EEG-73

PREOPERATIONAL RADIATION SURVEILLANCE OF THE WIPP PROJECT BY EEG FROM 1996 - 1998

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Environmental Evaluation Group
New Mexico

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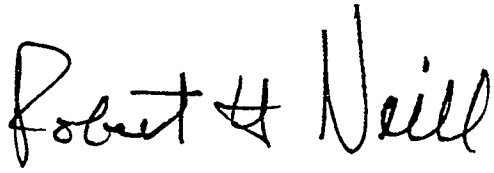
October 1999

DISCLAIMER

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. 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 EEG to the New Mexico Institute of Mining and Technology and continued the original contract DE-AC04-79AL10752 through DOE contract DE-ACO4-89AL58309. 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 of the suitability of the proposed site; the design of the repository, its planned operation, and its long-term integrity; suitability and safety of the transportation systems; suitability of the Waste Acceptance Criteria and the compliance of the generator sites with them; and related subjects. These analyses include assessments of reports issued by the DOE and its contractors, other federal agencies and organizations, as they relate to the potential health, safety and environmental impacts from WIPP. Another important function of EEG is the independent environmental monitoring of background radioactivity in air, water, and soil, both on-site and off-site.



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ACRONYMS

ACTL	Action Level
Am	Americium
ANSI	American National Standards Institute
bgs	Below Ground Surface
Bq	Becquerel
C & C	Consultation and Cooperation
CFR	Code of Federal Regulations
cps	Counts per second
Cs	Cesium
deg	Degrees
DOE	U. S. Department of Energy
DQO	Data quality objectives
EEG	Environmental Evaluation Group
EML	Environmental Measurements Laboratory
EPA	U. S. Environmental Protection Agency
FAS	Fixed air sampler
FPM	Field Procedures Manual
ft	Feet
GPS	Global Positioning System
in	Inch
ha	Hectare
HEPA	High efficiency particulate air
ISO	International Organization for Standardization
KeV	Thousand electron volts
km	Kilometer
LANL	Los Alamos National Laboratory
LPM	Laboratory Procedures Manual
LVAS	Low volume air sampler
m	Meter
mm	Millimeter
MBL	Mean baseline
MDA	Minimum detectable activity
MDC	Minimum detectable concentration
mi	Mile
min	Minute
mrem	Millirem
NCRP	National Council on Radiation Protection and Measurements
NIST	National Institute of Standards and Technology
NRIP	NIST Radiochemistry Intercomparison Program
NRC	U. S. Nuclear Regulatory Commission

Pu	Plutonium
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QC	Quality control
RH-TRU	Remote handled transuranic
ROI	Regions of interest
sec	Seconds
Sr	Strontium
Sv	Sievert
TDS	Total dissolved solids
Th	Thorium
TLD	Thermoluminescent dosimeter
TPU	Total propagated uncertainty
TRU	Transuranic
U	Uranium
WHB	Waste Handling Building
WID	Waste Isolation Division of Westinghouse Electric Corporation
WIPP	Waste Isolation Pilot Plant
WQSP	WIPP Groundwater Quality Surveillance Program
y	Year

EXECUTIVE SUMMARY

Average ^{241}Am, $^{239+240}Pu$ and ^{238}Pu concentrations measured by Environmental Evaluation Group (EEG) in ambient air near the Waste Isolation Pilot Plant (WIPP) site during 1996, 1997 and 1998 are consistent with similar data collected by the Waste Isolation Division of Westinghouse (WID) and measurements from northern New Mexico by the U. S. Environmental Protection Agency (EPA) and Los Alamos National Laboratory (LANL).

Through the use of replicate analyses of matrix blanks, minimum detectable activity (MDA), minimum detectable concentration (MDC) and action levels (ACTL) were established for the EEG measurement system. Screening models contained in NCRP Report #123 and current MDC for fixed air sample (FAS) filters indicate the EEG sampling and measurement methodology is capable of detecting chronic effluent air emissions from WIPP which are approximately 1000 times below the 40 CFR 191 Subpart A (US EPA 1990a) limit of $2.5E^{-4}$ Sv/y (25 mrem/y) and 40 CFR 61 Subpart H (US EPA 1990b) limit of $1.0\ E^{-4}$ Sv/y (10 mrem/y). A similar calculation using the NCRP worksheet with storm water effluent MDCs indicated the EEG measurement system can detect actinide releases that are approximately 20 times below the dose limits in 40 CFR 191 Subpart A.

Action levels were established to determine a level of radionuclide activity which, if exceeded would initiate an investigation into the radiochemical process to determine the validity of the measurement. Investigation would include a check for cross-contamination, review of calculations, and recount of the sample.

The EPA guidance for implementation of 40 CFR 191 Subpart A (US EPA 1997) states the EPA expectation that monitoring of radionuclide emissions should be capable of detecting one tenth of the 25 mrem/y public dose limit. Data in this report indicate that the EEG monitoring program is capable of measuring such levels.

This is the last pre-operational data report to be issued since WIPP became operational in March 1999. Data contained in this report and previous pre-operational reports form the radionuclide baseline against which future operational measurements can be compared.

The EEG internal and external quality control (QC) programs reflect the quality of environmental measurements contained in this report. Through the analysis of external National Institute of Standards and Technology (NIST) and Environmental Measurements Laboratory (EML) samples the required precision and accuracy is demonstrated.

1.0 INTRODUCTION

The Environmental Evaluation Group's (EEG) radiological surveillance program's purpose is to independently measure background radioactivity in air, water and soil at the Waste Isolation Pilot Plant (WIPP) and in surrounding communities. The WIPP has been certified by the U. S. Environmental Protection Agency (EPA) as a repository for the disposal of transuranic (TRU) radioactive waste resulting from defense activities of the United States.

EEG began environmental monitoring in 1984 under the terms of the July 1981 Consultation and Cooperation (C & C) Agreement and the December 1982 Supplemental Stipulated Agreement (NM v. US DOE 1982) which is summarized in Appendix A.

Program objectives are to verify the accuracy and precision of the Department of Energy's (DOE) environmental program (Spiegler 1984). Previously published pre-operational data are in Kenney et al. (1990), Kenney and Ballard (1990), Kenney (1991), Kenney (1992), Kenney (1994) and Kenney et al. (1998). Environmental samples are independently collected by EEG, although some water samples and effluent air samples are collected with the cooperation and assistance of the Westinghouse Electric Corporation Waste Isolation Division (WID), the DOE's management and operating contractor for WIPP site activities.

Environmental samples were originally analyzed by independent laboratories not affiliated with the DOE. However, in 1993 the EEG established a radiochemical laboratory because of high variability in results from commercial laboratories (Rodgers and Kenney 1997). Subsequently, the EEG helped establish a laboratory intercomparison program with the National Institute of Standards and Technology (NIST). The intercomparison program helps participating laboratories to maintain a high level of accuracy and precision in radiochemical analyses.

Although the present environmental monitoring program is based on the 1982 Supplemental Stipulated Agreement, monitoring capabilities have been greatly enhanced by the addition of on-site air sampling, including daily samples from the underground effluent exhaust system.

The EEG screens the daily air samples for radioactivity and will collect special samples if a radiological release is suspected. After screening, the daily sample filters are composited by calendar quarter for more sensitive radiochemical analysis. The on-site sampling provides the best assurance that no radioactive releases have occurred. Air and water samples were obtained from nearby communities. The more distant sampling provides an indiction of environmental radioactivity variations in southeast New Mexico. Community sampling is also useful in discriminating non-WIPP radioactivity, such as occurred from Chernobyl nuclear fallout in 1986.

2.0 WIPP SITE INFORMATION

2.1 Radioactive Waste Inventory

Under terms of the Waste Isolation Pilot Plant Land Withdrawal Act, Public Law 102-579 (US Congress 1992) the facility is limited to a maximum waste volume capacity of 176,000 m^3 (6.2 million cubic feet) and a maximum remote handled transuranic (RH-TRU) volume capacity of 7,080 m^3 (250,000 ft^3). The Land Withdrawal Act of 1992 limits the RH-TRU activity to 5.1 million curries.

2.2 Regulatory Requirements

The U.S. Environmental Protection Agency (EPA) regulates offsite doses from the WIPP site (US EPA 1990a). Subpart A of 40 CFR 191 established a regulatory limit for the combined annual radiation doses to the public of 25 mrem to the whole body and 75 mrem to critical organs. The effective dose from WIPP emissions will be limited by the requirements of 40 CFR

191 Subpart A and 40 CFR 61 Subpart H. The EPA regulations apply to routine emissions from the WIPP operations.

2.3 General Area

The WIPP facility is located in Eddy County in southeastern New Mexico, approximately 42 km (26 mi) east of Carlsbad (Figure 1). The facility is located on a sandy plain at an elevation of 1,040 m (3,410 ft) above sea level. Prominent surface features near the facility include the Livingston Ridge and Nash Draw, about 8 km (5 mi) west of the facility. Nash Draw is a shallow drainage course between 8 km (5 mi) and 18 km (11 mi) in width, characterized by surface impoundments of brine water. Livingston Ridge is a bluff that marks the eastern edges of Nash Draw. Other prominent features of the region include the Pecos River, located about 22 km (14 mi) west of the facility, and the Carlsbad Caverns National Park about 68 km (42 mi) west-southwest of the WIPP facility.

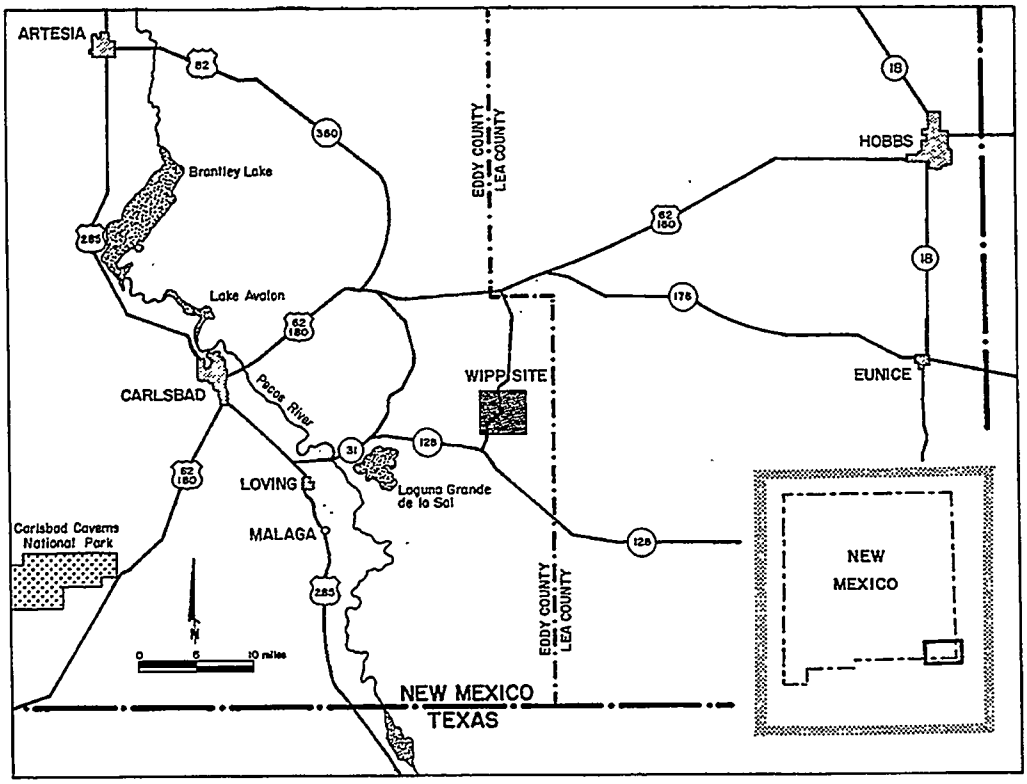

Figure 1. Location of the WIPP Site

The nearest population centers are the village of Loving (population 1,500) located 29 km (18 mi) southwest of the facility, and the city of Carlsbad (population 28,400) located 42 km (26 mi) west of the facility. Other New Mexico towns within an 80 km (50 mi) radius include Artesia, Eunice, Hobbs, Jal, and Lovington.

The climate in the region of the facility is semi-arid with an average annual precipitation in Carlsbad of 338 mm (13.3 in) based upon data collected between 1961 and 1990. During 1996, 1997 and 1998 the Carlsbad FAA airport reported precipitation that averaged 325 mm per year (12.8 in per year) (US DOC 1996, 1997 and 1998). Much of the precipitation falls during intense thunderstorms in the spring and summer. Winds are predominantly from the southeast toward the northwest (US DOE, WIPP 1991).

2.4 WIPP Site

Surface structures of the facility are located in sections 20 and 21 of township 22 south, range 21 east, in Eddy County, New Mexico. The surface areas around WIPP are divided into several areas (US DOE, WIPP 1999) as indicated in Figure 2. The "property protection area" is 14 ha (35 acres) and contains most of the surface structures associated with WIPP. This area is enclosed by a chain link fence and patrolled by security guards to maintain restricted access. The "exclusive use area" encompasses 171 ha (424 acres), surrounds the property protection area and is marked with a barbed wire fence. The "off-limits area" is the next larger subdivision encompassing 587 ha (1,450 acres) and is posted as a no trespassing area. The 4,144 ha (16 square mile) outermost facility boundary surrounding the exclusive use area is the "WIPP site boundary".

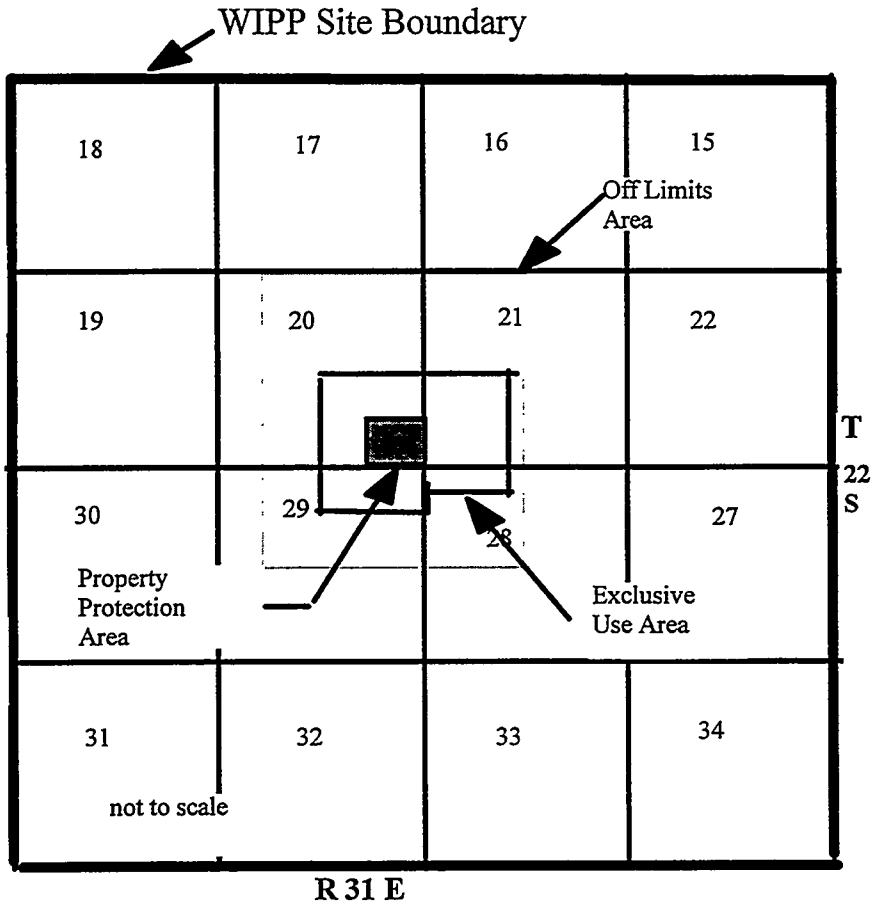

Figure 2. Zones at the WIPP Site

2.5 Geology and Subsurface Hydrology

Geologically, the WIPP repository horizon is situated at a depth of 655 m (2,150 ft) below land surface in the Permian Age Salado Formation (Figure 3). The Salado is a 610 m (2,000 ft) thick bedded-salt formation overlain by the Rustler Formation. The Rustler Formation consists of anhydrite and siltstone beds and contains two water-bearing zones, the Magenta and Culebra Dolomites, at 170 m (568 ft) and 205 m (672 ft) below land surface, respectively. Each of these is approximately 7.5 m (25 ft) thick. Transport in the water-bearing units of the Rustler Formation has been treated as the main potential hydrologic pathway to the biosphere from the repository. The Culebra Dolomite is considered to be the most important hydrologic pathway for

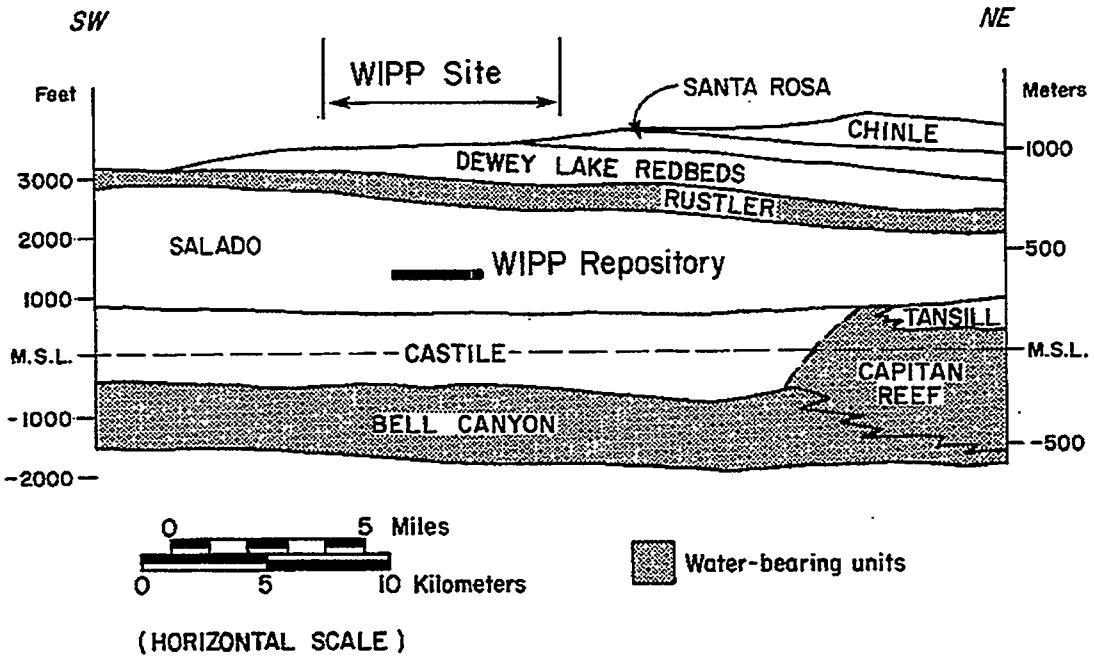

Figure 3. Stratigraphy of the WIPP Site

release calculations because it is the most transmissive unit in the area. An interpretation (Sandia 1989) of the Culebra freshwater-head data indicates a southerly flow across the WIPP site. The flow turns to the southwest south of the site. Radiological baseline data for the Culebra are being collected because of their importance to long-term release scenarios.

Chaturvedi and Channell (1985) suggested that the two major discharge points for waters from the Rustler Formation, which overlies the WIPP repository, are the Pecos River in an area known as Malaga Bend and Laguna Grande de la Sal. The Laguna Grande de la Sal receives flow from several springs along the margin of the lake. Potentiometric contours for various zones within the Rustler point to the Laguna Grande de la Sal as a secondary discharge point for the Rustler water. Because the Rustler Formation lies directly above the Salado Formation which contains the WIPP repository, EEG includes water samples from the discharge areas of the Rustler Formation in the radionuclide baseline program.

2.5.1 Water in the Dewey Lake Redbeds and Santa Rosa Formation Near the WIPP Shafts

Inflow of water in the exhaust shaft has been observed at least since 1995 and it has increasingly interfered with the air sampling operations at Station A. The WIPP project conducted investigations in 1996 (INTERA 1997) and 1997 (DE&S 1997) to estimate the quality and the extent of the shallow groundwater in the vicinity of the shafts. Four boreholes (C-2505, C-2506, C-2507, and ES-001) penetrated water-bearing horizons between 48 and 63 feet below ground surface (bgs) in the lower Santa Rosa Formation sandstones and the upper Dewey Lake Redbeds Formation mudstones; the three C series holes were completed as monitoring and testing wells. C-2505 and C-2506 are within 25 feet of the exhaust shaft, while C-2507 is located 200 feet south of the exhaust shaft. In addition, twelve 2-inch diameter piezometers were installed to depths of up to 82 feet bgs in the area bounded by the four WIPP shafts to study the areal extent, water quality, and water level in the shallow subsurface in this area.

Water levels in the wells C-2505, C-2506, and C-2507 were 44.8 ft, 44.7 ft, and 42.5 ft bgs respectively (approximately 3370 ft above mean sea level) in October 1996, and rose 1.6 to 2.6 ft in the next 5 months. Water stood in 11 out of 12 piezometers at about the same depth; one piezometer (PZ-8) was dry.

Total dissolved solids (TDS) in the water in these wells ranged from 11,500 mg/l in C-2506 to 4000 mg/l in C-2507 when tested in October 1996. The water samples collected in February 1997 showed lower TDS concentrations compared with the October 1996 values. In C-2506 the TDS decreased from about 11500 to 6000 mg/l, while in C-2505 the TDS decreased from about 8500 to 4500 mg/l (DE&S 1997, p. 7). The average sustainable pumping rate for the wells and the piezometers was about 0.6 gpm (DE&S 1997, p. 66).

Based on the absence of water in this zone during the inspection of the exhaust shaft in 1984, the project has hypothesized that the recharge to the lower Santa Rosa/upper Dewey Lake Redbeds zone has occurred since 1984 (DE&S 1997, p. 77).

The investigation concluded that the source of water in the shaft may be the groundwater in the lower Santa Rosa/upper Dewey Lake Redbeds Formations in the shaft area.

> The data obtained from the installation, sampling, and testing associated with wells C-2505, C-2506, and C-2507 indicate that a water-saturated horizon is present in the lower Santa Rosa/upper Dewey Lake Formations in the depth range where water is leaking into the exhaust shaft (50 to 80 feet bgs). (INTERA 1997, p. 23)

With respect to the lateral extent of the water-bearing zone, the investigation concluded:

> Of the twelve piezometers and three wells installed at WIPP between September 1996 and August 1997, only PZ-8 is dry. In every other monitoring well water is present, indicating that the investigative area bounded by PZ-11 to the north and west, PZ-12 to the south, and PZ-9 to the east appears saturated with water (figure 4.1). The area defined by those boundaries is approximately 80 acres in size. It is also likely that the saturated area is significantly larger than the present 80- acre investigative area, but in order to clearly define the areal extent of water within the Santa Rosa Formation additional boreholes would have to be drilled. (DE&S 1997, p. 69)

2.6 Area Industries

Three ranches (Mills, Smith, and Mobley) have property in the vicinity of the WIPP facility. The Mills ranch headquarters is located 5.6 km (3.5 mi) south-southwest of the facility center, the Smith headquarters is 8.8 km (5.5 mi) west-northwest of the facility, and the Mobley ranch is 9.6 km (6 mi) southwest of the facility. Several earthen rain water catchment tanks used for cattle watering are located near the WIPP site. Noya, Hill, Indian and Red tanks collect water over a large area that is subject to atmospheric fallout and are ideal environmental sampling points.

Although there are no dairies within 40 kilometers (25 miles) of the WIPP facility, a large amount of alfalfa is grown in the Pecos Valley between Roswell and Malaga, New Mexico. The

alfalfa crop is used in cattle feeding operations mainly in New Mexico and Texas. Cotton and pecans are the other major crops grown in the Pecos Valley.

Several potash mining operations are located in the area of Nash Draw. DOE purchased all potash leases within the 16 sections comprising the WIPP facility. However, there are two active oil and gas leases in the southwest corner of the WIPP site. One lease is in the north-half of section 31 and the other is in the south-half of section 31, T-22-S, R-31-E (Silva and Channell 1992). These two oil and gas leases are at depths greater than 6,000 feet and are part of the James Ranch Unit.

2.7 Gnome Site

In 1961 the Atomic Energy Commission detonated a nuclear device 370 m (1216 ft) below land surface at the Gnome Site which is located approximately 8.8 km (5.5 mi) southwest of the WIPP Site boundary. The Gnome Project was part of the Plowshare Program to demonstrate the peaceful use of atomic energy. Following detonation fission products vented from the underground for more than 24 hours. In 1994, an EEG environmental survey of the plume fallout area measured ^{241}Am, ^{238}Pu, and $^{239+240}Pu$ particulate contamination and slightly elevated ^{137}Cs contamination on the ground surface (Kenney et al. 1995).

3.0 ENVIRONMENTAL PROGRAM DESCRIPTION

While the WID has a broad radiation surveillance program, the EEG program is focused on elements designed to maintain public confidence that there are no significant radioactive releases from the WIPP, and that WIPP radionuclides are not present in key air and food chain pathways. The current EEG preoperational environmental sampling and analytical plan is shown in Table 1. The four major elements of the program are air, surface water, groundwater and facility effluent sampling. At present, soil and vegetation samples are not routinely acquired and analyzed.

Table 1. EEG Preoperational Radiological Sampling and Analysis Plan

Environmental Medium	Location	Sample/Analysis Frequency	Parameter
Air	3 off-site and 3 on-site low volume air sampler locations	Continuously/ Quarterly Composite	^{238}Pu, $^{239+240}Pu$, ^{241}Am, ^{137}Cs
Surface Water	Pecos River 2 locations Laguna Grande de La Sal Surface stock tanks 5 locations	Annually/Annually	^{238}Pu, $^{239+240}Pu$, ^{241}Am
Groundwater	7 wells	Annually/Annually	^{238}Pu, $^{239+240}Pu$, ^{241}Am
Municipal Drinking Water	4 systems	Annually/Annually	^{238}Pu, $^{239+240}Pu$, ^{241}Am
WIPP Air Effluent	2 underground ventilation exhaust (Stations A & B)	Continuously/ Quarterly Composite	^{238}Pu, $^{239+240}Pu$, ^{241}Am, ^{137}Cs
WIPP Storm Water Effluent	WIPP Zone I effluent	Annually/Annually	^{238}Pu, $^{239+240}Pu$, ^{241}Am
Soil	3 on-site	Annually/Annually	^{238}Pu, $^{239+240}Pu$, ^{241}Am

Note: The results of soil samples collected and analyzed during a study of the Gnome site can be found in EEG Report #58 (Kenney et al. 1995).

3.1 Program Overview

The three air samplers on the WIPP site are located in the most prevalent downwind directions from the facility, and although they might be useful in confirming accidental releases, the primary purpose is to obtain baseline data. One sampler is located within the property protection area (Figure 2). Air samplers near population centers are also important in documenting the variability of the radioactivity background, and provide a measure of confidence radionuclides disposed at WIPP are not present in the area.

