417829

Analysis Report for Estimating Dose from Cattle , Vegetable Consumption and Inhalation Pathways Utilizing Contaminated Water from the Top of the Salado, Culebra, and Selected Marker Beds for an Undisturbed Case Supporting Review Compliance Certification Application

Document Version 1.01

WBS # 1.2.01.5.3.1

Leo J. Rahal		6849	2/26/97
Leo J. Rahal	**Signature**	**Organization**	**Date**
Principal Investigator			
		6848	2/26/97
Hong-Nian Jow	**Signature**	**Organization**	**Date**
Department Manager			
for Leo Gomez		6849	2/26/97
Leo S. Gomez	**Signature**	**Organization**	**Date**
Technical Reviewer			
Deborah Coffey		6811	2/26/97
Deborah Coffey	**Signature**	**Organization**	**Date**
Wendell D. Weart		6000	2/26/97
Wendell Weart	**Signature**	**Organization**	**Date**
Managerial Reviewer			
Margaret Chu		6801	2/26/97
Margaret Chu	**Signature**	**Organization**	**Date**
Deputy Program Manager Wipp			

TABLE OF CONTENTS

List of Tables **3**

1.0 Introduction **4**
1.1 Purpose of this Analysis and Background Information 4
1.2 Bounding Analysis 7
1.3 Dose Calculation Results 9

2.0 Summary of Compliance with the Individual Protection Standard **10**

3.0 Software Used for Analysis **11**
3.1 Point of Contact 11

4.0 Calculational Procedure **12**

5.0 References **13**
Appendix A: Listing of Input and Output Data Files for Dose Calculation: Marker Bed 139 (Table A-1) 14
Appendix B: Graph of Mass Loading Data Taken from 1991 to 1996 for Lea County 15
Appendix C: Procedure for Extraction of NUTS data used in this analysis 16

List of Tables

Table		Page
1-1	Maximum Concentrations of Radionuclides (Undiluted) Within the Salado Interbeds at the Disposal System Boundary occuring at 10,000 yrs. after Closure. (Modified from Table 8-1, CCA)	6
1-2	GENII-A *Input Parameters for Farm Family* Scenario	8
1-3	GENII-A Input Parameters for Cattle Rancher Scenario	8
1-4	GENII-A Input Parameter for Farm Family Inhalation Pathway	8
1-5	Calculated Annual Committed Effective Doses at 10,000 yrs. after closure	9
A-1	Listing of Input and Output Data Files for Dose Calculations: Marker Bed 139	14

1.0 Introduction

This analysis report summarizes the background, analysis procedure and results for the Waste Isolation Pilot Plant (WIPP) Repository dose calculation resulting from (1) consumption of beef cattle drinking water from a stockpond utilizing a contaminated ground-water source by a rancher residing at the location of the well; (2) consumption of crops irrigated from a contaminated ground-water source by a farm family residing at the location of the well; and (3) inhalation of resuspended irrigated soil. The requirements and standards which form the guidance for this calculation are set forth in the following paragraphs. This analysis represents a continuation of the drinking water pathway calculation, reported in Chapter 8 of the CCA.

1.1 Purpose of this Analysis and Background Information

The purpose of this analysis is to provide quantitative analysis of pathways for human exposure to radionuclides which potentially may be released through MB 139 (and Mbs 138, a & b) at the site boundary during 10,000 years of undisturbed performance. The CCA contained results of a conservative and bounding analysis of the hypothetical doses from consumption of contaminated drinking water, (Chapter 8, CCA). This analysis uses the same conservative and bounding assumptions used in the CCA to examine alternative exposure pathways. Specifically, this analysis presents dose calculations for ingestion pathways for beef and irrigated crops, and for the inhalation of resuspended particles of irrigated soil. These analyses were performed to address comments raised by the EPA in their review of the CCA **[EPA-1]**.
The undiluted sources for this analysis appear in Table 1-1. A dilution factor of 32.4 was used for the purpose of achieving a potable water supply. This was based on a recommendation of 10,000 ppm (mg/L) TDS for potential drinking water sources contained in 40 CFR 191 (1993) . However, in the NALCO Water Handbook **[NA-1]** a value of 500 ppm (mg/L) TDS is indicated as the level for potable water.

