EEG-90

EEG OPERATIONAL RADIATION SURVEILLANCE OF THE WIPP PROJECT DURING 2002

Donald H. Gray
Sally C. Ballard

Environmental Evaluation Group
New Mexico

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Donald H. Gray
Sally C. Ballard

Environmental Evaluation Group
7007 Wyoming Boulevard NE, Suite F-2
Albuquerque, New Mexico 87109

and

505 North Main Street
Carlsbad, New Mexico 88220

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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
Director

EEG STAFF

Lawrence E. Allen, M.S., Geologic Engineer

George Anastas, CHP, PE, DEE, Health Physicist/Nuclear Engineer

Sally C. Ballard, B.S., Radiochemical Analyst

Radene Bradley, Secretary III

James K. Channell, Ph.D., CHP, Deputy Director

Patricia D. Fairchild, Secretary III

Donald H. Gray, M.A., Laboratory Manager

John Haschets, Assistant Environmental Technician

Linda P. Kennedy, M.L.S., Librarian

Lanny W. King, Environmental Technician

Thomas M. Klein, M.S., Environmental Scientist

Jill Shortencarier, Executive Assistant

Matthew K. Silva, Ph.D., Director

Susan Stokum, Administrative Secretary

Ben A. Walker, B.A., Quality Assurance Specialist

Scott B. Webb, Ph.D., Health Physicist

Judith F. Youngman, B.A., Administrative Officer

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ACRONYMS AND SYMBOLS

ACTL	Action Level
ANOVA	Analysis of variance
CEMRC	Carlsbad Environmental Monitoring and Research Center
CFR	Code of Federal Regulations
DOE	US Department of Energy
DQO	Data quality objective
EEG	Environmental Evaluation Group
EPA	US Environmental Protection Agency
FAS	Fixed Air Sampler
LLD	Lower limit of detection
LVAS	Low volume air sampler
MDA	Minimum detectable activity
MDC	Minimum detectable concentration
MOU	Memorandum of Understanding
NESHAPS	National Emission Standards for Hazardous Air Pollutants
TLD	Thermoluminescent dosimeter
TRU	Transuranic
TSP	Total Suspended Particulate
WHB	Waste Handling Building
WIPP	Waste Isolation Pilot Plant
WTS	Washington TRU Solutions

Radionuclides:

Am	Americium
Be	Beryllium
Cs	Cesium
Pb	Lead
Pu	Plutonium
Sr	Strontium

Used in Figures and Tables:

mBq/L	milli-Becquerels (10^{-3} Bq) per liter
nBq/m^3	nano-Becquerels (10^{-9} Bq) per cubic meter
pCi	picoCurie (10^{-12} Ci)
k	coverage factor (multiple of standard deviation)
M	mean
Mrem/quarter	millirem per quarter
n	number of samples
NA	not available
s	small sample standard deviation
σ	large sample standard deviation

EXECUTIVE SUMMARY

The Environmental Evaluation Group (EEG) has measured the levels of ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{241}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 2002. 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, by an agreement between the DOE and the EPA, at 40 CFR 61, Subpart H.

Based on these analyses and applying appropriate parametric and non-parametric statistical tests for significant differences the EEG concludes that:

1. WIPP operations during 2002 did not result in measurable releases of radioactive materials to the environment or radiation doses to the public.

2. Four of the means of measurements of radionuclides in the environment around WIPP during 2002 were different from the preoperational baseline level, but none of the individual measurements contributing to those means exceeded the minimum detectable activity (MDA).

3. Two measurements of ^{90}Sr in drinking water exceeded both the MDA and the action level (ACTL); but because of lower-than-normal chemical recoveries, both are probably overestimates. The highest result was only about ⅓ of the National Primary Drinking Water Standard for ^{90}Sr of 8 picoCuries (pCi) per liter. Neither could have resulted from WIPP operations.

4. Comparison of the EEG's 2002 results with those of other monitoring organizations revealed four sets of measurements which did not agree, but none of the results exceeded their respective MDAs.

These conclusions are based on the assumption that the samples collected under EEG's radiation surveillance program are truly representative of the air (effluent or ambient) or water sampled. The EEG has questioned the sampling process for the underground effluent air monitoring in the past. Recent results of a study by the EEG (Gray 2003) involving measurements of the naturally-occurring atmospheric tracer radionuclides ^{7}Be and ^{210}Pb support an increased level of confidence that the effluent air samples are representative for the smaller (<2-micron-diameter) aerosol particles. Further work is needed and planned to assess the representativeness of the effluent air samples for particles in the 2 to 10-micron range.

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 and others (1990), Kenney and Ballard (1990), Kenney (1991), Kenney (1992), Kenney (1994), Kenney and others (1998), and Kenney and others (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 and others 1999). The EEG published its first operational monitoring report in September 2000 (Gray and others 2000) The present report is the EEG's fourth operational monitoring report and contains results obtained from sample collections and other activities during calendar year 2002. 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.

For the 2002 sampling year, the EEG adopted liquid scintillation counting as the method of choice for ^{90}Sr analyses, in place of gas-flow proportional counting. Although a less sensitive method than proportional counting, liquid scintillation counting incorporating spectral analysis of alpha and beta emissions is much more immune to interferences and misinterpretation of results. The minimum detectable activity (MDA) and minimum detectable concentration (MDC) values for ^{90}Sr in Appendix F, Table F1 reflect this change. Other 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.

1.1 Air Effluent Monitoring

In previous operational reports, largely on the basis of the radionuclide measurements of samples obtained from the effluent airstream at Station A, the EEG has concluded that operations at the WIPP site have not resulted in detectable releases of radionuclides to the environment. This conclusion was based on the assumption of representative sampling at Station A. In recent years (Neill 1995, Kenney and others 1999) that assumption has been called into question because of the presence of water entering the exhaust shaft through cracks in the shaft liner, resulting in wet sampling probes and lines and salt encrustation problems at Station A.

While this report was in preparation, the EEG began to reexamine archived data from analysis by gamma spectrometry of filter samples from Station A and Station D. Station D is an alternative sampling location established recently in the E300 drift, close to the air exhaust shaft. Station D uses the same sample head design and the same sample media (filters) as are used at Station A, but is unaffected by water inflow to the exhaust shaft. Samples from Station D are archived following gamma spectrometry.

The purpose of the reexamination was to track and compare the measured concentrations of ^{7}Be and ^{210}Pb at the two sampling locations. Both ^{7}Be and ^{210}Pb are naturally-occurring radionuclides. The action of cosmic rays on nitrogen and oxygen in the stratosphere produces ^{7}Be. Measurements of ^{7}Be in samples collected near the surface of the earth are used as an indicator of meteorological processes which cause the atmosphere to "turn over". The radon daughter ^{210}Pb is produced by decay of natural uranium in the surface of the earth. Once formed, both ^{7}Be and ^{210}Pb rapidly attach to smaller (<2 micron diameter) atmospheric aerosol particles and are widely used to monitor processes, such as precipitation, which remove aerosol particles from the air.

The results of this reexamination have recently been published in EEG-88 (Gray 2003). Briefly, analysis of the data revealed that, despite ongoing problems with wet probes and sample lines and salt encrustation of probes and lines, the measured concentrations of ^{7}Be and ^{210}Pb at both Station A and Station D were statistically the same for the period from September 2001 to the present. This indicates that, for the aerosol associated with ^{7}Be and ^{210}Pb, the sampling regime at the Station A skid of record (skid A-3) was relatively unaffected by the water inflow and salt encrustation problems observed between September 2001 and the present.

A number of concerns remain including the magnitude of aerosol particle losses for the larger size fractions (> 2 micron) due to the water and salt encrustation problems. In an attempt to address this concern, the EEG will include isotopic uranium analyses and total suspended particulate (TSP) mass measurements for Station A and Station D samples collected in the 2003 sampling year. Uranium in the local aerosol comes predominantly from soil resuspension, and TSP mass is typically bimodal with one of the maxima occurring between 1 and 30 microns diameter (Seinfeld 1975, p 89). Both uranium and TSP concentrations should be significantly influenced by the concentration of larger-sized particles.

1.2 Strontium Analysis in Groundwater

This report will be the last to include routine analysis results for ^{90}Sr in groundwater. Strontium analysis in water containing high levels of total-dissolved-solids is both costly and very labor-intensive. An adequate baseline has been established for ^{90}Sr in groundwater if the need arises in the future for comparisons; but because there is no known hydrologic connection between the repository and either the Culebra or Dewey Lake formations, no feasible mechanism exists whereby WIPP operations could release ^{90}Sr directly into either of these formations. The decision to eliminate these analyses will be re-evaluated annually and they will be resumed if necessary.

2.0 PREOPERATIONAL BASELINE

A summary of the concentrations of ^{241}Am, ^{238}Pu, $^{239/240}Pu$, ^{241}Pu, ^{137}Cs, and ^{90}Sr measured by the EEG in effluent air, ambient 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 and others 2000); for all others, except for the 1996 and 1997 low volume air sampler (LVAS) samples which were archived, the samples represent 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 EEG-67 (Kenney and others 1998) and EEG-73 (Kenney and others 1999). The ^{90}Sr data are the corresponding values from EEG-79 (Gray and others 2000) and EEG-81 (Gray and Ballard 2001). The uncertainties in Table 1 represent two standard deviations (2s), or the approximately 95% confidence interval of the results. 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 872 measurements, 19 were found to be statistical outliers by the Grubbs test (Taylor 1987). These were disqualified only after identification of possible causes.

The ^{241}Pu results in Table 1 came from re-analysis of a set comprising about 50% of the archived Pu analysis air samples. The total of 49 samples was made up of 3 from 1993, 12 from 1994, 18 from 1995, 13 from 1998, and 1 each from 1996, 1997, and 1999.

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)
^{241}Pu	214 ± 3600 (n = 10)	-175 ± 540 (n = 39)			
^{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 ± 5600 (n = 15)	1260 ± 2290 (n = 44)	8.6 ± 29.4 (n = 8)	9.5 ± 40.1 (n = 11)	7.3 ± 28.6 (n = 13)

3.0 OPERATIONAL MONITORING RESULTS

3.1 Air Effluent and Environmental Monitoring

The results of air effluent and environmental monitoring during 2002 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).

For the 2002 sampling year, the EEG analyzed samples of the facility effluent air collected at Station A by monthly composites, rather than quarterly composites as had been done in the past. There were two principle reasons for doing this. First, Washington TRU Solutions (WTS) analyzes monthly composites of fixed air sampler (FAS) samples and publishes the results in its annual Environmental Monitoring Reports. In addition to verification of WIPP's compliance with the EPA standards, a secondary but nonetheless important function of EEG's environmental monitoring program is to provide an independent check of the WTS results. As long as the ability to verify compliance with the standards is not compromised, an independent check is best accomplished if the results of the two organizations arise from duplicate samples. Second, with WIPP now well into the operational phase, it may be prudent to conduct more frequent and more timely checks for possible chronic low-level releases.

Inherent in the smaller sample volume, represented by a monthly composite, is a reduction in the ability of the analytical system to distinguish a real signal due to the presence of the target radionuclide from the background "noise" of the analysis. However, offsetting this disadvantage, at least partially, is a reduced blank correction from the smaller monthly composite and a corresponding reduced blank variability. Table F1 in Appendix F, listing the current MDA, MDC, and action levels, has been modified to reflect the increased frequency of analysis of Station A samples. Samples from Station B continue to be analyzed on a quarterly basis. Comparison of the MDA and MDC values in Table F1 for Station A and Station B samples show that MDA is slightly reduced for monthly composites, but MDC is approximately the same.

Table 2. Results of Specific Radionuclide Measurements from Samples Collected in 2002

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	-18 ± 130 -19 ± 42	7.6 ± 19	0.05 ± 0.07	0.08 ± 0.51	0.11 ± 0.42
$^{239/240}Pu$	45 ± 80 27 ± 72	15 ± 13	0.14 ± 0.35	0.18 ± 0.47	0.14 ± 0.31
^{238}Pu	33 ± 70 11 ± 44	3.5 ± 9.0	0.28 ± 1.48	0.0 ± 0.30	0.19 ± 0.28
^{241}Pu	-860 ± 6000 NA	-120 ± 370			
^{137}Cs	92 ± 4500 450 ± 2000	610 ± 940	40 ± 13	29 ± 34	29 ± 45
^{90}Sr	-2100 ± 11000 -3000 ± 7000	720 ± 1600	57 ± 90	-13 ± 29	-6.3 ± 74

For the 2002 sampling year, of a total of 302 possible measurements, 16 were lost as a result of instrument or processing problems in the lab, and 6 additional were rejected due to failure of the sample to meet a laboratory data quality objective (DQO), mostly low chemical recoveries. These 22 lost analyses are indicated in the Appendix A and B tables as “NA”.

