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December 20, 2002

Ms. Darlene Higgs
U.S. Nuclear Regulatory Commission
Division of Waste Management
High Level Waste Branch
Mail Stop T-7 F-3
Washington, DC 20555

Dear Ms. Higgs:

Enclosed is a copy of the EEG report, *EEG Operational Radiation Surveillance of the WIPP Project During 2001*, EEG-84, by Donald H. Gray, Sally C. Ballard, and James K. Channell, December, 2002. Reported are EEG's measurements of ^{241}Am, $^{239/240}$Pu, ^{238}Pu, ^{137}Cs, and ^{90}Sr in air and water samples collected at and around the WIPP site during 2001. For a six-year period prior to receipt of waste in March 1999, EEG's radiation surveillance established baseline concentrations for ^{241}Am, $^{239/240}$Pu, ^{238}Pu, and ^{137}Cs. These preoperational measurements were published in EEG-67 and EEG-73, and are summarized in this report. Also summarized in this report are the baseline concentrations measured by EEG for ^{90}Sr in 1999 and 2000.

Overall, the results of EEG's measurements in samples collected in 2001 are not different from the corresponding baseline measurements, and, from this, the EEG concludes that operations at the WIPP during 2001 did not result in measureable releases of radionuclides to the environment.

Sincerely,

Matthew K. Silva
Director

MKS:DG:ss
Enclosure

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EEG-84

EEG OPERATIONAL RADIATION SURVEILLANCE OF THE WIPP PROJECT DURING 2001

Donald H. Gray
Sally C. Ballard
James K. Channell

Environmental Evaluation Group
New Mexico

December 2002

EEG-84
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EEG OPERATIONAL RADIATION SURVEILLANCE OF THE WIPP PROJECT DURING 2001

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December 2002

FOREWORD

The purpose of the New Mexico Environmental Evaluation Group (EEG) is to conduct an independent technical evaluation of the Waste Isolation Pilot Plant (WIPP) Project to ensure the protection of the public health and safety and the environment of New Mexico. The WIPP Project, located in southeastern New Mexico, became operational in March 1999 for the disposal of transuranic (TRU) radioactive wastes generated by the national defense programs. The EEG was established in 1978 with funds provided by the U.S. Department of Energy (DOE) to the State of New Mexico. Public Law 100-456, the National Defense Authorization Act, Fiscal Year 1989, Section 1433, assigned the EEG to the New Mexico Institute of Mining and Technology and continued the original contract DE-AC04-79AL10752 through DOE contract DE-AC04-89AL58309. The National Defense Authorization Act for Fiscal Year 1994, Public Law 103-160, and the National Defense Authorization Act for Fiscal Year 2000, Public Law 106-65, continued the authorization.

EEG performs independent technical analyses on a variety of issues. Now that the WIPP is operational, these issues include facility modifications and waste characterization for future receipt and emplacement of remote-handled waste, generator site audits, contact-handled waste characterization issues, the suitability and safety of transportation systems, mining of new panels, analysis of new information as part of the five year recertification cycles as mandated by the WIPP Land Withdrawal Act. Review and comment is also provided on the annual Safety Analysis Report and Proposed Modifications to the Hazardous Waste Facility Permit. The EEG also conducts an independent radiation surveillance program which includes a radiochemical laboratory.

Matthew K. Silva
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ACRONYMS AND SYMBOLS

ACTL	Action Level
Am	Americium
ANOVA	Analysis of variance
Bq	Becquerel
CEDE	Committed-effective-dose equivalent
CEMRC	Carlsbad Environmental Monitoring and Research Center
CFR	Code of Federal Regulations
Cs	Cesium
DOE	U. S. Department of Energy
DQO	Data quality objective
EEG	Environmental Evaluation Group
EPA	U. S. Environmental Protection Agency
ICRP	International Commission on Radiological Protection
LLD	Lower limit of detection
LSC	Liquid scintillation counter
LVAS	Low volume air sampler
M	Mean
MDA	Minimum detectable activity
MOU	Memorandum of Understanding
mrem	Millirem
NCRP	National Council on Radiation Protection and Measurements
NESHAPS	National Emission Standards for Hazardous Air Pollutants
Pu	Plutonium
s	Sample standard deviation
Sr	Strontium
TLD	Thermoluminescent dosimeter
TRU	Transuranic
WHB	Waste Handling Building
WIPP	Waste Isolation Pilot Plant
WTS	Westinghouse TRU Solutions

EXECUTIVE SUMMARY

The Environmental Evaluation Group (EEG) has measured the levels of ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{137}Cs, and ^{90}Sr in samples of air and water collected at and in the vicinity of the U. S. Department of Energy's (DOE) Waste Isolation Pilot Plant (WIPP) during 2001. The WIPP received the first shipment of waste in March 1999 and became operational at that time. The EEG has compared these levels to those measured in the preoperational phase, prior to receipt of waste, as well as to the results of other monitoring organizations and to the U. S. Environmental Protection Agency (EPA) dose standards established for the WIPP at 40 CFR 191, Subpart A, and, by an agreement between the DOE and the EPA, at 40 CFR 61, Subpart H.

Based on these analyses and applying a *t* test for significant differences for normally-distributed data (Taylor 1987), or analysis of variance (ANOVA) for non-normal data, the EEG concludes that:

1. Three measurements of radionuclides in the environment around WIPP during 2001 were different from the preoperational baseline levels. Only two of these – ^{241}Am in both the Loving and WIPP3 low volume air sampler (LVAS) samples, first quarter and second quarter, respectively – exceeded the minimum detectable activity (MDA). These measurements were carefully investigated, but no clearly assignable cause was discovered. No measurements of ^{241}Am in effluent air from the WIPP underground exceeded the action level, and converting the highest LVAS measured concentration to radiation dose yielded a committed dose of much less than 1% of the limit allowable under the EPA standard.

2. Comparison of the EEG's 2001 results with those of other monitoring organizations revealed two sets of measurements which did not agree. One set – ^{241}Am in surface water – was found to be in agreement with the corresponding EEG baseline. The other – ^{90}Sr in groundwater – was probably a result of ^{226}Ra interference in the EEG 2001 analysis. Methodologies are being reviewed to address this problem.

3. WIPP operations during 2001 did not result in measurable releases of radioactive materials to the environment or radiation doses to the public.

1.0 INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is an underground repository near Carlsbad in southeast New Mexico, owned and operated by the U. S. Department of Energy (DOE) for the purpose of safely disposing of waste materials generated by the nation's nuclear weapons production programs. These waste materials are contaminated with varying levels of transuranic (TRU) radionuclides, principally isotopes of plutonium and americium. Since 1978 the Environmental Evaluation Group (EEG) has been responsible for independent technical oversight of the DOE's activities at WIPP. Since 1985 this responsibility has included on-site and off-site monitoring of transuranic radionuclides and fission products in air, soil, and water. Prior to the opening of WIPP the purpose of these monitoring efforts was to establish a baseline for comparison with future measurements. The EEG's program for conducting radiation surveillance of the WIPP project has been fully described in Kenney et al. (1990), Kenney and Ballard (1990), Kenney (1991), Kenney (1992), Kenney (1994), Kenney et al. (1998), and Kenney et al. (1999). The radionuclides measured by the EEG in this program account for more than 98% of the potential public radiation dose from WIPP operations (DOE 1996). Brief descriptions of the EEG air and water sampling locations appear in Appendix E.

The first shipment of waste arrived at WIPP in late March 1999, and the EEG published its final preoperational report in October 1999, covering results of the surveillance program for 1996 through 1998 (Kenney et al. 1999). The EEG published its first operational monitoring report in September 2000. The present report is the EEG's third operational monitoring report and contains results obtained from sample collections and other activities during calendar year 2001. This report also compares these results to:

1. The preoperational baseline measured by the EEG and reported in the above-referenced preoperational reports.

2. The results of other organizations engaged in environmental monitoring at and around the WIPP site, where direct comparisons can be made.

3. The U.S. Environmental Protection Agency's (EPA) standards governing the operation of WIPP; namely, 40 CFR 191 Subpart A and 40 CFR 61 Subpart H, adopted by agreement between DOE and EPA.

The procedures established for the preoperational phase and the overall goals of the program are unchanged, unless noted herein. The terminology applied to uncertainties in this report has been modified somewhat from previous reports to more closely comply with common practice.

2.0 PREOPERATIONAL BASELINE

A summary of the concentrations of ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{137}Cs, and ^{90}Sr measured by the EEG in air and water at and in the vicinity of the WIPP site for the period prior to receipt of waste appears in Table 1. For ^{90}Sr, the data represent samples collected during 1999 and 2000 (Gray et al, 2000); for all others, except for the1996 and 1997 LVAS samples which were archived, they pertain to the six-year period prior to receipt of waste. The transuranic and ^{137}Cs data in Table 1 are the means and uncertainties of the results found in the appendices of Kenney et al. (EEG-67, 1998) and Kenney et al. (EEG-73, 1999). The ^{90}Sr data are the corresponding values from Gray et al. (EEG-79, 2000) and Gray and Ballard (EEG-81, 2001). The uncertainties in Table 1 represent two standard deviations (2s), or the approximately 95% confidence interval of the results. This was incorrectly described in the first operational report (EEG-79) as the 95% confidence level of the means. The result for ^{90}Sr in Table 1 is different from that appearing in EEG-81. The EEG-81 value incorrectly included the first quarter result from 1999, which resulted from a sample that failed to meet the data quality objective (DQO) for minimum sample size, and should have been excluded from the dataset. The units are nano-Becquerels (10^{-9} Becquerels)-per-cubic-meter (nBq/m^3) for air and milli-Becquerels (10^{-3} Becquerels)-per-liter (mBq/L) for water. The numbers of measurements in each data set are given in parentheses. For water samples, if the calculated results were less than 0.1 mBq/L, the results were rounded to zero. Of 823 measurements, 19 were found to be statistical outliers by the Grubbs test (Taylor 1987). These were disqualified only after investigation into possible causes.

Table 1. Mean EEG Preoperational Baseline

Radionuclide	Effluent Air M ± 2s (nBq/m^3)	Ambient Air M ± 2s (nBq/m^3)	Drinking Water M ± 2s (mBq/L)	Surface Water M ± 2s (mBq/L)	Ground Water M ± 2s (mBq/L)
^{241}Am	25 ± 177 (n = 18)	27 ± 109 (n = 79)	-0.1 ± 1.4 (n = 17)	-0.3 ± 2.0 (n = 30)	0.3 ± 2.4 (n = 32)
$^{239/240}$Pu	25 ± 200 (n = 20)	23 ± 56 (n = 88)	0 ± 0.8 (n = 17)	-0.2 ± 0.7 (n = 34)	0.1 ± 1.4 (n = 36)
^{238}Pu	13 ± 96 (n = 18)	6 ± 62 (n = 90)	0.1 ± 0.8 (n = 19)	0 ± 1.0 (n = 31)	0.1 ± 1.5 (n = 34)
^{137}Cs	880 ± 7800 (n = 23)	60 ± 2460 (n = 104)	20 ± 50 (n = 5)	22 ± 130 (n = 8)	-30 ± 110 (n = 10)
^{90}Sr	1040 ± 5650 (n = 15)	1260 ± 2290 (n = 44)	8.6 ± 29.4 (n = 8)	9.5 ± 40.1 (n = 11)	7.3 ± 27.5 (n = 13)

3.0 OPERATIONAL MONITORING RESULTS

3.1 Air Effluent and Environmental Monitoring

The results of air effluent and environmental monitoring during 2001 are summarized in Table 2. The values in Table 2 are the means and two standard deviations (2s) of the results for the data in Appendices A and B of this report. The "expanded uncertainty" used in the Appendices is the combined standard uncertainty of the measurements multiplied by a coverage factor (k) to express an interval about the measured value within which the "true" value may be expected to lie at some specified level of confidence – in this case, approximately 95%. The combined standard uncertainty expresses the standard deviation of the result and includes both random and systematic sources of uncertainty. Further discussion is found in the ISO Guide to the Expression of Uncertainty in Measurement (ISO 1992).

Table 2. Results of Specific Radionuclide Measurements from Samples Collected in 2001

Radionuclide	Effluent Air M ± 2s Station A Station B (nBq/m^3)	Ambient Air M ± 2s (nBq/m^3)	Drinking Water M ± 2s (mBq/L)	Surface Water M ± 2s (mBq/L)	Ground Water M ± 2s (mBq/L)
^{241}Am	23 ± 202 52 ± 162	19 ± 100	0.30 ± 0.93	-0.28 ± 0.18	-0.03 ± 1.21
$^{239/240}$Pu	-7.4 ± 70.5 -11 ± 26	16 ± 27	-0.05 ± 0.21	-0.04 ± 0.28	-0.03 ± 0.43
^{238}Pu	-3.3 ± 155 -9.8 ± 29.3	12 ± 33	0.37 ± 0.45	-0.30 ± 0.39	0.31 ± 1.15
^{137}Cs	610 ± 9300 -360 ± 7380	880 ± 1900	9.4 ± 58	0.88 ± 25	9.2 ± 55
^{90}Sr	1030 ± 2710 1130 ± 5580	1120 ± 1140	1.8 ± 25	14.6 ± 9.4	25 ± 30

For the 2001 sampling year, of a total of 233 possible measurements, 20 were rejected as a result of instrument or processing problems in the lab, and 5 additional were rejected due to failure of the sample to meet a sampling data quality objective. These 25 rejected analyses are indicated in the Appendix A and B tables as "NA".

A total of six measurements during 2001 exceeded the MDA: two for ^{241}Am and four for $^{239/240}$Pu. All were in LVAS samples. The ^{241}Am measurements were obvious outliers and are discussed below. The $^{239/240}$Pu measurements were not outliers, nor did they exceed the EEG action level; therefore, they are considered to be members of the baseline population.

The analysis results from the 2001 sampling year were evaluated against three criteria:

1. Grubbs' Outlier Test (Taylor 1987) to identify greater than expected within-group variances.

2. Action Level (ACTL) (Rodgers & Kenney 1997), defined in previous reports as the upper-95% confidence level of the baseline measurements, to identify measurements which appear to exceed the baseline.

3. The *t* test (Taylor 1987) to determine whether the means of the 2001 measurements differ significantly from the baseline means for normally-distributed data; for non-normal data, an analysis of variance (ANOVA) test was applied.

The outlier test is a preliminary test applied to the data before application of the ACTL, *t*, and ANOVA tests. Data failing the outlier test are rejected only if a clearly definable analytical or sampling problem can be identified. Subsequently, the ACTL, *t*, and ANOVA tests are applied to all remaining data.

