EEG-52

AN EVALUATION OF AIR EFFLUENT AND WORKPLACE RADIOACTIVITY MONITORING AT THE WASTE ISOLATION PILOT PLANT

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Environmental Evaluation Group
New Mexico

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Environmental Evaluation Group 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.

EEG-7 Chaturvedi, Lokesh, WIPP Site and Vicinity Geological Field Trip. A Report of a Field Trip to the Proposed Waste Isolation Pilot Plant Project in Southeastern New Mexico, June 16 to 18, 1980, October 1980.

EEG-8 Wofsy, Carla, The Significance of Certain Rustler Aquifer Parameters for Predicting Long-Term Radiation Doses from WIPP, September 1980.

EEG-9 Spiegler, Peter, An Approach to Calculating Upper Bounds on Maximum Individual Doses From the Use of Contaminated Well Water Following a WIPP Repository Breach, September 1981.

EEG-10 Radiological Health Review of the Final Environmental Impact Statement (DOE/EIS-0026) Waste Isolation Pilot Plant, U. S. Department of Energy, January 1981.

EEG-11 Channell, James K., Calculated Radiation Doses From Radionuclides Brought to the Surface if Future Drilling Intercepts the WIPP Repository and Pressurized Brine, January 1982.

EEG-12 Little, Marshall S., Potential Release Scenario and Radiological Consequence Evaluation of Mineral Resources at WIPP, May 1982.

EEG-13 Spiegler, Peter, Analysis of the Potential Formation of a Breccia Chimney Beneath the WIPP Repository, May, 1982.

EEG-14 Not published.

EEG-15 Bard, Stephen T., Estimated Radiation Doses Resulting if an Exploratory Borehole Penetrates a Pressurized Brine Reservoir Assumed to Exist Below the WIPP Repository Horizon - A Single Hole Scenario, March 1982.

EEG-16 Radionuclide Release, Transport and Consequence Modeling for WIPP. A Report of a Workshop Held on September 16-17, 1981, February 1982.

EEG-17 Spiegler, Peter, Hydrologic Analyses of Two Brine Encounters in the Vicinity of the Waste Isolation Pilot Plant (WIPP) Site, December 1982.

EEG-18 Spiegler, Peter and Dave Updegraff, Origin of the Brines Near WIPP from the Drill Holes ERDA-6 and WIPP-12 Based on Stable Isotope Concentration of Hydrogen and Oxygen, March 1983.

EEG-19 Channell, James K., Review Comments on Environmental Analysis Cost Reduction Proposals (WIPP/DOE-136) July 1982, November 1982.

EEG-20 Baca, Thomas E., An Evaluation of the Non-Radiological Environmental Problems Relating to the WIPP, February 1983.

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.

EEG-25 Chaturvedi, Lokesh, Occurrence of Gases in the Salado Formation, March 1984.

EEG-26 Spiegler, Peter, Proposed Preoperational Environmental Monitoring Program for WIPP, November 1984.

EEG-27 Rehfeldt, Kenneth, Sensitivity Analysis of Solute Transport in Fractures and Determination of Anisotropy Within the Culebra Dolomite, September 1984.

EEG-28 Knowles, H. B., Radiation Shielding in the Hot Cell Facility at the Waste Isolation Pilot Plant: A Review, November 1984.

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FOREWORD

The purpose of the 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, is being constructed as a repository for the permanent 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-AC04-89AL58309.

The EEG performs independent technical analyses of the suitability of the proposed site; the design of the repository, it's planned operation, and its long-term integrity; suitability and safety of the transportation systems; suitability of the Waste Acceptance Criteria and the generator sites' compliance 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 the WIPP. Another important function of the EEG is independent environmental monitoring of background radioactivity in air, water, and soil, both on-site and in the surrounding communities.

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ACKNOWLEDGMENTS

This report resulted from data collection begun two years ago by Mr. Curtis Hare, EEG Environmental Technician, who in cooperation with staff of the Westinghouse Electric Corporation, Waste Isolation Division (WID) at the WIPP, developed methods for transferring operational data from WIPP continuous air monitors (CAMs) to computer data files. Mr. Hare designed systematic methods for printing and storing CAM operational data.

Mr. Ben Walker, EEG Environmental Technician, developed automated computer methods for analyzing and archiving CAM computer data, and he analyzed data and provided most of the computer graphs found in Section 7.0 and the Appendices.

Figures 1 through 4 were drawn by Ms. Georgia Bayliss of Aurora, Colorado from originals found in the FSAR and information provided by the WID. Pictures in Figures 3, 6, 8, 9, and 10 were provided by the WID.

Dr. Jim Mewhinney of the Department of Energy (DOE) and many other DOE and WID staff contributed technical information to this report.

Mr. Mark Grimson and Dr. Candis Haigler of the Department of Biological Sciences, Texas Tech University, Lubbock, Texas prepared the light and electron micrographs found in Figures 25 through 38.

EEG technical report editing was cheerfully provided by Mr. Jim Kenney, Mr. Don Gray, and Dr. Jim Channell. Ms. Betsy Kraus assisted on report formatting and editing. Mrs. Susan Stokum assembled, organized and typed the editorial corrections in the report.

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EXECUTIVE SUMMARY

Improvements are needed in the Waste Isolation Pilot Plant (WIPP) air effluent and workplace radioactivity monitoring prior to receipt of radioactive wastes. This report provides a detailed review of radioactivity air monitoring regulatory requirements and related facility design requirements. Air monitoring data, supplied by the Westinghouse Isolation Division, are analyzed.

The WIPP Final Safety Analysis Report (FSAR) requires that the WIPP radiological facilities always have multiple confinement barriers to prevent the accidental release of radioactive material to the environment. The Waste Handling Building has standard confinement barriers that satisfy the regulatory requirements, but the underground confinement barriers include a more complex system for filtering air in the event of an accidental release.

A continuous air monitor (CAM) is an integral part of the underground confinement barrier strategy. For the last four years, the reliability and sensitivity of the CAMs have been the subject of numerous reports and meetings which are summarized in this report.

Data supplied to the Environmental Evaluation Group (EEG) show that the Station A CAM, which monitors the underground exhaust, does not satisfy the requirements of the FSAR. The CAM system is not fail-safe, and operations appear to be affected by high levels of salt aerosol and poor detector performance.

Additional test information is needed to establish the limits of CAM performance. Findings and recommendations are also provided on alternative monitoring methods, procedures and calculations.

RECOMMENDATIONS

(1) Alpha and beta CAMs should be fail-safe, and methods should be developed to immediately identify non-operational status. These modifications are necessary to satisfy FSAR requirements for waste handling, ventilation diversion, and limiting conditions for operation.

(2) A plan should be developed and formal testing completed that will establish the CAM performance limitations. The extreme environmental conditions to which CAM systems will be subjected should be considered in the testing plan. The CAM accuracy should be determined when monitoring aerosol mixtures of salt, radon/thoron progeny and plutonium. This information should be available as a formal report.

(3) WIPP staff have identified salt exposure as an important factor in alpha detector failures and subsequently developed new detector specifications. If procured, new detectors should be tested as part of a complete CAM system prior to operational installation at WIPP. Testing should include those tests recommended in (2) above.

(4) The on-site dose calculation codes should be revised to include backwash and building wake effects. In the event calculation codes can not be appropriately revised and certified, then stack-related empirical corrections factors should be experimentally derived for use in on-site and off-site plume dispersion calculations. This information is essential to establishing effluent CAM alarm levels.

(5) Like the alpha CAM, the beta CAM system performance should be formally tested. A test report should be available and specify such things as the method of background correction, expected radionuclide sensitivity, energy/count rate relationships, and actual test data.

(6) Quality control and maintenance of all effluent monitoring systems should be improved. In particular, sampling probes should be routinely cleaned to prevent salt buildup, and procedures should specify maximum allowable salt buildup. Replacement of non-certified materials and components needs to be expedited.

(7) Accurate laboratory methods for analyzing transuranic radionuclides on salt-laden FAS filters should be developed and documented as part of off-site dose compliance monitoring requirements. Particular attention should be given to quality assurance.

(8) Methods for evaluating salt aerosol concentrations in underground areas should be developed before underground emplacement of radioactive wastes.

(9) The consistent accuracy of LCO CAM systems must be established prior to emplacement of radioactive wastes underground. If LCO CAMs can not be shown to satisfy the intent of the FSAR, then alternative confinement and monitoring methods should be developed.

(10) The FSAR should be revised according to DOE Order 5481.1B, Chg 1, 5/5/87, paragraph 3.1.(3) "to identify and demonstrate conformation with applicable guides, codes, and standards. Deviations from current design criteria shall be evaluated and documented in the facility safety analysis report." Specific

explanations should be provided regarding DOE Order 6430.1A requirements for confinement systems, CAM testing, classification of the CAM as a safety class system, and use of redundant monitoring at the underground exhaust point.

(11) Many EEG and expert CAM panel recommendations need resolution. These expert suggestions are particularly important in establishing and improving the performance capabilities of the CAM systems. A formal DOE report, or letter, should state the resolution of technical suggestions and recommendations. The 39 findings, in Section 8.0 of this report, should be specifically addressed.

(12) Workplace monitors have less restrictive regulatory requirements than effluent CAMs. Even so, workplace CAM performance in high-salt-aerosol areas should be improved, and CAM maintenance should be given higher priority. As in recommendation (8) above, it is particularly important to establish the extremes of salt aerosol concentrations in Room 1 of Panel 1 where workplace monitors are essential.

1.0 INTRODUCTION

The objective of this report is to determine if the Waste Isolation Pilot Plant (WIPP) has adequate means to preclude radioactive releases to the environment and to prevent unnecessary exposure of site workers and the public. The requirements, calculations, methods, equipment, and monitoring data for measurement of potential airborne radioactive material at the WIPP are examined in the report.

Although continuous air monitors (CAM) performed poorly in the harsh environment of the underground repository, this report should not be construed as an evaluation of manufacturer's equipment performance claims. To the contrary, the CAM systems appeared to perform as designed when used as workplace monitors in the clean environment of the Waste Handling Building. It does not appear that the CAMs were designed for use in the salt aerosol found in the underground repository.

The Environmental Evaluation Group (EEG) reviewed the adequacy of WIPP effluent and workplace monitoring as part of EEG's mission which was established in 1978. Background information on facility layout, CAM design, and regulatory requirements are shown in Sections 2.0, 3.0, and 4.0. All major meetings and reports are sequentially documented in Section 5.0. Section 6.0 is the EEG response to the most recent U. S. Department of Energy (DOE) letter on CAM operations. Section 7.0 contains reviews of actual CAM monitoring data. Detailed findings and discussion are presented in Section 8.0. The Appendices contain copies of letters, information and selected monitoring data.

The capability of the original WIPP CAMs was questioned in the March 1988 EEG-38 report titled A Critical Assessment of Continuous Air Monitoring Systems at the Waste Isolation Pilot Plant (Rodgers and Kenney 1988). The WIPP management accepted the EEG-38 report premise that the 1988 system was inadequate for operational needs, and a new system was procured. The EEG-38 report contained the recommendation that CAM systems:

> . . . must be subjected to thorough performance testing by an experienced laboratory with the capability of creating test conditions covering the expected range of environmental conditions to be found at WIPP.

Formal testing is particularly important because salt aerosol, typically found in the underground repository, interferes with normal CAM operation. The DOE contracted with the Inhalation Toxicology Research Institute (ITRI) to measure salt aerosol concentrations at the WIPP and to perform feasibility testing of CAMs (Hoover et al. 1988, Newton et al. 1990). The ITRI experiments provided valuable data, but the experiments were not full-range equipment performance tests. The ITRI studies helped establish CAM instrument settings and the affect layers of salt might have on the ability of CAMs to measure plutonium alpha particles.

Although the EEG-38 report specifically recommended performance testing of the CAMs, full-range testing has apparently not been completed, and no DOE comprehensive test report has been provided to the EEG. The EEG evaluation in this report is based on information from WIPP technical reports, responses to EEG letters, and technical meetings. Since January 1991, the DOE has provided the EEG copies of minute-to-minute operational data and hourly alpha spectra from selected CAMs.

This report documents the extensive review initiatives of the EEG. The conclusions and recommendations are based only on the information made available to the EEG. The referenced CAM data are actual unmodified data, although EEG developed various display formats. As documented in this report, the DOE could not or would not provide key information which made the EEG review more difficult and protracted.

2.0 THE WIPP ON-SITE FACILITIES

The WIPP on-site facilities consist of above-ground buildings and underground mined areas as shown in Figures 1 and 2. The underground areas include the repository, experimental rooms and proposed repository rooms. Four shafts extend from the surface to the 2,050 feet (625 meters) deep mine. The salt-handling shaft and the air-exhaust shaft were part of the original 1983 excavations. The waste and air-intake shafts were added later.

2.1 Facility Layout

The important above ground facilities are the Waste Handling Building and the HEPA Filtration Building. Adjacent to the HEPA Filtration Building are two exhaust stacks that vent all air effluent from the underground. The exhaust stacks are 32.8 feet (10 meters) high, contiguous with ventilation ducts, and in close proximity to the exhaust filter building (Figure 3). This configuration is important to the discussion in Section 5.20 of this report.

Radioactive contact-handled transuranic (CH-TRU) waste shipments will be unloaded south of the Waste Handling Building, and the TRUPACT-II[1] container will be opened and unloaded at a dock inside the Waste Handling Building (Figure 4). Air pressure inside the Waste Handling Building receiving area is negative to the outside and adjacent rooms. All Waste Handling Building air effluent is exhausted through a series of high efficiency particulate (HEPA) filters.

Drums, boxes, and bins are transported to the underground via the waste handling shaft. Repository Room 1 of Panel 1 (Figure 2) is

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[1] TRUPACT-II is the radiological shipping container used during the highway transport of CH-TRU drums, boxes and bins.