Two measurements during 2002 exceeded the MDA. Both were of ^{90}Sr in drinking water and both also exceeded the action level (ACTL). However, although both met the laboratory’s DQO for chemical recovery (20%), they showed lower than normal recoveries and, consequently, the calculated concentrations are probably overestimates of the true value. In any event, since ^{90}Sr is not yet an appreciable part of the WIPP inventory (WWIS 2003), they are not likely to be due to WIPP activities. Furthermore, the highest observed value (106 mBq/L) was less than 36% of the National Primary Drinking Water Standard (8 pCi or 296 mBq/L) for ^{90}Sr (40 CFR 141.16).

The analysis results from the 2002 sampling year were evaluated against three criteria:

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

2. Action level (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. As mentioned in EEG-73, when the ACTL is exceeded, an internal investigation into the cause begins. The investigation includes, but is not limited to verification of calculations, counting instrument operation, and contamination of glassware. Currently if the investigation fails to indicate a probable cause the value is not rejected.

3. The 2-sample *t* and analysis of variance (ANOVA) tests to determine whether the means of the 2002 measurements differ significantly from the baseline means for normally-distributed data; for non-normal data, a non-parametric test was applied. In those cases where the level of significance for normality was close to 0.05, all three tests were applied.

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

Four measurements (^{239}Pu in surface water at Noya tank and at Station B – third quarter, ^{241}Am at S1- second quarter, and ^{137}Cs at S2 – fourth quarter) were found to be outliers, but none exceeded the MDA, and they are not considered to be significant. Two measurements (^{238}Pu in Loving drinking water and ^{239}Pu at Noya tank) exceeded the action level, but not the MDA and likewise are not considered significant.

Four measurements exceeded the action level for ^{90}Sr but, as noted above, only two of these exceeded the MDA. The principle reason for this was the change in 2002 in the analytical method of choice for ^{90}Sr. The liquid scintillation counter typically exhibits a ^{90}Sr background of 3 – 5 counts-per-minute, compared to only about 0.4 count-per-minute for proportional counting.

Inherent in the higher background is a higher background variability leading to a higher variability in blank analyses, which is the basis for the MDA determination. The action level, on the other hand, is determined by the **baseline** ^{90}Sr measurements which were obtained by proportional counting. Since the EEG determines MDA from a subset of blanks run closely in time with, and by the same methodology as, the samples to which the blank correction is applied, currently the MDA is about twice the action level.

Appendix C contains the results of the matrix blanks analyzed with the samples from the year 2002 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 and others 1999). Quarterly external dose measurements as determined by TLDs during 2002 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 2002 was 18.8 mrem/quarter ± 5.0 mrem/quarter (2σ) and the control TLD dose was 19.5 ± 2.0 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 2002 doses are not statistically different from the preoperational baseline doses in EEG-73. Based on measurements of control TLDs for the year 2002, the quarterly lower limit of detection (LLD) was 3.7 mrem/quarter. Thus, a quarterly dose from WIPP operations that exceeded about 4 mrem should be detectable. None of the TLDs in 2002 exceeded the LLD (which would have been a gross value of 23.2 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. The heavy dashed horizontal lines represent the current MDC. Concentrations of ^{241}Pu, ^{137}Cs and ^{90}Sr should be read from the right-hand Y scale.

Application of the 2-sample *t*, ANOVA, and non-parametric tests, as appropriate, via Minitab™ statistical software[a] revealed that four of the measurements in Table 2 differed from the preoperational baseline at the 95% confidence level. These were:

1. ^{137}Cs in groundwater,
2. ^{239}Pu in surface water,
3. ^{90}Sr in surface water, and
4. ^{137}Cs in ambient air.

The reported value for ^{137}Cs in groundwater was higher than the baseline value, but none of the individual measurements averaged to arrive at the value in Table 2 exceeded the MDA. The reported value for ^{239}Pu in surface water was strongly influenced by the Noya tank sample identified above as an outlier. However, as noted above, the value did not exceed the MDA and is not considered significant. ^{90}Sr in groundwater was significantly **lower** than the baseline. The reported value for ^{137}Cs in ambient air is higher than the baseline value but, as in the case of groundwater, none of the measurements exceeded the MDA.

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

4.2 Comparison to the Operational Results from Other Organizations

Radiological surveillance monitoring of WIPP is also being conducted by 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.

Comparison with operational data from the WTS monitoring program for 2002 revealed that two results – ^{241}Am in both FAS and LVAS samples - appeared to be different at 95% confidence. In both cases the WTS values were higher than the EEG values and also higher than the corresponding EEG baseline values. Non-parametric tests (Mann-Whitney for 2-way and Kruskal-Wallis for 3-way tests of the median) were used for these comparisons. However, neither of the WTS results exceeded their MDA. All other direct comparisons between the EEG and WTS results in air and water samples revealed no statistically significant differences.

Comparison of CEMRC's results for FAS samples, downloaded from their web site, showed that the CEMRC values were lower than the corresponding EEG values at the 95% confidence level for ^{238}Pu and ^{239}Pu. (CEMRC 2003) However, in both cases, the reported values were well below the respective organization's MDCs.

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; NESHAPS compliance may be demonstrated either by monitoring facility effluent air or, provided certain conditions are met, by environmental monitoring at critical receptor locations.

In previous reports comparisons to EPA standards were relative to NESHAPS (40 CFR 61) for airborne facility effluent measurements, and relative to 40 CFR 191.03(b) for ambient air measurements. In this report for ambient air (LVAS) measurements the EEG has invoked Section 61.93(b)(5) of NESHAPS, which permits direct comparisons of environmental airborne concentrations with the limiting values found in Table 2 of Appendix E of NESHAPS.

The ratios of the upper 95% limit values for the means (Mean + 2s) from the tables in Appendix A to the limiting values either found in Appendix E, Table 2 or resulting from CAP88PC (Parks 1992) calculations, as appropriate, were determined. The results obtained were then expressed as percentages of the appropriate standard and appear in Table 3, with the total of the individual isotopic dose contributions in the last row.

Table 3. Comparison of Measurements to the Standard

Applicable Standard→	40 CFR 61 (10 mrem – by CAP88PC)	40 CFR 61 (10 mrem)*
Radionuclide	FAS	LVAS
^{241}Am	0.0002%	0.04%
$^{239/240}Pu$	0.0001%	0.04%
^{238}Pu	0.0000%	0.02%
^{241}Pu	0.0000%	0.01%
^{137}Cs	0.0000%	0.22%
^{90}Sr	0.0001%	0.33%
Total	0.0004%	0.65%

*Compliance concentrations from 40 CFR 61, Appendix E. Table 2.

5.0 CONCLUSIONS

The results of the EEG's radiation surveillance of the WIPP project during 2002 show that operations at the site during 2002 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 much 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 2002 is not different from the baseline dose before WIPP became operational. From this, the EEG concludes that WIPP operations during 2002 did not result in measurable doses to the public.

