris from DOE's Nevada test site. Figure 9 presents the tritium disposed in the classified area between 1959 and 1983. Between 1959 and 1962, small quantities of radioactively contaminated inorganic acids and organic solvents were disposed in Pit SP-1 located in the southeast corner of the classified area. Wastes disposed in the unclassified area trenches included construction and demolition materials, contaminated equipment and soils, lead shielding, shipping casks, cardboard, dry solids, and various crates, drums, and boxes. Wastes were disposed in this area at random with no regard to waste source or type.

In 1967, trench D in the unclassified area was used for disposal of an estimated 204,000 gallons of reactor coolant water. Sandia's records estimate that 1 curie of total radioactivity (primarily from tritium, and possibly from Na-24 and Mn-56) was discharged into the trench over a period of one month. Disposal began at 11:30 a.m. May 11, 1967, and continued more or less continuously until 12:45 p.m. on June 22, 1967.



Legend

-  Mixed Waste Landfill
-  Trench/Pit Location
-  Road
-  Fence

FIGURE 2
Mixed Waste Landfill
Trenches & Pits



Sandia National Laboratories, New Mexico
 Environmental Geographic Information System



FIGURE 5: Lovelace Waste in Trench E, looking South, May 1980



FIGURE 6: "Unclassified Waste" Disposal in Trench B, looking South, circa 1974



FIGURE 7: Trench F looking South, circa 1987

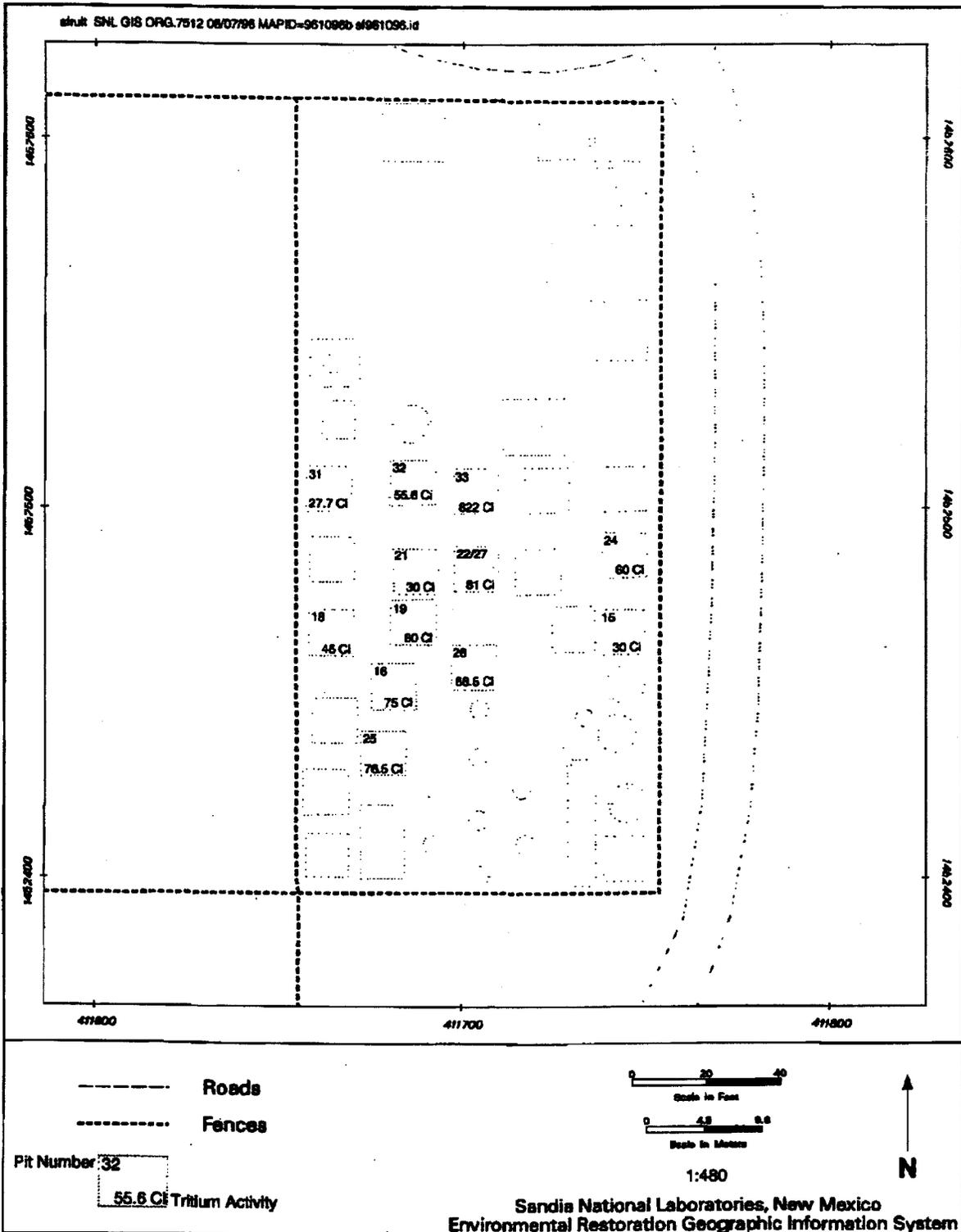
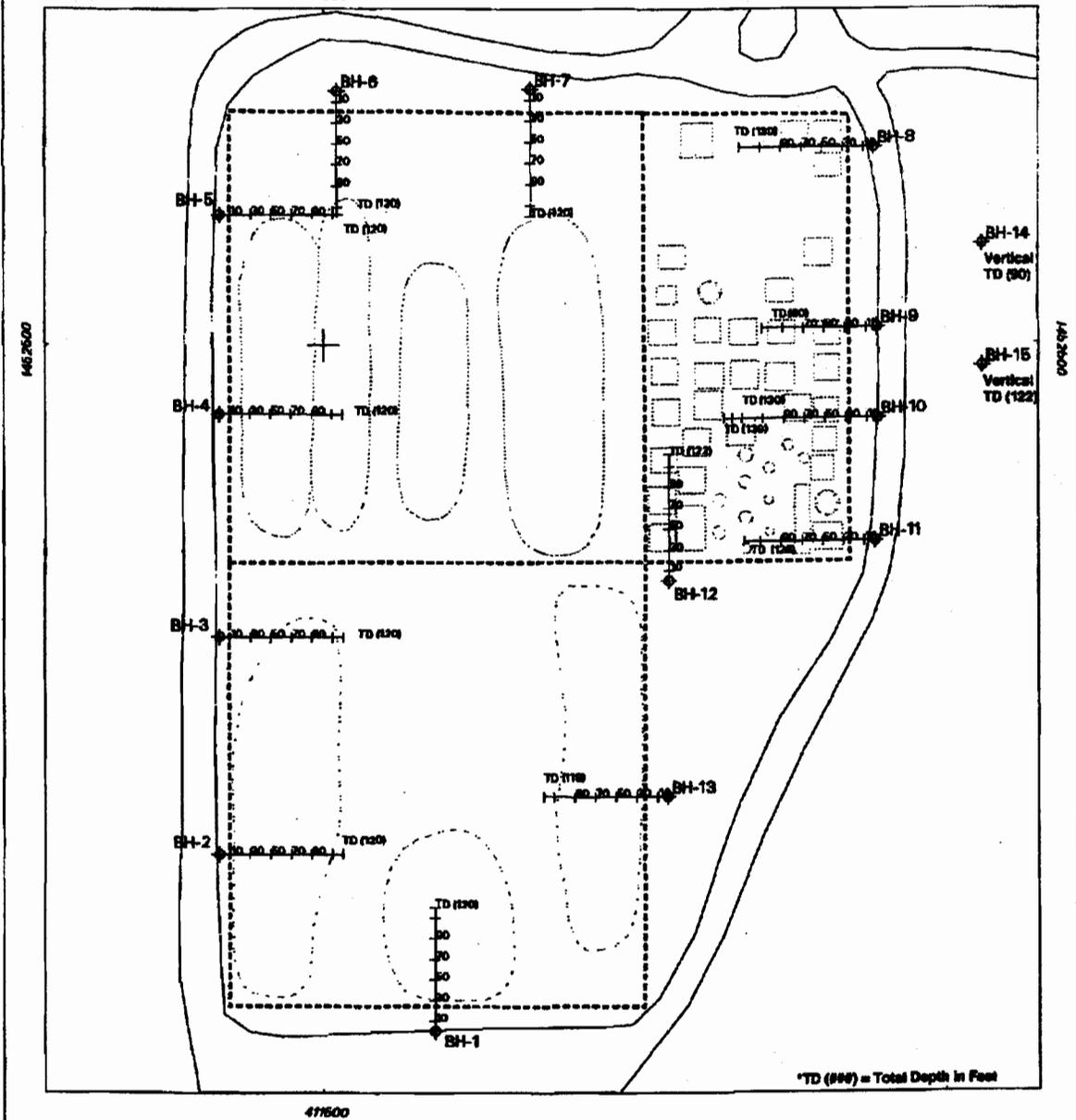


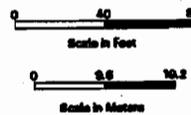
FIGURE 9: Classified Area Tritium Disposal, 1959-1983



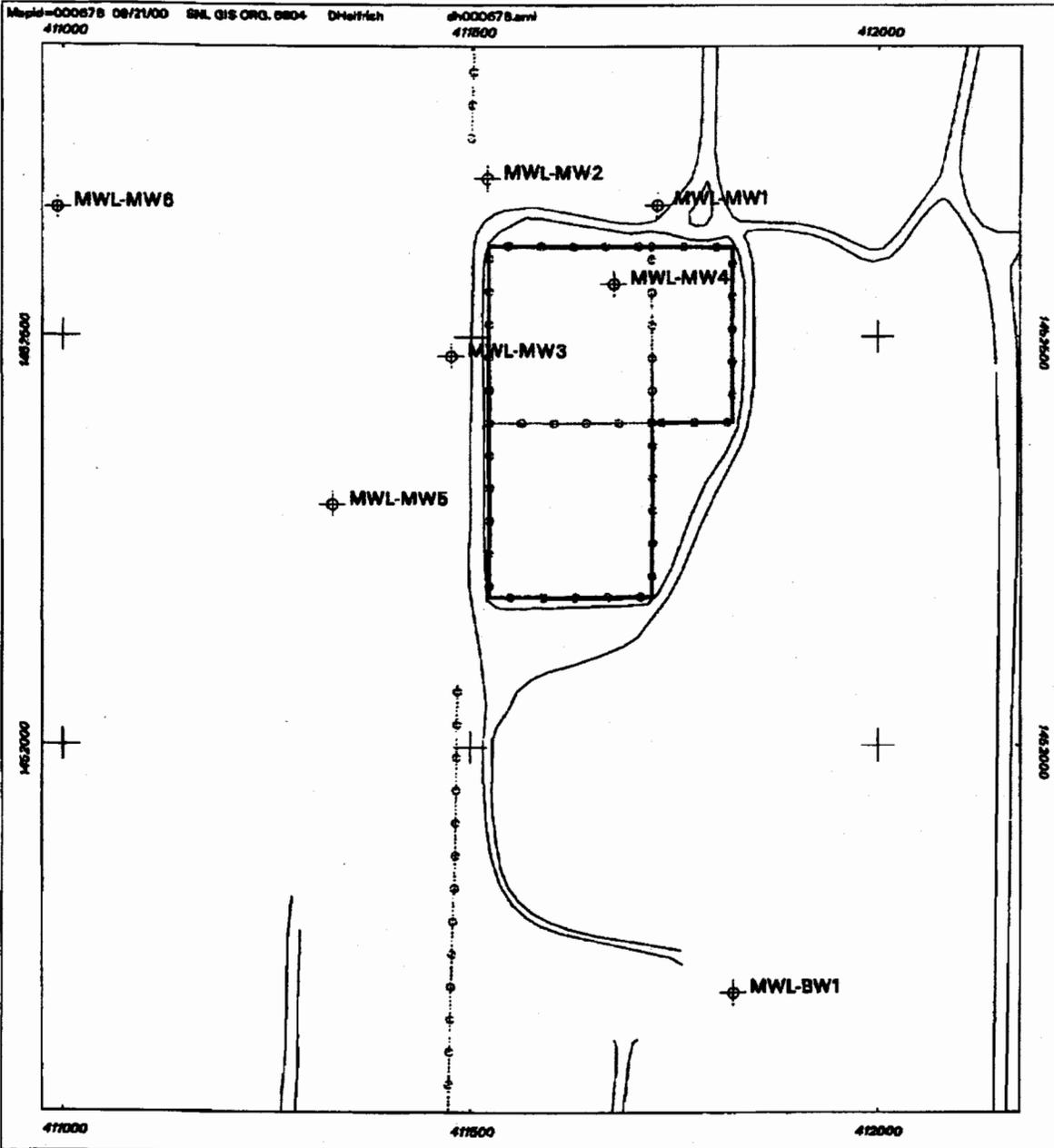
Legend

- ◆----- Horizontal Surface Projection of Borehole Showing Sampling Depths
- Road
- Fence
- Pits and Trenches

**FIGURE 10:
Phase 2
RFI Soil
Boring Locations**



Sandia National Laboratories, New Mexico
Environmental Geographic Information System



Legend

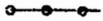
-  Monitoring well
-  Road
-  Fence
-  Mixed Waste Landfill

FIGURE 11
Monitoring Wells in the
Vicinity of the
Mixed Waste Landfill



Sandia National Laboratories, New Mexico
Environmental Geographic Information System

3.0 Peer Review Process

The formal peer review of Sandia's MWL was conducted at two separate meetings. On March 22 and 23, 2001 an open public meetings were held at the Doubletree Inn in Albuquerque, New Mexico. A second open public meeting of the peer panel was held on May 11, 2001 at the same location. Prior to these peer panel meetings, a separate meeting was held at the University of New Mexico in Albuquerque on March 6 and 7, 2001 to discuss the process with the public; no peer panel members attended this session. The advertisements for these meetings were published in the Albuquerque Journal and Albuquerque Tribune and are reproduced in Appendix C. The first meeting was to describe the process, the role of WERC, and to gather public input. During the two actual peer review meetings, full and frank discussions between the peer reviewers and the original performers of the work occurred. The initial peer panel meeting (March 22 and 23) reviewed information on the site, historic waste inventory, soil and hydrologic information, characterization data, and critiques of DOE's work. A tour of the site was also made during this meeting. At the second peer panel meeting (May 11) the peer panel presented their initial findings and conclusions, and directed specific questions to DOE and Sandia National Laboratories representatives. A Draft MWL Peer Review report was prepared based on these meetings. This report was made available to the public and DOE/Sandia in hard copy and through the Internet at www.werc.net on July 9, 2001. A public meeting to receive comments on the draft report was held on August 16, 2001. Comments received were used to help the panel complete the final report. An addendum to this document will be made available by September 30, 2001 that responses to each comment received.

DOE's basic components of the proposed action for the MWL presented to the peer panel, as described by their representatives, are:

- 1) The Mixed Waste Landfill at Sandia National Laboratories is not a threat to human health and environment if left undisturbed; at least for the next several decades. Greatest risk is to workers from high activity waste, principally cobalt 60, if retrieval is used. In the future, this risk will be much less because of natural decay. Table 1 provides a listing of the radionuclides present in the MWL, their respective half-life in years, the estimated total Curie levels in 1989 (6,736 Ci), in 1999 (2,971 Ci), in 2009 (1,560 Ci), in 2019 (933 Ci), 2029 (608 Ci), in 2039 (419 Ci), and so on through the year 2289.
- 2) To provide an extra layer of protection from erosion and infiltration, DOE's plan is to place a 3-foot-thick vegetative cover with up to 40 inches of sub-grade for purposes of leveling the site with the site monitored for the next 30 to 40 years.
- 3) At this future date (30 to 40 years) the decision process should be reopened to investigate and identify a final solution.