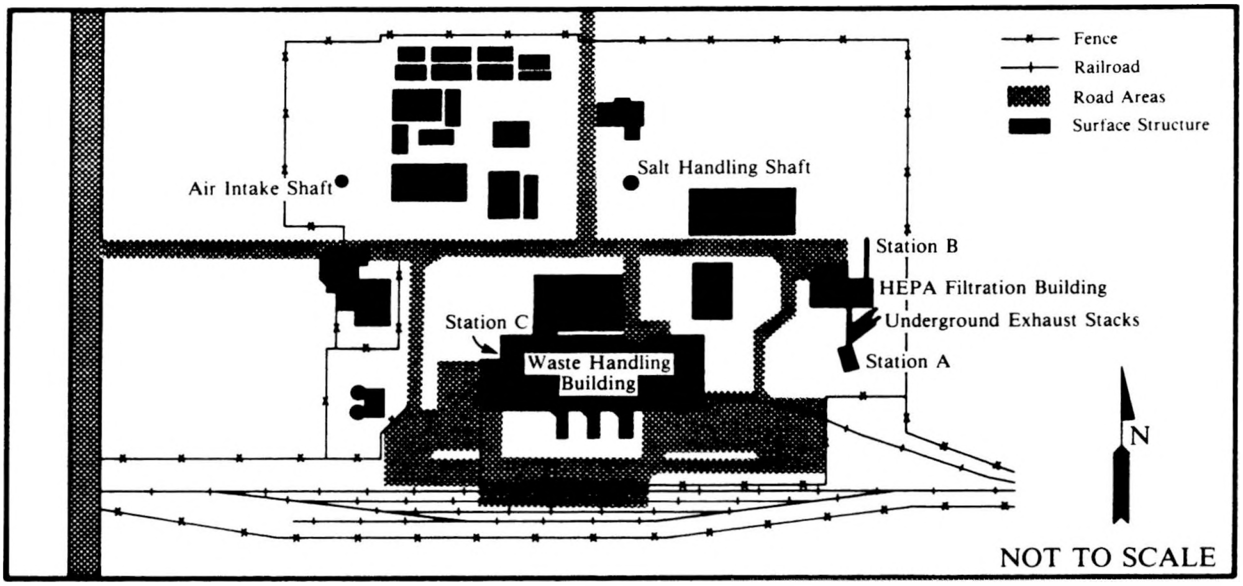


Figure 1. Above Ground Site Map

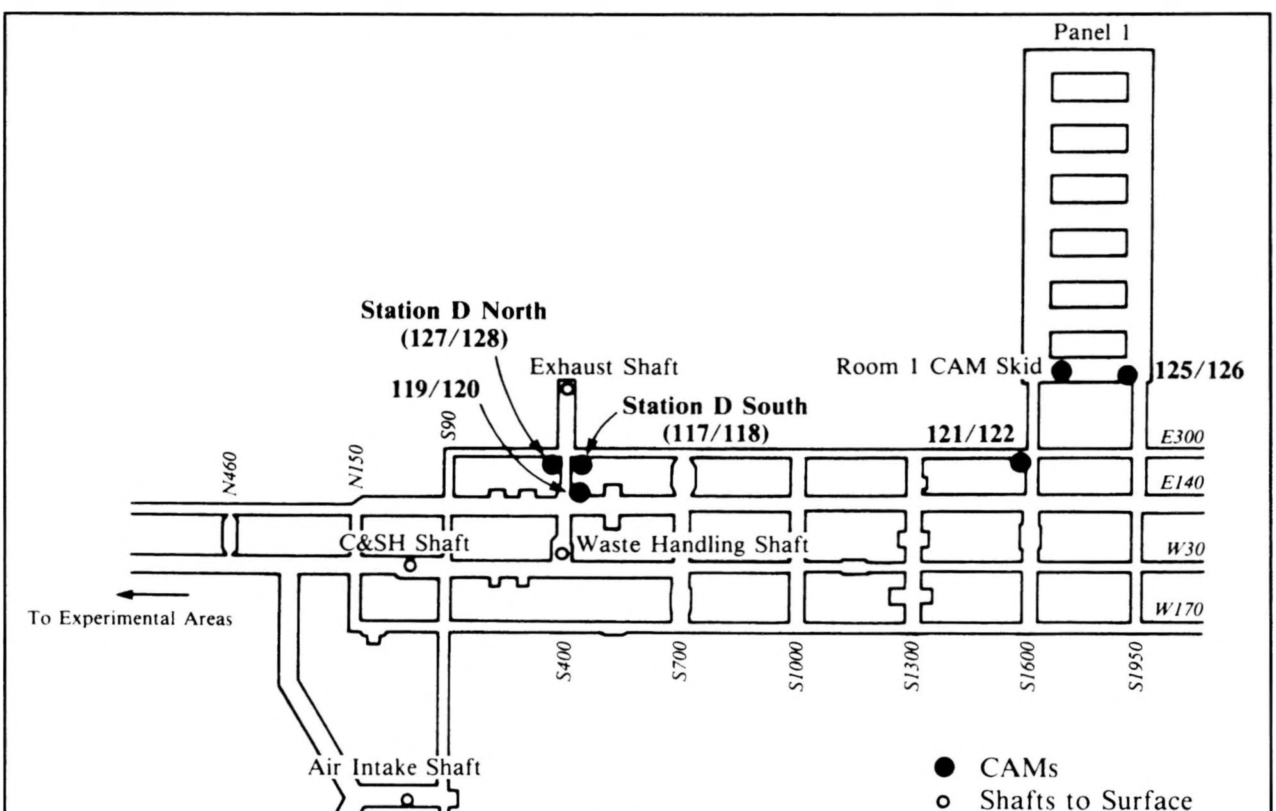
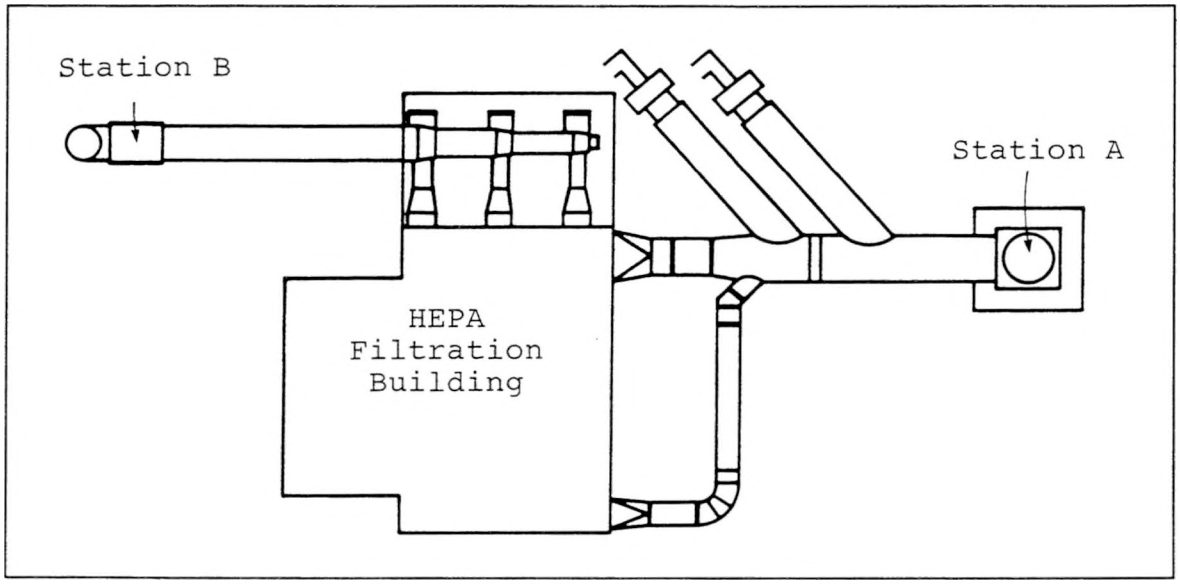


Figure 2. Underground Site Map



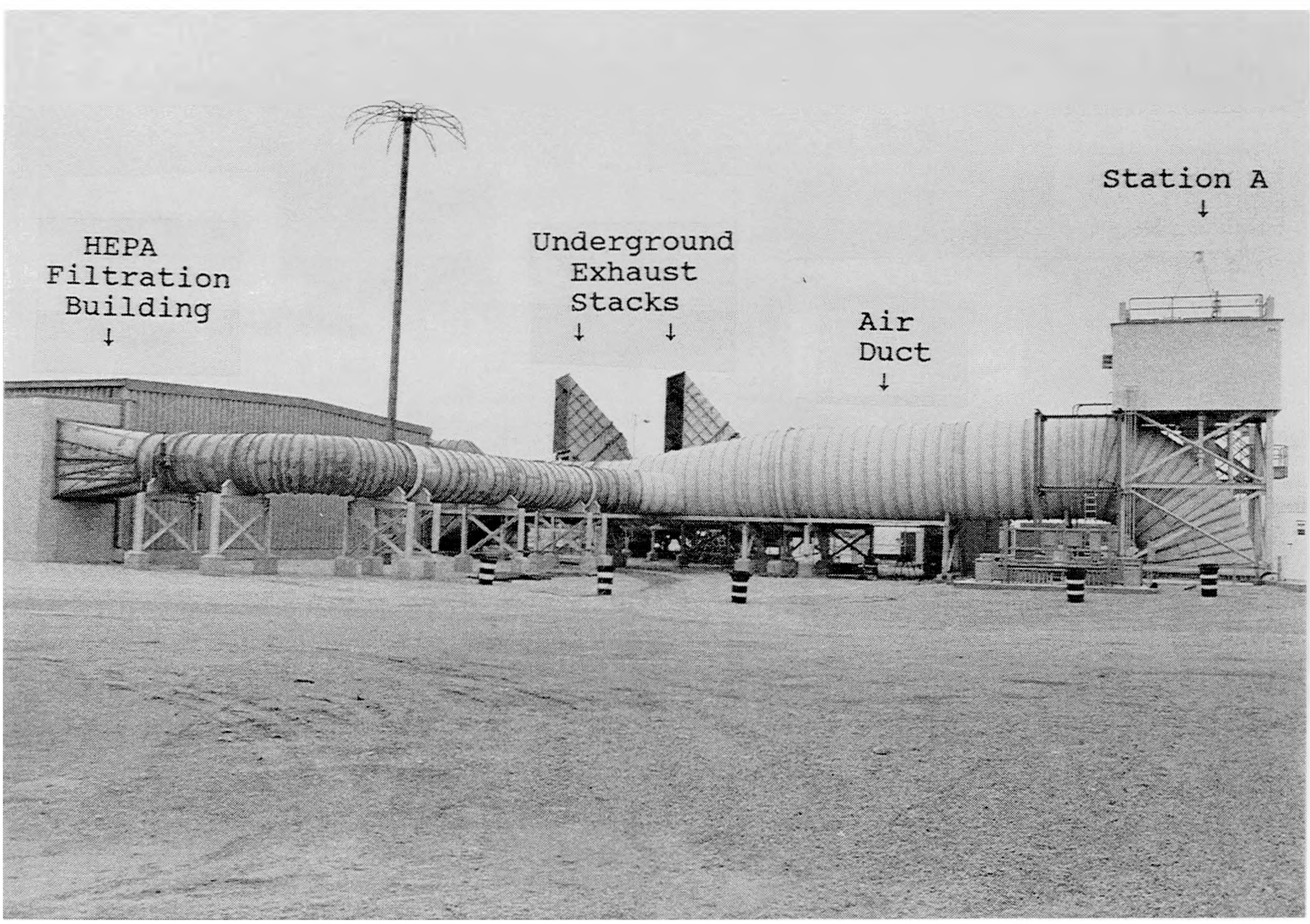


Figure 3. Picture of Underground Exhaust Stack and Station A
(view is to the northeast)

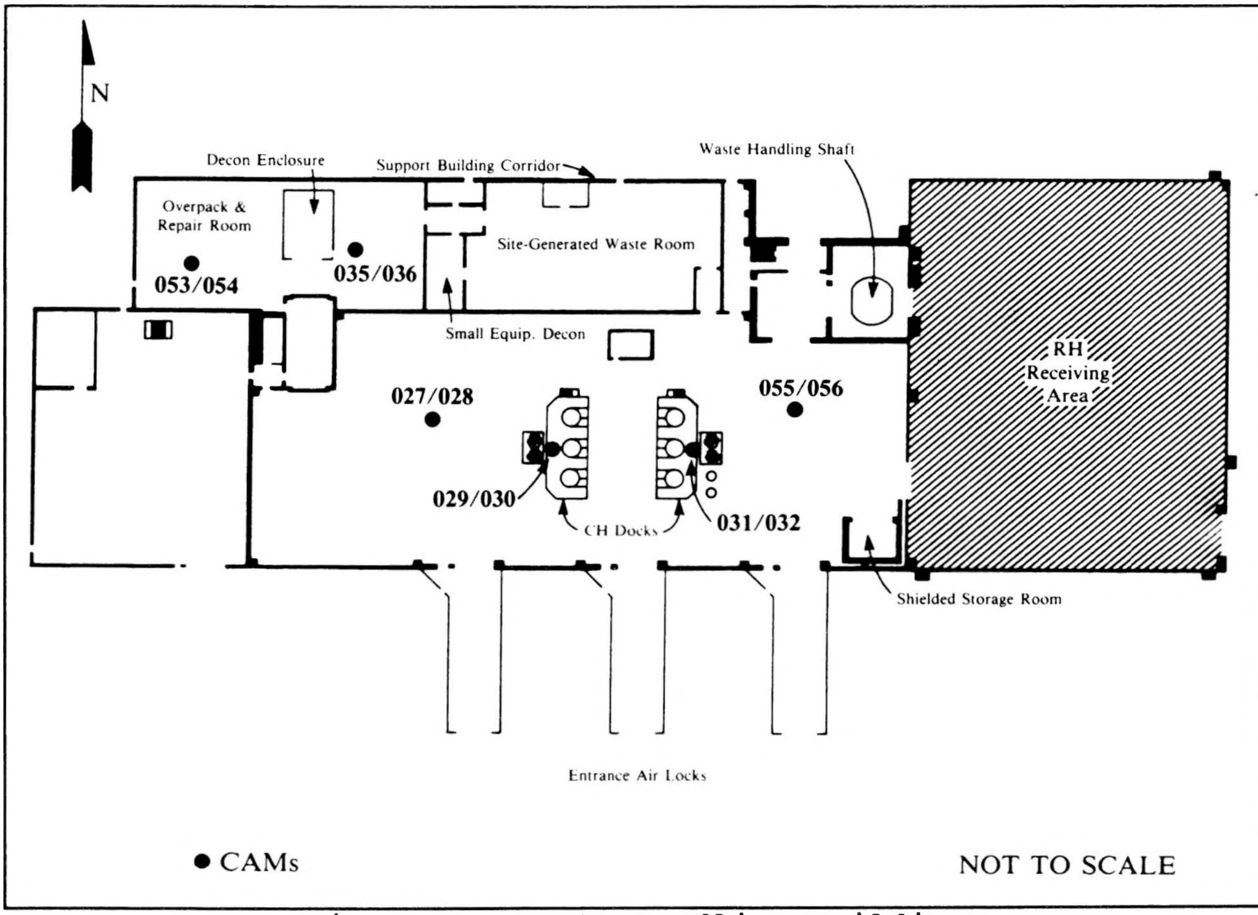


Figure 4. Waste Handling Building

instrumented to handle waste boxes for the proposed experimental test phase (Westinghouse 1991). Most air is drawn into the mine through the air intake shaft; although there is a positive flow down the waste and salt-handling shafts. Underground air flow is controlled by a series of barriers, baffles, and back-flow prevention mechanisms.

Room 1, Panel 1 air effluent goes directly to the environment without filtration (Westinghouse 1990). Air transit time is about three minutes from repository Panel 1, Room 1 to the environment. If a radiological release occurs, the underground exhaust must be diverted to the exhaust filtration building which contains HEPA filtration. Properly designed HEPA filtration will filter greater than 99.9% of airborne particulate (ANS 1980b), but the exhaust flow rate is reduced from about 425,000 CFM (cubic feet per minute) to 60,000 CFM. This flow reduction is the major reason effluent is not continuously filtered. CAM measurements provide the only real-time radiological monitoring information for making the decision to divert air to HEPA filtration.

2.2 CAM Locations and Requirements

Both alpha and beta effluent CAMs are required at Stations A, B, and C as stated in the Final Safety Analysis Report (FSAR), Chapter 10 (Westinghouse 1990). Station A is the sampling station located above the underground exhaust shaft (Figure 1 and 3). Station B air sampling is from the exhaust filtration building effluent (Figure 1), and Station C sampling is from the post-HEPA effluent of the Waste Handling Building.

The FSAR, Chapter 10 includes requirements for alpha and beta workplace CAMs to be placed near the east and west Waste Handling Building unloading docks, and in the overpack and repair room. Other workplace CAMs are necessary to satisfy various occupational worker monitoring requirements (U.S. DOE 1988).

In a May 14, 1991 meeting (Section 5.17), the DOE provided copies of viewgraphs indicating the locations of strategically placed CAM systems (see Figures 2 and 4). The even numbered locations refer to beta CAMs, and the odd numbers indicate alpha CAMs.

Although the Westinghouse Electric Corporation, Waste Isolation Division (WID) has installed 71 CAM systems (alpha and beta), not all these CAM systems are required for facility operation. Non-operability of either the alpha or beta Station A CAM for one hour requires the underground ventilation to be stopped or diverted to the exhaust filter building. If two Station A CAMs are non-operational for 1 hour, then mine ventilation must be stopped. There are similar restrictions on Station C. Station B non-operability is allowed for 24 hours (Westinghouse 1990).

There are no specified CAM alarm set points documented in the FSAR. The prerogative to establish alarm levels is left to the WIPP Radiation Safety Manager. Consequently, the term "operable" must be defined. Limiting Conditions for Operation (LCO) requirements are defined in the Chapter 10 of the FSAR. The LCO and operational safety requirements are defined below (Westinghouse 1990).

> 10.1.1 Safety Limits: Safety Limits are limits on important process variables that are found to be necessary to reasonably protect the integrity of the principle physical barriers that guard against the uncontrolled release of hazardous materials... Safety Limits are to be established on those process variables that could result in a "design basis" or "maximum credible" accident with expected consequences exceeding DOE guidelines.
>
> 10.1.3 Limiting Conditions for Operation: LCOs are those administratively established constraints on facility equipment and operating parameters that shall be adhered to during operation of the facility.

No Safety Limits are identified in the FSAR, but effluent monitors are considered LCO systems. The DOE Order[2] 6430.1A (U.S. DOE 1989) defines the following:

> Design basis accidents (DBAs). Postulated accidents, or natural forces, and resulting conditions for which the confinement structure, systems, components and equipment must meet their functional goals. These safety class items are those necessary to assure the capability: to safely shut down operations, maintain the plant in a safe shutdown condition, and maintain integrity of the final confinement barrier of radioactive or other hazardous materials; to prevent or mitigate the consequences of accidents; or to monitor releases that could result in potential offsite exposures.

The application of this regulation, and its intent, continues to be an unresolved issue between the EEG and the DOE for

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[2] A DOE Order is a regulation issued by the U.S. Department of Energy.

emplacement of drums (Little 1985; Neill 1991a). The EEG states that dual confinement is necessary for emplacement of drums in the underground repository. The tests bins are designed to provide a dual confinement (Westinghouse 1991), but waste drums have only one confinement barrier.

The DOE also claims that CAM systems are <u>not</u> part of the confinement strategy (Arthur 1992). The EEG requested in a letter (Neill 1991a):

> . . . that DOE should develop specific numerical performance criteria for the CAMs that monitor exhaust ventilation. This information will allow us a basis for agreeing on the meaning of "operational" CAMs.

The DOE response was as follows (Hunt 1991d):

> DOE has provided substantial details of CAM sensitivity and operability in the Waste Isolation Pilot Plant Alpha Continuous Air Monitoring System report transmitted to EEG on June 20, 1991. Operating procedures can be found in WP 12-5, Radiation Safety Manual. These reports and procedures, along with the Operational Readiness Review recently conducted, have ensured that the WIPP CAMs are ready for first receipt of waste.
>
> The WIPP CAMs, including the CAMs that monitor exhaust ventilation, meet all performance criteria as listed in DOE orders and verified by the above mentioned review teams, thus newly developed specific numerical criteria are not needed.

The DOE has not provided any CAM performance information, other than daily operational data, since the August 30, 1991 letter referenced above.

3.0 GENERAL INSTRUMENT AND SYSTEM DESIGN

Alpha CAMs measure alpha particles and beta CAMs measure beta particles. Alpha particles are always produced by transuranic wastes, and consequently the alpha CAM is the monitor of choice to detect and quantify airborne transuranic material. In transuranic wastes, beta particles are usually of a very low energy and are difficult to detect (Faust 1988), and therefore beta CAMs are relegated to verifying the absence of higher energy beta-emitting contaminants in airborne releases.

The CAMs at the WIPP are used both in clean environments and in the salt repository. The WIPP CAM equipment was apparently purchased from one manufacturer in 1988, but the technical reports indicate that there have been significant modifications by others. It does not appear that the original procurement considered the harsh environment of the underground salt repository. In the last year, another manufacturer was contracted to supply salt-resistant alpha detectors which could be installed in the existing CAM systems. It should be noted that there have been several different types of detectors and sample collection schemes used at the WIPP. This report concentrates on the results of measurements rather than the appropriateness of each design.

3.1 Alpha Particle Production

Radionuclides present in the WIPP waste are listed in Table 1. Although the exact inventory will vary, the radionuclides ^{238}Pu (plutonium), ^{239}Pu, ^{241}Pu and ^{241}Am (americium) will be the major contributors in an airborne release. The major radioactive emissions and half-lives of the key WIPP radionuclides are listed in Table 2. Alpha particles are the predominant emission.