Four transuranic (TRU) radionuclide measurements were found to be outliers but could not be rejected. Two of these, both ^{238}Pu determinations, did not exceed either the action level or the MDA and were deemed to be members of the baseline population. The remaining two, ^{241}Am in the Loving LVAS from the first quarter and ^{241}Am in the WIPP3 LVAS from the second quarter, exceeded both the action level and the MDA and were investigated, but no assignable cause was discovered in either case. A quality control (QC) sampler, which is an LVAS sampler that can be moved and co-located with off-site samplers to provide a field duplicate, was running alongside the WIPP3 sampler during the second quarter. Analysis of the WIPP3 QC sample yielded results which did not exceed either the MDA or the action level.

The calculated ^{241}Am concentrations (184 and 168 nBq/m^3) were then evaluated against the 25 mrem annual dose limit imposed by 40 CFR 191.03(b), using estimates from International Commission on Radiological Protection Report 23 (ICRP 1975) for "reference man" and dose factors in Federal Guidance Report 11 (Eckerman 1988). For continuous exposure to these concentrations the derived committed-effective-dose equivalent (CEDE) would be about 0.08%, or less, of the standard, therefore the consequences for public health are considered to be insignificant.

The ^{241}Am concentrations in the above samples appear to be statistically real values. However, the contamination is almost certainly not from normal WIPP operations for several reasons:

1. No WIPP effluent air measurement exceeded an ACTL.

2. No WIPP waste shipments should have gone through Loving before May 2001, when the first Savannah River site shipment arrived.

3. The sample obtained from the QC sampler, co-located with WIPP3, did not show elevated ^{241}Am.

4. Inspection of the ^{241}Am LVAS tables in the Appendices of EEG-67 and EEG-73, covering the pre-operational phase, revealed results which are approximately equal to or higher than the elevated results observed in 2001.

As discussed in EEG-81, the extremely low ^{241}Am activity found in the Loving and WIPP3 air samples could have resulted from trapping a single sub-micron size particle, called a "hot" particle, on the filter. Elevated ^{241}Am was also found in the Loving sample from the 3rd quarter of 2000, but even the highest levels observed to date represent only about 0.1% of the 25-mrem regulatory limit and are of no concern in terms of public health. It could be interesting to do a future scientific study aimed at identifying possible sources; however, there is no public health reason for such an investigation unless activity levels are observed that are at least two orders of magnitude higher.

One ^{90}Sr measurement (WQSP-4) exceeded the ACTL but did not exceed the MDA, and is not considered to be significant.

Appendix C contains the results of the matrix blanks analyzed with the samples from the year 2001 sample collection period. All sample measurements in this report were blank-corrected, meaning the average result of the blank analyses from Table C1 was subtracted from the corresponding sample result.

3.2 TLD Data

The EEG deploys environmental thermoluminescent dosimeters (TLDs) at selected points along the WIPP exclusive use boundary for the purpose of providing a direct assessment of WIPP's compliance with the 40 CFR 191 Subpart A dose standard (Kenney et al. 1999). Quarterly external dose measurements as determined by TLDs during 2001 are reported in Appendix D, including a "control" TLD which was kept in the EEG office in Carlsbad and was unaffected by WIPP operations. The average quarterly dose (excluding the control) during 2001 was 20.3 mrem/quarter ± 4.5 mrem/quarter (2σ) and the control TLD dose was 19.6 ± 5.8 mrem/quarter. Doses for 1998 (the last preoperational year) averaged 18.3 ± 5.3 (sample) and 17.8 ± 7.5 (control) mrem/quarter. Therefore, the observed 2001 doses are not statistically different from the preoperational baseline doses in EEG-73. Based on measurements of control TLDs for the year 2001, the quarterly lower limit of detection (LLD) was 9.8 mrem/quarter. Thus, a quarterly dose from WIPP operations that exceeded about 10 mrem should be detectable. None of the TLDs in 2001 approached the LLD (which would have been a gross value of 29.3 mrem/quarter).

A more detailed discussion of the TLD program and statistical treatment of the data is provided in Appendix D.

4.0 DISCUSSION OF RESULTS

4.1 Comparison to the EEG Preoperational Baseline

Tables 1 and 2 are summarized and compared graphically in Figures 1 through 5 on the following pages. The bars in Figures 1 through 5 represent the upper and lower 95% limits and the horizontal dash inside each bar is the mean value. Concentrations of ^{137}Cs and ^{90}Sr should be read from the right-hand Y scale.

Application of the 2-sample *t* and ANOVA tests via Minitab™ statistical software[a] revealed that two of the measurements in Table 2 differed from the preoperational baseline at the 95% confidence level. The measurement of ^{137}Cs in ambient air exhibited an elevated mean with respect to the baseline. However, as tabulated in Table 3 the higher amount does not present a health concern and, in fact, is somewhat reduced from the value for 2000. Also, ^{90}Sr in groundwater was slightly elevated with respect to the baseline. However, ^{90}Sr is not yet a significant part of the WIPP underground inventory, and, even if it were, at present there is no known hydrologic connection between the repository and the groundwater sampling wells.

4.2 Comparison to the Operational Results from Other Organizations

Radiological surveillance monitoring of WIPP is also being conducted by the Westinghouse TRU Solutions (WTS) and the Carlsbad Environmental Monitoring and Research Center (CEMRC). Where direct comparisons are possible, it is useful to compare monitoring data among the three organizations. Four measurements of ^{239}Pu in ambient air were reported by CEMRC for 2001 (CEMRC 2002). An ANOVA test comparing the mean (± 2 standard deviations) of the CEMRC measurements (5.6 ± 2.6 nBq/m^3) with the EEG 2001 mean value (16 ± 27 nBq/m^3) for ^{239}Pu in ambient air indicated no statistically significant difference at the 95% confidence level ($p = 0.128$).

Comparison with operational data from the WTS monitoring program for 2001 yielded two measurements which appeared to be different at 95% confidence: ^{241}Am in surface water ($P = 0.002$) and ^{90}Sr in groundwater ($P = 0.016$). A further ANOVA was performed in Minitab™ on each dataset with inclusion of the corresponding (and much larger) EEG baseline dataset to determine whether the apparently divergent results could be judged to be part of the baseline population. Inclusion of the baseline revealed that for ^{241}Am in surface water the three datasets (baseline, EEG 2001, and WTS 2001) were not different at 95% confidence ($P = 0.301$). However, when the same test was applied to the results for ^{90}Sr in groundwater, the differences still appeared to be significant ($P = 0.037$), and further investigation was conducted.

[a] Minitab is a registered trademark of Minitab, Inc., www.minitab.com.

Inspection of the data and pair-wise comparisons via Minitab™ showed agreement between the WTS value for 2001 and the EEG baseline, but that both values were significantly lower than the EEG value for 2001. One of the archived 2001 ^{90}Sr samples was re-assayed by liquid scintillation spectrometry. The liquid scintillation counter (LSC) was acquired by the EEG during 2001 and has the capability of doing simultaneous alpha and beta spectrometry. The re-assayed sample showed a measurable amount of an alpha emitter, probably ^{226}Ra, known to be naturally present in groundwaters and which was likely incompletely removed during the radiochemical analysis. Until recently, the EEG measured ^{90}Sr by gas-flow proportional counting, which is very sensitive but is subject to interference from alpha-particle emitters.

Based on these investigations, the EEG concludes that the apparently elevated ^{90}Sr results in groundwater were likely due to ^{226}Ra interference. Procedures are being developed and tested for carrying out all future ^{90}Sr assays by liquid scintillation spectrometry, while maintaining gas-flow proportional counting as a back-up methodology.

All other direct comparisons between the EEG and WTS results in air and water samples revealed no statistically significant differences.

4.3 Comparison to the EPA Standard

The dose standards applied by the U. S. Environmental Protection Agency to WIPP operations are found both in 40 CFR 191.03(b) and, following a memorandum of understanding (MOU) between DOE and EPA (EPA&DOE 1995), in 40 CFR Part 61.92, the National Emission Standards for Hazardous Air Pollutants, or NESHAPS. Respectively, these are annual committed-effective-dose-equivalents to any member of the public of 25 mrem and 10 mrem. The NESHAPS standard applies to effluent airborne releases only. Comparisons to EPA standards in this and future operational reports will be relative to NESHAPS for airborne facility effluent measurements, and relative to 40 CFR 191.03(b) for all other measurements having implications for WIPP's compliance with the pertinent regulations.

Comparisons of concentration measurements to a dose standard require appropriate conversions. In the preoperational reports, the EEG applied the methods found in NCRP 123 (NCRP 1996) to measurements of facility effluent air, sampled at Station A (Kenney et al. 1999). The EEG's analytical methodology provided sufficient sensitivity to detect releases which could potentially result in doses to the highest-risk individual of a few percent of the standard. EPA, in its guidance for the application of 40 CFR 191, Subpart A (EPA 1997), recommends the use of CAP88PC (Parks 1992) for estimating doses both to populations and to the individual at highest risk, based on effluent measurements made at a point of release. The EEG will follow the EPA's recommendation for this and future reports.

For measurements made at a receptor location, such as for ambient air samples versus a point-of-release location, a simpler dose-conversion factor can be used in some cases. For measurements of ambient air (LVAS) samples, the EEG uses the dose-conversion factors in Federal Guidance Report No. 11 (Eckerman 1988) and assumes intakes of 8,400 m^3/year of air, based on the ICRP No. 23 "reference man" (ICRP 1975).

Using the upper 95% limit values for the means (Mean + 2s) from the tables in Appendices A and B as input values, the dose estimates obtained from these conversions were then expressed as percentages of the appropriate standard and the results appear in Table 3, with the total of the individual isotopic dose contributions in the last row.

Table 3. Comparison of Measurements to the Standards

Applicable Standard→	NESHAPS (10 mrem)		40 CFR 191 (25 mrem)
Radionuclide	Effluent Air		Ambient Air
	Station A	Station B	
^{241}Am	<0.01%	<0.01%	0.05%
$^{239/240}Pu$	<0.01%	<0.01%	0.02%
^{238}Pu	<0.01%	<0.01%	~0.01%
^{137}Cs	<0.01%	<0.01%	<0.01%
^{90}Sr	<0.01%	<0.01%	<0.01%
Total	<0.01%	<0.01%	0.08%

5.0 CONCLUSIONS

The results of the EEG's radiation surveillance of the WIPP project during 2001 show that operations at the site during 2001 did not result in detectable releases of radionuclides to the environment. Except as noted above, where direct comparisons can be made, the EEG results are similar to the results of other organizations engaged in radiation surveillance at WIPP. The sensitivity of the EEG's methods is such that releases from the air exhaust shaft, resulting in a dose to any member of the public of less than 0.01% of the standard, would have been detected.

Finally, an evaluation of the results of environmental sampling at various locations around the site relative to the applicable EPA radiation dose standards shows that the estimated dose to an individual residing year-round at a sampled location during 2001 is not different from the baseline dose before WIPP became operational. From this, the EEG concludes that WIPP operations during 2001 did not result in measurable doses to the public.