Radionuclide	Half-Life (years)	Estimated Ci in 1989	Estimated Ci in 1999	Estimated Ci in 2009	Estimated Ci in 2019	Estimated Ci in 2029	Estimated Ci in 2039	Estimated Ci in 2049	Estimated Ci in 2059	Estimated Ci in 2069	Estimated Ci in 2169	Estimated Ci in 2269
	Year >>	1989	1999	2009	2019	2029	2039	2049	2059	2069	2169	2269
Co-60	5.27	3600	939.7	252.3	67.7	18.2	4.9	1.3	0.4	0.0	0.0	0.0
H-3	12.30	2400	1366.2	777.7	442.7	252.0	143.5	81.7	46.5	8.6	0.0	0.0
Sr-90	29.10	410	323.1	254.6	200.7	158.2	124.6	96.2	77.4	37.9	3.5	0.3
Cs-137	30.17	410	325.9	259.0	205.8	163.6	130.0	103.3	82.1	41.2	4.1	0.4
Pu-239	87.70	1.2E-03	1.1E-03	1.0E-03	9.5E-04	8.7E-04	8.1E-04	7.5E-04	6.9E-04	5.4E-04	2.5E-04	1.1E-04
Am-241	432.00	1.2E-03	1.2E-03	1.2E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.0E-03	8.7E-04	7.4E-04
Np-236	1602.00	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Pu-238	24100.00	1.2E-03										
U-238	4470000000.00	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3
Th-232	14000000000.00	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total Ci in Future Years		6736	2971	1580	933	608	419	301	223	104	23	16

TABLE 1
Radionuclides Present in the Mixed Waste Landfill and Estimated Curie Levels Over Time

- The inventory was encased in 400 mil plastic bags and allowed to release at a prescribed rate over 40 years. The first 30 years represents present day while the additional 10 years represents a point in time 10 years forward. Simultaneously, the inventory and concentration released were decayed at the half-life rate for tritium.

4.3.2 Modeling assumptions

- Migration pathway – The model was first run to limit migration to the vertical direction. Subsequent modeling was made to simulate only horizontal migration to determine a horizontal advection factor applied to spatial vertical data.
- The model was run for a total for 40 years to explain the existing subsurface activities at year 30 (assumed current point in time) and forward for 10 years (for predictive purposes).
- Subsurface tritium activities were computed in “mixing cells”, 10 ft. in diameter and in thickness, starting at 30 ft. in depth (the “center” of the first cell), and for every 10 ft. (e.g. 40, 50, etc.) to a total depth of 70 or 80 ft. The layout of these mixing cells is shown in Figure 12 in which row 1 represents 30 ft. and row 5 represents 80 ft.
- Hydrological and soil parameters assumed include:

		Source
unsaturated hydraulic conductivity	5×10^{-7} centimeters/second	(5)
volumetric water content	10 %	(6) (7)
diffusivity	1×10^{-9} meters ² /second	(3) (6)
soil bulk density	1.5 grams/cubic centimeter (g/cc)*	(5)

* Average value for all boreholes was 1.92 g/cc; however the value for the borehole modeled was 1.38 g/cc, therefore 1.5 g/cc is a conservative average.

- The total inventory is assumed to be contained in 100 “packets” that represent 100% of the initial inventory. A packet is defined within the GoldSim® model as a unit of measure of the total source volume. Fifty-percent (50%) of the packets were failed between 0 and 40 years. This effectively releases

$$[(0.5) * (2,400 \text{ Ci} - \text{inventory})] / (9,696 \text{ Ci/gram}) = 0.124 \text{ grams of tritium}$$

where 0.248 grams of tritium represent the total inventory. This provides a reasonable release scenario, allowing for natural decay of the remaining 0.124 grams of tritium.

4.3.4 Modeling Results

The following plots are provided as examples of the typical output from GoldSim® used to predict tritium concentration at soil sample locations in BH-9 and BH-12. Figure 15 shows the unexposed mass of tritium remaining in the inventory over the 40-year modeling period (time is in years).

Figures 16 and 17 show the advective concentration (in mg/L, computed from the inventory release in mg, and knowing the soil bulk density and average moisture content) and diffusive flux (in milligrams/year) for classified area pit 33. In Figure 16, the black line shows the concentration moving vertically out of cell 33 (at 25 ft.) while the remaining lines show concentration moving downward from each mixing cell. In Figure 17, diffusive flux is shown for tritium moving in the soil water from pit 33 to all other burial pits at a depth of 30 ft.

Typical plots used to analyze the horizontal diffusion factor are given in Figures 18 through 20 for the cells immediately to the left of cell 24 shown in Figure 13. Concentration over time is computed for cells at lateral distances of 10, 20 and 30 ft. from cell 24 (rows 11, 10, and 9 shown in Figure 13) at a depth below the ground surface of 30 ft. Using the upper most concentration plots for column 5 (the same column and "up-gradient" of assumed flow direction), the net "reduction" in peak concentration from row 11 to row 10 is approximately 75%. The reduction from row 10 to row 9 is also on the order of 75%. In fact, when this analysis is performed for cells throughout the grid shown in Figure 13, the average horizontal reduction in concentration between all cells is 75%. Therefore, the net concentration remaining becomes 25% (or 100% - 75%) of the concentration in upstream regions. The 25% factor was used to compute the horizontal tritium concentration with time applied to the vertical advective flux.

As the last step in predicting tritium concentrations in boreholes BH-9 and BH-12, advective flux values were computed at a 30-year time period following source burial in mixing cells beneath pits 33 and 25, respectively. The horizontal diffusion concentration factor was applied to values at a rate of 0.25 per 10 ft. of distance away from the source cell center (as described above). As an example, using the geometry defined in Figure 14 and assuming a concentration at the 50 ft. mixing cell of $1.05 (10^{-6})$ milligrams/liter (mg/L) of tritium, the "reduced" horizontal concentration values are computed as follows:

region "a" $1.05 (10^{-6}) * 0.25 (1 \text{ cell displaced}) = 0.2625 (10^{-6}) \text{ mg/L of tritium}$

region "b" $0.2625 (10^{-6}) * 0.25 (1 \text{ additional cell displaced}) = 0.0656 (10^{-6}) \text{ mg/L of tritium}$

This procedure was repeated for regions adjacent to pits 25 and 33. The results of the calculations for boreholes BH-9 and BH-12 are given in Table 2. The table gives predicted values using GoldSim® and the values obtained by sampling in mg/L of tritium. In all cases, with the exception of the sample at 30 ft. in BH-12, the orders of magnitudes of the predictions are in good agreement with the sampled values.

Apparently, the unusually high sampled value of 0.78 (10^{-6}) mg/L of tritium cannot be replicated by modeling using a subsurface transport process model alone and the simplified assumptions made herein. In such circumstances, there may be other concentrating influences that remain unknown and cannot be modeled. This is reasonable and should be expected in any modeling effort.

Table 2: Results of GoldSim® modeling used to predict borehole tritium sampled data

1994-1995 sampling						
Depth downhole ft	BH 12 sampled		predicted	BH 9 sampled		predicted
	pCi/L	mg/L (10^{-6})	mg/L (10^{-6})	pCi/L	mg/L (10^{-6})	mg/L (10^{-6})
30	7,800,000	0.78	0.059	46,800	0.00468	0.0034
40			0.061			0.0026
50	210,500	0.02105	0.042	16,600	0.00166	0.0017
60			0.026			0.00079
70	2,580	0.000258	Negl.	14,780	0.001478	Negl.
80						
90	1,480	0.000148		10,570	0.001057	

Negl. – negligible values computed (at or below the detection limits for tritium),
 Picocuries/L (pCi/L)

It should be pointed out that the predicted value of 0.061(10^{-6}) mg/L at 40 ft. downhole is slightly greater than the value computed at 30 ft. This is due to the spatial locations of the samples relative to the base of pit 25. Borehole BH 12 is inclined 30 degrees toward pit 25 and passes adjacent to and slightly under pit 25 nearer to the 40 ft. sample than the 30 ft. sample. Therefore, at 30 ft., the sample farther removed from the pit base would be expected to show a lower activity.

The predicted values at depth (below 60 ft.) do not appear to match the sampled data as the predicted attenuation of tritium concentration with depth is higher than the data suggest. Hence, the model does not appear to fully take into account other possible transport mechanisms/or controls at depth, where documented physical changes in soil/moisture properties take place (e.g. from silty-sandy, poor moisture retention soils to clayey-silty-sandy, high moisture retention soils). In the modeling process, it is assumed that soil properties do not change with depth. Only the near-surface soils types (with low moisture contents) have been modeled. Therefore, migration of above-background tritium values at depths below 90 ft. should reasonably be predicted using the GoldSim® model for more complicated runs where soil and hydraulic properties are varied with depth. This was, however, beyond the scope of this review and only the near-surface soil types were modeled.

The future concentrations of tritium migration have been assessed in the modeling process. Figures 16 and 17 are used to present the worst-case scenario in predicting the

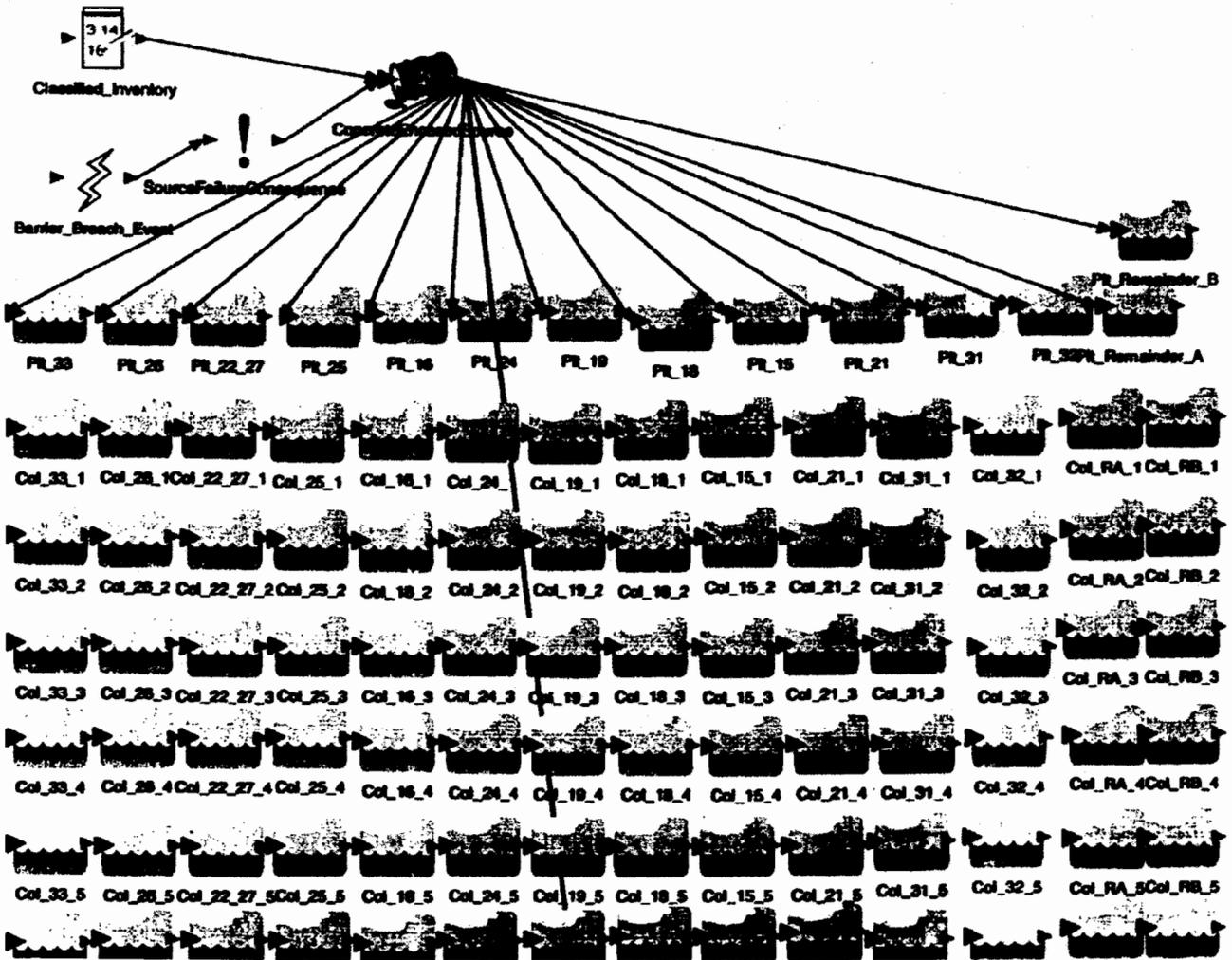
6) Wolford, R. A., Modeling the Infiltration of Reactor Coolant Water from Trench D at the Mixed Waste Landfill: Sandia National Laboratories, New Mexico. Sandia National Laboratories

Environmental Restoration Project, Albuquerque, NM. March 27, 1997.

7) Roepke, C.S., Strong, W.R., Nguyen, H.A., McVey, M.D., and Goering, T.J. Unsaturated Hydrologic Flow Parameters Based on Laboratory and Field Data For Soils Near the Mixed Waste Landfill, Technical Area III, Sandia National Laboratories/New Mexico, SAND 96-2090, August 1996.

8) Peace, J.L., Goering, T.J., and McVey, M.D., Tritium in Surface Sols at the Mixed Waste Landfill, Technical Area 3, Sandia National Laboratories/New Mexico, SAND95-1611, April 1996.

9) Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation, Environmental Restoration Project Sandia National Laboratories, Albuquerque, New Mexico, September 1996



31

FIGURE 12
Physical layout of mixing cells below classified area pits used to model tritium transport using GoldSim®

EncasedSource

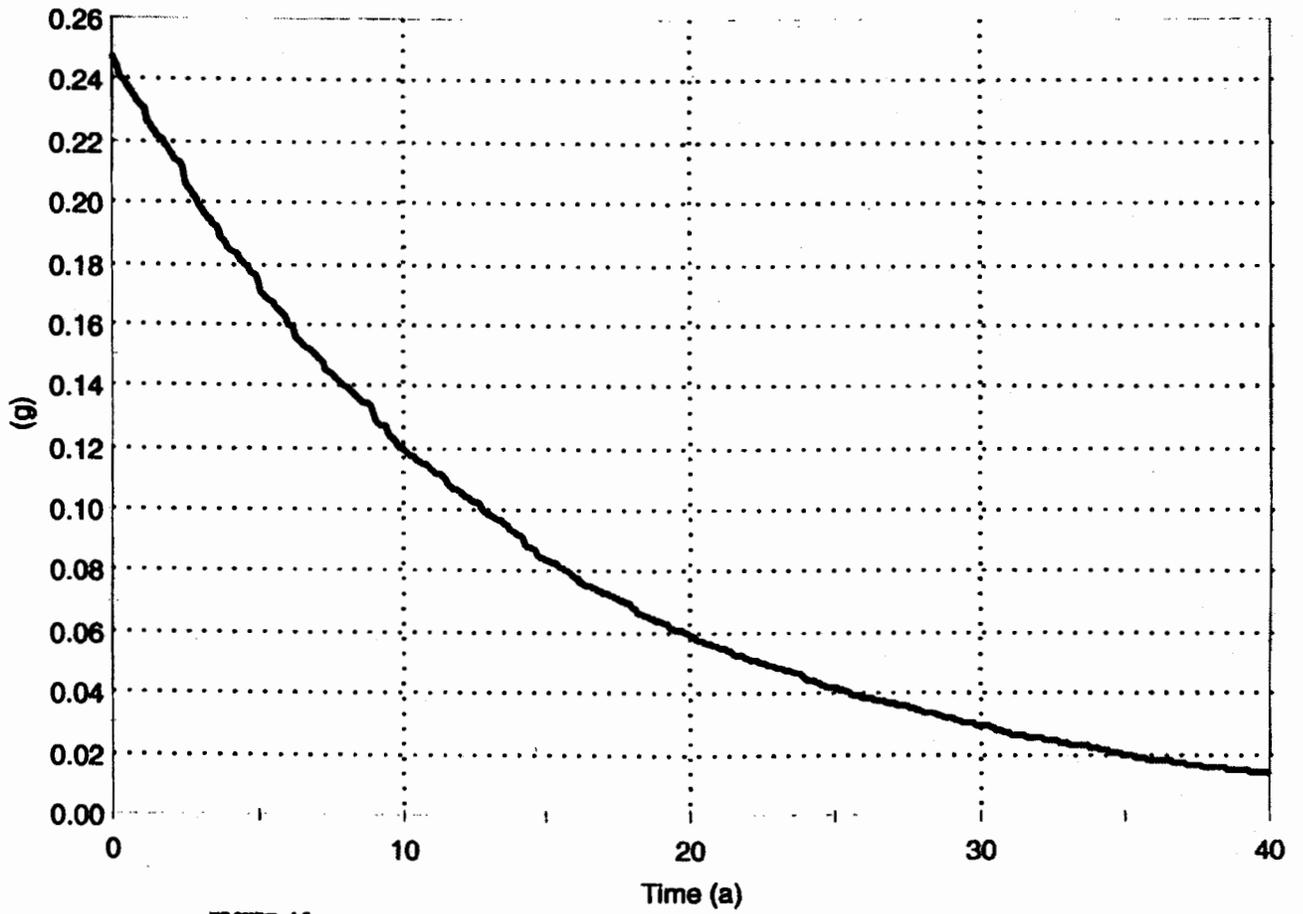


FIGURE 15
Unexposed tritium mass remaining in the classified area inventory by year over 40 years from burial

Col_33_1

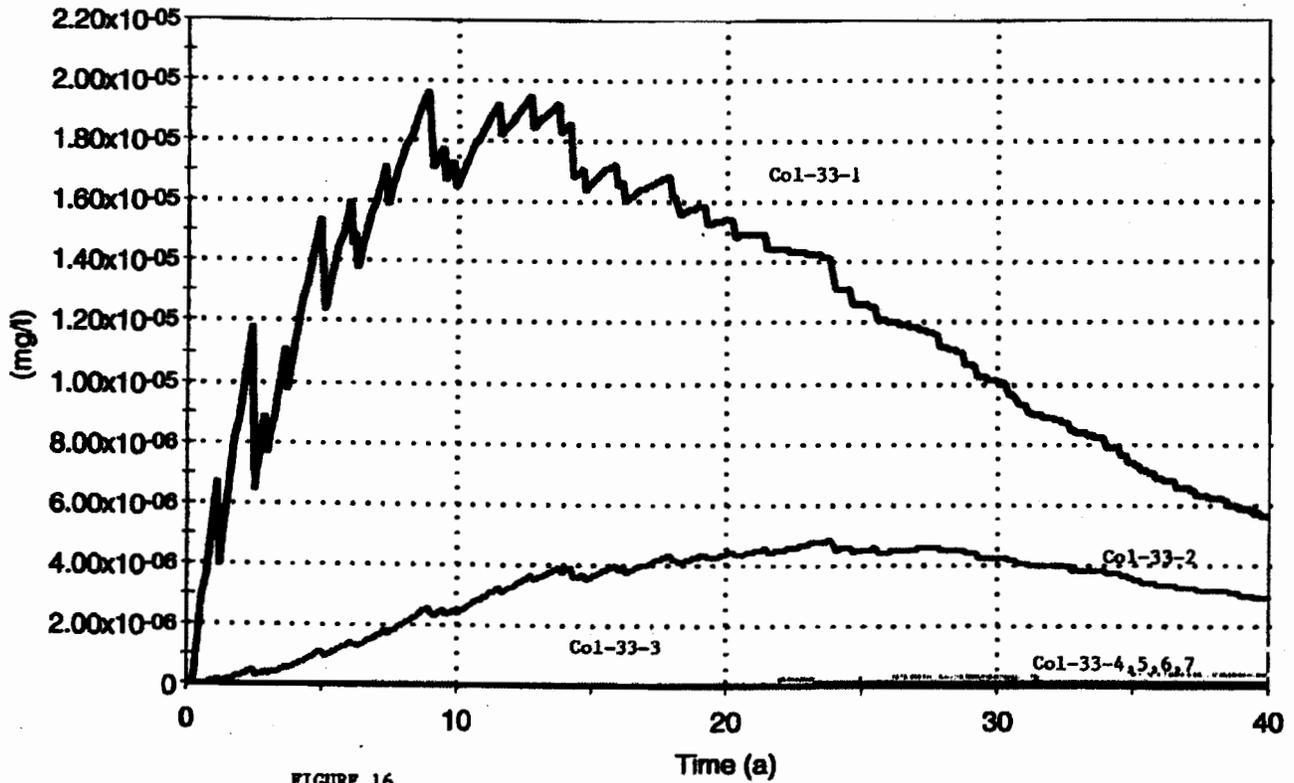


FIGURE 16

Advective concentrations computed for 40 years in mixing cells beneath classified area pit 33

— Col_33_1.Concentration_in_Water[Tritium]	— Col_33_2.Concentration_in_Water[Tritium]
— Col_33_3.Concentration_in_Water[Tritium]	— Col_33_4.Concentration_in_Water[Tritium]
— Col_33_5.Concentration_in_Water[Tritium]	— Col_33_6.Concentration_in_Water[Tritium]
— Col_33_7.Concentration_in_Water[Tritium]	

Pit_33

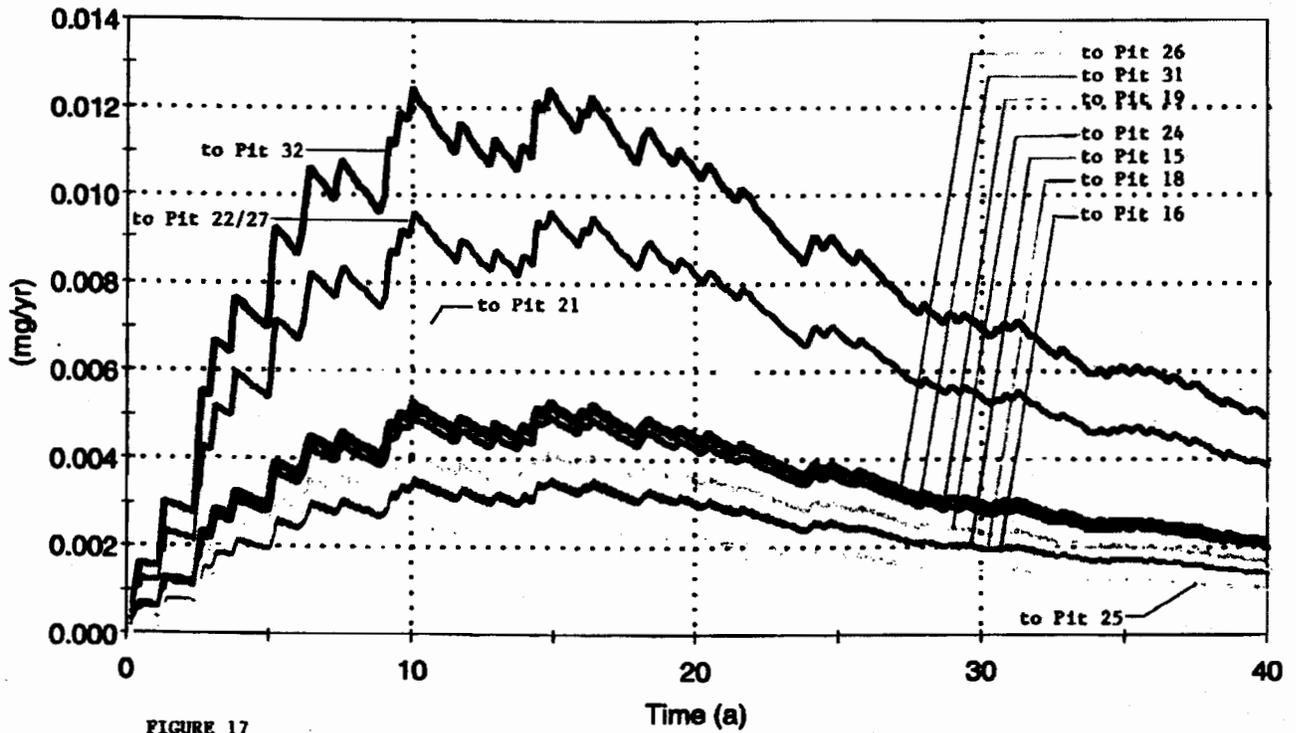


FIGURE 17
Diffusive mass flux from pit 33 computed at 30 ft. in depth for 40 years in mixing cells beneath classified area pits

— Pit_33.Water_to_Water_in_Pit_32[Tritium]	— Pit_33.Water_to_Water_in_Pit_22_27[Tritium]
— Pit_33.Water_to_Water_in_Pit_21[Tritium]	— Pit_33.Water_to_Water_in_Pit_24[Tritium]
— Pit_33.Water_to_Water_in_Pit_19[Tritium]	— Pit_33.Water_to_Water_in_Pit_31[Tritium]
— Pit_33.Water_to_Water_in_Pit_26[Tritium]	— Pit_33.Water_to_Water_in_Pit_16[Tritium]
— Pit_33.Water_to_Water_in_Pit_18[Tritium]	— Pit_33.Water_to_Water_in_Pit_15[Tritium]
— Pit_33.Water_to_Water_in_Pit_25[Tritium]	

Row11_Col1

96

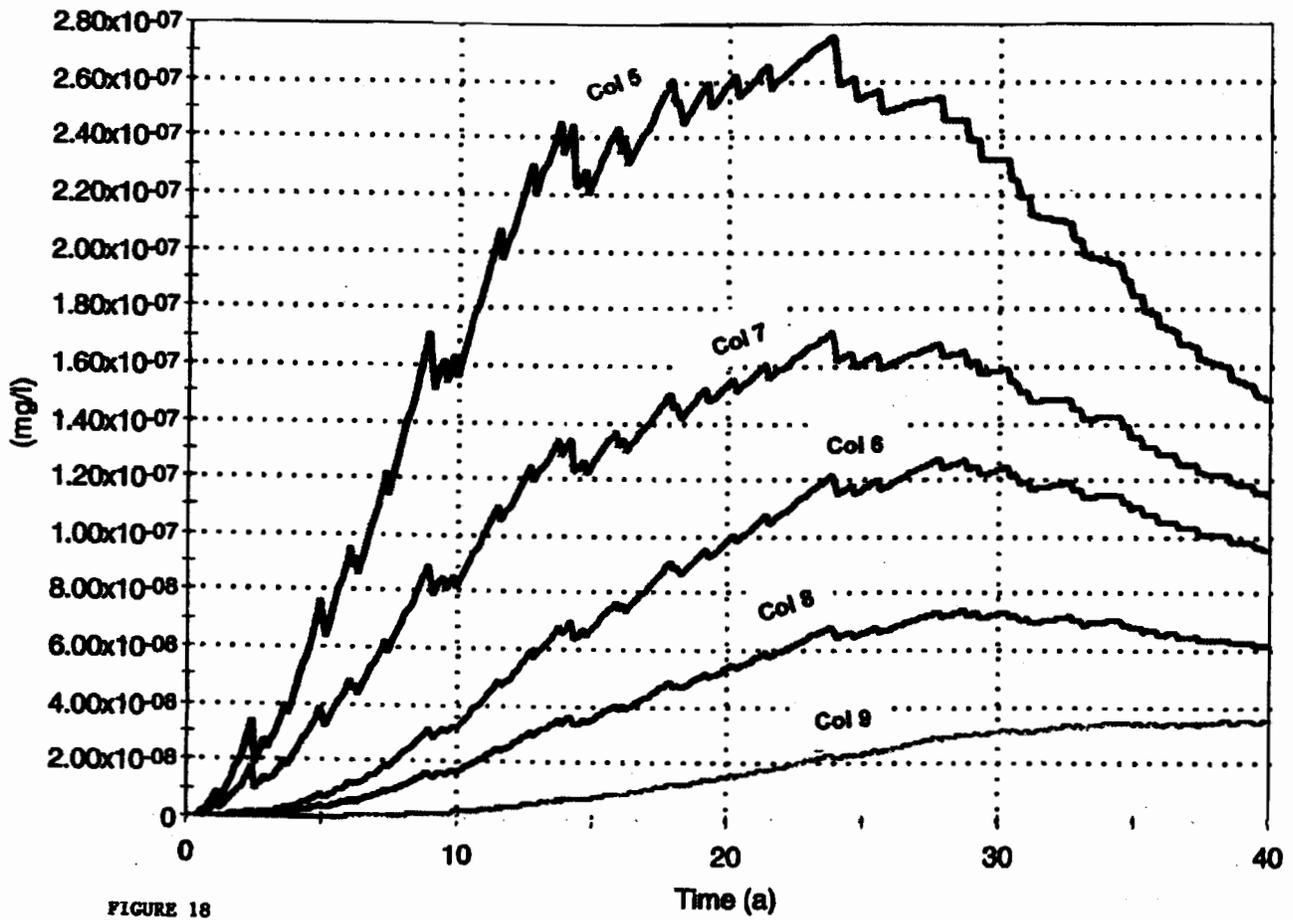


FIGURE 18
Tritium concentration over time from pit 24 at 30 ft. from the ground surface in row 11 for all columns (1 through 9 shown in Figure 2); note that concentrations in columns 1 through 4 are zero as flow does not take place in this direction

Row10_Col1

37

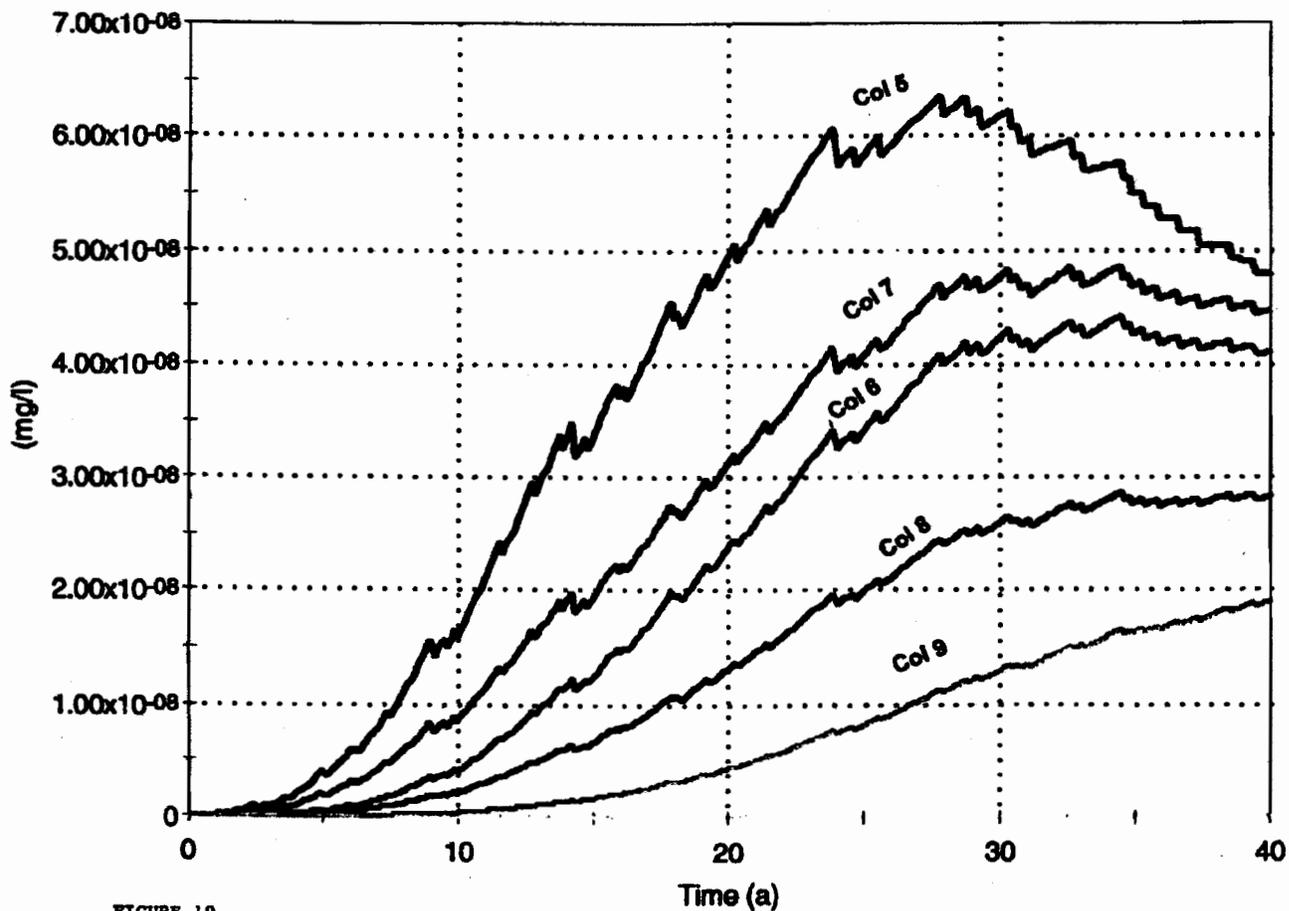


FIGURE 19
Tritium concentration over time from pit 24 at 30 ft. from the ground surface in row 10 for all columns (1 through 9 shown in Figure 2); note that concentrations in columns 1 through 4 are zero as flow does not take place in this direction