Surface water samples are taken from stock watering tanks (rain catchment ponds), the Pecos River and Laguna Grande de la Sal. The tank sample data are important for baseline

radioactivity and animal-to-man food chain analyses. If a radioactive air plume were released at the WIPP, the tanks provide important sampling points. It is unlikely that radioactivity from WIPP would enter the Pecos River or Laguna Grande de la Sal, but these sampling site data are useful for long-term monitoring and public assurance and verification that there is no increase in the amount of radionuclides common to those in WIPP at these locations. Groundwater and municipal drinking water samples are also routinely acquired. These sampling locations are not likely to be affected by any WIPP radioactivity releases, but because water is a primary vector in the food chain, the samples are collected and analyzed.

An accidental release from the underground air effluent, through the exhaust stack, is the most likely pathway for accidental radioactivity releases from the WIPP. These scenarios are postulated in the WIPP Safety Analysis Report (US DOE, WIPP 1999). If an underground operations accident were to occur, air samples would be collected from Stations A and B, the final release points of the underground repository exhaust ventilation. Hence, the EEG collects sampling filters from Station A each day, screens the filters for radioactivity, and performs the more sensitive radiochemical analyses on a composite of all filters collected during each quarter. The daily sampling program allows documentation of the variability of radioactivity background and trends.

Storm water runoff is collected from areas that could potentially become contaminated from residues on transport vehicles or TRUPACT-II containers or atmospheric fallout. These samples establish a background needed to determine whether there has been contamination spread by storm water runoff.

From time to time, soil and vegetation samples will be taken to verify WIPP measurements and to establish the variability of background radioactivity. The EEG tested techniques and methods in a limited study at the Gnome site. The results of this study were reported in EEG-58 (Kenney et al. 1995).

3.2 Radionuclides of Interest

Prior to 1993 environmental samples were sent to a commercial laboratory and analyzed for ^{238}Pu, $^{239+240}Pu$,, ^{241}Am ^{137}Cs, $^{233+234}U$, ^{235}U, ^{228}Th, ^{230}Th, ^{232}Th and ^{90}Sr . In 1993 EEG developed its own radiochemical laboratory. For samples collected after 1992 this list was reduced to ^{238}Pu, $^{239+240}Pu$, ^{241}Am ^{137}Cs. The radionuclides in the present analytical suite, with the addition of ^{90}Sr, account for greater than 98% of the potential public radiation dose from WIPP operations (US DOE, CAO 1996). Other radionuclides may be added to the laboratory analysis, depending on the WIPP inventory and their potential value as environmental indicators. All sample analyses for this report were performed in EEG's radiochemistry laboratory.

3.3 WIPP Effluent Monitoring

Unfiltered exhaust air from the underground repository is the most important WIPP effluent. The exhaust air is normally unfiltered because of the mine safety requirement for high underground air ventilation. The nominal underground exhaust air flow is 200 m^3/s (425,000 scfm) and is reduced to 28 m^3/s (60,000 scfm) when two banks of high efficiency particulate air (HEPA) filters are employed (US DOE, WIPP 1999).

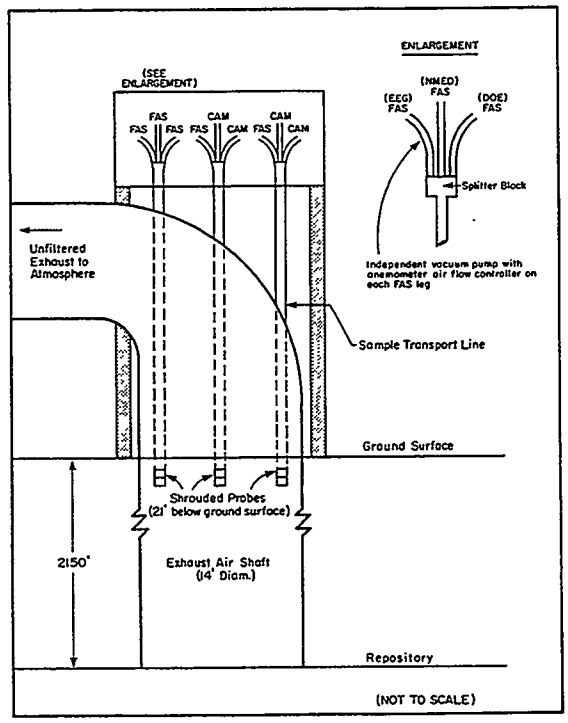

Figure 4. Station A

EEG collects sampling filters each day from a fixed air sampler (FAS) located in Station A. Sample lines with specially designed shrouded probes extend into the exhaust shaft as shown in Figure 4. Tests of the shrouded probe confirmed that this configuration allows collection of representative air samples (McFarland 1993). However, these tests were conducted with dry probes and transport lines. Particulate samples collected during wet conditions may not be

representative as defined in ANSI/HPS N13.1-1999 (ANSI 1999). Thus, there is a potentially large source of random sampling error associated with the presence of moisture in the exhaust shaft.

3.3.1 Problem of Water in the Exhaust Shaft

Observation of video inspections since 1995 show that water droplets enter the shrouded probe and transport line and often wet the air filter which causes loss of air flow through the filter. Air sample flow through the shrouded probe must be maintained between 136 l/min (4.8 scfm) and 204 l/min (7.2 scfm) to maintain an adequate transmission of particulates (McFarland 1993). During 1996 through 1998 air samples could be collected only 78% of the time available. The loss of sampling was the result of power-outages (planned and unplanned), wet filters, maintenance and other causes.

As described in Section 2.5 of this report, the source of water seeping in the shaft appears to be the groundwater which has saturated the sandstones and the mudstones of the lower Santa Rosa and upper Dewey Lake Redbeds Formations at a depth below approximately 50 feet bgs in a large area in the central part of the WIPP site. An inspection team of WID estimated the flow rate from a stream of water seen leaking into the shaft in the March 22, 1995, video recording to be 0.2 gpm (288 gpd). The WID inspection team noted that the water leaking into the shaft dries up by the dry air rising through the shaft:

> Note that the underground exhaust fans cause significant evaporation/atomization of the water droplets. Therefore only a small amount of this stream reaches the WIPP underground and is available to leach out lead from the lead packing existing in the exhaust shaft well. (Westinghouse 1995).

The November 10, 1995, minutes of the WID Working Committee to Resolve Underground Water Issues (Westinghouse 1995) also reported that the studies conducted by Texas A&M University indicated that "condensation from relative humidity is an insignificant contributor to the droplet formation in the Exhaust Shaft."

WID hypothesized in 1996, however, that the source of water in the exhaust shaft may be from condensation of humid air during its passage through the shaft and published the results of an investigation to check this hypothesis in October 1996 (Westinghouse 1996). The investigation consisted of analysis of psychrometric data for two one-week periods, January 23-27, 1995, and July 17-21, 1995, representing a winter and a summer week. The results of this analysis are presented in Graph 3.3.1 of Westinghouse (1996), reproduced here as Figure 5. The graph shows the calculated precipitation in the shaft for the two one-week periods, the solid line representing the analysis of the January data and the broken line for the July data. The zero on the Y-axis (Gal/Min) represents neither precipitation nor evaporation. The positive numbers above the zero line represent calculated precipitation from condensation of humid air in the shaft and the negative numbers below the zero line represent evaporation of the water flowing in the shaft due to the passage of dry air through the shaft. Note that except a single point from the July data, all points from both weeks indicate the results to be in the negative region. The graph shows that, except on July 18, 1995, the air passing through the shaft during the two week test periods *evaporated* (not *precipitated*) between 1 and 5 gallons per minute of water from the shaft.

The following conceptual picture of the origin of water in the exhaust shaft emerges from the video recordings in the shaft, the results of shallow groundwater testing by three wells and 12 piezometers, and the results of the analysis of psychrometric data.

The water is leaking in the shaft starting at a depth of approximately 50 feet below the ground surface through cracks in the shaft liner. The walls of the shaft are wet from this depth downward. Some water flows under gravity down the wall of the shaft and some through fractures in the grout, emerging as a stream where fractures bring it into the shaft. The video recording of March 22, 1995, shows one such stream at about 105 feet below the top measuring point for the depth of the camera, or approximately 75 feet below the ground surface. Frequent video recordings made by WID have shown continued flow of water into the shaft. During a recording observed by the EEG personnel on June 3, 1999, it appeared to be raining in the shaft

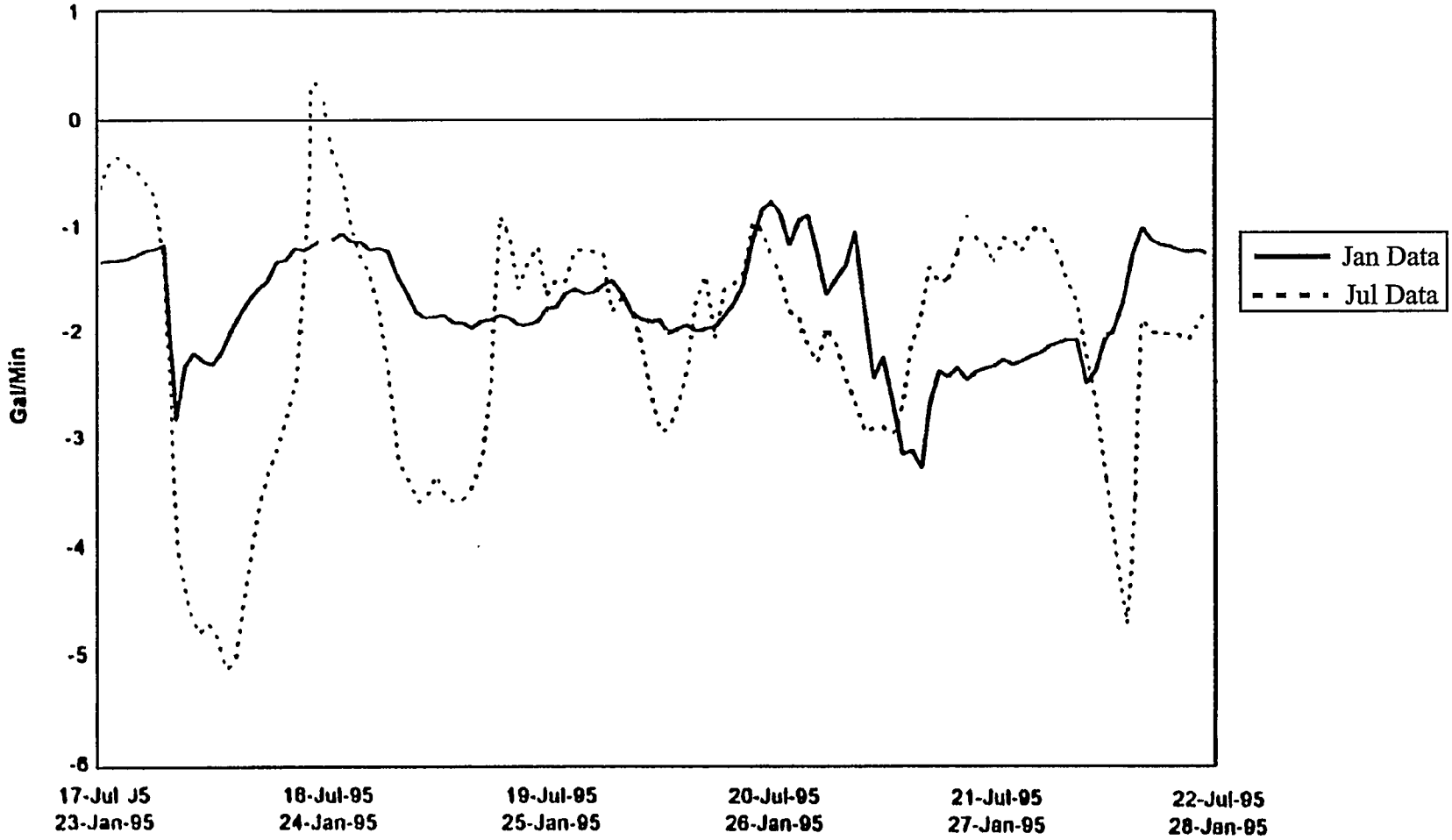

Figure 5: Calculated Precipitation in the Exhaust Shaft at the WIPP (DOE/WID 96-2208)

and the camera had to be repeatedly pulled out to clean and dry the lens. Rising air creates droplets of this water which mix with salt dust and coat the filters at Station A with a wet salt layer. More water collects in the bottom sump of the shaft when the airflow through the shaft is low, less when the airflow is high. On occasional exceptionally humid days, even high airflow may not dry up the water, and in fact on rare occasions, may contribute to it through condensation of humid air passing through the shaft.

This conceptual model explains the wide variability in the weekly collection of water from the sump. According to the two year (January 1997 and January 1999) data provided by DOE to EEG in January 1999, a reported maximum of 1,265 gallons were collected during the week ending on August 10, 1998, and a minimum of 30 gallons during the week ending on June 23, 1997. The largest weekly collection reported to date is 2,035 gallons in the summer of 1995 (date not reported; reported by Teddy Garcia during the October 13, 1995, meeting of the WID Working Committee to Resolve Underground Water Issues).

The solution to the water leakage problem in the shaft appears to be to stop the groundwater inflow in the shaft. This can be accomplished by grouting the exhaust shaft or de-watering the "perched" aquifer in the area of the shaft through first continuous and then periodic pumping. The EEG experience for the 1995-99 period is that without solving the water inflow problem, the fixed air sampler at Station A may not provide reliable data to accurately assess a suspected radioactive release, or document the absence of one, through this pathway.

Station B was not operational during the time of this study. Station B also contains sampling lines with shrouded probes, and this configuration was tested to confirm that representative samples will be collected from the post-filter air exhaust stream. The EEG will routinely collect samples at Stations A & B during operations (Figure 6).

The FAS flow rate at Stations A and B is 57 l/min (2 scfm). Station A sampling filters are changed following approximately 24 hours of sampling, resulting in a nominal sample volume of 82 m^3 (2,880 ft^3). During the preoperational period, filters have not been changed on weekends

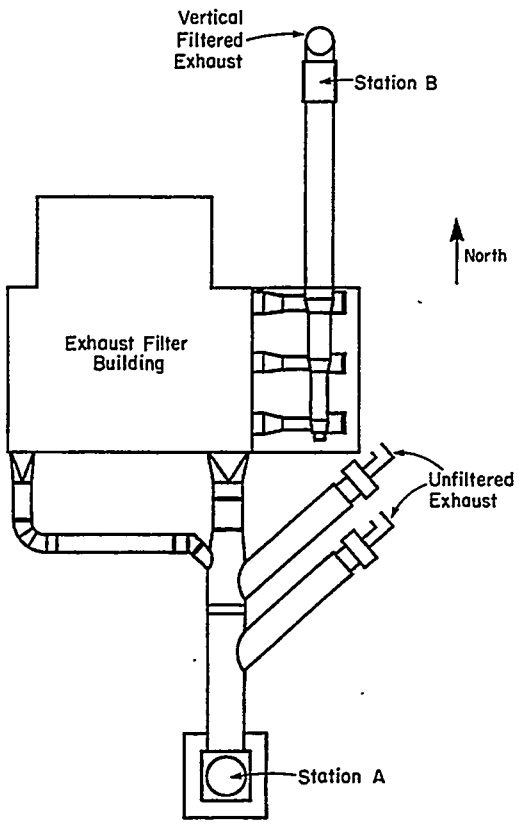

Figure 6. Location of Station A and B

and holidays due to the low accumulation of mining dust on the filters. Quarterly composites of FAS filters contain an air sample volume of approximately 7,340 m^3 (259,200 ft^3).

A tamper evident seal is installed on the FAS with each new filter. FAS air flow is regulated by an anemometer and flow controller, and electronically recorded each minute. EEG staff are present for each filter exchange and collect electronic data from a flow data recorder in Station A at the time of filter exchange.

Waste Handling Building (WHB) air effluent passes through two banks of HEPA filters prior to discharge. DOE maintains a FAS at Station C that records post-HEPA filter radioactivity in the WHB exhaust duct. Due to the low probability of a release through this double HEPA filtered discharge, EEG does not collect air samples from Station C.

The second effluent stream from the WIPP facility is storm water discharged from the property protection area. Rainfall on the paved areas around the facility collects in drainage-ways before discharge into evaporation/seepage areas outside of the property protection area. Should radionuclides be present on the buildings, equipment or paved areas they could be present in the storm water effluent. EEG collects this storm water effluent when available and will collect soil/sediment samples from areas which receive this effluent during the preoperational and operational phases.

3.4 Air Surveillance

Ambient air sampling (as opposed to the effluent air sampling from Stations A and B) is conducted by the strategic placement of low volume air samplers (LVAS) at the WIPP facility (Figure 7). The Site-1 (S-1) sampler is located approximately 225 meters (738 ft) north northwest of the WIPP exhaust shaft inside the property protection area. The LVAS designated as Site-2 (S-2) is located approximately 500 m (1,600 ft) northeast of the WIPP exhaust shaft. The Site-3 LVAS (S-3) is located approximately 1,000 m (3,300 ft) northwest of the WIPP exhaust shaft in the predominate downwind direction from the exhaust stacks (Figure 8).

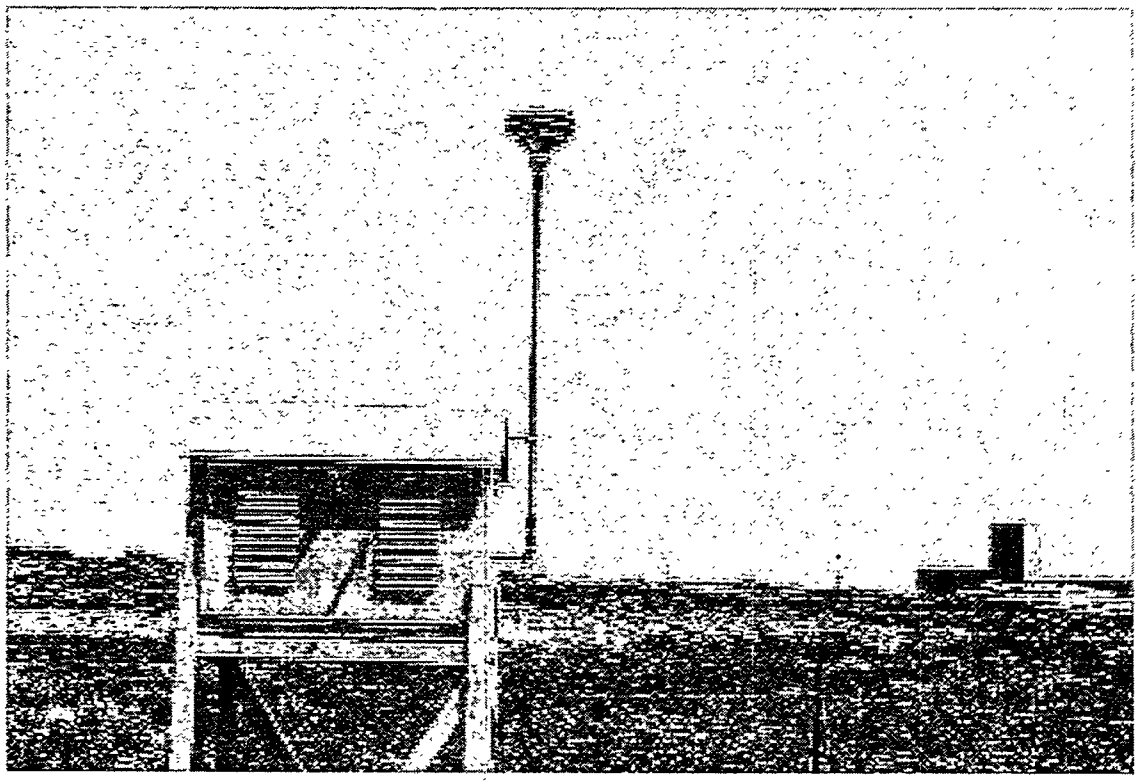

Figure 7. Typical EEG WIPP Site Low Volume Air Sampling Station

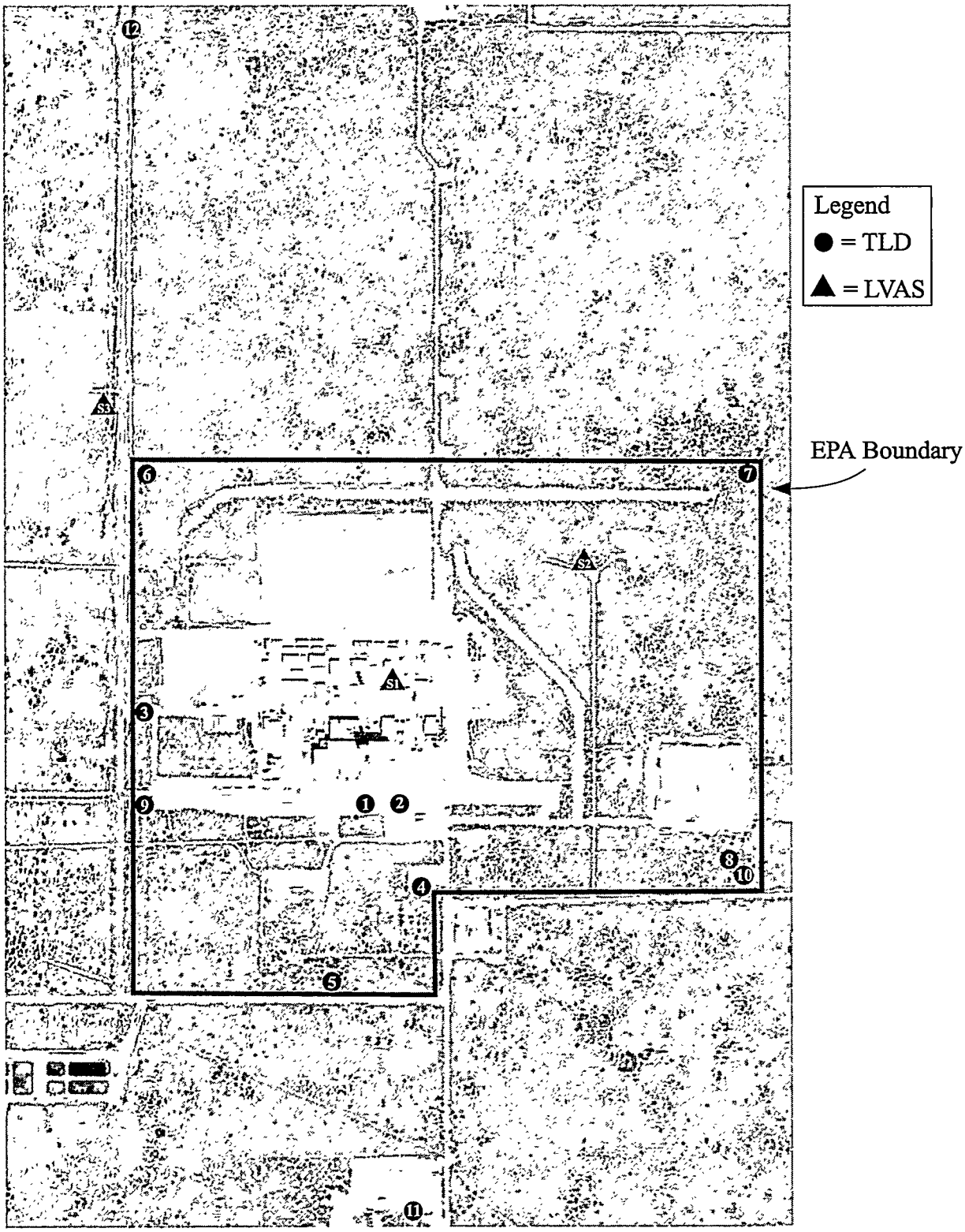

Figure 8: LVAS and TLD Locations at WIPP

In addition, low volume air samplers are also continuously operated in Artesia, Carlsbad, and Loving, New Mexico. The LVAS in Artesia is located near the west end of Jaycee Park near the intersection of 26th and Dr. R. W. Harper Drive (township 22S, range 25E, section 24). The Carlsbad LVAS is located at 505 N. Main Street (township 22S, range 27E, section 6). The Loving LVAS is located near the intersection of 5th Street and Elm Street at the Loving Fire Station (township 23S, range 28E, section 21). The LVAS located in Hobbs was discontinued January 1, 1998. Air sampling in Hobbs was stopped because the proposed transportation routes no longer include Hobbs, the WIPP site is located approximately 61 km (38 miles) from Hobbs and an ambient air baseline has been established for the vicinity of Hobbs during prior years. The latitude and longitude of each air sampling location is shown in Table 2. The coordinates were obtained using the global positioning system (GPS).

Table 2. Air Sampling Locations

AIR SAMPLE SITE	NORTH LATITUDE (deg. min. sec.)	WEST LONGITUDE (deg. min. sec.)
SITE 1	32° 22' 23.9"	103° 47' 32.0"
SITE 2	32° 22' 28.9"	103° 47' 15.8"
SITE 3	32° 47' 53.7"	103° 47' 53.7"
ARTESIA	32° 49' 19.9"	104° 26' 42.3"
CARLSBAD	32° 25' 31.4"	104° 13' 35.3"
LOVING	32° 17' 16.1"	104° 05' 50.3"

Gross alpha and gross beta screening of individual LVAS filters conducted prior to 1993 was discontinued and replaced with gamma spectroscopy screening. The gamma spectroscopy methods provide information on specific gamma emitting radionuclides such as ^{241}Am and ^{137}Cs. Gross alpha and gross beta measurements exhibit high variability, especially if the measurements are done within a few days of the end of the sample collection, due to fluctuations in radon progeny concentrations, self attenuation and filter attenuation. These concentrations also vary

due to atmospheric changes associated with the seasons. Gamma spectroscopy is less sensitive to these sources of variability.

Low volume air samplers collect air particulates on 102 mm (4 in) diameter borosilicate microfiber filters at a nominal rate of 227 l/min (8 ft^3/min). A typical sampling period lasts for seven days which provides a single filter volume of approximately 2.3 x 10^3 m^3 (8.1 x 10^4 ft^3). Individual LVAS filters are screened after 24 hours by gamma spectroscopy for possible elevated activity in the ^{137}Cs and ^{241}Am regions of interest. These samples are composited on a quarterly basis by site and analyzed for ^{137}Cs, ^{241}Am, ^{238}Pu, and $^{239+240}Pu$. The quarterly sample volume is used in the calculation to determine radionuclide activity concentration and total propagated uncertainty (TPU).

The air sample filter holder is located in an upward facing, non-directional configuration. The filter is protected from rain and snow degradation through the use of a rain shield described by Liu and Pui (1980). Wind tunnel test performed at the University of Minnesota using the rain shield design indicate high aspiration efficiency with little dependence on wind speed (Liu and Pui 1980).