Three hundred realizations of the modeling system were generated during the CCA analyses for the containment requirements (Chapter 6, CCA). These same realizations were also used for individual and groundwater protection requirements (Chapter 8, CCA). These 300 realizations are comprised of three sets (or replicates) of one hundred realizations each, generated using the Latin Hypercube sampling technique. Of the 300 realizations, none show any radionuclides reaching the top of the Salado through the sealed shafts.

Nine of the 300 realizations show concentrations of radionuclides greater than zero reaching the accessible environment through the anhydrite interbeds. All of the remaining 291 realizations show that no radionuclides reach the accessible environment during the regulatory time frame of 10,000 years after repository closure through the anhydrite interbeds. A receptor in the accessible environment could not come in contact with the anhydrite interbeds located at a depth greater than 2000 feet. Table 1-1 shows the maximum concentrations of radionuclides calculated by the modeling evaluation as reaching the accessible environment in the nine non-zero realizations. The full range of

estimated values for radionuclide concentrations is from zero to the values shown in Table 1-1. The maximum concentration values shown in Table 1-1 occur 10,000 years after closure. These are the same values used in Chapter 8, CCA.

For the purposes of this analysis, the maximum concentration set, Replicate 3 Vector 64, was used to determine doses for the cattle, vegetable consumption, and inhalation pathways since this represents the largest concentration and gave the largest dose from drinking water as reported in Chapter 8, Table 8-2, CCA.

40 CFR Part 194.51 states that doses must be estimated for an individual who resides at the location in the accessible environment where that individual would be expected to receive the highest exposure from radionuclide releases from the disposal system. All potential pathways for exposure associated with the undisturbed performance of the repository must be assessed (40 CFR § 194.52).

Table 1-1. Maximum Concentrations of Radionuclides (Undiluted) Within the Salado Interbeds at the Disposal System Boundary Occuring at 10,000 yrs. after Closure(Modified from Table 8-1, CCA)

Realization No.	Vector No.(1)	Concentration (Curies/liter)				
		^{241}Am	^{239}Pu	^{238}Pu	^{234}U	^{230}Th
1	Replicate 1 Vector 46	1.36×10^{-17}	4.33×10^{-12}	N (2)	5.82×10^{-13}	2.10×10^{-14}
2	Replicate 2 Vector 16	N	5.13×10^{-14}	N	6.77×10^{-15}	1.89×10^{-17}
3	Replicate 2 Vector 25	N	1.35×10^{-15}	N	1.65×10^{-16}	7.00×10^{-18}
4	Replicate 2 Vector 33	1.32×10^{-17}	7.18×10^{-14}	N	9.76×10^{-15}	9.36×10^{-16}
5	Replicate 2 Vector 81	N	6.23×10^{-18}	N	N	N
6	Replicate 2 Vector 90	N	5.20×10^{-16}	N	7.40×10^{-17}	N
7	Replicate 3 Vector 3	3.50×10^{-18}	3.08×10^{-13}	N	4.32×10^{-14}	1.07×10^{-16}
8	Replicate 3 Vector 60	5.98×10^{-17}	7.41×10^{-14}	N	9.09×10^{-15}	2.30×10^{-15}
9	Replicate 3 Vector 64	5.42×10^{-17}	5.85×10^{-12}	N	7.61×10^{-13}	4.68×10^{-15}
10-300	-	N	N	N	N	N

1. The procedure used to extract these values from the NUTS data is described in Appendix C.

2. Values less than 10^{-18} curies per liter are considered to be negligible (N) relative to the other values and are not reported.