Table 1. Representative Radionuclide Content of CH-TRU Waste in a 55-Gallon Drum as shown in Table 7.2-1 of the FSAR (Westinghouse 1990)

Radionuclide	Ci/Drum
^{232}Th (thorium)	6.6×10^{-7} (6.6E-07)
^{233}U (uranium)	1.7×10^{-2} (1.7E-02)
^{235}U	8.8×10^{-7} (8.8E-07)
^{238}U	3.5×10^{-6} (3.5E-06)
^{237}Np	2.2×10^{-5} (2.2E-05)
^{238}Pu	11 (1.1E+01)
^{239}Pu	0.85 (8.5E-01)
^{240}Pu	0.19 (1.9E-01)
^{241}Pu	6.8 (6.8E+00)
^{242}Pu	3.1×10^{-5} (3.1E-05)
^{241}Am	1.7 (1.7E+00)
^{244}Cm	3.4×10^{-2} (3.4E-02)
^{252}Cf	5.4×10^{-3} (5.4E-03)
Total	20.6 Ci/drum

Table 2. Major Emissions from CH-TRU Waste (data from ICRP 1983, Faust 1988)

Radionuclide	Half-Life (yr)	Primary Mode of Decay		Yield, %
		Particle	Energy (MeV)	
^{238}Pu	87.7	α (alpha)	5.50 5.46	71.6 28.3
^{239}Pu	2.41×10^{4}	α (alpha) α (alpha) α (alpha)	5.156 5.143 5.105	73.8 15.2 10.7
^{240}Pu	6.54×10^{3}	α (alpha) α (alpha)	5.168 5.124	73.4 26.5
^{241}Pu	14.4	ß (beta) α (alpha) α (alpha)	.0222(E,max) 4.897 4.854	100.0 2.04×10^{-3} 2.97×10^{-4}
^{241}Am	432	α (alpha) α (alpha) α (alpha)	5.486 5.443 5.389	85.2 12.8 1.4

Alpha monitoring is difficult because alpha particles have a very limited range. A thin layer of salt may stop or significantly degrade the particle energy, and prevent detection. If the alpha particle reaches the detector, then a large electronic pulse is produced.

3.2 Typical Alpha Measurement Concerns

CAMs are designed to filter a representative sample of air, and the sampling filter is positioned in close proximity to the alpha detector. Radioactive material on the filter can emit alpha particles which will strike the detector and produce measurable electronic pulses. The filter is periodically removed and replaced to prevent clogging.

For alpha air concentration to be properly quantified, instrument variables, such as the following, must be carefully tested and documented:

- air flow through filter
- particle sizes collected
- uniformity of sample on filters
- filter-detector distance
- reproducible measurement conditions

Consensus national standards provide detailed guidelines on testing the limitations of CAM monitoring systems (ANS 1980a).

Naturally occurring radiations can interfere with CAM measurements. In EEG-38 (Rodgers and Kenney 1988), it was reported that naturally occurring radon/thoron progeny significantly interfered with the WIPP CAM measurement of transuranic alpha particles.

3.3 Radon Background

Radon or thoron progeny[3] are collected on CAM filters and interfere with the measurement of transuranic radionuclides. Radon progeny produce more detector counts than thoron progeny, but thoron progeny persist for a longer period of time (Seiler et al. 1988).

The radionuclides uranium (^{238}U) and thorium (^{232}Th) occur naturally in geological formations. The ^{238}U decays by emitting an alpha particle and becomes thorium (^{234}Th). The ^{234}Th is also radioactive and decays by emitting a beta particle, and another radionuclide $^{234}Pa^{m}$ is produced. One of the ^{238}U decay products is ^{222}Rn (radon), a noble gas that migrates through rock and soil formations and normally dissipates in the air. A building or unusual atmospheric condition can trap ^{222}Rn causing its progeny to increase in concentration. In Table 3, each radon daughter radionuclide decays to another product until stable lead (^{206}Pb) is produced (U.S. DHEW 1970).

As shown in Table 3, the ^{222}Rn progeny produce alpha, beta and gamma emissions. Several of the ^{222}Rn progeny are short half-life alpha emitting radionuclides, and the subsequent high decay rates cause significant interference with plutonium and americium measurements.

Like the decay of ^{238}U, naturally occurring ^{232}Th produces a long chain of radionuclides. One of the ^{232}Th daughters, thoron (^{220}Rn), is also an inert gas which migrates similarly to radon (^{222}Rn). The immediate decay progeny of thoron have longer half-lives than radon progeny (Table 4).

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[3] The radioactive decay products (or daughter products) of radon and thoron series decay are usually referred to as progeny.

Table 3. Radon Decay Series (Major Pathways)*

Nuclide**	Historical Name	Half-Life	Major Radiation Energies (MeV) and Intensities		
			α	β	γ
$^{222}Rn_{86}$	Emanation Radon (Rn)	3.823d	5.49 (100%)		
$^{218}Po_{84}$	Radium A	3.05m	6.00(~100%)		
$^{214}Pb_{82}$ (99.98%)	Radium B	26.8m		0.65 (50%) 0.71 (40%) 0.98 (6%)	0.295 (19%) 0.352 (36%)
$^{214}Bi_{83}$	Radium C	19.7m		1.0 (23%) 1.51 (40%) 3.26 (19%)	0.609 (47%) 1.120 (17%) 1.764 (17%)
$^{214}Po_{84}$ (99.98%)	Radium C'	164μs	7.69 (100%)		
$^{210}Pb_{82}$	Radium D	21y		0.016 (85%) 0.061 (15%)	0.047 (4%)
$^{210}Bi_{83}$	Radium E	5.01d		1.161(~100%)	
$^{210}Po_{84}$	Radium F	138.4d	5.30 (100%)		
$^{206}Pb_{82}$	Radium G	Stable			

*Data from <u>Radiological Health Handbook</u> (U.S. Dept. of HEW 1970)
**Daughter nuclide listed below parent nuclide

Table 4. Thoron Decay Series (Major Pathways)*

Nuclide**	Historical Name	Half-Life	Major Radiation Energies (MeV) and Intensities		
			α	β	γ
$^{220}Rn_{86}$	Emanation Thoron (Tn)	55s	6.29 (100%)		
$^{216}Po_{84}$	Thorium A	0.15s	6.78 (100%)		
$^{212}Pb_{82}$	Thorium B	10.64h		0.346 (81%) 0.586 (14%)	0.239 (47%) 0.300 (3.2%)
$^{212}Bi_{83}$	Thorium C	60.6m	6.05 (25%) 6.09 (10%)	1.55 (5%) 2.26 (55%)	0.040 (2%) 0.727 (7%) 1.620 (1.8%)
$^{212}Po_{84}$ (64%)***	Thorium C'	304ns	8.78 (100%)		
$^{208}Tl_{81}$ (36%)***	Thorium C"	3.10m		1.28 (25%) 1.52 (21%) 1.80 (50%)	0.511 (23%) 0.583 (86%) 0.860 (12%) 2.614 (100%)
$^{208}Pb_{82}$	Thorium D	Stable			

*Data from <u>Radiological Health Handbook</u> (U.S. Dept. of HEW 1970)
**Daughter nuclide listed below parent nuclide
***From ^{212}Bi

3.4 Measuring Alpha Air Concentration

Regulations and consensus standards (U.S. DOE 1988, U.S. CFR 1992, ICRP 1977, ICRP 1983) require that air concentrations of long half-life transuranics be strictly limited. For ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am, the allowable air concentrations are two orders of magnitude less than short half-life alpha-emitting radon or thoron radionuclides.

At the WIPP, radon and thoron progeny background count rates are one to two orders of magnitude greater than the proposed plutonium alarm level. The strict limits and high background both make transuranic alpha monitoring difficult.

3.5 Differentiating Transuranics from Radon

As shown in Tables 3 and 4, radon and thoron progeny emit alpha particles with higher kinetic energy than ^{238}Pu, ^{239}Pu, and ^{241}Am alpha particles (Table 2). The WIPP alpha CAM uses a spectrometer to identify the various alpha particle energies. The output from the spectrometer results in a spectrum as shown in Figure 5.

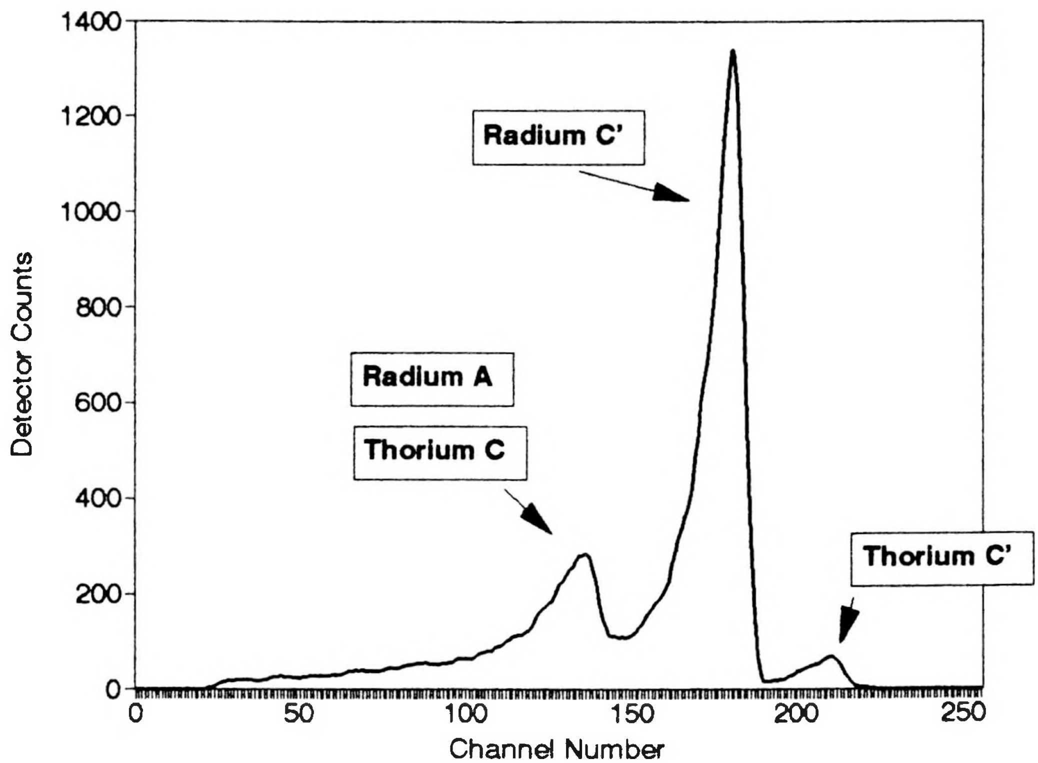

Figure 5. Typical Radon/Thoron Alpha Spectrum

When an alpha particle interacts with a detector, the energy transfer is not usually 100 per cent. The result is a broad "peak." In Figure 5, the peak width for radon and thoron alpha particles is relatively broad, and some counts from higher energy alpha particles are recorded in lower energy channels or regions.

The alpha spectrum in Figure 5 can be divided into regions of interest (ROIs) as shown in Figure 7. The ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am alpha particles are of similar energy and peaks are produced in the plutonium ROI or ROI-1. Some counts in the plutonium ROI result from degraded radon or thoron alpha particle energies. The interfering counts must be subtracted from ROI-1 to determine net plutonium counts. This is accomplished by subtracting a percentage of the counts in higher radon/thoron peaks from the ROI-1 region. The method for subtracting radon/thoron interference in the ROI-1 region was defined as an algorithm (Newton et al. 1990).

3.6 Algorithm

A typical Waste Handling Building CAM system skid is pictured in Figure 6 which shows a radial entry alpha detector and a beta CAM with sample line. A typical output from the spectrometer results in a spectrum as shown in Figure 7, with ROIs 2, 3, and 4 being radon/thoron regions, and ROI-1 is the plutonium region.

The empirical relationship used to predict interfering radon/thoron counts in ROI-1 is as follows:

$$\text{ROI-1}_{(Rn/Tn)} = k\,[(\text{ROI-2}) * (\text{ROI-3})] \,/\, (\text{ROI-4} + 1)$$

where

$\text{ROI-1}_{(Rn/Tn)}$ = predicted radon/thoron counts in ROI-1

k = k-factor, constant

ROI = Regions of Interest, counts in range of channels, as shown in Figure 7

The number of ROI-1 plutonium counts is determined by subtracting the predicted radon/thoron counts from the total ROI-1 counts. If no plutonium or americium is present on the CAM filter, then the net ROI-1 counts should be zero.

Figure 6. CAM Skid in Waste Handling Building

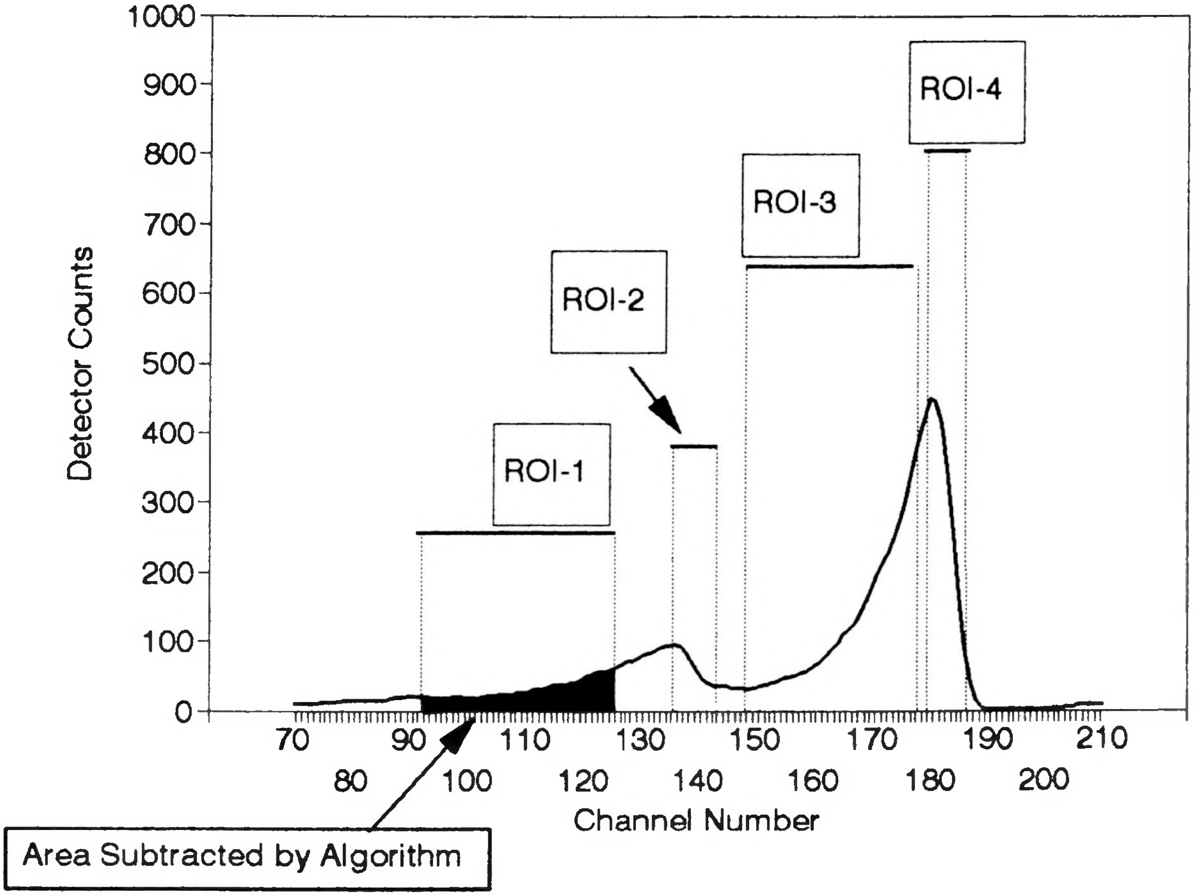

Figure 7. Pu ROI with Rn/Tn Contribution

The appropriateness of the algorithm was reviewed by the ITRI (Newton et al. 1990). If salt collects on a filter, then the shape of the alpha spectrum can be altered, and subsequently the number of counts subtracted from the ROI-1 region could be incorrect. Also affecting the subtraction process is the constant "k" value. If the k-factor is incorrect, then the wrong number of counts would be subtracted from the plutonium ROI. As is shown later in the report, the alpha spectrum is significantly changed by salt loading and detector malfunction.

3.7 Beta CAMs

Beta CAMs are a requirement of the FSAR, Chapter 10 (Westinghouse 1990). There are numerous beta emitting radionuclides in the radon and thoron decay series (Tables 3 and 4). Like alpha CAMs, the radon/thoron progeny will significantly interfere with the measurement of beta radiation. The EEG has not received any basic operational description of the WIPP beta CAMs, how radon/thoron background is subtracted, or what radionuclides will be measured.

4.0 REGULATORY REQUIREMENTS

The WIPP CAMs are required for workplace monitoring, effluent monitoring, and to minimize radiological releases from the underground mine. There are several regulations requiring air monitoring. The CAM sensitivity and testing requirements vary according to the CAM function. The discussion below considers those regulations directly applicable to the DOE and DOE contractors.

4.1 Applicability of Regulations

The responsible regulatory organization within the DOE should be identified so that there is a common approach for interpreting regulations. In a November 19, 1990 letter from R. H. Neill, EEG Director, to A. Hunt, DOE Project Manager (Appendix A), the EEG requested that the DOE identify the organization that determines applicability of the DOE regulations. The DOE responded in a March 27, 1991 letter from A. Hunt to R. H. Neill (Appendix B) with the following:

> The determination whether a particular DOE Order or other regulatory requirement applies to WIPP must be determined on a case by case basis.

The EEG asked in the November 19, 1990 letter that the DOE:

> . . . identify the organization within the DOE that has the responsibility for determining whether or not WIPP will abide by all or part of the DOE regulations.