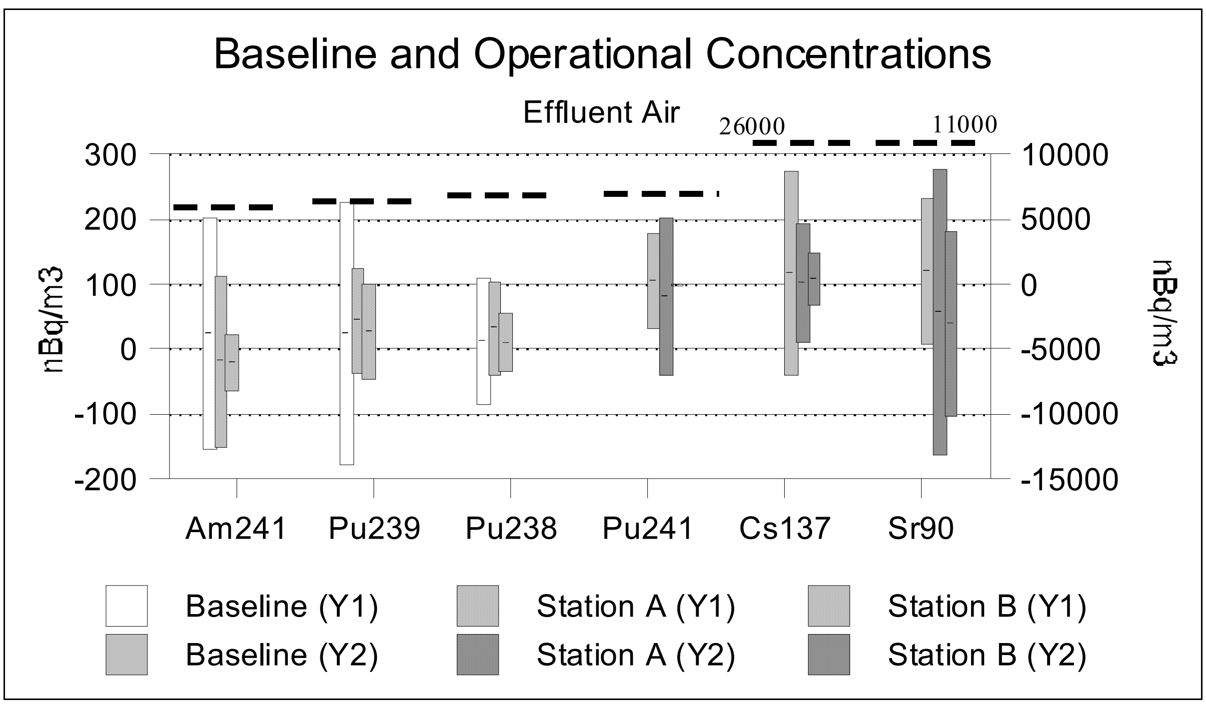

Figure 1. Baseline and 2002 Measurements in Effluent Air

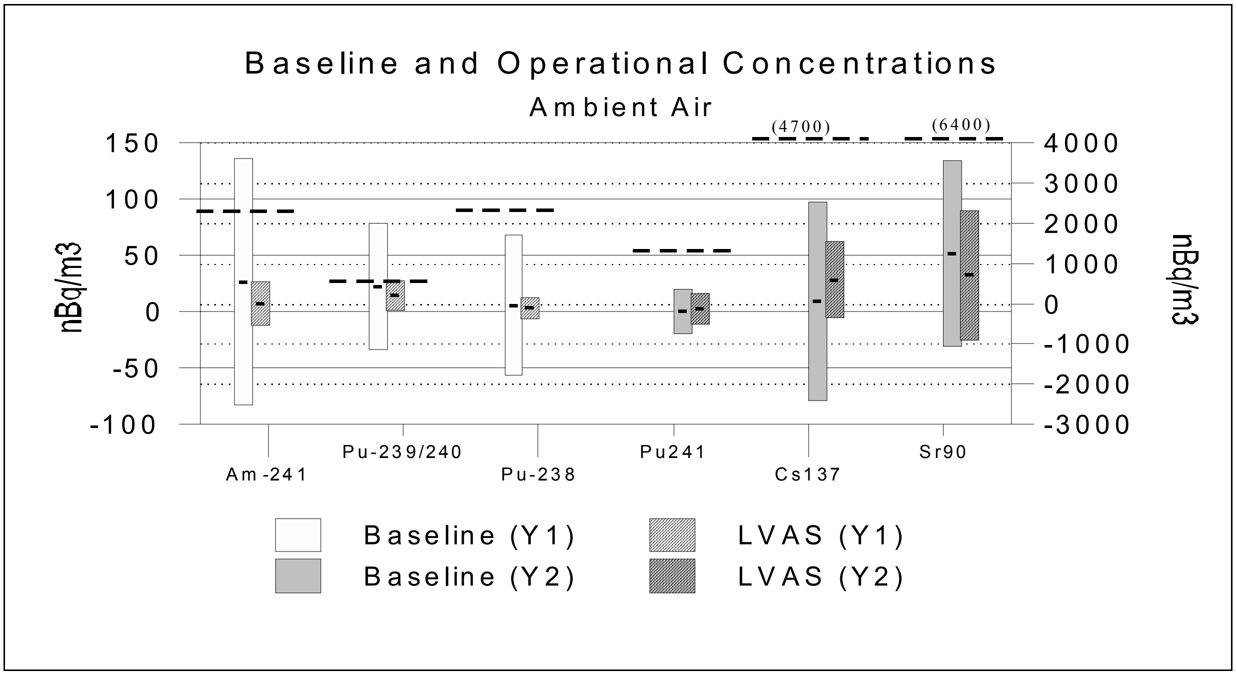

Figure 2. Baseline and 2002 Measurements in Ambient Air

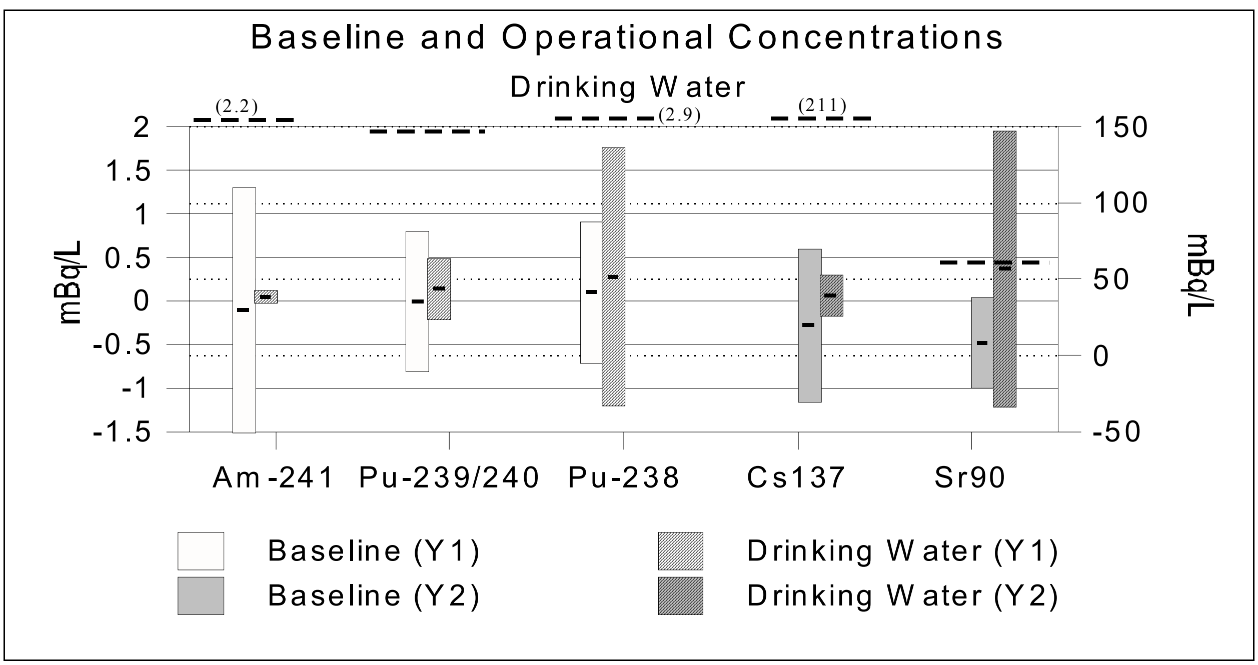

Figure 3. Baseline and 2002 Measurements in Drinking Water

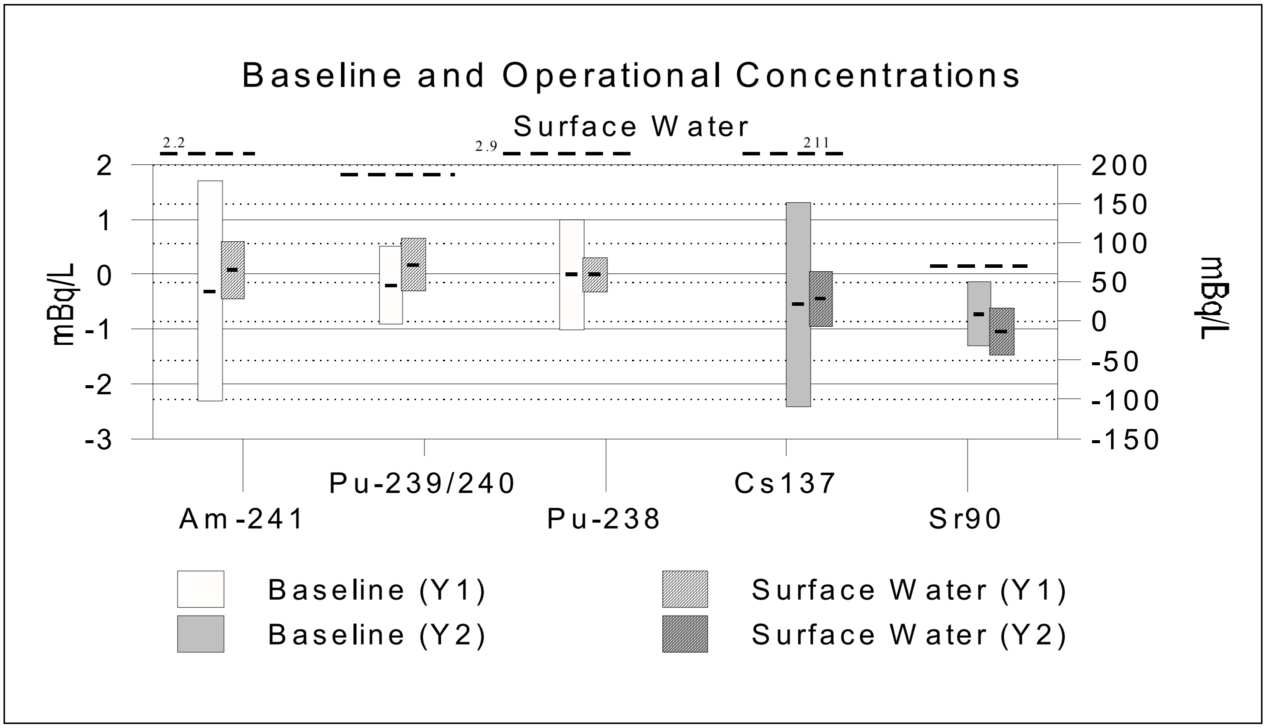

Figure 4. Baseline and 2002 Measurements in Surface Water

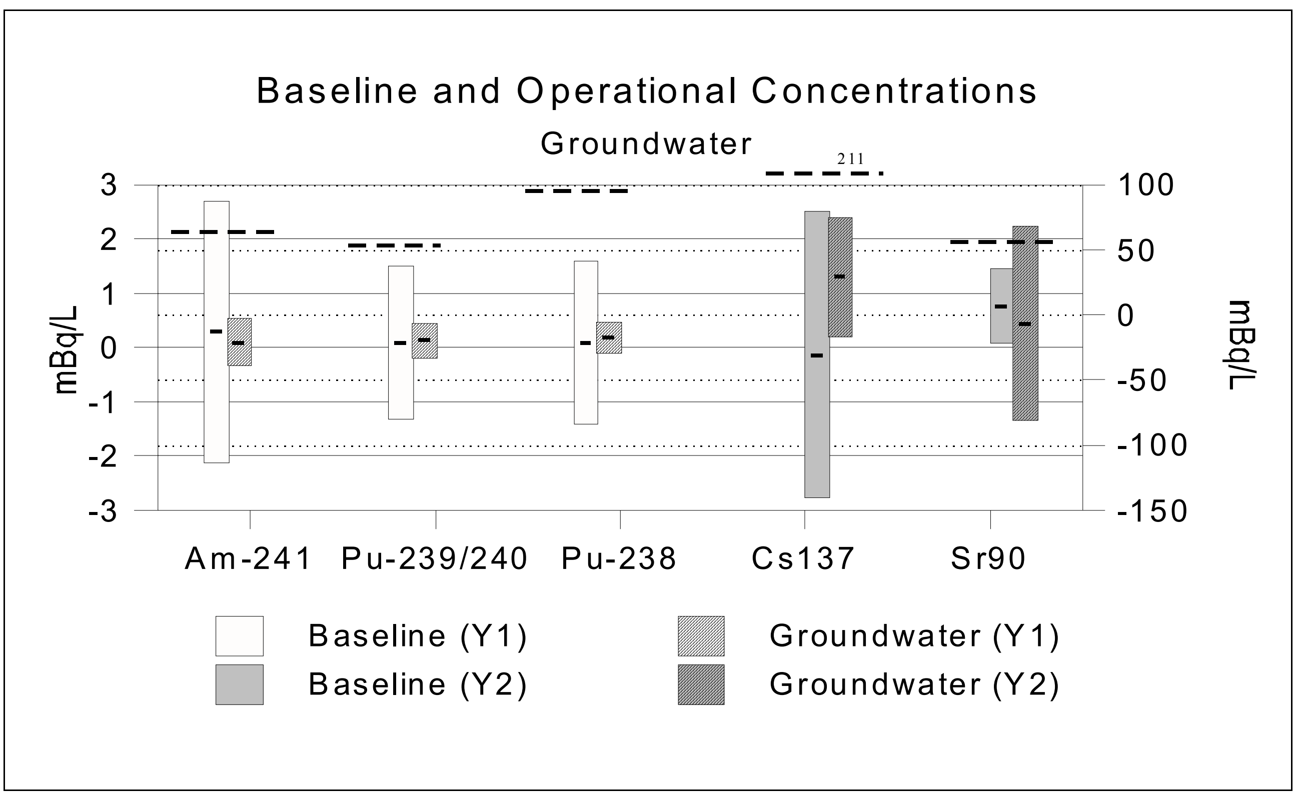

Figure 5. Baseline and 2002 Measurement of Groundwater

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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 2002

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)
January	2523	-29	183	14	129	21	132
February	2331	NA	NA	55	133	92	171
March	2374	46	200	68	218	-26	225
April	2414	-65	149	61	168	-1	129
May	2482	-65	158	-6	101	27	196
June	2253	57	220	103	389	63	463
July	2500	-71	151	13	126	41	140
August	2529	-17	183	118	166	6	131
September	2303	-130	175	-11	150	27	229
October	2519	46	176	48	200	70	201
November	2309	48	195	32	117	70	158
December	2462	NA	NA	51	152	5	176
		Mean	$2s_m$	Mean	$2s_m$	Mean	$2s_m$
		-18	130	45	80	33	70

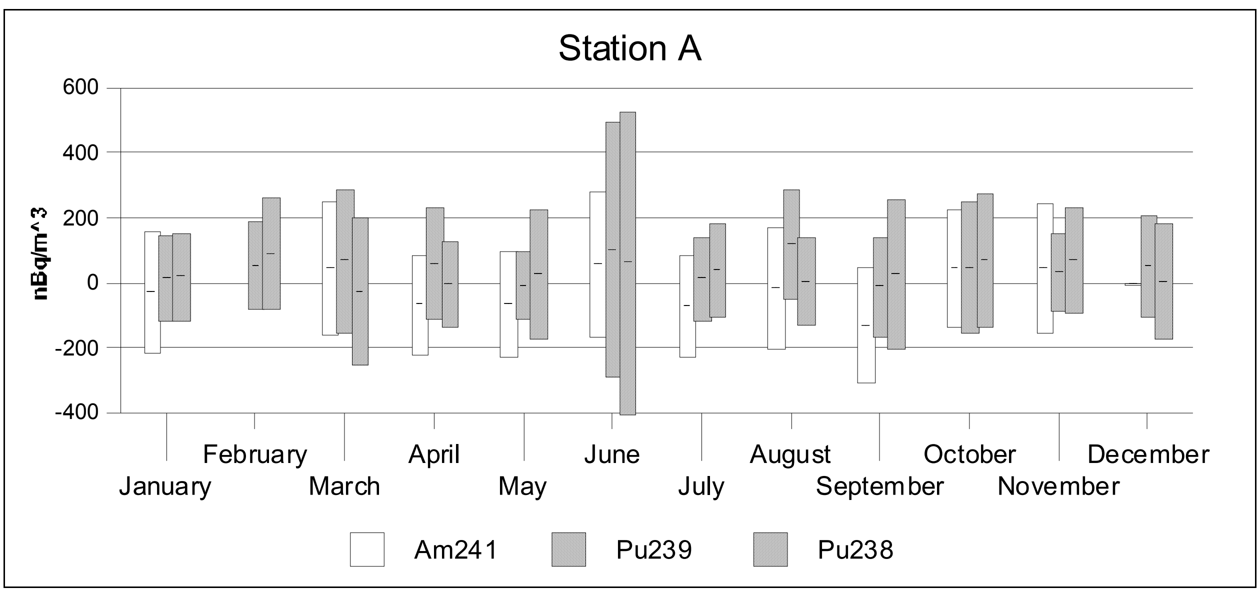

Figure A1. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Station A Samples During 2002