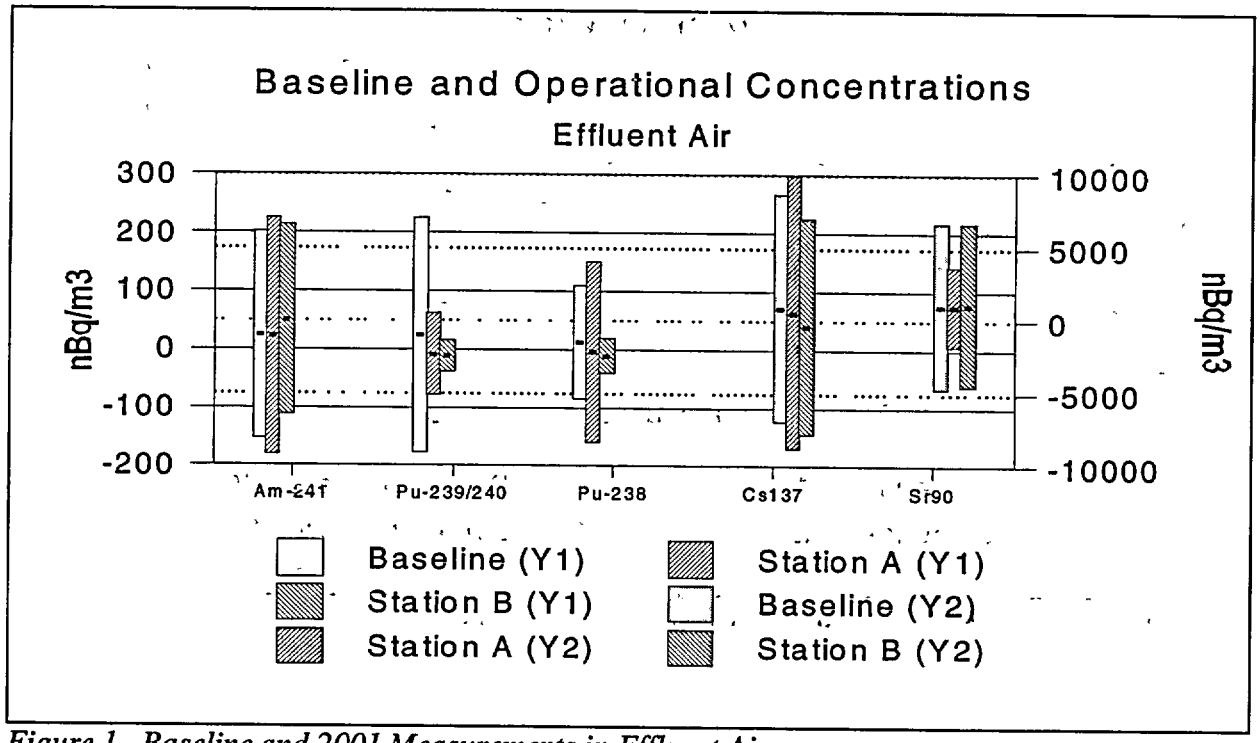

Figure 1. Baseline and 2001 Measurements in Effluent Air

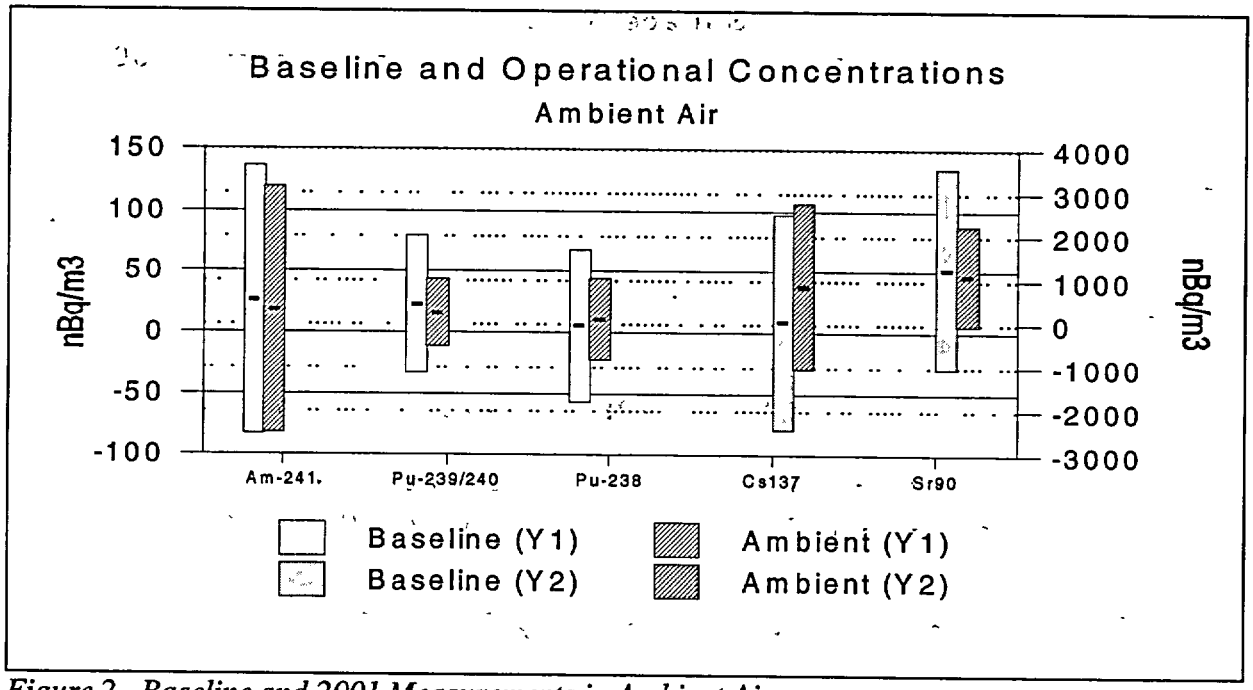

Figure 2. Baseline and 2001 Measurements in Ambient Air

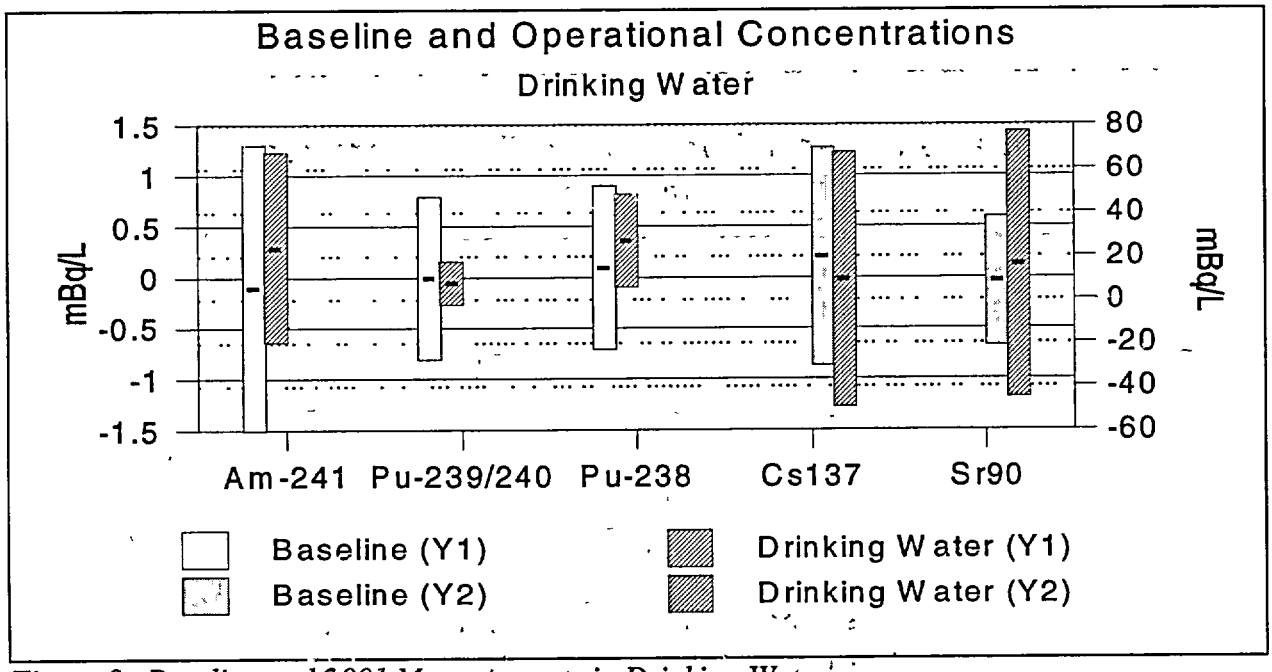

Figure 3. Baseline and 2001 Measurements in Drinking Water

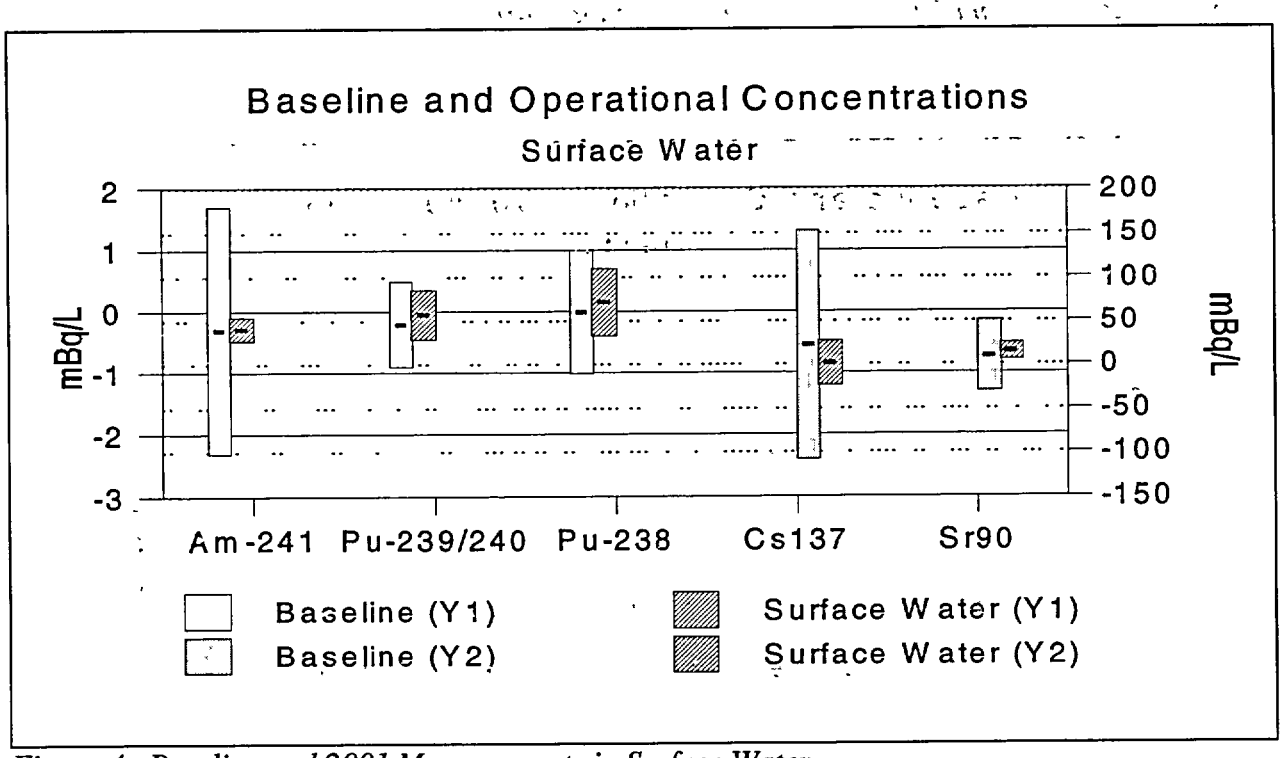

Figure 4. Baseline and 2001 Measurements in Surface Water

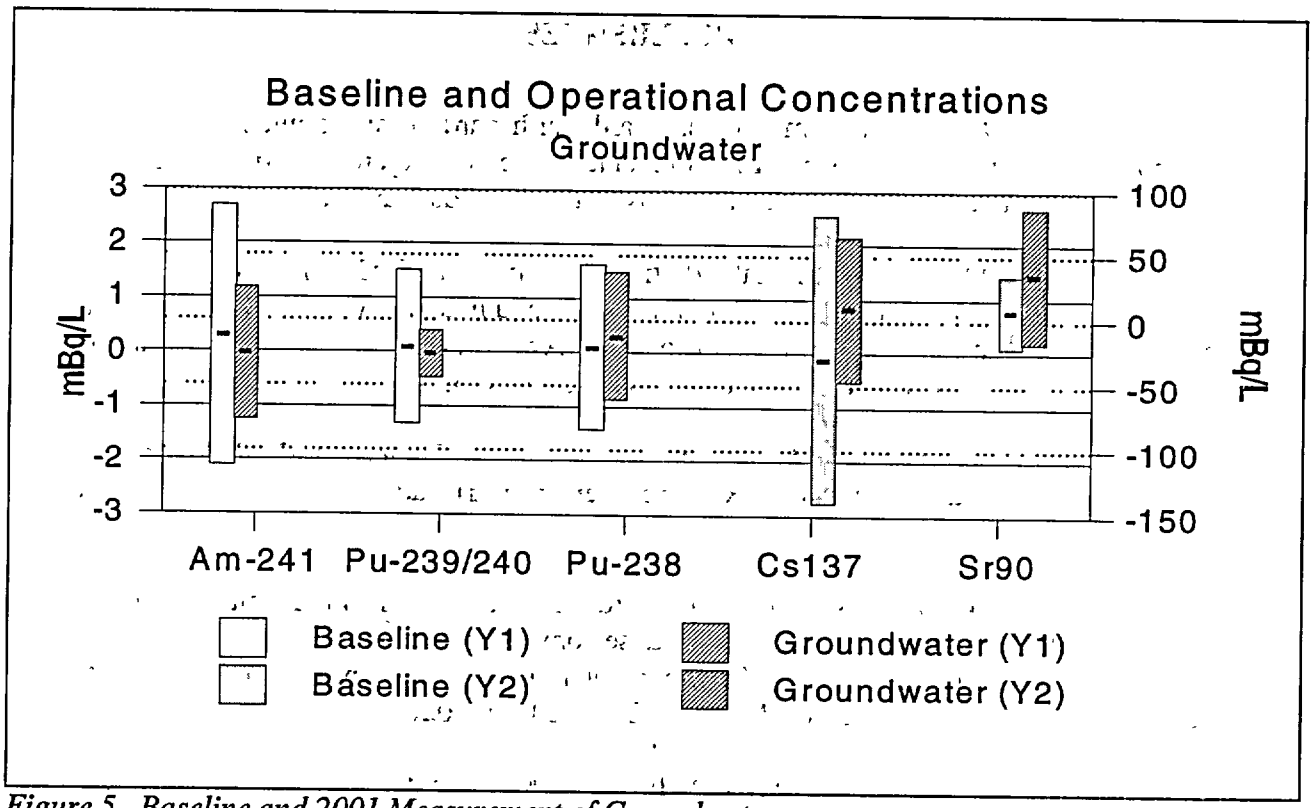

Figure 5. Baseline and 2001 Measurement of Groundwater

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APPENDICES

(Note: "Expanded Uncertainty" in the following tables is defined in Chapter 6 of the ISO Guide to the Expression of Uncertainty in Measurement [ISO 1992])

APPENDIX A. AIR SAMPLE DATA

Table A1. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Station A Samples During 2001

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{241}Am CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	$^{239/240}Pu$ CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{238}Pu CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2001	6003	1.73E+02	2.12E+02	1.47E+01	6.68E+01	3.27E+01	7.83E+01
2ND 2001	6655	-2.76E+01	1.35E+02	-1.19E+01	5.94E+01	6.65E+01	9.08E+01
3RD 2001	6642	-1.22E+01	1.30E+02	2.29E+01	6.80E+01	1.58E-01	7.41E+01
4TH 2001	7268	-4.23E+01	1.31E+02	-5.54E+01	8.26E+01	-1.12E+02	1.28E+02
		Mean	2s	Mean	2s	Mean	2s
		-2.28E+01	2.02E+02	-7.43E+00	7.05E+01	-3.27E+00	1.55E+02

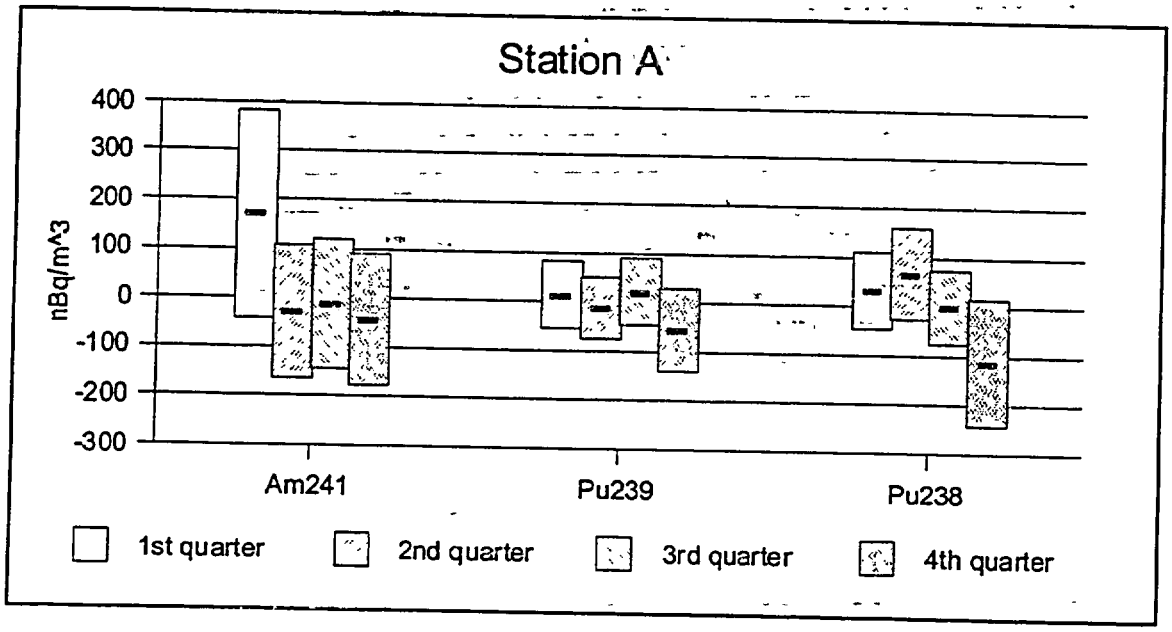

Figure A1. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Station A Samples During 2001