A DOE policy seemed to be implied in the March 27, 1991, DOE letter regarding applicability of DOE Order 6430.1A:

> "DOE organizations with first-line responsibilities for facility projects shall determine to what extent these criteria shall be applied to projects in process under

prior issuances of DOE 6430.1." This has been interpreted to mean that in the chain of command of DOE management for WIPP, a decision can be made as to the applicability of 6430.1A. (underlined for emphasis)

DOE Order 6430.1 is one of the DOE regulations which establishes requirements for facility air monitoring. At present, it appears that the responsibility for deciding the applicability of the DOE safety regulations resides with the same "chain-of-command" responsible for management, construction, and fiscal accounting. The DOE recognizes their regulatory process needs revision, as discussed below.

4.2 Codification of the DOE Orders

At a DOE Radiation Protection Conference held August 27-29, 1991, the DOE Headquarters staff revealed a plan to codify existing DOE health and safety regulations. The process involves publishing proposed rules in the Federal Register, allowing for public comment, and eventually publishing a final regulation in the Code of Federal Regulations. For example, the DOE Order 5480.11 (U.S. DOE 1988) is in the process of codification as 10 CFR Part 835 per the Federal Register, December 9, 1991. The 10 CFR Part 835 has many air monitoring requirements. The effect of the codification process may be to clarify regulatory language and to standardize health and safety requirements within the DOE.

4.3 Workplace Air Monitoring

Workplace air monitoring refers to the measurement of airborne radioactive material in places where radiation workers are located and is required by DOE Order 5480.11. The CAM has a limited but important workplace monitoring role at nuclear facilities. The CAM is not expected to be sensitive to chronic, low-level radiation releases, but rather was designed to alert workers to abnormally high air concentrations of radioactive material. Bioassay and fixed air sampling methods are retrospective methods used to verify that there are no low-level continuous exposures. The regulations also require that low doses be minimized, and that the design of the facility preclude any unnecessary exposure.

4.3.1 Continuous Air Monitors (CAMs). DOE Order 5480.11, paragraph 9.g.(3)(a) states that:

> Air Monitoring. Ambient air monitoring shall be performed in occupied areas with the potential to exceed 10 percent of any derived air concentration values given in Attachment 1.[4] Representative ambient air monitoring samples should be taken in strategic locations to detect and evaluate airborne radioactive material at work locations. Data obtained from air monitoring shall be used for assessing the control of airborne radioactive material in the workplace; it should not normally be used to evaluate the dose equivalent to radiation workers. Air monitors shall be routinely calibrated and maintained, and should be capable of measuring one DAC when averaged over 8 hours (8 DAC-hours).

The term DAC means derived air concentration and is in units of radioactivity per unit volume (μCi/ml, microcuries per milliliter). The DAC-hour term means DAC times the duration (hours). DOE Order 5480.11 requires air monitoring if 0.1 DAC is possible, but the monitor only has to be capable of measuring an 8 DAC-hour concentration (e.g. 1 DAC continuously for an 8 hour period).

If an 8 DAC-hour concentration were collected, then the CAM system should alarm. If a worker breathed an 8.0 DAC-hour concentration, then the resulting annual dose would be about 20 mrem annual committed effective dose equivalent (ICRP 1978). The 20 mrem dose is an estimate, but it is offered as a perspective on the relationship of airborne concentration to personnel dose.

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[4] The reference to Attachment 1 is the attachment contained in DOE Order 5480.11.

A panel of DOE CAM experts (Carter et al. 1991) used the DOE Order 5480.11 as the basis for most of their recommendations on CAMs. The expert panel report stated a concern over the 8 DAC-hour limit which was interpreted to apply only to laboratory conditions. This proviso of laboratory conditions appears in the proposed 10 CFR 835.

It seems reasonable to state that CAM performance criteria are only for ideal conditions. For non-laboratory conditions, there are no specified criteria. For chronic, continuous releases below the 8 DAC-hour limit, a worker could theoretically receive as much as 5,000 mrem in a year. Although this level of chronic exposure is not likely because of other monitoring requirements, the example suggests that CAMs are not designed for the measurement of low-level chronic releases. A similar example is given in a recently published DOE guidance manual (U.S. DOE 1992).

The CAM workplace function is one of alerting the worker to unusually high air concentrations of radioactive material. The DOE Order 5480.11 regulation makes this distinction in paragraph 9.g.(3)(a) by stating that air monitors "should not normally be used to evaluate the dose equivalent to radiation workers."

4.3.2 Alternate Monitoring Methods. Because CAMs are relegated to the role of measuring higher level releases, alternative monitoring methods are necessary. One method is to use a fixed air sampler (FAS) to continuously collect airborne samples in a designated area. The FAS filter is periodically collected for analysis in the laboratory. Depending on the laboratory method, the analysis can be very sensitive, but the FAS analysis has the disadvantage of being retrospective.

Personnel dose is also determined by bioassay. For example, a worker could inhale airborne radioactive material which would be deposited in the lungs. Special detection instruments are used to measure individual uptake per requirements in DOE Order 5480.11, paragraph 9.g.(2). The regulation states:

> Internal Radiation. Internal dose evaluation programs (including routine bioassay programs) shall be adequate to demonstrate compliance with the radiation protection standards in paragraph 9b. Such programs are required for radiation workers exposed to surface or airborne radioactive contamination where the worker could receive 0.1 rem (0.001 sievert) annual effective dose equivalent from all intakes of all radionuclides from occupational sources, or if any organ or tissue dose equivalent could exceed 5 rem (0.05 sievert) annual dose equivalent.

DOE Order 5480.11, paragraph 9.b. requires that the annual radiation worker dose be limited to 5,000 mrem; although there are qualifiers with regard to organ dose, unborn children, age and emergencies.

4.3.3 ALARA. Radiation doses must be limited in accordance with the as-low-as-reasonably-achievable (ALARA) principle of DOE Order 5480.11, paragraph 9.a. as follows:

> Maintaining Radiation Exposures As Low As Reasonably Achievable (ALARA). It is DOE's policy that exposures to radiation resulting from DOE operations be maintained within limiting values given in paragraph 9 and as far below all limiting values as reasonably achievable. This policy applies to annual, committed, and cumulative dose equivalents. Plans and programs used to assure that occupational radiation exposures are maintained ALARA shall be documented.

Part of a good ALARA program is to design or modify the workplace to reduce the possibility of worker exposure. This design objective is clearly stated in DOE Order 5480.11, paragraph 9.j.(1)(c):

> Internal Radiation Exposure. As a design objective, exposure of personnel to inhalation of airborne radioactive material is to be avoided under normal operating conditions to the extent reasonably achievable. This will normally be accomplished by confinement and ventilation.

4.4 Effluent Monitoring

Effluent monitoring refers to the monitoring of routine and non-routine releases of radioactive material from a facility to the environment. The DOE requirements for routine releases are found in DOE Order 5400.5, 2-8-90, titled "Radiation Protection of the Public and the Environment" (U.S. DOE 1990). The regulations do not have stated limits on accidental releases, but the facility design should be sufficient to prevent accidental releases. The regulations do limit site worker and public dose, and the facility must incorporate ALARA design principles.

The routine release requirements are complex because several different federal laws are relevant. The EEG requested (Appendix A) that the DOE provide an interpretation of DOE Order 5400.5, and the DOE response (Appendix B) discusses both off-site and on-site dose limitations (Appendix B). The DOE response is summarized below:

(1) 40 CFR 61, NESHAPS, limits individuals of the public to a dose of 10 mrem in a year, off-site, where the public resides or abides.

(2) 40 CFR 191, Part 1, limits individual whole body dose to 25 mrem in a year and dose to an organ to 75 mrem in a year. The DOE interprets this to apply only to off-site doses.

(3) DOE Order 5400.5, requires the reporting of 10 mrem in a year to the relevant DOE program office and the Deputy Assistant Secretary of Environment (DOE). The DOE states that this regulation must be interpreted in concert with other regulations; although no explanation was offered as to the meaning of this statement. A

reading of DOE Order 5400.5 provides the following definition:

> Public Dose means the dose received by member(s) of the public from exposure to radiation and to radioactive material released by a DOE facility or operation, whether the exposure is within the DOE site boundary or off-site.

(4) DOE Order 5480.11, requires a member of the public to be limited to 100 mrem in a year. The DOE interprets this limit as an on-site requirement. Consequently, this limit applies to total dose, from external exposure or internal uptake, routine releases or accidental releases. This was confirmed by the DOE letter in Appendix B which states:

> . . . WIPP has adopted the public dose limit of 100 mrem per year to apply to members of the public who receive exposures on site.

There are several ways to determine radiation dose as listed in DOE Order 5400.5, Chapter 1, Section 10. These requirements are stated as follows:

a. Standard Methods. Data developed by the Department to demonstrate that DOE operations comply with applicable standards and requirements should be correct and representative. Accordingly, this Order requires that calculations of dose to the public from exposures resulting from both routine and unplanned activities be performed using standard EPA or DOE dose conversion factors or analytical models prescribed in regulations applicable to DOE operations.

b. Supplemental Documents. The dose conversion factors and derived concentrations needed to make dose evaluations to meet DOE requirements are provided in Chapter III and three supplemental documents: EPA-520/1-88-020, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration Factors for Inhalation, Submersion and Ingestion; "

DOE/EH-0071, "Internal Dose Conversion Factors for Calculation of Dose to the Public," and DOE/EH-0700, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public." The dose conversion factors in these documents provide the primary basis for determining compliance with this Order...

c. EPA Models. The use of AIRDOS/RADRISK, CAP-88, or AIRDOS-PC models is prescribed by EPA in 40 CFR Part 61, Subpart H, to evaluate potential doses from airborne releases. Thus, two evaluations of doses from airborne pathways could be required: one to satisfy 40 CFR Part 61 requirements and one for DOE purposes using contemporary dosimetry. [Caution: Unless modified, AIRDOS/RADRISK (also known as CAP-88 or AIRDOS-PC) is not suitable for calculating doses from accidents.]

In option a. appropriate data must be collected and the dose to the public derived by an acceptable calculation. The second method suggests using tabular effluent concentration data on air and water concentrations for individual radionuclides. These concentration limits are specified in DOE Order 5400.5 (U.S. DOE 1990), and limiting effluent to these specified concentrations will keep the public dose below the required limits. The DOE is quick to point out that these limits apply only to "routine" releases (Appendix B).

The methods described in c. refer to certified computer calculation codes, which are only appropriate for a specific set of conditions. If release conditions are as stated in the computer code, then effluent concentration limits can be derived by one or more of the dose evaluation methods.

Regardless of the method used, the allowable effluent airborne radiation concentration limit must be established. Once established, then the required CAM alarm level can be derived. If the CAM can accurately and consistently measure radiation below the alarm level, then the radiation dose to public and workers can be adequately monitored.

4.5 Minimizing Facility Releases

A properly designed nuclear facility will have minimal routine and non-routine releases. DOE Order 6430.1A deals with "General Design Criteria for Department of Energy Facilities" (U.S. DOE 1989). The EEG requested that the DOE specify the version of the Order used for the design of the WIPP (Appendix A) because the Order has been reissued several times in the last eleven years. The older versions of the Order have significantly different requirements. The DOE response was as follows (Appendix B):

> DOE 6430.1A became effective on April 6, 1989. It superseded DOE 6430.1, which became effective on December 12, 1983. DOE 6430.1 in turn was preceded by a draft version, DOE 6430., dated June 10, 1981. (It should be noted that there was no final version bearing the designation "DOE 6430."). The design for the Waste Handling Building was formally approved in November 1983. Construction was begun in April 1985 and was completed in May 1987.
>
> In view of the above, the EEG is correct in its observation that the construction of the WIPP facility was completed after the effective date of DOE 6430.1 (but before the effective date of DOE 6430.1A). The quoted paragraph from our October 22, 1990 letter contains an error. It should have stated "... DOE Orders 6430.1 and 6430.1A were issued after the completion of the design of those portions of the facility;..." The DOE 6430.1 series are design criteria; therefore, the important consideration is when design of a facility is completed relative to the effective date of the order. As stated in Section 0101-1, "These criteria shall be applied in the planning, design, and development of specifications for facilities, including the preparation of site-specific general design criteria and project-specific design criteria during the project planning phase." The Waste Handling Building was designed in accordance with the requirements of DOE 6430., since that was the version of the General Design Criteria in effect at the time the design of the Waste Handling Building was approved.

This carefully worded DOE response did not fully address our concern. The EEG's concern was the design of the underground confinement and monitoring systems, not simply the Waste Handling

Building. The underground site and design validation activities are a continuing process. From Chapter 1.5.3 of the FSAR (Westinghouse 1990) the following paragraphs are referenced:

> The WIPP Project has pursued a phased approach to evaluating the acceptability of the site and the validity of the designs of pertinent structures. The initial phases of this evaluation process are described briefly here . . . .
>
> A program of investigation referred to as the SPDV was undertaken to provide confirmation of the characteristics of the facility location and to evaluate the design concepts (Figure 1.5.2). Completed in March 1983, the SPDV program spanned nearly two years. One 12-foot diameter and one 6-foot diameter shaft were drilled to the storage horizon depth of about 2150 feet, four rooms were excavated to the storage-room design dimensions, and connecting and exploratory drifts were excavated in support of this program.
>
> The results of the SPDV program supported the decision to proceed with the development of the WIPP facility, geotechnical measurements continued in support of the Design Validation (DV) process, which resulted in the Design Validation Final Report[2] issued in October 1986.

It is interesting to note that the October 1986 Design Validation Final Report states the following:

> Detailed design of the WIPP, begun in 1981 and completed in 1984, included design of the surface and underground facilities and the reference design for the underground openings.

This would seem to contradict the DOE position that the "facility" design was completed prior to November 1983. The Preliminary Design Validation Report, March 3, 1983, describes the initial construction of the underground. The emphasis of the report is on geological considerations.

Exhaust flow rate is an important aspect of the safety analysis. The 1981 underground design had 2 shafts and a ventilation exhaust rate of 60,000 CFM. The 1986 design was similar to the present day design, but the present-day air intake shaft was not part of the facility. The air intake shaft construction was not completed until 1988, and this facility modification had a major impact on ventilation design. The nominal exhaust flow rate was increased from 60,000 CFM to 460,000 CFM.

The DOE has insisted that design criteria were established prior to November 1983, thereby invoking the applicability of draft DOE Order 6430, which was superseded a month later. It appears that the underground design was an ongoing process, and major construction changes have occurred as recently as 1988. DOE Order 5481.1B, Chg 1, May 19, 1987 (U.S. DOE 1987) is particularly relevant as this DOE Order required a safety analysis with respect to current design criteria. The change order states:

> Additions have been made to Paragraph 3, "Basic Requirement," concerning safety analysis and documentation. These additions are in response to a recommendation contained in GAO Report RCED-86-175, "Nuclear Safety: Safety Analysis Reviews for DOE's Defense Facilities Can Be Improved," of 6-6-86, which recommends that safety analysis reports include a detailed comparison of the plant against current DOE design criteria, highlighting and explaining any deviations.

To evaluate the performance of a monitoring system, the applicable regulation must be referenced. In the case of the CAM, acceptance criteria could be based upon DOE Order 6430, DOE Order 6430.1, or perhaps DOE Order 6430.1A. If older criteria are used, then the CAM performance requirements are minimal. If current requirements are used, then CAM performance requirements are quite different. Below is a discussion of the relevant requirements of these Orders.

4.5.1 DOE Order 6430, Draft, 6-10-81. Although the DOE has not acknowledged that the DOE Order 6430, Section XXI, Plutonium

Facilities, applies to the WIPP (Little 1985), the key effluent requirement of Section XXI is as follow:

> EFFLUENT CONTROL AND MONITORING. Effluent (both radioactive and nonradioactive) from the plutonium handling facility include air and gaseous exhaust and liquid wastes. The contamination in the effluent shall be as low as reasonably achievable, commensurate with the latest accepted technology at the time of the design. Emphasis shall be placed on reducing total quantities of effluent (both radioactive and nonradioactive) released to the environment. In any event, the effluent concentrations of plutonium shall not exceed the Radioactivity Concentration Guide (RCG), in Chapter XI (Requirements for Radiation Protection) of DOE 5480.1, for uncontrolled areas measured at the point of discharge (e.g. exhaust ducts and stacks) during normal operations. Consideration shall be given to recirculation systems for process ventilation. Provisions shall be made for retention systems for liquid effluent. All effluent streams shall be sampled or monitored as appropriate to assure accurate measurements of all releases under normal and DBA conditions.

It should be noted that this regulation requires that the effluent be as low as reasonably achievable, and that the monitoring system be "commensurate with the latest accepted technology at the time of the design." The regulation goes on to describe the requirements for ventilation filtration, a requirement for one CAM, and one fixed sampler. The CAM and fixed sampler can be the same unit.

DOE Order 6430 (U.S. DOE 1981) references DOE Order 5480.1 (U.S. DOE 1980) which restricts plutonium effluent concentrations. The restrictions are based on 500 mrem in a year and a concentration limit not to exceed the Derived Concentration Guide (DCG) at the "fence line." For example, the ^{238}Pu (insoluble) DCG limit is 3×10^{-11} μCi/ml, and the DCG can be multiplied by a stack dispersion factor.

A peripheral issue in DOE Order 6430 is the dose requirement at the site boundary (fence line). As pointed out in EEG-29 (Little

1985), use of the DOE Order 6430 draft criteria, and a less conservative dose requirement at the fence line, was the basis for not classifying the CAM system as a "critical system."

4.5.2 DOE Order 6430.1, 12-12-83. DOE Order 6430.1 (U.S. DOE 1983) is very similar to the DOE Order 6430 draft with some important exceptions. Section XXI, 7.h. contains the following requirement:

> Design objectives for the (facility) confinement system shall be an essentially zero exposure of the public and plant personnel to airborne contamination. [The word facility was added for clarification.]

