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Sandia National Laboratories
Waste Isolation Pilot Plant

Analysis Package for PANEL: Compliance Recertification Application

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1.0 Introduction

1.1 Background

The Waste Isolation Pilot Plant (WIPP) is located in southeastern New Mexico and has been developed by the U.S. Department of Energy (DOE) for the geologic (deep underground) disposal of transuranic (TRU) waste. Containment of TRU waste at the WIPP is regulated by the U.S. Environmental Protection Agency (EPA) according to the regulations set forth in Title 40 of the Code of Federal Regulations, Parts 191 and 194. The DOE demonstrates compliance with the containment requirements in the regulations by means of a performance assessment (PA), which estimates releases from the repository for the regulatory period of 10,000 years after closure.

In October 1996, DOE submitted the Compliance Certification Application (CCA) to the EPA, which included the results of extensive PA analyses and modeling. After an extensive review, in May 1998 the EPA certified that the WIPP met the criteria in the regulations and was approved for disposal of transuranic waste. The first shipment of waste arrived at the site in March 1999.

The results of the PA conducted for the CCA were subsequently summarized in a Sandia National Laboratories (SNL) report [1] and in refereed journal articles [2].

The DOE is required to submit an application for re-certification every five years after initial receipt of waste. The re-certification applications take into account any information or conditions that have changed since the original certification decision. Accordingly, the DOE is conducting a new PA in support of the Compliance Recertification Application (CRA).

1.2 Purpose

This document presents the results of the PANEL portion of the PA for the CRA. The calculations to be completed for the PA for the CRA are outlined in AP-105 [3]. PANEL is run as part of the Salado Flow and Transport analysis, which is outlined in AP-99. [4]. In combination, the analysis packages for BRAGFLO [5] and for Salado Transport [6] and this document comprise the analysis reports resulting from the activities specified in AP-099.

PANEL is a code that calculates the activity of radionuclides throughout the regulatory period, and the concentrations of radionuclides mobilized in brine, either as dissolved isotopes or as isotopes sorbed to colloids. PANEL is also used to calculate radionuclide flow to the Culebra for certain intrusion scenarios.

SNL originated the PANEL code for use in WIPP PA. PANEL version 3.60 was used in the CCA. Subsequently, PANEL was revised to version 4.00 to simplify the PA calculation sequence, and to accommodate a change in the software that maintains the parameter database [7]. In preparation for the CRA, PANEL was further revised to version 4.02 to accommodate an increase in the number of sampled parameters for radionuclide solubilities [8]. PANEL 4.02 was validated according to the requirement of NP 19-1 [9] and used in the CRA calculations. For more information on PANEL, see the Users Manual Version 4.02 [10].

1.3 Outline

This document first describes the methodology that PANEL applies to its calculations, then presents the results of the various PANEL calculations used in PA.

2.0 Methodology

For WIPP PA, PANEL calculates the concentrations of mobilized radionuclides and the radionuclides released to the Culebra in multiple intrusion scenarios. The code runs for concentrations of mobilized radionuclides are called source term calculations, and code runs for releases to the Culebra are termed E1E2 calculations.

2.1 Inventory

The radionuclide inventory for the CRA calculations is reported in TWBIR [11]. The results in this document used the radionuclide inventory for the CRA.

2.2 Parameters

In preparation for the CRA, actinide solubilities were re-calculated [12]. The results in this document used the revised parameters for radionuclide solubilities for the CRA.

2.3 PANEL Source Term

For the source term calculations, PANEL computes the concentration of radionuclides mobilized in brine that may be present in the waste. The total mobilized concentration consists of a dissolved component and up to four colloidal components: humic, microbial, intrinsic, and mineral fragment colloids. The PA includes uncertainty in the parameters that describe each radionuclide's solubility, its partitioning among colloid species, the oxidation state of each isotope, and for microbial activity in the repository. All these uncertain parameters result in uncertainty in the concentration of mobilized radionuclides. For more information about the computation of mobilized concentrations, refer to the PANEL 4.00 Design Document [13] and the PANEL 4.02 User's Manual [10].

Next we outline the methodology for computing each component of the actinides source term. The computation for all actinides follows this pattern. The units for all components of the source term are moles per liter.

2.3.1 Dissolved Component

The first step in determining the source term for an actinide is to determine the oxidation state of the actinide. The base solubility value is then read from the parameter database from material SOLMOD# (# being the oxidation state), using one of the following property names: SOLSOH, SOLSOC, SOLCOH, of SOLCOC. The value for a particular vector is determined by brine type (**C**astile or **S**alado, determined by the fourth letter) and buffer (either $Mg(OH)_2$/**H**ydromagnisite or $Mg(OH)_2/CaCO_3$, determined by the last letter). The buffer is determined by the presence or absence of microbial activity: when microbial activity is present, the buffer is $Mg(OH)_2$/Hydromagnisite; otherwise the buffer is $Mg(OH)_2/CaCO_3$.

The base solubility value is multiplied by 10^{SV}, where SV is a sampled value from the solubility variability function. This function is sampled independently for each brine type and oxidation state for each radionuclide. The variable SV is sampled from the distribution specified in the parameter database by material SOL*EL#* (where *EL* is either AM, PU, U, or TH and # is the oxidation state) and property names SOLCIM and SOLSIM, for Castile and Salado brines, respectively. The product of the base solubility value and the quantity 10^{SV} is the dissolved concentration of the actinide in that brine.

2.3.2 Colloidal Components

Once the dissolved component is known, the various colloid concentrations are determined by means of proportionality factors or by constants.

Five parameters are used for each radionuclide to compute the colloidal components. These parameters are found in the parameter database in the material name of the actinide (AM, NP, PU, U, and TH) and property names CONCMIN, CONCINT, CAPHUM, CAPMIC, and PROPMIC.

The mobilized concentration for humic colloids is obtained by multiplying the dissolved component by a factor that is defined for each oxidation state/brine type. This is obtained from the database for material name PHUMOX# (# is for the oxidation state) and property name PHUMSIM or PHUMCIM for Salado and Castile brine, respectively. However, the humic colloidal concentration cannot exceed the value of CAPHUM.

The mobilized concentration for microbial colloids is zero if there is no microbial activity. If microbial activity is present, the concentration is obtained by multiplying the dissolved component by the value of PROPMIC. However, the microbial colloidal concentration cannot make the total mobilized concentration exceed the value of CAPMIC.

The mobilized concentration for mineral fragment colloids is determined by the constant value of CONCMIN.

The mobilized concentration for intrinsic colloids is determined by the constant value of CONCINT.

2.3.3 Total Mobilized Concentration

The total mobilized concentration is the sum of the dissolved concentration and the four colloidal concentrations.

2.3.4 Use of Source Term Results in WIPP PA

Results of the source term calculations are used by the code PANEL in the E1E2 calculations. In addition, source term results are used by the codes NUTS and CCDFGF to determine the releases by transport through the Salado, releases to the Culebra, and releases from direct brine releases (DBR) from a drilling intrusion.

PANEL computes the concentrations of 23 radionuclides, as well as the total concentration of all radionuclides in EPA units. The total concentration in EPA units is used for the DBR releases, thus the DBR releases include all 23 radionuclides. Salado transport releases and releases to the Culebra are calculated for five lumped radionuclides [14]: AM241L, PU238L, PU239L, U234L, TH230L. The amounts in curies for each lumped radionuclide is calculated by combining like isotopes, as follows:

AM241L is the amount of AM241 plus the amount of PU241.
PU238L is the same amount as PU238.
PU239L is the amount of PU239 plus the amount of PU240 plus the amount of PU242.
U234L is the amount of U234 plus the amount of U233.
TH230L is the amount of TH230 plus the amount of TH229.

Use of lumped radionuclide concentrations reduces the number of transported species to a manageable number.

2.4 E1E2 Scenario

The WIPP PA defines six scenarios for calculating the consequences of a drilling intrusion [5]. An E1 intrusion assumes that a borehole passes through the repository and encounters a brine pocket in the Castile; an E2 intrusion is a borehole that does not encounter a brine pocket. The S6 scenario assumes that both an E1 and an E2 intrusion occur in the same waste panel. In this scenario, brine can flow from the Castile, through the waste in the panel, and then continue up an earlier, open borehole to the Culebra.

PANEL computes the amount of radionuclides released to the Culebra for an E1E2 scenario. PANEL combines the time-dependent mobilized concentrations of each lumped radionuclide with the brine flow volumes calculated by BRAGFLO. PANEL conservatively assumes that any radionuclide that rises above the disturbed rock zone above the waste panels reaches the Culebra. For more information on the methodology used by PANEL in the E1E2 calculations refer to the PANEL 4.00 Design Document [13] and the PANEL 4.02 User's Manual [10]

3.0 PANEL Results

In this section we present the results of the PANEL source term and E1E2 calculations for the CRA. As documented in [15], all PANEL runs were conducted using the WIPP PA run control system, and results are archived in CMS library for PANEL, PACMS2:[CMS.CMS_CRA1.CRA1_PANEL], in class CRA1.

3.1 PANEL Source Term

3.1.1 Mobilized Concentrations for Americium

For the CRA, Americium only occurs in oxidation state III.

Results from the PANEL source term calculations are presented for both brines (Salado and Castile). Results are mainly presented as scatter plots to illustrate the range of uncertainty in each radionuclide's mobilized concentration.

There will be five scatter plots for each brine type. The independent variable (abscissa) will always be WSOLAM3S (for Salado brine) or WSOLAM3C (for Castile brine). This variable is the sampled value of the solubility variability that varies from –2.0 to 1.4 in log units. Figures 1 to 5 are for Salado brine and Figures 6 to 10 are for Castile brine.

Figures 1 and 6 show the dissolved component of the source term.

Figures 2 and 7 show the humic component of the source term. The reason Figure 7 is not a straight line like Figure 2 is because the proportionality multiplier for humics in Castile brine is a sampled variable.

Figures 3 and 8 show the microbial component of the source term. The values are either zero or a constant times the dissolved component.

Figures 4 and 9 are constants for the mineral fragment component of the source term. The intrinsic portion of the source term is always zero for Americium.

Figures 5 and 10 show the total mobilized source term for Americium. This is the sum of the source term components. Figure 5 is two straight lines, depending on the presence of microbes. Figure 10 is two fuzzy lines, depending again on the presence of microbes and the sampled value of the humic proportionality value.