Row9_Col1

38

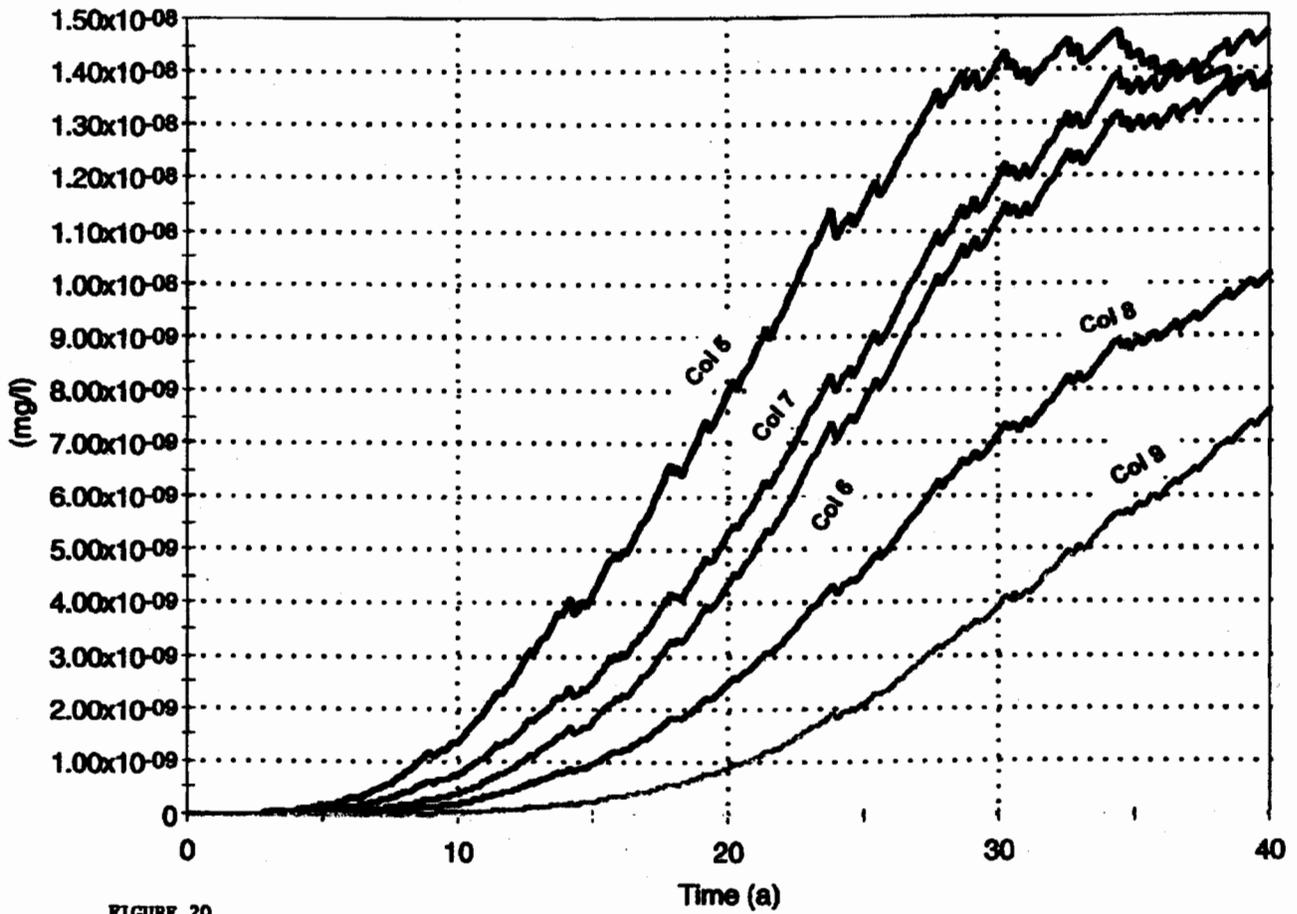


FIGURE 20
Tritium concentration over time from pit 24 at 30 ft. from the ground surface in row 9 for all columns (1 through 9 shown in Figure 2); note that concentrations in columns 1 through 4 are zero as flow does not take place in this direction

Given that monitoring well MW-4 is completed in a deeper zone than the surrounding wells and that the reported values for the chloride, nitrate, and conductivity data are within the range of values reported in Kirtland Air Force Base, it is inconclusive as whether reactor coolant water had reached the ground water based on the geochemical analysis by Mr. Doug Earp.

The reviewer performed a series of calculations and analyses to develop a more accurate determination of the likely area of the discharge water influx. The assumptions and results of these calculations are shown here.

1. An influx rate was matched with water discharge to determine maximum possible area coverage. The rate of discharge from a water truck for delivery of 5,000 gallons was used to estimate influx area for a range of influx rates obtained from field data and an expert on this subject. The results suggested an influx area of about 1,200 square feet was very likely. This value also corresponds to the approximate area covered in a recent field simulation of the truck discharge event by Sandia. Given an area of 1,200 square feet and using the Baskaran simplified calculational model, the 204,000 would have only saturated a zone from the surface to a depth of about 100 feet.
2. Photograph of Trench D (see Figure 8) was evaluated by the reviewer and it was estimated that the remaining area available in 1966 for discharge water influx was about 1,200 square feet. This value is estimated using the dimensions of the fence/gate.
3. Other considerations:
 - lateral movement of the water (K_H/K_V is 10 to 100), where K_H equals horizontal hydraulic conductivity and K_V equals vertical hydraulic conductivity
 - an aquitard at 100 feet—The soils become richer in clay/silt at this depth.
 - surface evaporation of the water

The above factors suggest a simple model assuming the volume directly under the influx area is very conservative. In all likelihood some of the 204,000 gallons of discharge water evaporated and there was likely considerable horizontal spreading.

In summary, using an area estimation of 1,200 square feet and reconsidering the variability in the geochemist of the groundwater at Kirtland Air Force Base it is unlikely that the 204,000 of reactor discharge water migrated to the water table.

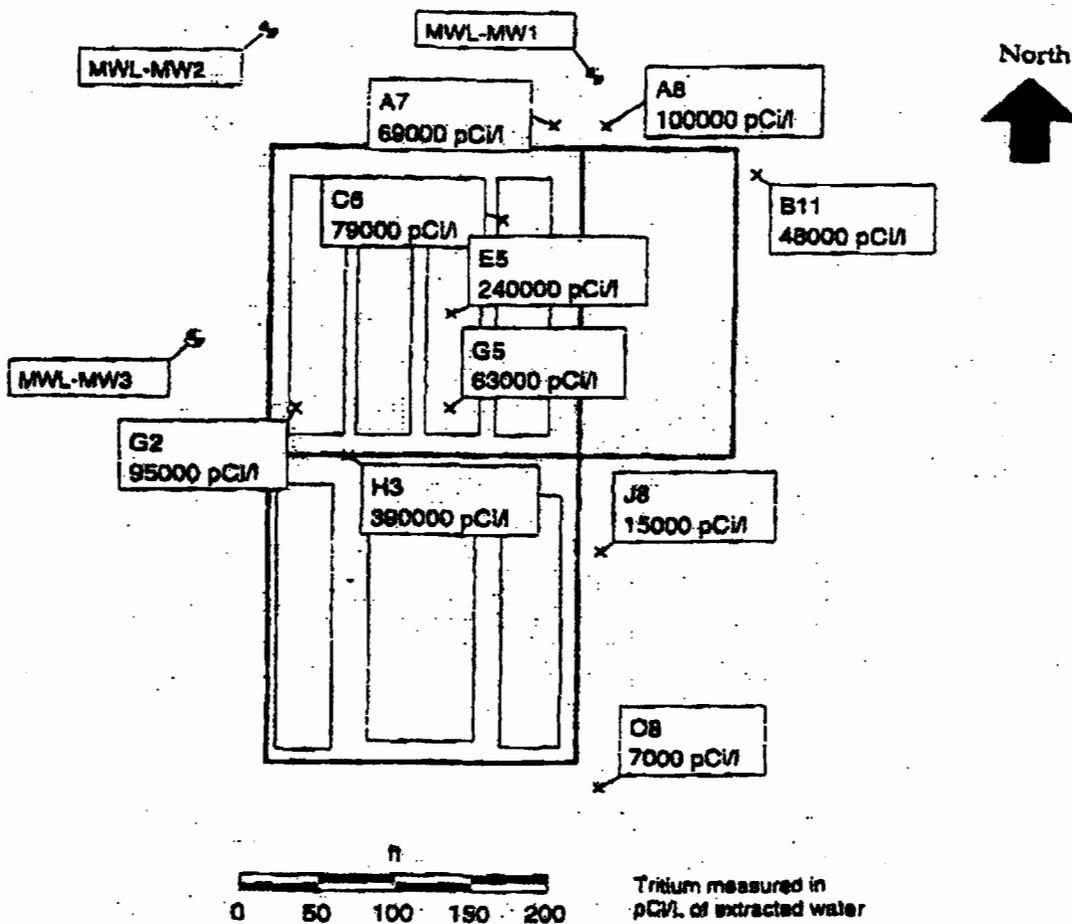


FIGURE 21
1990 Surface Soil Sample Tritium Results for Samples Above Background
 (Baskaran, "Mixed Waste Landfill Review", July 5, 2000 derived from Sandia National Laboratories Phase I and Phase 2 RCRA RFI reports)

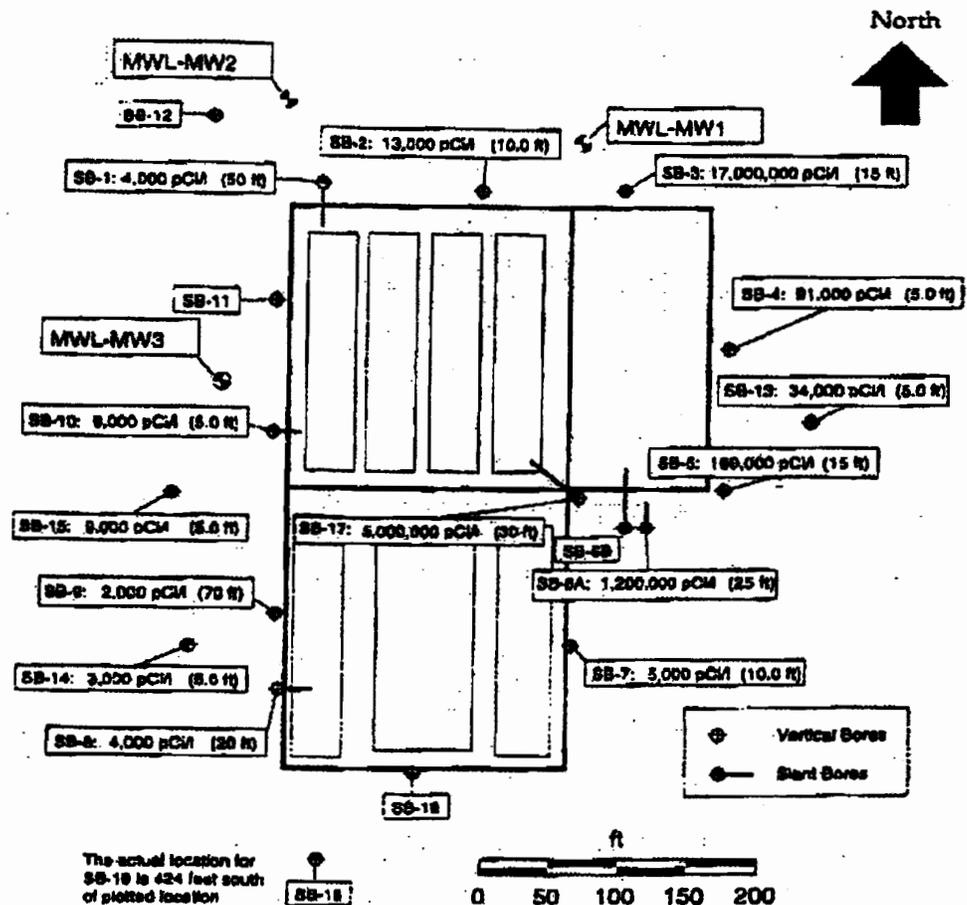


FIGURE 22
 Location and Depth of Maximum Subsurface Tritium
 Soil Concentrations Measured in pCi/L of Extracted Water
 (Baskaran, "Mixed Waste Landfill Review", July 5, 2000
 Derived from Sandia National Laboratories Phase 1
 and Phase 2 RCRA RFI reports)

statement requires further explanation. A more detailed discussion of the how the mean concentrations were determined is required to determine whether this approach is acceptable and all these values should be reported in the risk assessment section in table format.

- ✓ For arsenic, how many samples were there? How many had positive detection values (presumably all of them)? What were the range, mean, and 95th confidence limits for the bore hole samples? How many samples were used to determine the background concentration of arsenic? What were the range, mean, and 95th confidence limits for the borehole samples which determined the background concentration?
- ✓ For 1,1,2,2-tetrachloroethane, it is stated that only 1 sample had a positive detection value. What is the detection limit and how high above the detection limit was that 1 positive sample? Does this mean that the mean concentration is equal to:

$$\{(95 \text{ samples} \times \text{detection limit}) + (1 \text{ sample} \times \text{determined value})\}/96$$

- ✓ For methylene chloride, only 9 samples had positive detection values, but all were estimated. What is the detection limit and what is the range of values for the 9 positive samples? Again, is the mean concentration equal to:

$$\{(87 \text{ samples} \times \text{detection limit}) + (9 \text{ sample} \times \text{determined value})\}/96$$

- ✓ For trichloroethene, only 2 samples had positive detection values, but both were estimated. What is the detection limit and what are the values for the 2 positive samples? Again, is the mean concentration equal to:

$$\{(94 \text{ samples} \times \text{detection limit}) + (2 \text{ sample} \times \text{determined value})\}/96$$

- Additional statistical analysis of the sampling data may reveal that the samples in which 1,1,2,2-tetrachloroethane and trichloroethene were detected can be considered outliers. In addition, given that 1,1,2,2-tetrachloroethane, methylene chloride, and trichloroethene are not chemicals listed on the MWL inventory, the uncertainty assessment could further discuss the likelihood of why these chemicals were detected and if these sampling data are meaningful.
- Sandia National Laboratories states that the inhalation pathway is driving the risk above the proposed standard for arsenic and trichloroethene and exposure via the inhalation pathway represents a conservative estimate (pages 39 & 40). The conclusion that negation of the inhalation pathway is reasonable is not supported by any data or discussion in this document. It is likely that the rationale for reaching this conclusion has been addressed in previous meetings and reports.