This statement seems to give more importance to other facility design requirements found in DOE Order 6430 and 6430.1. Chapter XXI, Section 7.a.(1)(a) has the following requirements:

> Critical items and systems (ventilation, electrical, fire protection, and utility systems) shall be designed to provide confinement of radioactive materials under normal operations and DBA conditions. The degree of confinement of radioactive materials shall be sufficient to limit releases to the environment to the lowest reasonable achievable level. In no case shall the applicable exposure regulations be exceeded, either with respect to the operating personnel, or to the public at the boundary or nearest point of public access . . . .

The "nearest point of public access" is an important concept because it requires dose assessment closer to the release point than the "fence line." The Chapter XXI definition of a "critical item" is as follows:

> Those structures, systems, and components whose continued integrity and/or operability are essential to assure confinement or measure the release of radioactive materials in the event of DBA. Critical items shall be capable of performing required safety functions.

Critical systems require a stricter level of quality assurance and testing. With respect to fire resistance, Chapter XXI, Section 7.a.(5) states:

> The structural shell surrounding critical areas and operating area compartments and their supporting members shall be designed with sufficient fire resistance so that it will remain standing and continue to act as a confinement structure during the DBF (i.e. Design Basis Fire) postulated for the facility assuming failure of any fire suppression system which is not designed as a critical item... A high degree of reliability and/or redundance shall be required of all protective features of the ventilation system to assure its effective operation even if normal plant utility and fire protection systems fail.

Ventilation system requirements are found in Section 7.e.(1)(a).

> Ventilation systems shall be designed to confine radioactive materials under normal and DBA conditions and to limit radioactive discharges to the practicable minimum.

The specifications for ventilation, or the monitoring systems performance, are to be formalized and reviewed in the SAR process. Section 7.e.(1)(c) states:

> Safety analysis shall establish the minimum acceptable response requirements for the ventilation system, its components, and instruments and controls under normal, abnormal and accident conditions.

Section 7.e.(1)(e) states:

> The principle of compartmentalization shall be employed to limit the extent of contamination and minimize loss of productivity and property in the event of a DBA.

The DOE stated that the cited provisions do not apply to the WIPP because the facility is not a Plutonium Processing facility. Chapter XXI does state that the requirements apply to plutonium handling facilities, and reference is also made to the potential of releasing plutonium which would exceed the limits set forth in Chapter XI of DOE Order 5480.1a. DBAs considered in the FSAR would cause concentrations to exceed DOE Order 5480.1a limits. If the provisions of Chapter XXI are ignored, then there are no facility-specific design criteria in DOE Order 6430.1 which would apply to the WIPP as a nuclear facility.

It was not until the introduction of a new design criteria regulation, DOE Order 6430.1A, 4-6-89, that facility-specific design requirements were clearly specified for radioactive solid waste storage facilities. These requirements are more pertinent to the WIPP operations, but as stated by the DOE (Appendix B), the WIPP management will decide if they want to follow these criteria or not. If the facility is substantially modified, then the safety analysis must be based on DOE Order 6430.1A. Some key requirements of DOE Order 6430.1A are discussed below.

<u>4.5.3 DOE Order 6430.1A, 4-6-89</u>. The requirements of DOE Order 6430.1A are more restrictive than earlier superseded regulations. Key provisions in this document relate to confinement barriers and use of safety class systems in special facilities. The general requirements for special facilities state that safety class items are required (Section 0111-99.0.1):

> To prevent or mitigate the release of quantities and concentrations of radioactive materials that have the potential to exceed the release guideline contained in Section 1300.1.4, Guidance on Limiting Exposure to the Public.

Section 1300.1.4.2 states:

> <u>Accidental Releases:</u> Releases of hazardous materials postulated to occur as a result of DBA shall be limited by designing facilities such that at least one confinement system remains full functional following any credible DBA (i.e., unfiltered/unmitigated releases of hazardous levels of such materials shall not be

> allowed following such accident). Facility design shall provide attenuation features for postulated accidents (up to and including DBAs) that preclude offsite releases that would cause doses in excess of the DOE 5400 series limits for public exposure . . . .

The DOE Albuquerque Operations office staff stated in a letter that the EEG was misinterpreting the above section as it refers to accidental releases (Appendix B). The DOE justification was that DOE Order 5400.5 does not have concentration limits for accidental releases. To the contrary, the above paragraph does require that DBAs be limited by the design of the facility, and as mentioned previously, there is a requirement to limit public dose to 100 mrem, on-site or off-site, routine or accident, per DOE Order 5480.11. The intent is that accidental releases must be mitigated. The failure of the DOE to promulgate requirements for accidental release concentration limits in the DOE Order 5400 series does not appear to be an exemption from dose restrictions specified in DOE Order 5480.11.

Section 1300-1.4.3 states:

> Routine Releases: The annual dose resulting from postulated, planned, or expected releases from the proposed facility shall be considered in combination with the annual doses resulting from planned or expected releases from other facilities at the same site. The sum of the doses from the site shall be limited according to DOE radiation Standards of Protection of the Public in the Vicinity of DOE Facilities or subsequent guidance included in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series.

This section of the design Order does require that routine or chronic releases be limited to the concentration limits specified in DOE Order 5400.5.

Of great significance to the evaluation of effluent monitoring systems is the classification of these items as "Safety Class

Items." One of the characteristics of a safety class system per Section 1300-3.2 is:

> Those required to monitor the release of radioactive materials to the environment during and after a DBA.

This is important because safety class items require special considerations found in Section 1300-3. Some of these requirements are paraphrased below:

> . . . subject to appropriately high-quality design, fabrication, and industrial test standards and codes . . . .
>
> <u>Single Failure Criterion and Redundancy</u> to ensure against loss of capability . . . to include appropriate redundancy . . . and minimize the possibility of concurrent common-mode failures of redundant items.
>
> <u>Environmental Qualification of Equipment</u>
>
> <u>Equipment Operability Qualification</u>
>
> <u>Maintenance</u>
>
> <u>Testing</u>

Compliance with the referenced requirements is necessary to insure that monitoring systems are capable of performing their prescribed functions, are installed and properly maintained, and that <u>relevant</u> periodic testing occurs.

The DOE states (Appendix B) that the WIPP complies with the requirements of DOE Order 6430.1A , Section 1324-2.2.1 because routine release limits will not be exceeded. It appears that the DOE does not consider radiation doses from accidental releases as important in establishing compliance with facility design criteria. Section 1324.7.3.1 has the following requirement:

> Exhaust outlets that may contain transuranic or fission products shall be provided with two monitoring systems. These systems shall comply with Section 1589-99.0.1, Radioactive Airborne Effluent.

Section 1589-99.0.1 states:

> All exhaust ducts (or stacks) that may contain radioactive airborne effluent shall be provided with effluent monitoring systems that are designed in accordance with the applicable requirements contained in the directive on Radiation Protection of the Public and the Environment in the DOE 5400 series and the directive on Radiological Effluent Monitoring and Environmental Surveillance in the DOE 5400 series.

This section also references guidance in Section 1300.1.4.3 which was quoted above. The intent of the design regulations is to insure compliance with the environmental regulations which were discussed previously in the "Effluent Monitoring" section of this report.

4.5.4 FSAR Requirements. The requirements for confinement barriers and systems are specified in Chapter 3.3 of the FSAR (Westinghouse 1990) as follows:

> The WIPP facility is designed so that at all time there are barriers between the waste and the outside environment. These barrier are designed to reduce the consequences of radioactive releases to negligible levels, whether such releases are due to internal accidents or severe natural phenomena.

For the underground area, the primary confinement barrier is the drum or metal container that contains the radioactive waste. The secondary confinement barrier is the exhaust filter building HEPA filtration system. The exhaust air is normally diverted away from the HEPA filters. There must be a means for diverting the ventilation flow to the secondary confinement in the event of a radioactive release.

The CAM system provides the only method for detecting and quantifying radioactive releases, which in turn would signal the need to divert air to HEPA filtration. The CAM is part of the dynamic confinement system, as described in the FSAR. The CAMs should be classified as safety class systems with all the prerequisite requirements. The CAM effluent system requirements should meet DOE Order 6430.1A, 6430.1 and the FSAR, rather than conforming to the older DOE draft Order 6430 (Table 5).

Table 5. Facility Effluent Monitoring Requirements

DOE Order 6430 (draft) 6/10/81	DOE Order 6430.1 12/12/83	DOE Order 6430.1A 4/6/89	WIPP FSAR 5/90
(1) CAM not safety class (2) Fence line dose 500 mrem in a year (3) Only 1 CAM and 1 FAS at discharge (4) CAM must be "best available technology"	(1) Confinement systems limit public & plant personnel dose to essentially zero (2) Confinement to "nearest" point of public access" (3) Ventilation must confine & limits must be stated in FSAR (4) CAM is safety class & requires testing	(1) Confinement systems must remain after DBA (2) Tertiary confinement barriers required (3) CAM is safety class & extensive CAM testing required (4) Dual, redundant monitoring required (5) Fence line dose 10 mrem/yr	(1) Multiple confinement barriers required (2) HEPA filtration building is a confinement barrier

5.0 REPORTS AND COMMUNICATIONS

Since EEG-38 was published in March 1988, there have been numerous CAM-related formal reports and meetings with the DOE. Below is a sequential listing and synopsis of information provided in the reports and communications.

5.1 March 1988, EEG-38 Report

The EEG-38 report contained a description of the L X-ray CAM detection system used at the WIPP (Rodgers and Kenney 1988). It was shown that interference from natural radon and thoron progeny significantly reduced the sensitivity of the system. The report also discussed the importance of probe and transport-line design. There were four major recommendations:

(1) The Nuclear Research Corporation (NRC) L X-ray and beta CAMs must be subjected to thorough laboratory performance testing to demonstrate that they are capable of meeting the requirements of DOE Orders under realistic WIPP conditions.

(2) On-site confirmatory testing under worse-case conditions expected at various locations was recommended.

(3) Alternative approaches to the L X-ray detection of plutonium need to be considered in light of the apparent deficiencies in the present instrument design.

(4) The WIPP Project Office should make provisions for including the EEG in the needed CAM design review, peer reviews, and test plan development to ensure full and prompt review of plans to develop a sound alternative.

Following this EEG report, the WIPP abandoned the L X-ray CAM system in favor of alpha and beta monitoring systems. The alpha monitors had an algorithm to correct for background interference from radon and thoron progeny. Since that time, there have been numerous contractor studies and reports. The reports and formal meetings are documented below.

5.2 August 1988, DOE/WIPP 88-027 Report

The DOE published a report in August 1988 by A. R. McFarland, Texas A&M University on A Shrouded Aerosol Sampling Probe (McFarland et al. 1988). Data were provided on a sampling probe design for the WIPP underground exhaust shaft. Exhaust flow rates from 60,000 CFM to 420,000 CFM were considered, and the objective was to collect at least 50% of particles ranging up to 10μm aerodynamic diameter for all CAMs and FASs at Station A. The shrouded probe was tested at 6 CFM (170 L/min), and for particles of 10 μm the wall losses were 13%. This design was touted as a significant improvement over tradition isokinetic sampling probes.

5.3 September 1988, DOE/WIPP 88-024 Report

Another Texas A&M University report was published in September 1988 titled Tests of Model Waste Isolation Pilot Plant (WIPP) Exhaust Airflow Systems (Turner et al. 1988). This report recommended sampling locations for Station A and B, measured velocity and concentration profiles, and recommended that no flow straighteners be placed in Station B ducting. The report also evaluated turbulent flow problems that might be encountered in the exhaust shaft above ground ventilation system.

The effect of the two Texas A&M reports was to develop and verify the methods that should be used to collect representative samples from the underground exhaust (Stations A and B). The methodology appears to be a significant improvement compared to the traditional isokinetic sampling method recommended in ANSI N13.1 (ANS 1969).

5.4 November 1988, DOE Letter

A DOE letter (Tillman 1988) stated that an improved design of the NRC CAM detector/filter housing had been tested at Texas A&M University. Losses of 10 micron particles were shown to be less than 15%.

5.5 December 1988, ITRI Phase I Report

The DOE contracted with the ITRI in Albuquerque, New Mexico to evaluate and test the WIPP Continuous Air Monitor (CAM). The ITRI published a Phase I report (Hoover et al. 1988) that reported on the feasibility of using the WIPP CAM to meet regulatory requirements for continuous monitoring of airborne plutonium.

The emphasis of the report was to evaluate the WIPP alpha CAM's ability to measure an 8 DAC-hr (8 MPC-h) filter concentration of ^{238}Pu or ^{239}Pu. The report considered the following variables:

- Dust-free sensitivity to 8 DAC-hr
- False alarm rate
- Software (Algorithm) modifications
- Detector resolution
- Expected salt aerosol concentrations at the WIPP
- An improved aerosol inlet design
- Effect of salt aerosol concentration on sensitivity
- Quantifying of salt burial by the algorithm
- Salt failure limitations and characteristics

The conclusion of this report was that the alpha CAM's sampling method represented the "best available technology," per DOE draft

Order 6430 (U.S. DOE 1981) for detecting plutonium in the presence of salt and radon progeny.

The report provided data on loss of sensitivity as salt accumulated on the CAM filter. The experiments were performed at 1 CFM with an assumed 25% (50% of 2π) efficiency. As stated in this EEG report, sampling occurs at 2 CFM at Station A with detector efficiencies below 10%. Care should be exercised in quoting performance capabilities from the ITRI report without specification of detector efficiency.

5.6 <u>February 1989, EEG Letter</u>

The EEG provided a detailed review of the ITRI, Phase I report (Neill 1989a). The EEG recommended that a well-designed, long-term aerosol monitoring program be conducted at critical CAM locations. The emphasis was to determine radon progeny background and to correlate underground activities with CAM filter dust loading.

EEG recommended that research experiments be performed in which Pu/salt/radon progeny mixtures would be deposited on filters to reveal possible failure mechanisms. To date, the EEG has received no information about Pu/salt/radon experiments, and the DOE refused to comment on any plans for CAM research at the September 1991 Quarterly Meeting.

5.7 <u>November 1989, EEG Letter</u>

Detailed comments on the Phase II ITRI draft report were provided by the EEG (Neill 1989c). Requests were made for statistical information to support the assumptions in the report. A request for a meeting was made.

5.8 December 1989, Meeting

On December 4, 1989, a meeting was held with the DOE, the WID, and the ITRI staff. There were discussions on where CAMs would be located considering smoke generator studies, operational experience, gravimetric data, and the use of the radial entry sampling heads. Details of a Memorandum from Dr. Mark Hoover and Mr. George Newton, ITRI, to Dr. James Mewhinney, DOE/WIPP, were discussed. This memo also identified a need to network spectral information from CAMs and to train personnel to interpret spectral data. There were discussions on mass flow meters, the relevancy of 240,000 CFM flow rate to the proposed 420,000 CFM flow rate, use of k-factors, burial rates and loss of sensitivity, and the relevancy of electroplated standards for efficiency determinations. The ITRI staff also agreed to supplement their Phase II report with supporting data.

5.9 January 1990, ITRI Phase II Report

The ITRI published a Phase II follow up study (Newton et al. 1990) providing detailed alpha CAM analyses. The major results reported were:

- A definition of ROI-1 to improve ^{238}Pu and ^{239}Pu efficiency
- Evaluated advantages of detector and filter sizes
- Measurement of airborne salt concentrations
- Confirmation of salt burial thicknesses for ^{238}Pu and ^{239}Pu
- Change 1-minute count cycle to a 5-minute average
- Addressed false alarm rate

This study provided important data on the burial rate associated with filter salt loading (mg/cm^2). The burial rate is the basis of the WIPP's salt aerosol concentration limits; although some simplifying assumptions must be made.

5.10 January 1990, Meeting

On January 18, 1990, EEG met with the WID and the DOE to discuss the current status of the CAM system. The technical issues identified by the EEG staff were:

- Data on radial entry heads for the alpha CAM
- Data for ITRI Phase II report
- Requested EEG be involved in siting of CAM systems
- Requested continuing data be supplied for:
    - Alarm frequencies
    - DAC-hr settings and justification
    - Failure rate of CAM systems

The WID staff suggested a number of the CAM systems were not working, and the WID was not collecting gravimetric data on underground fixed air samplers (FAS) units.

The DOE stated that a commitment to EH inspectors was made to replace the old-style NRC samplers with the newly designed TAMU system.

Spectral data from the CAM systems were not available, and no measurements of ambient radon levels were being made. A plan was presented to interface various CAM systems with personal computers (PCs) to allow the collection of spectral data. There was also discussion about using an 8 to 10 DAC-hr alarm setting. Results of smoke studies were being sent to the DOE project office for approval and release to the EEG.

Causes for CAM alarms were discussed. The most significant alarm failure mode was identified as power transients (184 events). Maintenance activities caused another 137 alarms. Another 436 alarm events were caused by flow scale factor, low count rate, power interruptions, filter change outs, pump shut downs, and other reasons.

An active program was initiated to design and order uninterruptible power supplies (UPS) and power conditioners. Orders were placed with the manufacturer for new firmware to eliminate reset problems, power-protected circuitry, and gold-plated contact upgrades. A maintenance condition contact for CAM skids was to be installed.

The EEG staff found that there were no plans to exchange the beta CAM design from the NRC to TAMU design. No commitments were made by the DOE staff.

5.11 March 1990, Meeting

On March 12, 1990, another CAM meeting was held to determine the status of items discussed in the January 1990 meeting. The WID announced that power conditioners and UPS systems had been placed on the CAM systems and failures caused by electrical problems had ceased. Key LCO alpha CAMs had been upgraded with the TAMU designed samplers. Keep-alive sources had been installed on units experiencing low count-rate failures. Spectral data were being obtained from selected CAM systems instrumented with PC data collection stations.

The ITRI staff recommended that a 0.6 k-factor setting be used for the alpha CAM systems. PC data collection stations could be used to provide statistical analysis of data to confirm the 0.6 setting.