3.5 Water Surveillance

Groundwater samples are collected from water-bearing zones of the Dewey Lake Redbed Formation, the Culebra dolomite member of the Rustler Formation, and the Capitan Reef Formation. Many of the water samples from these wells are collected by EEG at the same time DOE samples are collected. The latitude and longitude coordinates (degrees, minutes, seconds) as determined by the GPS for each well location are in Table 3.

Table 3. Location of Water Wells Sampled

WELL NUMBER	NORTH LATITUDE (deg. min. sec.)	WEST LONGITUDE (deg. min. sec.)
WQSP -1	32° 23' 03.4"	103° 48' 13.5"
WQSP-2	32° 23' 19.5"	103° 47' 26.5"
WQSP-3	32° 23' 02.4"	103° 46' 48.7"
WQSP-4	32° 21' 33.1"	103° 46' 49.2"
WQSP-5	32° 21' 22.2"	103° 47' 32.9"
WQSP-6	32° 21' 35.1"	103° 48' 13.8"
WQSP-6A	32° 21' 35.7"	103° 48' 11.3"

The radiochemical analysis of ^{241}Am, $^{239+240}Pu$, ^{238}Pu, and ^{137}Cs concentrations in ground water samples are located in Appendix C.

Data from water samples collected from the Pecos River in Carlsbad provide a radionuclide baseline and a comparison for similar data from the Pierce Canyon area of the Pecos River about 19 km (12 mi) downstream from Carlsbad. Mercer (1983) suggests that saturated zones in the Rustler Formation discharge to the Pecos River near Malaga Bend, about a mile upstream of where the river enters Pierce Canyon. Because of the role of the Rustler Formation as a potential hydrologic pathway for radionuclide migration, preoperational data from these regions are important. Radionuclide baseline data are also collected from surface water (brine) in Laguna Grande de la Sal which is located 13 km (8 mi) southwest of the WIPP facility.

The samples from Laguna Grande de la Sal are collected from the eastern perimeter near IMC's No. 5 shaft. The saline lake is in the storm water drainage from the facility and is a discharge point for shallow groundwater in Nash Draw. Because particulates in air emissions from WIPP operations could fall onto the area watershed, water samples are collected from five nearby rain catchment basins used for livestock and game watering.

Table 4 contains the latitude and longitude (degrees, minutes, seconds) of each surface water sampling location as determined by GPS.

Table 4. Location of Surface Water Samples

SURFACE WATER BY (GPS)	NORTH LATITUDE (deg. min. sec.)	WEST LONGITUDE (deg. min. sec.)
STORM WATER	32° 22' 15.7"	103° 47' 43.7"
HILL TANK	32° 22' 53.0"	103° 50' 22.4"
INDIAN TANK	32° 17' 00.8"	103° 53' 01.2"
LAGUNA GRANDE	32° 19' 30.5"	103° 55' 35.4"
NOYA TANK	32° 26' 24.3"	103° 47' 39.5"
PECOS CBD	32° 25' 27.7"	104° 13' 11.1"
PECOS PC	32° 11' 20.4"	103° 58' 38.1"
RED LAKE	32° 27' 54.1"	103° 53' 52.2"
RED TANK	32° 22' 45.3"	103° 43' 14.8"

Figure 9 shows the relative location of surface water sampling locations. Radiochemical data from surface water samples are located in Appendix C.

Public drinking water systems used by communities near the WIPP facility are also sampled annually and analyzed to determine ^{241}Am, $^{239+240}Pu$, ^{238}Pu and ^{90}Sr concentrations. These water systems would not be expected to receive WIPP related contamination under presently postulated scenarios in the WIPP Safety Analysis Report (US DOE, WIPP 1999). However, it is necessary to understand the activity of the radionuclides of interest to establish the preoperational baseline.

Data resulting from the analysis of these public water supply systems are located in Appendix C. Because each systems receives water from various well locations it is not possible to assign GPS coordinates to a system composite sample.

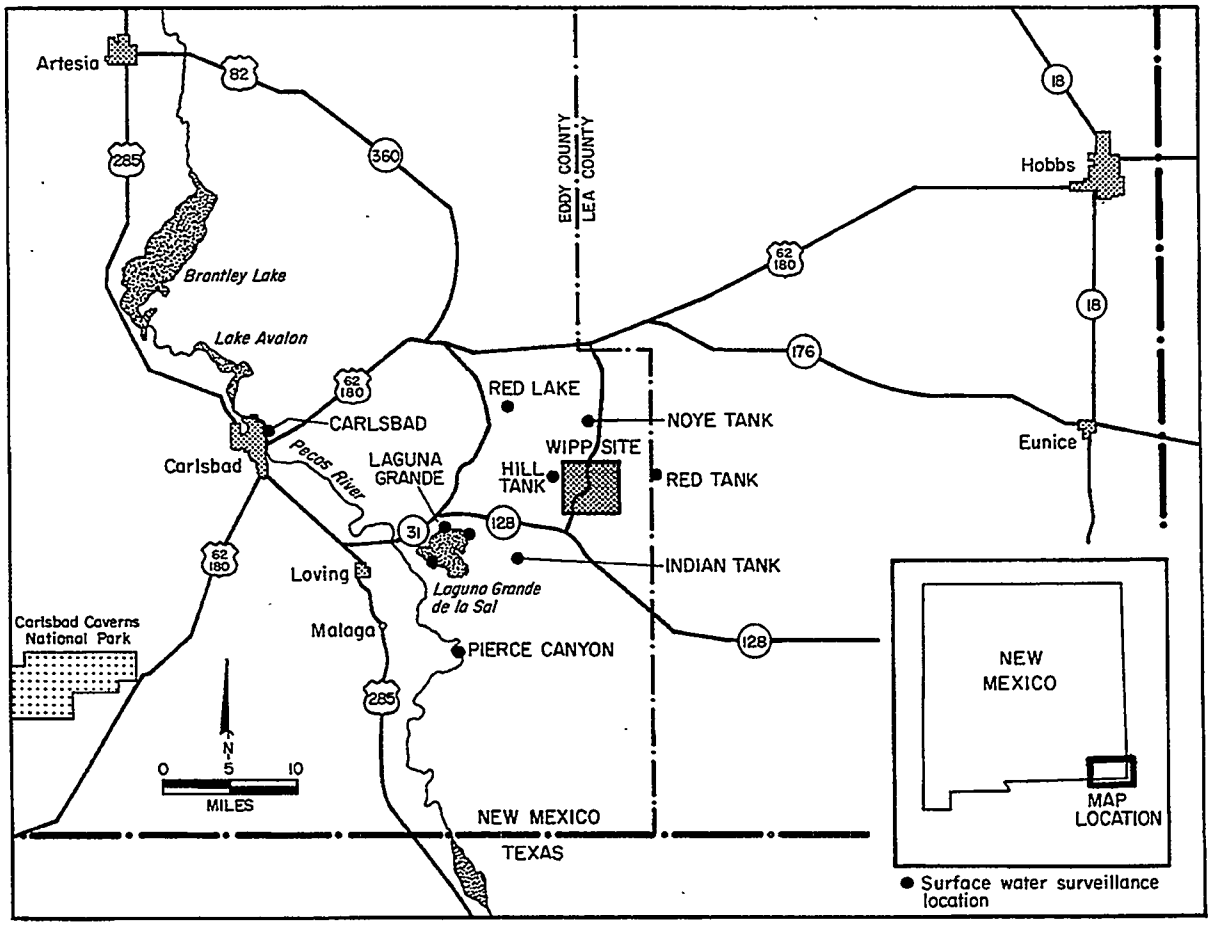

Figure 9. Surface Water Sampling Locations

3.6 Soil and Sediment Surveillance

Soil and sediment in the vicinity of WIPP contain a record of deposited radioactive fallout from past atmospheric nuclear weapons testing, as well as surface contamination from Project Gnome. ^{137}Cs was identified in the area of the Gnome site during an aerial gamma survey for the WIPP baseline studies (Berry 1989). It is believed that a certain amount of this deposited fallout may become re-suspended in air under certain atmospheric and soil conditions. Because WIPP TRU waste contain some of the fission products found in fallout, these data are an important component of the preoperational environmental baseline for WIPP.

During 1994 EEG conducted a detailed study of the radionuclide concentrations in a few locations at the Gnome site. The EEG study produced detailed maps of areas which exhibit elevated gamma activity that resulted from fission products venting from the Gnome access shaft. Gamma fields associated with the subsequent shallow burial of radioactive material were also identified. Selected soil samples from the ground surface at Gnome were radiochemically analyzed for ^{241}Am, ^{238}Pu and $^{239+240}Pu$. Analytical data from soil samples obtained for the Gnome study were published by Kenney et al. (1995).

3.7 Statistical Methods

In the EEG laboratory, individual air filter samples are screened using gamma spectroscopy to determine the presence or absence of ^{241}Am and ^{137}Cs. To provide an early estimate of possible contamination individual FAS filters are screened after a minimum decay of five hours while LVAS filters are counted after a minimum decay of 24 hours which allows time for the decay of some radon progeny. The gamma system consists of a reverse-electrode closed-end coaxial germanium detector enclosed in a four inch thick lead shield and a multichannel analyzer. Spectral files for each filter are analyzed for elevated levels in the ^{241}Am and ^{137}Cs regions. Regions of interest (ROI) used in the screening methodology were set using data collected from standard sources traceable to the NIST.

Filters composited by calendar quarter for each location were analyzed for ^{241}Am, ^{238}Pu, and $^{239+240}Pu$ using destructive radiochemistry followed by alpha spectroscopy. Analysis of transuranics was accomplished through the use of a recovery monitor, i.e., an accurately known amount of ^{242}Pu or ^{243}Am, as appropriate, added to each sample prior to destructive analysis, the measurement of which allowed correction of each sample for both counting efficiency and chemical recovery. The correction factor (K) in the equation below has units of measured-counts-per-second per becquerel (Bq).

The ^{137}Cs composite activity was determined using gamma spectroscopy before chemical destruction. Radiochemical analysis of environmental samples, presented in Appendix B, are required to quantify specific radionuclides common to the preoperational WIPP environment and WIPP waste. For reasons discussed below, it was desirable to analyze a number of "procedure" or "matrix" blanks along with the samples. These were unused filter composites or liter samples of deionized water free of the target nuclides (i.e., free of ^{238}Pu, $^{239/240}Pu$, ^{241}Am, ^{137}Cs and ^{90}Sr). These blanks were carried through the identical processing as the samples. The blank results appear later in this section and provided a means of correcting the sample results for any activity introduced solely as a result of the chemical processing, or simply from the matrix itself in the case of ^{137}Cs.

Analysis of the transuranics was done by alpha spectroscopy using four separate spectrometers. As samples were counted, the four detectors became contaminated at very low but highly variable levels, principally by recoil from trace contaminants in the samples which emitted high energy alpha particles. This process is almost unavoidable in alpha spectroscopy and is a principle cause for limited useful lifetimes of the detectors. These recoil contaminants generally appeared as high energy peaks in the alpha spectra, well above the ROIs for the target nuclides, but inevitably some counts from the high energy regions spilled down into the target ROIs, with the result that each detector gradually acquired it's own unique background activity in the ROIs.

For that reason, all alpha spectrometry measurements were corrected for the appropriate detector background as a first step for both blanks and samples. For a given matrix/nuclide combination, the blanks were then averaged and the average was subtracted from the results for individual samples.

The activity concentration of the transuranics was calculated by the following equation:

$$\textit{Net Activity Concentration } (Bq/m^3 \textit{ or } Bq/l) = \frac{\frac{cps_{samp} - cps_{bkg1}}{K_1} - \frac{cps_{blank} - cps_{bkg2}}{K_2}}{V} \quad (1)$$

where:

cps_x = ROI counts-per-second for the sample, its detector background (bkg1), the blank, and its detector background (bkg2),

V = the sample volume (m^3 or l)

K_n = correction factor described above, based on counting the "spike" activity for the sample measurement (K_1) and the blank measurement (K_2) and is equal to:

$$\frac{cps_{spike} - cps_{bkg}}{Bq\ (spike\ activity)} \qquad (2)$$

NOTE that the second term in the numerator of equation (1) is an average of all applicable blank measurements.

The TPU in the Appendices tables is the quadratic sum of all random and systematic errors for all measured quantities in the final result, multiplied by a coverage factor to achieve approximately 95% confidence. That is:

$$TPU = 2\times\sqrt{e_1^2+e_2^2+....+e_n^2} \qquad (3)$$

In practice, the different error terms are expressed in different units and must be converted to fractions or percentages of their source terms before they can be used in the equation. For the transuranics analyses, the sources of the error terms were as follows:

Counting errors (approximated by $\sqrt{N}$ divided by T, where N is the accumulated counts in the ROI in the counting interval, T)

4 terms (e_1 through e_4) expressing cps uncertainty for the target nuclide and recovery monitor nuclide, and the appropriate detector background counts.

Calibration factor errors

4 terms (e_5 through e_8) expressing the published uncertainty in the certified value of the activity concentration of the source solution used to prepare the recovery monitor solution, and the uncertainty in the weights obtained in preparing the recovery monitor solution and adding it to the sample or blank.

Blank correction error

1 term (e_9) expressing the 1-σ standard deviation of the mean of the appropriate average blank value used to correct the sample data.

Volume errors

1 term (e_{10}) expressing the uncertainty in the sample volume.

The factor 2 in the equation (3) is to achieve an approximate 95% confidence level for the TPU.

The ^{137}Cs determinations were done non-destructively with the result that no chemical recovery monitor was used. For the calculation of the activity concentration of the ^{137}Cs, equation (1) was modified as:

$$\textit{Net Activity Concentration } (Bq/m^3) = \frac{\frac{cps_{samp} - cps_{continuum1}}{\epsilon I} - \frac{cps_{blank} - cps_{continuum2}}{\epsilon I}}{V} \quad (4)$$

where:

cps_x = ROI counts-per-second for the sample, its gamma continuum (continuum1 - discussed below), the blank, and its gamma continuum (continuum2),

ϵ = the mean gamma-counting efficiency, in units of counts sec^{-1} per photon sec^{-1} emitted from the source for the appropriate counting geometry,

I = photon intensity, in units of photons sec^{-1} per disintegration sec^{-1} (or Bq), and

V = sample volume (m^3) or (l)

Note that the combination ϵI is the equivalent of (and has the same units, cps Bq^{-1}, as) the K factor in equation (1).

The TPU calculation for the ^{137}Cs measurements is identical to equation (3) except that the detector background errors of equation (3) are replaced with the uncertainty in the calculated continuum and the four terms of the calibration factor error are:

1 term expressing the uncertainty in the certified value of the photon-emission rate of the ^{137}Cs standard in units of photons-per-second from ^{137m}Ba,

1 term expressing the uncertainty in the intensity of the 662-keV gamma line of ^{137m}Ba, in units of ^{137m}Ba photon sec^{-1} per ^{137}Cs disintegration sec^{-1}, available in NCRP (58),

1 term expressing the standard deviation of multiple measurements of ϵ, and

1 term expressing the uncertainty in the decay correction, if applicable.

As before, the uncertainties are expressed as fractions or percentages to account for different units. The gamma continuum under the 662-keV peak ROI is calculated by linear interpolation between the four channels immediately above and the four channels immediately below the ROI.

Calculation of the MDA is based upon the method found in ANSI N 13.30, section 3.4.1. The MDA is a measure of the variance (S_b) of the analytical process. If the variance is based solely on the observed counts from a detector with the same blank (or no sample blank), then the S_b may be underestimated. A better estimate of S_b can be made by routine analysis of the environmental matrix devoid of the radioactivity of interest (i.e., uncontaminated air sample filters or distilled water). Air filter and water sample blanks are routinely analyzed along with environmental samples. The resulting blank data are used to calculate the MDAs and MDCs

shown in Tables 5, 6 and 7. The derived variance is more indicative of the total variance of the analytical measurement process. Control charting of these data can show when spurious counts appear in a matrix blank perhaps from cross-contamination from glassware or co-contamination of reagents (Rodgers and Kenney 1997). The MDA was calculated using equation (5):

$$MDA = \frac{4.65 \times S_b}{K\ T} \tag{5}$$

where:

MDA = Minimum Detectable Activity (Bq/composite)

4.65 = Constant for estimation of 95% confidence

S_b = Standard deviation of activity in a group of appropriate procedure matrix blanks

K = calibration constant containing the estimated yield and efficiency (counts-per-seconds/Bq)

T = count time (seconds)

Thus the calculation of minimum detectable concentration can be expressed as follows:

$$MDC = MDA/SAMPLE\ VOLUME \tag{6}$$

where:

MDC = Minium Detectable Concentration (Bq/volume)

MDA = Minimum Detectable Activity (Bq/composite)

Sample Volume = The average volume (m^3 or l) in a series of samples

The major objective of the EEG's preoperational environmental surveillance program is to measure the radionuclide concentrations in environmental samples from the vicinity of the WIPP facility. EEG reports all environmental radionuclide concentrations as values, including values less than the MDC or less than zero as suggested in U. S. Nuclear Regulatory Commission

(NRC) Regulatory Guide 4.14 (US NRC 1980). The MDA is an estimate of the sensitivity of a process and should not be compared to any single result.

The ACTL defined by Corley et al. (1981) is applied to determine if a single result is statistically different from the established baseline concentration at the 97.7th quantile (i.e., 97.7% confidence level). When an ACTL is exceeded in the EEG laboratory 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. Should the investigation fail to indicate a probable cause, results obtained by WID for similar samples is reviewed. The ACTL, for a given radionuclide concentration can be defined as:

$$ACTL = MBL + Q_{97.7} \tag{7}$$

where:

ACTL (Bq/sample composite) = the "action level" for a specific radionuclide

MBL (Bq/sample composite) = the mean preoperational baseline activity

Q97.7 = the 97.7% quantile for normally distributed data which can be estimated as 2 sigma, where sigma is the standard deviation of the preoperational data.

The MDA, MDC and ACTL values calculated for the EEG methodologies are found in Tables 5, 6 and 7. Each of three matrix types are shown, LVAS filters, FAS filters and water.

Table 5. FAS Matrix Blank Data

Radionuclide	No. of Blanks	Avg. Activity (Bq/Composite)	ACTL (Bq/Composite)	MDA (Bq/Composite)	MDC (Bq/m^3)
^{241}Am	13	$5.1E^{-4}$	$1.2E^{-3}$	$1.4E^{-3}$	$2.7E^{-7}$
$^{239+240}Pu$	13	$1.7E^{-4}$	$1.6E^{-3}$	$1.5E^{-3}$	$2.8E^{-7}$
^{238}Pu	14	$-6.3E^{-5}$	$2.9E^{-4}$	$1.6E^{-3}$	$3.1E^{-7}$
^{137}Cs	14	$-8.9E^{-4}$	$5.9E^{-2}$	$1.8E^{-1}$	$3.5E^{-5}$

Table 6. LVAS Matrix Blank Data

Radionuclide	No. of Blanks	Avg. Activity (Bq/Composite)	ACTL (Bq/Composite)	MDA (Bq/Composite)	MDC (Bq/m^3)
^{241}Am	11	$5.2E^{-4}$	$3.3E^{-3}$	$2.3E^{-3}$	$4.4E^{-7}$
$^{239+240}Pu$	12	$2.2E^{-4}$	$1.7E^{-3}$	$7.5E^{-4}$	$1.4E^{-7}$
^{238}Pu	14	$5.4E^{-4}$	$1.4E^{-3}$	$2.8E^{-3}$	$5.3E^{-7}$
^{137}Cs	20	$-8.9E^{-4}$	$3.5E^{-2}$	$1.4E^{-1}$	$3.5E^{-5}$

Table 7. Water Matrix Blank Data

Radionuclide	Number of Blanks	Avg. Activity (Bq/spl)	ACTL (Bq)	MDA (Bq/spl)	MDC (Bq/l)
^{241}Am	18	$9.0E^{-4}$	$4.2E^{-3}$	$2.3E^{-3}$	$2.3E^{-3}$
$^{239+240}Pu$	21	$2.5E^{-4}$	$1.5E^{-3}$	$1.8E^{-3}$	$2.5E^{-3}$
^{238}Pu	21	$1.9E^{-4}$	$1.8E^{-3}$	$2.1E^{-3}$	$2.6E^{-3}$
^{137}Cs	21	$-1.6E^{-2}$	$1.0E^{-1}$	$1.9E^{-1}$	$1.9E^{-1}$

3.8 External Dose Measurements

The regulatory limit for external dose to the public from the WIPP facility is contained in 40 CFR 191 Subpart A. The EPA has established the exclusive use area boundary as the compliance point for the 25 millirem per year dose limit. In 1998 EEG deployed environmental thermoluminescent dosimeters (TLDs) at certain points along the WIPP exclusive use area boundary. The location of EEG's environmental TLDs can be seen in Figure 8. Each dosimeter contains five lithium fluoride chips which are returned to a commercial vendor for analysis each quarter.

4.0 DISCUSSION OF FINDINGS

4.1 Air Data

Inhalation of transuranic radionuclides poses a significant health risk. Consequently, regulatory release limits are extremely low. Hence, measuring chronic radioactive releases from the underground repository provides the greatest monitoring challenge.

To determine if the EEG sampling and radiochemical processes are sensitive enough to measure chronic releases before they exceed regulatory limits, EEG used a screening calculation recommended by the National Council on Radiation Protection and Measurements (NCRP 1996). The simplified method, "Screening Models for Releases of Radionuclides to Atmosphere, Surface Water and Ground," provides very conservative limits for assessing environmental releases. If the regulatory limits are approached, then immediate investigative action would be necessary. The NCRP report is a series of simple screening techniques that can be used to demonstrate the capability of a measurement system to measure a dose standard. If compliance with regulatory limits can be demonstrated using these screening models, then more sophisticated modeling techniques are not necessary. The NCRP report emphasizes that "doses" estimated by

the model are strictly for comparison with an environmental standard and are not intended to represent estimates of actual doses to individuals.

The NCRP report provides three levels of screening. Level I, which was applied to data contained in this report, is the most conservative (i.e., would tend to overestimate dose), Level II is less conservative, and Level III is the least conservative. The suggestion is to use the most conservative level and resort to less conservative level as needed.

Each radionuclide concentration used in the NCRP screening technique was assumed to be continuously released at the MDC for one year. The total underground exhaust ventilation volume was calculated based upon the assumption of a continuous flow rate of 12,000 m^3/min (425,000 scfm). The MDC values for each radionuclide measured in the FAS matrix blanks are contained in Table 5. The MDC values for FAS filters from Station A were applied to the NCRP Screening Level I. Table 8 contains NCRP Screening Level I results and the regulatory dose limit. The derived dose from underground air emissions from Station A was found to be 1.4 x 10^{-7} Sv/y. The EEG effluent air monitoring program will detect doses approximately 1,000 times below the regulatory limit of 1.0 x 10^{-4} Sv/y (10 mrem/y) in 40 CFR 61 Subpart H or 2.5 x 10^{-4} Sv/y (25 mrem/y) in 40 CFR 191 Subpart A.

Table 8. Effluent Air Dose Estimates (NCRP #123 Level I)

	Radionuclide		
	^{241}Am	$^{239+240}Pu$	^{238}Pu
FAS MDA (Bq/QTR)	$1.4E^{-3}$	$1.5E^{-3}$	$1.6E^{-3}$
Q (Bq/s)	$3.8E^{-5}$	$3.9E^{-5}$	$4.2E^{-5}$
V (m^3/s)	$2.0E^{+2}$	$2.0E^{+2}$	$2.0E^{+2}$
C_e (Q/V)	$1.9E^{-7}$	$1.9E^{-7}$	$2.1E^{-7}$
C (Bq/m^3)	$4.7E^{-8}$	$4.9E^{-8}$	$5.3E^{-8}$
SF ($Sv/Bq/m^3$)	1.00	1.00	0.89
SV(Sy/y)	$4.7E^{-8}$	$4.9E^{-8}$	$4.7E^{-8}$
TOTAL ^{241}Am, $^{239+240}Pu$, ^{238}Pu (Sv/y) = $1.4E^{-7}$			
LIMIT (Sv/y) = $1.0E^{-4}$ (40 CFR 61 SUBPART H)			
LIMIT (Sv/y) = $2.5E^{-4}$ (40 CFR 191 SUBPART A)			

Elements of Table 8 are as follow:

Q (Bq/s) = The release rate of the radionuclide entered above is the MDA of the radionuclide (Bq/quarter composite times 4) divided by the number of seconds per year which corrects for exhaust volume/sample volume.

V (m^3/s) = The volumetric flow rate of the exhaust vent (m^3/s).

C_e (Q/V) = The radionuclide concentration in the exhaust air. The release rate is activity (Bq) divided by volumetric air flow (m^3).

C (Bq/m^3) = A factor used for assumption that the wind blows in the direction of a potentially exposed person 25% of the time.

SF ($Sv/Bq/m^3$) = The Screening Factor which is selected from Table 1.1 of NCRP #123 for the specific radionuclide. The value of SF includes all significant potential pathways of exposure.

SV (Sv/y) = Screening value which is the atmospheric concentration (C) multiplied by the screening factor (SF).

Total (Sv/y) = The sum of all radionuclides measured (SV).

40 CFR 61H (Sv/y) = The regulatory dose limit of 10 mrem/year ($1.0x\ 10^{-4}$ Sv/y).

The EEG's reported radionuclide air concentrations were next compared to those concentrations published by EPA and Los Alamos National Laboratory (LANL) for sites in New Mexico. The concentrations given in Table 9 and shown in Figure 10 are averages of the analytical results from ambient air samples collected in Santa Fe, New Mexico by EPA, from Los Alamos by LANL and near the WIPP site by EEG. Average concentrations measured by the various organizations appear to agree, within statistical uncertainties.