Table A2. ^{137}Cs and ^{90}Sr Measurements in Station A Samples During 2001

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{137}Cs CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{90}Sr CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2001	6003	2.12E+03	1.57E+04	2.60E+03	6.21E+03
2ND 2001	6655	4.70E+03	1.40E+04	7.83E+02	6.02E+03
3RD 2001	6642	-6.10E+03	1.19E+04	1.39E+03	5.99E+03
4TH 2001	7268	1.72E+03	1.18E+04	-6.61E+02	6.24E+03
		Mean	2s	Mean	2s
		6.09E+02	9.33E+03	1.03E+03	2.71E+03

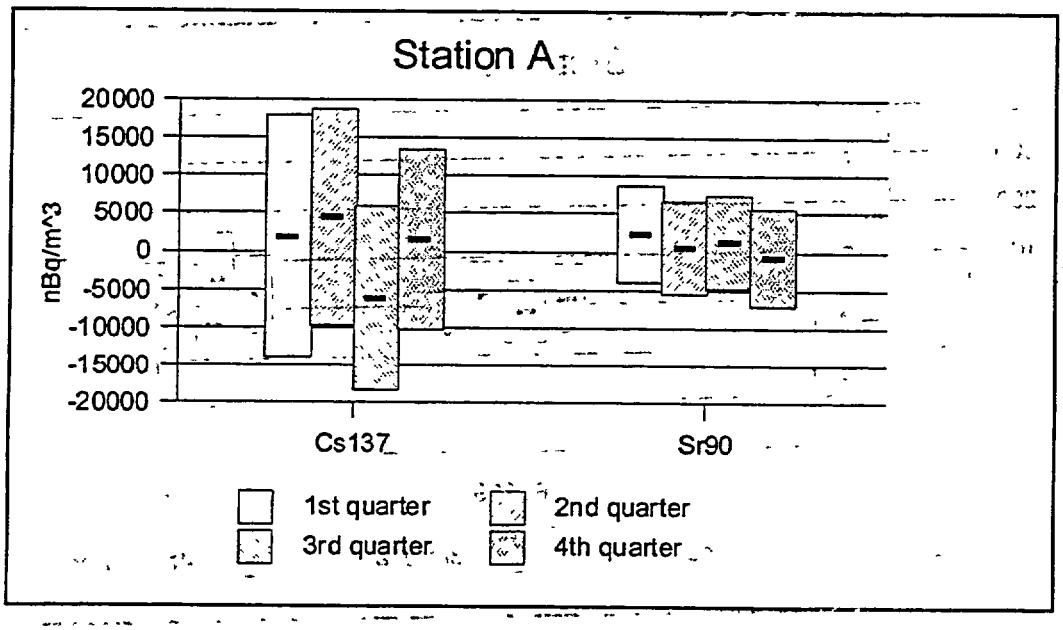

Figure A2. ^{137}Cs and ^{90}Sr Measurements in Station A Samples During 2001

Table A3. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Station B Samples During 2001

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{241}Am CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	$^{239/240}Pu$ CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{238}Pu CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2001	6384	-1.10E+02	1.40E+02	2.99E+00	6.58E+01	-9.36E+00	6.51E+01
2ND 2001	7036	8.59E+01	1.27E+02	-2.97E+00	5.55E+01	1.06E+01	6.17E+01
3RD 2001	7160	7.92E+01	1.36E+02	-2.16E+01	4.95E+01	-2.20E+01	6.20E+01
4TH 2001	7087	-6.87E+01	1.18E+02	-2.30E+01	6.96E+01	-1.86E+01	7.89E+01
		Mean	2s	Mean	2s	Mean	2s
		5.15E+01	1.62E+02	-1.12E+01	2.63E+01	-9.84E+00	2.93E+01

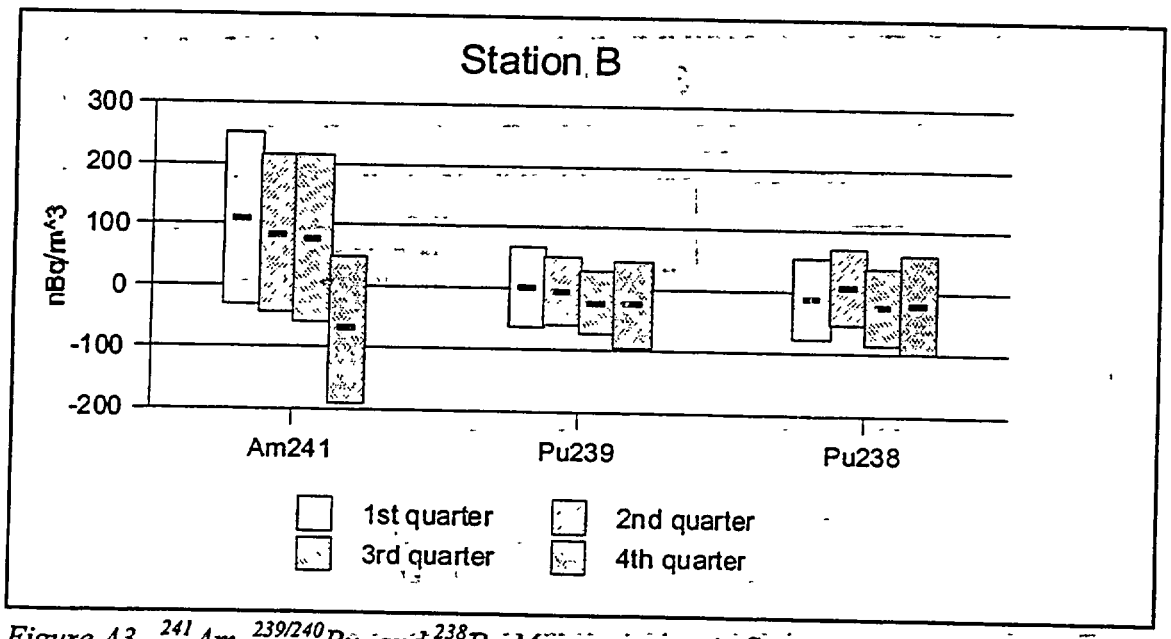

Figure A3. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Station B Samples During 2001

Table A4. ^{137}Cs and ^{90}Sr Measurements in Station B Samples During 2001

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{137}Cs CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{90}Sr CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2001	6384	-4.31E+03	2.28E+04	5.31E+03	6.61E+03
2ND 2001	7036	-2.36E+03	2.08E+04	-1.69E+02	5.80E+03
3RD 2001	7160	3.96E+03	2.10E+04	-3.90E+02	5.69E+03
4TH 2001	7087	1.26E+03	1.80E+04	-2.31E+02	6.34E+03
		Mean	2s	Mean	2s
		-3.63E+02	7.38E+03	1.13E+03	5.58E+03

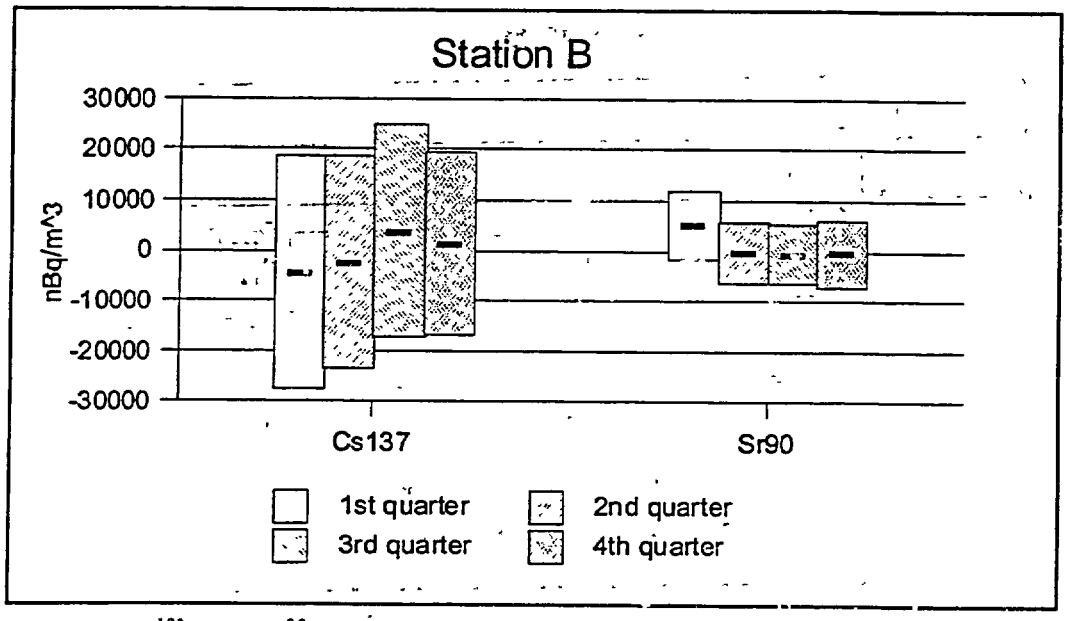

Figure A4. ^{137}Cs and ^{90}Sr Measurements in Station B Samples During 2001

Table A5. ^{241}Am Measurements in LVAS Samples During 2001

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2001	27852	-2.09E+00	3.14E+01
CARLSBAD	1ST 2001	31096	8.67E+00	2.88E+01
LOVING	1ST 2001	29721	1.84E+02	5.65E+01
WIPP 1	1ST 2001	31388	-9.80E+00	2.79E+01
WIPP 2	1ST 2001	29575	-2.67E+00	2.92E+01
WIPP 3	1ST 2001	30102	1.22E+01	2.57E+01
ARTESIA	2ND 2001	25813	-6.33E+00	3.27E+01
CARLSBAD	2ND 2001	27772	7.51E+00	3.16E+01
LOVING	2ND 2001	28237	-3.55E+00	2.65E+01
WIPP 1	2ND 2001	29188	9.32E-01	2.57E+01
WIPP 2	2ND 2001	26736	-3.40E+00	3.09E+01
WIPP 3	2ND 2001	27163	1.68E+02	4.78E+01
WIPP 3 QA	2ND 2001	25102	8.62E+00	3.41E+01
ARTESIA	3RD 2001	25365	8.65E+00	3.46E+01
CARLSBAD	3RD 2001	29101	1.59E+01	3.16E+01
LOVING	3RD 2001	28917	1.81E+01	3.19E+01
WIPP 1	3RD 2001	11796	NA	NA
WIPP 2	3RD 2001	26311	5.04E+00	3.24E+01
WIPP 3	3RD 2001	26458	1.02E+01	3.29E+01
ARTESIA	4TH 2001	27853	-2.18E+01	4.73E+01
CARLSBAD	4TH 2001	33984	5.07E+01	3.37E+01
LOVING	4TH 2001	34715	-7.99E+00	2.56E+01
WIPP 1	4TH 2001	33581	9.34E+00	2.72E+01
WIPP 2	4TH 2001	29626	2.11E+00	3.00E+01
WIPP 3	4TH 2001	30066	-2.85E+00	2.96E+01
			Mean	2s
			1.87E+01	1.00E+02