1.2 Bounding Analysis

Uncertainty in the calculation of radionuclide concentrations in the anhydrite interbeds is described in Section 6.1.2 (**[CCA-1]**) . Additional uncertainty is involved in the calculation of doses resulting from the specified exposure pathways. Given this uncertainty, the DOE has elected to perform a bounding analysis using assumptions that do not represent reality, but that would result instead in a bounding estimate that is much greater than any reasonably expected dose to a receptor. If this unrealistic bounding analysis results in calculated doses to the receptor that are below the regulatory limit, compliance with the standard can be demonstrated.

The bounding analysis used for this assessment is based on the following factors and assumptions:

1. No specific transport mechanism is postulated. Instead, all of the contaminants reaching the accessible environment within the anhydrite interbeds during the year of maximum releases (10,000 years after closure) within the 10,000 year period, are assumed to be available to a receptor.

2. Brine derived from the anhydrite interbeds has total dissolved solids (TDS) concentrations of about 324,000 parts per million **[BR-1]**; this represents a concentration that is too high to be consumed by humans. For the bounding analysis, the calculation includes the dilution of this brine by a factor of 32.4 to a TDS concentration of 10,000 parts per million.

3. The resulting annual committed effective dose is calculated based on a 50-year dose commitment. Calculations were performed using the GENII-A dose code (Appendix GENII, CCA). A 50-year dose commitment is selected because this period is specified in Appendix B of 40 CFR Part 191.

4. The parameters associated with the individual receptors for each scenario appear in Tables 1-2, 1-3, and 1-4. Data related to food pathways, irrigation and inhalation were selected as representative values typical of the associated activities **[NRC-1]**, **[DOE-1]**, except where noted.

Table 1-2 GENII-A Input Parameters for Farm Family Scenario-
Terrestrial Food Consumption Utilizing Irrigation from Ground Water Source.

Food Type	Grow Time Days	Irrigation Rate (cm/yr)	Time months	Yield kg/m2	Consumption Holdup (days)	Consumption Rate (kg/yr)
Leaf	90	100	6	1.5	14	15
Root	90	100	6	4.0	14	140
Fruit	90	100	6	2.0	14	64
Grain	90	100	6	0.8	180	72

Table 1-3 GENII-A Input Parameters for Cattle Rancher Scenario.

Food Type	Consumption Rate (kg/yr)	Consumption Holdup (days)	Drinking Water Contamination Fraction	Diet Fraction	Grow Time days	Stored Feed Irrigation Rate (cm/yr)	Stored Feed Time (months)	Stored Feed Yield (kg/m3)	Stored Feed Storage Time (days)
Beef	70	34	1	1	90	100	6	0.8	180

Table 1-4 GENII-A Input Parameters for Farm Family Inhalation Pathway

Breathing Rate	270 cm^3/sec. (Chronic)
Inhalation Period	8760 hours/yr.
Mass Loading Factor	1.0E-04 gm/m^3

The mass loading factor is based on data representative of regional resuspension data for the 1991 to 1996 time period , **Appendix-B** and **[AIRS-1].** Section 194.51 states that DOE shall assume that an individual resides at the single geographic point where that individual would receive the highest dose. With the bounding analysis, the DOE complies with the intent of this criterion, but the specific location of the receptor is not identified because all of the contaminants reaching the accessible environment within the anhydrite interbeds during the year of maximum releases are assumed to be directly available to the receptor, regardless of the location of the receptor. The well from which the receptor drinks is assumed to be located such that the contaminants reaching the anhydrite interbeds are delivered directly to the well. This well is the source of the

stockpond from which the cattle drink and from which irrigation for feed and vegetable crops is obtained. Additionally, an inhalation calculation for the farm family represents a pathway by which dried irrigated soil is resuspended above the farm area and inhaled by the farm inhabitants. The data used in this analysis appear in Tables 1-2, 1-3, and 1-4. Data related to food pathways, irrigation, and inhalation were selected as representative values typical of the associated activities **[NRC-1]**, **[DOE-1]**, except where noted .

The bounding analysis dose calculation was performed using the GENII-A code, Version 2.10 **[GEN-1]**. This program runs on the DEC Alpha System. Appendix GENII of the CCA **[CCA-1]** describes the modeling method. GENII-A incorporates dose-calculation guidance provided in Appendix B of 40 CFR Part 191.