Thus, as an outside scientific reviewer without knowledge of this previous process, there are minor items in this report that require clarification: (1) if this report is to serve as a final summary document of the risk assessment process for the outside public and scientific community, and (2) in order to fully understand the risk assessment process that led to the conclusion that the risk posed to ecological receptors is below that requiring action.

6.2.1 Significant Issue of Concern on the Ecological Risk Screening Assessment

- Sandia National Laboratories fails to apply an uncertainty factor when extrapolating the NOAEL (no observed adverse effect level) from the test species to the species of interest. This represents a significant limitation in estimating the risk potentially posed by COPECs to the ecological receptors. This may be less of a concern for extrapolation of NOAEL values determined in laboratory rats and mice to deer mice, but is of significant concern when extrapolating from mallards and ring doves to burrowing owls. There clearly will be differences in sensitivity among species and extrapolation must be applied in ecological risk assessment when effects for a valued species (burrowing owl in this case) must be estimated from data for a test species (mallard and ring doves) (Suter, 1993). The EPA "Risk Assessment Forum" recommended applying an uncertainty factor of 5 to account for differences in species sensitivity.
- It is understood that the standard procedure approved by New Mexico regulators and applied at the Sandia National Laboratories is to use body-scaling factors to adjust for differences in species sensitivity and not to apply uncertainty factors. The approach applied in this ecological risk assessment assumes that different species with similar body size will be equivalent in their toxicological sensitivity to a given chemical. Numerous studies in the scientific peer-reviewed literature do not support this assumption.
 - ✓ For example, the body size of lake trout and rainbow trout embryos are the same, but a body concentration of 75 part per trillion (ppt) of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, a persistent environmental pollutant, will kill the lake trout, while a body concentration of 500 ppt is needed to kill the rainbow trout (Walker et al., 1991; Walker and Peterson, 1991).
 - ✓ Similarly, mammals also exhibit dramatic species differences in their sensitivity to the same chemical even after body size is taken into account. An example of this is the responsiveness of different mammalian species to the limb teratogenicity of thalidomide. Even when body size is taken into account, only rabbits, humans, and non-human primates exhibit a significant teratogenic response to thalidomide exposure, while rats, cats, hamsters, and all but one mouse species do not (Addendum I, reviewed in Schardein 2000). And humans are more sensitive than any laboratory species tested.

- ✓ These are only two of numerous examples of species differences in toxicological sensitivity to chemicals demonstrated in the literature. Failure to adequately address potential differences in species sensitivity significantly limits the conclusions that can be made from the *SWMU 76: Ecological Risk Screening Assessment* dated 05/01/01.

6.2.2 Minor Issues Requiring Clarification on the Ecological Risk Screening Assessment

If this report is intended to serve as a final summary document of the risk assessment process for the outside public and scientific community, the following items require clarification or additional explanation.

- Sandia National Laboratories discuss a variety of approaches to decrease uncertainty associated with estimation of the true risk posed by the SWMU 76 to ecological receptors; however, the final hazard quotients and total hazard indices are never presented. In order for reviewers to evaluate the final conclusions of the report that ecological risks are predicted to be low, a final table must be included that documents the hazard quotients when using more realistic analyte concentrations and home range values and the final HI (hazard index) value for each ecological receptor. This is in contrast to the human health risk assessment where Sandia discusses its uncertainty assessment and then reports the new HQ (hazard quotient) values and cancer risk factors based on applying new uncertainty criteria. This should also be conducted for the ecological risk assessment.
- Page 46. VII.3.1.3 Ecological Receptors. It was never mentioned whether burrowing owls are resident at Kirtland Air Force Base. Given that the burrowing owl has been designated as a species of management concern by the U.S. Fish and Wildlife Service in Region 2, it would be nice to know if any censuses have been conducted and what the current status of burrowing owl population is on the Base. Given that the presence of small mammals at SWMU 76 was taken as a sign that COPECs are not having a significant impact on the small mammal population adjacent to the site, it would be useful to know the status of burrowing owl populations as well.
- Page 54. VII.3.5 Uncertainty Assessment. A thorough discussion of all the uncertainties associated with this risk assessment needs to be conducted in order to convince readers that the risk posed to ecological receptors is low. It is agreed that use of the maximum measured COPEC analyte concentrations and assumption of 2.6 acre SWMU 76 making up the entire home range of the burrowing owl represent conservative estimates for calculation of COPEC hazard quotients. These two assumptions will result in an overestimation of the potential risk. However, modeling the deer mouse as strictly herbivorous, omnivorous, or

Section 6.0 References

Shardein, J.L. 2000. Thalidomide: The Prototype Teratogen. *In* Chemically Induced Birth Defects, 3rd Edition. (Shardein, J.L. ed.), Marcel Dekker, Inc., New York, NY. Pp. 89-119.

Suter, G.W., II. 1993. Organism level effects. *In* Ecological Risk Assessment. Lewis Publishers, Chelsea, MI. pp. 175-246.

Walker, M.K., J.M. Spitsbergen, J.R. Olson, and R.E. Peterson. 1991. 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (TCDD) toxicity during early life stage development of lake trout (*Salvelinus namaycush*). *Can. J. Fish. Aquat. Sci.* 48(5): 875-883.

Walker, M.K., and R.E. Peterson. 1991. Potencies of polychlorinated dibenzo-*p*-dioxins, dibenzofurans, and biphenyls, relative to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin, for producing early life stage mortality in rainbow trout (*Oncorhynchus mykiss*). *Aquat. Toxicol.* 21: 219-238.

U.S. Environmental Protection Agency. 1993. A review of ecological assessment case studies from a risk assessment perspective. EPA/630/R-92/005.

7.3 Validity of Uranium Measurements pre-2001

Between 1993 and 1995 four separate analytical laboratories reported uranium activity and U-238/U-235 activity ratios. The isotopic activity values were made by measuring the radioactivity of these isotopes, i.e., disintegration rates for the isotopes. The errors of measuring activity with this method can be substantial because the time required to count disintegrations can be long (10 seconds/disintegration/L for a reported U-235 measurement of 2.6 pCi/L and 3.7 minutes/disintegration/L for a U-238 measurement of 0.12 pCi/L). The uranium isotope activities, their associated errors (2-sigma values for 95% uncertainty), the U-238/U-235 activity ratios, and the uncertainty of the ratios calculated by propagation of error are tabulated in Table 3 and plotted in Figure 23. The interpretation by the Baskaran report was that the U-238/U-235 activity ratios were significantly less than 21.67 and therefore suggested possible leaching of uranium by the MWL to the groundwater. This interpretation, cannot be statistically justified for the following reasons:

- One laboratory, ITAS-OAK Ridge, has isotopic activity ratios that are significantly larger than 21.76 (mean activity ratio is 30.58). However, this laboratory does not report the associated error and it is therefore impossible to calculate the uncertainty of the activity ratio. An isotopic activity ratio that is larger than 21.76 is difficult to interpret, anyway.
- TMA Eberline laboratory also reports an isotopic activity ratio (mean activity ratio is 22.98) that is larger than 21.76. However, their precision is very poor; it is the poorest of the three reporting laboratories (see Figure 23). The range for the relative errors of the uranium isotopic activity ratios is 33-92% of the calculated ratio. This translates to absolute error margins that are 4.7 to 38.7 units above and below the reported isotopic activity ratio.
- The remaining two labs (Quanterra and LAS) have all of their values below the accepted 21.76 ratio (implications of altering the natural abundance in favor of U-235). However, again the precision is very poor, 35-95% relative error for Quanterra and 31-39% relative error for the LAS lab.
- For the three labs that report statistical errors (Figure 23), the measurements are indistinguishable from each other; i.e., because the uncertainty ranges are so large, the values between the labs are not significantly different. Except for two measurements, all the 2-sigma error bars overlap (95% uncertainty).

Some labs have isotopic activity ratios >21.76 and others have values <21.76 . Yet all are statistically indistinguishable with 95% (2-sigma) error margins. The precision is poor. Thus, the assumption presented by the Baskaran report that uranium from the MWL might be affecting the groundwater, although not unreasonable, is questionable.

Methods that are valid for the heavy elements may not necessarily apply to the hydrogen isotopes, tritium for example. Hydrogen isotopes have established natural abundance ratios that can be used to calibrate the method. Important for these trace measurements are the limit of detection (LOD) and the limit of quantitation (LOQ). Reliable data will take into consideration signal to noise measurements and LODs are signals that are 3-sigma above the background and LOQs are signals that are 10-sigma above background.

7.6 Hazardous Wastes - Minor Concerns

Besides the radionuclides, there are hazardous chemicals buried in the MWL. Some of the chemicals that were detected may not originate from the MWL. Certainly, the detection of phthalic acid esters and other derivatives is a case where these compounds can be ignored as being leachates from the MWL. Phthalates occur in samples because they are ubiquitous. A statement to this effect is sufficient.

Organic compounds were also detected and they might be attributed to the monitoring well casings and packer apparatus and thus could be dismissed as leachates from the MWL. This supposition needs to be tested and reported. A suggestion would be to subject the drilling components and packer assemblies to water and the conditions in the well. The solution would then be selectively tested for the specific compounds. If the selective compounds appear in this "blank", then leaching by the MWL can be disregarded for these compounds. To this end, the suspected packer assembly associated with the toluene detection will be removed in the summer/fall of 2001 and replaced. Sandia National Laboratories is planning on performing tests to determine if this assembly is the source of the toluene.

7.7 Data Points that are Considered "Outliers" - Statistical Evaluation

There are a few cases where the presence of a compound or radionuclide in a sample is questionable or at least needs to be evaluated. The first concerns that should be addressed are the LOD and LOQ that were noted above. If the measurements are quantitative, then there are statistical tests to confirm, refute, or reject the existence of the "outlier" data. Even the simple Q-test could be applied. A statistical basis for data rejection should be used in every case that applies. As long as the MWL is not excavated, then continued monitoring is necessary to improve and augment the database. This becomes paramount for rejection criteria since they are based on statistical evaluations.

Figure 23. U-238/U-235 Ratios (95% uncertainty error bars), 3 Analytical Labs

65

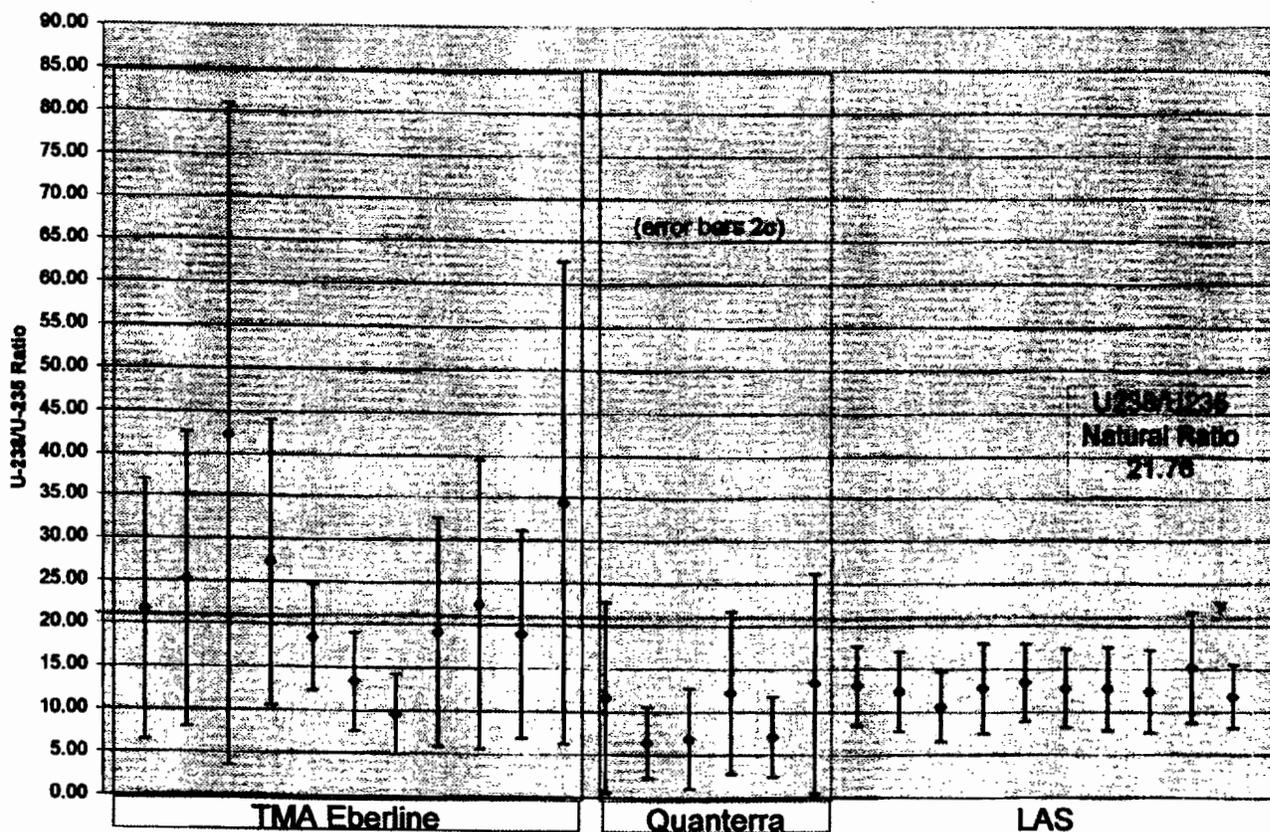


Table 3. Uranium Isotopic Ratio Analyses / Monitoring Radioactive Disintegrations