Table A2. ^{137}Cs, ^{90}Sr and ^{241}Pu Measurements in Station A Samples During 2002

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)	^{241}Pu Calculated Conc. (nBq/m^3)	Expanded Uncert. (k=2) (nBq/m^3)
January	2523	-3	20819	-7642	6751	-1211	9565
February	2331	1266	29280	685	7623	2282	10247
March	2374	-1801	22176	-2184	7214		
April	2414	2632	21757	-6861	7084		
May	2482	-486	21178	-4563	6696		
June	2253	-2396	23421	-2509	8965		
July	2500	-3387	20826	8223	25665	-3648	9633
August	2529	1536	20755	NA	NA		
September	2303	-3546	23038	NA	NA		
October	2519	234	20782	-1086	8935		
November	2309	2752	22805	-9708	9803		
December	2462	2094	21407	4417	9212		
		Mean	$2s_m$	Mean	$2s_m$	Mean	$2s_m$
		92	4515	-2123	11062	-859	5961

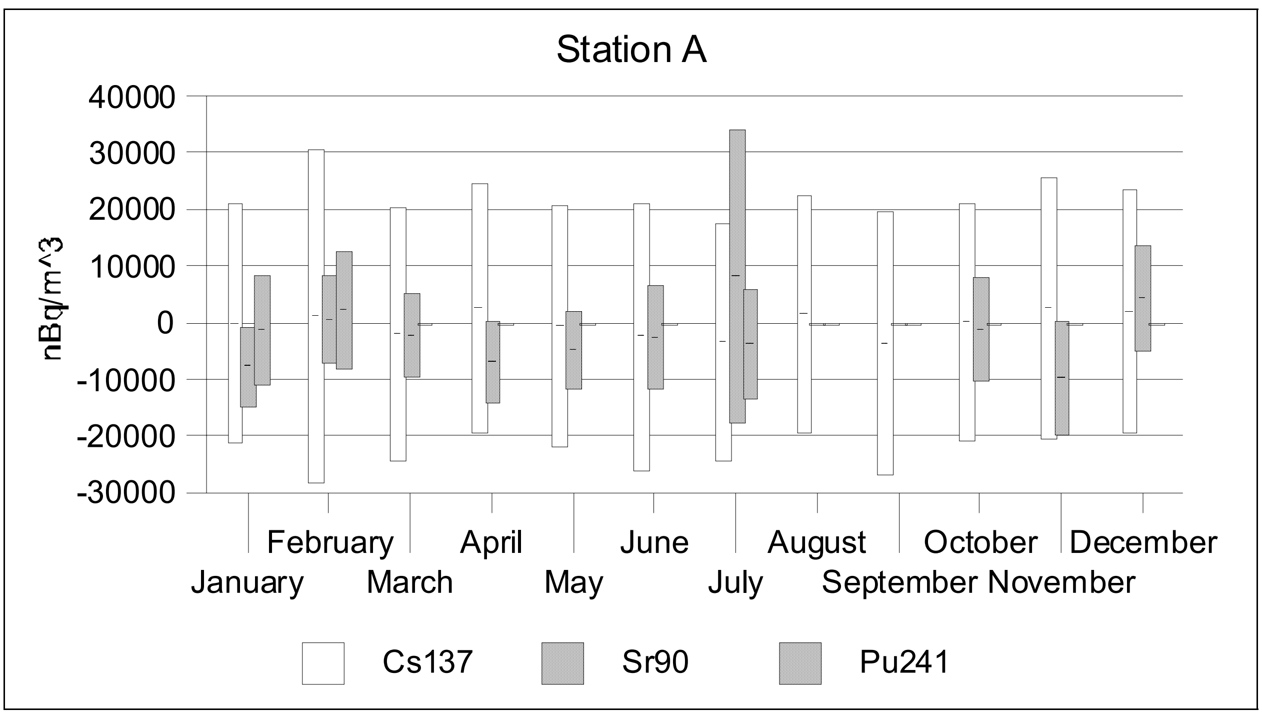

Figure A2. ^{137}Cs, ^{90}Sr and ^{241}Pu Measurements in Station A Samples During 2002

Table A3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Station B Samples During 2002

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 Quarter	7657	NA	NA	34.25	122.03	27.82	105.53
2nd Quarter	6718	-34.34	55.43	59.25	79.80	18.87	65.34
3rd Quarter	7826	4.56	58.65	-12.18	76.18	-14.12	118.95
4th Quarter	7535	-27.95	67.41	NA	NA	NA	NA
		Mean	2s	Mean	2s	Mean	2s
		-19.24	41.72	27.11	72.49	10.86	44.17

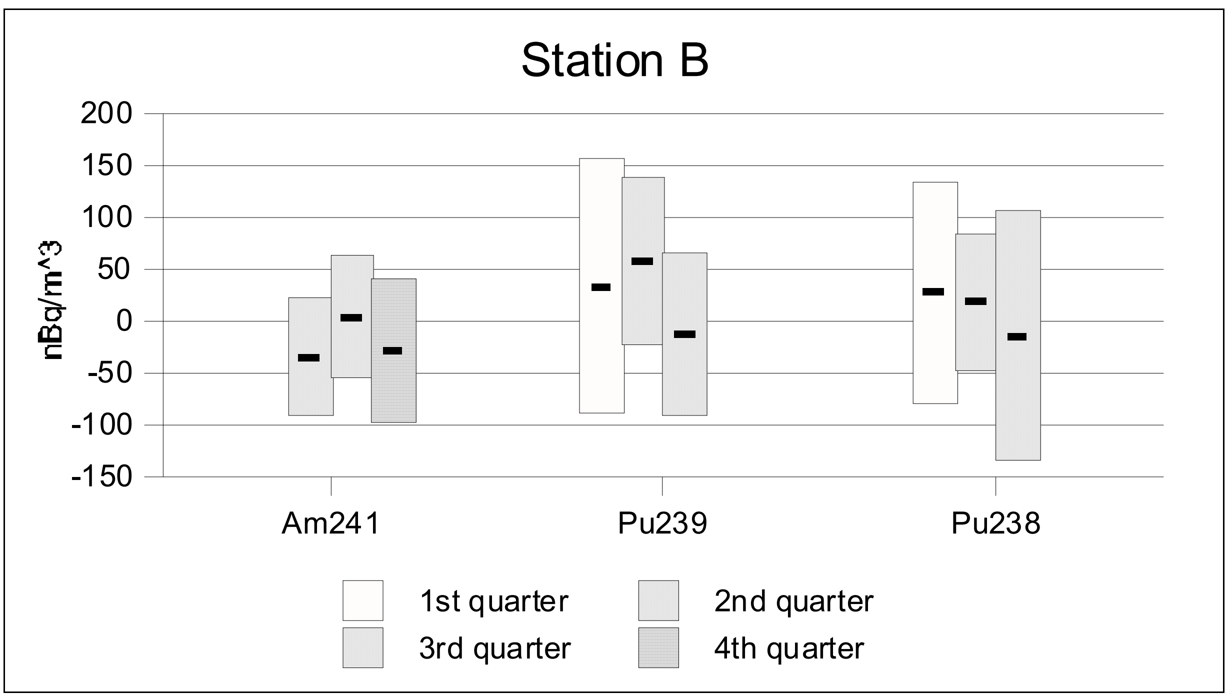

Figure A3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Station B Samples During 2002

Table A4. ^{137}Cs and ^{90}Sr Measurements in Station B Samples During 2002

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 Quarter	7657	1006	6861	264	4536
2nd Quarter	6718	-859	7767	-1483	5132
3rd Quarter	7826	1424	6710	-7853	4315
4th Quarter	7535	237	7021	-2960	4536
		Mean	2s	Mean	2s
		452	2006	-3008	6977

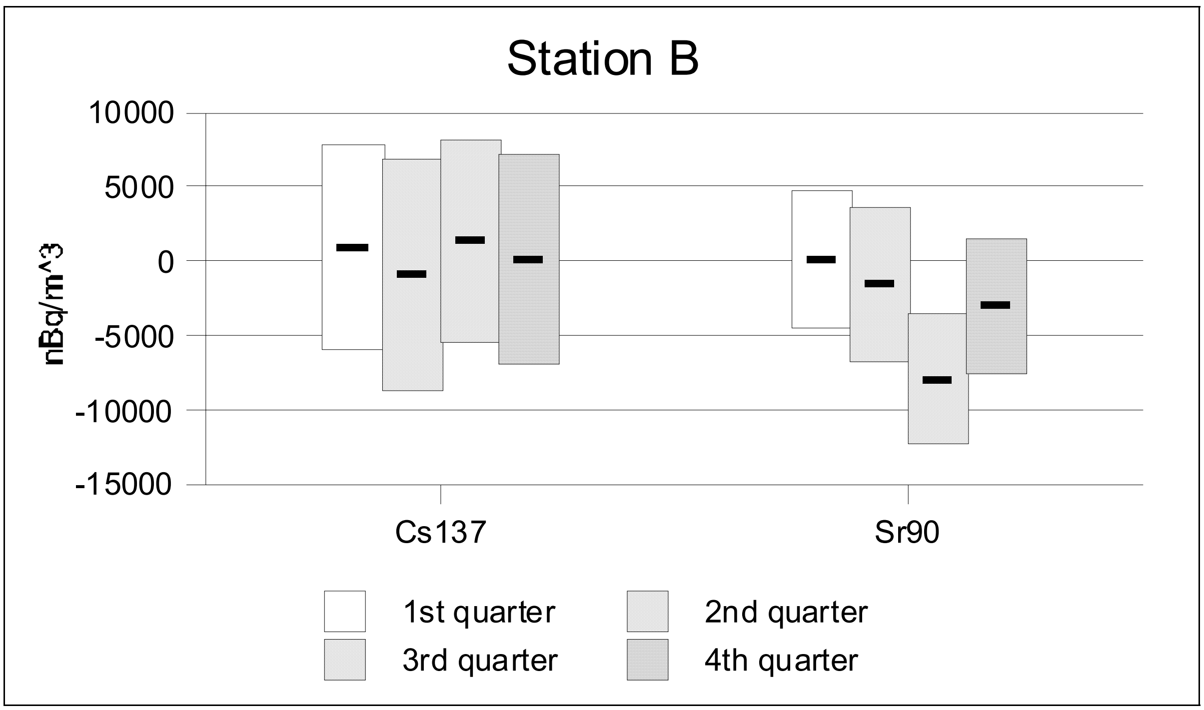

Figure A4. ^{137}Cs and ^{90}Sr Measurements in Station B Samples During 2002

Table A5. ^{241}Am Measurements in LVAS Samples During 2002

LVAS Sample Location	Quarter Sample Collected	Sample Volume (m^3)	Calculated Concentration (nBq/m^3)	Expanded Uncert. (k=2) (nBq/m^3)
Artesia	1ST 2002	27739	-2.91	32.61
Carlsbad	1ST 2002	27440	19.88	33.39
Loving	1ST 2002	31137	9.62	32.29
S1	1ST 2002	29408	13.58	31.19
S2	1ST 2002	29826	14.77	29.77
S3	1ST 2002	30627	3.70	27.49
Artesia	2ND 2002	30051	20.71	32.04
Carlsbad	2ND 2002	27159	26.08	35.34
Loving	2ND 2002	28087	15.86	33.32
S1	2ND 2002	27228	-21.43	41.35
S2	2ND 2002	28909	-4.27	31.83
S3	2ND 2002	29699	11.06	29.81
Artesia	3RD 2002	28497	11.72	34.47
Carlsbad	3RD 2002	24340	7.27	37.79
Loving	3RD 2002	28238	9.47	32.46
S1	3RD 2002	26866	1.31	34.40
S2	3RD 2002	25866	3.98	34.10
S3	3RD 2002	28482	9.55	31.70
Artesia	4TH 2002	23735	7.43	37.82
Carlsbad	4TH 2002	27040	6.78	33.01
Loving	4TH 2002	28458	9.15	32.79
S1	4TH 2002	30619	1.75	30.41
S2	4TH 2002	27739	4.02	32.21
S3	4TH 2002	28528	4.35	31.43
			Mean	$2s_m$
			7.64	19.03