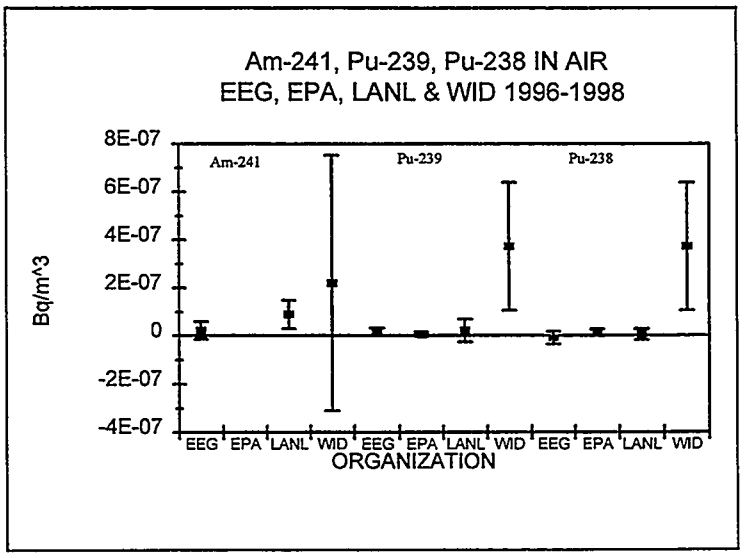

Figure 10. Comparison of EEG98, WID 96-97, LANL 96-97 and EPA 96 Average Actinide Concentration Data from Samples Collected in New Mexico

Table 9. Average Air Concentration of Actinides in New Mexico

Actinide	EEG[a]		LANL[b]		EPA[c]		WID[d]	
	Activity (Bq/m^3)	2 Sigma (Bq/m^3)	Activity (Bq/m^3)	2 Sigma (Bq/m^3)	Activity (Bq/m^3)	2 Sigma (Bq/m^3)	Activity (Bq/m^3)	2 Sigma (Bq/m^3)
^{241}Am	2.3×10^{-8}	3.6×10^{-8}	8.9×10^{-8}	5.9×10^{-8}	N/A	N/A	2.2×10^{-7}	5.3×10^{-7}
$^{239+240}Pu$	1.7×10^{-8}	1.6×10^{-8}	2.2×10^{-8}	4.8×10^{-8}	5.9×10^{-9}	8.5×10^{-9}	3.7×10^{-7}	2.7×10^{-7}
^{238}Pu	-9.0×10^{-9}	2.6×10^{-8}	5.6×10^{-9}	2.2×10^{-8}	1.3×10^{-8}	1.4×10^{-8}	3.7×10^{-7}	2.7×10^{-7}

[a] Data are average concentrations in air samples collected by EEG near the WIPP site during 1998.
[b] Data are average concentrations in air samples collected by LANL from Santa Fe, Espanola and Pojoaque, New Mexico during CY 1996 and 1997 (LANL 1997 and LANL 1998).
[c] Data are average concentrations in air samples collected by EPA from Santa Fe, New Mexico during 1996 and analyzed by EPA (US EPA 1999).
[d] Data are average concentrations in air samples collected by WID near the WIPP site during 1996 and 1997. (US DOE, WIPP 1997 and US DOE, WIPP 1998)

Analytical radiochemistry data and graphical representations of quarterly LVAS filter data obtained from composites of each site are contained in Appendix B. There appears to be a negative bias in the ^{238}Pu concentrations shown in Appendix C. The causes of this bias are under investigation.

4.2 Water Data

The NCRP screening methodology for surface water effluent was also applied to analytical results from storm water effluent samples. Specific radionuclide MDCs were used as the source term (Bq/m^3) for ^{241}Am, $^{239+240}Pu$, and ^{238}Pu. The calculation assumed that all WIPP storm water effluent contained ^{241}Am, $^{239+240}Pu$, and ^{238}Pu at concentrations equal to the EEG's MDAs. The NCRP screening Level I for surface water was calculated using the following data:

C_o (Bq/m^3) = The Bq/m^3 value was the MDA for the radionuclide (Bq/l) times 1000 to obtain Bq/m^3.

SF ($Sv/Bq/m^3$) = The screening factors (level I) were chosen from NCRP No. 123, table 2.1 for each radionuclide in freshwater.

SV (Sv) = The screening value is the product of the annual average concentration and the screening factor.

Total (Sv) = The sum of all the various radionuclide screening values.

Limiting Value (Sv) = The regulatory limit used was 2.5×10^{-4} Sv/y contained in 40 CFR 191A.

Table 10 contains the results of calculations using the NCRP screening level I for surface water. Clearly, the EEG sampling and analytical methodology is capable of measuring actinides in water that would produce a dose of 1.3×10^{-5} Sv/y which is about 20 times below the regulatory limit of 2.5×10^{-4} Sv/y specified in 40 CFR 191 Subpart A.

Table 10. Surface Water Dose Estimates (NCRP #123 Level I)

	Radionuclide		
	^{241}Am	$^{239+240}Pu$	^{238}Pu
Co (Bq/m^3)	$2.3E^{0}$	$2.5E^{0}$	$2.6E^{0}$
SF (Sv per Bq/m^3)	$2.0E^{-6}$	$1.7E^{-6}$	$1.5E^{-6}$
SV (Sy/y)	$4.6E^{-6}$	$4.2E^{-6}$	$3.9E^{-6}$
TOTAL ^{241}Am, $^{239+240}Pu$, ^{238}Pu (Sv/y) = $1.3E^{-5}$			
REG. LIMIT (Sv/y) = $2.5E^{-4}$ (40 CFR 191 A)			

Radiochemistry data from water samples are contained in Appendix C. The average ^{239}Pu and ^{241}Am concentrations in surface water samples collected between 1996 and 1998 was -3.6×10^{-4} and -2.3×10^{-4} Bq/l respectively. The magnitude of the bias is much less than the MDC for these analysis and is not considered significant.

Ground water samples are frequently concentrated brines which present special analytical problems and must be diluted prior to analysis. The dilution factor exaggerates any analytical bias and uncertainty in the final calculated result. This effect can be seen, for example, in the ^{241}Am results in Table C9 for the samples collected from wells WQSP-1, WQSP-3, and WQSP-6 in 1997.

Sewage effluent receives only sanitary waste water. Fire water and storm water that may be used in the facility is not discharged to the sanitary sewer system. The possibility of radioactive contamination of the total retention sewage lagoons is minimal. For these reasons the EEG does not monitor the sewage lagoon system for actinides.

4.3 Soil and Sediment Data

Radiochemical analyses of soil samples collected during 1997 and 1998 had not been completed at the time of this report. Results of these analyses will be included in subsequent reports.

4.4 TLD Data

Average external dose measurements as determined by thermoluminescent dosimeters during 1998 are contained in Appendix E. The average quarterly dose during 1998 was 18.3 mrem/quarter ± 5.3 mrem/qtr (2 sigma) and the calculated annual dose averaged 73.2 mrem/year ± 9.8 mrem/year (2 sigma). The calculated quarterly lower limit of detection was 8.7 mrem/quarter (Rodgers 1998). An event yielding a single quarterly dose of 25 mrem would be easily detected. However, chronic exposures near 6.25 mrem/qtr (25 mrem/year) would be below the sensitivity of the TLD measurement system.

5.0 QUALITY ASSURANCE

The quality assurance program (QAP) under which the data in this report was gathered, analyzed, and presented is described in the EEG "Quality Assurance Program Plan for the Environmental Evaluation Group's Environmental Surveillance of the WIPP Project" (QAPP). The EEG QAPP was originally developed using guidance from the EPA Interim Guidelines and Specifications for Preparing Quality Assurance Program Plans, QAMS-005/80 (US EPA 1980), and Quality Assurance Program for the Nuclear Radiation Assessment Division (US EPA 1992). The current document is Revision 2; the principal changes were that Revision 1 added the program goals, and Revision 2 changed personnel responsibilities and titles to fit the program objectives and requirements.

The EEG QAPP describes the goals for EEG's environmental surveillance program (Section 2), the program's organization (Section 3.0), the responsibilities of the various personnel within the program (Section 3.1), training and certification requirements and methods (Section 3.2), quality objectives for both sampling and analysis (Section 4.1), the internal and external quality control programs (Section 4.2 and 4.3), document control requirements (Section 4.5), requirements for sample custody (Section 6.0), equipment calibration (Section 8.0), and data reduction, validation, and reporting (Section 9). The EEG QAPP requires that quality-affecting processes be specified in written procedures; the EEG Field Procedures Manual (FPM) and the EEG Laboratory Procedures Manual (LPM) contain these procedures.

An internal auditor reporting directly to the EEG director performs audits at least twice each year; these audits are performed using checklists based on the requirements listed in the QAPP, FPM, and LPM, and findings are tracked until resolved. An independent external audit is also performed each year.

5.1 Traceability and Acceptance Criteria

A central, guiding principle for EEG's quality assurance activities, as they relate to laboratory measurements, involves the idea of measurement traceability. The term "traceability" has been defined variously, but the International Organization for Standardization (ISO) defines it as

> "the property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, *through an unbroken chain of comparisons* all having stated uncertainties" [italics added] (ISO 1993).

EEG adopts the position that all laboratory measurements should exhibit the property of traceability, wherever possible. In practice, the requisite "unbroken chain of comparisons" is best maintained by participation in external intercomparison or measurements assurance programs providing blind samples matching, as closely as possible, the combinations of matrices and radionuclides encountered in our environmental surveillance program. In this way, the

validity of EEG's environmental surveillance data are supported by nationally or internationally recognized standards to the extent that the results of the analyses of intercomparison samples are deemed acceptable.

The assignment of acceptability to a result is not a straightforward process. Acceptability may be assigned with respect to program goals. Specific program goals drive the development of specific data quality objectives (DQO) and these can be used to assess acceptability with respect to goals. However, unless all interested parties (i.e., stakeholders) can agree to accept a common set of DQOs, valid comparisons between sets of data from different sources may be difficult to make and may reduce public confidence.

This is why traceability and the corollary issue of acceptability is important. If all laboratories participating in WIPP environmental radioactivity surveys maintain traceability to common standards, or to standards from different sources that themselves have a point of commonality, and all can agree to adopt common criteria for acceptability, data comparisons are validated, and EEG, as a technical oversight group, can best fulfill its environmental surveillance responsibility to the public.

These concerns have been addressed in two American National Standards Institute (ANSI) standards.

ANSI N42.22-1995, Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control (ANSI 1995) provides a simple calculation for commercial manufacturers of radioactive sources to determine whether their sources may be labeled as "traceable to NIST" within set limits. The criterion for acceptance is given by the formula:

$$|V_N - V_m| \leq 3\sqrt{\sigma_N^2 + \sigma_m^2}$$

where

V_N = the NIST (or otherwise certified) value,

V_m = the mean of the replicate measured values,

σ_N = the total propagated uncertainty (TPU), at 1-σ, of the certified value, and

σ_m = the TPU, at 1-σ, of the mean of the replicate measured values.

That is, whenever the measured bias is less than 3 times the quadratic sum of the associated uncertainties, the measurement is deemed to be traceable to NIST (or other certifying body) *within the limits specified by* σ_m. Of course, in the application of this criterion, a laboratory could set the TPU of its measured mean artificially high and still claim traceability to the certifying body. However, the magnitude of the acceptable TPU should be set by programmatic needs and should be governed by the program's DQOs. Thus, meeting the traceability acceptance criterion would not necessarily mean acceptability of the data with respect to the program's DQOs. In this way, a laboratory maintains control of its own data assessment while providing a point of comparison with other laboratories.

ANSI N42.23-1997, Measurement and Associated Instrument Quality Assurance for Radioassay Laboratories, establishes a framework within which radioassay laboratories may demonstrate, through a system of reference and monitoring laboratories, measurement traceability to NIST. The demonstration process is called "traceability testing". The testing involves analysis by service laboratories (i.e., those providing a service - radiochemical analysis, for example - to a customer) of blind samples provided by a reference or monitoring laboratory, and reporting the results back to the reference or monitoring laboratory, which then evaluates and, often, publishes the results. This level of testing is currently provided by a number of commercial and government laboratories, such as DOE's Environmental Measurements Laboratory (EML). In a sense, then, participants in the EML Quality Assurance Program could correctly claim to be traceable to EML for their measurements. But, the ISO definition of traceability seems to be more restrictive since it requires an "unbroken chain" back to "international or national standards". EML is not the repository for the national standards in radiometrology; that responsibility lies with NIST.

At present the N42.23 framework is not fully implemented, since the link in the chain between NIST and the reference/monitoring labs is missing. Efforts are underway to forge the final link and establish the requisite traceability relationships involving laboratories with the capability to function as reference or monitoring laboratories. These efforts will take some time to bear fruit.

In the meantime, NIST, with the support of a number of DOE- and EPA-supported and university laboratories, including EEG, has established and is running an interim program called the NIST Radiochemistry Intercomparison Program (NRIP).[1] Under NRIP, NIST directly provides participants with traceability testing samples appropriate to their missions and traceability certificates, called Reports of Traceability, based on their reported results. Under this interim program, NIST is functioning as an N42.23 reference lab. A real and valid concern is that, as the program adds new participants, NIST will reach a "saturation point" and be unable to accommodate additional requests for traceability testing samples. This concern provides impetus to bring additional reference labs into the N42.23 framework as soon as possible.

Since the radiochemistry lab became operational in 1993, EEG has participated in the EPA's Performance Evaluation Studies Program, the EML Quality Assurance Program, and, lately, the NRIP. These programs have provided external assessments of the EEG's laboratory capabilities in the analyses contained within this report. The following section contains the data resulting from participation in those programs.

5.2 Data

The following tables contain the external quality control (QC) data accumulated in support of the sample analysis results in this report. Tables 11 and 12 contain the results from analysis of water and air filters, respectively. In the following tables the results are evaluated (pass/fail or

[1] A list of current participants is available by contacting the Ionizing Radiation Division, Radioactivity Group, NIST.

acceptable/not acceptable) with respect to both the program's DQOs and the ANSI N42.22 criterion for traceability.

The program's DQOs are detailed in the QAPP. Briefly, they are:

	Accuracy	Precision (95%)
Activities ≤ 10 times MDA*	±30%	30%
Activities > 10 times MDA	±20%	20%

*MDA = minimum detectable activity (see Section 3.4)

The results in these tables must pass **both** accuracy and precision DQOs in order to pass. The listed uncertainties are 1-σ uncertainties.

One analysis - Cs-137 in EML(9/98) - failed the recovery requirement of EEG's data quality objectives but passed the ANSI traceability test. The reason for this is unclear but is suspected to be related to the difficulty of accurately determining the counting efficiency of extended sources counted close to a gamma-ray detector. EEG is presently investigating other counting geometries in an effort to resolve this problem.

Table 11. Results of External QC Sample Analyses in Water

Sample ID	Nuclide	Units	Certified	Measured	DQO?	Traceable?
NRIP (2/98)	^{241}Am	mBq/g	29.6 ± 0.1	28.8 ± 1.6	pass	yes
NRIP (2/98)	^{238}Pu	mBq/g	19.5 ± 0.1	19.4 ± 0.5	pass	yes
EML (2/98)	^{137}Cs	Bq/l	46.0 ± 1.7	55.1 ± 4.7	pass	yes
EML (2/98)	^{241}Am	Bq/l	1.226 ± 0.050	1.21 ± 0.04	pass	yes
EML (2/98)	^{238}Pu	Bq/l	2.526 ± 0.060	2.31 ± 0.07	pass	yes
EML (2/98)	^{239}Pu	Bq/l	1.650 ± 0.061	1.59 ± 0.05	pass	yes
EML (9/98)	^{137}Cs	Bq/l	50.0 ± 1.7	54.5 ± 2.8	pass	yes
EML (9/98)	^{241}Am	Bq/l	1.250 ± 0.080	1.250 ± 0.033	pass	yes
EML (9/98)	^{238}Pu	Bq/l	1.100 ± 0.010	1.111 ± 0.026	pass	yes
EML (9/98)	^{239}Pu	Bq/l	1.410 ± 0.040	1.458 ± 0.033	pass	yes

Table 12. Results of External QC Sample Analyses in Air Filters

Sample ID	Nuclide	Units	Certified	Measured	DQO?	Traceable?
NRIP (12/97)	^{241}Am	mBq/filter*	134.5 ± 0.5	133.7 ± 8.0	pass	yes
NRIP (12/97)	^{238}Pu	mBq/filter*	88.7 ± 0.3	87.3 ± 6.1	pass	yes
NRIP (2/99)	^{241}Am	mBq/filter*	206 ±1	194 ± 11	pass	yes
NRIP (2/99)	^{238}Pu	mBq/filter*	205 ± 1	201 ± 7	pass	yes
EML (2/98)	^{137}Cs	Bq/filter	11.86 ± 0.96	10.5 ± 0.9	pass	yes
EML (2/98)	^{241}Am	Bq/filter	0.0687 ± 0.0031	0.0759 ± 0.0043	pass	yes
EML (2/98)	^{238}Pu	Bq/filter	0.0695 ± 0.0032	0.0687 ± 0.0023	pass	yes
EML (2/98)	^{239}Pu	Bq/filter	0.0624 ± 0.0018	0.0691 ± 0.0024	pass	yes
EML (9/98)	^{137}Cs	Bq/filter	22.47 ± 1.03	17.51 ± 1.30	fail	yes
EML (9/98)	^{241}Am	Bq/filter	0.510 ± 0.008	0.478 ± 0.013	pass	yes
EML (9/98)	^{238}Pu	Bq/filter	0.460 ± 0.005	0.482 ± 0.010	pass	yes
EML (9/98)	^{239}Pu	Bq/filter	0.420 ± 0.006	0.433 ± 0.009	pass	yes

* normalized to an average of five filter masses.

6.0 CONCLUSIONS

Average concentrations of radionuclides measured in environmental media during 1996, 1997, and 1998 are consistent with similar measurements in New Mexico by EPA and LANL. The current methodology is appropriate for determining pre-operational baseline concentrations of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu in air and water near the WIPP facility and in surrounding communities. Data contained in this report when combined with similar data from previous years form a baseline against which future concentrations obtained during the operational phase at WIPP can be compared. Sensitivity of the EEG's exhaust air monitoring program is sufficient to quantify any increase in environmental levels of these radionuclides which are about 1,000 times below regulatory limits contained in 40 CFR 61 Subpart H and 40 CFR 191 Subpart A.

Measurement of ^{241}Am, $^{239+240}Pu$, and ^{238}Pu concentrations in water effluent from the facility can identify an increase above background approximately 20 times below the amount required to exceed WIPP's regulatory limit contained in 40 CFR 191 Subpart A.

Additional confidence in the EEG analytical process comes from participation in various external laboratory intercomparison programs and independent program audits. Results from these programs and audits validate the quality of EEG's results.

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APPENDICES

APPENDIX A

Excerpts from the Supplemental Stipulated Agreement

The agreement for the joint environmental monitoring program between the State of New Mexico and the U. S. Department of Energy is contained in the December 28, 1982 Supplemental Stipulated Agreement. The following sections are taken from pages 1 through 9 of Appendix A of that document.

Appendix A of Supplemental Stipulated Agreement
The State of New Mexico's Environmental Monitoring Program for WIPP

The State of New Mexico's environmental radiation surveillance program for WIPP operations is designed to serve as an independent means to evaluate the accuracy and precision of the results as determined by the Department of Energy's program. Such a meaningful, independent State role is crucial for public confidence and acceptance given the fact that WIPP is exempted from NRC licensing and inspection requirements. In order to maintain this independence the State will require the following: (1) that split samples will be taken by a procedure approved by the State and DOE, and, if the parties so desire, under the observation of the designated representatives of both agencies on a routine collection schedule; that, where applicable, sample preparation will follow established quality assurance/quality control procedures to insure a homogenous mixture prior to taking aliquots; (2) that the sample schedule and location will be expanded or altered in accordance with any reasonable request by the representatives of the State of New Mexico; (3) that sample analyses will be performed by laboratories not affiliated with nor under contract with the Department of Energy to perform analysis of WIPP environmental monitoring samples; and (4) that a State quality control program will be established and maintained for routine calibration of air samples and thermoluminescent dosimeters in addition to the intercomparison of specific radionuclide analyses by a referee laboratory program, such as the one certified by the National Bureau of Standards or the Environmental Protection Agency.

A. Preoperational Phase (Begins Two Years Prior to Waste Emplacement).

1. External Gamma Exposure

Duplicate thermoluminescent dosimeters (TLD's) at all of the DOE's stations.

2. Soil

Random split sampling and specific isotopic analyses for up to 30% of the DOE's scheduled program.

3. Atmospheric Particulates

Duplicate high volume air particulate sampler(s) adjacent to the DOE's station in the area of maximum predicted downwind ground deposition. The State representative may elect to monitor the sampling, monitoring and analytic process rather than take duplicate samples.

4. Water and Sediments

Random split samples and specific isotopic analyses for up to 30% of the DOE's scheduled program.

5. Product and Meat

Locally produced fruit, vegetables, meat and poultry random split samples and the same analysis for up to 30% of the DOE's scheduled program.

B. Operational Phase

The operational radiation surveillance program will be similar to the preoperational phase. The final design of the program, however, will be based on a review of the environmental data collected during the two years prior to waste emplacement operations. Two additional high volume air sampling stations are planned for (1) an area downwind determined to be the area of largest risk to population during the operational phase and, (2) a location remote and 180 degrees from the previous location and on the opposite side of the WIPP Site.

C. Decommissioning and Decontamination Phase

The level environmental radiological surveillance developed during the operational phase shall be continued during and for at least two years following complete decommissioning and decontamination of the surface facilities. This is to include both the State and the Department of Energy's programs. In addition, increased surface soil and vegetation samples will be collected and analyzed to ensure decontamination standards in effect at the time are met.

D. Post-Operational Phase

The final environmental radiological surveillance phase will primarily serve to ensure the public that resuspension of contaminated ground surface particles, if any, is not creating a potential long-term inhalation problem. The program will also include continued analyses on an annual basis of some selected soil, and surface and ground water sampling locations as determined by a review of the data and/or the most critical pathways to man. The minimum program projected at this time and to be continued for a period of not less than five (5) years following termination of the decommissioning and decontamination phase is:

(1) Intermittent operation of the state-operated high volume air sample stations.
(2) Four annual soil surface samples.
(3) Four annual water samples.
(4) Thermoluminescent dosimeters.

APPENDIX B: Air Sample Radiochemistry Data

Note 1: "Quarter" is Calendar Quarter

Note 2: N/A in the table indicates results not available.

Table B1. ^{241}Am Concentrations in LVAS Samples During 1998

SAMPLE LOCATION CODE	LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED ^{241}Am CONC. (Bq/m^3)	^{241}Am +/- TPU (Bq/m^3)
A	ARTESIA	1ST 1998	28117	1.5E-08	3.3E-08
C	CARLSBAD	1ST 1998	27476	-2.9E-09	2.8E-08
L	LOVING	1ST 1998	29085	3.1E-08	3.6E-08
1	WIPP 1	1ST 1998	27521	1.9E-08	3.7E-08
2	WIPP 2	1ST 1998	28070	-2.3E-09	5.3E-08
3	WIPP 3	1ST 1998	28070	-5.7E-09	2.7E-08
A	ARTESIA	2ND 1998	27810	2.0E-08	3.4E-08
C	CARLSBAD	2ND 1998	28293	3.5E-09	2.6E-08
L	LOVING	2ND 1998	28896	4.6E-09	2.8E-08
1	WIPP 1	2ND 1998	25240	5.5E-08	4.2E-08
2	WIPP 2	2ND 1998	25565	3.9E-08	4.8E-08
3	WIPP 3	2ND 1998	26206	1.7E-08	4.7E-08
A	ARTESIA	3RD 1998	26603	1.8E-08	3.7E-08
C	CARLSBAD	3RD 1998	31412	-1.7E-08	2.0E-08
L	LOVING	3RD 1998	27018	-1.9E-08	2.4E-08
1	WIPP 1	3RD 1998	30232	N/A	N/A
2	WIPP 2	3RD 1998	28301	N/A	N/A
3	WIPP 3	3RD 1998	24562	N/A	N/A
A	ARTESIA	4TH 1998	25024	2.0E-08	3.3E-08
C	CARLSBAD	4TH 1998	28488	-2.0E-09	2.6E-08
L	LOVING	4TH 1998	25840	1.8E-07	6.3E-08
1	WIPP 1	4TH 1998	28563	3.8E-08	4.3E-08
2	WIPP 2	4TH 1998	20772	N/A	N/A
3	WIPP 3	4TH 1998	25279	4.7E-08	4.0E-08

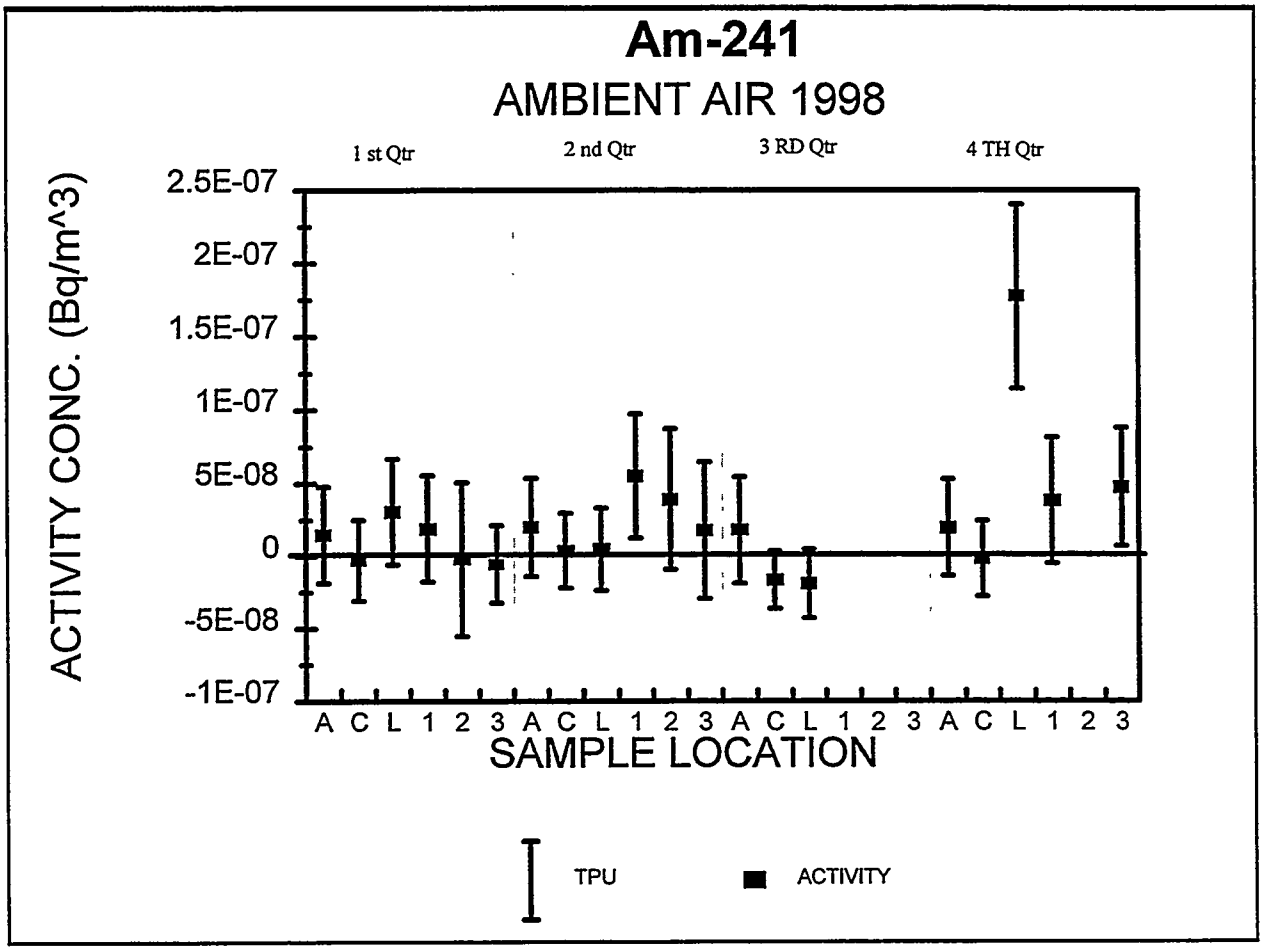

Figure B1. ^{241}Am Concentrations in LVAS Samples During 1998

Table B2. $^{239+240}Pu$ Concentrations in LVAS Samples During 1998

SAMPLE LOCATION CODE	LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED $^{239+240}Pu$ CONC. (Bq/m^3)	$^{239+240}Pu$ +/- TPU (Bq/m^3)
A	ARTESIA	1ST 1998	28117	1.8E-09	1.3E-08
C	CARLSBAD	1ST 1998	27476	1.1E-08	1.4E-08
L	LOVING	1ST 1998	29085	9.0E-09	1.1E-08
1	WIPP 1	1ST 1998	27521	9.4E-09	1.3E-08
2	WIPP 2	1ST 1998	28070	1.1E-08	1.3E-08
3	WIPP 3	1ST 1998	28070	1.2E-08	1.2E-08
A	ARTESIA	2ND 1998	27810	1.7E-08	1.6E-08
C	CARLSBAD	2ND 1998	28293	2.5E-08	1.6E-08
L	LOVING	2ND 1998	28896	7.5E-08	2.4E-08
1	WIPP 1	2ND 1998	25240	3.4E-08	1.9E-08
2	WIPP 2	2ND 1998	25565	2.8E-08	1.8E-08
3	WIPP 3	2ND 1998	26206	4.2E-08	2.8E-08
A	ARTESIA	3RD 1998	26603	2.1E-08	1.7E-08
C	CARLSBAD	3RD 1998	31412	1.2E-08	1.2E-08
L	LOVING	3RD 1998	27018	1.2E-08	1.6E-08
1	WIPP 1	3RD 1998	30232	N/A	N/A
2	WIPP 2	3RD 1998	28301	N/A	N/A
3	WIPP 3	3RD 1998	24562	N/A	N/A
A	ARTESIA	4TH 1998	25024	8.7E-09	1.8E-08
C	CARLSBAD	4TH 1998	28488	4.1E-09	1.1E-08
L	LOVING	4TH 1998	25840	7.5E-09	1.8E-08
1	WIPP 1	4TH 1998	28563	2.3E-09	1.2E-08
2	WIPP 2	4TH 1998	20772	N/A	N/A
3	WIPP 3	4TH 1998	25279	3.8E-09	1.6E-08