Analytical lab	date	U-238 activity (pCi/L)	U-235 activity (pCi/L)	uncertainty U-238 (2σ)	uncertainty U-235 (2σ)	isotopic ratio 238/235	% rel uncertainty U-238	% rel uncertainty U-235	relative error of ratio	for plotting only	for plotting only	absolute error of ratio
TMA	8/11/93	2.6	0.12	0.44	0.082	21.67	16.9	68.3	70	TMA Eberline	21.67	15.3
Eberline	9/11/93	2.5	0.099	0.30	0.066	25.25	15.6	66.7	68	TMA Eberline	25.25	17.3
	10/11/93	3	0.071	0.5	0.084	42.25	16.7	90.1	92	TMA Eberline	42.25	36.7
	10/11/93	3	0.11	0.41	0.066	27.27	13.7	60.0	62	TMA Eberline	27.27	16.8
	11/11/93	2.4	0.13	0.21	0.042	18.46	8.8	32.3	33	TMA Eberline	18.46	6.2
	14/11/93	2.6	0.21	0.49	0.082	13.33	17.5	39.0	43	TMA Eberline	13.33	5.7
	2/5/94	2.2	0.23	0.49	0.1	9.67	22.3	43.5	46	TMA Eberline	9.57	4.7
	3/5/94	1.8	0.094	0.42	0.082	19.15	23.3	66.0	70	TMA Eberline	19.15	13.4
	3/5/94	2	0.069	0.46	0.054	22.47	23.0	71.9	75	TMA Eberline	22.47	17.0
	4/5/94	1.9	0.1	0.42	0.08	19.00	22.1	60.0	64	TMA Eberline	19.00	12.1
	31/5/94	2.1	0.061	0.48	0.048	34.43	22.9	78.7	82	TMA Eberline	34.43	28.2
Quanterra	24/10/94	2.33	0.2	0.7	0.18	11.65	30.0	90.0	95	Quanterra	11.65	11.1
	25/10/94	2.45	0.38	0.64	0.22	8.46	26.1	57.9	64	Quanterra	6.45	4.1
	25/10/94	2.2	0.32	0.71	0.25	8.68	32.3	78.1	85	Quanterra	8.68	5.8
	27/10/94	3.18	0.28	0.81	0.19	12.23	25.5	73.1	77	Quanterra	12.23	9.5
	27/10/94	3.05	0.43	0.8	0.26	7.09	26.2	60.5	66	Quanterra	7.09	4.7
	28/10/94	2.94	0.22	0.85	0.2	13.36	26.9	90.9	95	Quanterra	13.36	12.7
LAS	17/4/95	2.41	0.184	0.25	0.082	13.10	10.4	33.7	35	LAS	13.10	4.8
	17/4/95	2.02	0.163	0.22	0.058	12.39	10.9	35.6	37	LAS	12.39	4.8
	19/4/95	1.81	0.171	0.22	0.062	10.58	12.2	36.3	36	LAS	10.58	4.0
	19/4/95	1.81	0.142	0.21	0.056	12.75	11.6	39.4	41	LAS	12.75	5.2
	16/10/95	2.26	0.169	0.22	0.054	13.37	9.7	32.0	33	LAS	13.37	4.5
	16/10/95	1.66	0.146	0.2	0.05	12.74	10.8	34.2	36	LAS	12.74	4.6
	20/10/95	2.23	0.176	0.25	0.065	12.67	11.2	36.9	39	LAS	12.67	4.9
	20/10/95	1.72	0.139	0.2	0.051	12.37	11.6	36.7	36	LAS	12.37	4.8
	20/10/95	1.76	0.116	0.19	0.048	15.17	10.8	41.4	43	LAS	15.17	6.5
	23/10/95	2.21	0.167	0.22	0.056	11.82	10.0	29.4	31	LAS	11.82	3.7

Table 4. Uranium Isotopic Ratio Analyses / ICP - Mass Spectrometry

Analytical lab	date	U-238 activity (pCi/L)	U-235 activity (pCi/L)	uncertainty U-238 (2 σ)	uncertainty U-235 (2 σ)	isotopic ratio 238/235	% rel uncertainty U-238	% rel uncertainty U-235	relative error of ratio	for plotting only	for plotting only	absolute error of ratio
806 lab rpedp	5/4/01	1.431	0.066	0.067	0.006	21.68	6.1	9.1	11	1	21.68	2.4
	9/4/01	1.67	0.079	0.047	0.001	21.14	2.8	1.3	3	2	21.14	0.7
	18/4/2001	2.028	0.095	0.118	0.003	21.35	5.8	3.2	7	3	21.35	1.4
	6/4/01	1.373	0.065	0.066	0.004	21.12	6.3	6.2	9	4	21.12	1.9
	4/4/01	1.548	0.072	0.041	0.002	21.47	2.7	2.8	4	5	21.47	0.8
	16/4/2001	2.444	0.113	0.276	0.013	21.63	11.4	11.5	16	6	21.63	3.5
	17/4/2001	2.207	0.103	0.183	0.009	21.43	8.3	8.7	12	7	21.43	2.6
	17/1/2001	3.249	0.151	0.091	0.003	21.52	2.8	2.0	3	8	21.52	0.7
	18/1/2001	2.853	0.134	0.114	0.006	21.29	4.0	6.0	7	9	21.29	1.5

been quantified in documents available for review. These data would also be very useful for proposing alternatives to excavating today and estimating a future date at which time the landfill would be excavated.

8.4 Summary of Analytical/Radiochemistry and Measurement Errors

A key issue that arose in the review of MWL reports, sampling data, and outside reviews was an argument that the U-238/U-235 activity ratios were less than 21.76 in ground water samples and hence suggested non-natural or anthropogenic sources of uranium existed beyond the MWL. Analytical results from two laboratories report mean values that are larger than the accepted natural abundance activity ratio of 21.76, and two other laboratories reported mean values that are less than the 21.76 values. However, the precision is extremely poor, and the activity ratio is not established. A recent round of analytical testing provides a method of measuring activity ratios using mass spectrometry and the precision is very tight. The method also strongly suggests that the uranium levels are those of the natural abundance of the element and thus it can be concluded that the MWL has not leached uranium into the groundwater. However, a different laboratory should confirm this finding using similar analytical methods to add an element of accuracy.

8.5 Additional Observations

It is recommended that Sandia National Laboratories should compile all of the relevant information related to this site in one document series. Much of this information is currently available in two public reading rooms in Albuquerque that are maintained by Sandia National Laboratories. The first is located at the University of New Mexico, Zimmerman Library, Government Information Department; and the second location is in an office building at 8338 B Comanche Road NE.

APPENDIX A

**Biographic Sketches of
Peer Panel Members
and Facilitators**

Appendix A
Biographic Sketches of Peer Panel Members and Facilitators

Peer Panel Members:

AIMONE-MARTIN, Catherine - Dr. Aimone-Martin received her BS degree in Geological Engineering from Michigan Tech and a Ph.D. from Northwestern University in Mineral Resources Engineering and Management and Civil (Geotechnical) Engineering. Dr. Aimone-Martin is a Professor Mineral Engineering at New Mexico Institute of Mining and Technology. Since 1971, she has worked in the mining industry and with geotechnical consulting firms in both the U.S. and Canada. Her research and training work spans 20 years with academia and national laboratories. Dr. Aimone-Martin's expertise is in the areas of soil mechanics and rock mechanics, explosives engineering and blasting vibration control, site investigation, drilling, instrumentation, engineering aspects of surface and groundwater, mine permitting and reclamation compliance, and geostatistics. Her experience includes the design and construction of mining and civil engineering projects such as solid waste landfills, earth dams and other hydrologic retention structures, slope stability analysis and assessment of earthquakes and blasting vibrations. Dr. Aimone-Martin has acted as Principal Engineer in the site investigation and permitting of three solid waste and one hazardous waste landfills in New Mexico. Since 1989, she has worked with both Sandia National Labs and Westinghouse WID on rock mechanics and performance assessment of the Waste Isolation Pilot Project (WIPP). Dr. Aimone-Martin serves on numerous committees and review panels for the National Research Council and the National Science Foundation, is a Board Member of the New Mexico Mining Association, and recently, appointed to the Surface Coal Mining Commission by New Mexico Governor Gary Johnson.

CAMPANA, Michael - Dr. Campana received his BS degree in Geology from the College of William and Mary, and an MS and a Ph.D. degree in Hydrology from the University of Arizona. He was at the Desert Research Institute from 1976-1989 and also taught in the University of Nevada's Hydrologic Sciences Program during this period. He is currently the Director, Water Resources Program and a Professor, Department of Earth and Planetary Sciences at the University of New Mexico. Dr. Campana has over twenty-five years experience in the academic field with responsibilities in geology, hydrogeology, earth and planetary sciences, and water resources. He is a Fulbright Scholar who taught watershed management at the University College of Belize and provided research assistance to Egyptian hydrologists and engineers. Over the past twelve years, Dr. Campana has performed research in hydrogeology for the U.S. Geological Survey, State of New Mexico, U.S. Department of Energy, Sandia National Laboratories, and the National Science Foundation and has over 50 publications. He is a member of the National Research Council's Committee on USGS Water Resources Research; and holds board positions with the Association of Ground-Water Scientists and Engineers, Universities Council on Water Resources, and the American Institute of Hydrology.

assessment of existing technologies for DOE's radioactive and mixed waste problems, molten salt oxidation for the treatment of organic wastes, a proprietary Russian technology for the separation of cesium and strontium from high-level wastes, and engineering barriers for DOE's Waste Isolation Pilot Plant. Mr. Carlson has participated on two peer panels which evaluated the technology options for treating mixed waste at Los Alamos National Laboratory and at the Savannah River Site.

WERC Staff:

GHASSEMI, Abbas - Dr. Ghassemi received his BS from the University of Oklahoma and his MS and Ph.D. in Chemical Engineering from New Mexico State University in Las Cruces, NM. He has more than 20 years of industrial, academic, chemical, and environmental hands-on engineering experience. Dr. Ghassemi is an Associate Professor Chemical Engineering and is the Executive Director of WERC (a Consortium for Environmental Education & Technology Development). Over the past 10 years, Dr. Ghassemi has been responsible for managing the following WERC programs: Industrial Affiliates, Summer Environmental Design Institute, International Environmental Design Contest, outreach, technology transfer and demonstration, new business development and new technology development programs. Prior to joining NMSU, Dr. Ghassemi compiled extensive experience in technical and marketing management, process control, process operation and optimization by more than ten years of employment at Fisher Controls International and Monsanto Company. He has extensive experience in the environmental field including pollution prevention, waste management, environmental remediation, and technology identification. He has served as technical expert in several environmental litigation cases as well as technical peer review panels and international training projects in the environmental health and risk assessment fields. He is the author of more than 75 papers and publications in the fields of process control, thermodynamics, environmental engineering and education. He is also co-editor and contributor to several textbooks in the area of environmental technology and management.

APPENDIX B

Sandia National Laboratories

Mixed Waste Landfill

Inventory of Disposed Materials by Pit and Trench

943 ft³ of TA-5 routine operational and miscellaneous decontamination waste.

TRENCH B

HEPA filters, fiberglass filters, final and prefilters; MFP-, DU-, and tritium-contaminated vacuum cleaners; cables; ultra-sonic air samplers; irradiated diodes, transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; MFP- and tritium-contaminated fume hoods, ducting, motors, fans, and plenums; boxes of fluorescent light bulbs; sanding disks; neutron generator tubes; backing plates from TA-5 experimental apparatus; packing materials and wooden shipping crates; metal drums from NTS containing DU; alpha-contaminated gas bottles; empty liquid scintillation vials; Ta-182 contaminated platinum-tungsten scrap; heater elements; 10 Ci tritium targets; neutron generator magnets; 14 each empty steel gas cylinders contaminated with DU; 9 each MFP-contaminated ceramic tubes; 1.5-gallons of solvents absorbed on vermiculite in sealed A/N cans; 6 each small storage cabinets; vacuum system components including water circulators, valves, diffusion pumps, fittings, gas analyzers, and vacuum pumps; gas sample bottles from NTS; tritium-contaminated tools; DU metal shavings and cuttings; Victoreen Sr-90 ion chambers; glove box and work bench; demineralizer vessel from reactor; neutron radiograph equipment; thermal reflecting rings; micro scales; Kr-85 light sources; 11 kg deuterium containing 0.25 Ci of tritium; 1-gallon toluene absorbed on vermiculite in sealed A/N can; static meter; Ta-182 pellets; demineralization and radiography tubes.

1326 ft³ of TA-5 routine operational and miscellaneous decontamination waste.

TRENCH C

Nuclear fuel shipping cask cleanup debris; tritium and C-14 labeled amino acids and tritium labeled uridine; scrap metal contaminated with DU from burn test; 7.1 Ci tritium pellets; uranyl nitrate; "dining car" test hardware; MFP-, DU-, and tritium-contaminated vacuum cleaners; vacuum hose contaminated during cleaning of thorium cloth and thorium cloth debris; concrete crucibles used in reactor safety studies; Kr-85 particle size analyzer; 1,000 lead bricks contaminated with tritium and Na-22; 43 MFP-contaminated lead bricks; 73 each integrated circuits; Ba-133 reactor bolts; flexible glove box ducting; 2 each mechanical vacuum pumps; Sr-90 contaminated carpet; Cs-137 spark gaps; Na-22 cleanup materials, source holders, and shield (1.5 rem/hr on contact); DU-contaminated waste containers; tritium-contaminated vacuum system and power supply; DU billet, hemisphere, and sphere; Pu-238 contaminated hood exhaust hose; Co-60 debris from trailer used to support nuclear fuel shipping cask; MFP-contaminated hot exhaust system prefilters, HEPA filters, and absolute pressure filters; containerized DU residue, turnings, metal workings, and cuttings; surge voltage arrester; tritium-contaminated pump; irradiated diodes, transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; wooden shipping crates; 13 each Po-210 contaminated static eliminators; one each 62 mCi Se-75 source and one each 1.0 mCi Ta-182

TRENCH E

38 each 55-gallon drums of MFP-contaminated spent demineralizer resin; 7 each 55-gallon drums from Three Mile Island containing MFP-contaminated cables, instruments, and electronic components; 11 each Po-210 contaminated static eliminators; 10-gallons Cs-137 solution solidified with Safe-T-Set in sealed A/N can; oil from lapidary shop solidified with soil in sealed A/N can; irradiated diodes, transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; 6 each irradiated 9 ft 10 in. long X 9 in. dia. stainless steel storage tubes and holding rings; activated top and bottom reactor vessel sections; hydraulic pumps; ion pumps; steel frame and motor assembly from "KIVA" door; burned wood from weapons experiment; 2 each burned empty 55-gallon drums; MFP-contaminated vacuum pumps; obsolete and old test equipment and materials used in reactor fuel tests; DU-contaminated glove box; HEPA filters from hot exhaust plenum; DU-contaminated vacuum and filtering system bracket and assembly; DU-contaminated machine shop cabinets, work tables, filters, and ground cloths; 4 each TV cameras; 45 Ci neutron generator tubes; DU-contaminated crucibles; janitorial barrels; vacuum pumps; file cabinets; 70 lbs. thoria-contaminated soil; tritium-contaminated ion pump; one damaged DU-contaminated shake table or "vibrator" for sieving powdered DU; 10,000 lbs. of decommissioned reactor debris from extensive modifications to the reactor including ventilation ducts, conduit, PVC, nuts and bolts, hot water radiators, metal support parts, concrete, insulation, cable, air blowers, camera equipment, light bulbs, metal stands, electronic equipment, vacuum cleaners, pumps, coveralls, lumber, scaffolding, tables, chairs, gauges, regulators, valves, glove boxes, and stainless steel; 2,500 ft³ of DU-contaminated soil; plywood ventilation duct; Mettler balance; Sartorius balance; fume hood; Magniwhirl bath; lab furnace; obsolete fire alarm system and associated electrical equipment; scrap wire; 11 each 55-gallon drums numbered 1 through 11: drums 1 through 3 contain 18 nanocuries/gram alpha emitters, drums 4 through 11 contain 8 nanocuries/gram alpha emitters; 2 kg thorium; 8 kg DU; 122 Ci tritium.

Trace amounts of Ce-144, K-40, Zr-95, Nb-95, Sr-85, Eu-152, Eu-155, Ni-63, and Po-210.

Radioactive waste from the Inhalation Toxicology Research Institute (ITRI): ITRI typically disposed of their radioactive waste at the commercial radioactive waste disposal site in Beatty, Nevada. The state of Nevada closed this radioactive disposal site in 1979. SNL, NM accepted a shipment of 119 each 55-gallon drums and 13 plywood boxes of radioactive waste from ITRI in October 1979. A copy of the ITRI radioactive shipment record dated 4/28/80 is attached.

1,093 ft³ of routine operational waste and miscellaneous decontamination waste.

TRENCH F

Tritium and DU-contaminated glove boxes; ducting; stainless steel; 6 each 55-gallon poly drums containing MFP-contaminated spent demineralizer resin; wooden shipping crates; steel cladding

and zirconium insulation; dilute nitric acid neutralized with CaCO_3 , Na_2CO_3 , and NaHCO_3 and solidified with yellow powder material; Electro-glo electropolishing agent solution with concentrated phosphoric acid neutralized with Na_2CO_3 and NaOH and solidified with yellow powder material; lab benches; metal table; two each glove boxes; HEPA and prefilters.

There are 5 spent, nuclear fuel-shipping casks of various sizes in Trench F. They include the Hallam cask, the Helicopter cask, the IF-100 cask, the IF-200 cask, and the Yankee cask. These casks were subject to various destructive tests in the mid-1970's to meet Nuclear Waste Policy Act certification requirements for shipping spent nuclear fuel assemblies. These casks, soon to be retired, were removed from active service for destructive testing. The casks were equipped with fuel mock-ups for destructive testing.