1.3 Dose Calculation Results

The maximum doses calculated to result from the releases listed in Table 1-1 after applying the factors and assumptions listed above, are shown in Table 1-5. Because of the conservative and unrealistic assumptions underlying the analysis, the bounding doses are greater than any realistic doses that could be delivered to a receptor. The calculated bounding doses are well below the regulatory standard, which is an annual committed effective dose of 15 millirem. The full range of estimated radiation doses is from zero to some value less than the bounding values shown in Table 1-5

Table 1-5 Calculated Annual Committed Effective Doses at 10,000 yrs. after Closure

Scenario .	Annual Committed Effective Dose (millirem)
Farm Family Inhalation	**3.1×10^{-4}**
Farm Family Ingestion	**4.6×10^{-1}**
Cattle Rancher	**3.3×10^{-8}**

For comparison, the maximum dose reported in the CCA for the drinking water pathway is 4.7×10^{-1} millirem/yr, (Table 8-2 of the CCA).

2.0 Summary of Compliance with the Individual Protection Standard

In performing the compliance assessment, the DOE applied a bounding-analysis approach using unrealistic assumptions that result in the over-estimation of potential doses and contaminant concentrations. This conservative approach assumes that all contaminants reaching the accessible environment are directly available to a receptor. Using this very conservative approach, the calculated maximum potential dose to an individual would be about one-thirtieth of the individual protection standard.

3.0 Software Used for Analysis

NUTS **[NU-1]**
GENII-A , **Version 2.10 [GEN-1], [GEN-2], [GEN-3]**
This program runs on the DEC Alpha System under VMS Operating system.
This analysis was performed by Leo J. Rahal, the code sponsor.

3.1 Point of Contact

Code Sponsor: **GENII-A** Leo J. Rahal , Org. 6849, Geo-Centers Inc. (505) 766-9629
The GENII-A code was run on the DEC Alpha system using VMS. The calculations were performed by Leo J. Rahal , the code sponsor.

Radionuclide source data were obtained from the **NUTS [NU-1]** output through the **Compliance Assessment Methodology Controller** (CAMCON) library data access process. All calculations were performed within the **Configuration Management System** (CMS) environment to ensure QA procedures are followed.

4.0 Calculational Procedure

The following information describes the calculation procedure used to evaluate doses at selected times and locations. These input and output files are listed in Appendix A, Table B-1. The Description column indicates the location, vector number and time for the input data obtained from the NUTS code. The output files are generated by running these input files according to the command given in Appendix A, i.e.@run_gi2 100 where 100 is the number associated with the data file gi2_calc100.inp for example. For the purpose of this analysis the time selected was 10,000 years after closure. 10,000 years is the cut-off time for required calculations. The 10,000 year period represents the time at which maximum values occur within the required 10,000 year period. The GENII-A **[GEN-1]** dose code determined the dose corresponding to this selected time.

5.0 References

[AIRS-1] U.S. Environmental Protection Agency. 1992. National Air Data Branch, **Aerometric Information Retrieval System**. Total suspended particulate information for LEA County.

[BR-1] Data taken from BRAGFLO output file relating to brine inventory at 10,000 years after closure for Replicate 1 , Scenario 1 (Undisturbed Case), Vector 46. The file from which these data were taken is as follows: **DISK$TINA_CCA, 19963:[BF.JDMILLE.CCA, 1996.POSTALG.R1S1]OSTALG_CCA, 1996_R1_S1_V046.CDB**

[CCA-1] Compliance Certification Application for the Waste Isolation Pilot Plant, United States Department of Energy Waste Isolation Pilot Plant, Carlsbad Area Office, Carlsbad, New Mexico, October 29, 1996.

[DOE-1] Performance Assessment Task Team Progress Report . Radioactive Waste Technical Support Program, May 1994. DOE/LLW-157 Revision 1.