5.12 April 1990, Smoke Test Video

The DOE provided a copy of the smoke test video tape on April 26, 1990 (Steinbruegge 1989). The smoke studies were used as a basis for siting Waste Handling Building and underground CAMs. The video showed air dispersion of simulated respirable size particles. Smoke flow patterns indicated a circular turbulence and significant mixing of the smoke. The study was performed before the current modifications of the underground Panel 1, Room 1.

There was no assessment of off-normal scenarios, but the smoke patterns tended to verify that respirable particles will quickly move away from the release points. This report appears to have motivated the initiative to design the TRUPACT-II shroud which covers the TRUPACT-II lid opening during unloading.

5.13 May 1990, Meeting

On May 30, 1990, a meeting was held to discuss the need for a test plan. There were technical discussions on the smoke studies and the EEG provided a detailed presentation of the workplace and effluent CAM requirements and DOE Order 6430.1A design requirements. The presentation was similar to the one provided in the regulatory section of this report. The importance of using concentration limits and the 100 mrem "public dose" limit were specifically addressed.

The EEG requested that a proof-of-design document be published on the CAM performance with special emphasis on: detection capability, sensitivity, accuracy, precision, environmental effects (pressure, humidity, power, electrical transients), failure frequencies, and linkage to a primary calibration. There was a discussion on the necessity of linking primary and secondary calibrations, and daily performance checks.

5.14 December 1990, EEG Letter

The EEG requested detailed information about the CAM alarm settings, regulatory interpretations, and the worker radiation monitoring program (Neill 1990). Because of the reported operational problems with CAMs, the EEG also requested that computer data from CAM systems be routinely provided for review.

5.15 April 1991, DOE Letter

The DOE responded to the EEG's December 5, 1990 letter by promising to send a report discussing problems and CAM operational setpoints (see Section 5.17 below).

The response discussed the rationale for the CAM settings which would preclude off-site dose. There was also the statement that the CAP-88 air dispersion modeling code had been accepted by EPA. While this statement is accurate, the statement does not mean CAP-88 is adequate to assess potential on-site doses or to predict doses from accidental releases. The exceptions are discussed in the review of the Stoller report (Section 5.20).

5.16 May 1991, Expert Panel Meeting

The DOE invited the EEG staff to attend a May 14, 1991 DOE CAM expert panel meeting as observers, but the EEG was not allowed to hear or participate in the final deliberations of the panel. The EEG was allowed to listen to presentations, receive copies of viewgraphs and offer comments.

The quality of the WID presentations was good, but the emphasis was on CAMs as workplace monitors. In the sessions which EEG was allowed to attend, there was no actual operational data showing spectral degradations, influence of salt, or effect of salt on the ROI-1 count rate. The final committee report did not contain specific operational data. It appeared the committee's conclusions were based upon presentations and information provided by the WID at the meeting. A review of the committee report is provided later in this report, Section 5.23.

5.17 May 1991, DOE Operational Report

On May 21, 1991, the DOE transmitted a copy of an internal paper titled "Operational Sensitivity and Performance of the Eberline Alpha-6 Continuous Air Monitor at the Waste Isolation Pilot Plant." No author was identified.

The report included a lengthy discussion of operational problems, graphs of salt filter loading, and summary graphs on the plutonium channel count rate.

Six recommendations were listed and are summarized below:

(1) Modification of the algorithm is needed.

(2) Optimize use of the algorithm (k) constant.

(3) Improve on-line performance with UPS and line conditioner systems.

(4) Delete data during service periods.

(5) Redesign or replace the TAMU sample chamber because of difficulties of reproducing filter/detector geometry. (This was thought to be the source of some negative Pu channel excursions.)

(6) Network the CAMs via fiber optic systems.

5.18 June 1991, ITRI Laboratory Test Report

The ITRI published a report titled Response of the Eberline Alpha-6 to Low Level Releases of Plutonium: Laboratory Tests and Workplace Experience, June 21, 1991 (Hoover and Newton 1991). The report evaluated the Alpha-6 performance as a "workplace" CAM.

Nine figures were published which showed the response of the Alpha-6 to ^{239}Pu, with and without radon progeny, and an unplanned ^{239}Pu release within the ITRI glovebox containment. Data were not provided for all figures. The radon progeny data were listed as total accumulated counts, without count rate information. The format of this data did not allow comparisons with measured WIPP radon progeny levels.

During the course of experiments there were two unplanned releases of ^{239}Pu in the glovebox which alarmed the alpha CAM monitor. Data from one release were reported at the 100 CPM level. These data provide qualitative information about the alpha CAM response in the presence of radon progeny. Quantitative comparisons with the WIPP radon background were only suggestive in nature.

The ITRI report did not include salt loading as a variable. There was also no systematic calibration linkage between the ITRI and WIPP monitors, or to the National Institute of Standards and Technology (NIST), and there was no specific identification of model type and serial number so that data could be linked to previous reports.

An important qualitative observation was that a small plutonium peak could be observed in the presence of a relatively high radon progeny background, in the absence of salt aerosol. This observation lends support to the need to visually observe displays of accumulated spectra.

5.19 <u>June 1991, ITRI In-Line Sampler Report</u>

The ITRI report <u>Laboratory Tests on the In-line Sampling Head for the Eberline Alpha-6 Continuous Air Monitor</u> provides valuable feasibility testing of an innovative prototype in-line detector design (Newton and Hoover 1991).

The sampler appears to have the advantages of collecting 50% of particles smaller than 10 μm aerodynamic diameter, and the particles are delivered to the filter in a uniform manner. The sample head is designed to reproduce filter-detector spacing and facilitate filter changes. The efficiency of the detector is similar to that of the Alpha-6.

Although this system was suggested as an enhancement for the WIPP and the Savannah River Site, the WIPP is not presently using this system.

5.20 January 1991, Stoller Report

The S. M. Stoller Corporation contracted with the WID, to produce a report titled "Verification of the Station A Alpha CAM Alarm Set Point at the Waste Isolation Pilot Plant" (Hunt 1991a). The report documents calculations performed with the Environmental Protection Agency computer air dispersion code CAP-88 Version 1.01. CAM alarm settings at Station A (the point of release of underground exhaust) are based on this report. It must be emphasized that the Stoller calculations apply only to chronic releases.

The Stoller report contains four different release conditions and uses a Rocky Flats Newly Generated CH-TRU source term. The maximum dose point-of-reference was 4,000 meters NW of the ventilation exhaust air shaft. Based on the stated conditions, a Station A alarm setting of 40 CPM (alpha) was recommended to preclude an annual 10 mrem dose to the Maximum Individual at Risk (MIR). For off-site releases, the 40 CPM value appears to be very conservative because the following assumptions are used: an 8 hour CAM sampling period, maximum exhaust flow rate, and a worst-case pure alpha emission.

An on-site analysis of dose potential was also offered. The calculation was performed at 100 meters from the release point. A correction factor (0.22) for occupancy was used. The release conditions used in the off-site calculations were assumed. A maximum on-site dose commitment of 8.59 mrem MIR in a year was suggested if off-site doses were 10 mrem in a year.

At the WIPP, there are two stacks, approximately 10 meters in height, which discharge at a 45° angle to the ground horizon (see Figure 3). This design is not optimum for dispersing and diluting effluent. The traditional design, a vertical stack, is assumed in the CAP-88 code programming. The code also allows for an area or ground release. Because of the unusual WIPP stack design, the Stoller report calculations assume an effective stack height based on the stack angle. The vertical stack modeling methodology is used in lieu of an angular method.

The CRC Handbook of Environmental Radiation (Klement 1982) suggests that downwash calculations should be applied when the exit velocity is less than 1.5 times the horizontal wind speed. This same approach is suggested in a Los Alamos guide for the design of non-reactor nuclear facilities (Elder et al. 1986). For the WIPP, a simple vector analysis suggests that vertical and horizontal velocity are equal when the wind speed is zero. This simplistic analysis suggests that a backwash correction should be applied to elevated releases. The WIPP exhaust also has a horizontal component, and depending on the magnitude and direction of the wind speed, the horizontal component is also subject to backwash.

Klement also suggests conditions in which releases (e.g. - WIPP) may be other than an elevated release. Klement states:

> For cases where the ratio of plume exit velocity to horizontal windspeed is between one and five, a mixed release mode should be assumed, in which the plume is considered as an elevated release during part of the

time and as a ground-level release (h_e = 0) during the remainder of the time.

The EEG requested that the DOE provide available site meteorological data, including the last several years (Neill 1991b). The DOE could not provide historical meteorological data, even though a meteorological station has been in operation for several years. The DOE has provided data since January 1992, well after the publication date of the Stoller report. Recent data indicate that average wind speed can be higher than 6.3 meters per second. Each WIPP stack has the capacity for a 212,500 CFM release rate with a duct constriction of about 10 feet diameter. The maximum vertical velocity at a 45° angle would be about 9.8 meters per second (see calculation Appendix C). It appears the WIPP effluent vertical velocity is not sufficient to preclude ground release calculational corrections.

In addition to ground release corrections, building wake effects must be considered. As shown in Figure 3, the HEPA filtration building is located approximately 8.5 meters from, and in direct line with, the horizontal releases from the underground exhaust stack. The HEPA filtration building roof is at approximately the same elevation as the lower portion of the rectangular exhaust stack aperture. As situated, the exhaust stack is in the SE quadrant of the facility secured area. The prevailing horizontal exhaust direction will cross diagonally through key on-site building locations. Backwash and fumigation conditions would likely occur in areas occupied by on-site personnel. This scenario was presented to the DOE at the February 1991 Quarterly Meeting. The DOE has not responded, and there apparently are no empirical data to verify exhaust effluent patterns.

If significant fumigation or backwash occurs at the WIPP, then the radionuclide component contributing to fence-line or off-site MIR calculations would be overestimated. The radioactivity lost from the off-site component should be accounted for in on-site dose calculations. Otherwise, the on-site dose calculations are not conservative. The Stoller report estimated that a maximum of 0.427 Curies of alpha source term could be chronically released, with a 40 CPM Station A alarm setting, before the off-site dose limit of 10 mrem in a year was reached. Even a very small undiluted fraction of this source term could cause the on-site 100 mrem in a year dose limit to be exceeded. A few nanoCuries (1.0 nanoCurie = 0.000000001 Curie) uptake of alpha transuranic radionuclides may result in more than an annual committed effective dose equivalent of about 100 mrem (Faust 1988).

In a section titled "Additional Findings," the Stoller report discusses maximum potential Curie release in the Test Phase. This section describes potential dose from resuspended contamination on boxes or drums. The Stoller report should not be confused with the more comprehensive approach in the FSAR which treats accident scenarios.

With respect to off-site effluent dose requirements, DOE Order 5400.5 suggests that appropriate dosimetry be used in accordance with 40 CFR Part 61, Subpart H requirements (U.S. CFR 1990). DOE Order 5400.5 states:

> <u>EPA Models</u>. The use of AIRDOS/RADRISK, CAP-88, or AIRDOS-PC models is prescribed by EPA in 40 CFR Part 61, Subpart H, to evaluate potential doses from airborne releases. Thus, two evaluations of doses from airborne pathways could be required: one to satisfy 40 CFR Part 61 requirements and one for DOE purposes using contemporary dosimetry. [Caution: Unless modified, AIRDOS/RADRISK (also known as CAP-88 or AIRDOS-PC) is not suitable for calculating doses from accidents.]

If CAP-88 is used for on-site calculations, then the 45° angle release, backwash and building wake effects corrections are needed. If the code is found inappropriate, then "contemporary dosimetry" should be used.

A review of basic mathematical models used in CAP-88 (Parks 1992) does not indicate that the model was designed for on-site dose calculations or that the code can take into account the 45° WIPP stack angle. The CAP-88 calculations use a Gaussian plume equation. Plume depletion is from scavenging, dry deposition, and radioactive decay. Area sources are allowed in the code, but this appears to be a different approach from ground releases because a reciprocity calculation is used to determine the relationship of source and receptor. At least in the CAP-88 reference (Parks 1992), there were no equations for non-elevated releases, building wake effects or downwash corrections. The Stoller report did not list or describe the basic equations used in their computer model.

With reference to 40 CFR 61, Subpart H, the basic off-site limit is expressed as follows:

> <u>61.92 Standard</u>
>
> Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.

The term "mrem/yr" implies a dose rate value, and in this case a concentration limit. This interpretation is consistent with the application of this regulation to continuous releases, not accidental releases. The CAM alarm limit interpretation should be based on the concentration limit, not the yearly dose limit.

5.21 <u>May 1991, Operational Sensitivity Paper</u>

On May 21, 1991, the DOE transmitted a copy of a paper by an unidentified author titled "Operational Sensitivity and Performance of the Eberline Alpha-6 Continuous Air Monitor at the Waste Isolation Pilot Plant" (Hunt 1991b). The report concluded that the alpha CAM system was adequate to meet the requirements of DOE Order 5480.11. The context of the report was limited to occupational exposure in the workplace, and there was no discussion of how alpha monitoring would preclude exposure of the public to 100 mrem in a year. It appeared the author only intended to comment on workplace monitoring, not effluent releases.

Some of the detailed findings are summarized as follows:

(1) The TAMU sampler (or NRC shield and holder) used for off-line sampling at Station A and other locations was reported to have mechanical problems. The result was inconsistent filter/detector gap spacing and degraded spectra. A negative plutonium count rate results.

(2) PC data collection systems occasionally fail. This results in a straight line data entry, although the CAM system may be operational.

(3) Surface deposit filters must be used to obtain valid data.

(4) Ventilation stoppage and extreme atmospheric inversion conditions cause abnormally high radon levels. A solution was to modify the k-factors (k-factors are discussed in Section 3.6 of this report).

(5) It was noted that concurrent operations such as mining and waste hauling can cause high salt aerosol concentrations which would preclude using a CAM system.

(6) A 6 of 6 count logic software was recommended to prevent false alarms caused by electronic spikes.

(7) The report recommended networking of CAM systems.

The report provided CAM plutonium channel measurements from selected months in 1990. This data demonstrated optimum performance. Several months of gravimetric data (filter loading data) indicated that salt loading was occasionally a problem. There was no correlation with mine activity.

5.22 June 1991, Air Monitoring Papers

Following a 11/8/89 request by EEG, the DOE transmitted two papers on air monitoring (Hunt 1991c). Although the package included much good information, the philosophy paper was developed after the CAM systems were installed, and 20 months after the EEG's request.

The first paper was titled "Waste Isolation Pilot Plant Alpha Continuous Air Monitoring System" by K. B. Steinbruegge, WID. The second paper was "Air Monitoring Philosophy at the WIPP" and a cover sheet was signed by staff in the health physics operation group and the responsible manager. The second paper appears to be part of an unnamed WIPP guideline manual.

The attachments were voluminous and contained a start-up test example (no actual data), start-up test program (no actual data), the WIPP procedures on alarm setpoints, calibration and operation information, functional test procedures, calibration source certificates, operability check procedures, and another copy of the May 21, 1991 operation sensitivity paper.

Start-up Test Program. A review of this document indicates that there is an extensive test of each CAM system with regard to operability. Although this information was appreciated, the EEG's intent was to determine the adequacy of the performance specifications. This was emphasized in the EEG's presentation May 30, 1990. Other than the specialized research performed by the ITRI, a "proof-of-design" test performed by an independent contractor and linked (by calibration) to the installed units has never been provided to the EEG.

Radiological Monitoring System Alarm Set Points. This section contained a copy of the WIPP procedure 12-533[5]. WP 12-533 lists alarms setpoint for area alpha CAMs, effluent alpha CAMs, area beta/gamma and effluent beta/gamma. The area alarm levels are based on the 8 DAC-hr criteria from DOE Order 5480.11. The alpha effluent alarm of 40 CPM is derived from the Stoller report, but a temporary alarm setting of 1,040 CPM is allowed if radon background, or other events, require adjustment of the alarm. There is no justification for the beta effluent alarm level. Area gamma alarms are established at 10 and 50 mrem/hr, for the HI and HI-HI alarms. There is no calculational support for the area gamma alarm setting.

Calibration and Operation of the Alpha Continuous Air Monitors. This section contained a copy of the WIPP procedure 12-530 on calibration and operations of the alpha CAM. Although there is a statement that electroplated ^{239}Pu sources are used and the source calibration is traceable to the NIST, there is no indication that these sources were intercompared with sources or instruments the ITRI used in their studies. The error associated with using electroplated sources, rather than filter sources, is undefined. Consequently, the calibration of the CAM system is not traceable to the NIST or to a primary calibration as per ANSI N42.18-1980 (ANS 1980a).

Acceptance criteria at Station A for CAM detector efficiency is 5% compared to 10% assumed efficiency in the Stoller report. This criterion allows a 50% non-conservative error.

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[5] The WP 12-533 is the procedure number used for internal reference at WIPP. This document and similarly referenced procedures were provided as part of the DOE letter.

Acceptance criteria for radial entry head CAM detector efficiency is 15% compared to an assumed 20% efficiency. This criterion allows a 25% non-conservative error for workplace monitoring.

Three one-minute values are recorded from the electroplated ^{239}Pu source and averaged to determine efficiency. This method does not take into account source positioning error.

Calibration adjustment is performed by repositioning the ^{239}Pu peak in channel 112 (radial) or 115 (other samplers) with a +/- 5 channel tolerance. No calibration error is associated with this discretionary step. Routine operability checks also allow repositioning of the RaC' peak +/- 5 channels (WP 12-518, Rev.5) without use of a calibration source. Repositioning of the RaC' peak is a gain/voltage correction which affects the efficiency of the ^{239}Pu peak. These errors remain undefined.

Functional tests (EQ071001,Rev.2) also depend on the RaC' peak adjustment technique.