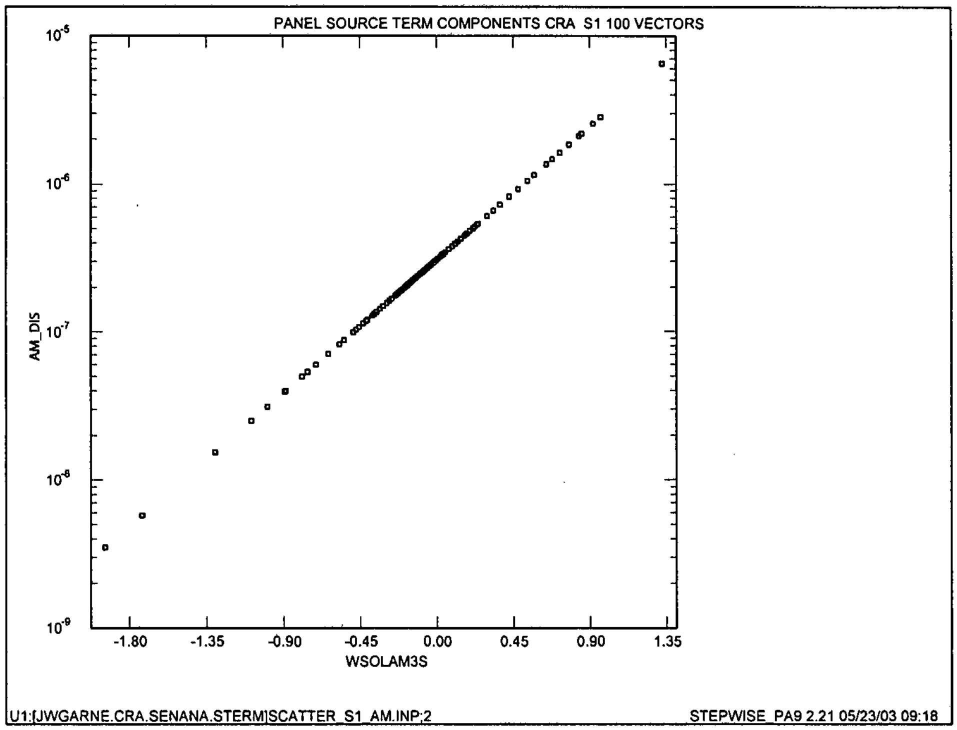

Figure 1 Americium Salado dissolved component of Source Term

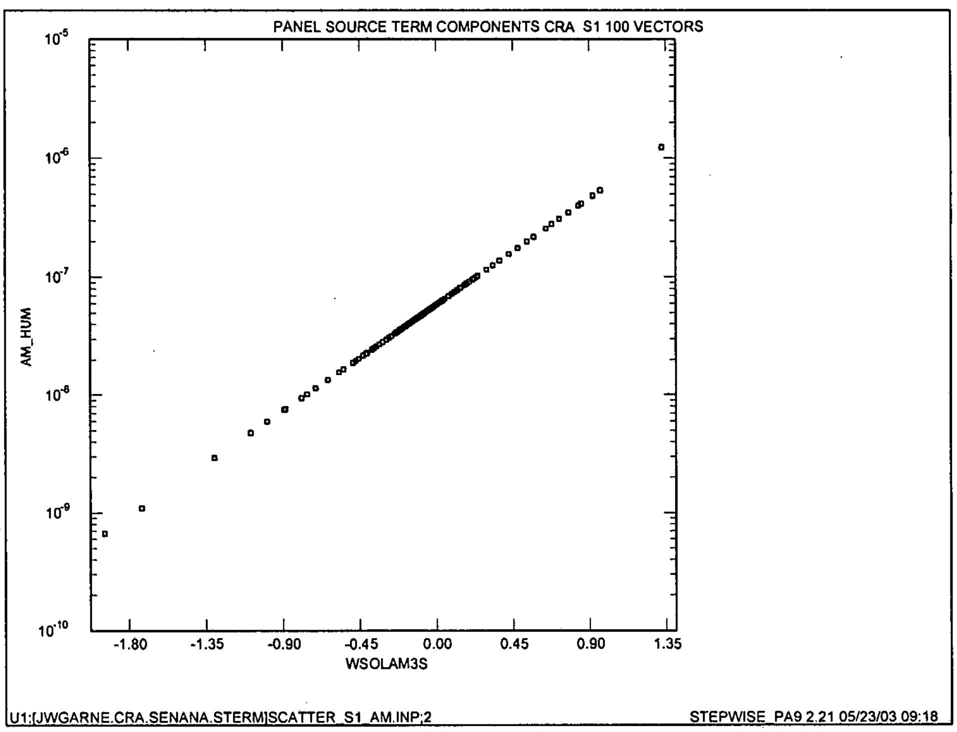

Figure 2 Americium Salado humic component of Source Term

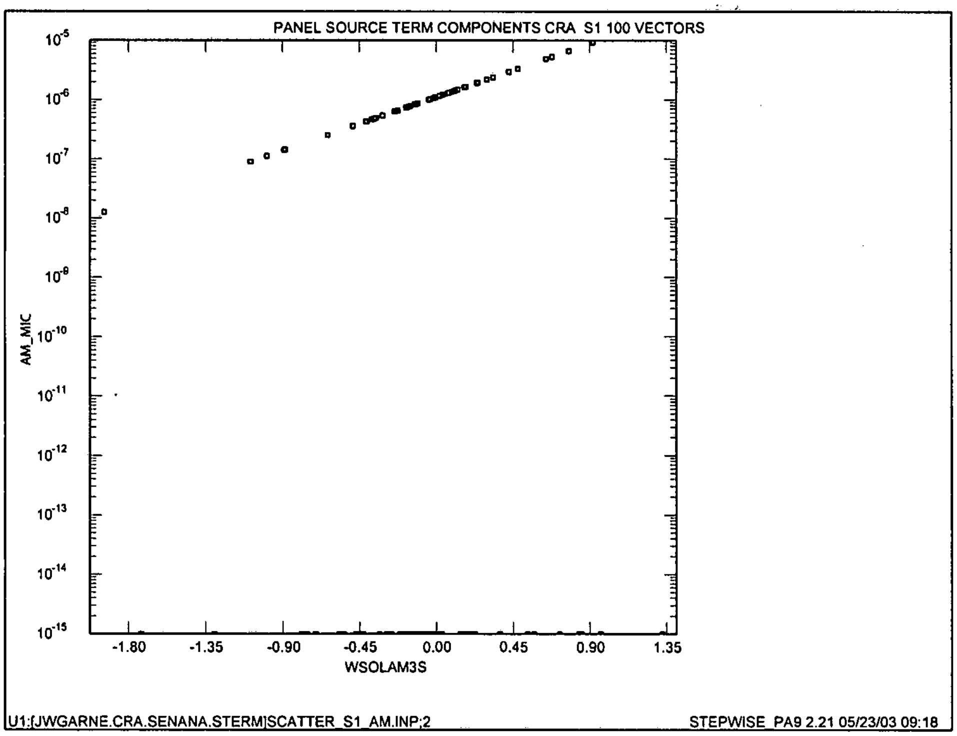

Figure 3 Americium Salado microbial component of Source Term

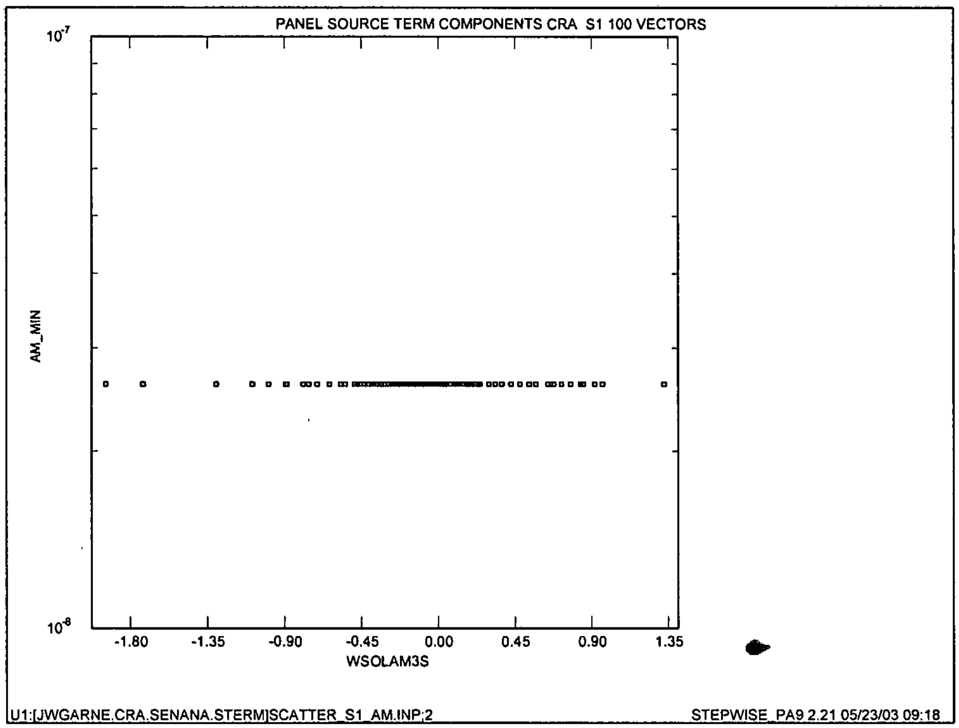

Figure 4 Americium Salado minerial fragment component of Source Term

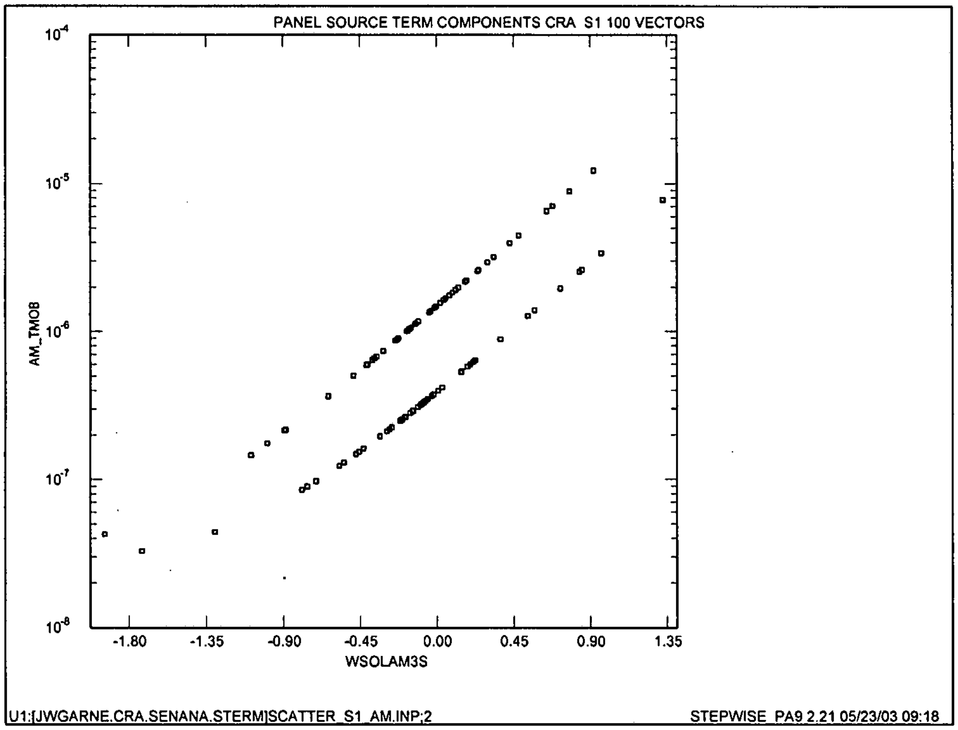

Figure 5 Americium Salado total Source Term

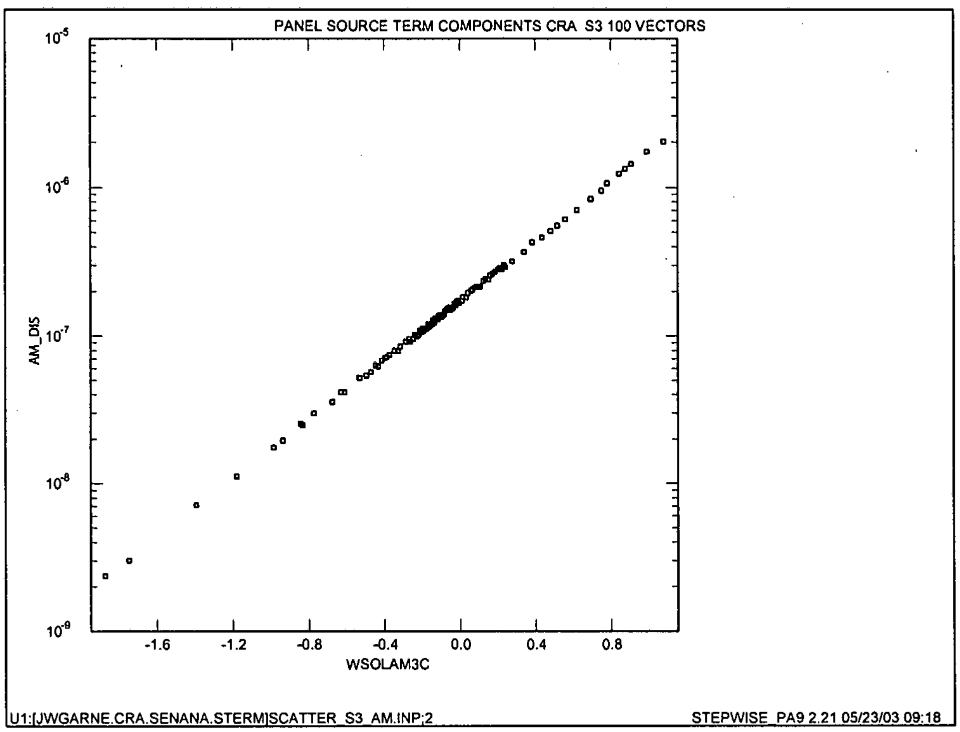

Figure 6 Americium Castile dissolved component of Source Term

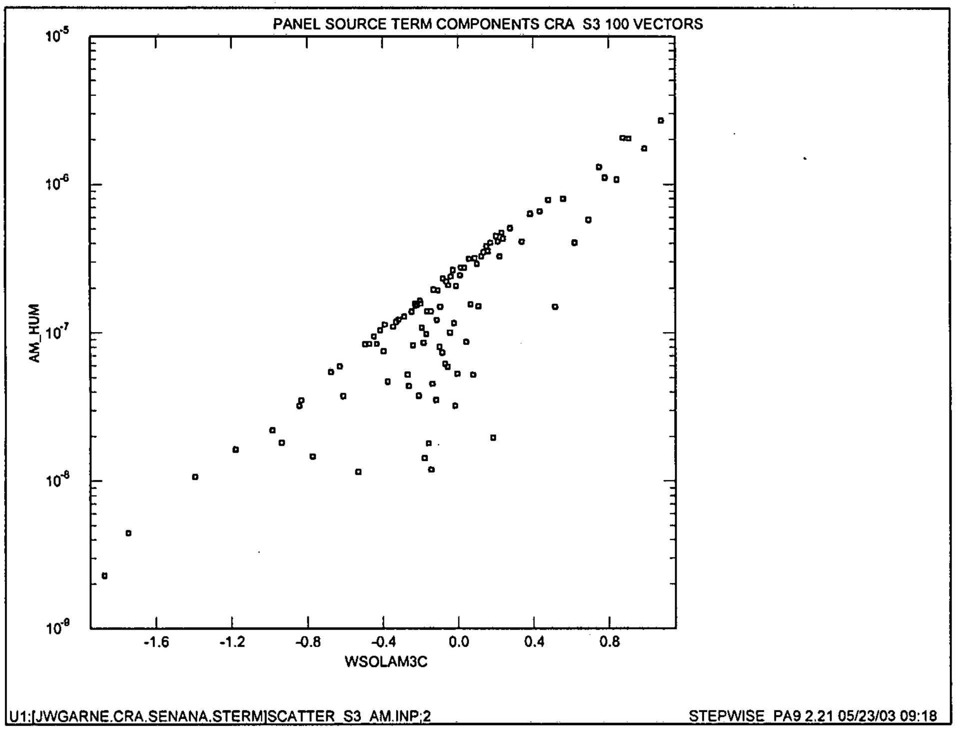

Figure 7 Americium Castile humic component of Source Term

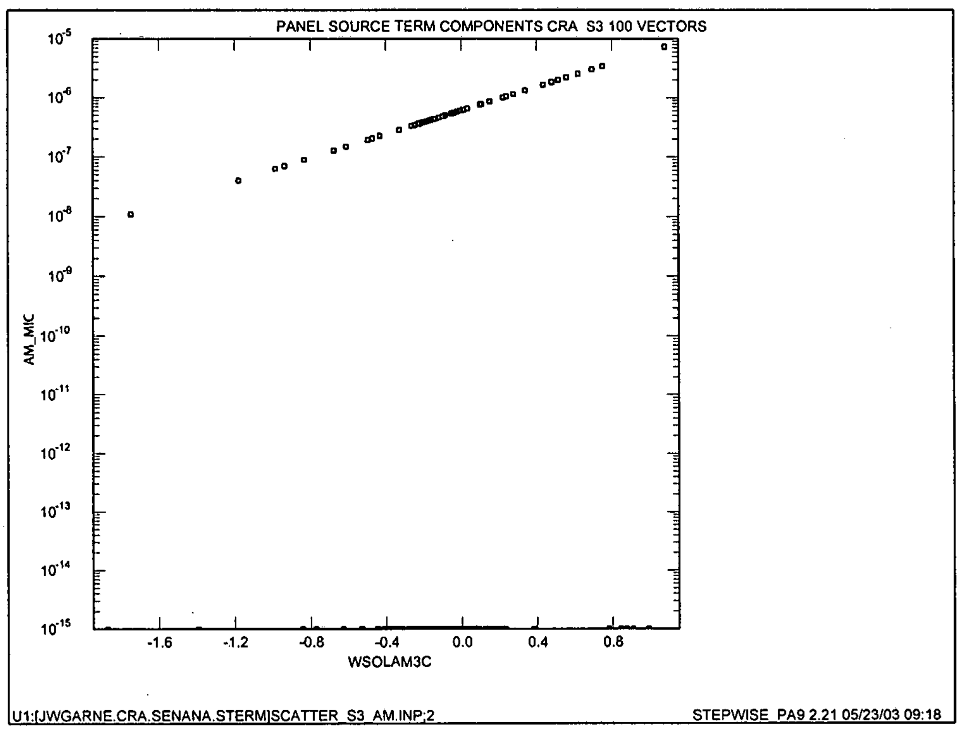

Figure 8 Americium Castile microbial component of Source Term

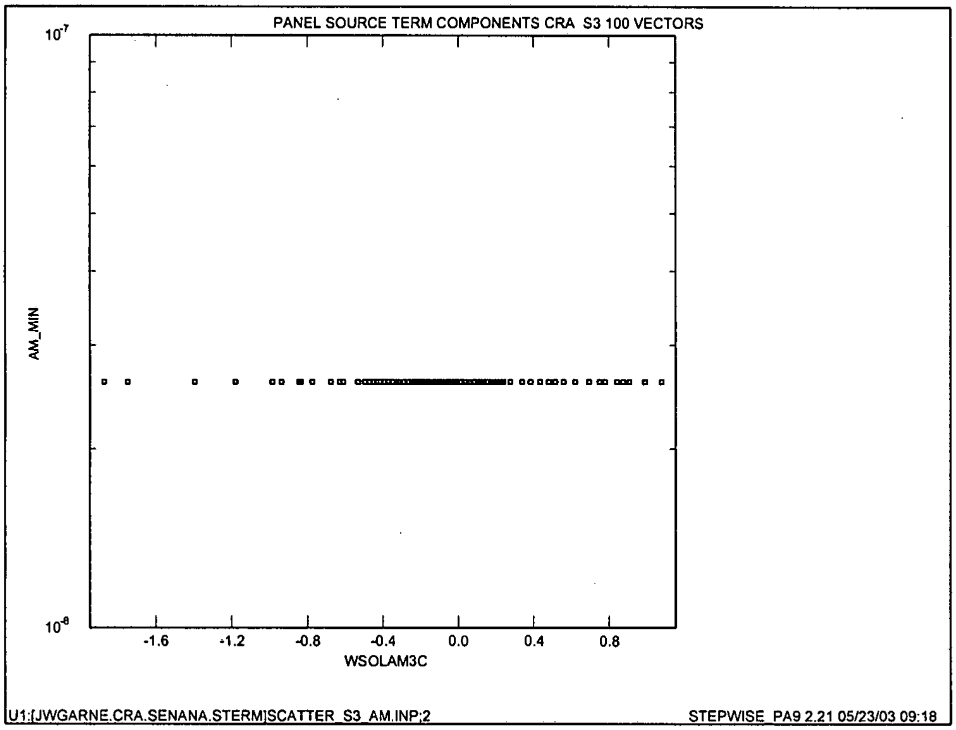

Figure 9 Americium Castile mineral fragment component of Source Term

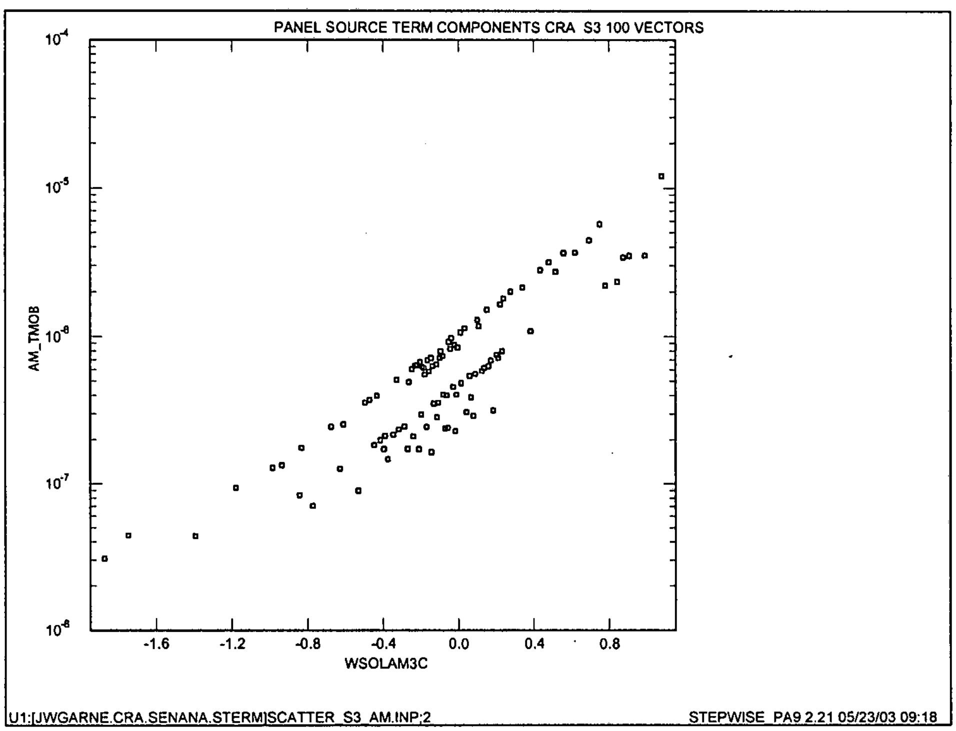

Figure 10 Americium Castile total Source Term

3.1.2 Mobilized Concentrations for Plutonium

In the CRA, Plutonium can occur in either oxidation state III or IV. There is a sampled variable with material name GLOBAL and property name OXSTAT that is uniform between 0 and 1. If this variable is less than or equal to .5, Plutonium will be in oxidation state III. If it is greater than .5, the oxidation state for Plutonium will be IV.

There will be six scatter plots for each brine type. The independent variable (abscissa) will always be WSOLPUS (for Salado brine) or WSOLPUC (for Castile brine). This variable is combined from the sampled value of the solubility variability that varies from –2.0 to 1.4 in log units for each oxidation state. Only the appropriate variability's (i.e., the variability for oxidation state III when the low oxidation state is used and the variability for oxidation state IV when the high oxidation state is used) are used. Figures 11 to 16 are for Salado brine and Figures 17 to 22 are for Castile brine.

Figures 11 and 17 show the dissolved component of the source term. Figure 11 has basically two straight lines that are determined by oxidation state. Figure 17 has three straight lines, since there is a different base solubility in Castile brines depending on buffer.

Figures 12 and 18 show the humic component of the source term. The reason Figure 18 is not three straight lines like Figure 17 is because the proportionality multiplier for humics in Castile brine is a sampled variable.

Figures 13 and 19 show the microbial component of the source term. We are back to two lines since the difference in base solubility by buffer type is masked by the zero multiplier when there is no microbial activity. The values are either zero of a constant times the dissolved component.

Figures 14 and 20 are constants for the intrinsic component of the source term.

Figures 15 and 21 are constants for the mineral fragment component of the source term.

Figures 16 and 22 show the total mobilized source term for Plutonium. This is the sum of the source term components.

See Appendix C for a list of values from the database used in the source term calculation from MATSET.