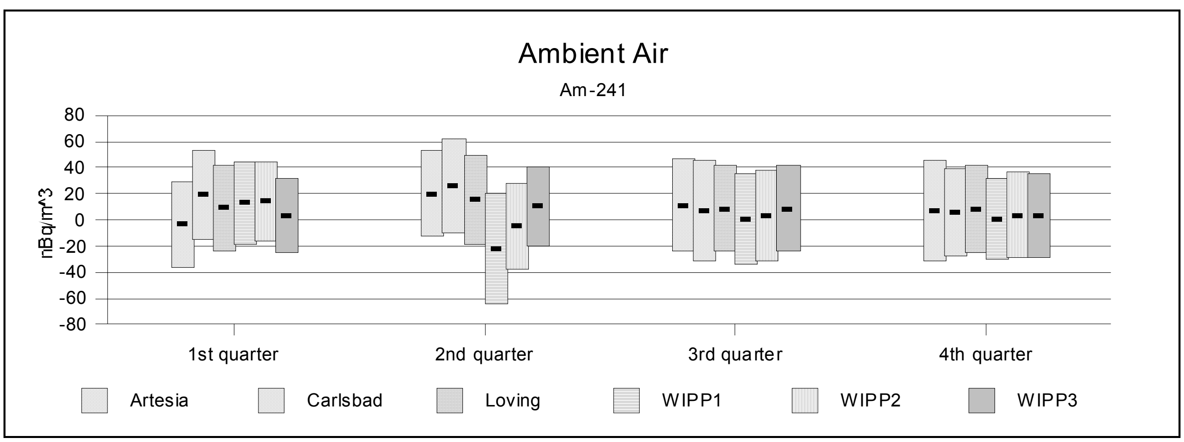

Figure A5. ^{241}Am Measurements in LVAS Samples During 2002

Table A6. $^{239/240}$Pu Measurements in LVAS Samples During 2002

LVAS Sample Location	Quarter Sample Collected	Sample Volume (m^3)	Calculated Concentration (nBq/m^3)	Expanded Uncert. (k=2) (nBq/m^3)
Artesia	1ST 2002	27739	20.89	26.62
Carlsbad	1ST 2002	27440	8.51	16.34
Loving	1ST 2002	31137	NA	NA
S1	1ST 2002	29408	16.64	21.19
S2	1ST 2002	29826	17.62	16.75
S3	1ST 2002	30627	12.19	85.84
Artesia	2ND 2002	30051	22.44	37.01
Carlsbad	2ND 2002	27159	21.67	24.18
Loving	2ND 2002	28087	25.12	30.07
S1	2ND 2002	27228	NA	NA
S2	2ND 2002	28909	14.96	84.00
S3	2ND 2002	29699	18.74	42.97
Artesia	3RD 2002	28497	20.94	22.37
Carlsbad	3RD 2002	24340	13.55	18.75
Loving	3RD 2002	28238	10.14	17.40
S1	3RD 2002	26866	11.89	22.00
S2	3RD 2002	25866	6.98	16.39
S3	3RD 2002	28482	9.36	14.81
Artesia	4TH 2002	23735	18.58	52.45
Carlsbad	4TH 2002	27040	NA	NA
Loving	4TH 2002	28458	12.27	25.99
S1	4TH 2002	30619	NA	NA
S2	4TH 2002	27739	NA	NA
S3	4TH 2002	28528	0.15	30.21
			Mean	$2s_m$
			14.88	12.63

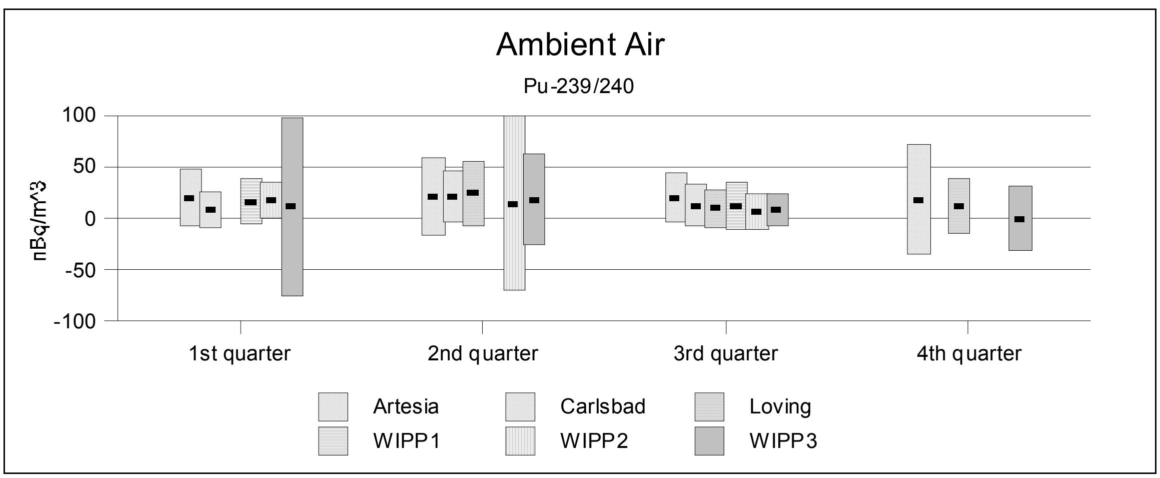

Figure A6. $^{239/240}$Pu Measurements in LVAS Samples During 2002

Table A7. ^{238}Pu Measurements in LVAS Samples During 2002

LVAS Sample Location	Quarter Sample Collected	Sample Volume (m^3)	Calculated Concentration (nBq/m^3)	Expanded Uncert. (k=2) (nBq/m^3)
Artesia	1ST 2002	27739	-0.05	23.34
Carlsbad	1ST 2002	27440	4.97	16.02
Loving	1ST 2002	31137	NA	NA
S1	1ST 2002	29408	10.97	22.21
S2	1ST 2002	29826	4.44	14.37
S3	1ST 2002	30627	NA	NA
Artesia	2ND 2002	30051	3.72	22.26
Carlsbad	2ND 2002	27159	4.22	18.49
Loving	2ND 2002	28087	4.06	25.11
S1	2ND 2002	27228	NA	NA
S2	2ND 2002	28909	0.56	52.03
S3	2ND 2002	29699	8.31	36.73
Artesia	3RD 2002	28497	-0.40	14.37
Carlsbad	3RD 2002	24340	2.37	28.20
Loving	3RD 2002	28238	0.15	17.37
S1	3RD 2002	26866	-4.10	20.76
S2	3RD 2002	25866	1.71	15.77
S3	3RD 2002	28482	2.03	24.10
Artesia	4TH 2002	23735	12.78	43.84
Carlsbad	4TH 2002	27040	NA	NA
Loving	4TH 2002	28458	8.72	28.72
S1	4TH 2002	30619	NA	NA
S2	4TH 2002	27739	NA	NA
S3	4TH 2002	28528	-2.08	37.11
			Mean	2s
			3.47	8.94

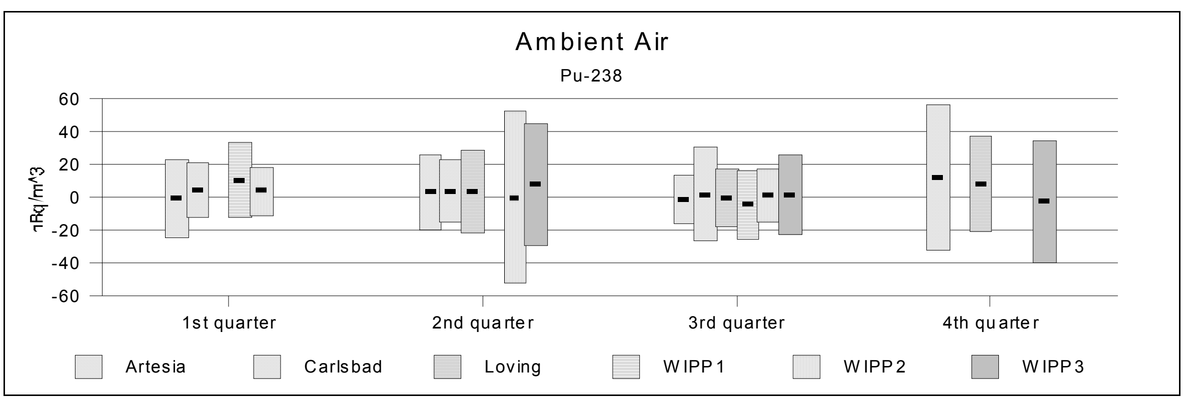

Figure A7. ^{238}Pu Measurements in LVAS Samples During 2002

Table A8. ^{241}Pu Measurements in LVAS During 2002

LVAS Sample Location	Quarter Sample Collected	Sample Volume (m^3)	Calculated Concentration (nBq/m^3)	Expanded Uncert. (k=2) (nBq/m^3)
Artesia	1ST 2002	27739	96	787
Carlsbad	1ST 2002	27440	-383	793
Loving	1ST 2002	31137	-371	708
S1	1ST 2002	29408	-238	742
S2	1ST 2002	29826	-196	728
S3	1ST 2002	30627	-42	718
Artesia	2ND 2002	30051		
Carlsbad	2ND 2002	27159		
Loving	2ND 2002	28087		
S1	2ND 2002	27228		
S2	2ND 2002	28909		
S3	2ND 2002	29699		
Artesia	3RD 2002	28497	-103	764
Carlsbad	3RD 2002	24340		
Loving	3RD 2002	28238	0	782
S1	3RD 2002	26866		
S2	3RD 2002	25866	119	846
S3	3RD 2002	28482		
Artesia	4TH 2002	23735		
Carlsbad	4TH 2002	27040		
Loving	4TH 2002	28458		
S1	4TH 2002	30619		
S2	4TH 2002	27739		
S3	4TH 2002	28528		
			Mean	2s
			-124	372

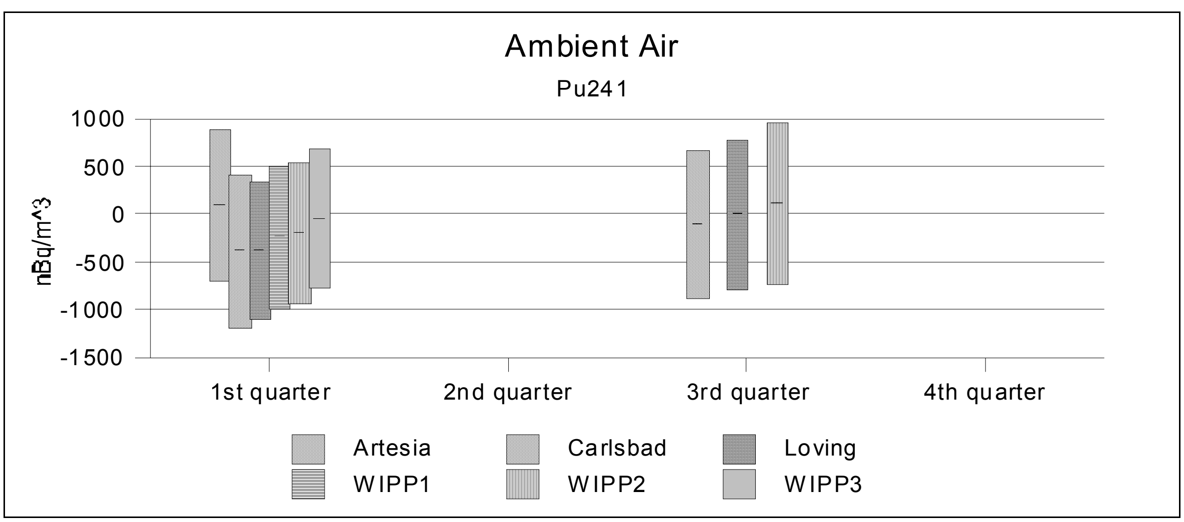

Figure A8. ^{241}Pu Measurements in LVAS Samples During 2002

Table A9. ^{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 2002	27739	763	1887
Carlsbad	1ST 2002	27440	756	1894
Loving	1ST 2002	31137	302	1697
S1	1ST 2002	29408	60	1804
S2	1ST 2002	29826	592	1750
S3	1ST 2002	30627	336	1706
Artesia	2ND 2002	30051	597	1753
Carlsbad	2ND 2002	27159	70	1960
Loving	2ND 2002	28087	576	1936
S1	2ND 2002	27228	1550	1938
S2	2ND 2002	28909	1022	1766
S3	2ND 2002	29699	431	1749
Artesia	3RD 2002	28497	-98	1817
Carlsbad	3RD 2002	24340	459	2139
Loving	3RD 2002	28238	781	1858
S1	3RD 2002	26866	591	1906
S2	3RD 2002	25866	461	1943
S3	3RD 2002	28482	-83	1809
Artesia	4TH 2002	23735	874	2206
Carlsbad	4TH 2002	27040	441	1940
Loving	4TH 2002	28458	439	1841
S1	4TH 2002	30619	1196	1798
S2	4TH 2002	27739	1903	1928
S3	4TH 2002	28528	526	1846
			Mean	2s
			606	942