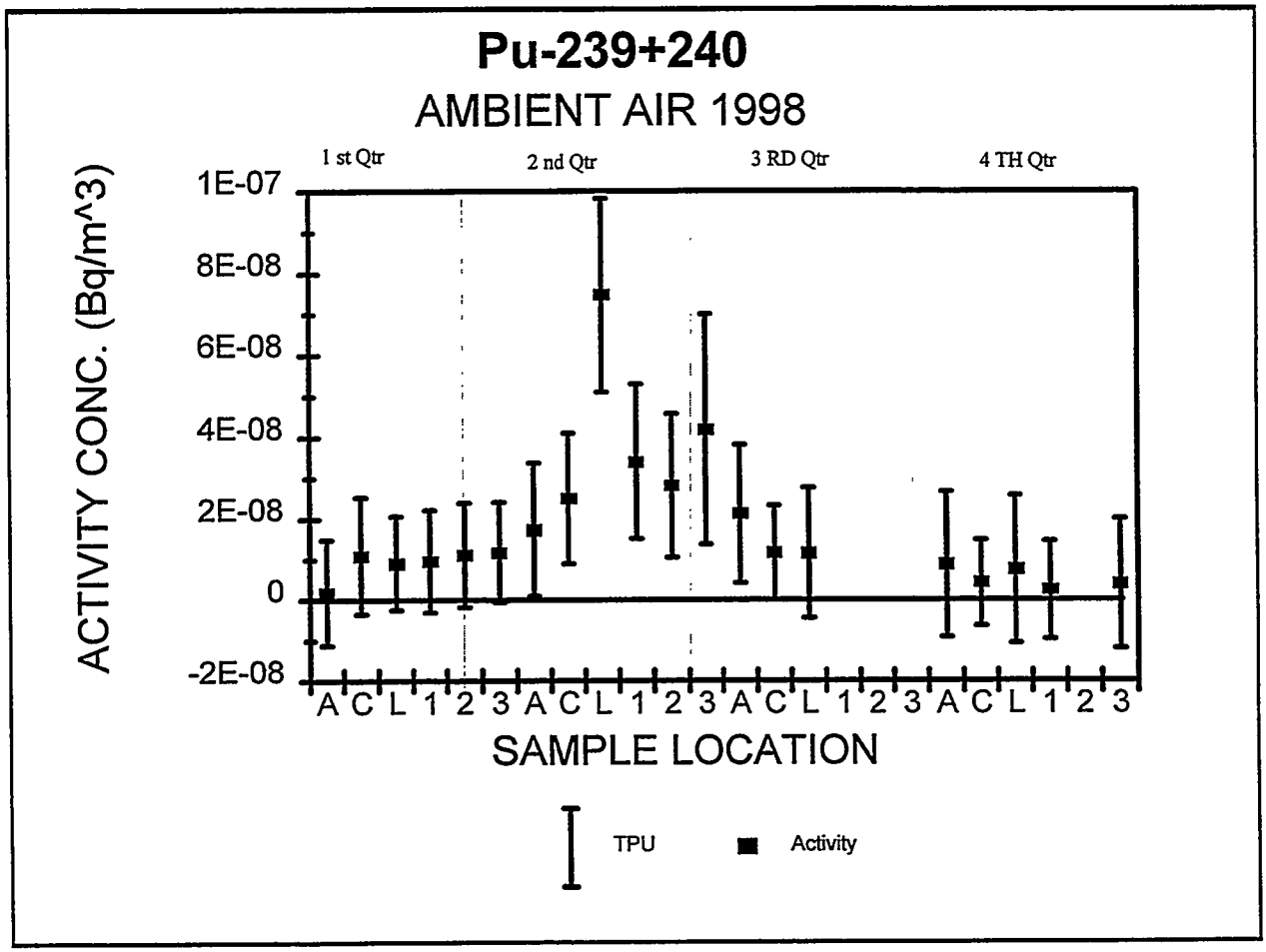

Figure B2. $^{239+240}Pu$ Concentrations in LVAS Samples During 1998

Table B3. ^{238}Pu Concentrations in LVAS Samples During 1998

SAMPLE LOCATION CODE	LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONC. ^{238}Pu (Bq/m^3)	^{238}Pu +/- TPU (Bq/m^3)
A	ARTESIA	1ST 1998	28117	2.2E-08	3.0E-08
C	CARLSBAD	1ST 1998	27476	-2.4E-08	2.3E-08
L	LOVING	1ST 1998	29085	5.5E-09	2.5E-08
1	WIPP 1	1ST 1998	27521	-1.6E-08	2.4E-08
2	WIPP 2	1ST 1998	28070	-3.3E-08	2.4E-08
3	WIPP 3	1ST 1998	28070	-2.1E-08	2.2E-08
A	ARTESIA	2ND 1998	27810	-2.0E-08	2.3E-08
C	CARLSBAD	2ND 1998	28293	-1.8E-08	2.3E-08
L	LOVING	2ND 1998	28896	-1.3E-08	2.3E-08
1	WIPP 1	2ND 1998	25240	-1.6E-08	2.4E-08
2	WIPP 2	2ND 1998	25565	-1.5E-08	2.6E-08
3	WIPP 3	2ND 1998	26206	3.2E-08	3.6E-08
A	ARTESIA	3RD 1998	26603	-2.6E-08	2.4E-08
C	CARLSBAD	3RD 1998	31412	-2.3E-08	2.1E-08
L	LOVING	3RD 1998	27018	-2.2E-08	2.6E-08
1	WIPP 1	3RD 1998	30232	N/A	N/A
2	WIPP 2	3RD 1998	28301	N/A	N/A
3	WIPP 3	3RD 1998	24562	N/A	N/A
A	ARTESIA	4TH 1998	25024	-1.4E-08	2.7E-08
C	CARLSBAD	4TH 1998	28488	1.7E-08	2.7E-08
L	LOVING	4TH 1998	25840	-2.4E-08	3.0E-08
1	WIPP 1	4TH 1998	28563	2.5E-08	3.1E-08
2	WIPP 2	4TH 1998	20772	N/A	N/A
3	WIPP 3	4TH 1998	25279	1.7E-09	3.0E-08

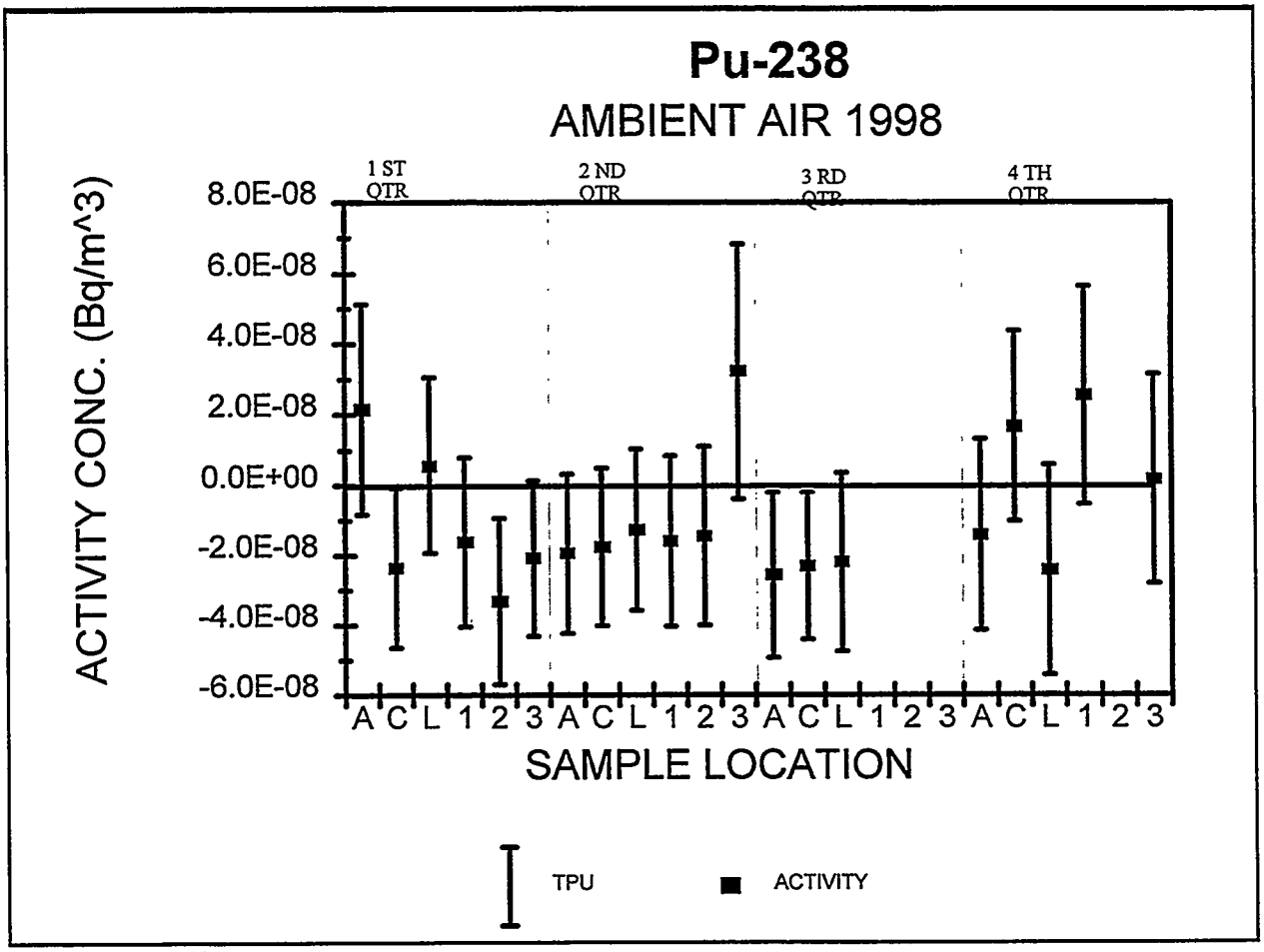

Figure B3. ^{238}Pu Concentrations in LVAS Samples During 1998

Table B4. ^{137}Cs Concentrations in LVAS Samples During 1998

SAMPLE LOCATION CODE	LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED AIR CONC. ^{137}Cs (Bq/m^3)	^{137}Cs +/- TPU (Bq/m^3)
A	ARTESIA	1ST 1998	28117	-7.3E-08	2.6E-06
C	CARLSBAD	1ST 1998	27476	-2.3E-07	2.6E-06
L	LOVING	1ST 1998	29085	-7.0E-08	2.5E-06
1	WIPP 1	1ST 1998	27521	-4.7E-07	1.1E-06
2	WIPP 2	1ST 1998	28070	4.4E-07	2.5E-06
3	WIPP 3	1ST 1998	28070	2.9E-07	2.6E-06
A	ARTESIA	2ND 1998	27810	-3.8E-07	2.6E-06
C	CARLSBAD	2ND 1998	28293	-8.4E-07	2.7E-06
L	LOVING	2ND 1998	28896	-7.2E-07	2.5E-06
1	WIPP 1	2ND 1998	25240	-1.4E-06	3.1E-06
2	WIPP 2	2ND 1998	25565	-1.1E-06	3.0E-06
3	WIPP 3	2ND 1998	26206	5.9E-07	2.7E-06
A	ARTESIA	3RD 1998	26603	4.5E-08	2.7E-06
C	CARLSBAD	3RD 1998	31412	9.5E-07	2.2E-06
L	LOVING	3RD 1998	27018	-2.4E-06	3.3E-06
1	WIPP 1	3RD 1998	30232	6.3E-07	2.4E-06
2	WIPP 2	3RD 1998	28301	1.0E-06	2.6E-06
3	WIPP 3	3RD 1998	24562	-8.3E-08	2.8E-06
A	ARTESIA	4TH 1998	25024	2.5E-07	2.9E-06
C	CARLSBAD	4TH 1998	28488	-5.2E-07	2.6E-06
L	LOVING	4TH 1998	25840	4.6E-07	2.8E-06
1	WIPP 1	4TH 1998	28563	-1.2E-06	2.7E-06
2	WIPP 2	4TH 1998	20772	1.7E-06	3.5E-06
3	WIPP 3	4TH 1998	25279	-8.6E-07	2.9E-06

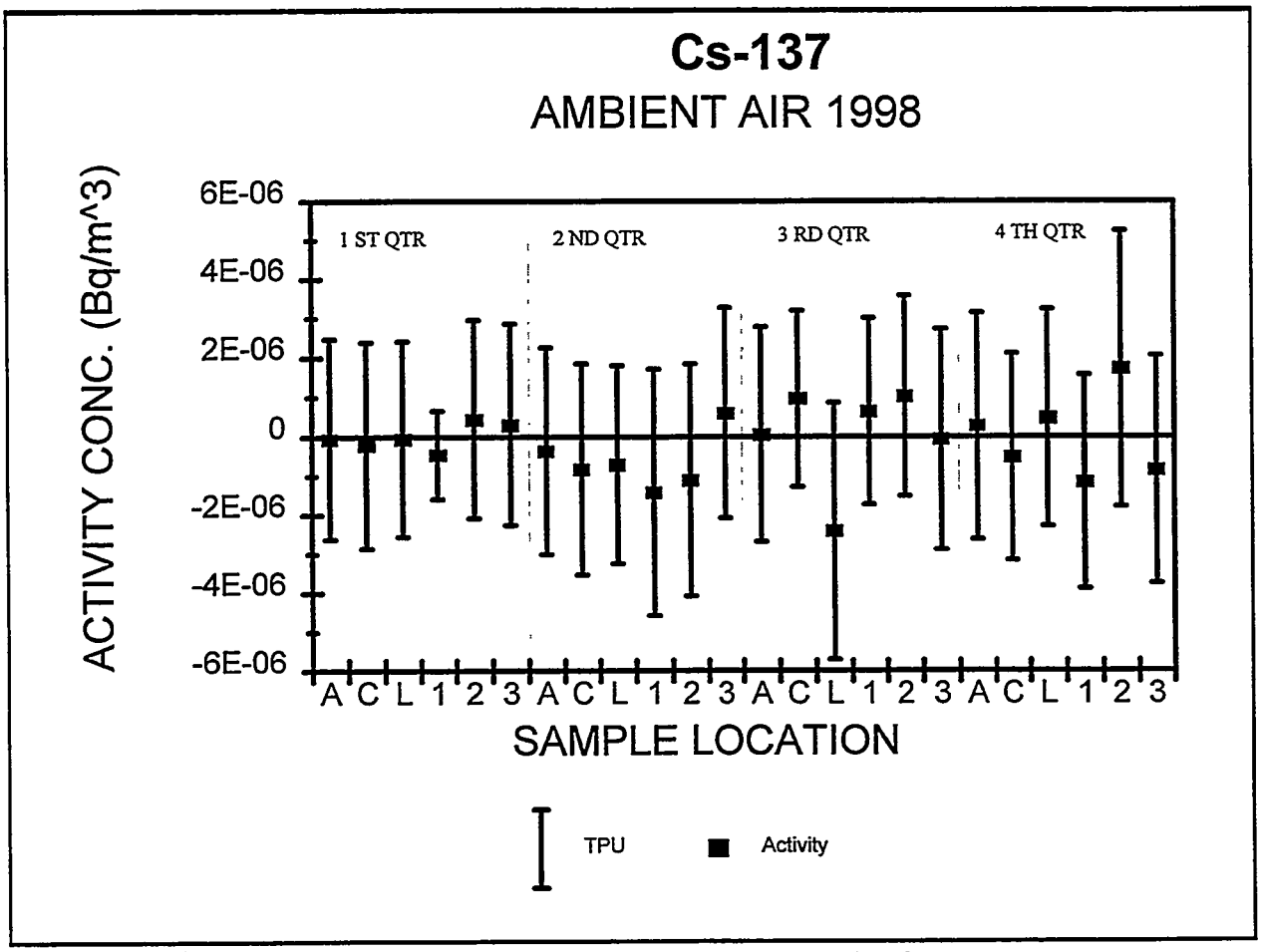

Figure B4. ^{137}Cs Concentrations in LVAS Samples During 1998

Table B5. ^{241}Am Concentrations in Station A Samples During 1996-1998

QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED AIR CONC. (Bq/m^3)	^{241}Am +/- TPU (Bq/m^3)
1ST 1996	6276	6.4E-08	1.6E-07
2ND 1996	5966	-3.7E-09	9.4E-08
3RD 1996	5925	N/A	N/A
4TH 1996	VOID	VOID	VOID
1ST 1997	4659	-1.4E-07	1.6E-07
2ND 1997	6210	-3.8E-08	1.2E-07
3RD 1997	6019	N/A	N/A
4TH 1997	4674	N/A	N/A
1ST 1998	5645	1.4E-08	1.8E-07
2ND 1998	6346	-5.3E-08	6.5E-08
3RD 1998	5813	-5.7E-09	1.3E-07
4TH 1998	4942	9.9E-08	1.2E-07

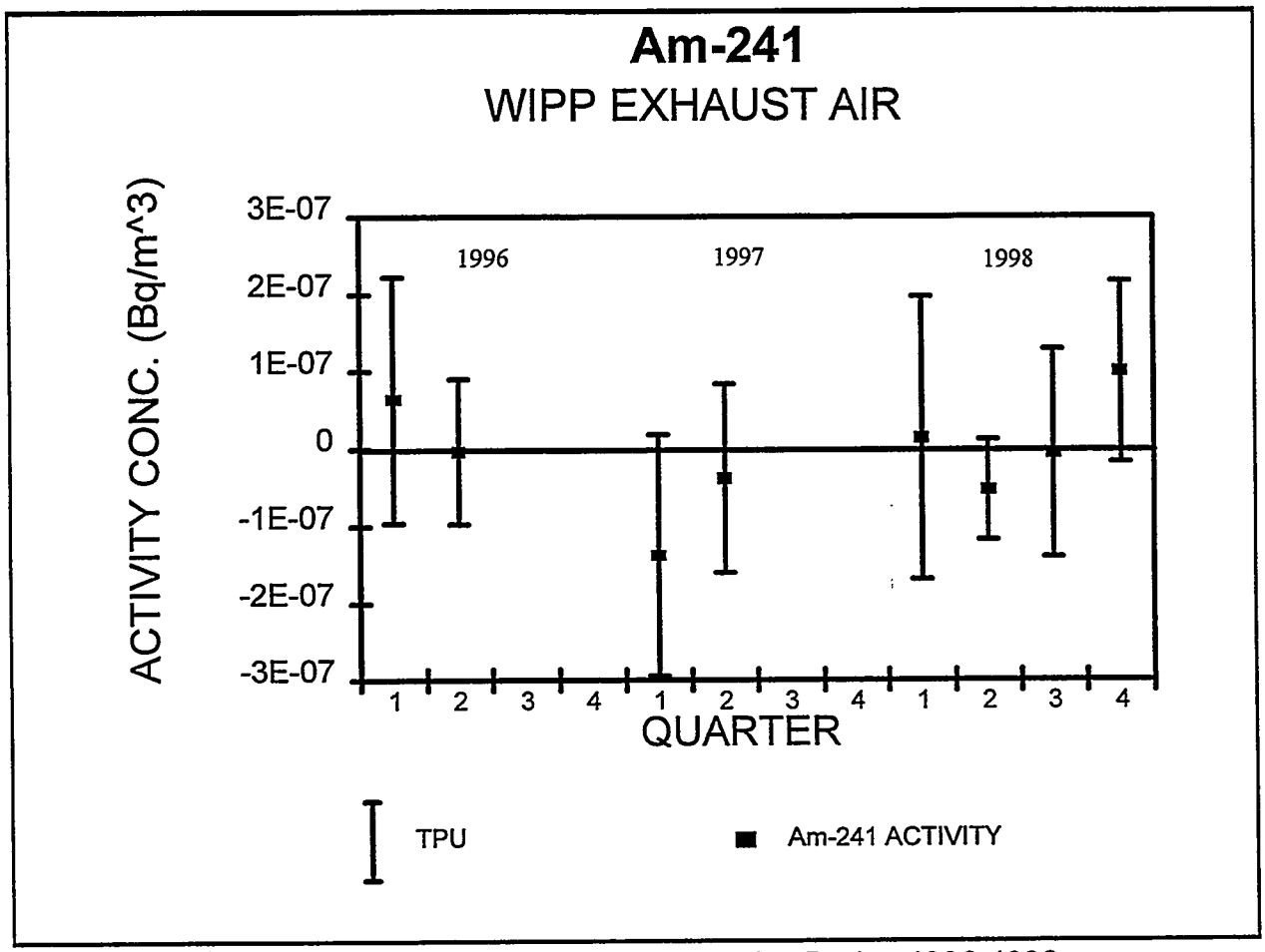

Figure B5. ^{241}Am Concentrations in Station A Samples During 1996-1998

Table B6. $^{239+240}Pu$ Concentrations in Station A Samples During 1996-1998

QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED AIR CONC. (Bq/m^3)	$^{239+240}Pu$ +/- TPU (Bq/m^3)
1ST 1996	6276	2.5E-08	5.8E-08
2ND 1996	5966	N/A	N/A
3RD 1996	5925	-1.8E-08	4.4E-08
4TH 1996	VOID	VOID	VOID
1ST 1997	4659	3.5E-08	7.1E-08
2ND 1997	6210	3.6E-08	5.5E-08
3RD 1997	6019	3.4E-08	7.5E-08
4TH 1997	4674	1.5E-08	1.1E-07
1ST 1998	5645	1.8E-07	1.1E-07
2ND 1998	6346	N/A	N/A
3RD 1998	5813	N/A	N/A
4TH 1998	4942	4.0E-08	9.8E-08

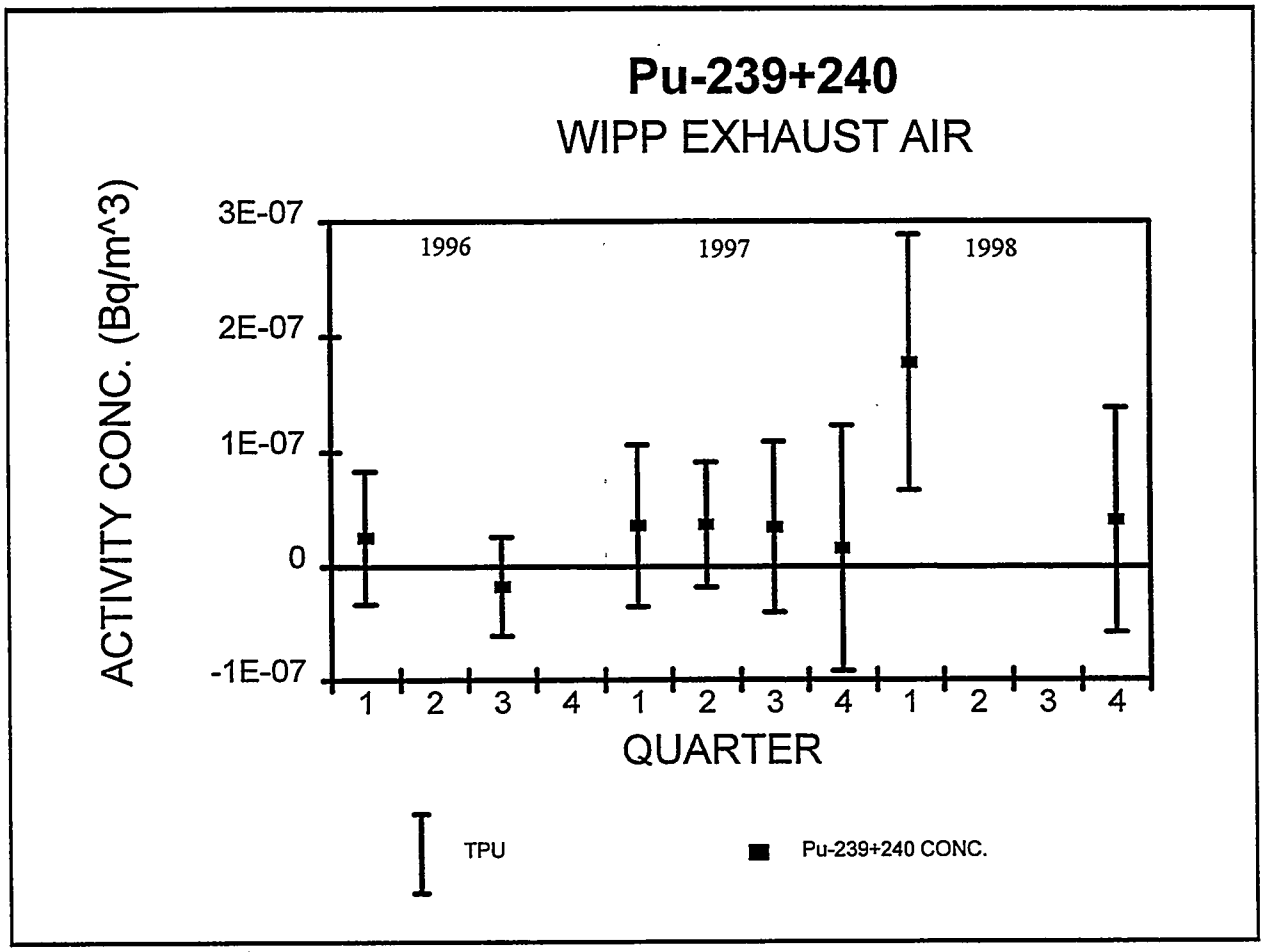

Figure B6. $^{239+240}$*Pu Concentrations in Station A Samples During 1996-1998*

Table B7. ^{238}Pu Concentrations in Station A Samples During 1996-1998

QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED AIR CONC. (Bq/m^3)	^{238}Pu +/- TPU (Bq/m^3)
1ST 1996	6276	2.3E-08	5.6E-08
2ND 1996	5966	N/A	N/A
3RD 1996	5925	-1.5E-08	1.4E-07
4TH 1996	VOID	N/A	N/A
1ST 1997	4659	5.1E-08	6.9E-08
2ND 1997	6210	-6.2E-09	3.1E-08
3RD 1997	6019	4.7E-09	9.9E-08
4TH 1997	4674	-2.0E-09	1.2E-07
1ST 1998	5645	2.4E-08	5.8E-08
2ND 1998	6346	N/A	N/A
3RD 1998	5813	N/A	N/A
4TH 1998	4942	5.7E-08	9.8E-08