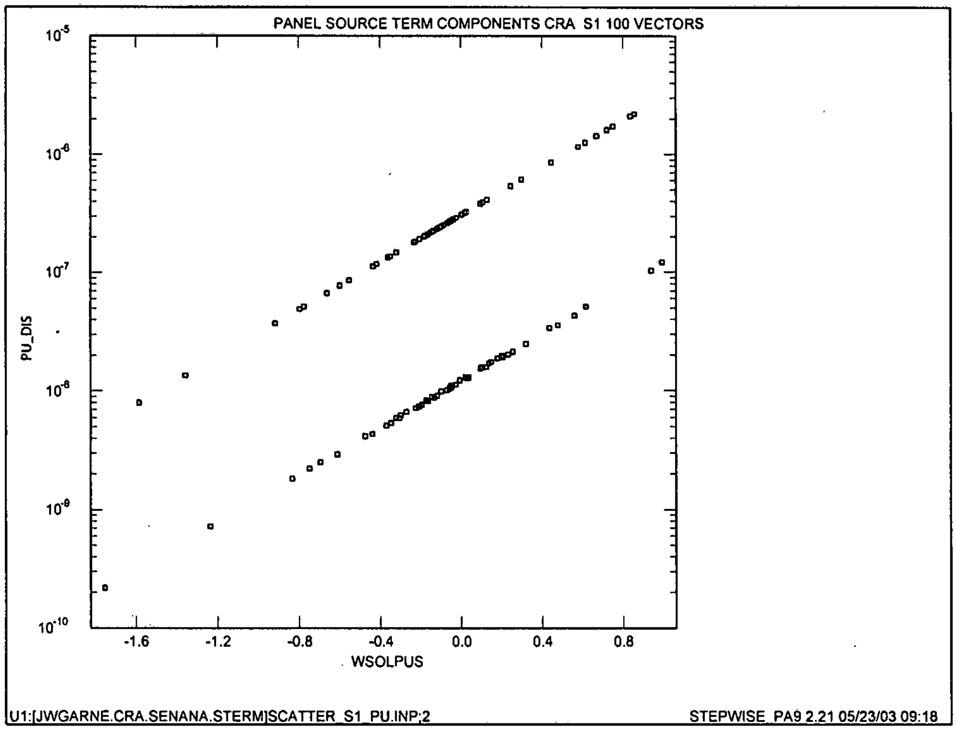

Figure 11 Plutonium Salado dissolved component of Source Term

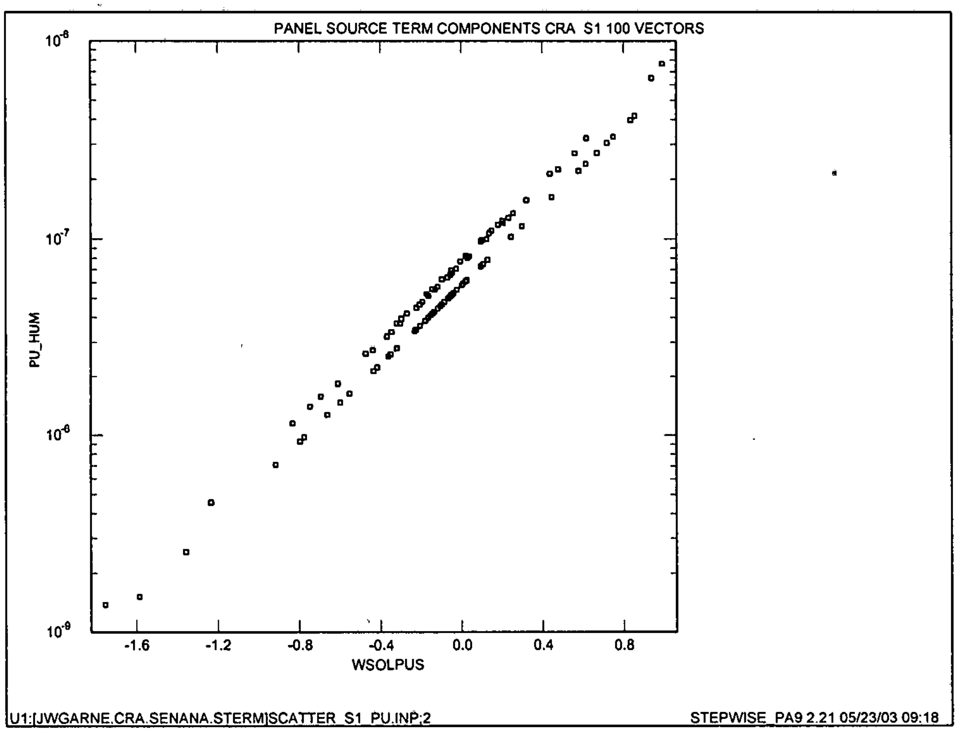

Figure 12 Plutonium Salado humic component of Source Term

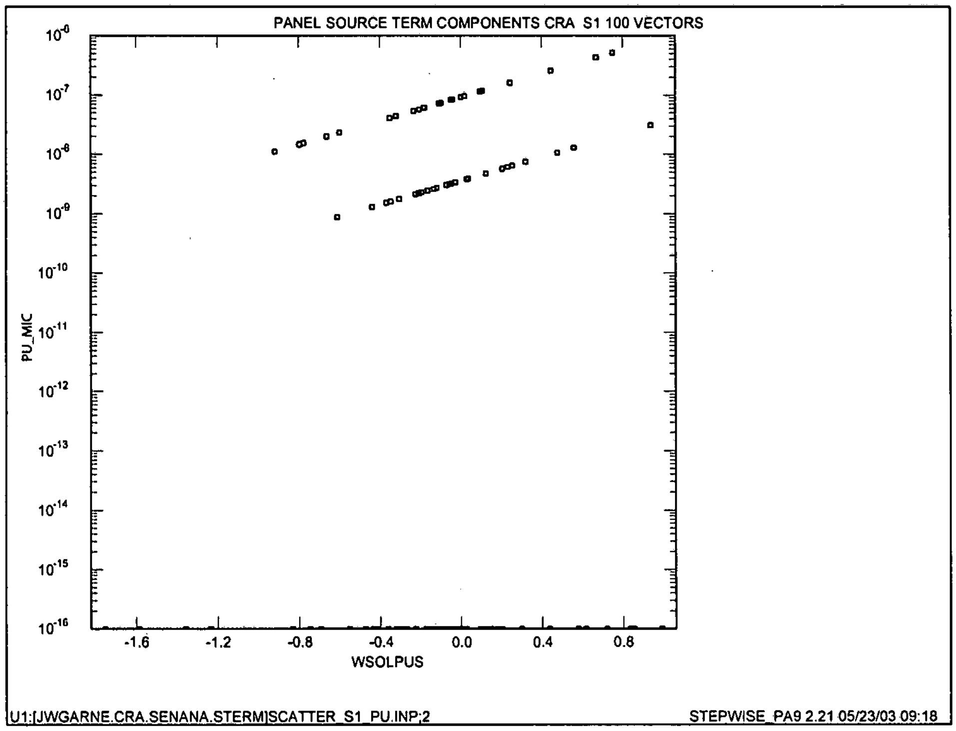

Figure 13 Plutonium Salado microbial component of Source Term

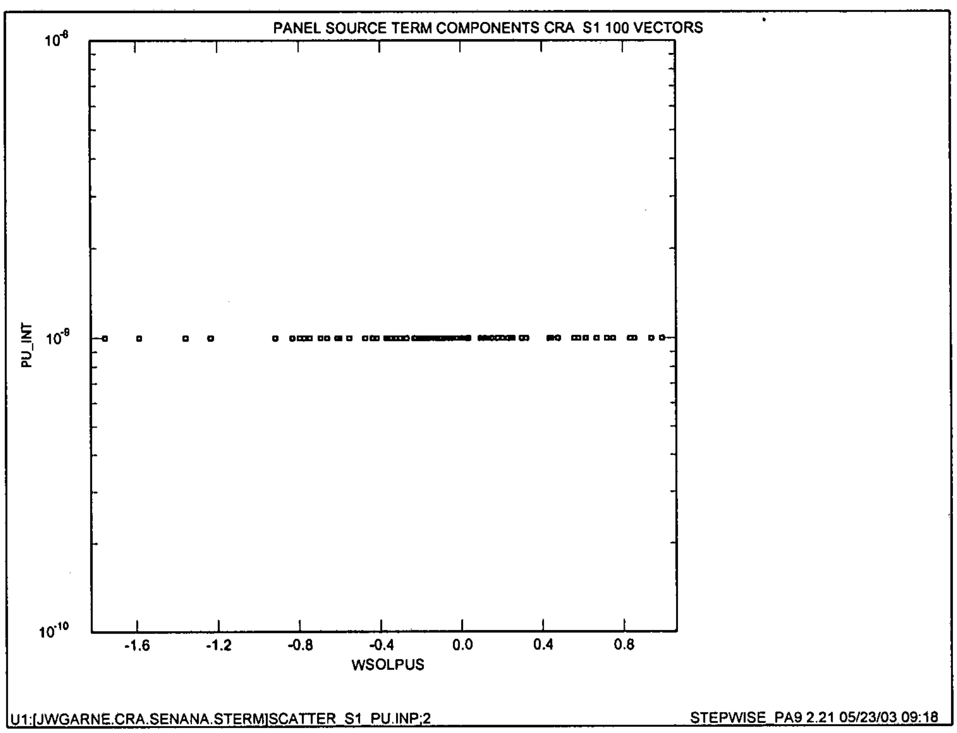

Figure 14 Plutonium Salado intrinsic component of Source Term

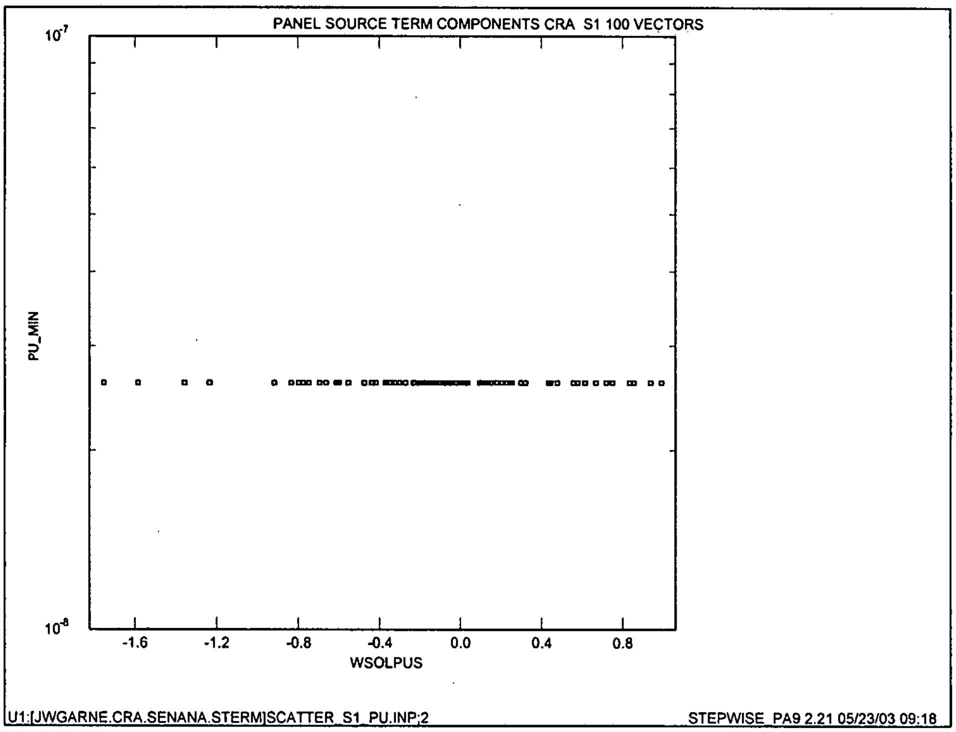

Figure 15 Plutonium Salado mineral fragment component of Source Term

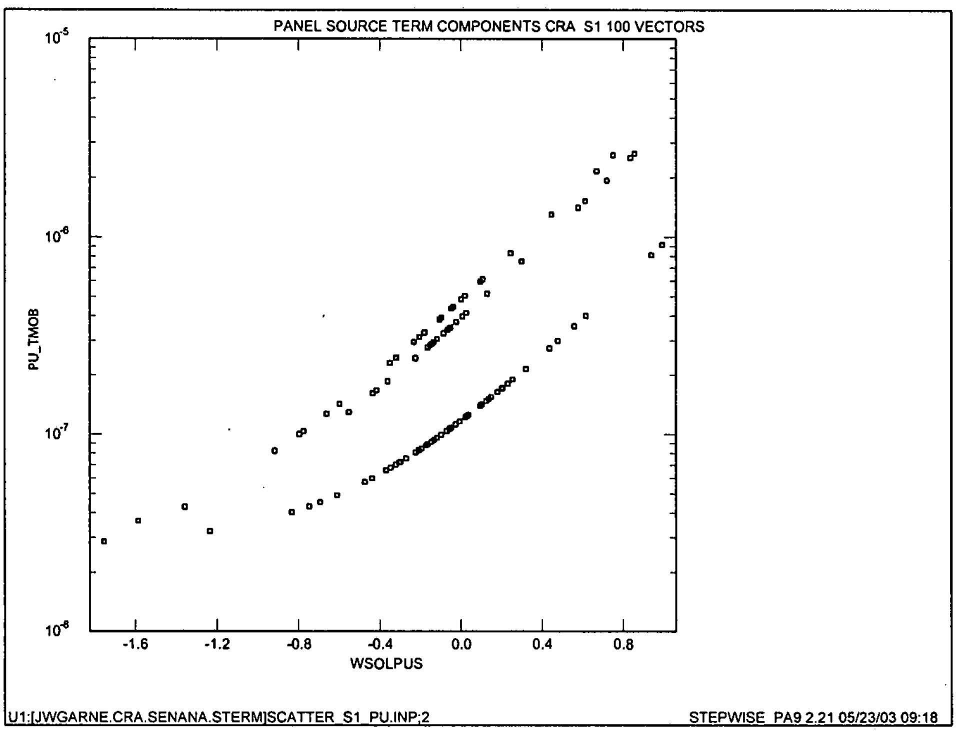

Figure 16 Plutonium Salado total Source Term

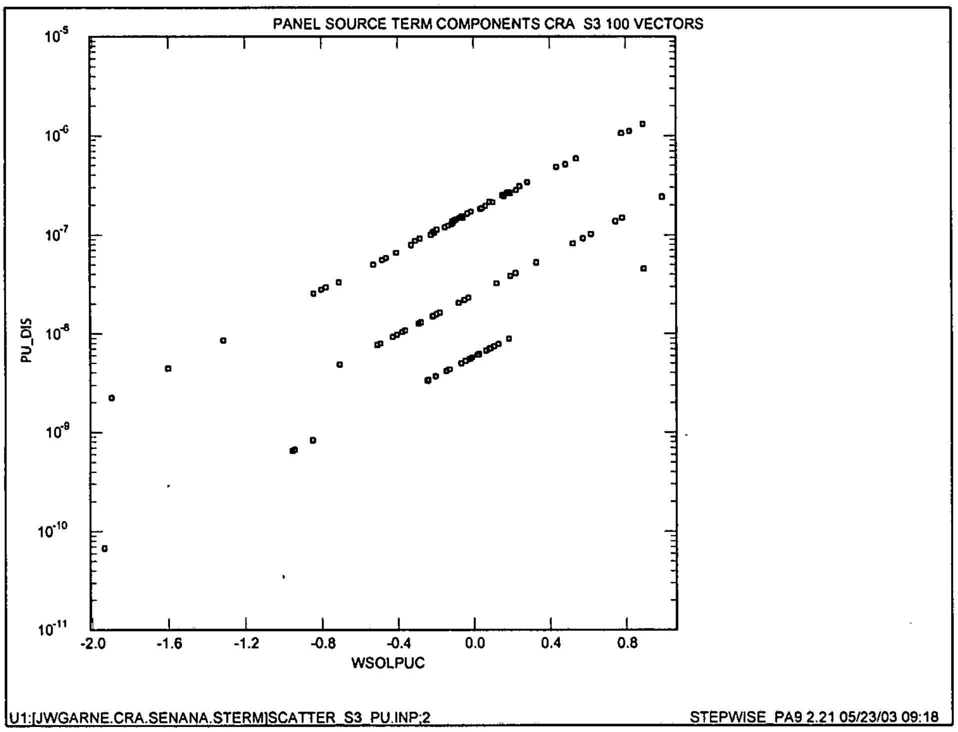

Figure 17 Plutonium Castile dissolved component of Source Term

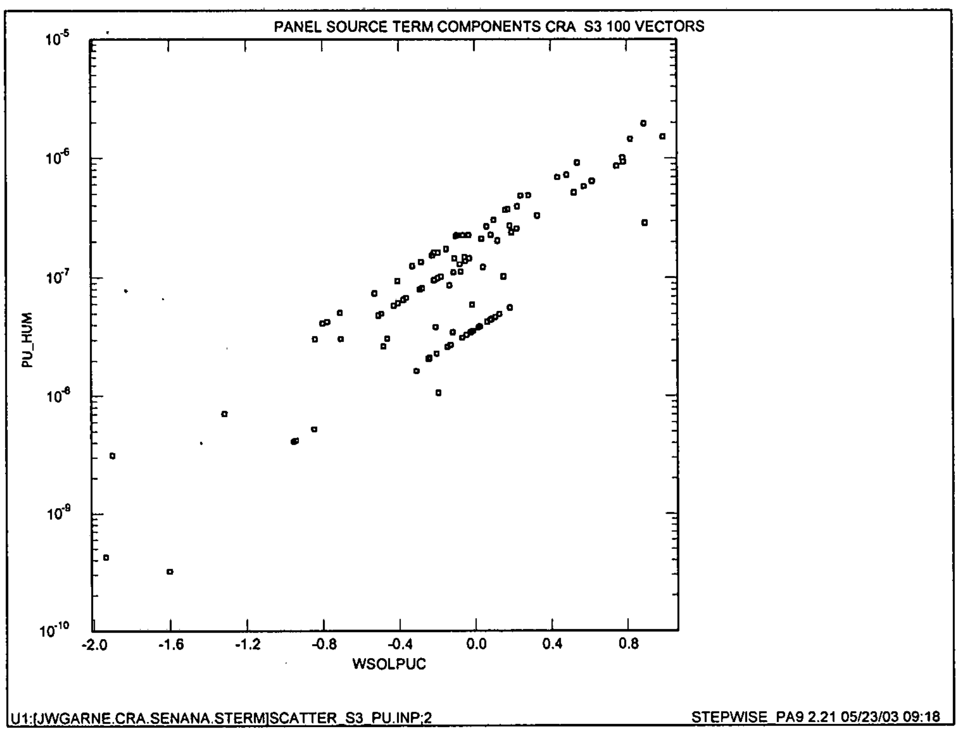

Figure 18 Plutonium Castile humic component of Source Term

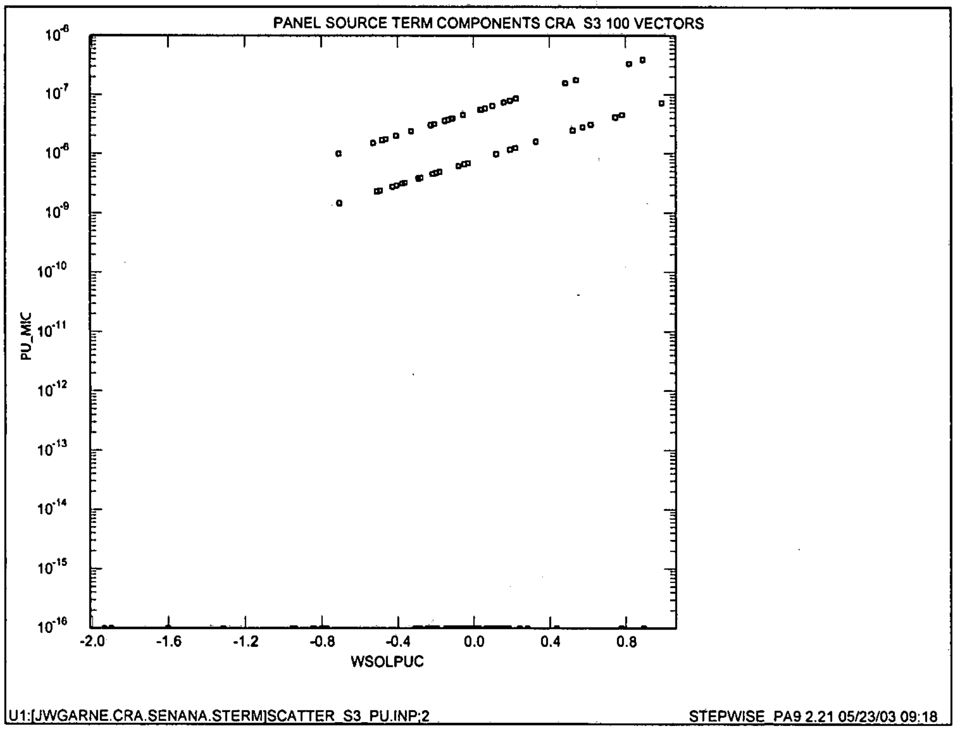

Figure 19 Plutonium Castile microbial component of Source Term

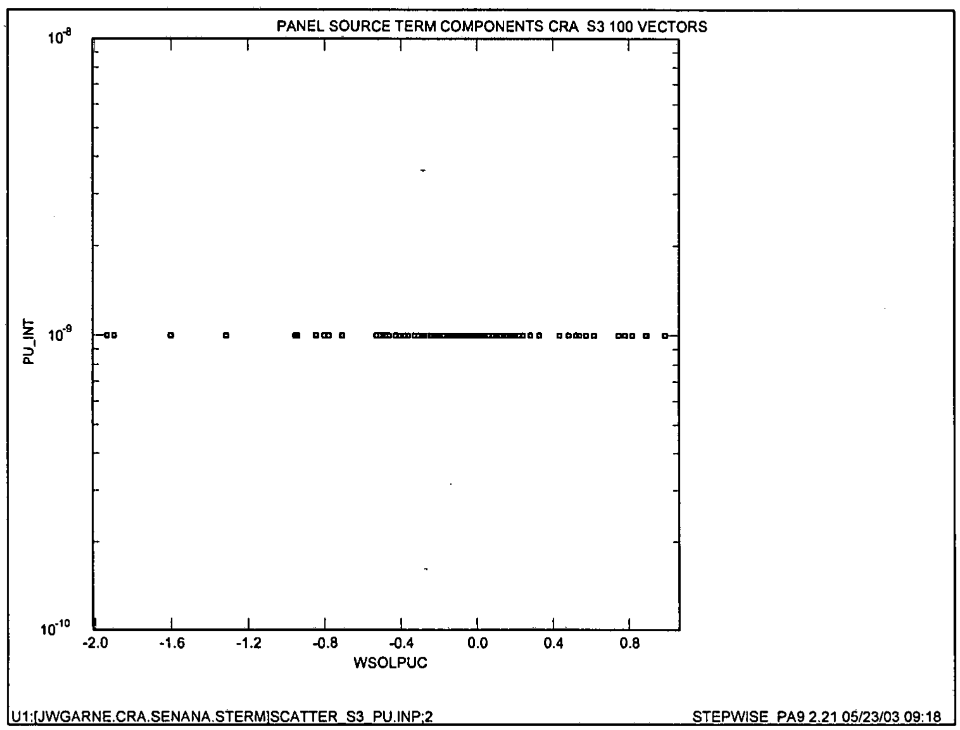

Figure 20 Plutonium Castile intrinsic component of Source Term

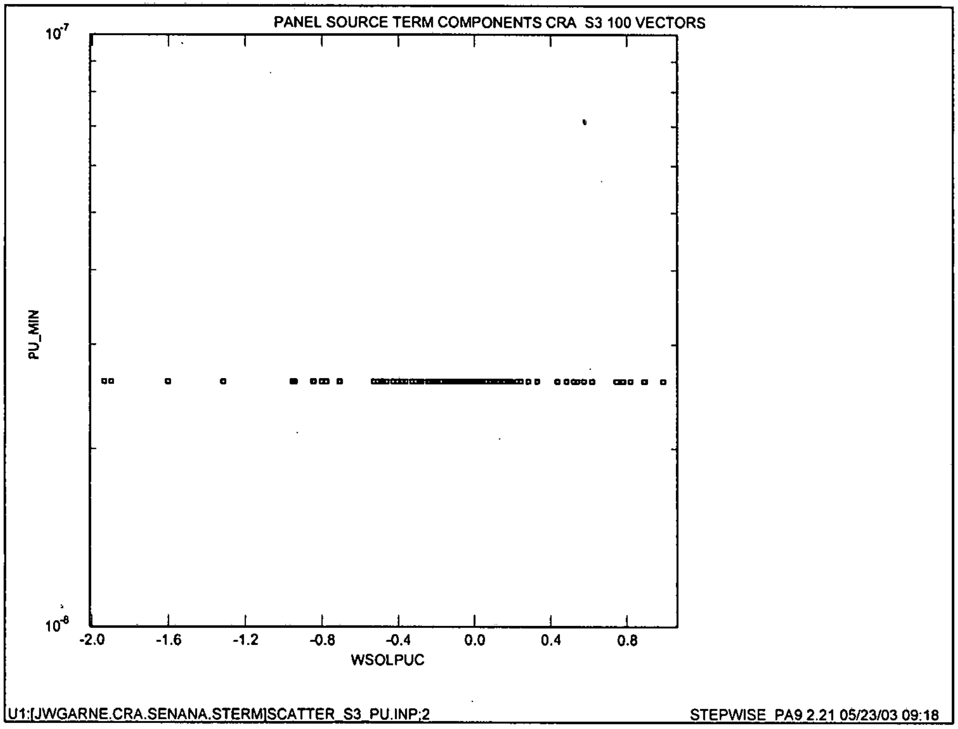

Figure 21 Plutonium Castile intrinsic component of Source Term

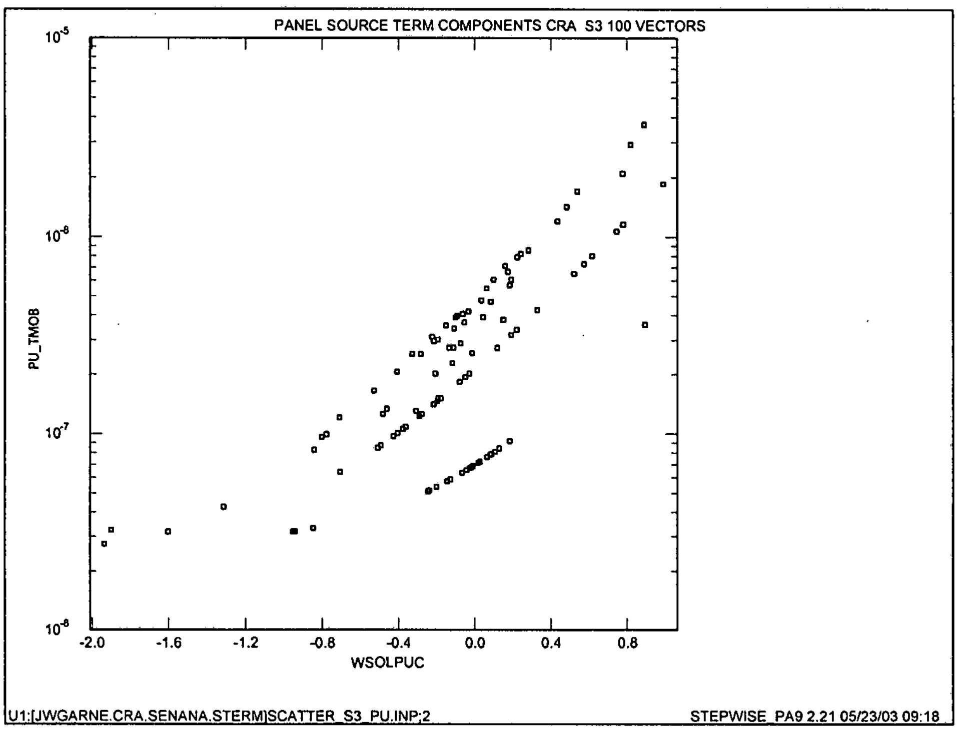

Figure 22 Plutonium Castile total Source Term

3.2 *PANEL Decay.*

PANEL is run in the Decay mode with the entire WIPP inventory so that plots can be generated to show how the radioactive inventory changes over the 10000-year regulatory period. The Figures 23 to 28 show the results of these decay calculations. These calculations are also used to compute the mole fractions of ^{234}U, ^{238}Pu, and ^{230}Th mentioned above. The variables plotted are SDE####,where SDE is the inventory of isotope #### in EPA units. The main contributors are ^{238}Pu,^{239}Pu,^{240}Pu, and ^{241}Am.