[EPA-1] Letter from EPA , Mary D. Nichols to Alvin Alm, Department of Energy. December 19, 1996

[GEN-1] WIPP PA User's Manual for GENII-A, Version 2.10. Document Version 1.00, WPO # 27751. November 13, 1995.

[GEN-2] Napier, B.A., R.A. Peloquin, D.L. Strenge and J.V. Ramsdell. 1988. GENII- *The Hanford Environmental Radiation Dosimetry Software System. Vol. 1: Conceptual Representation.* PNL-6584, Vol. 1. Richland, WA: Pacific Northwest Laboratory.

[GEN-3] Napier, B.A., R.A. Peloquin, D.L. Strenge and J.V. Ramsdell. 1988. GENII- *The Hanford Environmental Radiation Dosimetry Software System Vol. 2: User's Manual. PNL-6584, Vol. 1. Richland, WA: Pacific Northwest Laboratory.*

[NA-1] The NALCO Water Handbook, Frank N. Kemmer, Nalco Chemical Company. McGraw-Hill Book Company. 1987. Pg. 35.2 Table 35.1A.

[NRC-1] U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, " Regulatory Guide 1.109 (1997).

[NU-1] WIPP PA User's Manual for NUTS, Version 2.02. Document Version 1.00, WPO # 37927. May 28, 1996.

6.0 Appendices

Appendix A: Listing of Input and Output Data Files for Dose Calculation: Marker Bed 139 (Table A-1)

Table A-1 Input and Output Files for Dose Calculations [1]

INPUT FILE	OUTPUT FILE	DESCRIPTION
1. gi2_calc311.inp	gi2_calc311_trn.out	r3s1v064 10,000 yrs. MB139s (Farm Family- Food Ingestion)
2. gi2_calc312.inp	gi2_calc312_trn.out	r3s1v064 10,000 yrs. MB139s (Cattle Rancher)
3 gi2_calc812.inp	gi2_calc812_trn.out	r3s1v064 10,000 yrs. MB139s (Farm Family-Inhalation)