5.23 August 1991, Expert Panel Report

On August 23, 1991, EEG received a copy of the "WIPP Continuous Air Monitoring Program, Report of the External Expert Review Panel" report (Carter et al. 1991). The emphasis of the expert panel report was on workplace monitoring, although there were a few limited comments on other regulatory requirements. It is interesting that the Panel mentioned NESHAPS (40 CFR 61) requirements, but the Stoller report was apparently not considered. In addition the Panel advised the DOE that:

> For a new facility like WIPP, DOE Order 6430.1A (General Design Criteria) is also relevant. Among other things, it requires redundant monitoring and uninterruptible power supply to the effluent monitoring system.

As mentioned previously, the DOE was, and still is, reluctant to address DOE Order 6430.1A requirements, except as possible "enhancements" of the facility. The specific recommendations of the Panel are summarized as follows:

(1) "Document the CAM experience at the WIPP and make this information and data available to the DOE system and to the scientific community." (The panel emphasized timeliness.)

(2) "The CAMs are in a state of operational readiness and should be used to meet the health and safety requirements established for this important component of the radiological safety program." (Because workplace requirements were emphasized, it appears that the Panel was endorsing workplace use of CAMs.)

(3) CAMs should be improved and enhanced.

(4) Recommended 8 DAC-hr alarm could be raised or lowered in some circumstances.

(5) The TAMU (NRC) units should be replaced.

(6) Reduce operations in the underground to control salt dust aerosol concentrations. Install airborne salt monitors.

(7) Network CAMs and train technicians.

(8) Consider lowering CAM alarm for some short-term jobs.

(9) The Panel recommends that filters from FAS Stations A,B (when on-line) and C be composited at appropriate time intervals and analyzed for specific radionuclides using wet chemistry procedures. This process will increase

sensitivity of analysis, provide a record of environmental releases for legal/medical purposes, support demonstration of regulatory compliance, and represent state-of-the-art technology.

(10) Track availability of CAMs.

(11) Improve QA.

(12) Improve staff training.

(13) Initiate routine surveys in the Waste Handling Building and underground.

(14) Develop in-field analysis techniques.

(15) Analyze pre-operational data.

(16) Hire more technicians.

At a March 19, 1992 CAM meeting with the EEG, the DOE claimed completion of recommendations 2, 4, 10 and 12-16. Many of the incomplete items are relevant and important recommendations. Most important is number (9) which is linked to the similar requirements in NESHAPS regulations.

The DOE staff appeared most interested in item number 2, which may appear favorable but is not a prescriptive statement. The term "state of operational readiness" was not defined.

5.24 March 1992, Meeting

On March 19, 1992, the EEG staff met with the DOE, the WID, and the ITRI staff to discuss the CAM operational status. The WID staff presented extensive information on regulations and standards that they reviewed for applicability to the WIPP.

Although there was significant work done in reviewing regulations and standards, this work was not available as a formal report for technical review.

Data were presented on the operational availability of the CAM system. The summary implied that the LCO CAM system could be made operational a large percentage of the time (Appendix D-1), but the data indicates that the systems are not operational for significant periods of time. The WID discussed the problems of detector failure and indicated that detectors exposed to salt aerosol were failing because of degradation of the detector covering. It was also stated that epoxy glue failed at high temperatures and caused detectors to fail. The WID stated they were working on a new detector design.

The WID also presented selected EEG data on Pu channel counts and degraded spectra from the last year. Apparently the WID had not performed a similar analysis. Explanations were given for obvious detector failures, with associated negative plutonium channel excursion, for CAM 157 and CAM 121. The EEG's salt loading data were also presented for January 1992.

As mentioned above, a synopsis of the Expert Panel Report recommendations was given. Apart from the meeting, the EEG complained to the DOE that the EEG's specific questions had not been answered, and substantive data were not presented. The EEG requested formal responses to the panel's recommendations (Neill 1992). The May 4, 1992 letter and DOE responses are treated in Section 6.0 of this report.

6.0 PRESENT STATUS OF CAM SYSTEMS

As a result of the March 19, 1992 CAM meeting with the WID and the DOE staff, the EEG requested information regarding the CAM operational status (Neill 1992). The letter restated the EEG's viewpoint regarding the role of CAMs as workplace monitors, effluent monitoring, and as an alarm device for diverting underground exhaust to HEPA filtration (Appendix E). The May 4, 1992 letter included detailed questions which are reproduced below. Following each question is the DOE response (Arthur 1992), and the EEG's conclusion based upon the response. The questions are numbered as in the original EEG letter.

EEG QUESTION

1. Confinement Strategy of Underground Repository

   a. The only strategy for double confinement (per DOE 6430.1A) is presented in the 1991 FSAR Addendum for test bins. Please explain the dual confinement strategy for waste drums located underground.

DOE RESPONSE

1a. It is not correct to assume the same confinement strategy for waste drums and test bins. As discussed in the FSAR, the confinement strategy is to emplace the waste drums, as received, in the underground repository. As discussed in the FSAR Addendum, the test bins will have double confinement prior to being placed in the underground.

    In addition, it is important to note, the WIPP does not take credit for operation of the effluent CAMs in its accident assessments during either the test phase or the disposal phase.

EEG CONCLUSION (1a.)

The FSAR Chapter 3.3 requires that the WIPP facility have multiple confinement barriers at all times between the waste and the outside environment (see Section 4.5.4 of this report). From the answer provided, it appears that the DOE does not understand or intend to comply with the FSAR requirement.

EEG QUESTION

1b. Please provide a copy of the report described at the March 19, 1992 meeting concerning accident scenarios in the underground.

DOE RESPONSE

1b. At the March 19, 1992, meeting, the WIPP identified to the EEG several projects that were incomplete, but that we wanted the EEG to be aware of. The accident scenario report is not yet available for issue.

EEG CONCLUSION (1b.)

The FSAR documents creditable accident scenarios. There is no reason to believe that significant levels of radioactive material could not be accidently released to the environment (Mishima and Schwendiman 1973). The DOE claims that CAMs are not a necessary part of the mitigating strategy. As mentioned previously, the FSAR Chapter 3.3 requires multiple confinement barriers, and the HEPA filtration building is shown as the underground secondary confinement system. The CAMs are LCO systems and are needed to signal the diversion of air to the HEPA filtration building.

EEG QUESTION

2. LCO CAM Systems

   a. Calibration measurements. Please provide the sensitivity (counts/source activity) of each LCO alpha and beta CAM system. Please explain the traceability of CAM source calibration to a primary calibration (reference ANSI N13.10-1974, paragraphs

4.4). If this is not possible, explain if NIST-traceable filter sources were used to calibrate CAMs. Please note that DOE has not provided EEG any substantive information on the LCO beta CAMs, and EEG requests information comparable to that requested for alpha CAMs.

DOE RESPONSE

2a. The sensitivity for each alpha and beta LCO CAM, derived from the actual calibrations of those instruments, is provided in the enclosed table entitled "WIPP LCO CAM Calibration Data as of 06/10/92" (Enclosure 3).[6] Efficiencies for these CAMs range from 8.5 to 20.6 percent for alpha CAMs, and from 20.4 to 25.4 percent for beta CAMs.

CAM primary calibration is conducted with NIST-traceable sources, as described in the enclosed procedures WP 12-514 and WP 12-530 (Enclosures 4 and 5, respectively). Additional related procedures for functional checks and daily operability checks are also enclosed. They are WP12-534, EQ071001, EQ071000, and WP12-518 (Enclosures 6, 7, 8, and 9, respectively). Please note that only primary, NIST-traceable sources are used for all calibrations and monthly functional checks. No "check" sources are used. Certificates of Calibration for sources used in CAM calibrations are provided as Enclosure 10.

The letter references ANSI N13.10-1974, paragraph 4.4. "This standard applies to Continuous Air Monitors that measure normal releases, detect inadvertent releases, show general trends, and annunciate radiation levels that have exceeded predetermined levels." Section 4.4 of this Standard deals with calibration and states: "Ease and relevance of calibration, as well as instrument stability, are important factors affecting the selection of the system. The primary initial calibration should encompass the entire system, including the detector and sample collector and should be performable after the system has been installed. Secondary calibration and periodic maintenance of the partial system should be possible without using primary calibration techniques."

The Lovelace Inhalation Toxicology Research Institute (ITRI), the manufacturer of our alpha CAMs (Eberline), and the leading CAM-design laboratory (Los Alamos National Laboratories), all agree that the best alpha

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[6] See Appendix D-2

CAM energy (spectral) calibration is accomplished using freshly collected radon progeny. The WIPP uses freshly collected radon progeny as recommended by the manufacturer and then double checks the calibration with specially prepared, known, NIST-traceable plutonium source. NIST does not offer traceability for spectra of alpha sources, thus the reason for using the freshly collected radon progeny. The WIPP uses only NIST-traceable sources to determine counting efficiency. Certification sheets for these sources were provided to EEG in June of 1991, and are again provided herein, (see Enclosure 10).

Appendix II of the document provided to the EEG in June 1991 is the "Radiological Monitoring System Alarm Setpoint," WP 12-533. This procedure provides EEG with the details of the beta area CAM alarm setpoints (i.e., eight DAC Hour, HI Alarm and ten DAC Hour HI-HI Alarm setpoint). Appendix I of that document is the example start-up test procedure. This detailed start-up test was performed on all WIPP beta and alpha CAMs. The answer to the EEG question is located in WP 12-514, Calibration and Operation of the Beta/Gamma CAMs. This procedure requires the use of NIST-traceable sources for use in calibration of the beta CAMs. This procedure also requires that all beta CAM efficiencies must be greater than or equal to 20 percent.

EEG CONCLUSION (2a.)

The CAM sensitivity data are listed in Appendix D-2. In addition, the DOE provided CAM 121 (non-LCO) data indicating an average efficiency of 6.5%. Table 6 summarizes differences in detector efficiency. Notable is the lower efficiency for alpha effluent monitors which is attributable to a different size detector.

Electroplated sources are used as "primary" calibration sources. There is no assurance that electroplated calibration sources are in the same geometry as a filter source. The pictures in Section 7.10 (Figures 25 through 38) show the non-uniform character of the filter surface. The relationship between electroplated and filter sources has not been established per Section 5.4.10 of ANSI N42.18-1980 (ANS 1980a). Efficiency corrections for geometry are typically suggested by the manufacturer.

Table 6. Comparison of CAM Detector Efficiencies

System	% Efficiency (Mean)	% Efficiency (Range)
(α Effluent) 153, 157, 121	8.2	6.5 - 9.2
(α Workplace) 29, 31, 35	17.4	16.8 - 18.4
(β Effluent) 152, 156	24.2	23 - 25.4
(β Workplace) 30, 32, 36	21.6	21.5 - 23

The DOE-referenced experts did not concur that radon progeny are appropriate for efficiency calibrations, but rather are adequate for spectral calibrations. This is an important distinction because spectral calibration is the basis of the daily operability checks in the WIPP Procedure 12-518, Rev. 5, May 22, 1992. Data in the Section 7.9 indicate that loss of detector efficiency can occur when spectra appear normal.

The WIPP procedures were previously provided (Hunt 1991c). The EEG believes the DOE response was non-responsive because there were no test reports or proof-of-design evaluations of the beta CAMs. The WIPP Procedure WP 12-514, Rev. 3, 12/10/91, is characterized as an equipment operational verification. The EEG has not received any formal documentation that defines CAM performance limitations per recognized standards (ANS 1980a, ANS 1989).

EEG QUESTION

2b. Source integrity. Please provide information on the uniformity of geometry of alpha and beta calibration sources (reference ANSI N323-1979, paragraph 5.1). Please explain if one source is used to calibrate all LCO alpha CAM systems or if a variety of sources are used. If a variety of sources are used, please provide an intercomparison of these sources for flux and uniformity at the specified source-detector distance.

DOE RESPONSE

2b. The EEG referred to ANSI Standard N323-1979, paragraph 5.1. This Standard does not mention or require "uniformity of geometry of calibration sources." Members of the EEG staff have participated in meetings with the WIPP and the ITRI and should be aware that the WIPP is working with ITRI to improve this source (uniformity) technology. This improvement is underway, even though it is not a regulatory requirement, nor does it affect the calibration or operational reliability of the CAMs.

The WIPP suggests that the EEG also refer to paragraph 4.2.1 of the same ANSI Standard. Paragraph 4.2.1 states, "The calibration should be performed under the conditions specified by the manufacturer." The WIPP follows this directive and then uses sources traceable to NIST to additionally confirm the performance of the CAMs.

EEG CONCLUSION (2b.)

The answer was considered non-responsive.

Our question was discussed at a June 9, 1992 meeting with the DOE and the WID, and admittedly, the written EEG question was not clearly stated. The standard reference is ANSI N323-1978, rather than 1979. Paragraph 5.1 is a discussion of "derived standards" which are used when national standards do not exist. Subparagraph (3) suggests an alternative approach to NIST linkage:

> Where no National or Derived Standard exists, as in the case of specific energies or unusual sources, by establishment of a standard source or instrument with documented empirical and theoretical output or response characteristics.

The ANSI standards are not obligatory regulations, but rather they are consensus professional guidance, unless referenced as a requirement by a regulator.

The EEG referenced the ANSI standard because the NIST may not be able to provide a traceable calibration linkage to a filter source. In such case, the empirical and theoretical source characteristics should be established, particularly those relating to source uniformity.

The WIPP response contains the statement that uniformity does not affect the calibration. There is a significant difference in detector response between point and area sources because of "edge" effects. The EEG requested the source calibration conditions, but not as a critique of the ITRI's research program. The WIPP still has not provided any estimate of the calibration error associated with using an electroplated source as a primary source instead of a filter source.

There were no data to provide a calibration link between the WIPP calibrations and the ITRI experiments. In addition, the ITRI report does not contain sufficient quality assurance documentation to serve as a primary calibration reference measurement (a point made in the November 17, 1989 letter). Without NIST or primary calibration linkage, there is no determination of calibration accuracy. Therefore, the calibration is relegated to establishing precision. If a CAM is used as an effluent monitor per 40 CFR 61, then there are specific quality assurance and accuracy requirements.

From the data provided in Appendix D-2, it appears that one (or one set of) calibration source is used for each CAM geometry. This answers EEG's question about error introduced by variations between sources. It does not provide information about overall accuracy.

The WIPP comment that ANSI N323-1978 (ANS 1977) states "The calibration should be performed under the conditions specified by the manufacturer" is taken out of context. Paragraph 4.2 of the standard is one of the EEG's major concerns, and warrants a direct quote:

> 4.2.1 General. The reproducibility (precision) of the instrument should be known prior to making calibration adjustments. This is particularly important if the instrument failed to pass the source check (see 4.6) or if repairs have been made. To check reproducibility, the instrument should be exposed to a radiation field three or more times under identical conditions. The readings obtained should normally not deviate from the mean value by more than +/- 10 percent.
>
> The response of an instrument may vary as a function of such parameters as energy, temperature, pressure, humidity, and source/detector geometry. The primary calibration should be accomplished with known values of these parameters. The calibration should be performed under the conditions specified by the manufacturer. Alternatively, any of these parameters may be fixed to the condition in which the instrument is to be used routinely, and notation made of these values. The steps that constitute the primary calibration when taken in conjunction with 4.1 are described in 4.2.2.

The intent of ANSI N323-1978 is that the manufacturer's instrument specifications should specify the "limitations" of the instrument. The referenced statement above does not mean the manufacturer is responsible for the calibration procedure. The manufacturer would not have knowledge of the specific conditions at WIPP unless appraised of the unusual operating conditions. Manufacturers typically provide a general procedure that can be customized to the user's need.

The EEG has consistently requested primary calibration information, and has suggested systematic, independent testing of the alpha CAM to conditions expected at the WIPP. No such information has been provided.

EEG QUESTION

2c. Detector-filter distance. Please specify the exact filter-detector distance for all LCO alpha and beta CAMs. Please provide a test of position reproducibility (reference ANSI N42.17B-1989, paragraph 3.3) for CAMs that use the shielded detector holder device, commonly referred to as the Texas A&M shield, the NRC shield, or the filter holder device at Station A. Please provide similar test information for radial entry detector-filter systems.

DOE RESPONSE

2c. The EEG referenced ANSI N42.17B-1989 in relation to questions about the detector-to-filter distance. However, this is not the subject of the referenced standard. ANSI N42.17B-1989 is a standard that was written for manufacturers. In addition, Section 3.3 of ANSI N42.17B-1989 is titled, "Statistical Fluctuations," and states: "For any test involving the use of radiation, the magnitude of the statistical fluctuations of the reading arising from the random nature of radiation alone may be a significant fraction of the variation of the mean reading permitted in the test. A sufficient number of readings shall be taken to ensure that the mean value of such readings may be estimated with sufficient precision to demonstrate compliance or noncompliance with the test requirement." The section the EEG referenced then continues with guidance to obtain defined confidence levels (i.e., more about statistics).

It was with an understanding of this guidance and the statistical nature of radioactive processes that the WIPP entered into a program with the CAM manufacturer to modify the firmware to reduce statistical fluctuations (i.e., false alarms) through the use of statistically significant data acquisition intervals. We have provided the EEG with reports showing the significant reduction in CAM output variations using five-minute sampling periods rather than the original one-minute sampling period.

The distance between all alpha and beta CAM filters and the detectors is 5 mm. This spacing is maintained by engineered design, not by mechanically gauging this distance, as the EEG's question suggest. More effectively, the WIPP uses CAM daily operability checks, and monthly functional tests to maintain the CAMs' performance. The daily check of the location of the radon peak and the plutonium counts per minute history on the alpha CAMs, and the daily check of the rate meter indication on the beta CAMs are what ensures the CAMs operational reliability and sensitivity. These checks are detailed in WP 12-518.

EEG CONCLUSION (2c.)

The DOE's response is misleading. Our request was for data verifying the reproducibility of the filter/detector spacing. Apparently, simple tests were not performed to verify this important design feature.