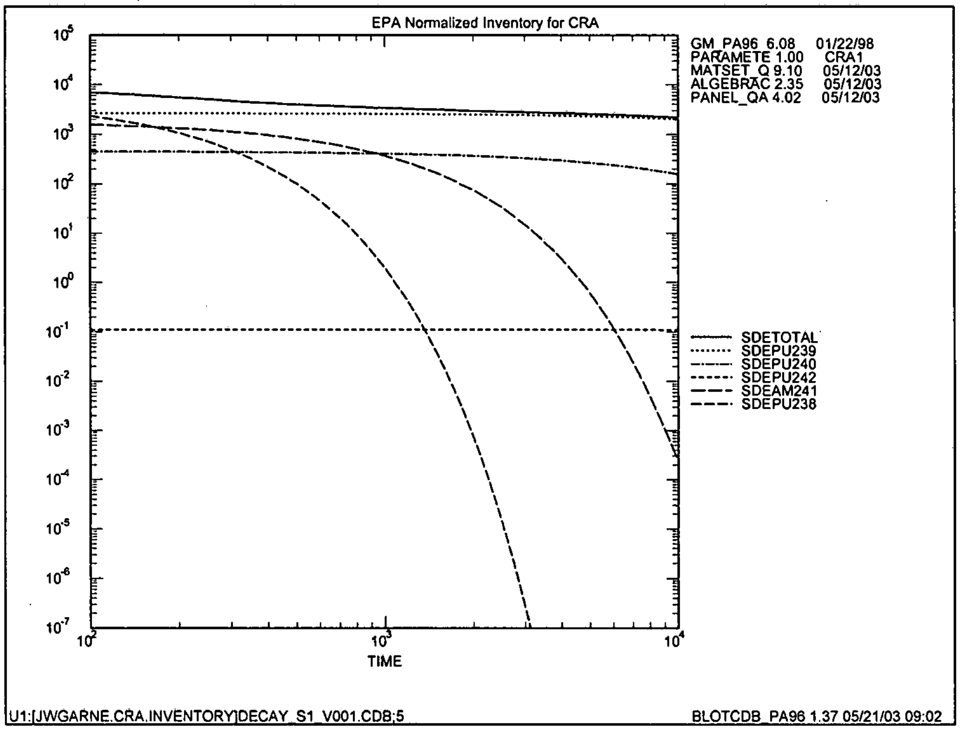

Figure 23 Time dependant inventories of Am and Pu isotopes

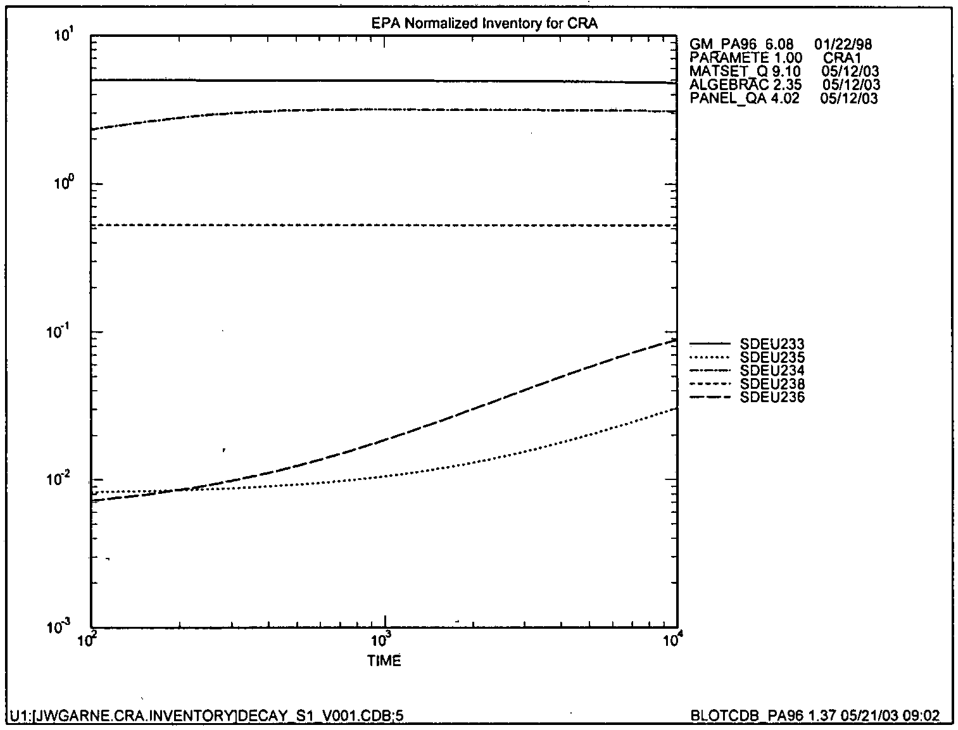

Figure 24 Time dependant inventories of U isotopes

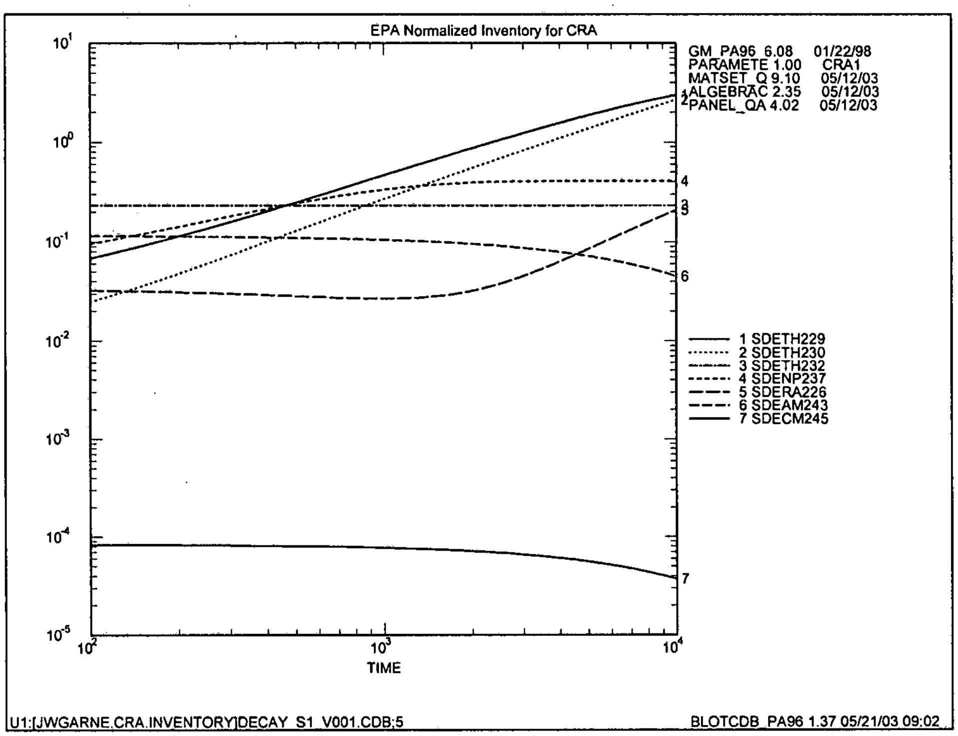

Figure 25 Time dependant inventories of various isotopes

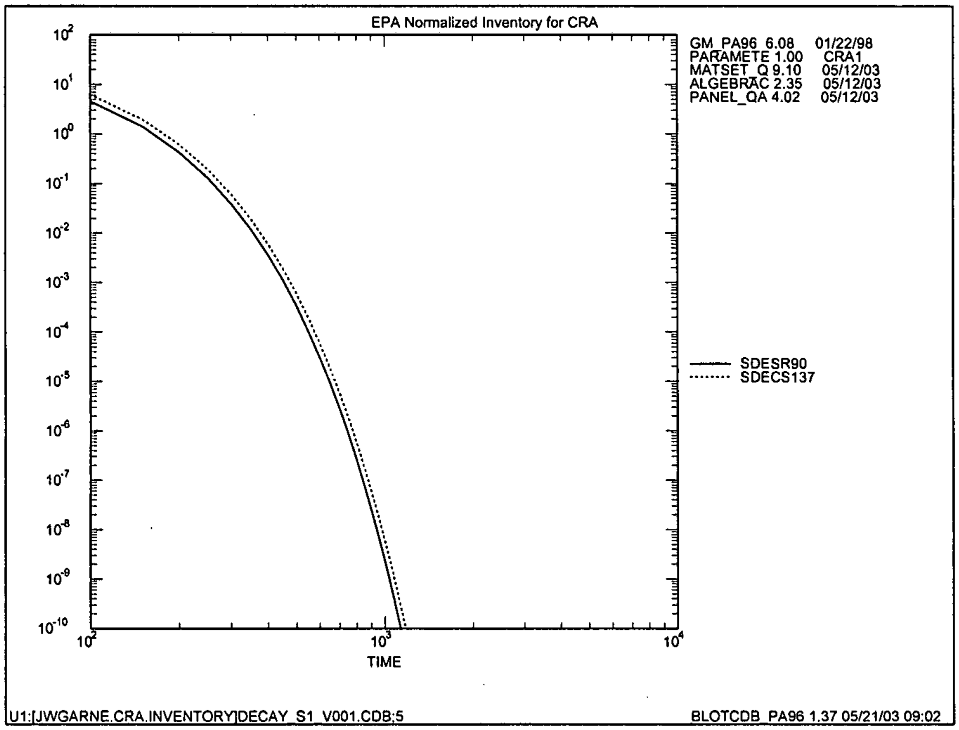

Figure 26 Time dependant inventories of Sr and Cs isotopes

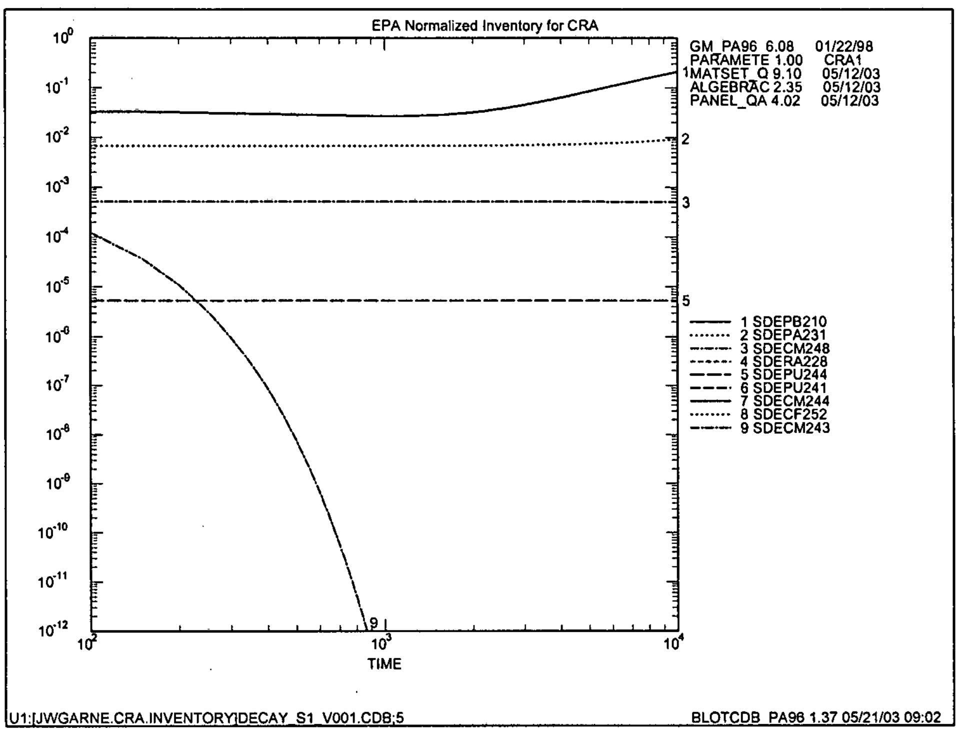

Figure 27 Time dependant inventories of various minor isotopes

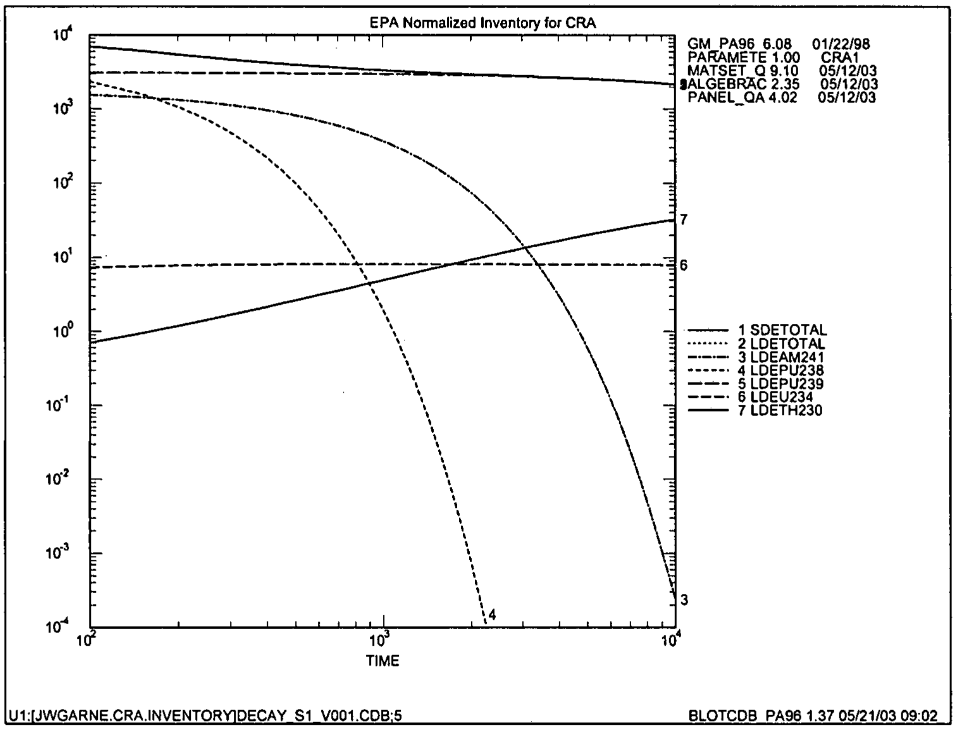

Figure 28 Time dependant inventories of lumped isotopes

3.3 PANEL Concentration

PANEL is run in the Concentration mode for Scenarios S1, S2, S3, S4, and S5 to obtain the source term information for NUTS. The source terms for S1, S4, and S5 are all equivalent, as are the source terms for S2 and S3. This is for ease of calculation in the scripting for NUTS. The concentration data for S1 (Salado brine) and S3 (Castile brine) are used together with the direct brine releases (volumes of brine) to obtain radionuclide releases through the direct brine pathway. Figures 29 to 38 show plots of these concentration calculations. The assumptions made for these calculations are that the brine volume in the panel of interest is 4,000 cubic meters and that the fraction of the inventory in this panel is .1044 The value .1044 is the ratio of the area of one of the outside panels to the area of all ten panels [16] and is input to PANEL through MATSET(see Appendix B). At times less than about 4000 years, the main contributor is ^{241}Am. As ^{241}Am decays (^{241}Am has a half-live of 432.2 years), there is not a sufficient quantity to achieve the Source Term limit. After that time, ^{239}Pu dominates.