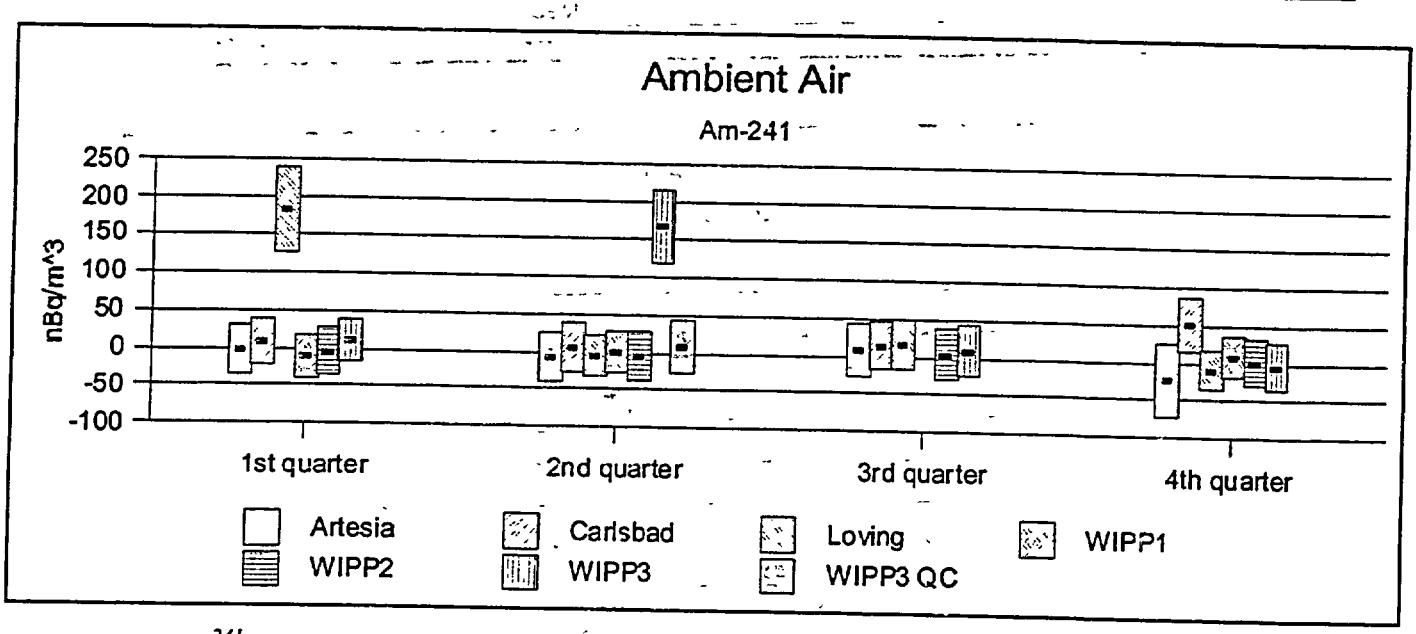

Figure A5. ^{241}Am Measurements in LVAS Samples During 2001

Table A6. $^{239/240}Pu$ Measurements in LVAS Samples During 2001

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2001	27852	2.63E+01	2.10E+01
CARLSBAD	1ST 2001	31096	6.19E+00	1.40E+01
LOVING	1ST 2001	29721	-1.53E+00	1.42E+01
WIPP 1	1ST 2001	31388	1.95E+01	2.88E+01
WIPP 2	1ST 2001	29575	7.59E+00	1.81E+01
WIPP 3	1ST 2001	30102	-1.45E+00	1.67E+01
ARTESIA	2ND 2001	25813	1.95E+01	2.02E+01
CARLSBAD	2ND 2001	27772	4.02E+01	2.17E+01
LOVING	2ND 2001	28237	2.61E+01	2.10E+01
WIPP 1	2ND 2001	29188	1.58E+01	1.82E+01
WIPP 2	2ND 2001	26736	2.35E+01	1.98E+01
WIPP 3	2ND 2001	27163	4.37E+01	2.65E+01
WIPP 3 QA	2ND 2001	25102	4.01E+01	2.50E+01
ARTESIA	3RD 2001	25365	5.19E+00	1.72E+01
CARLSBAD	3RD 2001	29101	1.18E+01	1.58E+01
LOVING	3RD 2001	28917	7.70E+00	1.67E+01
WIPP 1	3RD 2001	11796	NA	NA
WIPP 2	3RD 2001	26311	1.53E+01	1.97E+01
WIPP 3	3RD 2001	26458	1.99E+01	1.87E+01
ARTESIA	4TH 2001	27853	-7.84E+00	2.25E+01
CARLSBAD	4TH 2001	33984	3.26E+01	1.85E+01
LOVING	4TH 2001	34715	9.67E+00	1.38E+01
WIPP 1	4TH 2001	33581	6.99E+00	1.46E+01
WIPP 2	4TH 2001	29626	1.18E+01	1.99E+01
WIPP 3	4TH 2001	30066	1.44E+01	1.94E+01
			Mean	2s
			1.64E+01	2.70E+01

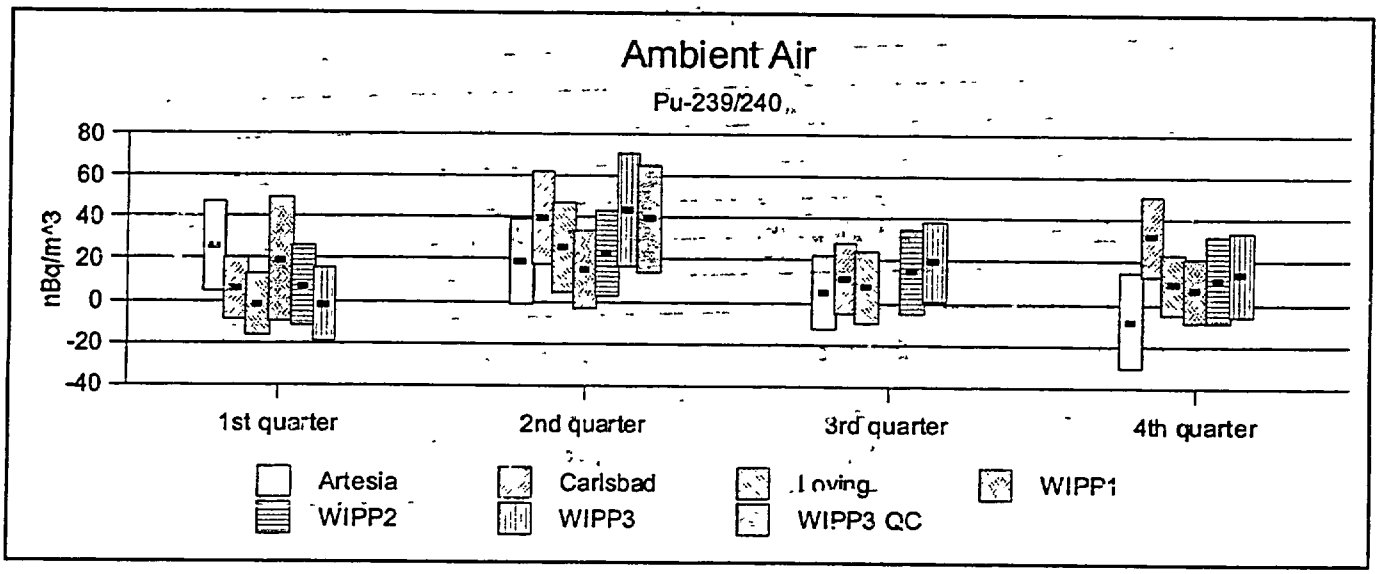

Figure A6. $^{239/240}Pu$ Measurements in LVAS Samples During 2001

Table A7. ^{238}Pu Measurements in LVAS Samples During 2001

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2001	27852	9.33E+00	1.90E+01
CARLSBAD	1ST 2001	31096	1.23E+01	1.75E+01
LOVING	1ST 2001	29721	7.84E+00	2.01E+01
WIPP 1	1ST 2001	31388	-2.04E+01	2.59E+01
WIPP 2	1ST 2001	29575	1.03E+01	2.00E+01
WIPP 3	1ST 2001	30102	2.38E+01	3.05E+01
ARTESIA	2ND 2001	25813	3.42E+01	2.44E+01
CARLSBAD	2ND 2001	27772	4.31E+01	2.35E+01
LOVING	2ND 2001	28237	7.82E+00	1.97E+01
WIPP 1	2ND 2001	29188	-1.92E-02	1.80E+01
WIPP 2	2ND 2001	26736	1.28E+01	1.96E+01
WIPP 3	2ND 2001	27163	3.56E+01	2.76E+01
WIPP 3 QA	2ND 2001	25102	4.60E+01	2.84E+01
ARTESIA	3RD 2001	25365	9.83E-01	1.84E+01
CARLSBAD	3RD 2001	29101	8.86E+00	1.76E+01
LOVING	3RD 2001	28917	-3.95E+00	1.78E+01
WIPP 1	3RD 2001	11796	NA	NA
WIPP 2	3RD 2001	26311	-2.69E+00	1.74E+01
WIPP 3	3RD 2001	26458	3.06E+00	1.81E+01
ARTESIA	4TH 2001	27853	3.40E+01	4.79E+01
CARLSBAD	4TH 2001	33984	9.80E+00	1.57E+01
LOVING	4TH 2001	34715	3.11E+00	1.44E+01
WIPP 1	4TH 2001	33581	1.61E+00	1.65E+01
WIPP 2	4TH 2001	29626	8.52E-01	2.26E+01
WIPP 3	4TH 2001	30066	-2.53E+00	1.60E+01
			Mean	2s
			1.15E+01	3.29E+01

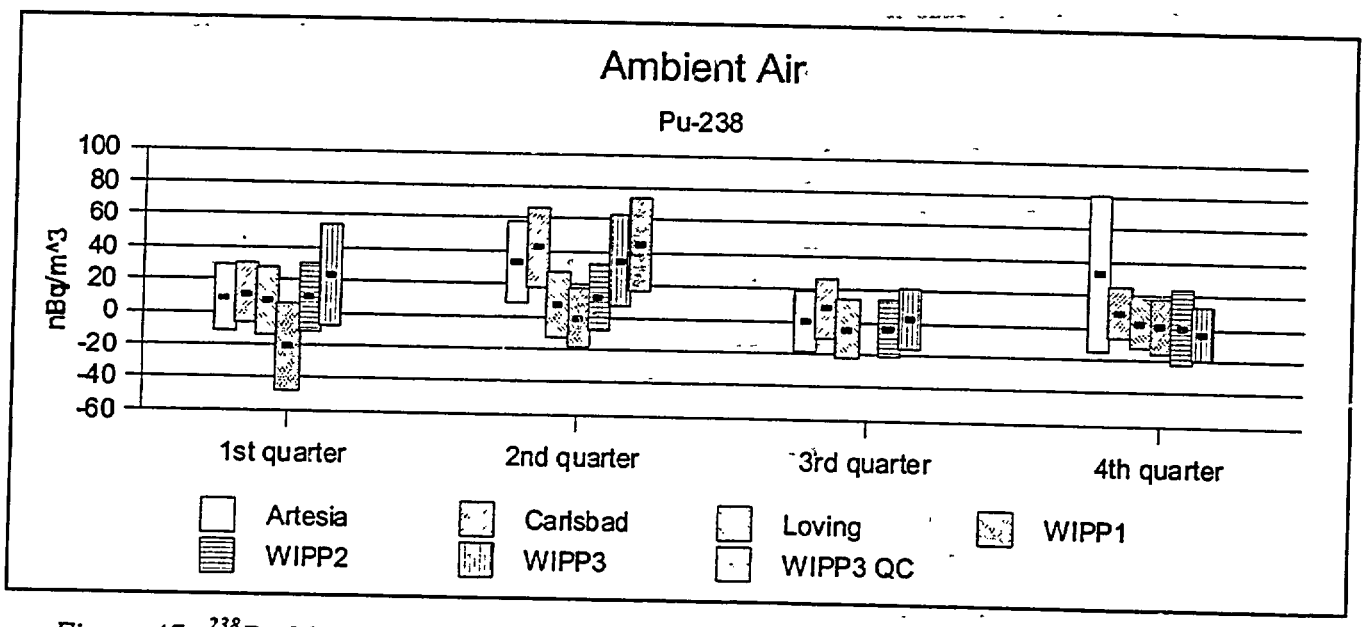

Figure A7. ^{238}Pu Measurements in LVAS Samples During 2001

Table A8. ^{137}Cs Measurements in LVAS Samples During 2001

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME. (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2001	27852	1.67E+03	4.91E+03
CARLSBAD	1ST 2001	31096	6.58E+02	4.30E+03
LOVING	1ST 2001	29721	-1.46E+03	4.64E+03
WIPP 1	1ST 2001	31388	NA	NA
WIPP 2	1ST 2001	29575	NA	NA
WIPP 3	1ST 2001	30102	1.37E+03	4.65E+03
ARTESIA	2ND 2001	25813	NA	NA
CARLSBAD	2ND 2001	27772	NA	NA
LOVING	2ND 2001	28237	NA	NA
WIPP 1	2ND 2001	29188	NA	NA
WIPP 2	2ND 2001	26736	NA	NA
WIPP 3	2ND 2001	27163	NA	NA
ARTESIA	3RD 2001	25365	3.39E+02	4.57E+03
CARLSBAD	3RD 2001	29101	2.06E+03	3.87E+03
LOVING	3RD 2001	28917	1.22E+03	3.99E+03
WIPP 1	3RD 2001	11796	NA	NA
WIPP 2	3RD 2001	26311	1.06E+02	4.48E+03
WIPP 3	3RD 2001	26458	1.56E+03	4.47E+03
ARTESIA	4TH 2001	27853	3.99E+02	3.63E+03
CARLSBAD	4TH 2001	33984	1.90E+03	2.88E+03
LOVING	4TH 2001	34715	1.03E+03	2.90E+03
WIPP 1	4TH 2001	33581	8.77E+02	2.78E+03
WIPP 2	4TH 2001	29626	-2.91E+02	3.43E+03
WIPP 3	4TH 2001	30066	1.72E+03	3.29E+03
			Mean	2s
			8.78E+02	1.90E+03

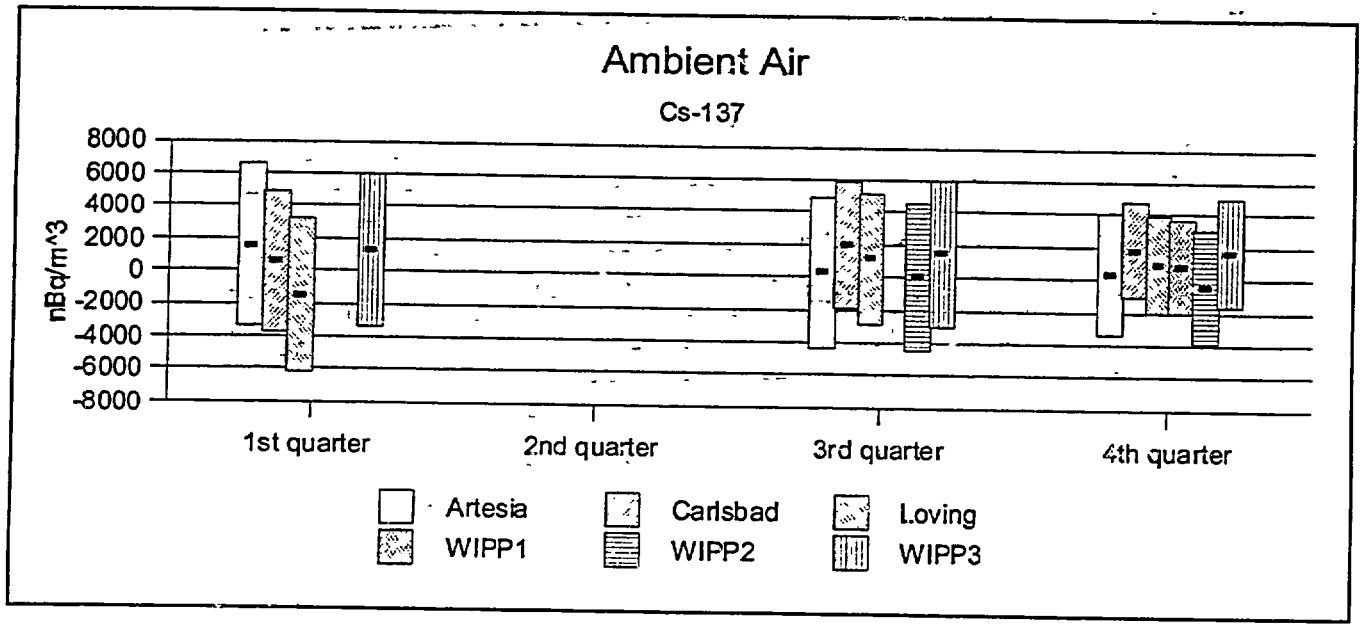

Figure A8. ^{137}Cs Measurements in LVAS Samples During 2001

Table A9. ^{90}Sr Measurements in LVAS Samples During 2001

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2001	27852	8.55E+02	1.38E+03
CARLSBAD	1ST 2001	31096	7.07E+02	1.25E+03
LOVING	1ST 2001	29721	1.03E+03	1.30E+03
WIPP 1	1ST 2001	31388	1.27E+03	1.23E+03
WIPP 2	1ST 2001	29575	6.79E+02	1.30E+03
WIPP 3	1ST 2001	30102	9.62E+02	1.28E+03
ARTESIA	2ND 2001	25813	-4.35E+02	1.81E+03
CARLSBAD	2ND 2001	27772	9.69E+02	1.43E+03
LOVING	2ND 2001	28237	7.22E+02	1.55E+03
WIPP 1	2ND 2001	29188	6.19E+02	1.43E+03
WIPP 2	2ND 2001	26736	1.58E+03	1.49E+03
WIPP 3	2ND 2001	27163	8.82E+02	1.51E+03
ARTESIA	3RD 2001	25365	1.29E+03	1.72E+03
CARLSBAD	3RD 2001	29101	1.25E+03	1.37E+03
LOVING	3RD 2001	28917	1.92E+03	1.35E+03
WIPP 1	3RD 2001	11796	NA	NA
WIPP 2	3RD 2001	26311	6.91E+02	1.55E+03
WIPP 3	3RD 2001	26458	9.67E+02	1.52E+03
ARTESIA	4TH 2001	27853	NA	NA
CARLSBAD	4TH 2001	33984	2.19E+03	1.35E+03
LOVING	4TH 2001	34715	1.88E+03	1.32E+03
WIPP 1	4TH 2001	33581	1.22E+03	1.33E+03
WIPP 2	4TH 2001	29626	1.40E+03	1.49E+03
WIPP 3	4TH 2001	30066	1.88E+03	1.53E+03
			Mean	2s
			1.12E+03	1.14E+03