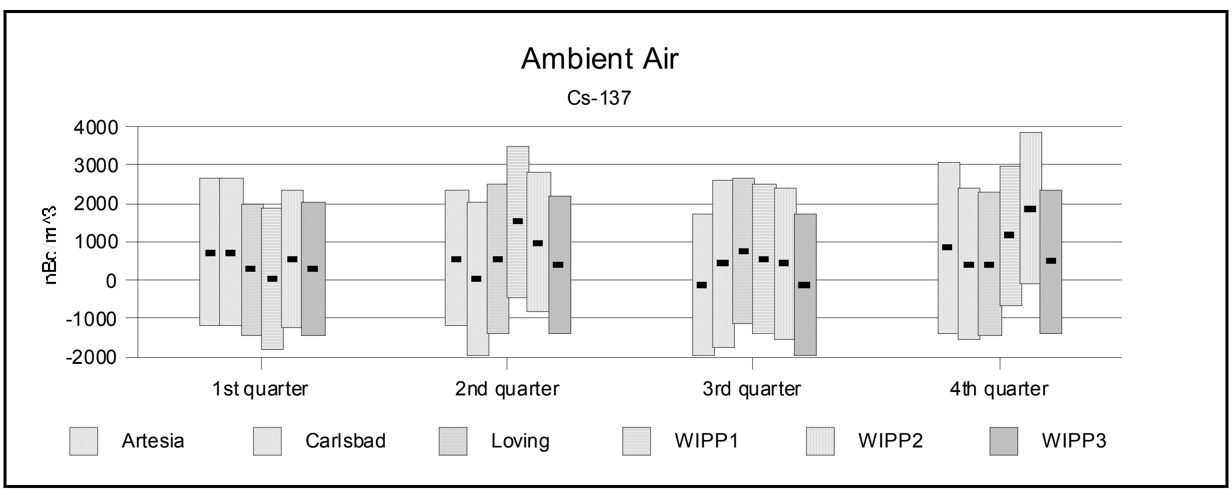

Figure A9. ^{137}Cs Measurements in LVAS Samples During 2002

Table A10. ^{90}Sr Measurements in LVAS Samples During 2002

LVAS Sample Location	Quarter Sample Collected	Sample Volume (m^3)	Calculated Concentration (nBq/m^3)	Expanded Uncert. (k=2) (nBq/m^3)
Artesia	1ST 2002	27739	964	3072
Carlsbad	1ST 2002	27440	893	3063
Loving	1ST 2002	31137	859	2792
S1	1ST 2002	29408	679	2877
S2	1ST 2002	29826	NA	NA
S3	1ST 2002	30627	969	2765
Artesia	2ND 2002	30051	678	3170
Carlsbad	2ND 2002	27159	499	3461
Loving	2ND 2002	28087	-137	3439
S1	2ND 2002	27228	1752	4878
S2	2ND 2002	28909	-831	3466
S3	2ND 2002	29699	2470	5188
Artesia	3RD 2002	28497	1468	3083
Carlsbad	3RD 2002	24340	2107	3944
Loving	3RD 2002	28238	1437	3071
S1	3RD 2002	26866	162	3168
S2	3RD 2002	25866	-16	3350
S3	3RD 2002	28482	211	3033
Artesia	4TH 2002	23735	1183	3686
Carlsbad	4TH 2002	27040	732	3198
Loving	4TH 2002	28458	279	3035
S1	4TH 2002	30619	NA	NA
S2	4TH 2002	27739	125	3092
S3	4TH 2002	28528	-508	2984
			Mean	2s
			726	1630

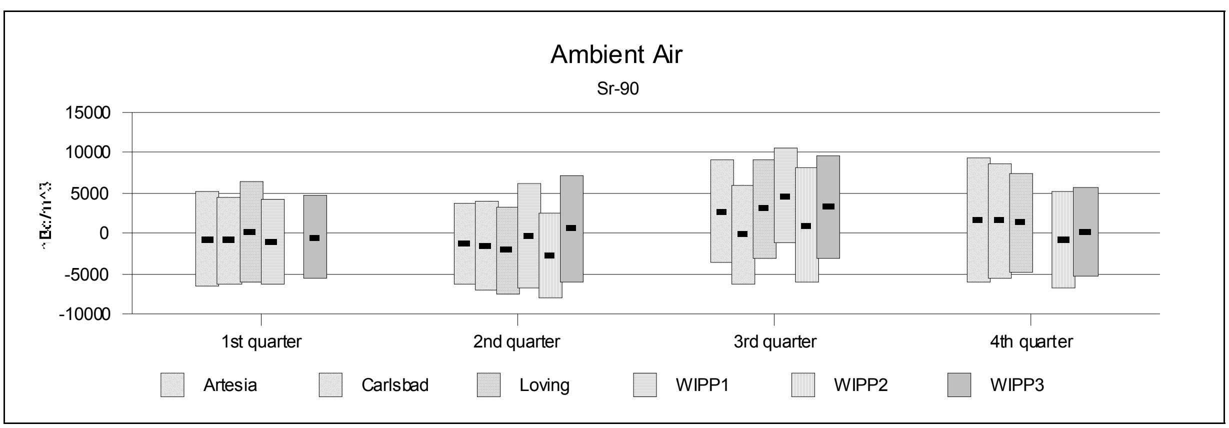

Figure A10. ^{90}Sr Measurements in LVAS Samples During 2002

APPENDIX B. WATER SAMPLE DATA

Table B1. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Groundwater During 2002

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	NA	NA	NA	NA	NA	NA
WQSP-2	0.29	0.51	0.29	0.88	0.20	1.27
WQSP-3	0.17	0.43	-0.09	0.83	0.17	1.29
WQSP-4	0.31	0.50	0.25	0.91	0.13	1.29
WQSP-5	-0.06	0.39	0.28	0.99	0.06	1.28
WQSP-6	-0.23	0.89	0.04	1.00	0.45	1.52
WQSP-6A	0.17	0.44	0.09	0.93	0.12	1.30
	Mean	2s	Mean	2s	Mean	2s
	0.11	0.42	0.14	0.31	0.19	0.28

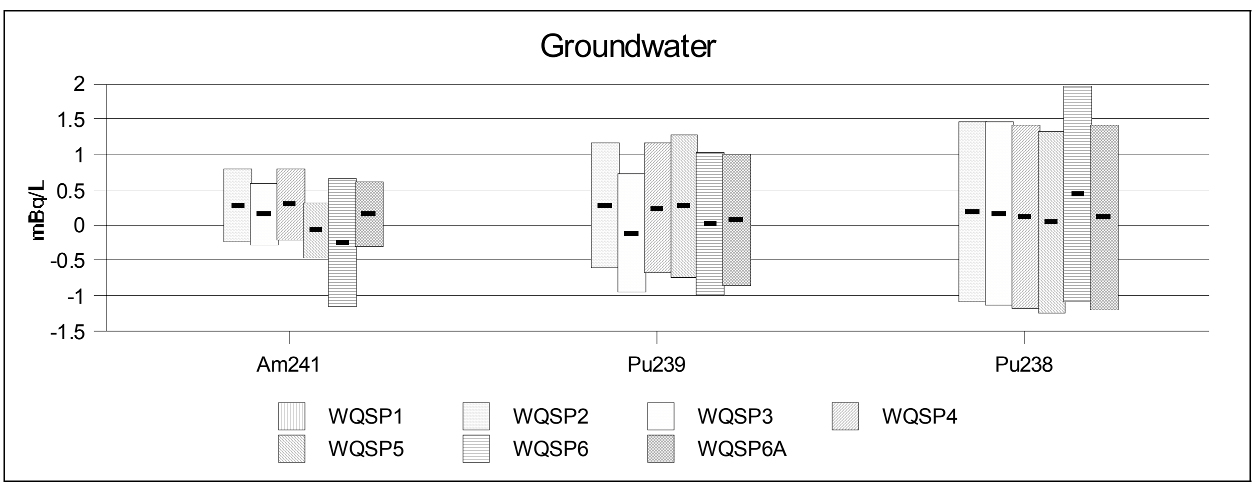

Figure B1. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Groundwater During 2002

Table B2. ^{137}Cs and ^{90}Sr Measurements in Groundwater During 2002

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	44.82	104.61	25.47	103.89
WQSP-2	35.80	105.40	-40.21	145.59
WQSP-3	59.70	115.20	-17.25	172.36
WQSP-4	-11.10	111.00	40.35	179.29
WQSP-5	37.20	104.00	-53.05	101.87
WQSP-6	18.10	101.20	6.91	132.16
WQSP-6A	21.90	95.00	NA	NA
	Mean	2s	Mean	2s
	29.49	45.33	-6.30	73.84

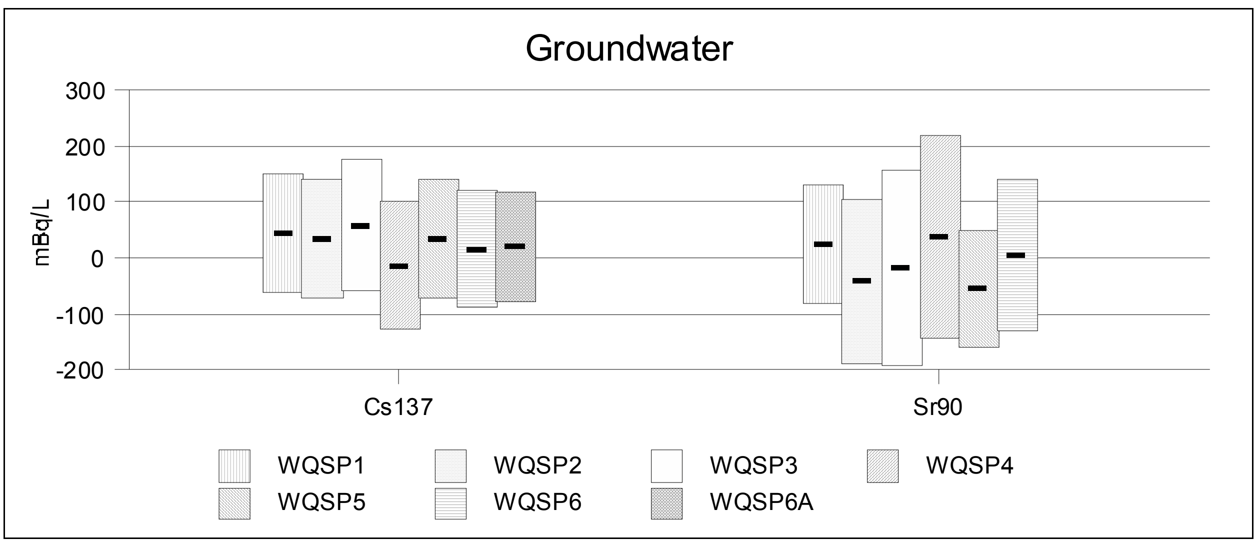

Figure B2. ^{137}Cs and ^{90}Sr Measurements in Groundwater During 2002

Table B3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Surface Water During 2002

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)
Indian Tank	-0.13	0.44	0.17	1.25	0.30	1.86
Noye Tank	0.51	1.01	0.68	5.20	-0.14	5.45
Pecos@Carlsbad	0.10	0.54	0.14	1.05	0.08	2.13
Pecos@Pierce	0.25	0.67	-0.07	2.17	0.03	2.41
Red Lake	0.04	0.41	0.14	1.24	-0.05	1.34
Red Tank	0.08	0.40	0.05	0.98	-0.12	1.33
WIPP Stormwater	-0.29	1.53	0.16	1.45	-0.06	1.40
	Mean	2s	Mean	2s	Mean	2s
	0.08	0.51	0.18	0.47	0.00	0.30