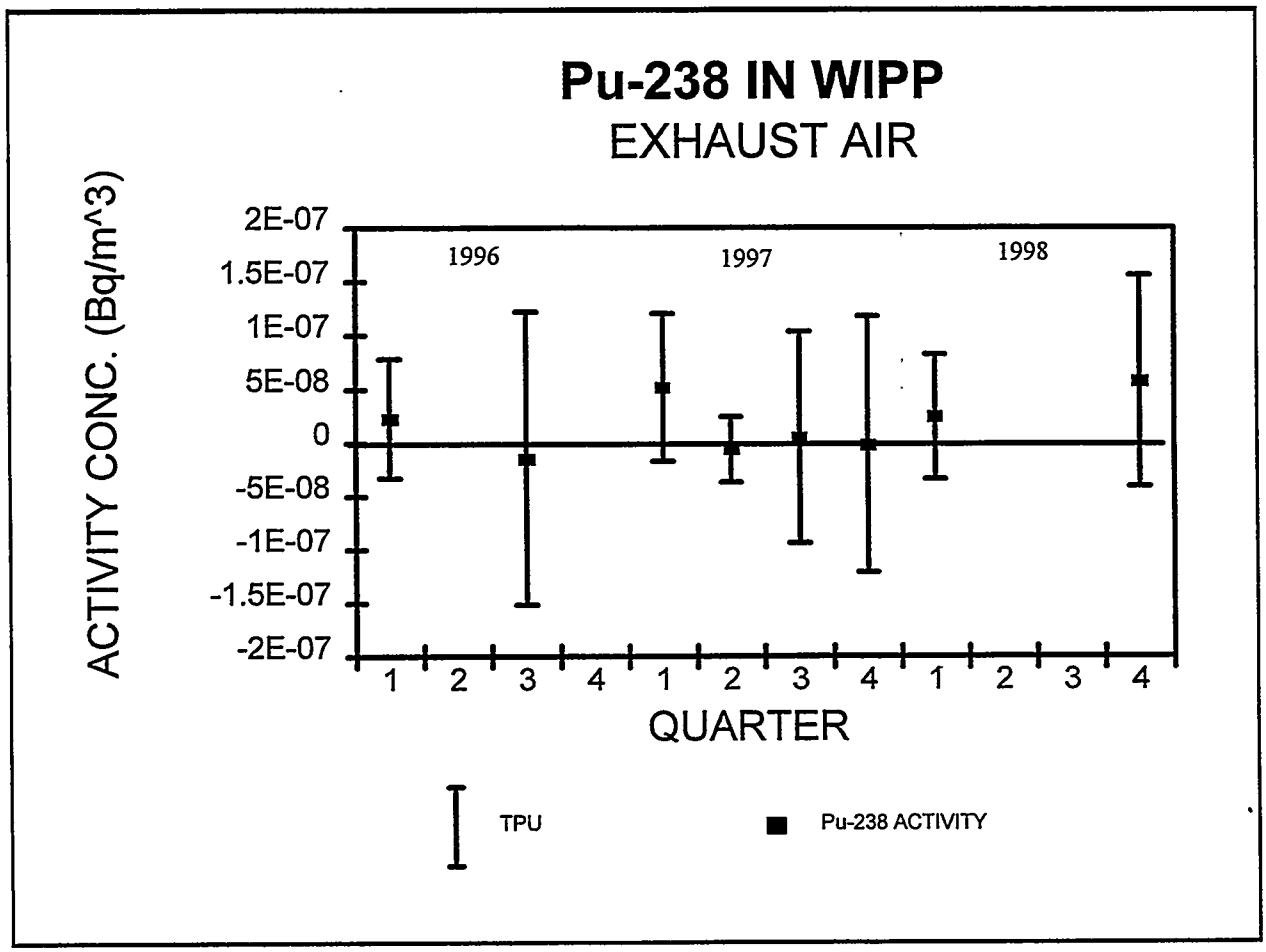

Figure B7. ^{238}Pu Concentrations in Station A During 1996-1998

Table B8. ^{137}Cs Concentrations in Station A Samples During 1996-1998

QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED AIR CONC. (Bq/m^3)	^{137}Cs +/- TPU (Bq/m^3)
1ST 1996	6276	9.4E-06	6.8E-06
2ND 1996	5966	1.8E-06	7.0E-06
3RD 1996	5925	-5.4E-06	6.9E-06
4TH 1996	VOID	VOID	VOID
1ST 1997	4659	4.4E-06	9.2E-06
2ND 1997	6210	2.1E-06	6.1E-06
3RD 1997	6019	-4.1E-06	6.6E-06
4TH 1997	4674	2.3E-06	8.5E-06
1ST 1998	5645	-2.9E-06	7.7E-06
2ND 1998	6346	2.9E-06	6.9E-06
3RD 1998	5813	4.3E-06	7.4E-06
4TH 1998	4942	3.5E-06	8.9E-06

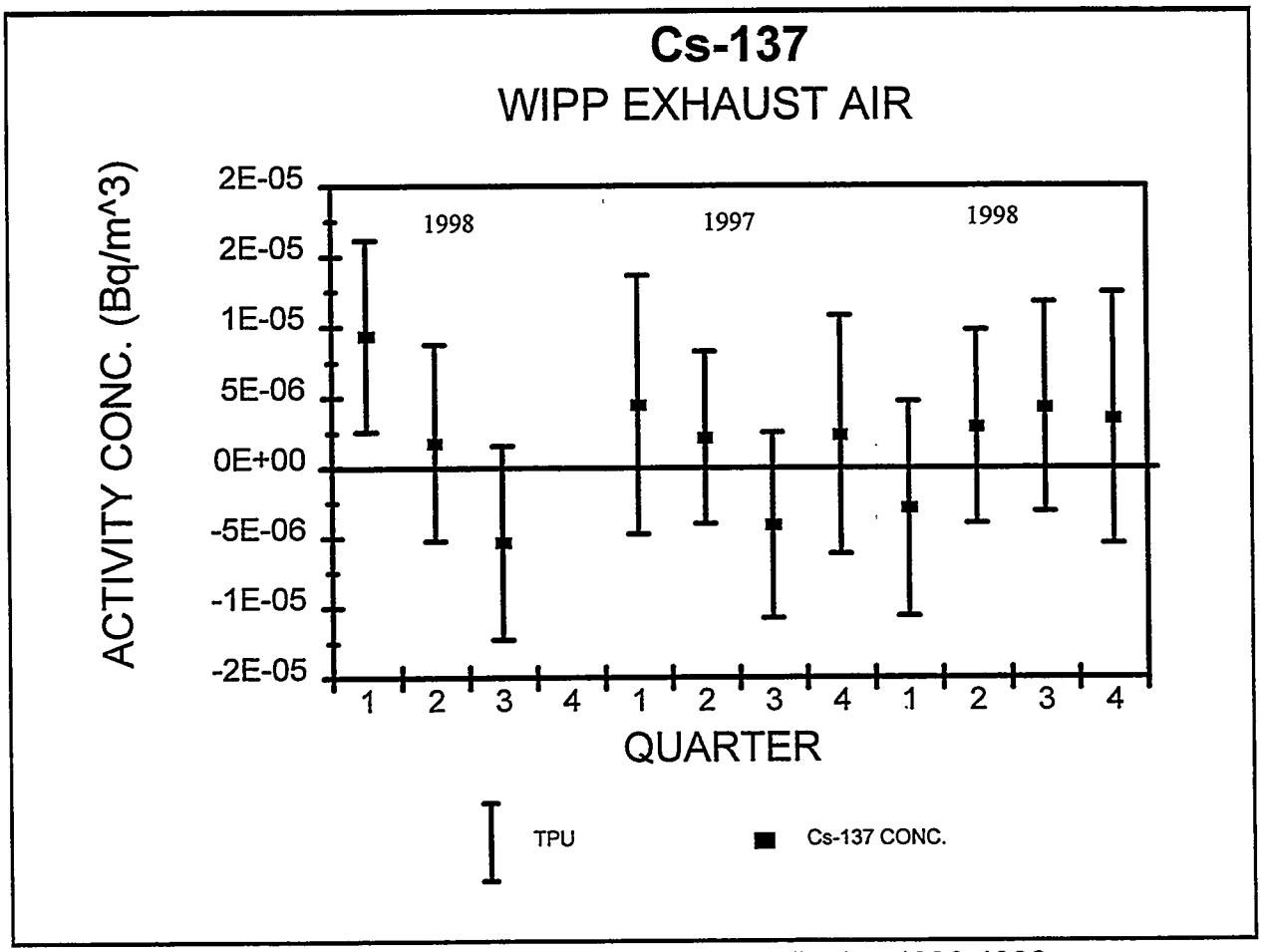

Figure B8. ^{137}Cs Concentrations in Station A Samples During 1996-1998

APPENDIX C: Water Sample Radiochemistry Data

Note: N/A in the table indicates results not available.

Table C1. ^{241}Am Concentrations in Public Water Systems During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	SYSTEM SAMPLED	^{241}AM ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/31/96	LOVING WSS	2.8E-04	1.5E-03
2	07/31/96	OTIS WSS	4.7E-04	1.6E-03
3	07/31/96	CARLSBAD WSS	-9.0E-04	1.2E-03
4	08/22/96	WIPP WSS	-1.7E-03	2.1E-03
5	03/06/97	CARLSBAD WSS	-4.8E-04	8.7E-04
6	07/17/97	LOVING WSS	-6.7E-04	1.1E-03
7	06/10/98	CARLSBAD WSS	-1.8E-04	9.0E-04
8	06/10/98	LOVING WSS	1.1E-03	1.2E-03
9	06/10/98	OTIS WSS	-1.3E-04	7.9E-04
10	06/23/98	WIPP WSS	-1.9E-04	7.2E-04

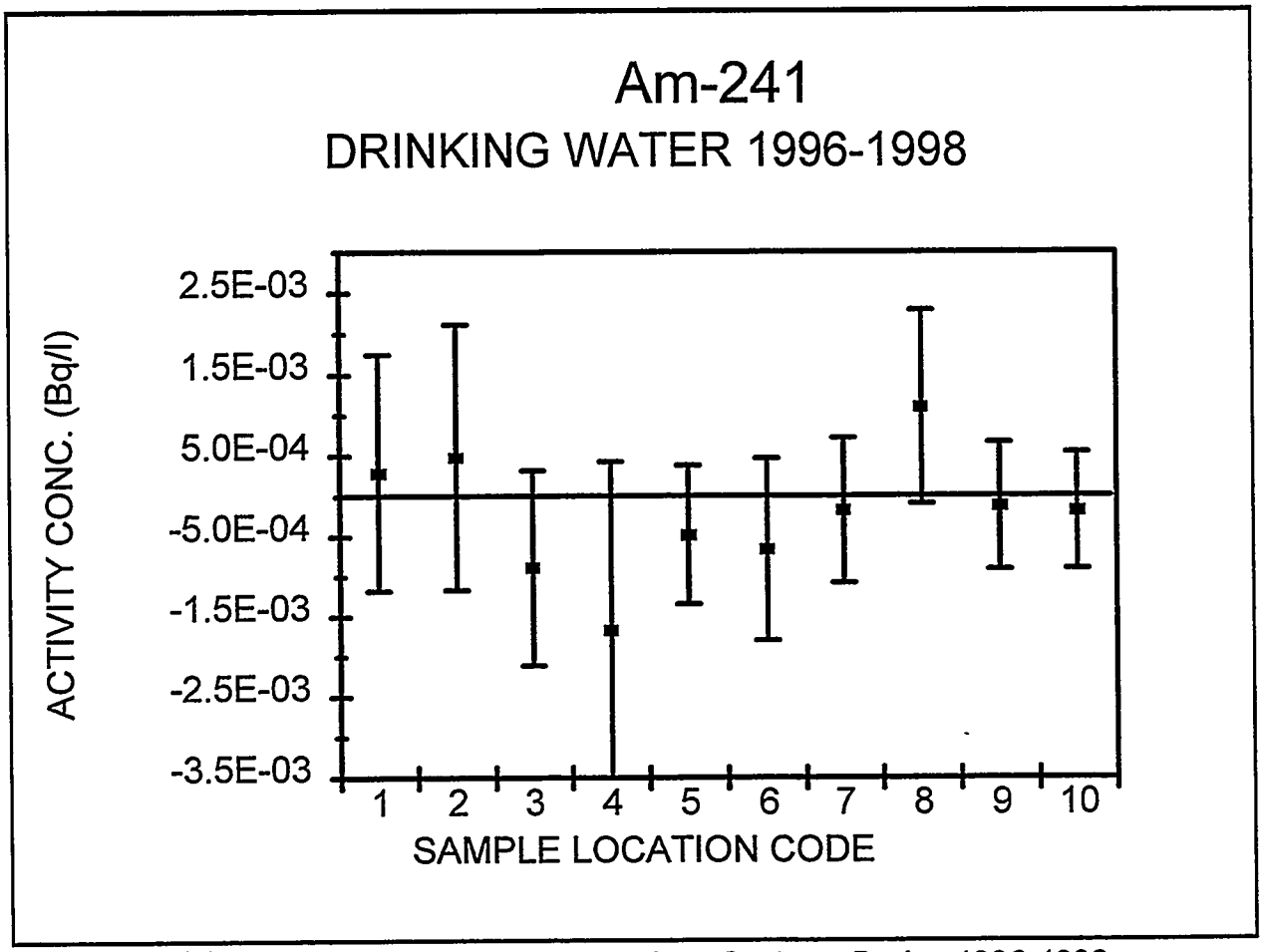

Figure C1. ^{241}Am Concentrations in Public Water Systems During 1996-1998

Table C2. $^{239+240}Pu$ Concentrations in Public Water Systems During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	SYSTEM SAMPLED	$^{239+240}PU$ ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/31/96	LOVING WSS	-2.9E-04	4.1E-04
2	07/31/96	OTIS WSS	-2.8E-04	4.1E-04
3	07/31/96	CARLSBAD WSS	-2.5E-04	1.2E-03
4	08/22/96	WIPP WSS	2.5E-04	5.6E-04
5	03/06/97	CARLSBAD WSS	-1.5E-04	4.2E-04
6	07/17/97	LOVING WSS	2.5E-04	5.9E-04
7	06/10/98	CARLSBAD WSS	-3.7E-05	4.5E-04
8	06/10/98	LOVING WSS	7.7E-04	6.1E-04
9	06/10/98	OTIS WSS	-2.0E-04	4.9E-04
10	06/23/98	WIPP WSS	6.5E-07	4.5E-04

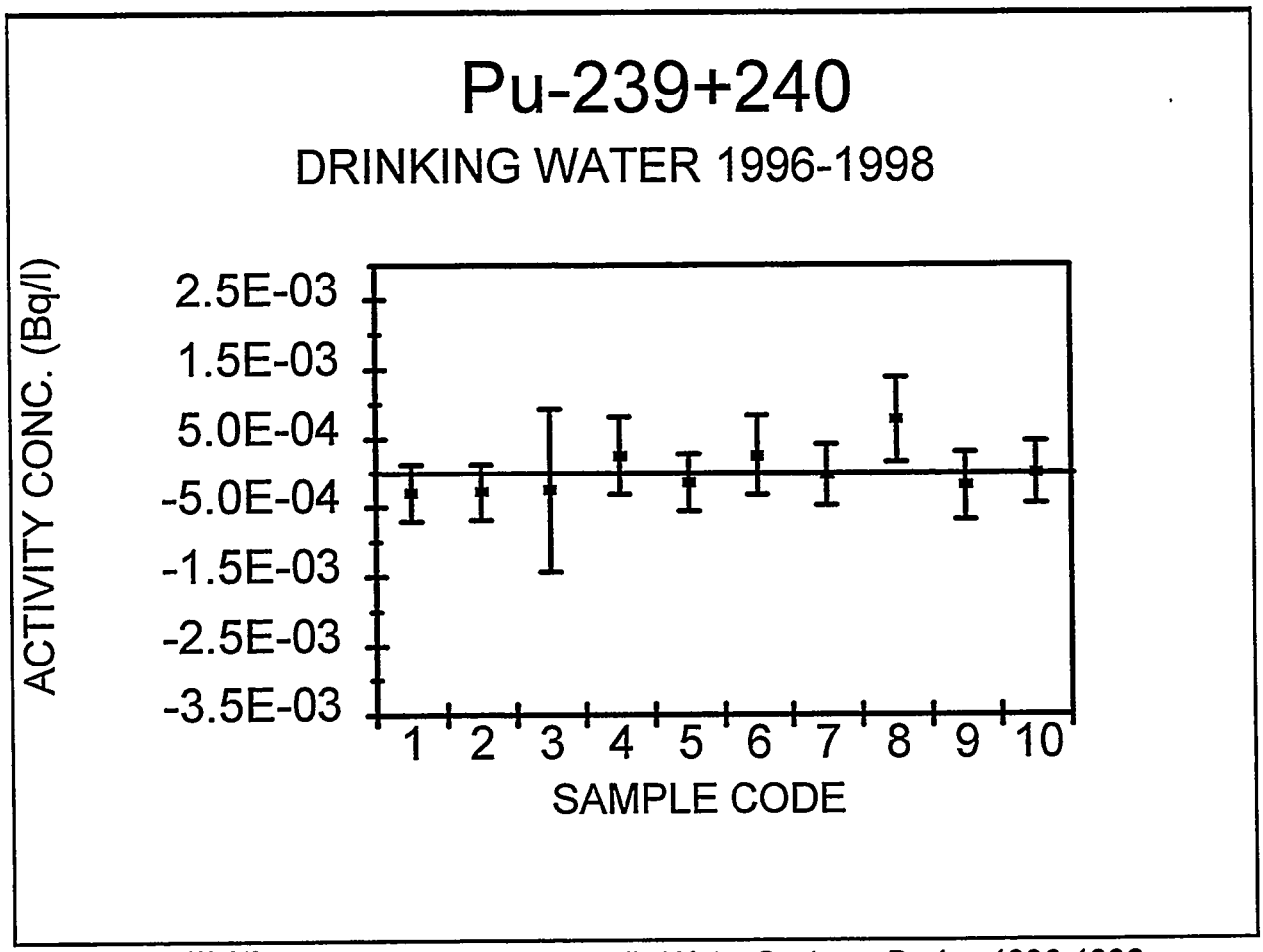

Figure C2. $^{239+240}$*Pu Concentrations in Public Water Systems During 1996-1998*

Table C3. ^{238}Pu Concentrations in Public Water Systems During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	SYSTEM SAMPLED	^{238}Pu ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/31/96	LOVING WSS	-8.8E-05	7.8E-04
2	07/31/96	OTIS WSS	8.4E-04	1.4E-03
3	07/31/96	CARLSBAD WSS	1.4E-04	1.5E-03
4	08/22/96	WIPP WSS	-3.6E-04	1.1E-03
5	03/06/97	CARLSBAD WSS	1.1E-03	7.7E-04
6	07/17/97	LOVING WSS	2.5E-04	7.5E-04
7	06/10/98	CARLSBAD WSS	2.4E-05	5.5E-04
8	06/10/98	LOVING WSS	-4.6E-04	6.5E-04
9	06/10/98	OTIS WSS	2.5E-04	6.3E-04
10	06/23/98	WIPP WSS	-8.9E-05	5.2E-04

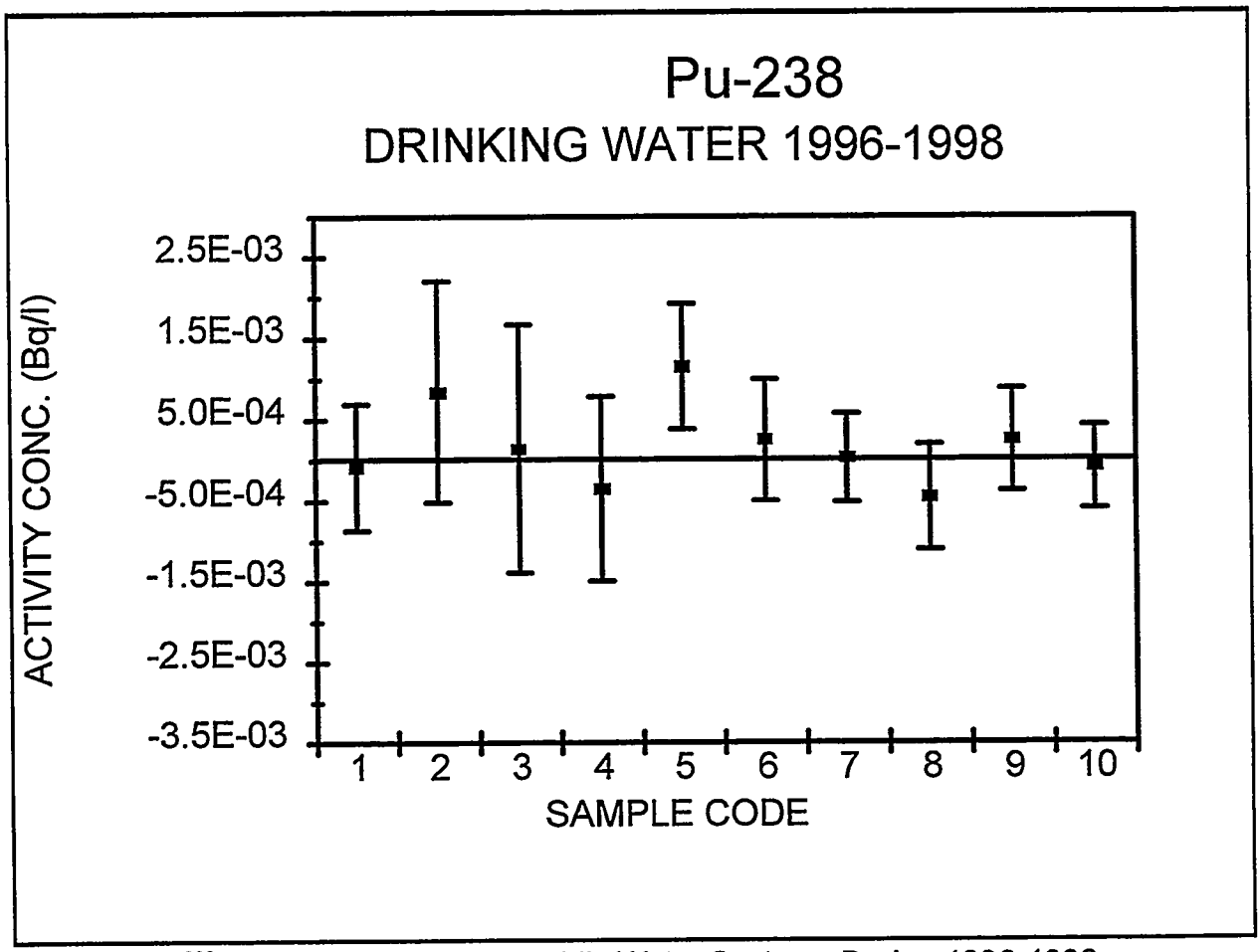

Figure C3. ^{238}Pu Concentrations in Public Water Systems During 1996-1998

Table C4. ^{137}Cs Concentrations in Public Water Systems During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	SYSTEM SAMPLED	^{137}Cs ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/31/96	LOVING WSS	N/A	N/A
2	07/31/96	OTIS WSS	N/A	N/A
3	07/31/96	CARLSBAD WSS	N/A	N/A
4	08/22/96	WIPP WSS	N/A	N/A
5	03/06/97	CARLSBAD WSS	N/A	N/A
6	07/17/97	LOVING WSS	4.7E-02	4.1E-02
7	06/10/98	CARLSBAD WSS	-3.1E-03	4.6E-02
8	06/10/98	LOVING WSS	4.5E-02	4.6E-02
9	06/10/98	OTIS WSS	1.7E-02	4.7E-02
10	06/23/98	WIPP WSS	-4.5E-03	4.9E-02