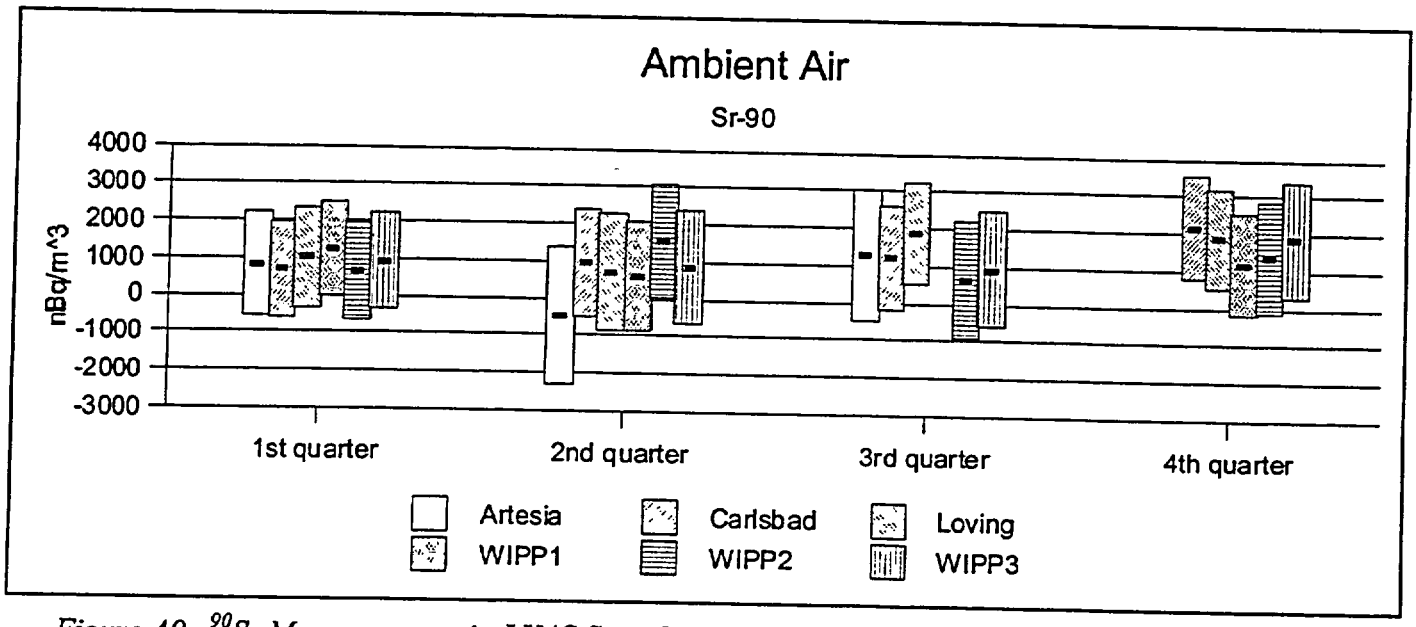

Figure A9. ^{90}Sr Measurements in LVAS Samples During 2001

APPENDIX B. WATER SAMPLE DATA

Table B1. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Groundwater During 2001

WATER WELL IDENTIFICATION	^{241}Am CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	$^{239/240}Pu$ CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{238}Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
WQSP-1	-0.32	0.85	-0.21	0.56	1.53	0.95
WQSP-2	-0.19	0.49	0.17	0.68	-0.27	0.50
WQSP-3	NA	NA	0.36	0.80	0.12	0.44
WQSP-4	-0.74	0.79	-0.18	0.53	0.30	0.48
WQSP-5	0.84	0.69	-0.18	0.50	0.26	0.35
WQSP-6	NA	NA	-0.05	0.53	0.26	0.46
WQSP-6A	0.26	0.55	-0.14	0.55	-0.03	0.50
	Mean	2s	Mean	2s	Mean	2s
	-0.03	1.21	-0.03	0.43	0.31	1.15

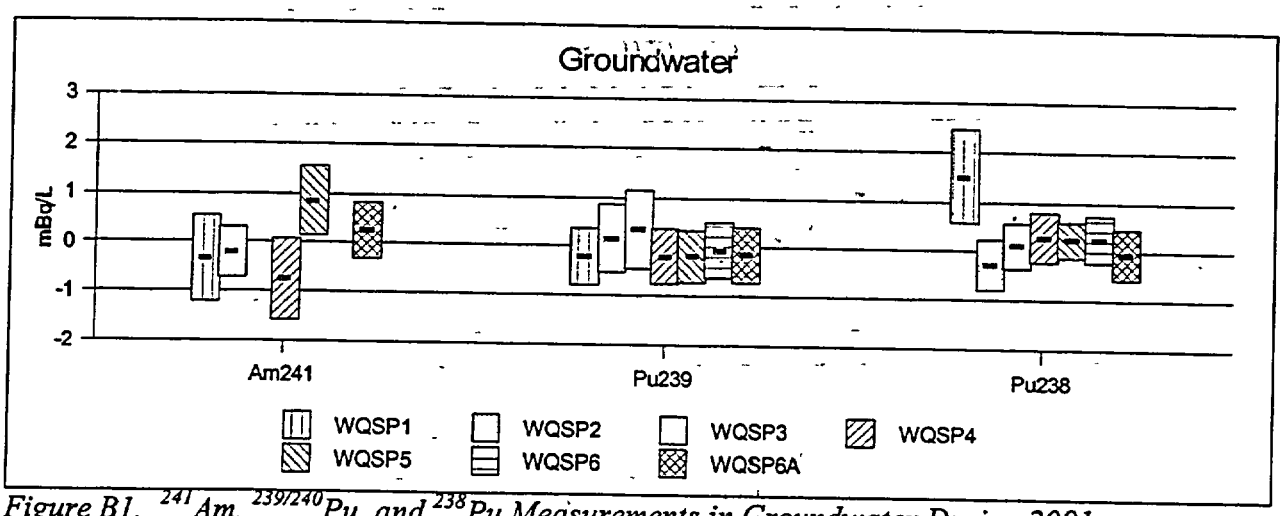

Figure B1. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Groundwater During 2001

Table B2. ^{137}Cs and ^{90}Sr Measurements in Groundwater During 2001

WATER WELL IDENTIFICATION	^{137}Cs CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{90}Sr CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
WQSP-1	10.58	142.24	NA	NA
WQSP-2	NA	NA	NA	NA
WQSP-3	-17.64	143.64	32.85	37.44
WQSP-4	37.04	144.41	41.92	64.38
WQSP-5	46.21	138.50	15.85	47.27
WQSP-6	-1.76	137.67	9.58	32.95
WQSP-6A	-19.05	133.62	NA	NA
	Mean	2s	Mean	2s
	9.23	55.03	25.05	29.87

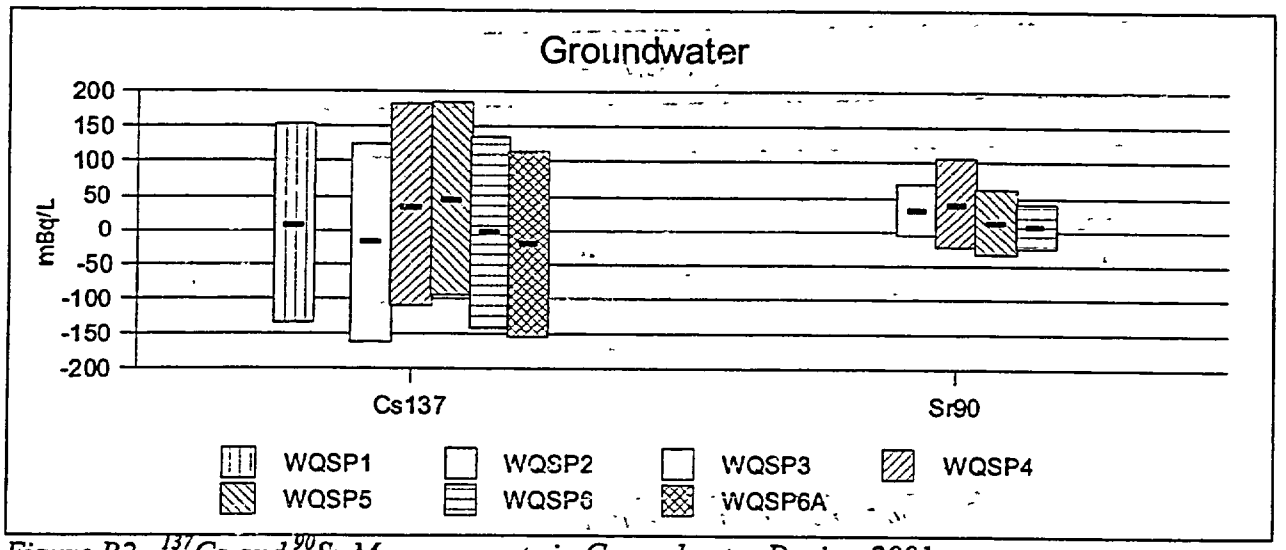

Figure B2. ^{137}Cs and ^{90}Sr Measurements in Groundwater During 2001

Table B3. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Surface Water During 2001

SAMPLE SITE	^{241}Am CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	$^{239/240}Pu$ CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) mBq/l)	^{238}Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
Pecos @ Carlsbad	-0.26	0.49	-0.05	0.53	-0.14	0.34
Pecos @ Pierce	-0.38	0.50	0.16	0.60	0.22	0.43
WIPP Stormwater	-0.20	0.49	-0.24	0.49	0.39	0.41
	Mean	2s	Mean	2s	Mean	2s
	-0.28	0.18	-0.04	0.40	0.16	0.55

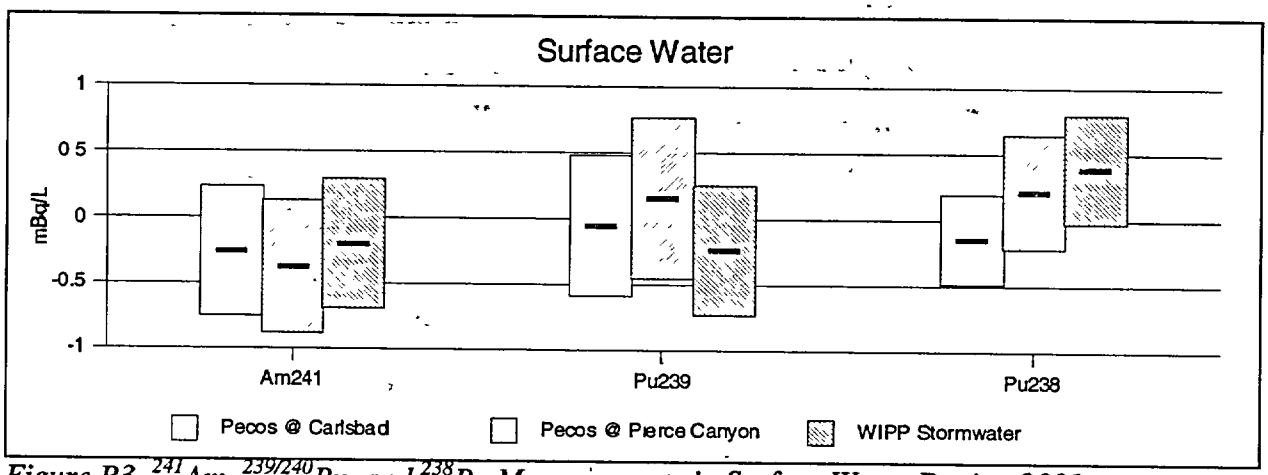

Figure B3. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Surface Water During 2001

Table B4. ^{137}Cs and ^{90}Sr Measurements in Surface Water During 2001

SAMPLE SITE	^{137}Cs CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{90}Sr CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
Pecos @ Carlsbad	9.88	117.90	17.86	22.12
Pecos @ Pierce	-8.11	120.65	11.24	23.62
WIPP Stormwater	NA	NA	NA	NA
	Mean	2s	Mean	2s
	0.88	25.44	14.55	9.36