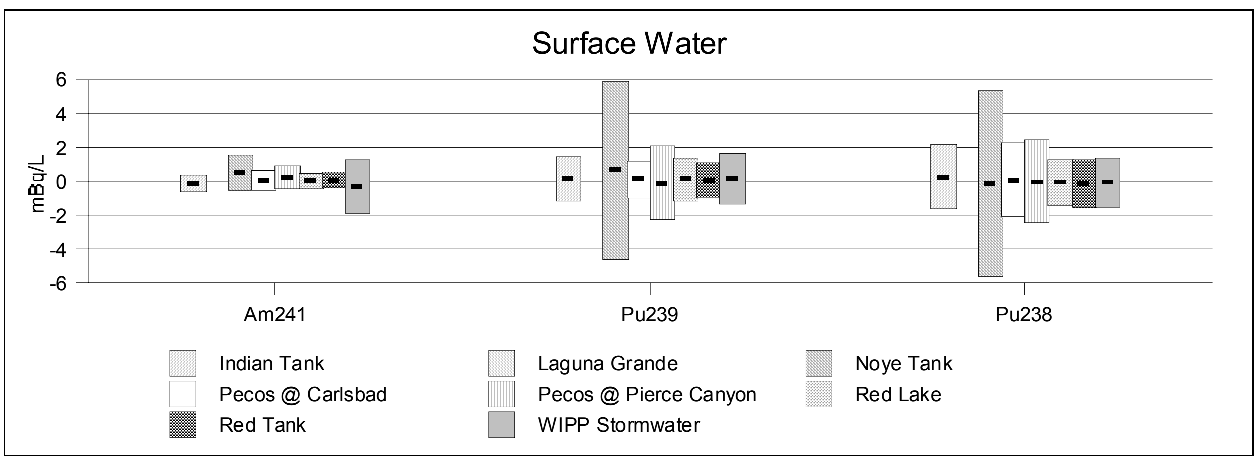

Figure B3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Surface Water During 2002

Table B4. ^{137}Cs and ^{90}Sr Measurements in Surface Water During 2002

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)
Indian Tank	46.39	98.75	-19.37	35.49
Noye Tank	7.22	97.63	11.83	38.26
Pecos @ Carlsbad	24.26	52.85	NA	NA
Pecos @ Pierce	14.12	51.15	NA	NA
Red Lake	31.94	98.46	-23.84	33.06
Red Tank	56.11	98.60	-18.61	41.11
WIPP Stormwater	26.39	96.25	-17.37	50.78
	Mean	2s	Mean	2s
	29.49	34.34	-13.47	28.71

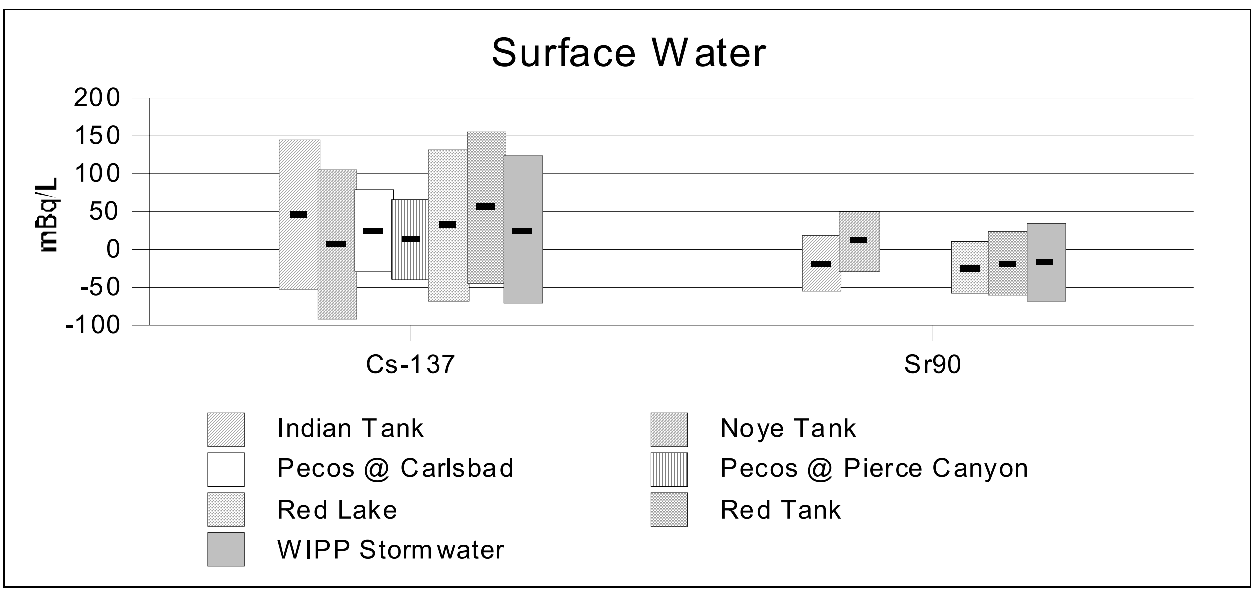

Figure B4. ^{137}Cs and ^{90}Sr Measurements in Surface Water During 2002

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	0.07	0.40	0.25	2.11	-0.44	2.39
Loving	0.08	0.75	0.05	1.16	1.29	2.20
Otis	0.01	0.40	-0.06	0.91	-0.04	1.60
WIPP	0.03	0.54	0.32	2.30	0.33	3.16
	Mean	2s	Mean	2s	Mean	2s
	0.05	0.07	0.14	0.35	0.28	1.48

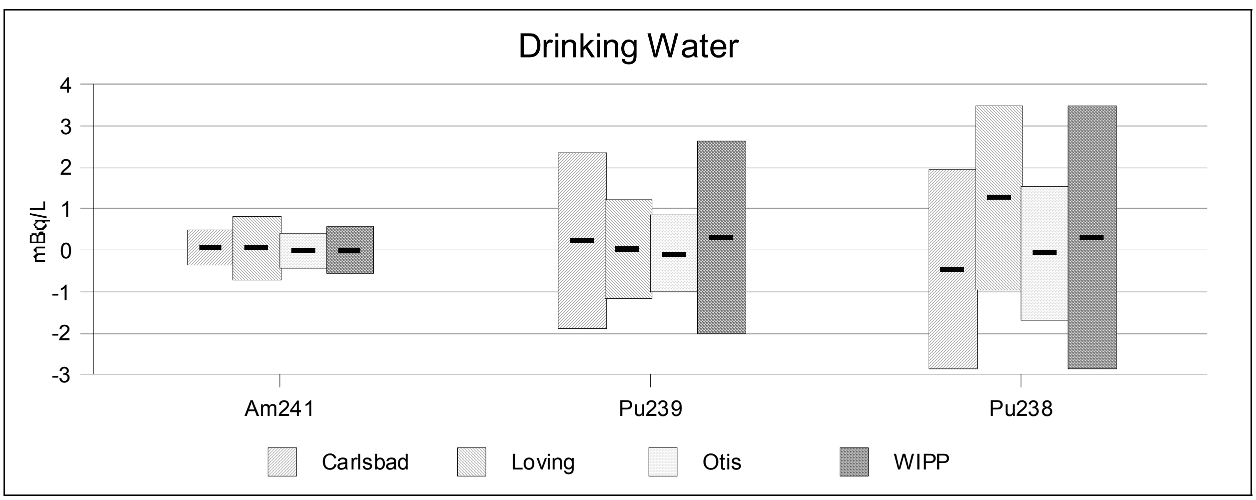

Figure B5. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Drinking Water During 2002

Table B6. ^{137}Cs and ^{90}Sr Measurements in Drinking Water During 2002

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	37.31	98.49	9.67	35.87
Loving	46.77	98.05	28.97	34.68
Otis	43.15	97.99	82.31	37.41
WIPP	31.74	98.94	106.53	44.94
	Mean	2s	Mean	2s
	39.74	13.22	56.87	90.33

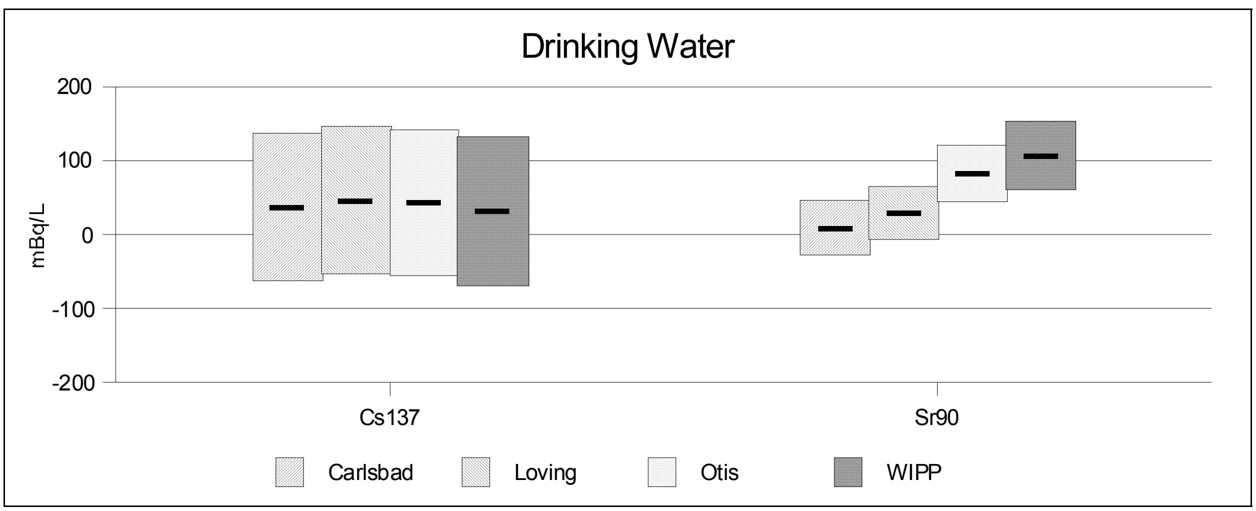

Figure B6. ^{137}Cs and ^{90}Sr Measurements in Drinking Water During 2002

APPENDIX C. MATRIX BLANK DATA

Table C1. Matrix Blank Results for the 2002 Sampling Period

Matrix Blank ID	^{241}**Am**	$^{239/240}$**Pu**	^{238}**Pu**	^{241}**Pu**	^{137}**Cs**	^{90}**Sr**
FAS (Effluent)	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite
FMB-030207	1.40E-05	4.00E-06	3.90E-05	-9.41E-03		4.38E-02
FMB-030307	-4.60E-05	8.20E-05	-1.17E-04			3.61E-02
FMB-030324	1.50E-05	4.30E-05	-3.90E-05			
FMB-021031	-6.20E-05	8.20E-05	-1.56E-04			
FMB-02232					-1.80E-03	
FMB-03037					1.46E-02	
FMB-000209				4.48E-03		
FMB-000922				-2.88E-03		
FMB-000306				-4.47E-03		
FMB-03043					-3.53E-03	
FMB-030530						1.53E-02
FMB-030324						3.63E-02
Mean	-1.98E-05	5.28E-05	-6.83E-05	-3.07E-03	3.08E-03	3.29E-02
2s	8.02E-05	7.47E-05	1.73E-04	1.15E-02	2.00E-02	2.45E-02
LVAS (Ambient)	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite
LMB-021218	-3.02E-04	6.08E-05	-5.53E-05			5.57E-02
LMB-021209					3.68E-03	
LMB-030106	2.07E-06	6.44E-06	-6.44E-05			4.27E-02
LMB-030429	-4.3E-05	1.65E-04	-5.34E-05	-3.00E-03		1.18E-01
LMB-030506					2.47E-02	
LMB-030508				-3.13E-03		9.05E-03
LMB-981006				3.78E-03		
LMB-980413				1.63E-03		
Mean	-1.14E-04	7.76E-05	-5.77E-05	-1.81E-04	1.42E-02	5.65E-02
2s	3.28E-04	1.62E-04	1.18E-05	6.88E-03	2.97E-02	9.15E-02
Water	Bq/L	Bq/L	Bq/L		Bq/L	Bq/L
WMB-020319	-1.72E-04	1.96E-04	0.00E+00		8.90E-03	
WMB-020416	2.63E-04	1.30E-04	-1.18E-04		1.19E-02	
WMB-020809	3.75E-05	-2.70E-04	3.00E-04		7.53E-02	3.86E-02
WMB-020905		2.44E-05	-4.89E-04		2.62E-02	
WMB-021015						5.28E-02
Mean	4.28E-05	2.00E-05	-7.66E-05		3.06E-02	4.57E-02
2s	3.80E-04	8.14E-04	1.24E-03		5.33E-02	2.57E-02

APPENDIX D. EEG TLD PROGRAM DESCRIPTION AND 2002 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 fluoride 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):

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

where x_i is the value of each chip
0 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):

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

2002 TLD DATA

The reported value and uncertainty for each control and environmentally deployed TLD in calendar year 2002 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 2002 (Millirem per Quarter)

TLD Badge Location(a)	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter	
	Dose	Uncert. (2σ)	Dose	Uncert. (2σ)	Dose	Uncert. (2σ)	Dose	Uncert. (2σ)
1	20	1.1	19	1.9	15	1.0	21	0.9
2	22	0.6	18	1.6	15	0.7	20	0.7
3	20	2.4	20	5.5	13	0.7	21	0.9
4	22	0.9	23	7.8	14	1.4	20	0.0
5	21	1.4	19	2.4	14	1.0	20	0.7
6	20	1.6	22	6.7	14	1.2	19	1.1
7	22	0.7	19	3.0	16	1.4	20	0.7
8	19	1.2	19	0.9	16	1.4	17	0.0
Control	**20**	**2.0**	**20**	**2.3**	**18**	**1.7**	**20**	**0.7**

(a) See Figure D1 for badge location

Lower Limit of Detection (LLD)

The average of the four control badges was 19.5 mrem/quarter and the standard deviation (1σ) was 1.0 mrem/quarter. Thus, the LLD is 3.7 mrem/quarter. The average and standard deviation of the 8 TLDs at the WIPP Site was 18.75 ± 2.76 mrem/quarter.