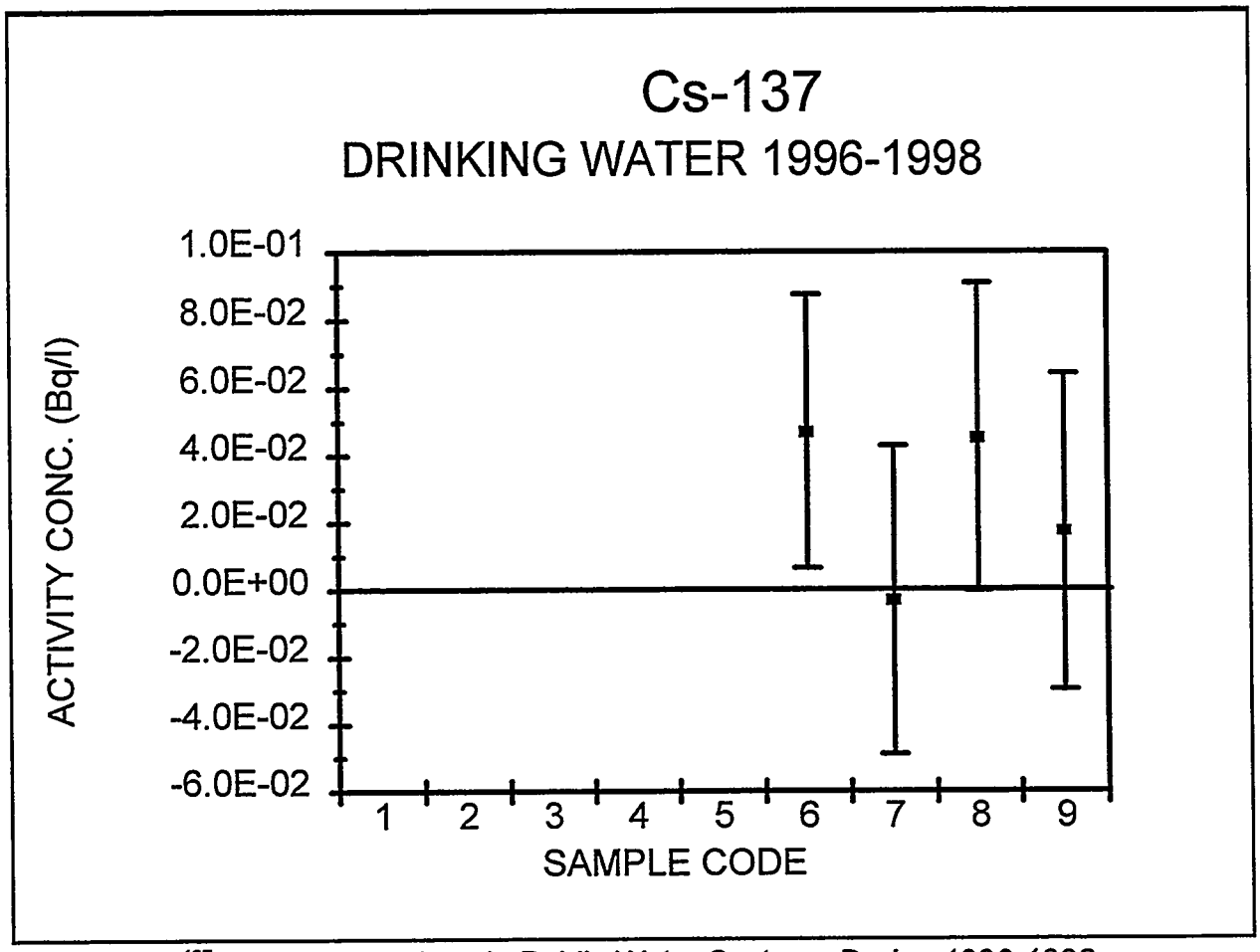

Figure C4. ^{137}Cs Concentrations in Public Water Systems During 1996-1998

Table C5. ^{241}Am Concentrations in Surface Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	LOCATION SAMPLED	^{241}AM ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/12/96	RED TANK	1.1E-03	1.7E-03
2	07/12/96	NOYA TANK	-7.9E-04	7.7E-04
3	07/12/96	HILL TANK	-1.3E-03	1.3E-03
4	07/31/96	PECOS @ P.C.	-8.4E-06	9.3E-04
5	08/22/96	INDIAN TANK	-8.8E-04	1.8E-03
6	09/26/96	PECOS @ CBD	-1.2E-03	1.3E-03
7	09/26/96	LAGUNA GRANDE	-9.7E-04	1.3E-03
8	06/14/96	WIPP EFFLUENT	4.3E-04	1.8E-03
9	03/05/97	PECOS @ CBD	N/A	N/A
10	04/03/97	WIPP EFFLUENT	-7.2E-04	6.5E-04
11	07/24/97	NOYA TANK	-1.1E-04	9.6E-04
12	07/28/97	HILL TANK	-3.5E-04	8.3E-04
13	07/28/97	RED TANK	-3.3E-05	1.4E-03
14	06/23/98	PECOS @ CBD	-2.0E-03	1.4E-03
15	06/23/98	PECOS @ P.C.	5.7E-05	1.1E-03
16	07/22/98	WIPP EFFLUENT	-1.4E-03	7.3E-04
17	07/29/98	HILL TANK	N/A	N/A
18	07/29/98	NOYA TANK	-5.1E-04	7.8E-04
19	07/29/98	INDIAN TANK	-9.0E-04	6.4E-04

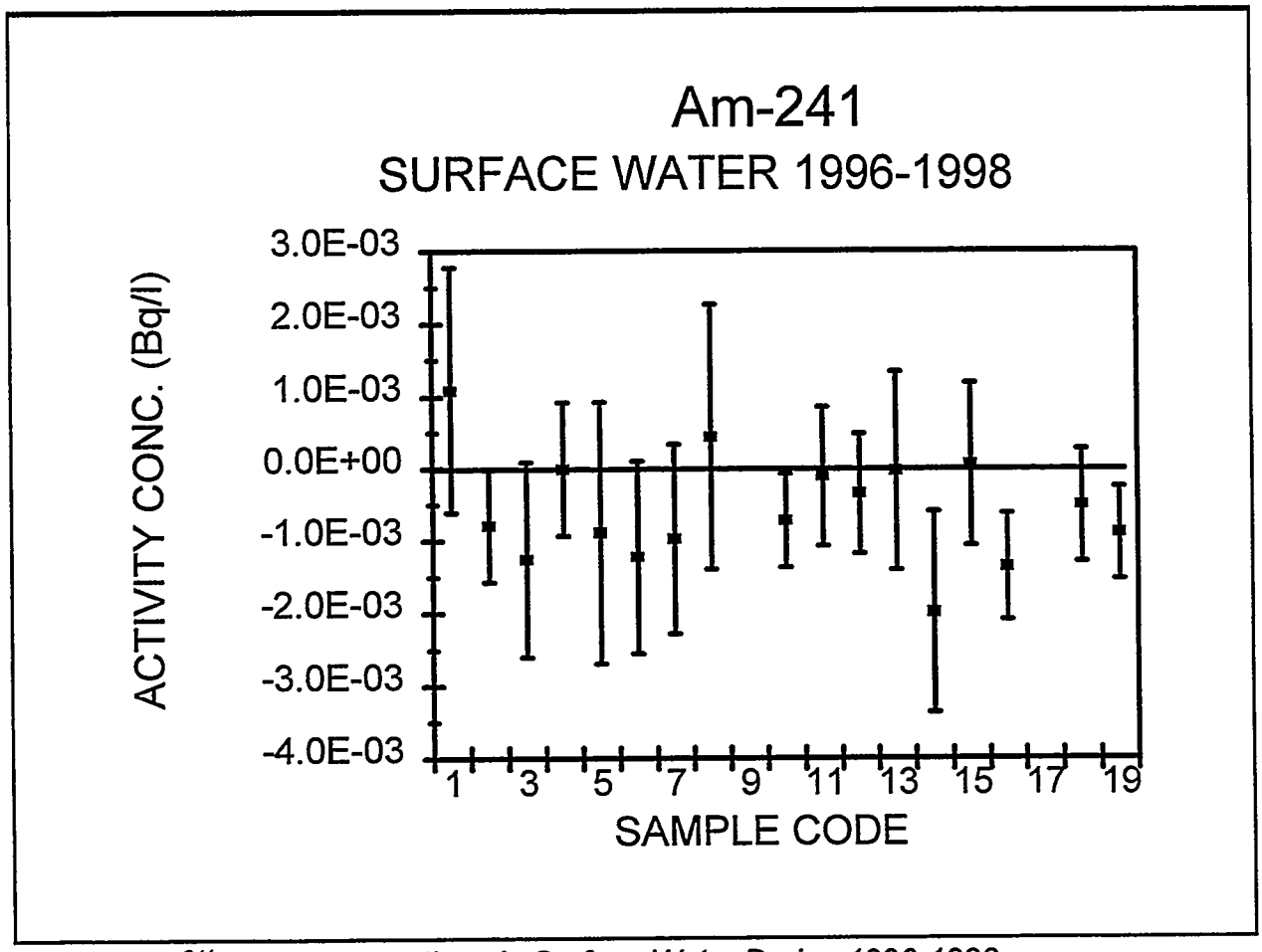

Figure C5. ^{241}Am Concentrations in Surface Water During 1996-1998

Table C6. $^{239+240}Pu$ Concentrations in Surface Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	LOCATION SAMPLED	$^{239+240}PU$ ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/12/96	RED TANK	5.3E-05	7.2E-04
2	07/12/96	NOYA TANK	2.7E-04	5.6E-04
3	07/12/96	HILL TANK	-5.9E-04	1.3E-03
4	07/31/96	PECOS @ P.C.	-1.1E-04	4.5E-04
5	08/22/96	INDIAN TANK	8.9E-04	8.5E-04
6	09/26/96	PECOS @ CBD	-1.8E-04	4.2E-04
7	09/26/96	LAGUNA GRANDE	3.1E-05	5.2E-04
8	06/14/96	WIPP EFFLUENT	2.8E-04	5.1E-04
9	03/05/97	PECOS @ CBD	-3.5E-05	5.8E-04
10	04/03/97	WIPP EFFLUENT	-4.4E-04	6.0E-04
11	07/24/97	NOYA TANK	2.2E-04	1.0E-03
12	07/28/97	HILL TANK	2.3E-04	5.7E-04
13	07/28/97	RED TANK	-1.2E-04	5.0E-04
14	06/23/98	PECOS @ CBD	3.4E-05	4.9E-04
15	06/23/98	PECOS @ P.C.	9.0E-05	5.0E-04
16	07/22/98	WIPP EFFLUENT	-1.2E-04	4.3E-04
17	07/29/98	HILL TANK	-3.5E-05	4.5E-04
18	07/29/98	NOYA TANK	2.4E-05	5.2E-04
19	07/29/98	INDIAN TANK	3.7E-06	4.7E-04

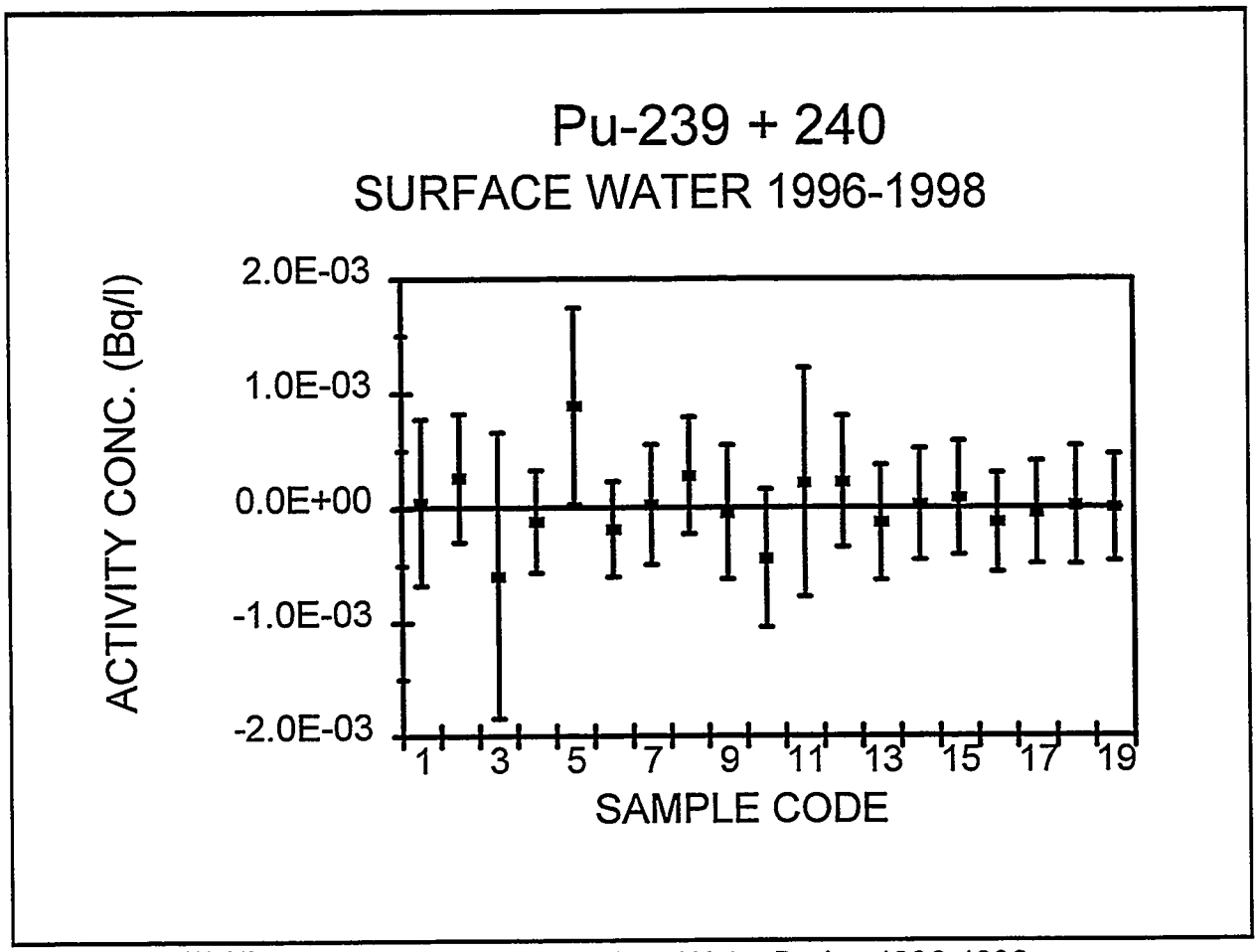

Figure C6. $^{239+240}$*Pu Concentrations in Surface Water During 1996-1998*

Table C7. ^{238}Pu Concentrations in Surface Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	LOCATION SAMPLED	^{238}PU ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/12/96	RED TANK	1.03E-03	1.30E-03
2	07/12/96	NOYA TANK	N/A	N/A
3	07/12/96	HILL TANK	4.95E-04	1.74E-03
4	07/31/96	PECOS @ P.C.	6.13E-04	6.61E-04
5	08/22/96	INDIAN TANK	-2.85E-04	9.77E-04
6	09/26/96	PECOS @ CBD	2.25E-03	7.87E-04
7	09/26/96	LAGUNA GRANDE	1.50E-03	9.45E-04
8	06/14/96	WIPP EFFLUENT	8.30E-04	6.80E-04
9	03/05/97	PECOS @ CBD	N/A	N/A
10	04/03/97	WIPP EFFLUENT	4.63E-04	8.54E-04
11	07/24/97	NOYA TANK	-1.90E-04	4.79E-04
12	07/28/97	HILL TANK	2.26E-04	7.42E-04
13	07/28/97	RED TANK	-6.39E-04	6.73E-04
14	06/23/98	PECOS @ CBD	5.22E-04	9.03E-04
15	06/23/98	PECOS @ P.C.	-2.58E-04	7.47E-04
16	07/22/98	WIPP EFFLUENT	-4.45E-04	6.82E-04
17	07/29/98	HILL TANK	2.58E-05	5.87E-04
18	07/29/98	NOYA TANK	-1.90E-04	4.91E-04
19	07/29/98	INDIAN TANK	-4.45E-04	6.33E-04

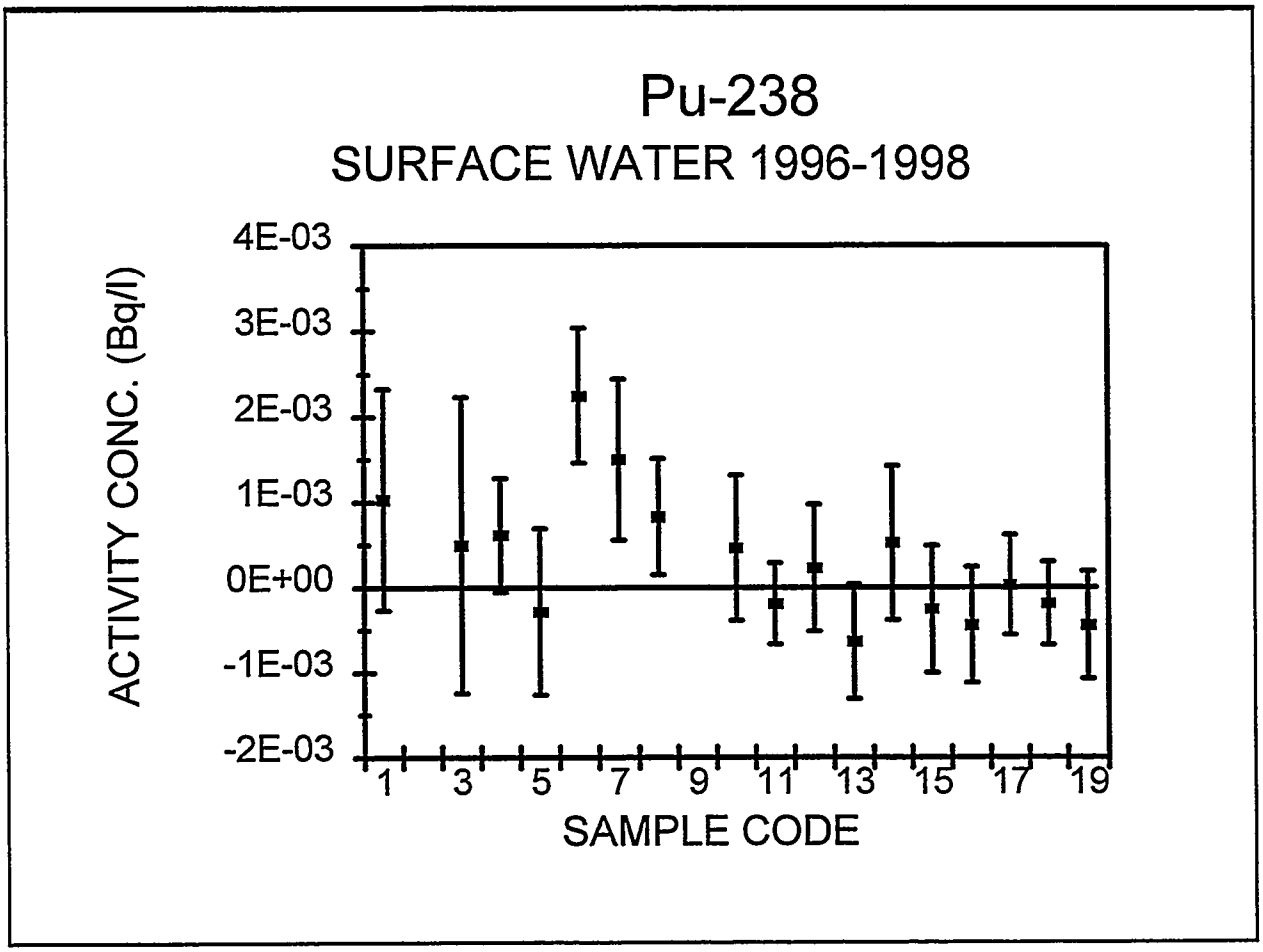

Figure C7. ^{238}Pu Concentrations in Surface Water During 1996-1998

Table C8. ^{137}Cs Concentrations in Surface Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	LOCATION SAMPLED	^{137}Cs ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	07/12/96	RED TANK	N/A	N/A
2	07/12/96	NOYA TANK	N/A	N/A
3	07/12/96	HILL TANK	N/A	N/A
4	07/31/96	PECOS @ P.C.	N/A	N/A
5	08/22/96	INDIAN TANK	N/A	N/A
6	09/26/96	PECOS @ CBD	N/A	N/A
7	09/26/96	LAGUNA GRANDE	N/A	N/A
8	06/14/96	WIPP EFFLUENT	N/A	N/A
9	03/05/97	PECOS @ CBD	N/A	N/A
10	04/03/97	WIPP EFFLUENT	N/A	N/A
11	07/24/97	NOYA TANK	4.6E-02	4.1E-02
12	07/28/97	HILL TANK	7.8E-02	4.1E-02
13	07/28/97	RED TANK	N/A	N/A
14	06/23/98	PECOS @ CBD	4.3E-02	4.7E-02
15	06/23/98	PECOS @ P.C.	3.9E-03	5.4E-02
16	07/22/98	WIPP EFFLUENT	-1.3E-03	4.9E-02
17	07/29/98	HILL TANK	-1.3E-01	4.8E-02
18	07/29/98	NOYA TANK	6.6E-02	4.6E-02
19	07/29/98	INDIAN TANK	6.7E-02	4.6E-02

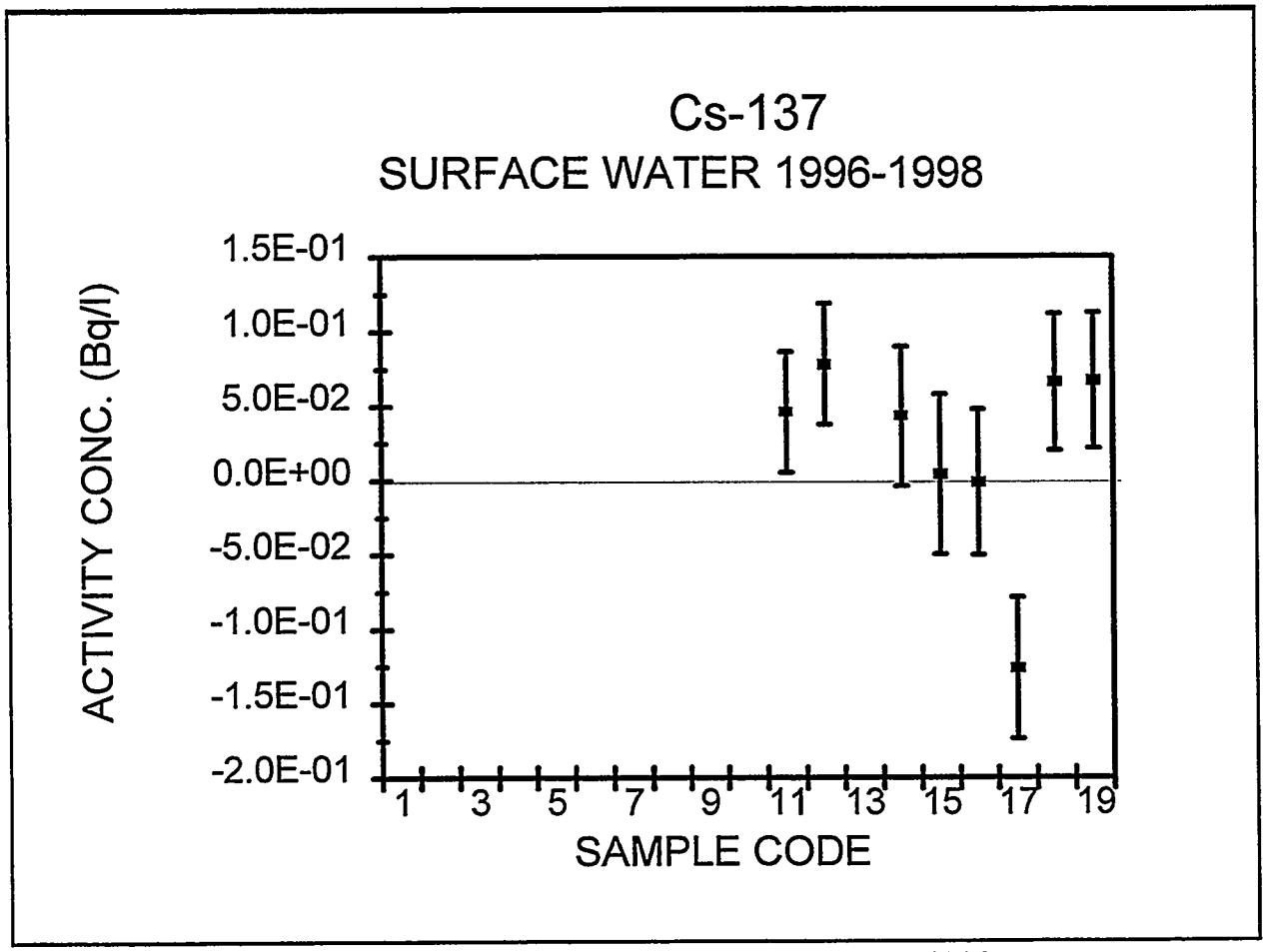

Figure C8. ^{137}Cs Concentrations in Surface Water During 1996-1998

Table C9. ^{241}Am Concentrations in Ground Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	WELL SAMPLED	^{241}Am ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	04/11/96	WQSP-1	1.4E-04	1.0E-03
2	06/06/96	WQSP-5	-9.0E-04	1.1E-03
3	08/08/96	WQSP-2	1.6E-03	1.7E-03
4	08/22/96	WQSP-3	4.3E-04	2.9E-03
5	04/03/97	WQSP-6	1.6E-03	4.1E-03
6	04/10/97	WQSP-6A	6.1E-05	7.8E-04
7	04/24/97	WQSP-1	3.5E-03	5.1E-03
8	05/08/97	WQSP-2	4.6E-03	1.8E-03
9	05/22/97	WQSP-3	6.5E-03	5.2E-03
10	06/05/97	WQSP-4	8.1E-04	1.5E-03
11	06/19/97	WQSP-5	-4.5E-04	1.1E-03
12	03/05/98	WQSP-1	-4.8E-04	8.0E-04
13	04/22/98	WQSP-3	8.1E-04	5.3E-03
14	05/06/98	WQSP-4	1.6E-03	2.1E-03
15	05/20/98	WQSP-5	-3.3E-04	9.4E-04
16	06/03/98	WQSP-6	-4.7E-04	1.0E-03
17	06/10/98	WQSP-6A	-1.9E-04	8.3E-04
18	08/12/98	WQSP-2	-3.6E-05	8.9E-04