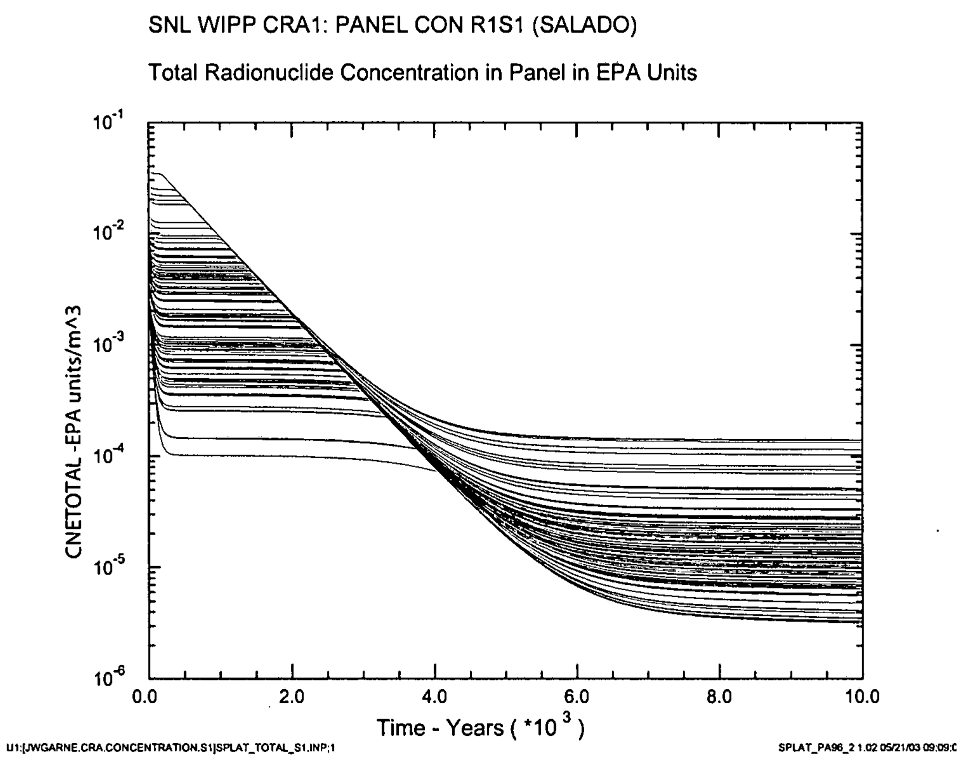

Figure 29 Time dependant total concentrations in Salado brine

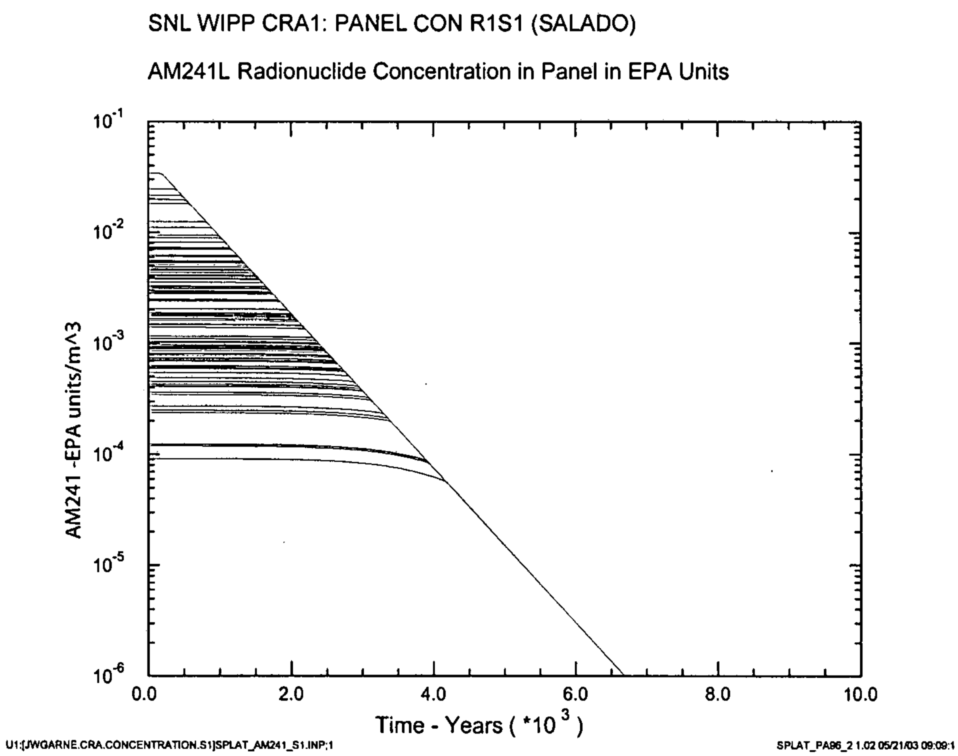

Figure 30 Time dependant AM241L concentration in Salado brine

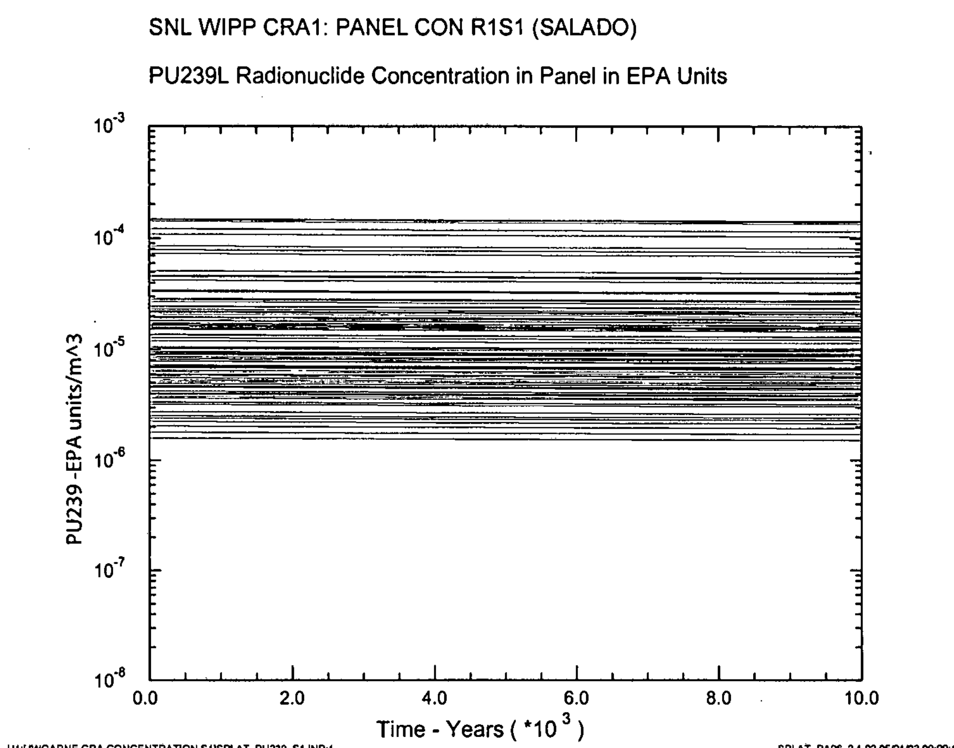

Figure 31 Time dependant PU239L concentration in Salado brine

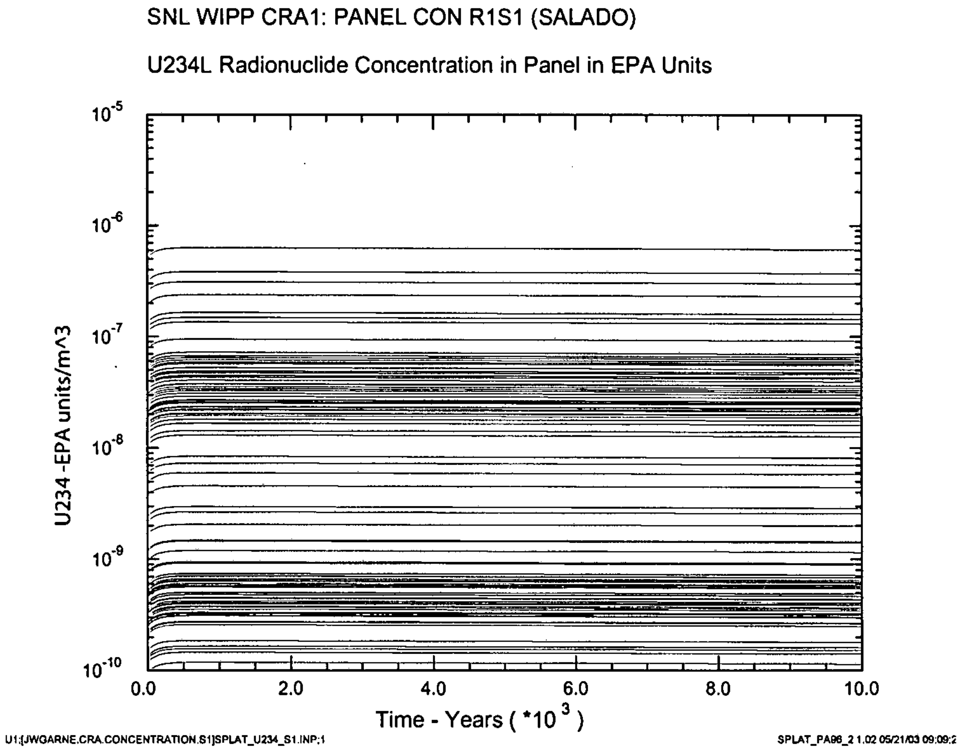

Figure 32 Time dependant U234L concentration in Salado brine

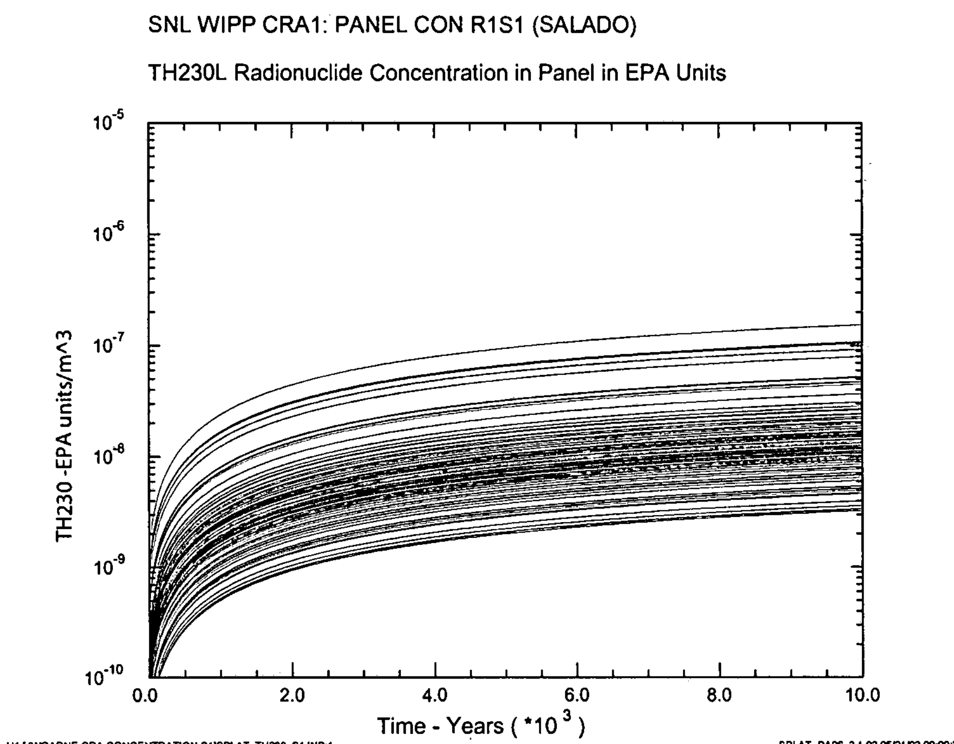

Figure 33 Time dependant TH230L concentration in Salado brine

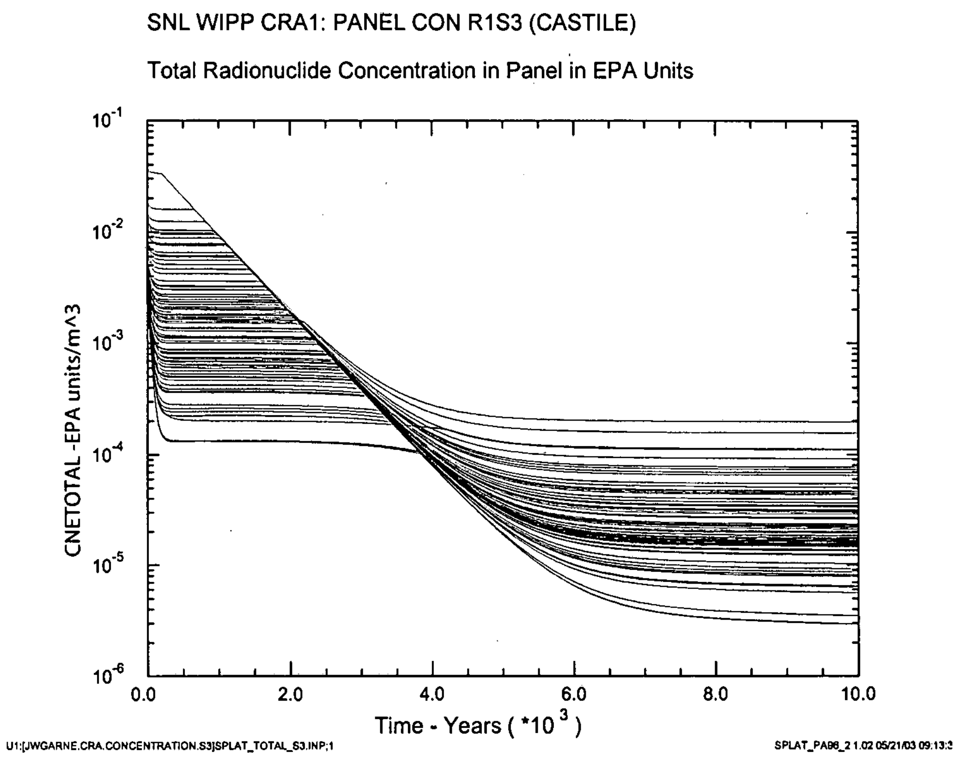

Figure 34 Time dependant total concentrations in Castile brine

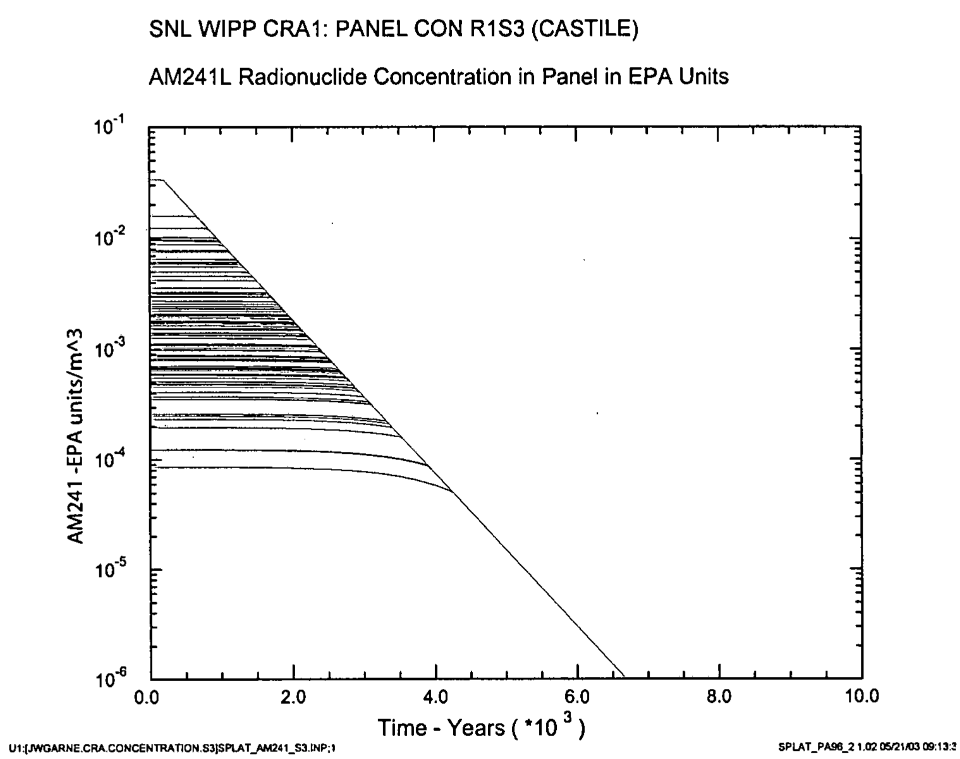

Figure 35 Time dependant AM241L concentration in Castile brine

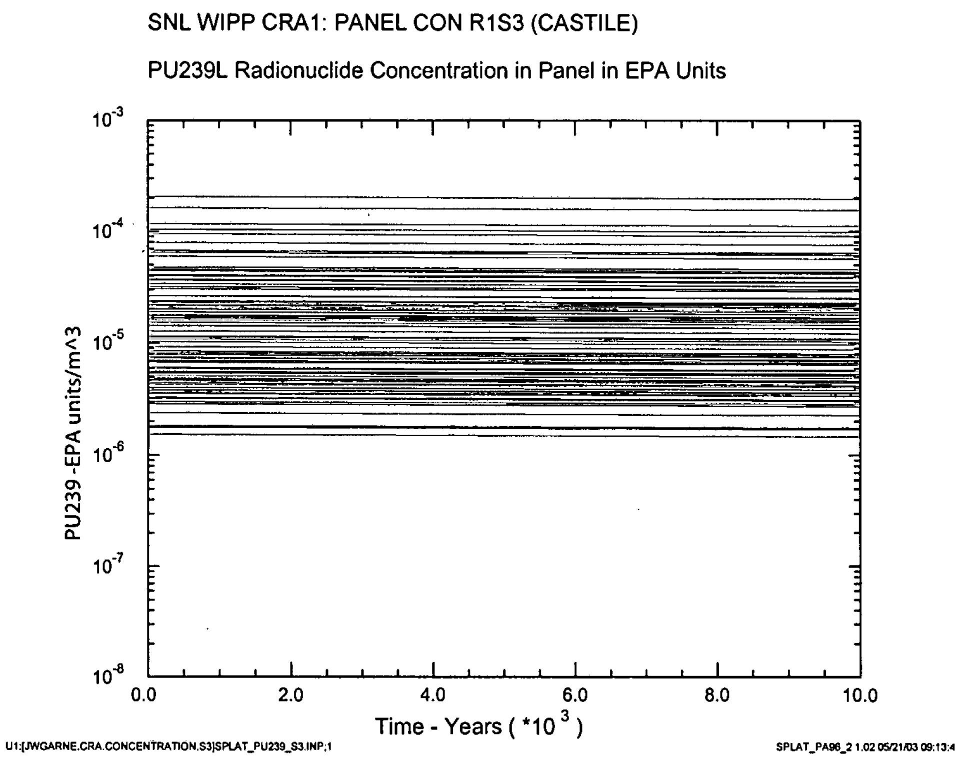

Figure 36 Time dependant PU239L concentration in Castile brine

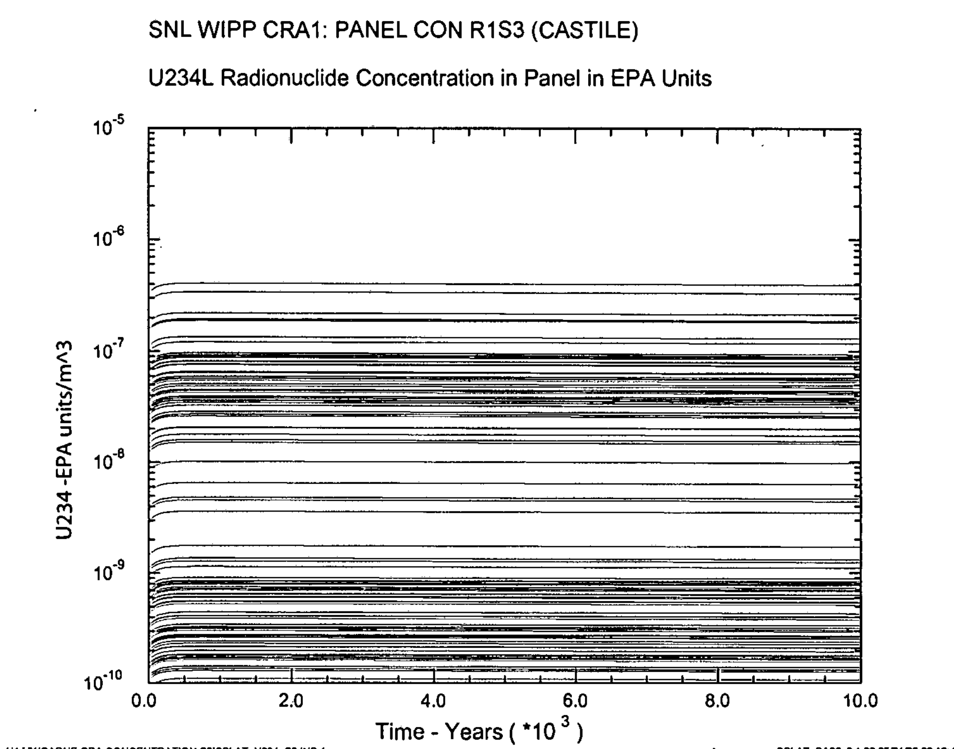

Figure 37 Time dependant U234L concentration in Castile brine

SNL WIPP CRA1: PANEL CON R1S3 (CASTILE)

TH230L Radionuclide Concentration in Panel in EPA Units

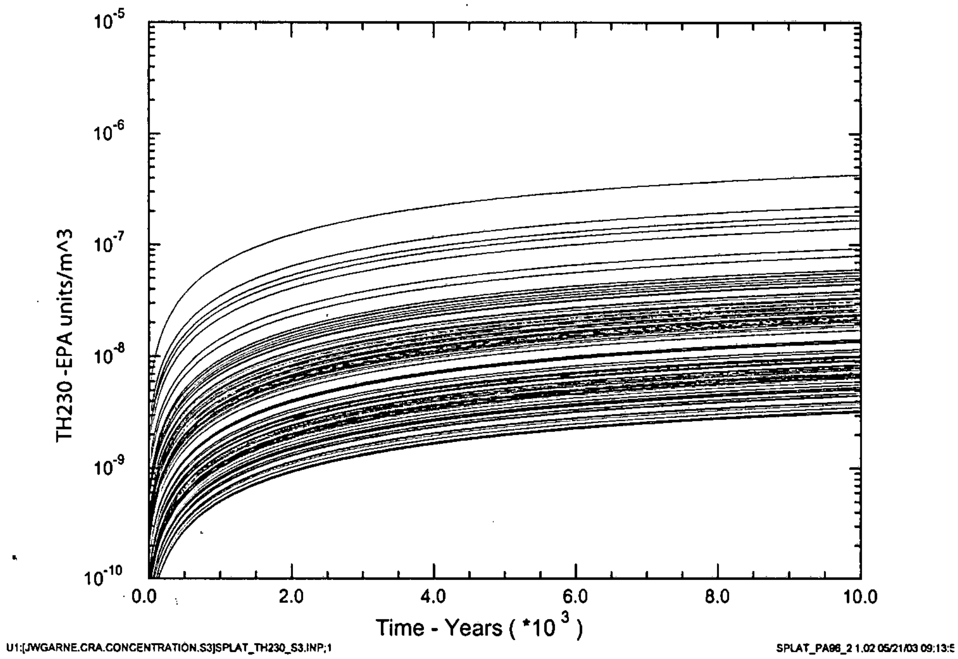

Figure 38 Time dependant TH230L concentration in Castile brine

3.4 PANEL Release to Culebra for E1E2 Scenario

PANEL is run in the standard mode for the S6 (E1E2) scenario to determine the radionuclide release to the Culebra. The definition of scenario is an intrusion into a panel that also hits a brine pocket and is followed by an intrusion into the same panel that does not hit a brine pocket. The volume of brine in the panel and the flow of brine past the disturbed rock zone (DRZ) of the Salado are obtained from the POSTBRAG runs of BRAGFLO results. In assuming that all brine that gets past the DRZ gets to the Culebra instantly is a very conservative assumption. In BRAGFLO, the S6 scenario has the second intrusion at 2000 years. The results of the PANEL calculations are shone in Figures 39 to 43.

Figures 44, 45, and 46 show releases to the Culebra from a S6 scenario at 2000 years that are not transported in the Culebra in EPA units. Figure 45 shows the release to the Culebra from ^{237}Np that is not transported and figure 46 shows the release to the Culebra from ^{243}Am that is not transported. Both ^{237}Np and ^{243}Am show releases to the Culebra larger than ^{234}U and ^{230}Th that are transported. Only a fraction of ^{234}U and ^{230}Th are removed with a single E2E1 while the entire panel's inventory of ^{237}Np and ^{243}Am are removed. Even then, only a fraction of an EPA unit is removed.

In order to make maximum use of the lengthy BRAGFLO runs, we also do time shifting of the BRAGFLO results. This is done by time shifting the two variables obtained from BRAGFLO so that the results start occurring at the desired time of intrusions. These extra times of intrusions are 100, 350, 1000, 4000, 6000, and 9000 years. See figures 47 to 52 for these results.

The assumption made for all of these calculations is that the fraction of the inventory in the panel intruded is .1044.

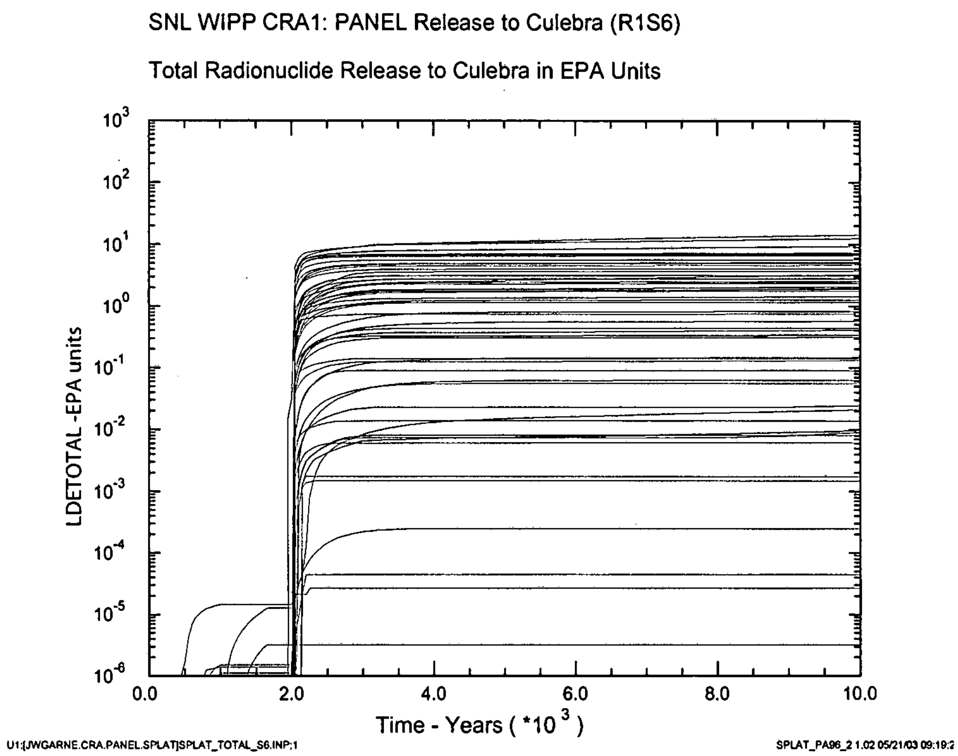

Figure 39 Cumulative total release to Culebra for E2E1 at 2000 years

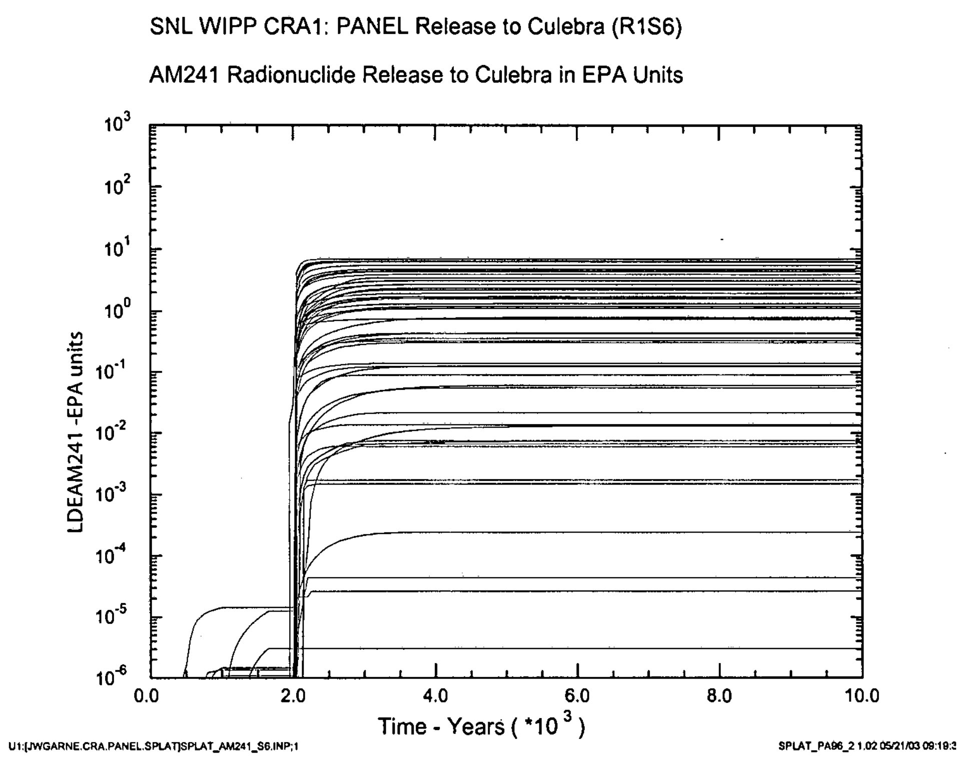

Figure 40 Cumulative AM241 release to Culebra for E2E1 at 2000 years

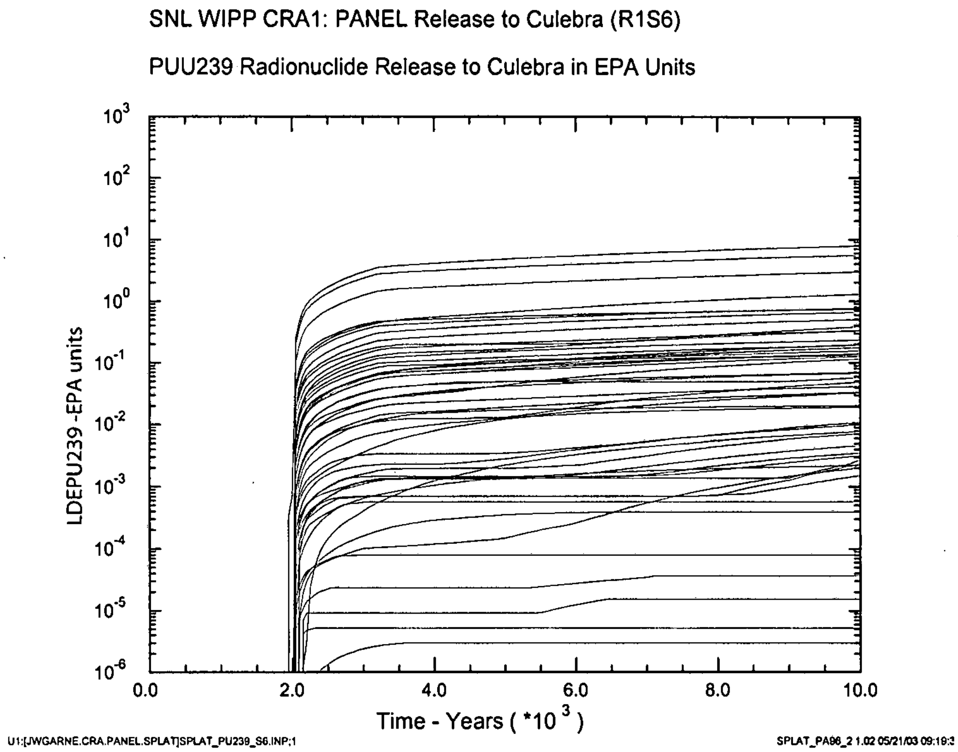

Figure 41 Cumulative PU239 release to Culebra for E2E1 at 2000 years

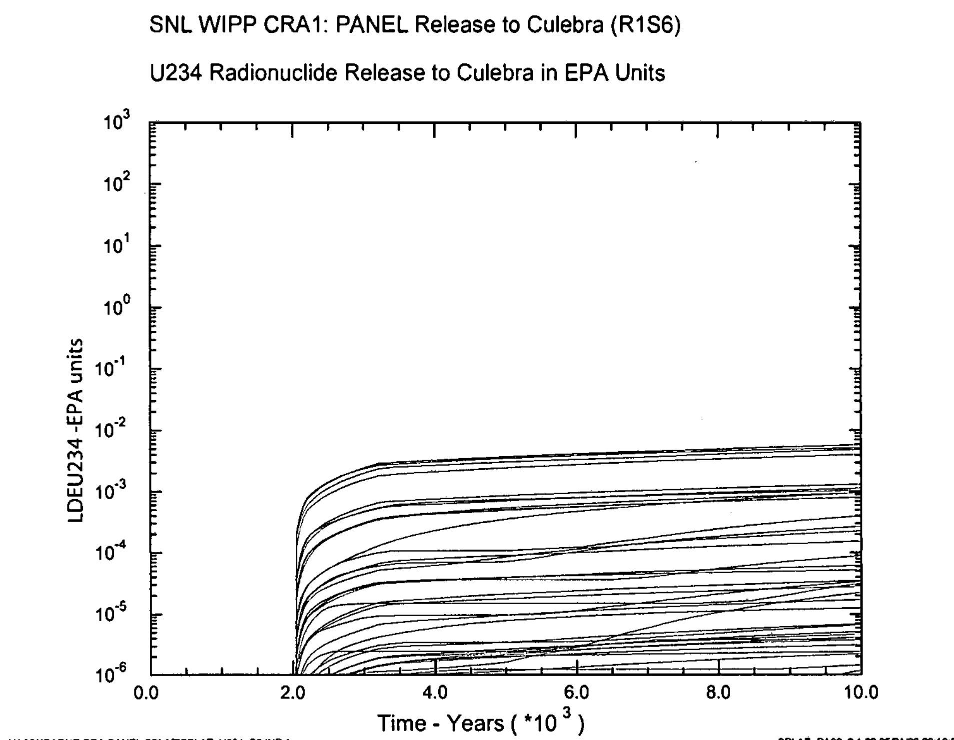

Figure 42 Cumulative U234 release to Culebra for E2E1 at 2000 years

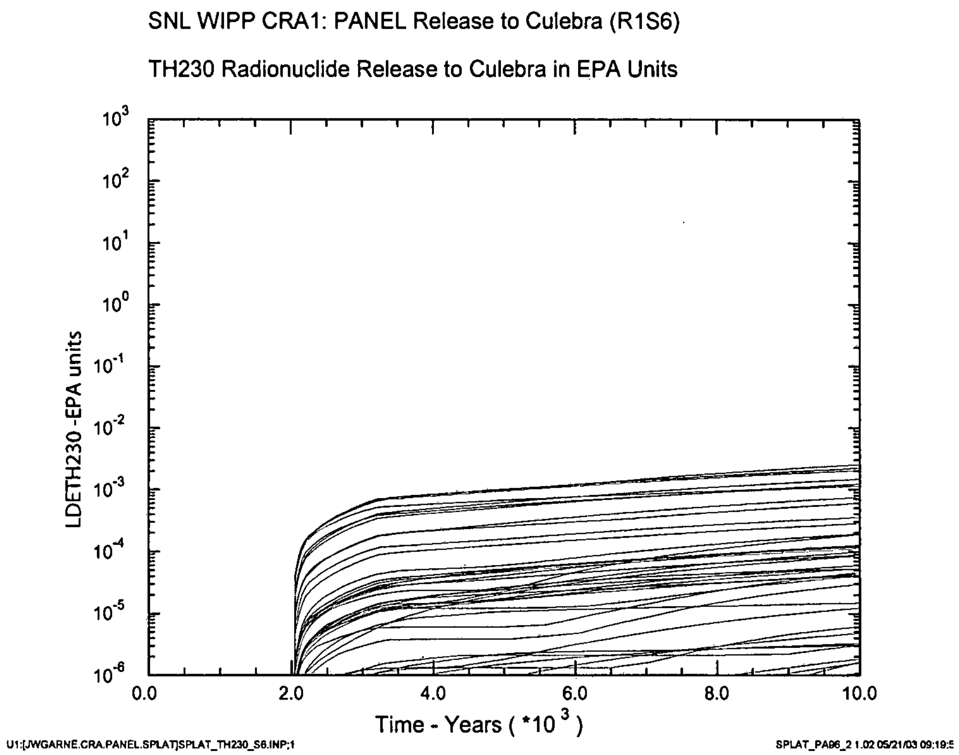

Figure 43 Cumulative TH230 release to Culebra for E2E1 at 2000 years

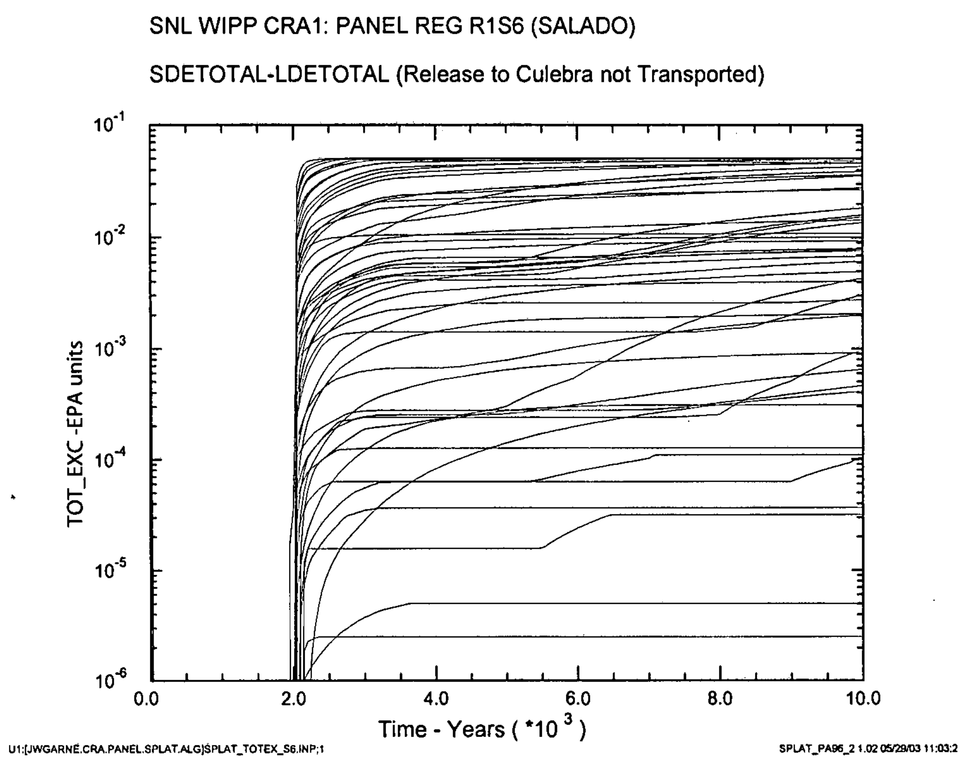

Figure 44 Cumulative total release to Culebra for Radionuclides not transported for E2E1 at 2000 years