The Nuclear Power Facility provided the Hallum cask to Sandia National Laboratories for torch fire tests. The Hallum cask is 19 ft long x 3 ft in diameter and weighs 40 tons. The cask consists of two stainless steel cylinders separated by 8.5 inches of lead shielding in the annulus.

Pratt and Whitney provided the Helicopter cask for drop tests from 2,000 ft above ground surface. The Helicopter cask is a pot-type cask weighing 3 tons. The interior cavity is 4 inches in diameter and 17.5 inches high surrounded by 10 inches of lead.

The Yankee cask and its Atlas railcar were provided by Westinghouse for sled-track impact tests. The Yankee cask is 13 ft long x 5 ft in diameter and weighs 37 tons. The cask consists of two stainless steel cylinders separated by 8.5 inches of lead shielding in the annulus.

The IF-100 and IF-200 casks were provided by General Electric for sled-track impact tests. The IF-100 cask is 13 ft long x 32 inches in diameter and weighs 22 tons. The cask consists of two stainless steel cylinders separated by 8.5 inches of lead shielding in the annulus. The IF-200 cask is 13 ft long x 3 ft in diameter weighing 25 tons. The cask consists of two stainless steel cylinders separated by 8.5 inches of lead shielding in the annulus.

A semi-tractor trailer or "carriage" used for transporting spent, nuclear fuel shipping casks is buried in Trench F. The trailer was contaminated with Cs-137. The trailer was contaminated by a leaking shipping cask that contained a spent, nuclear fuel assembly destined for TA-5. The cask that contained the spent, fuel assembly leaked water during shipment. The cask was decontaminated and returned to Savannah River via another trailer, however, the contaminated trailer was designated non-recoverable and buried. A picture of the trailer buried in Trench F is attached.

792 ft³ of routine operational and miscellaneous decontamination waste.

day. The vessel plates, at the time of burial, measured 2 rem/hour on contact. SP-4 is lined with concrete culvert and concrete bottom-cap making it the only lined pit at the MWL.

PIT SP-5

A 10,000 Ci Co-60 source is buried in SP-5. The 10,000 Ci Co-60 source was manufactured by Oak Ridge National Laboratories in 1960 and delivered to Sandia National Laboratories for deployment in the gamma irradiation facility. The source consists of 12 stainless steel rods, 12 inches long x 0.5 inches in diameter, each containing 8 cobalt metal pellets. Each cobalt pellet is 0.5 inches long. The cobalt metal pellets are located in the center of each rod with 4 inches of lead as shielding filling each end. Each cobalt rod contained approximately 840 Ci in September 1961. The Co-60 source was removed from service and transferred to SP-5 in June 1987. The Co-60 source was buried in a 6.7 ft³ lead burial cask, which was in turn encased in a 24 yd³ concrete burial cask. The original 10,000 Ci source will have decayed to 76 Ci as of September 1998, or 6.4 Ci per rod.

PIT 1

DU-contaminated weapons components; mass of DU unknown.

PIT 2

DU-contaminated debris bed; DU-contaminated weapons components; mass of DU unknown.

PIT 3A

DU-contaminated weapons components; 22 kg DU.

PIT 3B

DU-contaminated Mark III missile sections; mass of DU unknown.

PIT 4

DU-contaminated weapons components; mass of DU unknown.

PIT 5

DU-contaminated weapons components; mass of DU unknown.

PIT 6

DU-contaminated weapons components; mass of DU unknown.

PIT 7

DU-contaminated weapons components; 846 kg DU.

PIT 8

DU-contaminated weapons components; mass of DU unknown.

PIT 9

DU-contaminated weapons components; mass of DU unknown.

PIT 10

DU-contaminated weapons components; 178 kg DU.

PIT 11

7 NTS test shapes; 42 kg DU.

PIT 12

Neutron generator tubes; 1 kg thorium; 103 kg DU.

PIT 13

One each 1,800 Ci Co-60 source sealed in a lead and steel burial cask encapsulated in two truckloads of concrete; one each 98 microCi Ra-226 source, one each 1.3 microCi Ra-226 source, two each 5.0 microCi Ra-226 sources, and one each 1.0 microCi Ra-226 source encapsulated in concrete-filled A/N can.

PIT 14

One each sealed 5.0 microCi Po-210 source and source holder; one each sealed 1.0 microCi Po-210 source; miscellaneous uranium and beryllium waste; "Cypress" test debris from NTS; DU-contaminated vacuum cleaner; 3 Ci tritium water; 100 mCi tritium oxide; Pu-238, Po-210, and tritium-contaminated miscellaneous operational and lab waste; tritium-contaminated pumps and

valves; Pu-238 contaminated air sampler; neutron generator tubes; a large weapon shell (18 megaton WWII vintage); DU-contaminated weapons components; 178 kg DU.

PIT 15

One each 102.1 microCi Ra-226/Be source and one each 5.5 microCi source in a encapsulated in concrete-filled 55-gallon drum; fume hood filters and filter housings; reactor fuel element ends (5 rem/hr on contact); "Cypress" test debris from NTS; neutron generator tubes and targets; DU-contaminated weapons components; Pershing missile debris; 167 kg DU; 49 grams U-235; 30 Ci tritium.

PIT 16

One each sealed 2.5 Ci Co-60 source encapsulated in a concrete-filled lead cask; two each non-functional 1.5 mCi Ra-226 ionization alphasources encapsulated in a concrete-filled A/N can; nine each Ba-133 reactor bolts; 2 each 52 Ci Co-60 pencils encapsulated in a lead-lined concrete-filled 55-gallon drum; 2 each 10.0 microCi Ra-226/Be sources in lead container encapsulated in a concrete-filled 5-gallon A/N can; one each 1,000 Ci Co-60 source encapsulated in a lead-lined, concrete-filled 55-gallon drum; ionization chambers and current regulators; one each 0.8 mCi Kr-85 source encapsulated in a concrete-filled A/N can; one each 40 mCi Am-241 source encapsulated in a concrete-filled A/N can; one each 18.9 Ci Kr-85 nuclear battery in a steel tube encapsulated in concrete-filled A/N can; SER control rod guides encapsulated in a lead-lined, concrete-filled A/N can (50 rem/hr on contact); thorium metal scrap; one each Sb-124 source projectile (10 rem/hr on contact); 20 each 5.0 microCi Ra-226/Be sources in lead container encapsulated in concrete-filled A/N can; 2 kg thorium oxide; 2,390 kg DU; 75 Ci tritium.

PIT 17

"Casseto" and "Triga" parts from NTS; one each 0.5 mCi Ra-226/Be source, one each 36 Ci Co-60 source, and one each 6.0 Ci Sr-90 source each in a lead container encapsulated in concrete-filled 55-gallon drum; 11 each Kr-85 cells (8.1 mCi total); 2 each uranium carbide nose cones; uranium and zirconium scrap in a 55-gallon drum; 30 Ci tritium lab waste in brass tube; neutron generator tubes; dummy DU reservoir; DU scrap and machine parts; test specimens; brazed to aluminum; fusing and firing assemblies; DU-contaminated weapon components; 3 kg thorium oxide; 457 kg DU.

PIT 18

Pu-238 contaminated paper, gloves, small equipment, components, wire, and sockets; 12 each spark gap tubes; 7 each 10 microCi Ra-226/Be sources in a lead container encapsulated in concrete-filled 55-gallon drum; Pu-238 contaminated vacuum pump; radioactive rock; electrical

cables from junction box; reactor fuel element ends (5 rem/hr on contact); neutron generator tubes; Pershing missile test debris; DU-contaminated weapons components; 155 mm gun projectile with a Sb-124 source; 762 kg DU; 45 Ci tritium.

PIT 19

Tritium-contaminated buckets, clothing, swipes, rags, paper, work gloves, vacuum cleaner, and decontamination materials; reactor fuel element ends (5 rem/hr on contact); one each Sb-124 source projectile (10 rem/hr on contact); neutron generator tubes; scrap metal, DU-contaminated muffle furnace; irradiated diodes, transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; one each 3.5 microCi Co-60 source and one each 4.1 microCi Co-60 source in a lead container encapsulated in concrete-filled 55-gallon drum; Pershing missile test debris; tritium bed; scrap iron; Pu-238/239 contaminated filters; 621 kg DU; 60 Ci tritium.

PIT 21

Two each 3.4 microCi Co-60 sources, one each 31.8 microCi Sr-90 source, one each 100 microCi Co-60 source, one each leaking Sb-124 source, and one each spent Cs-137 source in a lead container encapsulated in concrete-filled 55-gallon drum; NTS irradiated material; DU-contaminated paper, towels, and poly bottles; plutonium oxide-contaminated filters, towels, tape, paper, cleaning and decontamination materials; 4 each irradiated thermal batteries; oil diffusion pump and baffle; irradiated diodes, transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; neutron generator tubes; Pershing missile test debris; DU-contaminated weapons components; 16 kg thorium; 1,731 kg DU; 0.1 grams Pu-238; 30 Ci tritium.

PIT 24

"Hudson Moon" and "Mint Leaf" test debris from NTS; 3 each 500 microCi Ra-226 ionization alphasources encapsulated in a concrete-filled A/N can; one each 45 Ci Co-60 source in a lead shield housing; irradiated diodes, transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; reactor fuel element ends (5 rem/hr on contact); tritium-contaminated General Electric vacuum system, trigger gauge, transducers, hoods, vacuum pump, and panels; Pu-238, Pu-239, U-235, and U-238 contaminated glove box, gamma probe, and stereo microscope; neutron generator tubes; Pershing missile test debris; DU-contaminated weapons debris; 140 kg DU; 60 Ci tritium.

PIT 25

Stainless steel sample cylinders; tritium-contaminated flexible vent; Pu-239 contaminated microscope slide and slide clamps; "Hudson Moon" test debris from NTS; irradiated diodes,

transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; one each 3.5 Ci Ir-192 source encapsulated in concrete-filled 5-gallon A/N can; Ta-182 wire, needles, and foil in lead pigs; 4 each 10 microCi Ra-226/Be sources in a lead container encapsulated in concrete-filled 55-gallon drum; one each 30 Ci Ir-192 source encapsulated in concrete-filled 10-gallon A/N can; Ba-133 reactor bolts; DU ballast, machine chips, cuttings, and turnings; head filters and prefilters; DU-contaminated penetration vehicles; one each Pu-238 contaminated stereo microscope, glove box, balance, and manipulator arm; reactor fuel element ends (5 rem/hr on contact); DU-contaminated ceramic base plates and electric furnace; irradiated scrap nickel and reactor material; DU-contaminated sputtering shield, O-rings, and steel wool; 15 each irradiated fission chambers; Be-contaminated glove box and balance; irradiated floor and exhaust hood coverings; tritium-contaminated ion pump; MFP-contaminated transistors, diodes, resistors, circuits, paper, and plastic; one each iridium iriditron, one each 11.6 microCi Ra-226 dew pointer in brass cylinder, one each DU aft simulator; neutron generator tubes; SRAM missile test debris; DU-contaminated weapons components; 1,431 kg DU; 76.5 Ci tritium.

PIT 26

Co-57 contaminated cleanup debris; DU machine chips, turnings, and cuttings; irradiated diodes, transistors, capacitors, resistors, circuit boards, voltage regulators, and other miscellaneous electrical components; 5 each carbon rings; DU-contaminated cloth, towels, and paper; MFP-contaminated machining wastes; 4 each 4.0 Ci Co-60 sources in a lead container encapsulated in concrete-filled 55-gallon drum; 100 microCi Na-22; DU-contaminated Pershing missile debris; DU-contaminated Sierra Army Depot debris; 18 each 1.8 microCi Ra-226 ionization alphanon gauges encapsulated in concrete-filled 32-gallon A/N can; Ta-182 wires in a lead pig; 3 each Victoreen Sr-90 ion chambers; DU-contaminated penetration ballast, noses, and aft simulators; 5 each sealed 389 microCi Ba-133 sources; 5 each sealed 160 microCi Ra-226 sources; 2 each sealed 10 microCi Ra-226 check sources; 2 each sealed 2.2 microCi Cs-137 check sources; 3 each sealed 4.6 microCi Co-60 solution in glass ampules; one each sealed 1.0 microCi Sr-90 solution in a glass ampule; and one each sealed 0.6 microCi Kr-85 gas in a glass ampule; firing and fusing sets; DU-contaminated weapons components; 5,525 kg DU; 88.5 Ci tritium.

PIT 27

One each DU nose ballast; one each tritium-contaminated shipping container; DU plates; 3 each empty steel gas cylinders; tritium targets; 2 each DU penetrators; enriched uranium tensile bars alloyed with Fe-50; 1 kg thorium oxide; neutron generator tubes; 155 mm gun debris; 3,246 kg DU; 81 Ci tritium.

INHALATION TOXICOLOGY RESEARCH INSTITUTE
LOVELACE BIOMEDICAL AND ENVIRONMENTAL RESEARCH INSTITUTE, INC.

RADIOACTIVE SHIPMENT RECORD FORM

From _____

Date 4/28/80

Page 1 of 4

Item No.	Rad. Level (mr/hr)		External Contamination Survey (ICPM)	Isotopes	Container Type	Radioactive Millicuries	Physical State	Contents	Container Cubic Feet
	Surface	at 3 feet							
	BKG.	BKG.	<100	238 Pu 239 Pu 55	Gal. Drum	.5	Solid	Plastic, glass, Paper	7.5
2	"	"	"	238 Pu 144 Pu	"	"	"	"	"
	"	"	"	238 Pu 239 Pu	"	"	"	"	"
	"	"	"	238 Pu	"	"	"	"	"
5	"	"	"	238 Pu	"	"	"	"	"
	"	"	"	238 Pu	"	"	"	"	"
	"	"	"	238 Pu 239 Pu	"	"	"	"	"
8	"	"	"	238 Pu 239 Pu	"	"	"	"	"
	"	"	"	238 Pu 239 Pu	"	"	"	"	"
1	"	"	"	238 Pu 239 Pu	"	"	"	"	"
12	"	"	"	238 Pu 241 Am	"	"	"	"	"
13	"	"	"	238 Pu 239 Pu	"	"	"	"	"
14	"	"	"	144 Ce 239 Pu	"	"	"	"	"
15	"	"	"	144 Ce 239 Pu	"	"	"	"	"
16	"	"	"	144 Ce 238 Pu	"	"	"	"	"
17	"	"	"	144 Ce 238 Pu	"	"	"	"	"
18	50	5	"	144 Ce	"	100	"	"	"
19	BKG.	BKG.	"	144 Ce 238 Pu	"	.5	"	"	"
25	"	"	"	134 Cs 239 Pu	"	"	"	"	"
26	"	"	"	134 Cs 239 Pu	"	"	"	"	"
27	"	"	"	134 Cs 241 Am	"	"	"	"	"
28	"	"	"	144 Ce 239 Pu	"	"	"	"	"
29	"	"	"	134 Cs 239 Pu	"	"	"	"	"
30	"	"	"	134 Cs 241 Am	"	"	"	"	"
31	"	"	"	134 Cs 239 Pu	"	"	"	"	"
32	"	"	"	238 Pu 239 Pu	"	"	"	"	"
33	"	"	"	144 Ce 239 Pu	"	"	"	"	"
34	"	"	"	144 Ce 239 Pu	"	"	"	"	"
35	"	"	"	239 Pu 241 Am	"	"	"	"	"
36	10.	0.4	"	238 Pu 169 Yb	"	50 (Yb 169)	"	"	"
37	BKG.	BKG.	"	144 Ce 238 Pu	"	.5	"	"	"
38	"	"	"	144 Ce 239 Pu	"	"	"	"	"
39	"	"	"	134 Cs 239 Pu	"	"	"	"	"
40	"	"	"	238 Pu 241 Am	"	"	"	"	"
TOTALS						166			265

All of the waste described above contains no free liquids and no transuranic elements with a radioactivity concentration greater than 10 nanocuries per gram.