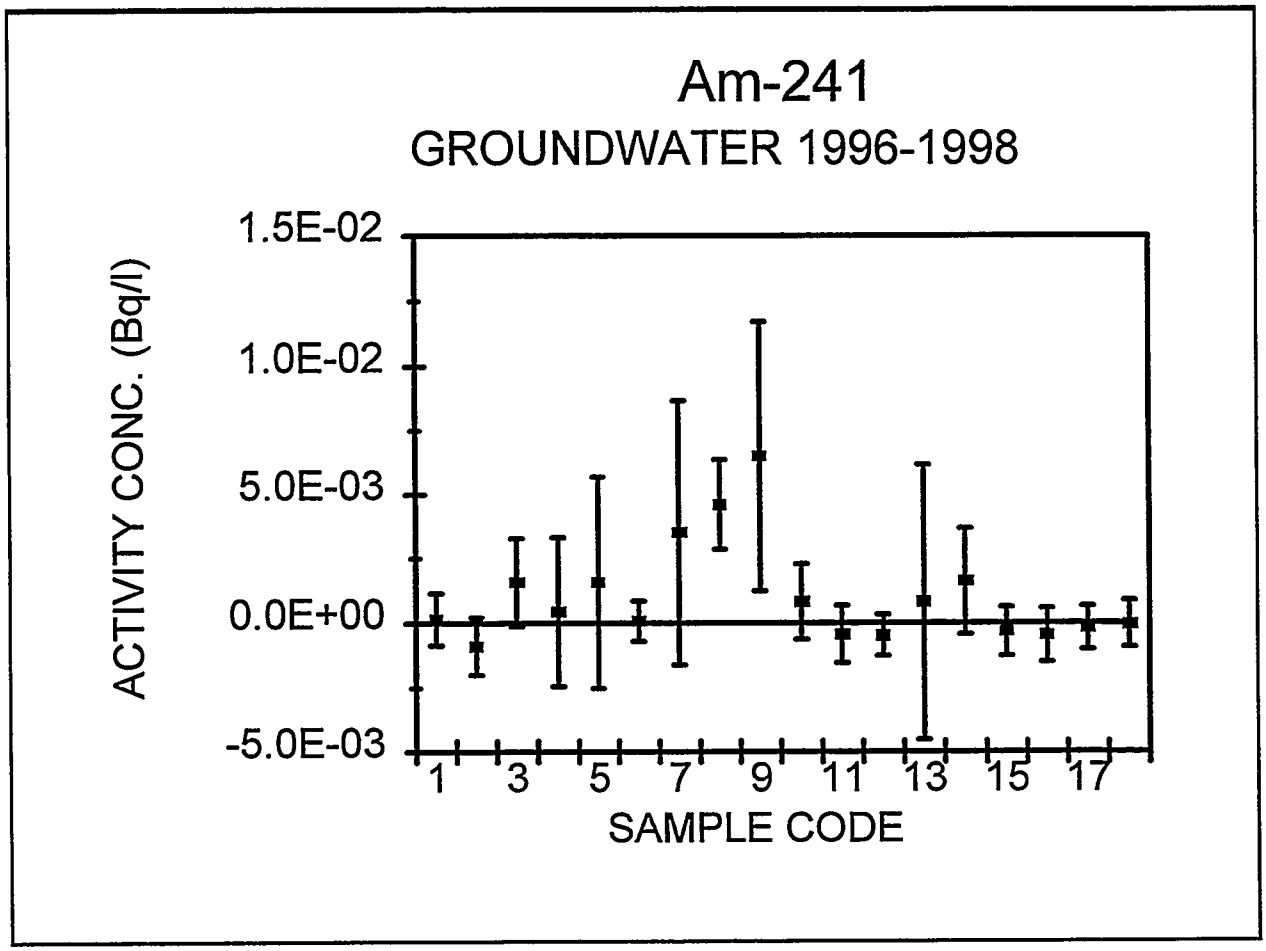

Figure C9. ^{241}Am Concentrations in Ground Water During 1996-1998

Table C10. $^{239+240}Pu$ Concentrations in Ground Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	WELL SAMPLED	$^{239+240}Pu$ ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	04/11/96	WQSP-1	3.4E-04	5.5E-04
2	06/06/96	WQSP-5	N/A	N/A
3	08/08/96	WQSP-2	2.1E-04	5.7E-04
4	08/22/96	WQSP-3	9.5E-04	8.2E-04
5	04/03/97	WQSP-6	1.5E-03	1.9E-03
6	04/10/97	WQSP-6A	-2.5E-04	4.1E-04
7	04/24/97	WQSP-1	9.4E-04	1.4E-03
8	05/08/97	WQSP-2	2.8E-04	6.8E-04
9	05/22/97	WQSP-3	8.3E-04	1.3E-03
10	06/05/97	WQSP-4	9.5E-04	8.6E-04
11	06/19/97	WQSP-5	-7.3E-06	4.9E-04
12	03/05/98	WQSP-1	-9.0E-05	4.5E-04
13	04/22/98	WQSP-3	2.0E-03	1.9E-03
14	05/06/98	WQSP-4	6.4E-05	7.4E-04
15	05/20/98	WQSP-5	6.7E-05	5.2E-04
16	06/03/98	WQSP-6	2.1E-04	5.3E-04
17	06/10/98	WQSP-6A	-5.5E-05	5.5E-04
18	08/12/98	WQSP-2	-9.7E-05	5.4E-04

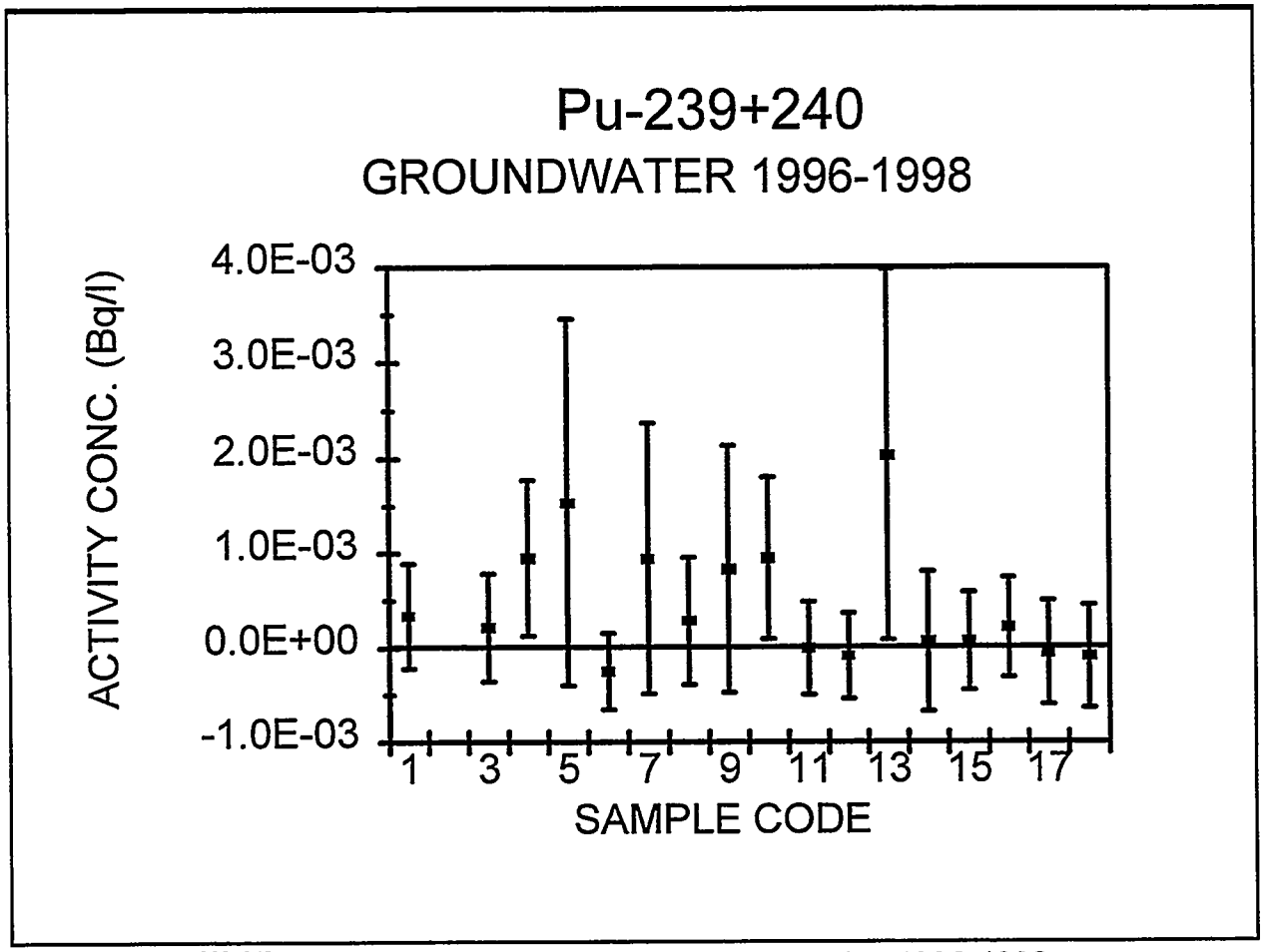

Figure C10. $^{230+240}Pu$ Concentrations in Ground Water During 1996-1998

Table C11. ^{238}Pu Concentrations in Ground Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	WELL SAMPLED	^{238}Pu ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	04/11/96	WQSP-1	6.9E-04	6.8E-04
2	06/06/96	WQSP-5	N/A	N/A
3	08/08/96	WQSP-2	-4.2E-06	8.3E-04
4	08/22/96	WQSP-3	-4.1E-04	7.0E-04
5	04/03/97	WQSP-6	1.2E-03	2.9E-03
6	04/10/97	WQSP-6A	3.6E-04	1.1E-03
7	04/24/97	WQSP-1	2.2E-03	2.8E-03
8	05/08/97	WQSP-2	7.3E-04	9.8E-04
9	05/22/97	WQSP-3	5.3E-04	2.3E-03
10	06/05/97	WQSP-4	-1.9E-04	4.9E-04
11	06/19/97	WQSP-5	4.2E-04	6.2E-04
12	03/05/98	WQSP-1	2.9E-04	6.4E-04
13	04/22/98	WQSP-3	3.9E-04	2.2E-03
14	05/06/98	WQSP-4	6.0E-04	9.5E-04
15	05/20/98	WQSP-5	N/A	N/A
16	06/03/98	WQSP-6	-6.5E-04	7.1E-04
17	06/10/98	WQSP-6A	-5.9E-05	6.1E-04
18	08/12/98	WQSP-2	5.8E-04	8.0E-04

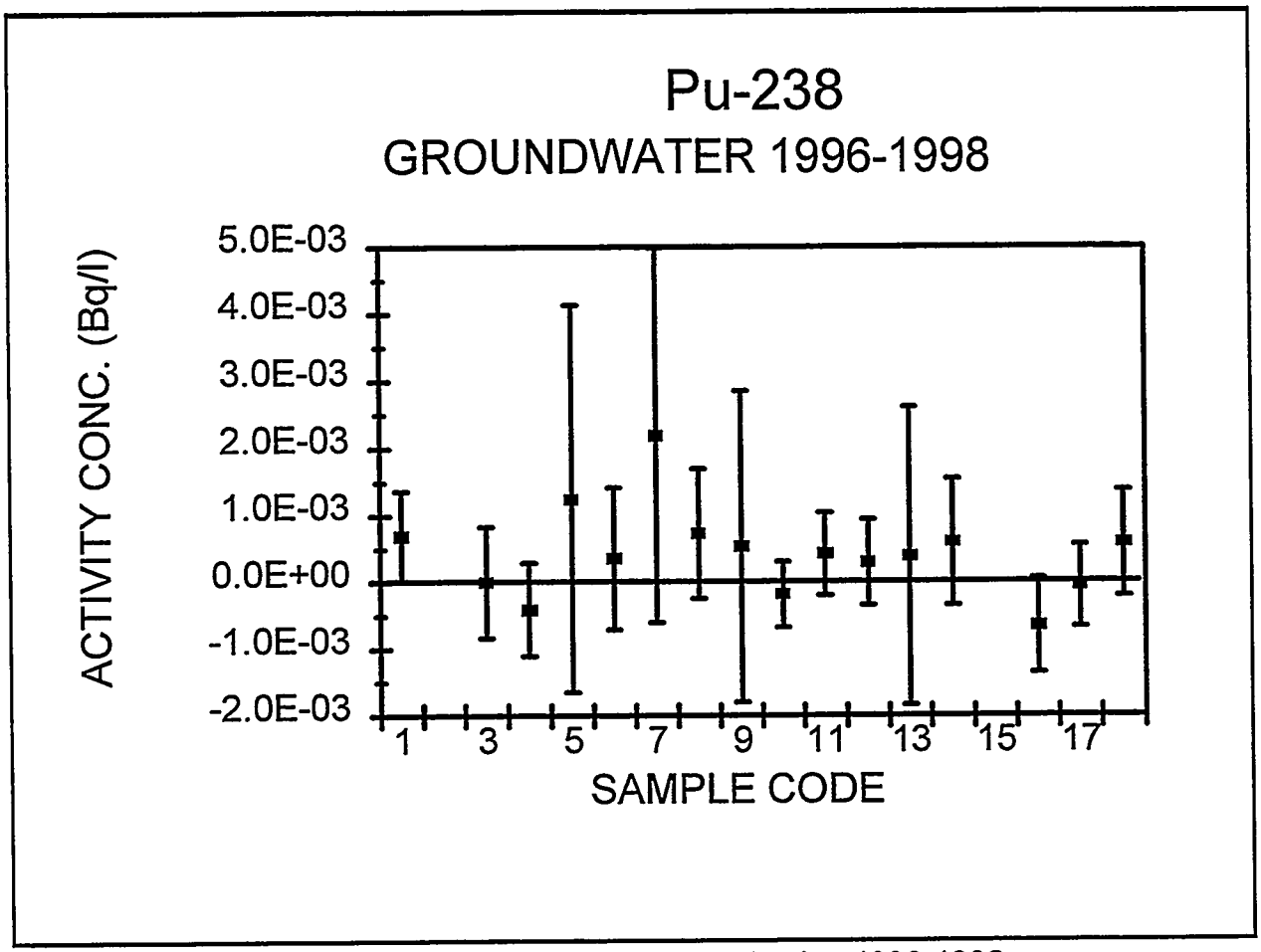

Figure C11. ^{238}Pu Concentrations in Ground Water During 1996-1998

Table C12. ^{137}Cs Concentrations in Ground Water During 1996-1998

SAMPLE I.D. CODE	SAMPLE DATE	WELL SAMPLED	^{137}Cs ACTIVITY (Bq/l)	TPU 2 SIGMA (Bq/l)
1	04/11/96	WQSP-1	N/A	N/A
2	06/06/96	WQSP-5	N/A	N/A
3	08/08/96	WQSP-2	N/A	N/A
4	08/22/96	WQSP-3	N/A	N/A
5	04/03/97	WQSP-6	N/A	N/A
6	04/10/97	WQSP-6A	N/A	N/A
7	04/24/97	WQSP-1	N/A	N/A
8	05/08/97	WQSP-2	N/A	N/A
9	05/22/97	WQSP-3	-7.4E-02	9.4E-02
10	06/05/97	WQSP-4	-1.4E-01	9.5E-02
11	06/19/97	WQSP-5	1.6E-02	4.1E-02
12	03/05/98	WQSP-1	-1.8E-02	9.3E-02
13	04/22/98	WQSP-3	-3.5E-02	9.3E-02
14	05/06/98	WQSP-4	-1.4E-02	9.5E-02
15	05/20/98	WQSP-5	-6.8E-02	8.8E-02
16	06/03/98	WQSP-6	-2.7E-02	8.9E-02
17	06/10/98	WQSP-6A	-7.2E-03	9.0E-02
18	08/12/98	WQSP-2	7.4E-02	1.1E-01

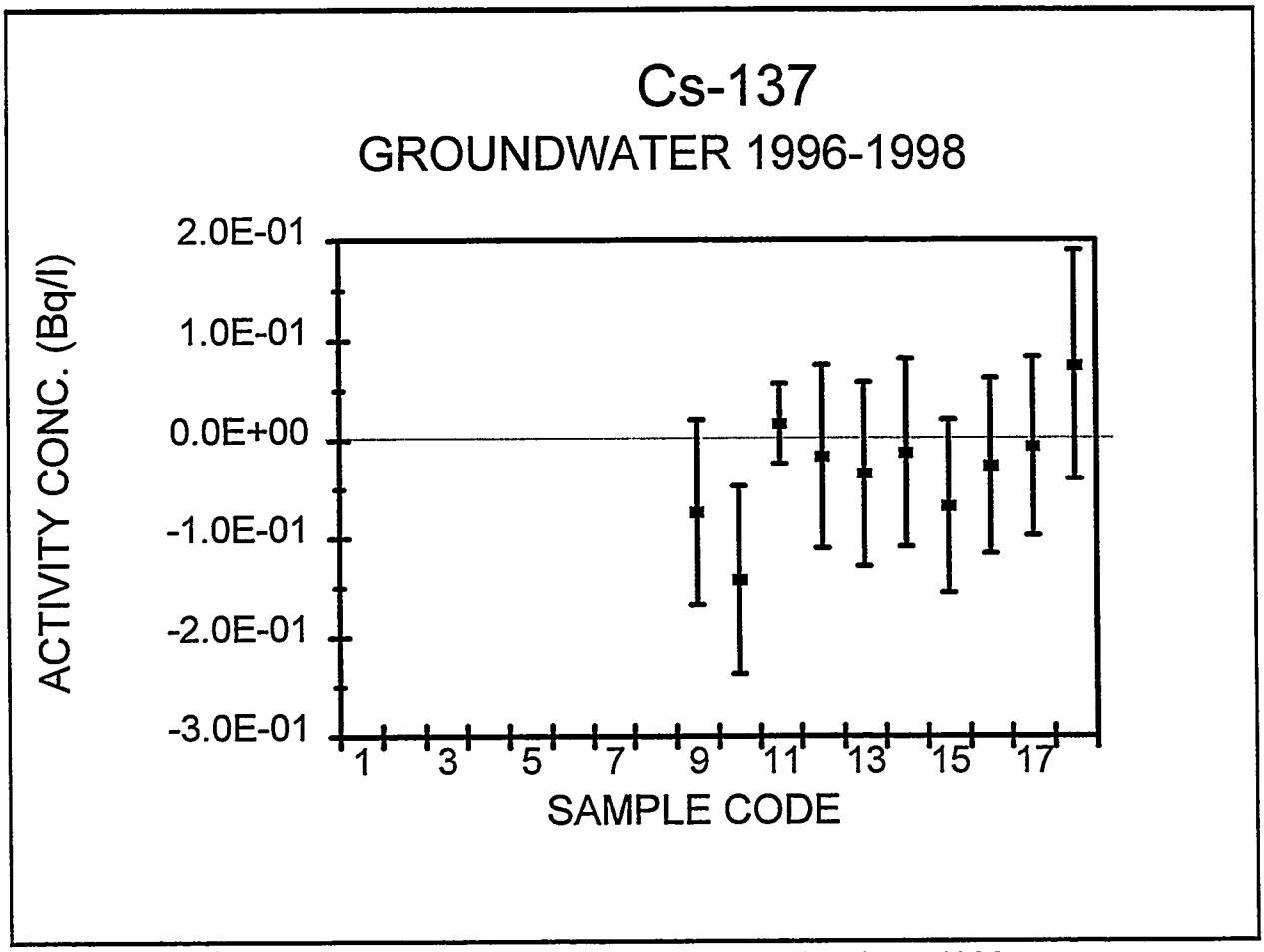

Figure C12. ^{137}Cs Concentrations in Ground Water During 1996-1998

APPENDIX D: Matrix Blank Data

Table D1. Water Matrix Blank Data

Water Matrix Blank ID	^{241}Am (Bq/l)	$^{239+240}Pu$ (Bq/l)	^{238}Pu (Bq/l)	^{137}Cs (Bq/l)
WMB 940921	4.7E-04	5.8E-04	2.3E-04	-8.1E-03
WMB 940708	0.0E+00	0.0E+00	2.2E-04	3.4E-02
WMB 950612	1.5E-03	-3.9E-04	-3.9E-04	-7.1E-03
WMB 951116	N/A	0.0E+00	1.2E-03	-1.4E-02
WMB 960408	N/A	9.4E-04	-9.4E-04	-9.8E-03
WMB 960801	8.1E-04	6.9E-04	6.9E-04	4.9E-02
WMB 940817	1.3E-03	-2.9E-04	4.4E-04	-2.2E-02
WMB 970327	6.3E-04	2.0E-04	N/A	-1.8E-02
WMB 970421	8.6E-04	1.0E-03	7.5E-04	-2.3E-02
WMB 970428	6.1E-04	2.5E-04	3.7E-04	6.5E-03
WMB 970619	N/A	1.0E-03	3.3E-04	6.5E-03
WMB 970717	5.7E-04	2.6E-04	0.0E+00	1.7E-02
WMB 970821	1.1E-03	0.0E+00	0.0E+00	3.4E-02
WMB 980318	1.5E-03	0.0E+00	0.0E+00	-3.4E-02
WMB 980522	1.9E-03	0.0E+00	5.6E-04	-1.1E-01
WMB 980617	4.6E-04	3.9E-04	-1.6E-04	-5.1E-02
WMB 980709	7.3E-04	3.4E-04	4.0E-04	-5.6E-02
WMB 980722	5.6E-04	0.0E+00	2.1E-04	-5.9E-02
WMB 980811	9.4E-04	6.5E-05	2.0E-04	-5.9E-02
WMB 980626	1.7E-03	1.8E-04	-2.7E-04	-6.2E-02
WMB 980819	5.8E-04	8.4E-05	0.0E+00	4.9E-02
AVERAGE =	9.0E-04	2.5E-04	1.9E-04	-1.6E-02
STANDARD DEVIATION =	4.9E-04	3.9E-04	4.5E-04	4.1E-02
MDA/MDC (Bq/l) =	**2.3E-03**	**1.8E-03**	**2.1E-03**	**1.9E-01**

Table D2. Station A Matrix Blank Data

Station A Matrix Blank	^{241}Am (Bq/Comp)	$^{239+240}Pu$ (Bq/Comp)	^{238}Pu (Bq/Comp)	^{137}Cs (Bq/Comp)
FMB-970910	7.7E-04	5.3E-04	2.0E-04	2.8E-02
FMB-A970922	4.8E-04	1.9E-04	2.6E-04	-4.2E-02
FMB-B970922	0.0E+00	-1.8E-04	-3.6E-04	6.4E-02
FMB-A971001	9.0E-04	7.5E-04	4.1E-04	2.4E-02
FMB-B971001	2.2E-04	6.6E-05	1.3E-04	-4.4E-02
FMB-A971008	3.6E-04	-8.3E-05	-3.3E-04	4.1E-03
FMB-B971008	3.1E-04	6.6E-05	1.3E-04	3.5E-02
FMB-C971008	1.1E-04	2.6E-04	6.6E-05	1.8E-02
FMB-D971008	5.8E-04	0.0E+00	-1.4E-04	-5.4E-02
FMB-980504	N/A	4.0E-04	-1.4E-04	-2.5E-03
FMB-980604	3.7E-04	2.8E-04	0.0E+00	-1.2E-02
FMB-980916	7.5E-04	3.7E-04	1.9E-04	-7.5E-02
FMB-980104	8.2E-04	N/A	-8.6E-04	2.7E-02
FMB-990406	9.0E-04	-4.5E-04	-4.5E-04	1.8E-02
AVERAGE =	5.1E-04	1.7E-04	-6.3E-05	-8.9E-04
STANDARD DEVIATION =	3.0E-04	3.2E-04	3.4E-04	4.0E-02
MDA (Bq/Comp) =	**1.4E-03**	**1.5E-03**	**1.6E-03**	**1.8E-01**
MDC (Bq/m^3) =	**2.7E-07**	**2.8E-07**	**3.1E-07**	**3.5E-05**

Table D3. LVAS Matrix Blank Data

LVAS Matrix Blank ID	^{241}Am (Bq/Comp)	$^{239+240}Pu$ (Bq/Comp)	^{238}Pu (Bq/Comp)	^{137}Cs (Bq/Comp)
LMB961104	4.1E-04	3.6E-04	5.7E-04	-2.1E-02
LMB961126	N/A	N/A	1.5E-03	3.3E-02
LMB961211	7.7E-05	N/A	7.5E-04	3.5E-03
LMB970108	1.5E-03	2.2E-04	1.6E-04	4.0E-02
LMB970129	6.4E-04	1.1E-04	-2.1E-04	2.8E-02
LMB970207	6.1E-04	4.1E-04	1.0E-03	1.9E-03
LMB970430	1.1E-03	2.8E-04	0.0E+00	-4.0E-02
LMB970611	9.6E-05	4.0E-04	9.6E-04	-4.3E-02
LMB970716	-1.4E-04	2.6E-04	1.4E-03	-4.6E-02
LMB970808	5.2E-04	-5.6E-05	1.2E-03	-3.7E-02
LMB980413	N/A	3.9E-04	2.4E-04	2.1E-02
LMB981012	N/A	5.5E-05	5.5E-05	-3.5E-02
LMB981201	1.2E-04	2.5E-04	-3.5E-04	-2.0E-02
LMB990305	8.6E-04	0.0E+00	3.8E-04	-1.7E-03
AVERAGE =	5.2E-04	2.2E-04	5.4E-04	-8.9E-04
STANDARD DEVIATION =	4.9E-04	1.6E-04	5.9E-04	3.0E-02
MDA (Bq/Comp) =	**2.3E-03**	**7.5E-04**	**2.8E-03**	**1.4E-01**
MDC (Bq/m^3) =	**4.4E-07**	**1.4E-07**	**5.3E-07**	**3.5E-05**

APPENDIX E: TLD Data

Table E1. Average Dose by TLD per Quarter

TLD NUMBER	QUARTER AVERAGE (mrem/qtr)	2 SIGMA (mrem/qtr)	UPPER (mrem/qtr)	LOWER (mrem/qtr)
01	18.5	4.3	22.8	14.2
02	18.5	5.6	24.1	12.8
03	18.6	7.2	25.7	11.4
04	18.2	4.1	22.2	14.1
05	17.6	6.2	23.8	11.4
06	18.1	5.1	23.2	12.9
07	18.6	5.0	23.6	13.6
08	18.0	4.8	22.8	13.2
09	19.2	5.4	24.6	13.8
11	17.7	4.3	22.0	13.3
12	18.9	6.4	25.3	12.5
13	17.8	4.7	22.5	13.1

Table E2. Average Dose by TLD per Year

TLD NUMBER	ANNUAL (mrem/qtr)	2 SIGMA (mrem/qtr)	UPPER (mrem/qtr)	LOWER (mrem/qtr)
01	74.0	8.6	82.6	65.4
02	73.8	11.5	85.3	62.3
03	74.2	14.4	88.6	59.8
04	72.6	8.2	80.8	64.4
05	70.4	9.1	79.5	61.3
06	72.2	9.8	82.0	62.4
07	74.4	10.8	85.2	63.6
08	72.0	9.3	81.3	62.7
09	76.8	8.5	85.4	68.3
11	70.6	8.1	78.7	62.5
12	75.6	11.1	86.7	64.5
13	71.2	8.1	79.3	63.1

APPENDIX F: 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.

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.

EEG-3 Neill, Robert H., et al., (eds.) Radiological Health Review of the Draft Environmental Impact Statement (DOE/EIS-0026-D) Waste Isolation Pilot Plant, U.S. Department of Energy, August 1979.

EEG-4 Little, Marshall S., Review Comments on the Report of the Steering Committee on Waste Acceptance Criteria for the Waste Isolation Pilot Plant, February 1980.

EEG-5 Channell, James K., Calculated Radiation Doses From Deposition of Material Released in Hypothetical Transportation Accidents Involving WIPP-Related Radioactive Wastes, October 1980.

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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EEG-21 Faith, Stuart, et al., The Geochemistry of Two Pressurized Brines From the Castile Formation in the Vicinity of the Waste Isolation Pilot Plant (WIPP) Site, April 1983.

EEG-22 EEG Review Comments on the Geotechnical Reports Provided by DOE to EEG Under the Stipulated Agreement Through March 1, 1983, April 1983.

EEG-23 Neill, Robert H., et al., Evaluation of the Suitability of the WIPP Site, May 1983.

EEG-24 Neill, Robert H. and James K. Channell, Potential Problems From Shipment of High-Curie Content Contact-Handled Transuranic (CH-TRU) Waste to WIPP, August 1983.

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