None of the TLDs in 2002 exceeded the LLD (which would have been a gross value of 23.2 mrem/quarter).

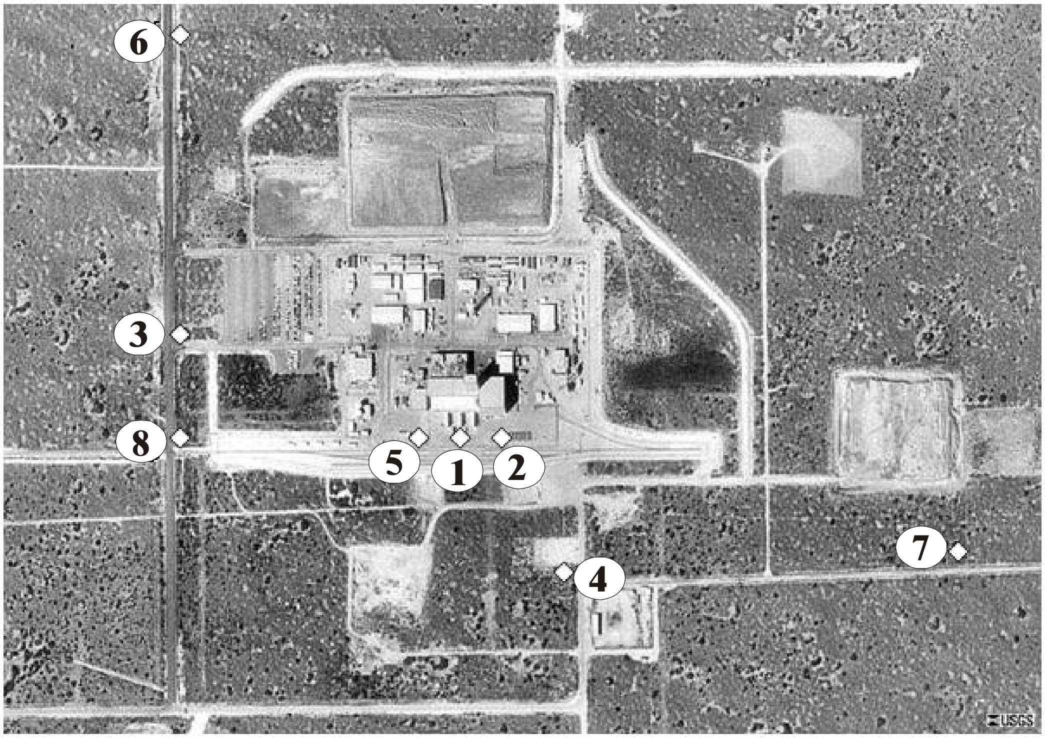

Figure D1. TLD Locations and Numbers

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.

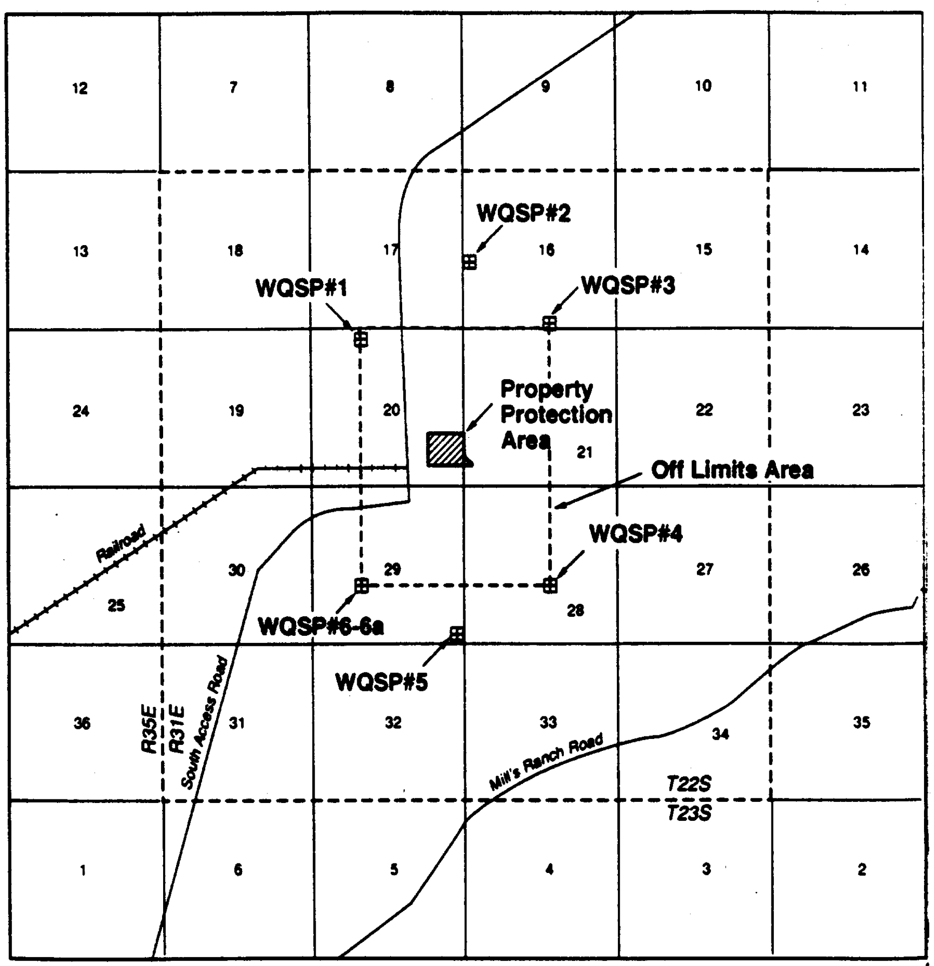

Figure E1. Groundwater Sampling Locations

Surface Water and Drinking Water

Surface water samples were collected at seven 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.

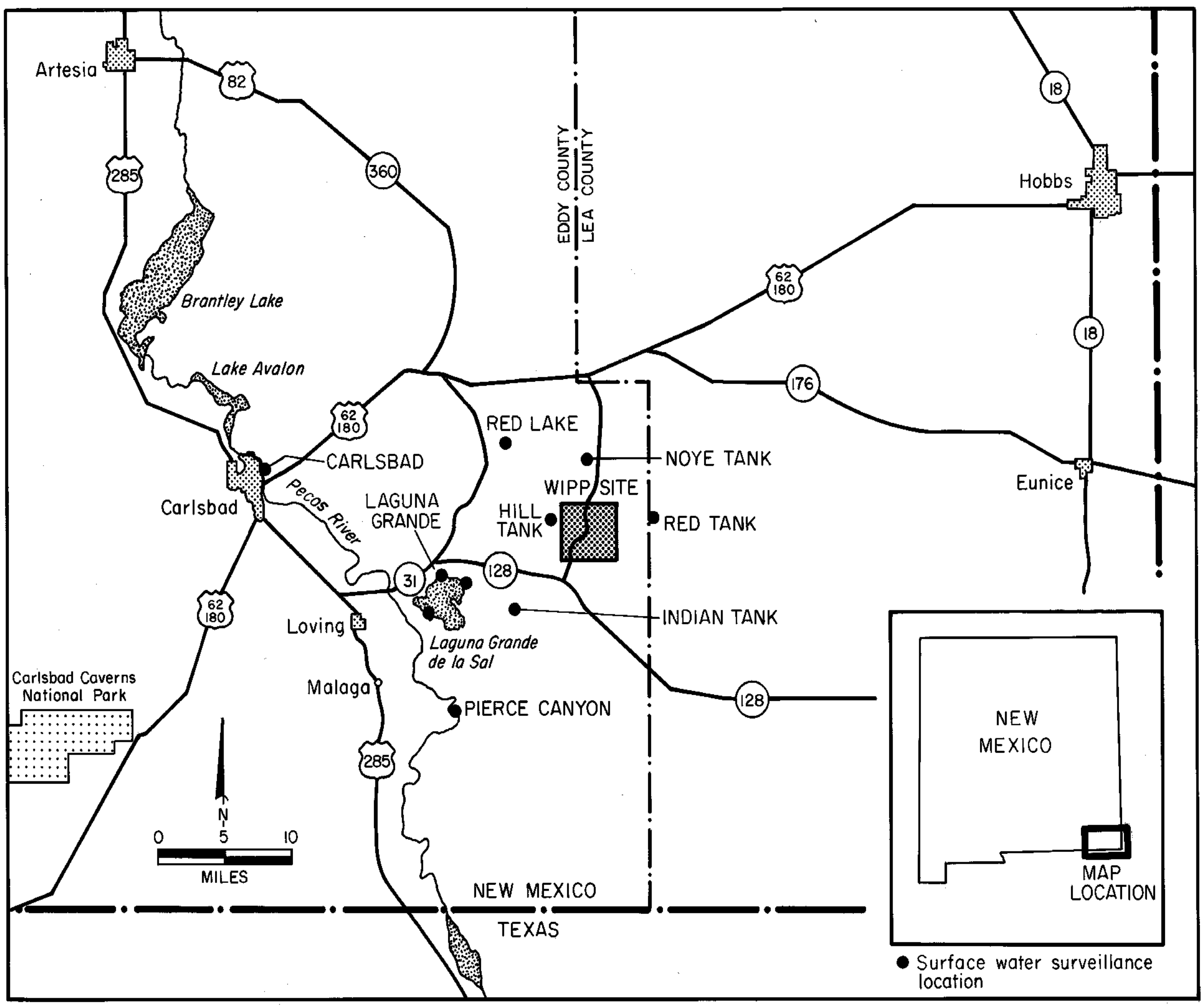

Figure E2. Surface Water Sampling Locations

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		MDA (mBq/sample)	Action Level* (mBq/sample)
		Value	Unit		
Fixed Air Samples (Station A – Monthly Composites)					
^{241}Am	4	260	nBq m^{-3}	0.65	1.5
^{239,240}Pu	4	160	nBq m^{-3}	0.41	1.6
^{238}Pu	4	245	nBq m^{-3}	0.61	0.8
^{241}Pu	4	11	μBq m^{-3}	27	28(9)
^{137}Cs	3	18	μBq m^{-3}	46	62
^{90}Sr	4	28	μBq m^{-3}	71	48
Fixed Air Samples (Station B – Quarterly Composites)					
^{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
^{241}Pu	9	9	μBq m^{-3}	65	28(9)
^{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
^{241}Pu	4	0.6	μBq m^{-3}	16	9.0(39)
^{137}Cs	29	6.0	μBq m^{-3}	150	64
^{90}Sr	19	8.5	μBq m^{-3}	213	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.

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 :Bq (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

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EEG-2 Review Comments on Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico SAND 78-1596, Volume I and II, December 1978.

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EEG-6 Geotechnical Considerations for Radiological Hazard Assessment of WIPP. A Report of a Meeting Held on January 17-18, 1980, April 1980.

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