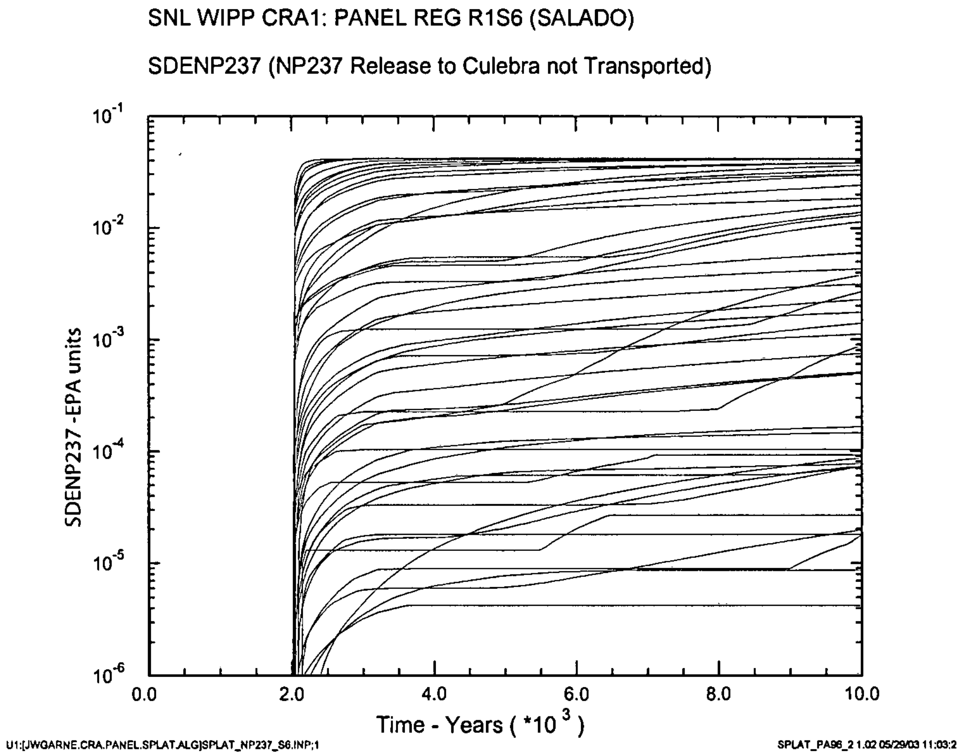

Figure 45 Cumulative NP237 release to Culebra for E2E1 at 2000 years (Not Transported)

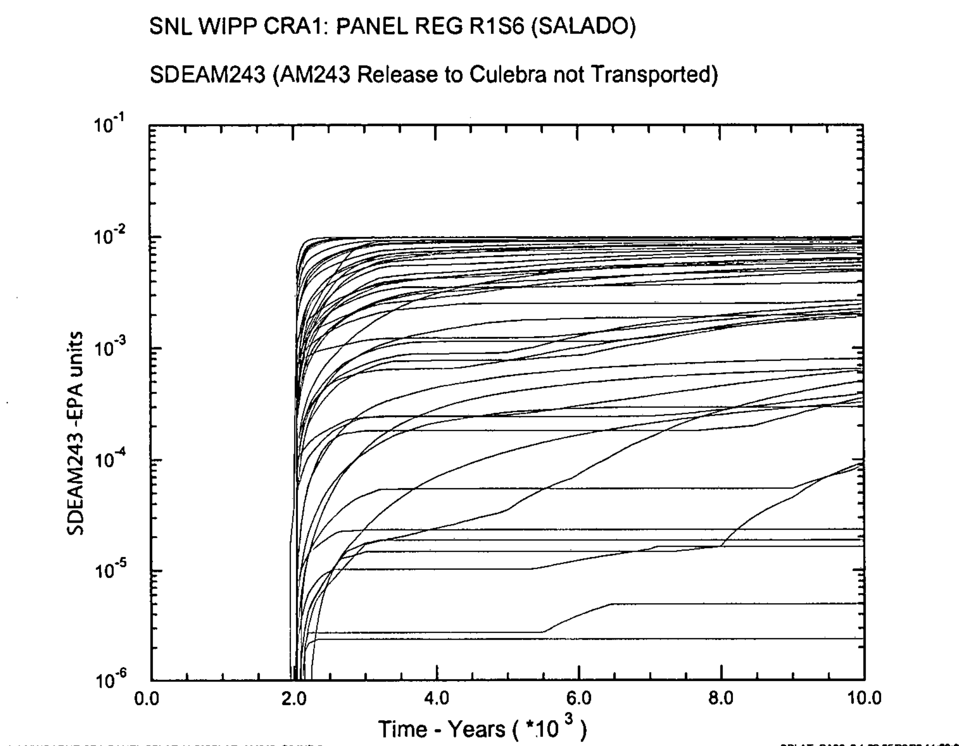

Figure 46 Cumulative AM243 release to Culebra for E2E1 at 2000 years (Not Transported)

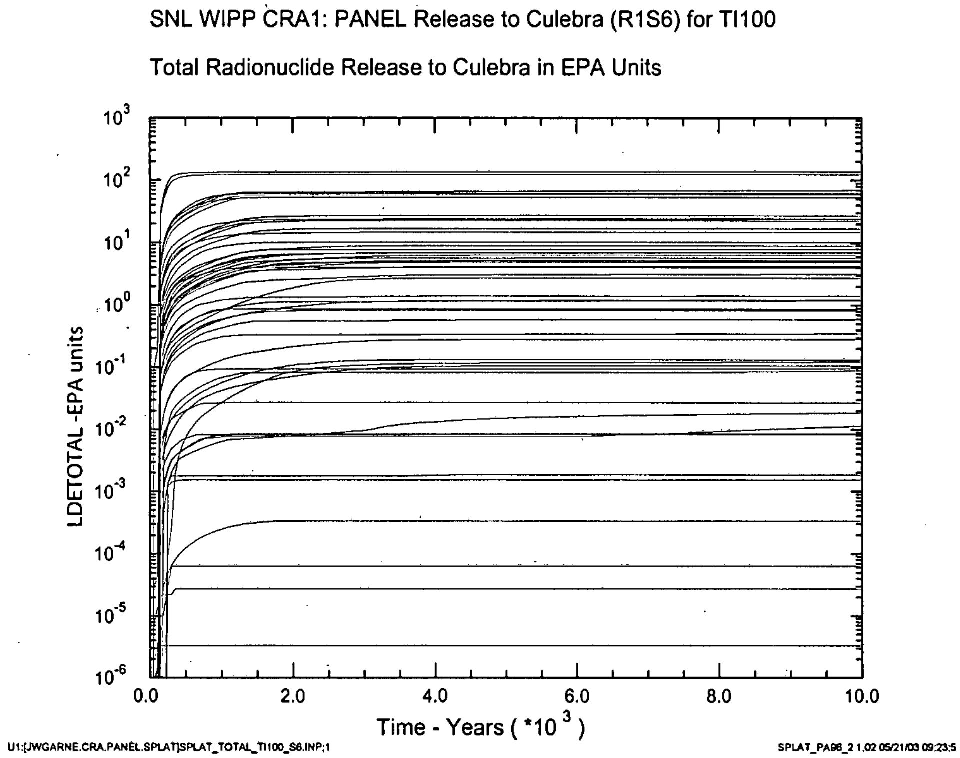

Figure 47 Cumulative total release to Culebra for E2E1 at 100 years

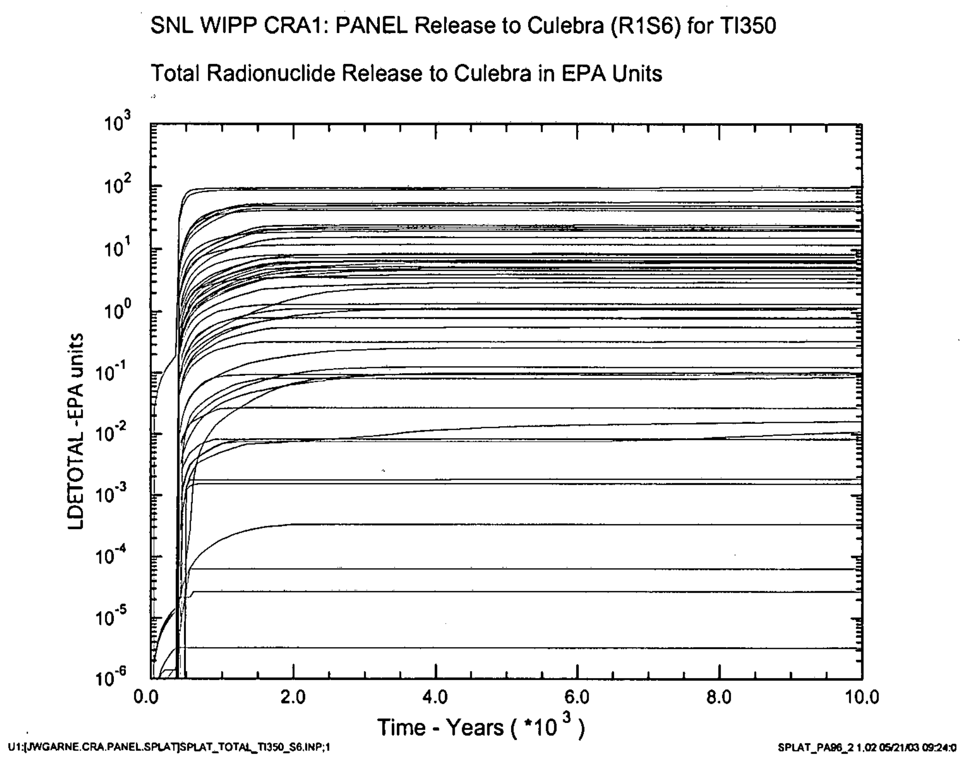

Figure 48 Cumulative total release to Culebra for E2E1 at 350 years

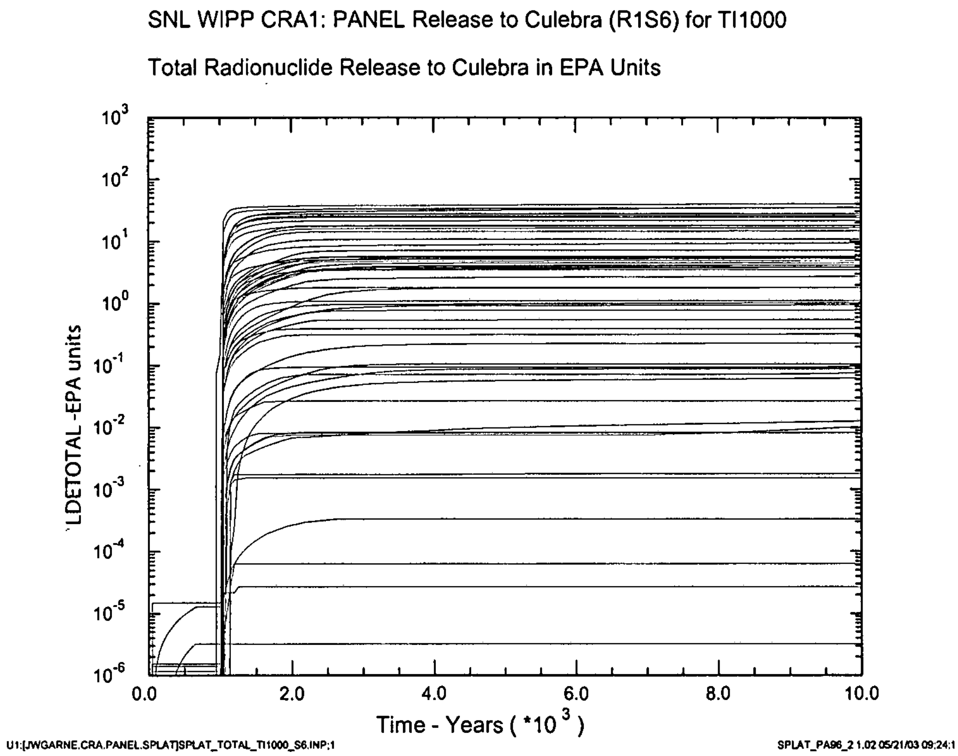

Figure 49 Cumulative total release to Culebra for E2E1 at 1000 years

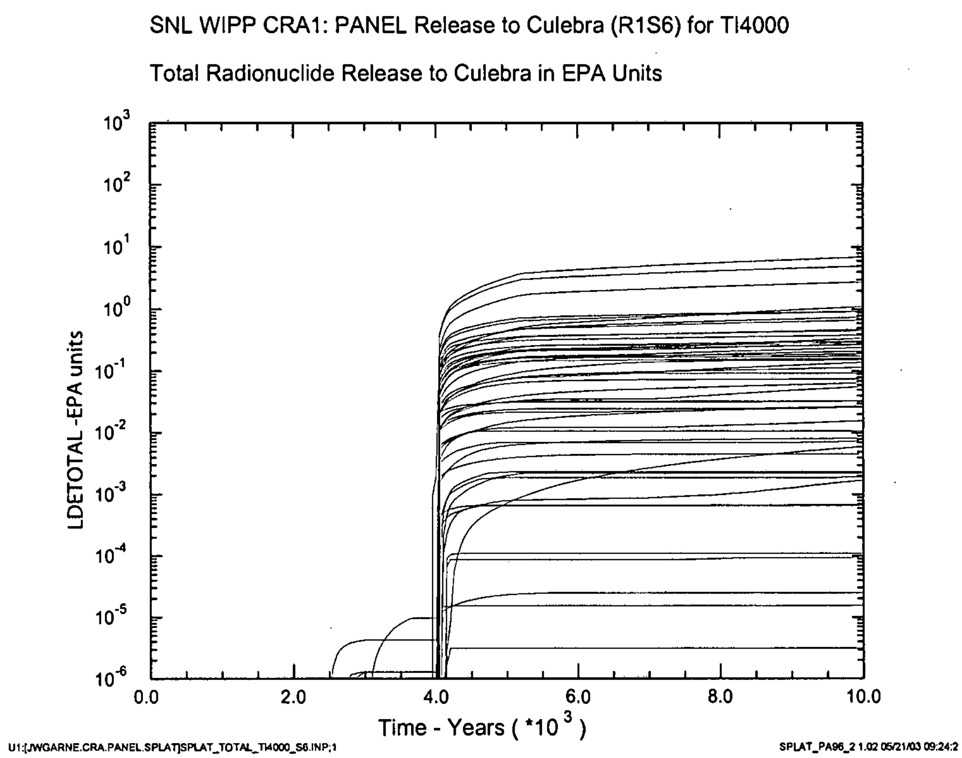

Figure 50 Cumulative total release to Culebra for E2E1 at 4000 years

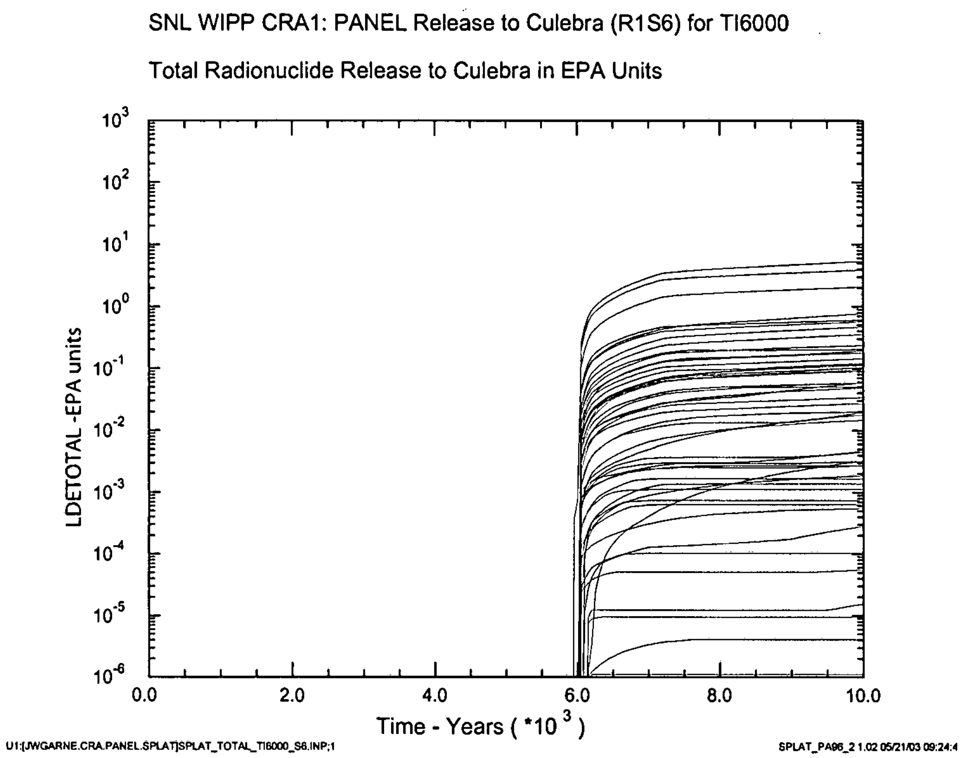

Figure 51 Cumulative total release to Culebra for E2E1 at 6000 years

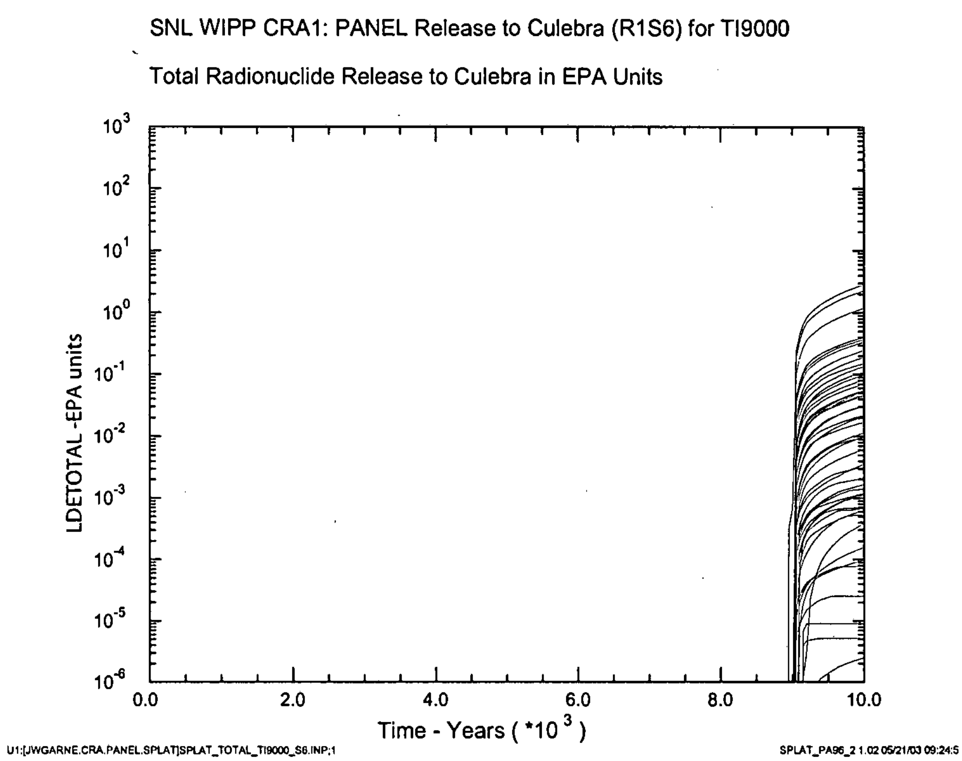

Figure 52 Cumulative total release to Culebra for E2E1 at 9000 years

3.5 Sensitivity Analysis of Release to the Culebra

A STEPWISE calculation was performed for the cumulative release to the Culebra at 10,000 years for an E2E1 intrusion at 2000 years. STEPWISE identifies which uncertain input variables have the strongest correlation to the uncertainty in the output variables. The first independent variable picked in all instances was BHPERM. The R^2 varied from .681 to .754. This is a variable that is used by BRAGFLO. Since the primary variable for release to the Culebra was not a source term variable, scatter plots of release vs. brine flow to the Culebra (BRAGFLO variable BNBHUDRZ) were generated. These plots are displayed in Figures 53 to 57. These plots show a linear relationship with some variability caused by the source term. Uranium shows two linear relationships, one for oxidation state IV and one for oxidation state VI. The variability attributed to source term is approximately one order of magnitude while the variability attributed to the brine flow is 10 orders of magnitude. See the BRAGFLO analysis package [5] for an analysis of brine release to the Culebra.