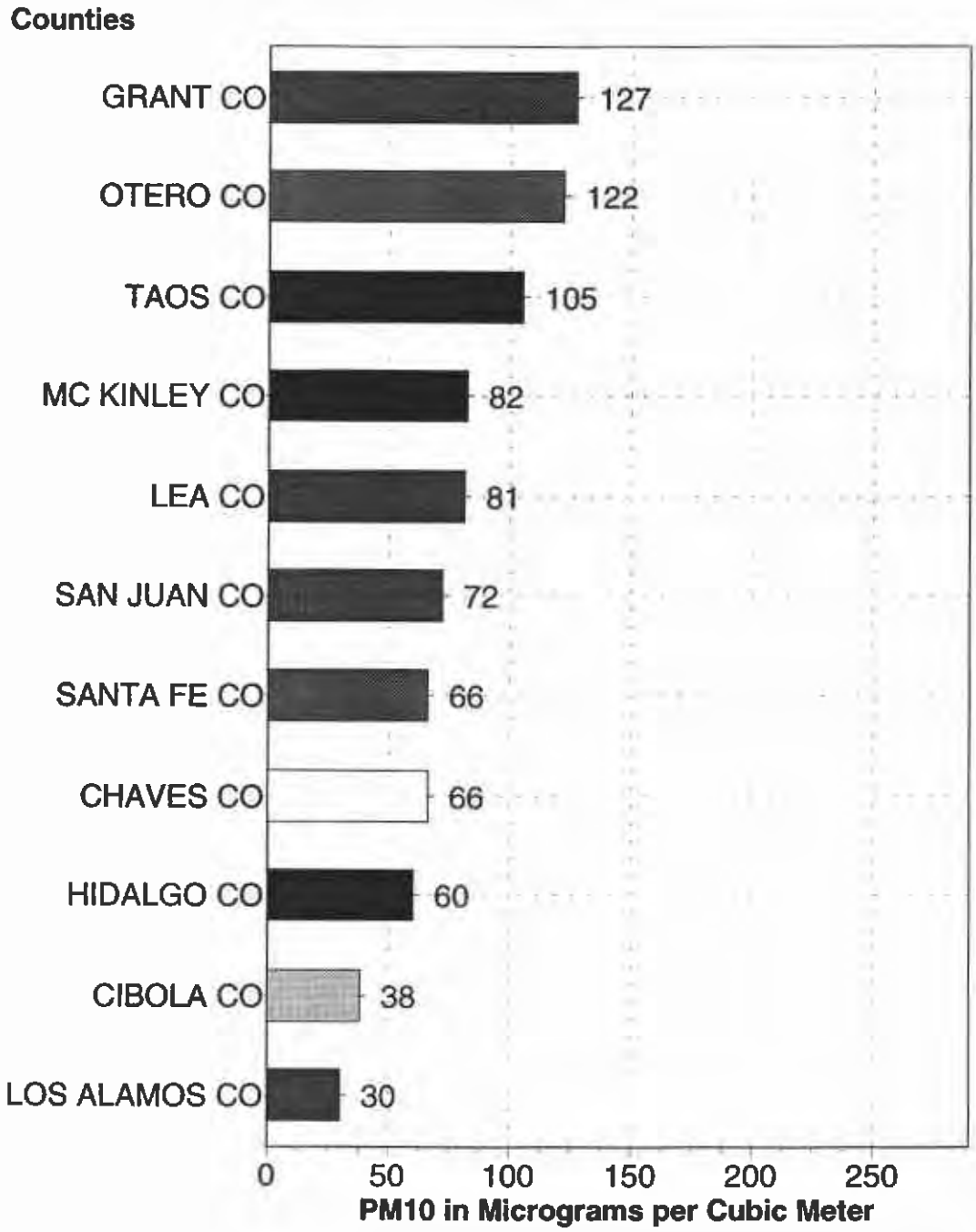
Footnote 1:
To run these data files type the following command: RUN_GI2 100 where 100 is the number associated with the data file GI2_CALC100.INP, for example.
An output file GI2_CALC100_TRN.OUT, will be generated.
The edit command EDT filename was used to open and edit input and output files.
Legend:
r3 replicate 3 of NUTS OUTPUT
s1 undisturbed case
v vector number

+

Appendix B: Graph of Mass Loading Data Taken from 1991 to 1996 for Lea County.

Max Value Chart for NEW MEXICO
PM10 Air Quality Monitors (All Years)

Data Extract



National Standard = 150.0000

Appendix C: Procedure for Extraction of NUTS data used in this analysis.

The directory U1:[JDMILLE.TEST] contains the following files used in the extraction of data from NUTS:

1. PA_NUTS_ISO_S1_CONC.INP , the equation file , plus the NUTS.CDB ouput file are used to extract data from NUTS.

2. PA_NUTS_ISO_CONC.COM is the command file for ALGEBRACDB **[ALG-1]** used to process these data.

3. The resulting CDB files are :

PA_NUTS_ISO_R1S1_CONC_V046.CDB
PA_NUTS_ISO_R2S1_CONC_V016.CDB
PA_NUTS_ISO_R2S1_CONC_V025.CDB
PA_NUTS_ISO_R2S1_CONC_V033.CDB
PA_NUTS_ISO_R2S1_CONC_V081.CDB
PA_NUTS_ISO_R2S1_CONC_V090.CDB
PA_NUTS_ISO_R3S1_CONC_V003.CDB
PA_NUTS_ISO_R3S1_CONC_V060.CDB
PA_NUTS_ISO_R3S1_CONC_V064.CDB

4. Selected times are obtained through processing by SUMMARIZE **[SUM-1]** , using the input file

PA_NUTS_ISO_S1_CONC.SMZ

5. This output is transferred to an EXCEL spreadsheet form through multiple files, one for each vector. The EXCEL input file, containing all vectors is PA_NUTS_ISO_S1_CONC.TBL.

6. All files have been transferred to the CMS system.

[ALG-1] **ALGEBRACDB** , WPO# 21247, 1995

[SUM-1] **SUMMARIZE** , WPO# 21781, 1995