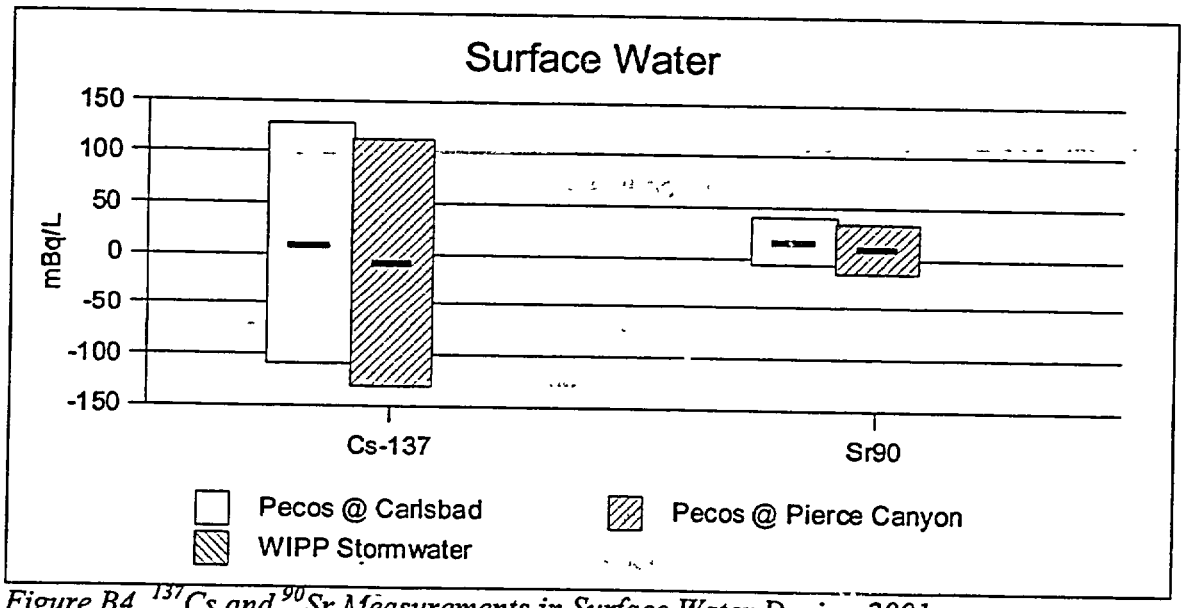

Figure B4. ^{137}Cs and ^{90}Sr Measurements in Surface Water During 2001

Table B5. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Drinking Water During 2001

PUBLIC WATER SUPPLY SYSTEM	^{241}Am CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	$^{239/240}Pu$ CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{238}Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
Carlsbad	0.37	0.57	0.07	0.66	0.65	0.62
Loving	0.09	0.52	-0.17	0.50	0.37	0.48
Otis	0.91	0.70	0.01	0.56	0.34	0.45
WIPP	-0.16	0.72	-0.09	0.50	0.10	0.28
	Mean	2s	Mean	2s	Mean	2s
	0.30	0.93	-0.05	0.21	0.37	0.45

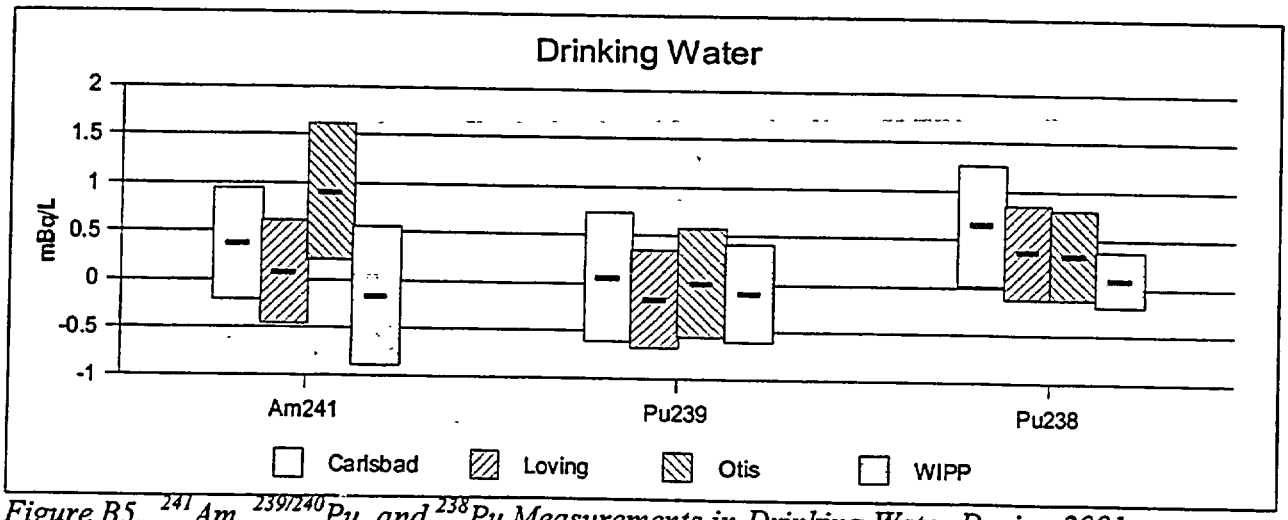

Figure B5. ^{241}Am, $^{239/240}Pu$, and ^{238}Pu Measurements in Drinking Water During 2001

Table B6. ^{137}Cs and ^{90}Sr Measurements in Drinking Water During 2001

PUBLIC WATER SUPPLY SYSTEM	CS-137 CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) mBq/l)	SR-90 CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
Carlsbad	29.98	135.66	NA	NA
Loving	NA	NA	-3.85	15.35
Otis	NA	NA	-6.95	16.10
WIPP	-11.29	120.45	16.18	21.93
	Mean	2s	Mean	2s
	9.35	58.36	1.79	25.11

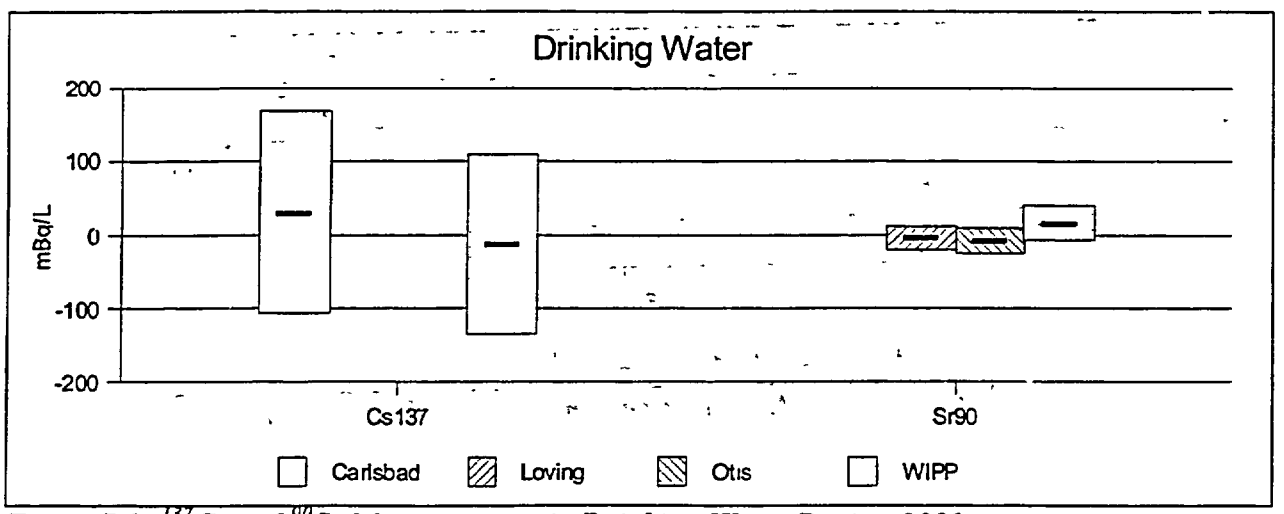

Figure B6. ^{137}Cs and ^{90}Sr Measurements in Drinking Water During 2001

APPENDIX C. MATRIX BLANK DATA

Table C1. Matrix Blank Results for the 2001 Sampling Period

Matrix Blank ID	^{241}Am	$^{239/240}Pu$	^{238}Pu	^{137}Cs	^{90}Sr
FAS (Effluent)	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite
FMB-010503	-1.53E-04	2.50E-04	1.22E-04	3.92E-02	3.81E-03
FMB-010731	8.59E-04	4.55E-04	3.85E-04	-2.22E-02	-1.70E-02
FMB-020204	4.13E-04	3.16E-05	-1.35E-05	9.17E-03	-1.37E-02
FMB-020523	2.84E-04	2.27E-04	-9.97E-05	3.88E-02	-4.76E-02
Unassigned	NA	NA	NA	-1.28E-02	NA
Unassigned	NA	NA	NA	4.94E-02	NA
Mean	3.51E-04	2.41E-04	9.85E-05	1.69E-02	-1.86E-02
2s	7.21E-04	3.00E-04	3.67E-04	5.48E-02	3.70E-02
LVAS (Ambient)	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite
LMB-010913	3.39E-04	2.48E-04	-7.94E-05	-2.78E-04	-1.15E-02
LMB-011210	4.06E-05	-5.16E-05	-5.73E-05	5.88E-03	7.25E-03
LMB-020222	-2.85E-04	1.96E-04	1.44E-04	2.56E-02	-4.85E-03
LMB-020606	2.30E-04	5.77E-05	1.57E-04	8.33E-03	-4.23E-02
LMB-020613	-9.71E-05	2.17E-04	1.06E-04	9.03E-02	-3.75E-02
Mean	4.55E-05	1.33E-04	5.41E-05	2.60E-02	-1.78E-02
2s	7.48E-04	3.46E-04	4.26E-04	6.66E-02	3.82E-02
Water	Bq/L	Bq/L	Bq/L	Bq/L	Bq/L
WMB-010529	NA	7.10E-04	-2.33E-04	4.30E-02	-2.55E-02
WMB-010910	2.53E-04	1.41E-04	-2.01E-04	NA	NA
WMB-010628	6.21E-04	2.25E-04	1.07E-04	7.05E-04	-1.85E-02
WMB-020107	8.49E-05	1.07E-04	-9.73E-05	3.39E-02	-1.17E-02
WMB-011105	NA	1.07E-04	-2.55E-04	NA	-1.61E-02
WMB-011004	-1.71E-05	1.34E-05	-2.67E-04	NA	NA
Mean	2.35E-04	2.17E-04	-1.58E-04	2.59E-02	-1.80E-02
2s	4.85E-04	4.58E-04	2.62E-04	3.64E-02	9.99E-03

APPENDIX D. EEG TLD PROGRAM DESCRIPTION AND 2001 DATA

TLD PROGRAM DESCRIPTION

The regulatory limit for external radiation to a member of the public outside the exclusive use boundary is 25 mrem per year (40 CFR 191, Subpart A). The EEG's thermoluminescent dosimeter (TLD) measurement program is to verify compliance with this limit.

The EEG has placed environmental TLDs at locations within and at the exclusive use boundary since October 1997. Each TLD contains five lithium flucride chips. Currently, five TLDs are located at five different locations at the exclusive use area boundary (as defined by EPA) and three TLDs are located within the exclusive use area along the railroad fence south of the Waste Handling Building (WHB) and the parking area where loaded TRUPACT-IIs are kept until they are moved into the WHB. One "control" TLD is kept at a protected location at the EEG office in Carlsbad. All nine TLDs are collected quarterly and returned to a commercial vendor for processing. The current locations of the TLD badges are shown in Figure D1.

Doses reported by the vendor include background radiation from terrestrial, radon, and cosmic sources. Any increased dose due to WIPP operations would also be included in the total dose reported. The net dose due to WIPP operations could then be determined by subtractions of an "appropriate" background value and with consideration of measurement uncertainty.

Possible Sources of Direct Radiation

The most likely source of direct radiation from WIPP operations is due to direct radiation from TRUPACT-II waste shipments as they approach the protected area, are checked at the entrance gate, and are detained on their transport trailers in the restricted parking area immediately south of the WHB. TRUPACT-IIs are often detained in the parking lot for 24-36 hours before being taken into the WHB. Doses from this source would be expected to vary from quarter to quarter depending on external doses from TRUPACT-IIs and cumulative residence times in the parking lot. Other sources of direct radiation from WIPP operations at exclusive use boundaries are much less likely. These include external doses from contamination or from releases from the exhaust shaft.

TLD #4 is located at the closest point on the exclusive use boundary from the restricted parking lot (about 230 meters). However, the three TLDs (#1, #2 and #5) located along the railroad fence are only 60-80 meters from the parking lot and should be the most likely TLDs to indicate the presence of radiation from WIPP operations.

Statistical Treatment of TLD Data

The four quarterly doses reported for a calendar year for the control TLDs are averaged and their standard deviation determined from the values of each of the five chips in a TLD badge (a total of 20 chips for the year). The standard deviation is determined from the expression (Rodgers 1998):

$$\sigma = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

where x_i is the value of each chip

$\bar{x}$ is the mean of all chips

n is the number of chips

EEG has also determined the mean and standard deviation for the group of TLD badges placed about the WIPP Site each year (exclusive of the control TLD). This has been done because of the belief that before the arrival of wastes that values determined from the set of TLDs about the site would be a more appropriate preoperational background.

The lower limit of detection (LLD) of any dose received from WIPP operations is determined assuming a normal distribution by the following expression (Rodgers 1998):

$$LLD = 3.29\,\sigma\sqrt{1 + 1/n}$$

2001 TLD DATA

The reported value and uncertainty for each control and environmentally deployed TLD in calendar year 2001 is shown in Table D1. The doses are gross values (i.e., the value of the control TLDs have not been subtracted and include the doses from terrestrial, radon, and cosmic source along with any possible does from WIPP operations).

Table D1. Quarterly Gross TLD Doses in 2001 (Millirem per Quarter)

TLD Badge Location(a)	1st Quarter Dose	1st Quarter Uncert. (2σ)	2nd Quarter Dose	2nd Quarter Uncert. (2σ)	3rd Quarter Dose	3rd Quarter Uncert. (2σ)	4th Quarter Dose	4th Quarter Uncert. (2σ)
1	23.6	1.0	19.8	3.0	19.2	5.6	16.6	3.3
2	24.2	4.4	19.6	1.8	18.0	1.4	16.6	2.2
3	24.2	2.6	19.4	3.2	19.4	3.2	16.2	2.6
4	24.25	2.0	19.6	2.2	19.2	3.6	16.6	3.9
5	27.0	8.2	19.0	2.0	20.4	5.0	17.6	5.0
6	24.0	3.2	23.0	4.9	18.6	4.4	17.4	3.8
7	24.6	2.2	22.0	4.6	18.4	4.2	17.0	4.0
8	24.2	2.2	21.0	3.5	19.6	6.3	18.4	2.2
Control	**22.6**	**1.8**	**19.6**	**1.1**	**19.4**	**5.2**	**16.6**	**6.1**

(a) See Figure D1 for badge location

Lower Limit of Detection (LLD)

The average of the four control badges was 19.55 mrem/quarter and the standard deviation (1σ) was 2.89 mrem/quarter. Thus, the LLD is 9.75 mrem/quarter (rounded to 9.8 mrem/quarter). The average and standard deviation of the 8 TLDs at the WIPP Site was 20.27 ± 2.24 mrem/quarter.