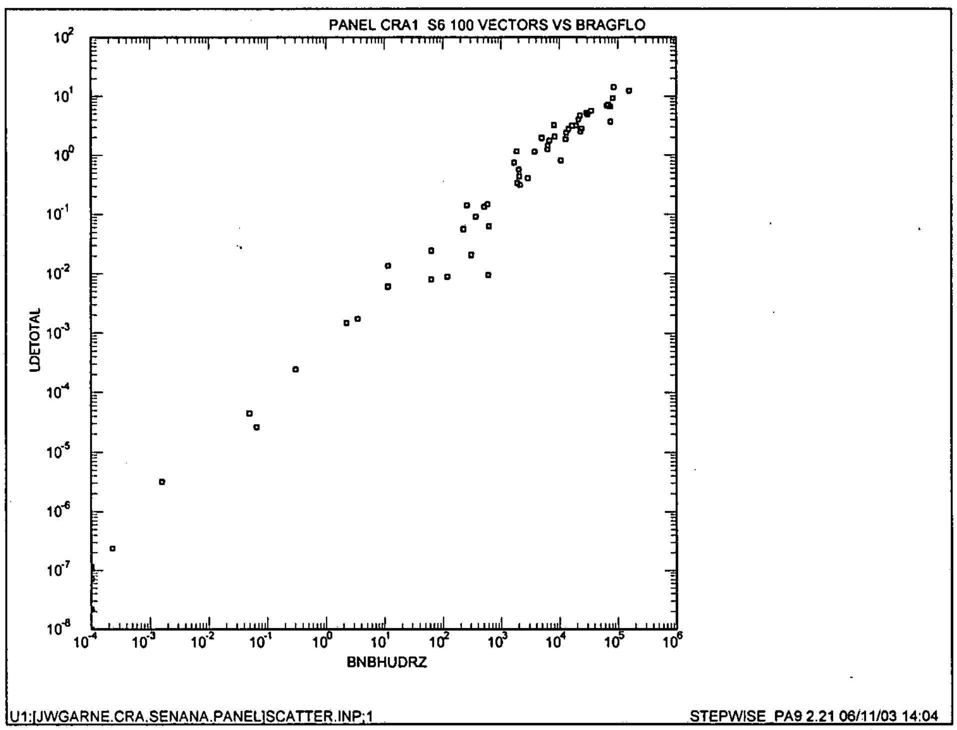

Figure 53 Cumulative brine release to Culebra for E2E1 at 2000 years vs. total radionuclide release to Culebra

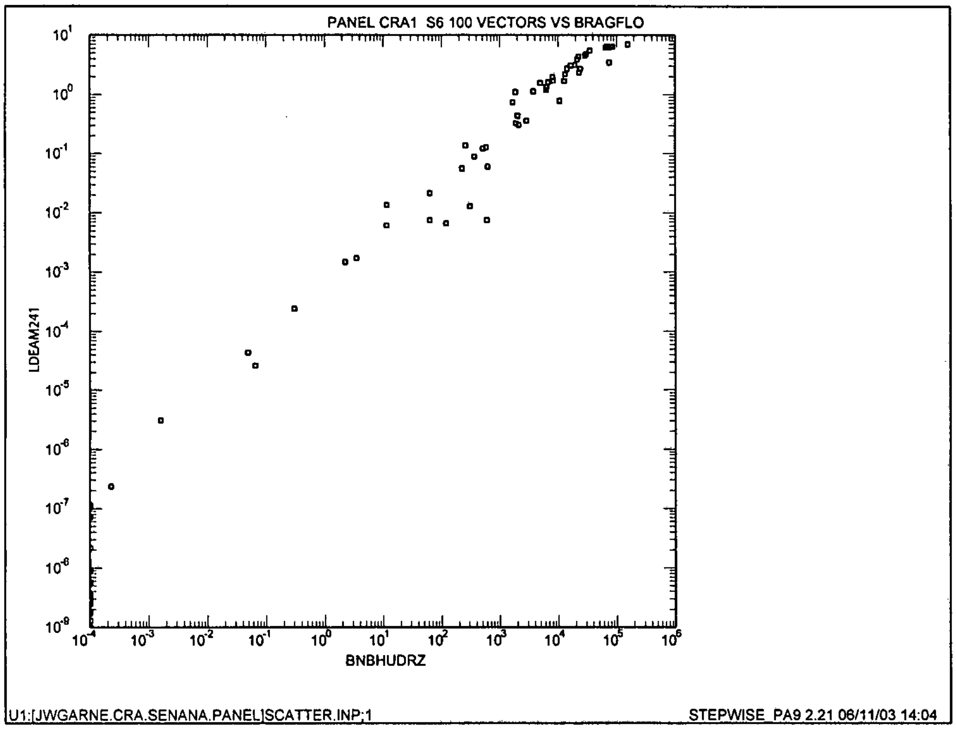

Figure 54 Cumulative brine release to Culebra for E2E1 at 2000 years vs. Americium release to Culebra

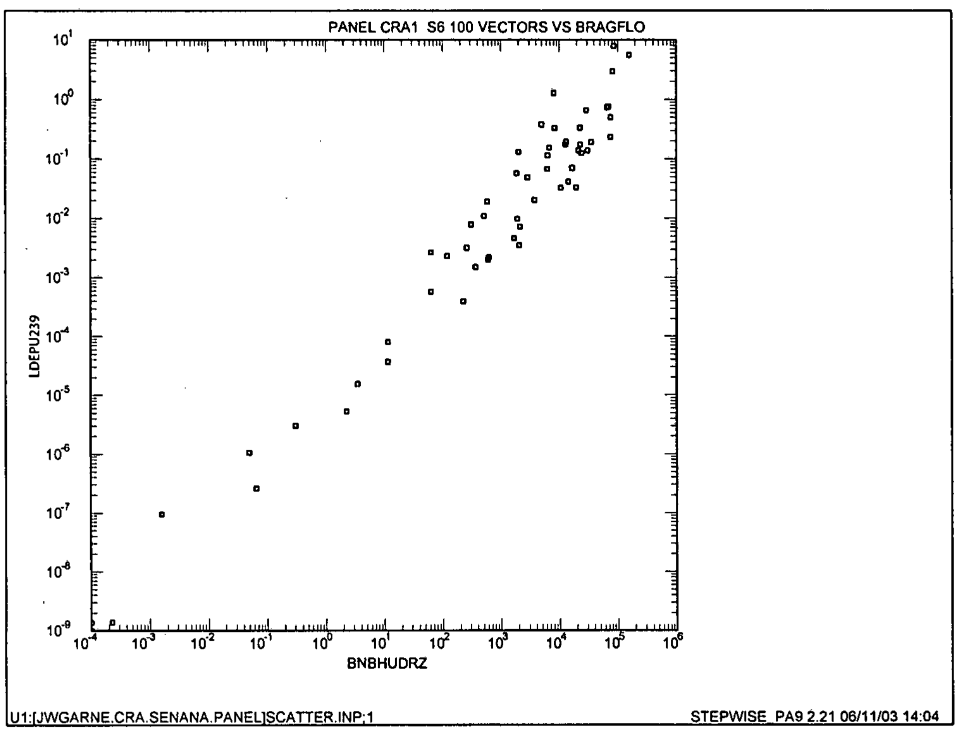

Figure 55 Cumulative brine release to Culebra for E2E1 at 2000 years vs. Plutonium release to Culebra

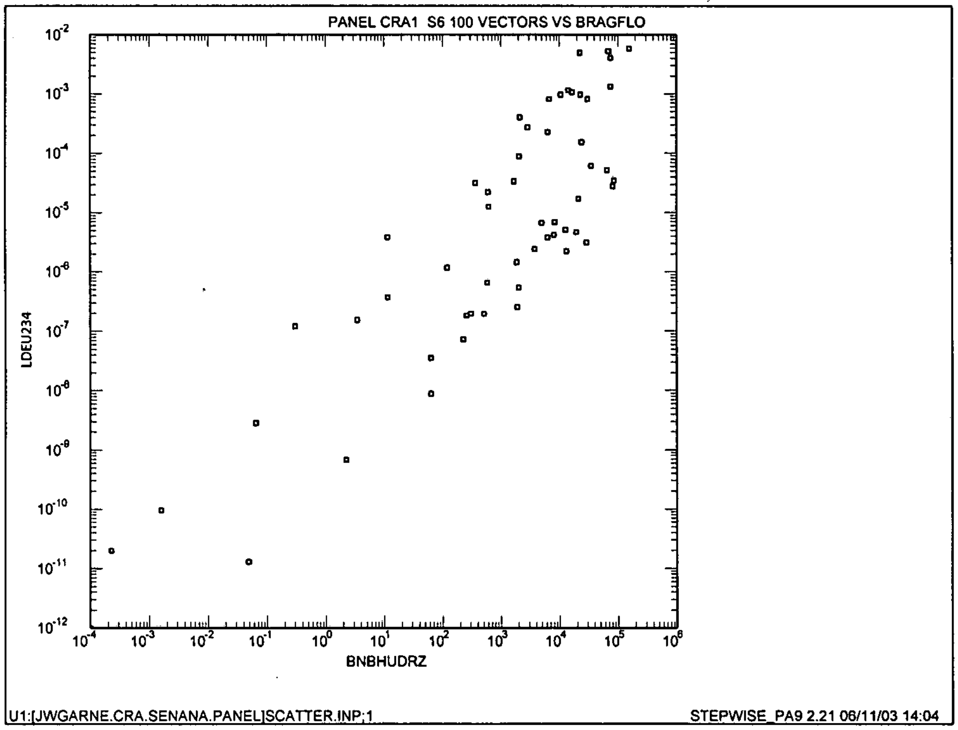

Figure 56 Cumulative brine release to Culebra for E2E1 at 2000 years vs. Uranium release to Culebra

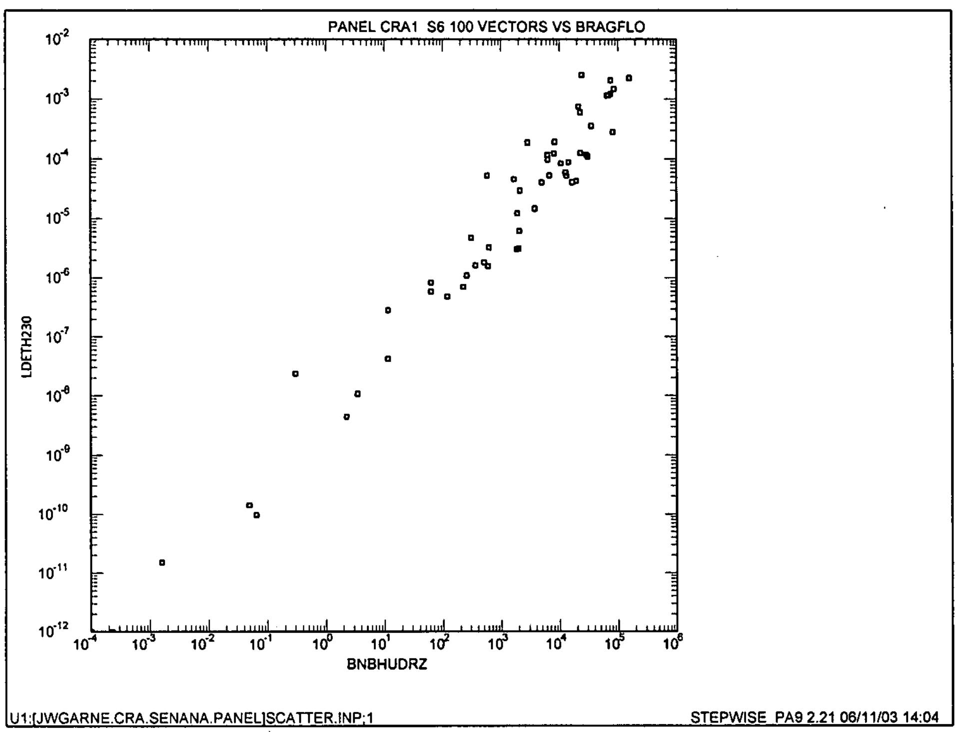

Figure 57 Cumulative brine release to Culebra for E2E1 at 2000 years vs. Thorium release to Culebra

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Appendix A

The following is the ALGEBRA input file that defines the mole fractions for use in source term modifications for the lumped isotopes.

```
ALLTIMES
U_MOLE=SDMU233/ATWEIGHT[27]+SDMU234/ATWEIGHT[28]+SDMU235/ATWEIGHT[29]+ &
       SDMU236/ATWEIGHT[30]+SDMU238/ATWEIGHT[31]
PU_MOLE=SDMPU238/ATWEIGHT[15]+SDMPU239/ATWEIGHT[16]+SDMPU240/ATWEIGHT[17]+ &
        SDMPU241/ATWEIGHT[18]+SDMPU242/ATWEIGHT[19]+SDMPU244/ATWEIGHT[20]
TH_MOLE=SDMTH229/ATWEIGHT[24]+SDMTH230/ATWEIGHT[25]+SDMTH232/ATWEIGHT[26]

MF_U=(SDMU233/ATWEIGHT[27]+SDMU234/ATWEIGHT[28])/U_MOLE
MF_PU=SDMPU238/ATWEIGHT[15]/PU_MOLE
MF_TH=(SDMTH229/ATWEIGHT[24]+SDMTH230/ATWEIGHT[25])/TH_MOLE

EXIT
```

The following is the GROPE listing of the mole fractions. The maximum mole fraction of ^{238}Pu to all Pu is the value at step 1. The value is ***6.77332E-03***, and the logarithm base 10 of this value is –2.17519. The value 2.17519 is set in the MATSET file in Appendix B as the property LSOLDIFF for Material PU238L. Likewise, step 17 is the maximum mole fraction for ^{234}U lumped and step 201 is the maximum mole fraction for ^{230}Th lumped.

```
                                 GROPECDB_PA96

 GGGGG   RRRRRR    OOOOO   PPPPPP   EEEEEEE   CCCCC   DDDDDD   BBBBBB            PPPPPP
GG    GG RR    RR OO    OO PP    PP EE       CC    CC DD    DD BB    BB          PP    PP
GG       RR    RR OO    OO PP    PP EE       CC       DD    DD BB    BB          PP    PP
GG       RRRRRR   OO    OO PPPPPP   EEEEE    CC       DD    DD BBBBBB            PPPPPP
GG   GGG RRRRR    OO    OO PP       EE       CC       DD    DD BB    BB          PP
GG    GG RR   RR  OO    OO PP       EE       CC    CC DD    DD BB    BB          PP
 GGGGG   RR    RR  OOOOO   PP       EEEEEEE   CCCCC   DDDDDD   BBBBBB   _______  PP

                          GROPECDB_PA96 Version 2.12
                            PROD PA96 Built 06/27/96
                            Sponsored by Amy Gilkey

                           Run on 05/02/03 at 14:16:00
                       Run on ALPHA AXP CCR OpenVMS V7.3-1

Database:  U1:[JWGARNE.CRA.INVENTORY]DECAY_MOLE_S1_V001.CDB;1
Written on:  05/02/03 13:58:03

CAMDAT Version:   1        (EXODUS Version:   1)

HISTORY TIME STEP VARIABLES

   Step        Time         MF_U          MF_PU         MF_TH
      1    0.00000E+00   4.70917E-04   6.77332E-03   6.60377E-07
      2    1.57785E+09   5.33740E-04   4.58261E-03   1.35416E-06
      3    3.15569E+09   5.76011E-04   3.09701E-03   2.09813E-06
      4    4.73354E+09   6.04440E-04   2.09192E-03   2.87502E-06
      5    6.31139E+09   6.23546E-04   1.41256E-03   3.67321E-06
      6    7.88923E+09   6.36371E-04   9.53606E-04   4.48487E-06
      7    9.46708E+09   6.44965E-04   6.43675E-04   5.30472E-06
```

8	1.10449E+10	6.50710E-04	4.34431E-04	6.12922E-06
9	1.26228E+10	6.54535E-04	2.93187E-04	6.95598E-06
10	1.42006E+10	6.57067E-04	1.97856E-04	7.78340E-06
11	1.57785E+10	6.58727E-04	1.33518E-04	8.61041E-06
12	1.73563E+10	6.59802E-04	9.00991E-05	9.43629E-06
13	1.89342E+10	6.60481E-04	6.07988E-05	1.02605E-05
14	2.05120E+10	6.60893E-04	4.10266E-05	1.10829E-05
15	2.20899E+10	6.61127E-04	2.76842E-05	1.19030E-05
16	2.36677E+10	6.61240E-04	1.86809E-05	1.27209E-05
17	2.52455E+10	***6.61272E-04***	1.26055E-05	1.35364E-05
18	2.68234E+10	6.61249E-04	8.50595E-06	1.43494E-05
19	2.84012E+10	6.61189E-04	5.73963E-06	1.51600E-05
20	2.99791E+10	6.61105E-04	3.87298E-06	1.59681E-05
21	3.15569E+10	6.61004E-04	2.61340E-06	1.67737E-05
22	3.31348E+10	6.60892E-04	1.76346E-06	1.75768E-05
23	3.47126E+10	6.60772E-04	1.18994E-06	1.83774E-05
24	3.62905E+10	6.60648E-04	8.02941E-07	1.91754E-05
25	3.78683E+10	6.60520E-04	5.41804E-07	1.99710E-05
26	3.94462E+10	6.60390E-04	3.65596E-07	2.07641E-05
27	4.10240E+10	6.60258E-04	2.46694E-07	2.15548E-05
28	4.26019E+10	6.60126E-04	1.66463E-07	2.23430E-05
29	4.41797E+10	6.59993E-04	1.12325E-07	2.31287E-05
30	4.57575E+10	6.59860E-04	7.57936E-08	2.39119E-05
31	4.73354E+10	6.59727E-04	5.11434E-08	2.46928E-05
32	4.89132E+10	6.59593E-04	3.45101E-08	2.54712E-05
33	5.04911E+10	6.59459E-04	2.32865E-08	2.62472E-05
34	5.20689E+10	6.59326E-04	1.57130E-08	2.70208E-05
35	5.36468E+10	6.59192E-04	1.06027E-08	2.77920E-05
36	5.52246E+10	6.59059E-04	7.15438E-09	2.85609E-05
37	5.68025E+10	6.58926E-04	4.82756E-09	2.93273E-05
38	5.83803E+10	6.58792E-04	3.25749E-09	3.00914E-05
39	5.99582E+10	6.58659E-04	2.19805E-09	3.08532E-05
40	6.15360E+10	6.58526E-04	1.48318E-09	3.16126E-05
41	6.31139E+10	6.58393E-04	1.00080E-09	3.23697E-05
42	6.46917E+10	6.58260E-04	6.75309E-10	3.31245E-05
43	6.62696E+10	6.58128E-04	4.55677E-10	3.38769E-05
44	6.78474E+10	6.57995E-04	3.07476E-10	3.46271E-05
45	6.94252E+10	6.57862E-04	2.07475E-10	3.53750E-05
46	7.10031E+10	6.57730E-04	1.39997E-10	3.61206E-05
47	7.25809E+10	6.57598E-04	9.44652E-11	3.68639E-05
48	7.41588E+10	6.57465E-04	6.37419E-11	3.76050E-05
49	7.57366E+10	6.57333E-04	4.30108E-11	3.83438E-05
50	7.73145E+10	6.57201E-04	2.90222E-11	3.90804E-05
51	7.88923E+10	6.57069E-04	1.95832E-11	3.98147E-05
52	8.04702E+10	6.56937E-04	1.32140E-11	4.05469E-05
53	8.20480E+10	6.56805E-04	8.91635E-12	4.12768E-05
54	8.36259E+10	6.56673E-04	6.01643E-12	4.20045E-05
55	8.52037E+10	6.56542E-04	4.05966E-12	4.27301E-05
56	8.67816E+10	6.56410E-04	2.73931E-12	4.34534E-05
57	8.83594E+10	6.56279E-04	1.84838E-12	4.41746E-05
58	8.99372E+10	6.56147E-04	1.24722E-12	4.48937E-05
59	9.15151E+10	6.56016E-04	8.41577E-13	4.56105E-05
60	9.30929E+10	6.55885E-04	5.67864E-13	4.63253E-05
61	9.46708E+10	6.55754E-04	3.83172E-13	4.70379E-05
62	9.62486E+10	6.55623E-04	2.58550E-13	4.77483E-05
63	9.78265E+10	6.55492E-04	1.74459E-13	4.84567E-05
64	9.94043E+10	6.55361E-04	1.17718E-13	4.91630E-05
65	1.00982E+11	6.55230E-04	7.94315E-14	4.98671E-05
66	1.02560E+11	6.55099E-04	5.35971E-14	5.05692E-05
67	1.04138E+11	6.54969E-04	3.61652E-14	5.12692E-05
68	1.05716E+11	6.54838E-04	2.44028E-14	5.19671E-05
69	1.07294E+11	6.54708E-04	1.64660E-14	5.26630E-05
70	1.08871E+11	6.54577E-04	1.11105E-14	5.33568E-05

71	1.10449E+11	6.54447E-04	7.49693E-15	5.40486E-05
72	1.12027E+11	6.54317E-04	5.05861E-15	5.47383E-05
73	1.13605E+11	6.54187E-04	3.41333E-15	5.54260E-05
74	1.15183E+11	6.54057E-04	2.30317E-15	5.61117E-05
75	1.16761E+11	6.53927E-04	1.55408E-15	5.67954E-05
76	1.18338E+11	6.53797E-04	1.04862E-15	5.74771E-05
77	1.19916E+11	6.53667E-04	7.07566E-16	5.81568E-05
78	1.21494E+11	6.53537E-04	4.77434E-16	5.88346E-05
79	1.23072E+11	6.53408E-04	3.22151E-16	5.95103E-05
80	1.24650E+11	6.53278E-04	2.17373E-16	6.01841E-05
81	1.26228E+11	6.53148E-04	1.46673E-16	6.08559E-05
82	1.27806E+11	6.53019E-04	9.89685E-17	6.15258E-05
83	1.29383E+11	6.52890E-04	6.67794E-17	6.21938E-05
84	1.30961E+11	6.52760E-04	4.50596E-17	6.28598E-05
85	1.32539E+11	6.52631E-04	3.04041E-17	6.35239E-05
86	1.34117E+11	6.52502E-04	2.05153E-17	6.41861E-05
87	1.35695E+11	6.52373E-04	1.38427E-17	6.48464E-05
88	1.37273E+11	6.52244E-04	9.34042E-18	6.55048E-05
89	1.38850E+11	6.52115E-04	6.30247E-18	6.61613E-05
90	1.40428E+11	6.51986E-04	4.25260E-18	6.68159E-05
91	1.42006E+11	6.51857E-04	2.86945E-18	6.74686E-05
92	1.43584E+11	6.51729E-04	1.93616E-18	6.81195E-05
93	1.45162E+11	6.51600E-04	1.30643E-18	6.87685E-05
94	1.46740E+11	6.51472E-04	8.81513E-19	6.94157E-05
95	1.48318E+11	6.51343E-04	5.94801E-19	7.00610E-05
96	1.49895E+11	6.51215E-04	4.01342E-19	7.07045E-05
97	1.51473E+11	6.51087E-04	2.70805E-19	7.13462E-05
98	1.53051E+11	6.50958E-04	1.82726E-19	7.19861E-05
99	1.54629E+11	6.50830E-04	1.23294E-19	7.26241E-05
100	1.56207E+11	6.50702E-04	8.31924E-20	7.32604E-05
101	1.57785E+11	6.50574E-04	5.61339E-20	7.38948E-05
102	1.59362E+11	6.50446E-04	3.78763E-20	7.45275E-05
103	1.60940E+11	6.50318E-04	2.55569E-20	7.51584E-05
104	1.62518E+11	6.50191E-04	1.72445E-20	7.57875E-05
105	1.64096E+11	6.50063E-04	1.16357E-20	7.64149E-05
106	1.65674E+11	6.49935E-04	7.85112E-21	7.70405E-05
107	1.67252E+11	6.49808E-04	5.29752E-21	7.76644E-05
108	1.68830E+11	6.49680E-04	3.57448E-21	7.82865E-05
109	1.70407E+11	6.49553E-04	2.41187E-21	7.89069E-05
110	1.71985E+11	6.49426E-04	1.62740E-21	7.95255E-05
111	1.73563E+11	6.49298E-04	1.09808E-21	8.01425E-05
112	1.75141E+11	6.49171E-04	7.40923E-22	8.07577E-05
113	1.76719E+11	6.49044E-04	4.99934E-22	8.13712E-05
114	1.78297E+11	6.48917E-04	3.37328E-22	8.19831E-05
115	1.79874E+11	6.48790E-04	2.27610E-22	8.25932E-05
116	1.81452E+11	6.48663E-04	1.53578E-22	8.32017E-05
117	1.83030E+11	6.48536E-04	1.03626E-22	8.38085E-05
118	1.84608E+11	6.48409E-04	6.99210E-23	8.44136E-05
119	1.86186E+11	6.48283E-04	4.71787E-23	8.50171E-05
120	1.87764E+11	6.48156E-04	3.18335E-23	8.56189E-05
121	1.89342E+11	6.48030E-04	2.14794E-23	8.62191E-05
122	1.90919E+11	6.47903E-04	1.44931E-23	8.68176E-05
123	1.92497E+11	6.47777E-04	9.77909E-24	8.74145E-05
124	1.94075E+11	6.47650E-04	6.59836E-24	8.80098E-05
125	1.95653E+11	6.47524E-04	4.45219E-24	8.86034E-05
126	1.97231E+11	6.47398E-04	3.00408E-24	8.91955E-05
127	1.98809E+11	6.47272E-04	2.02697E-24	8.97859E-05
128	2.00387E+11	6.47146E-04	1.36768E-24	9.03747E-05
129	2.01964E+11	6.47020E-04	9.22830E-25	9.09620E-05
130	2.03542E+11	6.46894E-04	6.22670E-25	9.15477E-05
131	2.05120E+11	6.46768E-04	4.20140E-25	9.21318E-05
132	2.06698E+11	6.46642E-04	2.83485E-25	9.27143E-05
133	2.08276E+11	6.46517E-04	1.91279E-25	9.32952E-05