G. J. Thompson 4/30/80

APPENDIX C

**Notices of the Public Meetings on the
Sandia National Laboratories
Mixed Waste Landfill Peer Review**

Notice of Public Meeting

To Discuss Sandia Laboratory's Mixed-Waste Landfill

WERC: A Consortium for Environmental Education and Technology Development will host the first in a series of public meetings regarding the Mixed-Waste Landfill located on Sandia National Laboratory's property in Albuquerque, NM. The objective of the meeting will be conducted to examine existing technical data, QA/QC for data collection, appropriateness of data, and the respective relevant technical conclusions made. The public is invited to attend these meetings.

Date: March 6 and 7

Time: 6:30-8 p.m.

Location: UNM Division of Continuing Education and Community Services Building, Room C
1634 University Blvd. NE

For more information, call (800) 523-5996.

Notice of Public Meeting To Discuss Sandia Laboratory's Mixed-Waste Landfill

WERC: A Consortium for Environmental Education and Technology Development will host the second in a series of public meetings regarding the Mixed-Waste Landfill located on Sandia National Laboratory's property in Albuquerque, NM. Presentations will be made by organizations that have previously been involved in reviewing the data. The public is invited to attend these meetings.

Dates/Times: March 22; 10 a.m. to noon, continuing at 2 p.m. to 5 p.m.

March 23; 9 a.m. to noon, continuing at 1 p.m. to 5 p.m.

Location: Albuquerque Doubletree Inn
Cutter Room, lower lobby level
201 Marquette Ave., NW

For more information, call (800) 523-5996

Notice of Meeting

To Discuss Sandia Laboratories' Mixed-Waste Landfill

WERC: A Consortium for Environmental Education and Technology Development will host the third in a series of meetings regarding the Mixed-Waste Landfill located on Sandia National Laboratories' property in Albuquerque, NM. The purpose of this panel meeting is to review the preliminary conclusions of panel members relative to adequacy of the scientific study of the landfill performance. The public is invited to attend this meeting.

Dates/Time: May 11, 8:30 a.m.

Location: Albuquerque Doubletree Inn
Cutter Room, lower lobby level
201 Marquette Ave., NW

For more information, call (800) 523-5996.

Advertisements of the Sandia National Laboratories
Mixed Waste Landfill
Peer Review meetings published
in the
Albuquerque Journal and Albuquerque Tribune

APPENDIX D

**Documents Available to
Peer Panel and Public**

Appendix D
Documents Available to Peer Panel and Public

WERC DOCUMENT #	DOCUMENT NAME
1	Strategy for Deployment of an Alternative Cover and Final Closure of the Mixed Waste Landfill, Sandia National Laboratories, New Mexico (April 1999)
2	Mixed Waste Landfill Map and Inventory, Volume 1
3	Mixed Waste Landfill Map and Inventory, Volume 2
4	Mixed Waste Landfill Map and Inventory, Volume 3
5	Report of the Phase 1 RCRA Facility Investigation of the Mixed Waste Landfill (September 1990)
6	Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation, Sandia National Laboratories, Albuquerque, New Mexico (September 1996)
7	DOE Oversight Bureau's Comments on Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation, Sandia National Laboratories, Albuquerque, New Mexico (September 1996)
8	Environmental Restoration Project DOE/SNL/NM Response to NMED October 30, 1998, NOD for "Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation, Sandia National Laboratories, Albuquerque, New Mexico" (January 1999)
9	Geologic Study of Near-Surface Sediments, Volumes I (September 1998)
10	Geologic Study of Near-Surface Sediments, Volume II (September 1998)

- 11 Addendum to Geologic Study of Near Surface Sediments
(December 1998)
- 12 Solute Interactions and Transport in Soils from Waste
Disposal Sites at Sandia National Laboratories (June 1982)
- 13 Analysis of Instantaneous Profile Test Data from Soils near
Mixed Waste Landfill, Technical Area 3, Sandia National
Laboratories, New Mexico (February 1996)
- 14 Results of the 1992 Sandia National Laboratories Hazardous
Air Pollutant Baseline Study (November 1992)
- 15 Measurement of Tritium and VOC Fluxes from the Mixed
Waste Landfill at Sandia National Laboratories, New Mexico
(January 1994)
- 16 Tritium in Surface Soils at the Mixed Waste Landfill,
Technical Area 3, Sandia National Laboratories, New
Mexico (March 1996)
- 17 Mixed Waste Landfill Semiannual Groundwater Monitoring
Report, April 1999, Sandia National Laboratories/New
Mexico (August 1999)
- 18 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
1
- 19 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
2
- 20 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
3
- 21 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
4

- 22 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
5
- 23 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
6
- 24 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
7
- 25 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
8
- 26 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
9
- 27 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
10
- 28 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
11
- 29 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
12
- 30 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
13
- 31 Semiannual Groundwater Sampling at the Mixed Waste
Landfill, Sandia National Laboratories/New Mexico, Volume
14

- 32 Semiannual Groundwater Sampling at the Mixed Waste Landfill, Sandia National Laboratories/New Mexico, Volume 14-a
- 33 Semiannual Groundwater Sampling at the Mixed Waste Landfill, Sandia National Laboratories/New Mexico, Volume 14-b
- 34 Semiannual Groundwater Sampling at the Mixed Waste Landfill, Sandia National Laboratories/New Mexico, Volume 14-c
- 35 Semiannual Groundwater Sampling at the Mixed Waste Landfill, Sandia National Laboratories/New Mexico, Volume 14-c2
- 36 Mixed Waste Landfill Review by Mark Baskaran-Final Report dated July 5, 2000
- 37 City of Albuquerque-Mixed Waste Landfill Data Analysis by Douglas Earp dated November 29, 2000
- 38 Draft Report on Background Groundwater Sampling at the Mixed Waste Landfill Sandia National Laboratories, Albuquerque - September 1990 - Prepared by International Technology (IT) Corporation (April 1991)
- 39 Draft Report - Comprehensive Environmental Assessment and Response Program - Phase I: Installation Assessment - Sandia National Laboratories - Prepared by the Department of Energy, Albuquerque Operations Office - Environment, Safety and Health Division - Environmental Programs Branch (September 30, 1987)
- 40 Deployment of an Alternative Cover and Final Closure of the Mixed Waste Landfill, Sandia National Laboratories, New Mexico - Prepared by Environmental Restoration Project, Sandia National Laboratories (September 23, 1999)
- 41 Report on Quarterly Ground-Water Sampling at the Mixed Waste Landfill, Sandia National Laboratories, Albuquerque, July 1991 - Prepared by IT Corporation (May 1992)

- 42 Groundwater Monitoring Wells Installation Mixed Waste Landfill - Prepared by Ecology and Environment, Inc. (December 1989)
- 43 Draft Final RCRA Facility Assessment Report of Solid Waste Management Units at Sandia National Laboratories, Albuquerque - Prepared by A.T. Kearney Inc., and Harding Lawson Associates (April 1987)
- 44 Groundwater Monitoring Program - Mixed Waste Landfill Ground Water Sampling and Analysis Plan (September 1990)
- 45 Strategy for Deployment of an Alternative Cover and Final Closure of the Mixed Waste Landfill, Sandia National Laboratories (April 12, 1999)
- 46 Report on Quarterly Ground-water Sampling at the Mixed Waste Landfill Sandia National Laboratories, Albuquerque, April 1991 - Prepared by IT Corporation (October 1991)
- 47 Application of Non-Intrusive Geophysical Techniques at the Mixed Waste Landfill, Technical Area 3, Sandia National Laboratories, New Mexico - Printed March 1996
- 48 Unsaturated Hydrologic Flow Parameters Based on Laboratory and Field Data for Soils Near the Mixed Waste Landfill, Technical Area III, Sandia National Laboratories/New Mexico - Printed August 1996
- 49 Report on Semiannual Groundwater Sampling at the Mixed Waste Landfill Sandia National Laboratories/New Mexico, March Through May 1994, Volume 1 - Prepared by IT Corporation (February 1995)

- 50 Preliminary Data From an Instantaneous Profile Test Conducted Near the Mixed Waste Landfill, Technical Area 3, Sandia National Laboratories/New Mexico - Printed April 1996
- 51 Analysis of Instantaneous Profile Test Data from Soils Near the Mixed Waste Landfill, Technical Area 3, Sandia National Laboratories/New Mexico - Printed February 1996
- 52 Report on Semiannual Ground-water Sampling at the Mixed Waste Landfill Sandia National Laboratories/New Mexico, January 1993 - Prepared by IT Corporation (July 1993)
- 53 A Preliminary Human Health Risk Assessment for the Mixed Waste Landfill, Sandia National Laboratories, Albuquerque, New Mexico - Prepared by Argonne National Laboratory (January 1995)
- 54 Report on Semiannual Ground-water Sampling at the Mixed Waste Landfill Sandia National Laboratories/New Mexico - November 1993 - Prepared by IT Corporation (May 1994)
- 55 Deployment of an Alternative Cover and Final Closure of the Mixed Waste Landfill Sandia National Laboratories, New Mexico (September 23, 1999)
- 56 Compliance Activities Work Plan for the Mixed Waste Landfill (August 26, 1991)
- 57 Mixed Waste Landfill Phase 2 RCRA Facility Investigation Work Plan
- 58 Responses to NMED Technical Comments on the Report of the Mixed Waste Landfill Phase 2 RCRA Facility Investigation Dated September 1996, Volume 1 (June 15, 1998)
- 58a Attachment to #58 - Nickel Concentrations in Groundwater at the Mixed Waste Landfill

- 59 Draft Report on Quarterly Ground-water Sampling at the Mixed Waste Landfill, October 1991 - Prepared by IT Corporation (May 1992)
- 60 Fiscal Year 1998 Annual Groundwater Monitoring Report (March 1999)
- 61 Report on Quarterly Ground-water Sampling at the Mixed Waste Landfill Sandia National Laboratories, Albuquerque, January 1991 - Prepared by IT Corporation (July 1991)
- 62 Draft Report on Semiannual Ground-water Sampling at the Mixed Waste Landfill Sandia National Laboratories, New Mexico July 1992 - Prepared by IT Corporation (January 1993)
- 63 Mixed Waste Landfill Project Location Maps
- 64 Mixed Waste Landfill Semiannual Groundwater Monitoring Report April, 1999 Sandia National Laboratories/New Mexico - Prepared by IT Corporation (August 1999)
- 65 Deployment of an Alternative Cover and Final Closure of the Mixed Waste Landfill, Sandia National Laboratories, New Mexico - Submitted to the New Mexico Environment Department September 23, 1999
- 66 Mixed Waste Landfill Design Report
- 67 Deployment of an Alternative Cover and Final Closure of the Mixed Waste Landfill, Sandia National Laboratories, New Mexico - Attachment #A - Preliminary Unsaturated Flow Modeling of the Design of a Closure Cover for the Mixed Waste Landfill dated September 23, 1999
- 68 Responses to the New Mexico Environment Department Request for Supplemental Information issued June 5, 2000
- 69 Request for Supplemental Information - Deployment of an Alternative Cover and Final Closure of the Mixed Waste

- Landfill, September 23, 1999 - Requested by the New Mexico Environment Department, February 16, 2001
- 70 FY97-99 Vegetation Analysis of ALCD Soil Amended Landfill Cover Plots
- 71 Construction Overview of Six Landfill Cover Designs
- 72 Alternative Landfill Cover Demonstration FY2000 Annual Data Report
- 73 Synopsis of Sandia/DOE Technical Concerns Regarding the Mixed Waste Landfill Report Prepared by Dr. Mark Baskaran, Department of Geology, Wayne State University
- 74 The Department of Energy and Sandia National Laboratories Response to Dr. Mark Baskaran's Final Report, "Mixed Waste Landfill Review"
- 75 Sigma Five Consulting Comments on July 12, 2000 Presentation of Dr. Baskaran by Fritz A. Seiler, dated August 5, 2000
- 76 Dr. Baskaran's Response to Seiler's Comments on the Mixed Waste Landfill, dated August 11, 2000
- 77 Comments on the Reply to My Review of the Baskaran Evaluation of the Sandia Mixed Waste Landfill Work by Fritz A. Seiler
- 78 Report on Semiannual Ground-Water Sampling at the Mixed Waste Landfill Sandia National Laboratories/Albuquerque January 1992 - Prepared by IT Corporation May 1992
- 79 Mixed Waste Landfill Semiannual Groundwater Monitoring Report, April 1998 Sandia National Laboratories - Prepared by IT Corporation July 1998
- 80 Mixed Waste Landfill Semiannual Groundwater Monitoring Report November 1998/January 1999 Sandia National Laboratories - Prepared by IT Corporation April 1999

- 91 Results of Ground Water Sampling at Sandia National Laboratories/Albuquerque Mixed Waste Landfill for Area MW-2
- 92 Results of Ground Water Sampling at Sandia National Laboratories/Albuquerque for Area MW-3
- 93 Ground-Water Sampling at the Mixed Waste Landfill - Area MW-4
- 94 A(n) Water, Non-Filtered Sample Submitted to the State of New Mexico, Department of Health, Scientific Laboratory Division, January 19, 2001 for Area MW-5 and MW-6
- 95 Results of Ground Water Sampling at Sandia National Laboratories/Albuquerque Mixed Waste Landfill - Area BW-1
- 96 Results of Non-Aqueous Soil Samples Submitted to American Environmental Network Inc. on June 4, 1998
- 97 New Mexico Environment Department Hazardous and Radioactive Materials Bureau Approved Background Concentrations, Sandia National Laboratories/Kirkland Air Force Base - September 1997
- 98 Well Database Summary Sheet provided to WERC Peer Review Panel March 23, 2001
- 99 Mixed Waste Landfill (MWL) Data Analysis by Douglas Earp, City of Albuquerque, dated December 14, 2000
- 100 Mixed Waste Landfill Data Analysis by Douglas Earp, City of Albuquerque, dated November 29, 2000 submitted to Dr. Bruce Thomson, Chair, Groundwater Protection Advisory Board
- 101 Information on Surface Soil Sampling for Tritium and Soil Gas Surveys provided to WERC Peer Review Panel March 23, 2001

113

Comments by Douglas Earp regarding Sandia's December
14, 2000 Memo

APPENDIX E

Acronyms and Initialisms

Appendix E Acronyms and Initialisms

Am	americium
A/N	Metal cans of various sizes for military ordinance storage
Ci	Curie(s)
Co	cobalt
COC	contaminate of concern
COPEC	constituents of potential ecological concern
Cs	cesium
DOE	U.S. Department of Energy
DU	depleted uranium
EPA	U.S. Environmental Protection Agency
ft.	feet or foot
g/cc	grams per cubic centimeter
H-3	tritium
HEPA	high efficiency particulate air (filter)
HI	hazard index
HQ	hazard quotient
K _H	horizontal hydraulic conductivity
K _v	vertical hydraulic conductivity
mg/L	milligrams per liter
Mn	manganese
MWL	Mixed Waste Landfill
Na	sodium
Ni	nickel
NOAEL	no observed adverse effect level
Pb	lead
pCi/L	pico curies per liter
Pm	promethium
ppb	parts per billion
ppt	parts per trillion
Pu	plutonium
PVC	Polyvinyl chloride
Ra	radium
RESRAD	(<u>residual radioactive</u>) a computer model developed at Argonne National Laboratory for DOE to calculate site-specific radiation doses and cancer risk to chronically exposed on-site receptors
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
Ru	ruthenium
Sr	strontium
SWMU	Solid Waste Management Unit
Tc	technetium
TEDE	total effective dose equivalent
U	uranium
WERC	a Consortium for Environmental Education & Technology Development
Yb	ytterbium