None of the TLDs in 2001 approached the LLD (which would have been a gross value of 29.3 mrem/quarter).

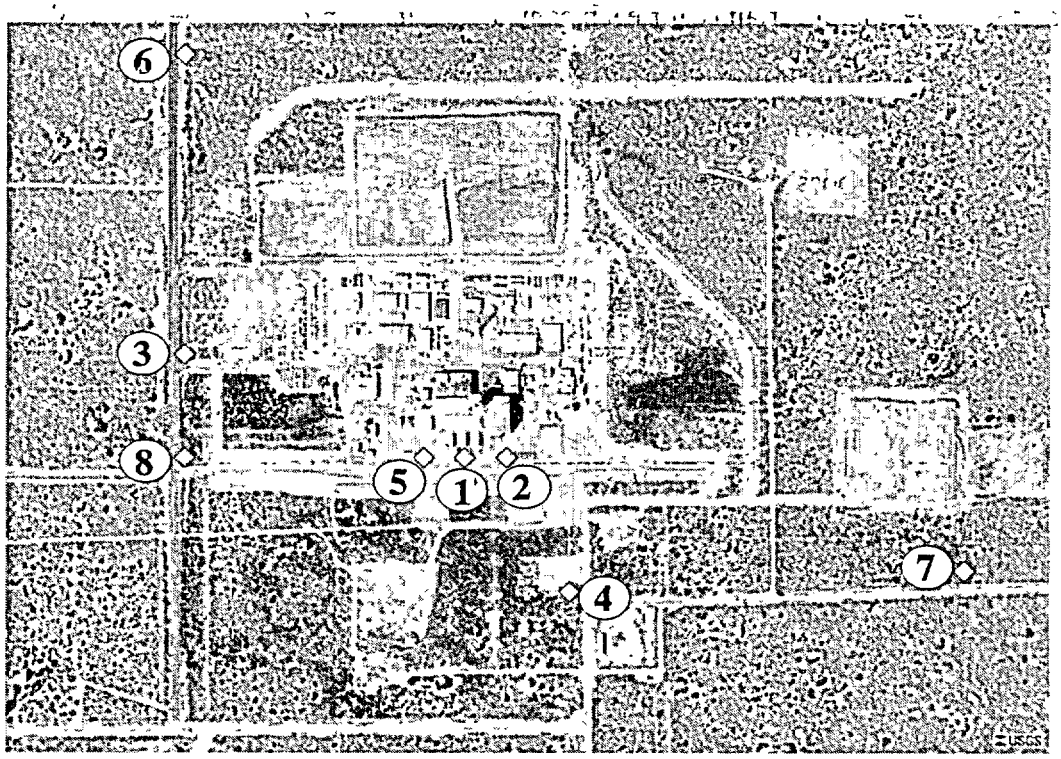

Figure D1. TLD Locations and Numbers

APPENDIX E. SAMPLE COLLECTION LOCATIONS

SAMPLE COLLECTION LOCATIONS

Detailed descriptions of the sampling locations are found in the preoperational reports, but are summarized in this Appendix.

Fixed Air Samplers (Effluent)

Three fixed air samplers are currently operating in the WIPP air effluent stream. These are Station A, located at the top of the air exhaust shaft and sampling the unfiltered exhaust, and Station B, located downstream of the HEPA filtration building, through which underground exhaust air can be diverted, if necessary. The third location is called Station D and is located underground, near the base of the exhaust shaft.

Low-Volume Air Samplers (Ambient)

Three low-volume air samplers are located on or close to the site, as listed below:

1. Approximately 225 meters northwest of the exhaust shaft (S1).
2. Approximately 500 meters northeast of the exhaust shaft (S2).
3. Approximately 1000 meters northwest of the exhaust shaft (S3).

Three additional low-volume air samplers are located in Artesia, Carlsbad, and Loving - the three population centers closest to the WIPP site and located on the main WIPP transportation routes.

Groundwater

Seven wells collect groundwater samples from the water-bearing zones of the Dewey Lake Redbed Formation, the Culebra dolomite member of the Rustler Formation, and the Capitan Reef Formation. Their approximate locations appear in Figure E1.

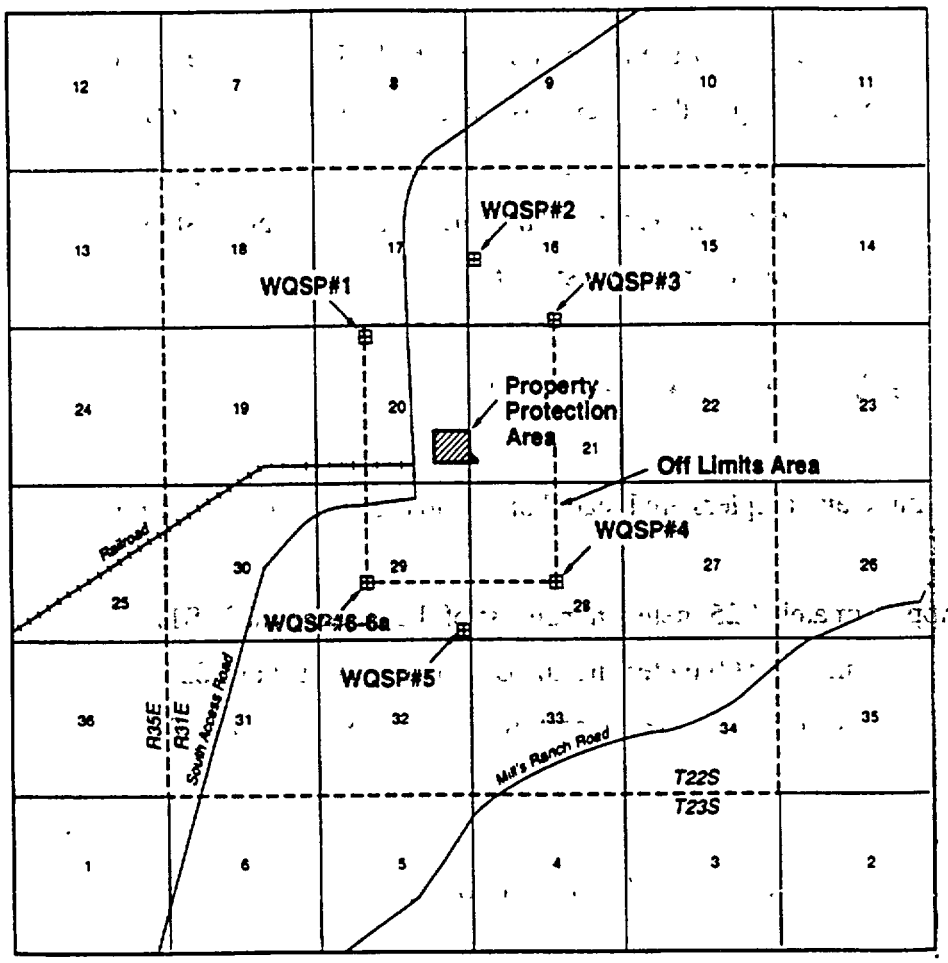

Figure E1. Groundwater Sampling Locations

Surface Water and Drinking Water

Surface water samples were collected at eight locations, shown in Figure E2. Surface water samples were collected only from the Pecos River at Carlsbad, the Pecos River at Pierce Canyon and WIPP stormwater runoff in 2001. Drinking water samples were collected from the public water supply systems at the WIPP site and the communities of Carlsbad, Loving, and Otis. Otis does not appear in the figure. Otis is a small community on the south edge of Carlsbad.

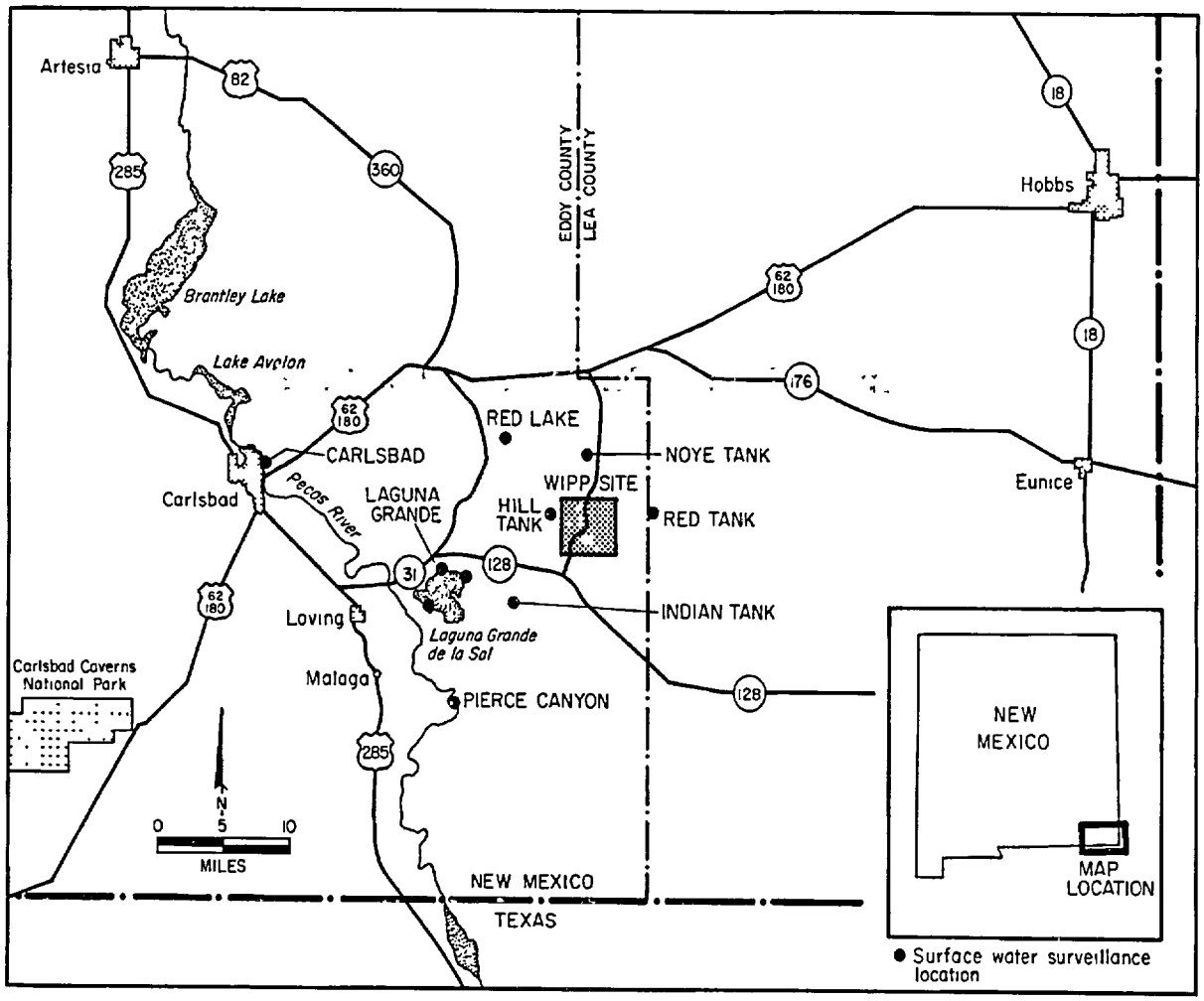

Figure E2. Surface Water Sampling Locations

Appendix F: MDA, MDC, Action Level

MDA, MDC, Action Level

Table F1, below, lists the current Minimum Detectable Concentrations (MDC), Minimum Detectable Activities (MDA), and Action Levels (ACTL) for the radionuclides of interest in the environmental matrices of the EEG radiation surveillance program.

Table F1. Current Minimum Detectable Concentrations, Minimum Detectable Activities, and Action Levels

Radionuclide	No. of Blanks	MDC Value	MDC Unit	MDA (mBq/sample)	Action Level* (mBq/sample)
Fixed Air Samples (Stations A and B)					
^{241}Am	22	280	nBq m^{-3}	2.0	1.5
$^{239,240}Pu$	24	190	nBq m^{-3}	1.4	1.6
^{238}Pu	25	210	nBq m^{-3}	1.5	0.8
^{137}Cs	25	22	µBq m^{-3}	160	62
^{90}Sr	11	13	µBq m^{-3}	94	48
Low Volume Air Samples					
^{241}Am	28	92	nBq m^{-3}	2.3	3.4
$^{239,240}Pu$	27	40	nBq m^{-3}	1.0	2.0
^{238}Pu	29	100	nBq m^{-3}	2.6	1.7
^{137}Cs	29	6.0	µBq m^{-3}	150	64
^{90}Sr	19	3.2	µBq m^{-3}	80	89
Water Samples					
^{241}Am	34	2.6	mBq L^{-1}	2.6	2.0
$^{239,240}Pu$	39	1.6	mBq L^{-1}	1.6	1.0
^{238}Pu	38	1.8	mBq L^{-1}	1.8	1.2
^{137}Cs	32	240	mBq L^{-1}	240	100
^{90}Sr	16	61	mBq L^{-1}	61	42

* Estimated for 7,200 m^3 sample (FAS) or 25,000 m^3 sample (LVAS)

The data in Table F-1 indicates that, in many cases, the action level is lower than the MDA. This happens because the populations of results from both the preoperational baseline and the blanks have very similar statistics; that is, the differences between them are generally small. In the definitions, which the EEG has adopted, a coverage factor of 4.65 is applied to the population standard deviation for the MDA, while the coverage factor for the action level is only 2.

This approach is widely used for normally-distributed data. In many cases the EEG's results are not normally distributed. An effort is underway to apply nonparametric methods to the environmental and blank data. The results of this effort will be published in a future report.

The values in Table F1 were derived using the following formulas:

MDA: 4.65 s_b where s_b is the standard deviation of the mean of the appropriate blank population for all blanks.

MDC: (MDA * F)/V where F is a factor to convert mBq to nBq (10^6) or to µBq (10^3), as appropriate, and V is the volume specified in the footnote to the table.

ACTL: $m_{base} + 2\ s_{base}$ where m_{base} is the mean of the appropriate preoperational baseline measurements and s_{base} is the standard deviation of the mean.

LIST OF EEG REPORTS

LIST OF EEG REPORTS

EEG-1 Goad, Donna, A Compilation of Site Selection Criteria Considerations and Concerns Appearing in the Literature on the Deep Disposal of Radioactive Wastes, June 1979.

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