134	2.09854E+11	6.46391E-04	1.29063E-25	9.38746E-05
135	2.11431E+11	6.46265E-04	8.70840E-26	9.44525E-05
136	2.13009E+11	6.46140E-04	5.87589E-26	9.50288E-05
137	2.14587E+11	6.46014E-04	3.96469E-26	9.56036E-05
138	2.16165E+11	6.45889E-04	2.67513E-26	9.61768E-05
139	2.17743E+11	6.45764E-04	1.80501E-26	9.67485E-05
140	2.19321E+11	6.45639E-04	1.21791E-26	9.73187E-05
141	2.20899E+11	6.45513E-04	8.21767E-27	9.78874E-05
142	2.22476E+11	6.45388E-04	5.54477E-27	9.84546E-05
143	2.24054E+11	6.45263E-04	3.74126E-27	9.90203E-05
144	2.25632E+11	6.45138E-04	2.52436E-27	9.95845E-05
145	2.27210E+11	6.45014E-04	1.70328E-27	1.00147E-04
146	2.28788E+11	6.44889E-04	1.14926E-27	1.00708E-04
147	2.30366E+11	6.44764E-04	7.75450E-28	1.01268E-04
148	2.31943E+11	6.44639E-04	5.23223E-28	1.01826E-04
149	2.33521E+11	6.44515E-04	3.53037E-28	1.02383E-04
150	2.35099E+11	6.44390E-04	2.38207E-28	1.02939E-04
151	2.36677E+11	6.44266E-04	1.60726E-28	1.03493E-04
152	2.38255E+11	6.44141E-04	1.08447E-28	1.04045E-04
153	2.39833E+11	6.44017E-04	7.31732E-29	1.04596E-04
154	2.41411E+11	6.43893E-04	4.93725E-29	1.05146E-04
155	2.42988E+11	6.43769E-04	3.33133E-29	1.05694E-04
156	2.44566E+11	6.43644E-04	2.24776E-29	1.06241E-04
157	2.46144E+11	6.43520E-04	1.51664E-29	1.06786E-04
158	2.47722E+11	6.43396E-04	1.02332E-29	1.07330E-04
159	2.49300E+11	6.43272E-04	6.90471E-30	1.07872E-04
160	2.50878E+11	6.43148E-04	4.65883E-30	1.08414E-04
161	2.52455E+11	6.43025E-04	3.14346E-30	1.08953E-04
162	2.54033E+11	6.42901E-04	2.12099E-30	1.09492E-04
163	2.55611E+11	6.42777E-04	1.43110E-30	1.10029E-04
164	2.57189E+11	6.42654E-04	9.65610E-31	1.10564E-04
165	2.58767E+11	6.42530E-04	6.51527E-31	1.11099E-04
166	2.60345E+11	6.42407E-04	4.39606E-31	1.11632E-04
167	2.61923E+11	6.42283E-04	2.96615E-31	1.12163E-04
168	2.63500E+11	6.42160E-04	2.00136E-31	1.12693E-04
169	2.65078E+11	6.42037E-04	1.35037E-31	1.13222E-04
170	2.66656E+11	6.41913E-04	9.11139E-32	1.13750E-04
171	2.68234E+11	6.41790E-04	6.14772E-32	1.14276E-04
172	2.69812E+11	6.41667E-04	4.14805E-32	1.14801E-04
173	2.71390E+11	6.41544E-04	2.79881E-32	1.15324E-04
174	2.72967E+11	6.41421E-04	1.88844E-32	1.15847E-04
175	2.74545E+11	6.41298E-04	1.27419E-32	1.16367E-04
176	2.76123E+11	6.41175E-04	8.59730E-33	1.16887E-04
177	2.77701E+11	6.41053E-04	5.80084E-33	1.17405E-04
178	2.79279E+11	6.40930E-04	3.91399E-33	1.17922E-04
179	2.80857E+11	6.40807E-04	2.64088E-33	1.18438E-04
180	2.82435E+11	6.40685E-04	1.78187E-33	1.18953E-04
181	2.84012E+11	6.40562E-04	1.20228E-33	1.19466E-04
182	2.85590E+11	6.40440E-04	8.11211E-34	1.19978E-04
183	2.87168E+11	6.40317E-04	5.47346E-34	1.20488E-04
184	2.88746E+11	6.40195E-04	3.69309E-34	1.20998E-04
185	2.90324E+11	6.40073E-04	2.49183E-34	1.21506E-04
186	2.91902E+11	6.39951E-04	1.68130E-34	1.22013E-04
187	2.93479E+11	6.39828E-04	1.13442E-34	1.22518E-04
188	2.95057E+11	6.39706E-04	7.65422E-35	1.23023E-04
189	2.96635E+11	6.39584E-04	5.16450E-35	1.23526E-04
190	2.98213E+11	6.39462E-04	3.48462E-35	1.24028E-04
191	2.99791E+11	6.39340E-04	2.35116E-35	1.24528E-04
192	3.01369E+11	6.39219E-04	1.58639E-35	1.25028E-04
193	3.02947E+11	6.39097E-04	1.07038E-35	1.25526E-04
194	3.04524E+11	6.38975E-04	7.22209E-36	1.26023E-04
195	3.06102E+11	6.38854E-04	4.87292E-36	1.26519E-04
196	3.07680E+11	6.38732E-04	3.28788E-36	1.27014E-04

197	3.09258E+11	6.38611E-04	2.21841E-36	1.27507E-04
198	3.10836E+11	6.38489E-04	1.49681E-36	1.27999E-04
199	3.12414E+11	6.38368E-04	1.00994E-36	1.28490E-04
200	3.13991E+11	6.38246E-04	6.81427E-37	1.28980E-04
201	3.15569E+11	6.38125E-04	4.59775E-37	***1.29469E-04***

Appendix B

The following MATSET input file is used to set the values needed for PANEL for a CCA run for concentration and standard type runs.

```
===========
! TITLE:    MATSET input file for PANEL (CRA for SOURCE term in PANEL runs)
! ANALYSTS: C. T. STOCKMAN, J. W. GARNER
! CREATED:  Feb 17, 2003
! A modification of the 1996 CCA Source Term MATSET input file
! PURPOSE:  PREPARE INPUT CDB FOR  PANEL
!==================================================================
!
*HEADING
 RUN=0
 SCALE=SOURCE
 SCENARIO=00
 TITLE=SOURCE TERM
!
*PRINT_ASSIGNED_VALUES
!
*UNITS=SI
!
*CREATE_BLOCK
  BLOCKID=      2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, &
           16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, &
           31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, &
           46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, &
           61, 62, 63, 64, 65
*RETRIEVE*NAME
 COORDINATE, DIM=3, NAMES=X, Y, Z
 MATERIAL,     1=GLOBAL, 2=REFCON, &
    3=AM241,  4=AM243,  5=CF252,  6=CM243,  7=CM244,  8=CM245, &
    9=CM248, 10=CS137, 11=NP237, 12=PA231, 13=PB210, 14=PM147, &
   15=PU238, 16=PU239, 17=PU240, 18=PU241, 19=PU242, 20=PU244, &
   21=RA226, 22=RA228, 23=SR90,  24=TH229, 25=TH230, &
   26=TH232, 27=U233,  28=U234,  29=U235,  30=U236,  31=U238,  &
   32=AM, 33=CF, 34=CM, 35=CS, 36=NP, 37=PA, 38=PB, 39=PM, 40=PU, &
   41=RA, 42=SR, 43=TH, 44=U,  &
   45=SOLMOD3, 46=SOLMOD4, 47=SOLMOD5, 48=SOLMOD6, &
   49=PHUMOX3, 50=PHUMOX4, 51=PHUMOX5, 52=PHUMOX6, &
   53=SOLAM3,  54=SOLPU3,  55=SOLPU4,  56=SOLTH4,  57=SOLU4,  58=SOLU6, &
   59=AM241L, 60=PU238L, 61=PU239L, 62=TH230L, 63=U234L,  64=BOREHOLE, &
   65=WAS_AREA
!MATERIALS 59-63 ARE LUMPED PARAMETERS FOR NUTS
!
 PROPERTY   MATERIAL=WAS_AREA,  NAMES =PROBDEG
 PROPERTY   MATERIAL=Global,    NAMES =OXSTAT
 PROPERTY   MATERIAL=REFCON,    NAMES =YRSEC,INVSCALE
!ISOTOPES
 PROPERTY   MATERIAL=Am241,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Am243,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Cf252,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Cm243,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Cm244,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Cm245,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Cm248,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Cs137,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Np237,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pa231,     NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
```

```
 PROPERTY   MATERIAL=Pb210,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pm147,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pu238,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pu239,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pu240,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pu241,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pu242,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Pu244,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Ra226,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Ra228,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Sr90 ,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Th229,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Th230,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=Th232,      NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=U233,       NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=U234,       NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=U235,       NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=U236,       NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
 PROPERTY   MATERIAL=U238,       NAMES =InvCHD,InvRHD,ATWEIGHT,HALFLIFE,EPAREL
!LUMPED ISOTOPES
 PROPERTY   MATERIAL=AM241L,     NAMES =InvCHD,InvRHD
 PROPERTY   MATERIAL=PU238L,     NAMES =InvCHD,InvRHD,LSOLDIFF
 PROPERTY   MATERIAL=PU239L,     NAMES =InvCHD,InvRHD
 PROPERTY   MATERIAL=TH230L,     NAMES =InvCHD,InvRHD,LSOLDIFF
 PROPERTY   MATERIAL=U234L,      NAMES =InvCHD,InvRHD,LSOLDIFF
!ELEMENTS
 PROPERTY   MATERIAL=AM,         NAMES =CONCMIN,CONCINT,CAPHUM,CAPMIC,PROPMIC
 PROPERTY   MATERIAL=NP,         NAMES =CONCMIN,CONCINT,CAPHUM,CAPMIC,PROPMIC
 PROPERTY   MATERIAL=PU,         NAMES =CONCMIN,CONCINT,CAPHUM,CAPMIC,PROPMIC
 PROPERTY   MATERIAL=TH,         NAMES =CONCMIN,CONCINT,CAPHUM,CAPMIC,PROPMIC
 PROPERTY   MATERIAL=U,          NAMES =CONCMIN,CONCINT,CAPHUM,CAPMIC,PROPMIC
!OXIDATION STATES
 PROPERTY   MATERIAL=SOLMOD3,    NAMES =SOLSOH,SOLCOH,SOLSOC,SOLCOC
 PROPERTY   MATERIAL=SOLMOD4,    NAMES =SOLSOH,SOLCOH,SOLSOC,SOLCOC
 PROPERTY   MATERIAL=SOLMOD5,    NAMES =SOLSOH,SOLCOH,SOLSOC,SOLCOC
 PROPERTY   MATERIAL=SOLMOD6,    NAMES =SOLSOH,SOLCOH,SOLSOC,SOLCOC
 PROPERTY   MATERIAL=PHUMOX3,    NAMES =PHUMSIM,PHUMCIM
 PROPERTY   MATERIAL=PHUMOX4,    NAMES =PHUMSIM,PHUMCIM
 PROPERTY   MATERIAL=PHUMOX5,    NAMES =PHUMSIM,PHUMCIM
 PROPERTY   MATERIAL=PHUMOX6,    NAMES =PHUMSIM,PHUMCIM
!SOLUBILITIES
 PROPERTY   MATERIAL=SOLAM3,     NAMES =SOLSIM,SOLCIM
 PROPERTY   MATERIAL=SOLPU3,     NAMES =SOLSIM,SOLCIM
 PROPERTY   MATERIAL=SOLPU4,     NAMES =SOLSIM,SOLCIM
 PROPERTY   MATERIAL=SOLTH4,     NAMES =SOLSIM,SOLCIM
 PROPERTY   MATERIAL=SOLU4,      NAMES =SOLSIM,SOLCIM
 PROPERTY   MATERIAL=SOLU6,      NAMES =SOLSIM,SOLCIM
!WASTE UNIT FACTOR
 PROPERTY   MATERIAL=BOREHOLE,   NAMES=WUF
!============================================================================
*SET*VALUES
!INVSCALE NEEDED UNTIL ADDED TO DATA BASE
 PROPERTY   MATERIAL=REFCON,     NAMES*VALUE: INVSCALE=.1044
! PROPERTY   MATERIAL=REFCON,     NAMES*VALUE: INVSCALE=1.
! PROPERTY   MATERIAL=PU238L,    NAMES*VALUE: LSOLDIFF=2.17519 CCA Value
 PROPERTY   MATERIAL=PU238L,    NAMES*VALUE: LSOLDIFF=2.16920
! PROPERTY   MATERIAL=TH230L,    NAMES*VALUE: LSOLDIFF=2.900 CCA Value
 PROPERTY   MATERIAL=TH230L,    NAMES*VALUE: LSOLDIFF=3.88783
! PROPERTY   MATERIAL=U234L,     NAMES*VALUE: LSOLDIFF=2.550 CCA Value
 PROPERTY   MATERIAL=U234L,     NAMES*VALUE: LSOLDIFF=3.17962
!
*END
!----------------------------------------------------------------------
```

The following ALGEBRA input file is used for all PANEL runs for the CCA. It sets the values for SOLS and SOLC depending on the microbial degradation switch. It also sets the half-lives and atomic weights for the lumped isotopes.

```
!
! DEFINE WMICDFLG
WMICDFLG=PROBDEG[B:65]
!
! NOW, DEFINE SOLS AND SOLC
!
LIMIT BLOCKS 45
SOLS=MAKEPROP(IFGT0(WMICDFLG,SOLSOH,SOLSOC))
SOLC=MAKEPROP(IFGT0(WMICDFLG,SOLCOH,SOLCOC))
!
LIMIT BLOCKS 46
SOLS=MAKEPROP(IFGT0(WMICDFLG,SOLSOH,SOLSOC))
SOLC=MAKEPROP(IFGT0(WMICDFLG,SOLCOH,SOLCOC))
!
LIMIT BLOCKS 47
SOLS=MAKEPROP(IFGT0(WMICDFLG,SOLSOH,SOLSOC))
SOLC=MAKEPROP(IFGT0(WMICDFLG,SOLCOH,SOLCOC))
!
LIMIT BLOCKS 48
SOLS=MAKEPROP(IFGT0(WMICDFLG,SOLSOH,SOLSOC))
SOLC=MAKEPROP(IFGT0(WMICDFLG,SOLCOH,SOLCOC))
!
DELETE WMICDFLG
!
! SET HALFLIFE AND ATWEIGHT FOR AM241L SAME AS FOR AM241
LIMIT BLOCK 59
ATWEIGHT=MAKEPROP(ATWEIGHT[B:3])
HALFLIFE=MAKEPROP(HALFLIFE[B:3])
! SET HALFLIFE AND ATWEIGHT FOR PU238L SAME AS FOR PU238
LIMIT BLOCK 60
ATWEIGHT=MAKEPROP(ATWEIGHT[B:15])
HALFLIFE=MAKEPROP(HALFLIFE[B:15])
! SET HALFLIFE AND ATWEIGHT FOR PU239L SAME AS FOR PU239
LIMIT BLOCK 61
ATWEIGHT=MAKEPROP(ATWEIGHT[B:16])
HALFLIFE=MAKEPROP(HALFLIFE[B:16])
! SET HALFLIFE AND ATWEIGHT FOR TH230L SAME AS FOR TH230
LIMIT BLOCK 62
ATWEIGHT=MAKEPROP(ATWEIGHT[B:25])
HALFLIFE=MAKEPROP(HALFLIFE[B:25])
! SET HALFLIFE AND ATWEIGHT FOR U234L SAME AS FOR U234
LIMIT BLOCK 63
ATWEIGHT=MAKEPROP(ATWEIGHT[B:28])
HALFLIFE=MAKEPROP(HALFLIFE[B:28])
!
END
```

Appendix C

List of values from database used in the source term calculation from MATSET

AM	CONCMIN	2.6000E-08	SDB: AM,CONCMIN
AM	CONCINT	0.0000E+00	SDB: AM,CONCINT
AM	CAPHUM	1.1000E-05	SDB: AM,CAPHUM
AM	CAPMIC	1.0000E+00	SDB: AM,CAPMIC
AM	PROPMIC	3.6000E+00	SDB: AM,PROPMIC
NP	CONCMIN	2.6000E-08	SDB: NP,CONCMIN
NP	CONCINT	0.0000E+00	SDB: NP,CONCINT
NP	CAPHUM	1.1000E-05	SDB: NP,CAPHUM
NP	CAPMIC	2.7000E-03	SDB: NP,CAPMIC
NP	PROPMIC	1.2000E+01	SDB: NP,PROPMIC
PU	CONCMIN	2.6000E-08	SDB: PU,CONCMIN
PU	CONCINT	1.0000E-09	SDB: PU,CONCINT
PU	CAPHUM	1.1000E-05	SDB: PU,CAPHUM
PU	CAPMIC	6.8000E-05	SDB: PU,CAPMIC
PU	PROPMIC	3.0000E-01	SDB: PU,PROPMIC
TH	CONCMIN	2.6000E-08	SDB: TH,CONCMIN
TH	CONCINT	0.0000E+00	SDB: TH,CONCINT
TH	CAPHUM	1.1000E-05	SDB: TH,CAPHUM
TH	CAPMIC	1.9000E-03	SDB: TH,CAPMIC
TH	PROPMIC	3.1000E+00	SDB: TH,PROPMIC
U	CONCMIN	2.6000E-08	SDB: U,CONCMIN
U	CONCINT	0.0000E+00	SDB: U,CONCINT
U	CAPHUM	1.1000E-05	SDB: U,CAPHUM
U	CAPMIC	2.1000E-03	SDB: U,CAPMIC
U	PROPMIC	2.1000E-03	SDB: U,PROPMIC
SOLMOD3	SOLSOH	3.0700E-07	SDB: SOLMOD3,SOLSOH
SOLMOD3	SOLCOH	1.6900E-07	SDB: SOLMOD3,SOLCOH
SOLMOD3	SOLSOC	3.0700E-07	SDB: SOLMOD3,SOLSOC
SOLMOD3	SOLCOC	1.7700E-07	SDB: SOLMOD3,SOLCOC
SOLMOD4	SOLSOH	1.1900E-08	SDB: SOLMOD4,SOLSOH
SOLMOD4	SOLCOH	2.4700E-08	SDB: SOLMOD4,SOLCOH
SOLMOD4	SOLSOC	1.2400E-08	SDB: SOLMOD4,SOLSOC
SOLMOD4	SOLCOC	5.8400E-09	SDB: SOLMOD4,SOLCOC
SOLMOD5	SOLSOH	1.0200E-06	SDB: SOLMOD5,SOLSOH
SOLMOD5	SOLCOH	5.0800E-06	SDB: SOLMOD5,SOLCOH
SOLMOD5	SOLSOC	9.7200E-07	SDB: SOLMOD5,SOLSOC
SOLMOD5	SOLCOC	2.1300E-05	SDB: SOLMOD5,SOLCOC
SOLMOD6	SOLSOH	8.7000E-06	SDB: SOLMOD6,SOLSOH
SOLMOD6	SOLCOH	8.8000E-06	SDB: SOLMOD6,SOLCOH
SOLMOD6	SOLSOC	8.7000E-06	SDB: SOLMOD6,SOLSOC
SOLMOD6	SOLCOC	8.8000E-06	SDB: SOLMOD6,SOLCOC
PHUMOX3	PHUMSIM	1.9000E-01	SDB: PHUMOX3,PHUMSIM
PHUMOX3	***PHUMCIM***	***1.3700E+00***	***SDB: PHUMOX3,PHUMCIM***
PHUMOX4	PHUMSIM	6.3000E+00	SDB: PHUMOX4,PHUMSIM
PHUMOX4	PHUMCIM	6.3000E+00	SDB: PHUMOX4,PHUMCIM
PHUMOX5	PHUMSIM	9.1000E-04	SDB: PHUMOX5,PHUMSIM
PHUMOX5	PHUMCIM	7.4000E-03	SDB: PHUMOX5,PHUMCIM
PHUMOX6	PHUMSIM	1.2000E-01	SDB: PHUMOX6,PHUMSIM
PHUMOX6	PHUMCIM	5.1000E-01	SDB: PHUMOX6,PHUMCIM
SOLAM3	***SOLSIM***	***-9.0000E-02***	***SDB: SOLAM3,SOLSIM***

SOLAM3	*SOLCIM*	*-9.0000E-02*	*SDB:*	*SOLAM3,SOLCIM*
SOLPU3	*SOLSIM*	*-9.0000E-02*	*SDB:*	*SOLPU3,SOLSIM*
SOLPU3	*SOLCIM*	*-9.0000E-02*	*SDB:*	*SOLPU3,SOLCIM*
SOLPU4	*SOLSIM*	*-9.0000E-02*	*SDB:*	*SOLPU4,SOLSIM*
SOLPU4	*SOLCIM*	*-9.0000E-02*	*SDB:*	*SOLPU4,SOLCIM*
SOLTH4	*SOLSIM*	*-9.0000E-02*	*SDB:*	*SOLTH4,SOLSIM*
SOLTH4	*SOLCIM*	*-9.0000E-02*	*SDB:*	*SOLTH4,SOLCIM*
SOLU4	*SOLSIM*	*-9.0000E-02*	*SDB:*	*SOLU4,SOLSIM*
SOLU4	*SOLCIM*	*-9.0000E-02*	*SDB:*	*SOLU4,SOLCIM*
SOLU6	*SOLSIM*	*-9.0000E-02*	*SDB:*	*SOLU6,SOLSIM*
SOLU6	*SOLCIM*	*-9.0000E-02*	*SDB:*	*SOLU6,SOLCIM*
GLOBAL	*OXSTAT*	*5.0000E-01*	*SDB:*	*GLOBAL,OXSTAT*
WAS_AREA	*PROBDEG*	*2.0000E+00*	*SDB:*	*WAS_AREA,PROBDEG*

Items above in bold and italics indicated that the values listed are replaced by sampled values before use in the source term calculations.