A problem was reported with the TAMU sampler in the DOE May 21, 1991, report (see Section 5.17 of this report). There is no assurance that this mechanical device properly reproduces the filter/detector spacing of 5 mm. As shown in Figure 8, a picture of the CAM 121 underground station, the lead, steel shield/ detector assembly must be loaded from the bottom. The detector is mechanically repositioned using the handle shown in Figure 8. There is evidence that detector efficiency and spectral uniformity change, and failure to accurately reproduce the 5 mm spacing could be a contributing factor.

On September 12, 1992, EEG staff found both Station A alpha CAM systems red-tagged. The red tag normally indicates that equipment should not be used. The DOE stated that the red tag was placed on the equipment in January 1992 because out-of-specification detector/filter spacers were being used.

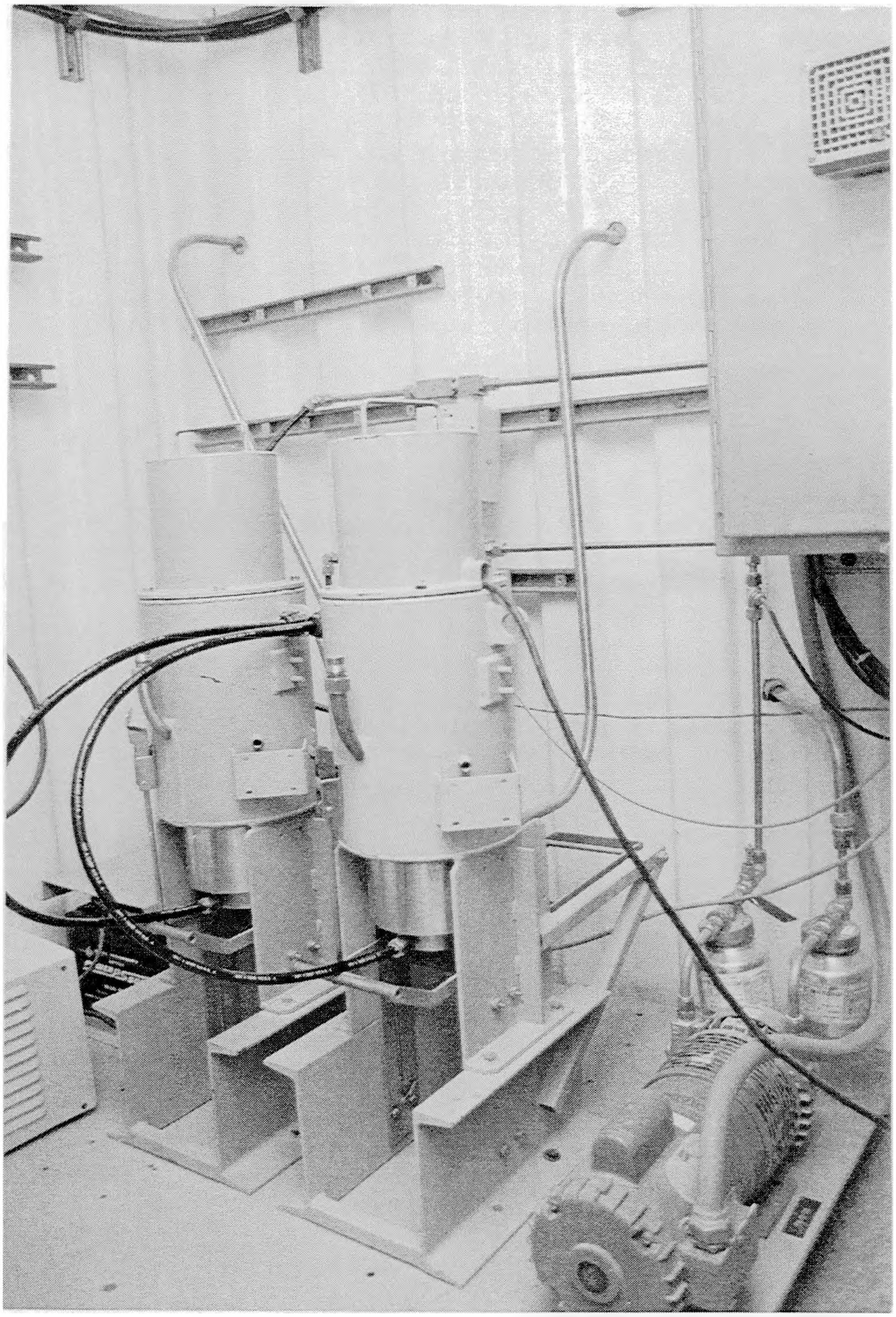

Figure 8. CAM 121/122 at S1600 and E300

EEG QUESTION

2d. NIST traceability. Please explain how periodic performance checks are quantitatively related to NIST standards and calibrations. As per ANSI N323-1978, paragraph 5.4, please explain how:

(1) The source instrument geometry is well understood and easily reproduced, and

(2) The instrument response to transuranics is well understood and is not critically dependent on instrument adjustment. Please explain the basis for the radon peak centering method now being used.

DOE RESPONSE

2d. As detailed above, the WIPP uses NIST-traceable sources for calibration and functional checks on all CAMs.

ANSI Standard N323-1978, paragraph 5.4, which the EEG has referenced, requires that "Check sources should provide radiation of the same type or types as provided by the sources used in the instrument calibration...." However, check sources may provide radiation different than that used for calibration if: (1) the source instrument geometry is well understood and easily reproducible, or (2) the instrument response to this radiation is well understood and is not critically dependent on instrument adjustment.

The WIPP fulfills the stated initial condition (i.e., sources provide radiation of the same type provided by the sources used in the instrument calibration). In fact, the same sources as used in calibration are used. Thus, it is not necessary to be concerned with the secondary conditions the EEG has questioned. The WIPP always attempts to use the most direct method of calibration and verification of its radiological instrumentation to avoid just this type of calibration issue.

EEG CONCLUSION (2d.)

The EEG does not consider an electroplated source to be a "primary" calibration source because it does not reproduce the same geometry as a filter. This is particularly important when salt accumulations complicate the source geometry.

For effluent monitors, there must be a clear understanding of errors associated with the measurement process. In the report, May 21, 1991 (Section 5.17 of this report), there was a formal acknowledgement of problems with detector/filter reproducibility in the TAMU sampler.

In addition, the daily operability checks are spectral (or energy) verifications not efficiency measurements. It appears that detector efficiency is not routinely measured, and unless the detector efficiency is known, the measurement accuracy can not be determined per regulatory requirements (U.S. CFR 1990).

EEG QUESTION

2e. Please provide k-factors used for each LCO alpha CAM.

DOE RESPONSE

2e. The alpha CAM k-factors for all LCO CAMs is presently 0.6.

EEG CONCLUSION (2e.)

The direct response was appreciated.

EEG QUESTION

3. Anomalous Spectral Data

EEG has been analyzing the DOE CAM data since January 1991 and our analysis of these data provided to DOE in December 1991, indicate significant degradation of spectra, and negative Pu channel counts. DOE representatives stated at the meeting March 19, 1992 that CAM detectors and coverings were being deteriorated by salt. It was also stated that high temperatures caused failure of the detector bonding materials. These problems were identified as root causes of degraded spectra.

a. Please identify the method for determining when a detector has failed, other than daily observation of the spectra by the technician.

b. Please quantify the sensitivity (counts/activity) associated with various degrees of degraded spectra. If this is not available, please indicate the sensitivity at the time detector failure becomes obvious, and actual measurements indicating the sensitivity.

DOE RESPONSE

3. The DOE representative reported in the March 19, 1992 meeting that, for the one CAM in question, the few days of observed negative plutonium channel counts were caused by the slow degrading of a single CAM detector. This degrading could have been caused by salt/moisture causing corrosion of the detector face. This degradation does not generally appear quickly. The degradation is observed over a three-or-more-day period before a detector failure alarm would be received.

3a. Detector failure is identified at the WIPP through the process of daily operational checks by trained Health Physics Technicians. This training is achieved through the completion of Qualification Card #QC 404.3 "Performance of Operability Checks of CAMs", and prerequisite qualification cards. Each individual conducting these checks is trained to recognize degrading spectra, e.g. shifts in the Po 214 peak, spectrum flattening or smearing, abnormal counts in the Pu ROI and lower channels, etc.

3b. The EEG requested detailed information associated with various degrees of degraded spectra. This information does not exist. It is the WIPP's policy to identify problems and then resolve the problem. In this specific case, the WIPP now knows that we can successfully maintain the CAMs in a fully operational status by replacing the detectors as soon as degraded spectra is observed. In this early stage of detector degradation, we can determine from the background radon progeny counts that the detector continues to report each and every alpha particle that strikes it, and the baseline confirms that the CAM algorithm is robust enough to compensate for this early loss of detector resolution.

EEG CONCLUSION (3.)

To state that only one CAM had negative counts for a few days is simply a misrepresentation of the facts. Our review of the data over the last year and one half indicates that CAM 121, CAM 153, and CAM 157 (installed in November 1991) frequently exhibit degraded spectra and negative Pu channel excursions. The EEG 1991 data analysis was provided to the DOE in December 1991 for their review. The CAM reliability is generally improved in the first six months of 1992, but this improvement may be due to lower salt aerosol concentrations. During the last six months of 1992, when salt aerosol concentrations increased, spectral degradations and loss of operability were increased.

The EEG does not have data on the cause of lengthy (several weeks) periods of degraded spectra. The DOE may have been aware that detectors were in failure mode, but the detectors were not replaced.

The DOE response indicates there is no method to determine detector failure other than observing the spectra and no data on the loss of detector efficiency during periods when spectra are degraded.

EEG QUESTION

4. Procurement of New Detectors

The proposed root-cause remedy for detector failure was to purchase detectors which would not be affected by salt, and the DOE stated that specifications were being developed. On May 30, 1990, EEG formally provided information regarding methods for acceptance testing of equipment (ANSI N13.10-1974). This standard suggests general methods for testing radiation detection systems, including tests for corrosive environments and temperature. Many problems are now being discovered by operational use. It is our opinion that these problems could have been avoided if the CAM systems were formally and independently tested, <u>prior to installation</u>. To avoid a repeat of this situation, we are again recommending that the DOE develop an acceptance test plan. To avoid confusion, an acceptance test is defined in ANSI N42.17B-1989 as follows: [Two pages of specifications recommendations are not included in this report but can be found in the original letter.]

DOE RESPONSE

4. Under the title of "Procurement of New Detectors," the EEG has indicated several ANSI standards of which they believe the WIPP should be aware. In particular, they referenced ANSI Standard N42.17B-1989. This standard does not apply to the WIPP operational CAM system. This standard is a standard for the manufacture of equipment and was placed into effect after the CAM system for the WIPP was purchased and installed. The standards that do apply to the WIPP are listed in the June 1991 documents provided to the EEG. In the second section of the first paper provided, eight mandatory industry standards were listed that expand the list the EEG has referenced. The WIPP believes that all these standards are very important and they have all been carefully studied for applicable compliance.

   The tests that the WIPP, as an operational facility, does perform on its CAMs were listed in the June 1991 document. They include a detailed start-up test, over two years of daily operational checks, over two years of monthly functional tests, over two years of annual calibrations, and over two years of functional tests/ calibration tests after maintenance. These tests have led to the exceptional operational and sensitivity record of the WIPP alpha and beta-gamma CAM system.

   A copy of the new "ruggedized" Alpha-Detector specification developed by WIPP is attached, and it is titled, "Continuous Air Monitor Alpha Detectors" (Spec. No. E R-383).

EEG CONCLUSION (4.)

It is interesting to note that the DOE reviewed various standards, but potential problems such as corrosive environments and temperature range are not addressed in equipment specifications. A review of the Alpha-Detector specifications developed by the WIPP and provided to the EEG indicates:

(1) There are no specifications for detector <u>efficiency</u>.

(2) The manufacturer is required to have an internal QA program, but there are no specific detector acceptance or performance tests.

(3) There is no requirement of the manufacturer to provide a performance test which characterizes the limitations of the detector with respect to the published specifications. Apparently, detectors will be installed at the WIPP and reliability determined from operational testing, per the following statement in the specifications:

> Failed detectors shall be returned to the manufacturer for analysis on the cause of failure at the expense of the Waste Isolation Pilot Plant.

It appears that a new type of detector must be procured because the original equipment was not adequate, and there was no performance test. The newly designed detectors will also be installed without benefit of independent performance testing. It appears after several years of experience with the alpha CAM system that the cause-effect relationship between salt (and other harsh conditions) and detector failures is not being addressed in the proposed detector procurement.

EEG QUESTION

5. Proof-of-Design Testing

Although ITRI provided some very valuable data regarding the sensitivity of CAM systems, additional data are needed. ITRI provided a loss of sensitivity analysis as salt accumulated on a ^{239}Pu spiked filter (reference ITRI Phase II Report, January 31, 1991) [Newton et al. 1990]. This information is useful, but the experimental conditions did not duplicate the expected scenario of a instantaneous ("puff") or chronic release. As we have recommended (in September 1991 Quarterly Meeting, December 1991 Quarterly Meeting, and March 1992 Quarterly Meeting), additional information is needed.

Because a salt aerosol and radon progeny are likely to be present if transuranics are released in the underground, the CAM system should be tested with transuranic-salt-radon progeny aerosol mixtures.

Information needed should include, but not be limited to, the following:

a. Expected salt particle size distribution and collection efficiency at various LCO sampling points. Efficiency of each LCO sampling system to deliver representative samples to the CAM filter. Empirical, rather than theoretical, data are needed. As an example, no testing data have been provided on the sampling transmission lines of underground CAMs in drift E-300.

b. Particle carrier mechanism, including justification for transuranic particles being attached or not attached to salt particles, and depletion of particles as a function of transit time and distance in the underground.

c. Data to indicate the loss of sensitivity with increasing salt aerosol filter deposits. This data should not be derived as in the ITRI, January 1991 report, but rather from actual testing with transuranic-salt-radon progeny aerosol as it is accumulated on the CAM filter.

This information is important in determining whether CAM systems will be responsive in the event of a radioactive release from the underground. Without this information, it can not be assumed that CAM systems will perform as characterized in the FSAR.

DOE RESPONSE

5. The EEG suggests, in effect, a set of research projects in this section. As has been shared with the EEG on several occasions, the WIPP makes use of the work performed at ITRI to help assure and advance our ability to measure low levels of airborne radioactivity in a dusty environment. The DOE works through the ITRI to advance this capability through meaningful tests using plutonium aerosols under carefully controlled conditions. Members of the EEG staff participated in a May 6, 7, and 8, 1992, vendor/users group meeting and a DOE Contractors Working Group meeting at the ITRI and should have current knowledge of the status of these advanced aerosol efforts. These research efforts continue to be supported by the DOE.

5a. Expected salt particle size distribution and collection efficiency at various LCO sampling points is detailed in the January 1990 report titled, "A CAM Sampler for Collection and Assessment of Alpha-Emitting Aerosol Particles". Generally, this report states that for 10 micrometer diameter particles, approximately 90 percent of the particles are collected. This laboratory data was obtained for both radial entry samplers (area CAMs) and effluent in-line samplers. Thus, this data can be applied to all CAMs installed in the underground, surface, and effluent flow path. All CAM sampling lines at WIPP have either been designed by Dr. A. McFarland at Texas A&M University - Aerosol Technology Laboratory or by the use of aerosol transport line design (computer) codes Dr. McFarland provided. The agreement between WIPP and the EEG was that WIPP would improve the representative sampling efficiency to >50 percent. All measurements data indicate that the WIPP has significantly exceeded that promise.

5b. The question concerning particle carrier mechanisms and attachment of transuranics is best answered by research facilities or scientific literature. These questions can not be answered by an operational facility such as the WIPP.

5c. To meet the operational needs of the WIPP, we will use the data that was obtained by the ITRI and reported in their January 1991 Phase II report. Additional work in the area discussed by the EEG is in progress at ITRI. We will continue to monitor the work of experts in the field and, as needed we will recommend work directions to these experts.

EEG CONCLUSION (5.)

The DOE's response to 5c. states that the referenced work is in progress at ITRI, but the DOE refuses to answer the EEG's questions about the scope of work. At the September 1991 Quarterly Meeting, the EEG staff made a direct request for a characterization of the WIPP-supported CAM research and development work. The DOE representative simply stated that he refused to discuss the work. The DOE letter contains no substantive information about work-in-progress. This is a clear example of non-cooperation by the DOE.

The response to part 5.a. indicates that there has been no testing of sample-line particle loss, other than by mock ups of Station A and D sampling systems. It is essential to test underground samplers which are exposed to significant concentrations of salt aerosol. The work obviously has not been completed.

The Figure 9 photograph was taken on September 11, 1992 and shows one of the sample line penetrations into the E300 drift by CAM 121 pictured in Figure 8. There is significant salt buildup on the outside and inside of the sample line. The other sample line had similar salt buildup.

Figure 10 shows one of the Texas A&M modified probes at Station D with approximately 16 mm buildup of salt. The EEG provided an expert report (Neill 1989b) from the Southern Research Institute which suggested that as little as 5 mm salt buildup on the shroud would result in unacceptable shroud performance.

The DOE's response to 5a. is a restatement of facts known by the EEG, but the answer does not address the question regarding the availability of empirical line-loss data. Obviously, the sampling line-loss studies were not performed.

The DOE response to 5b. states that the question could be answered at a research facility and not at an operational facility like WIPP. The EEG does not find that philosophy to be very constructive. In the Question 1b. above, reference was made to attempts to calculate particle plate out in the underground. It appears inconsistent to state analyses are not possible on one aspect of particle carrier mechanisms, but acknowledge efforts to calculate the results of particle deposition.

The EEG microscopically viewed salt-laden filters from Station A and found that the salt layers are not uniformly deposited. The DOE continues to offer the rationale that accidental radioactive releases will be deposited on the surface of any salt layer because salt is uniformly deposited. The DOE's hypothesis is that salt buildup will not affect the CAM

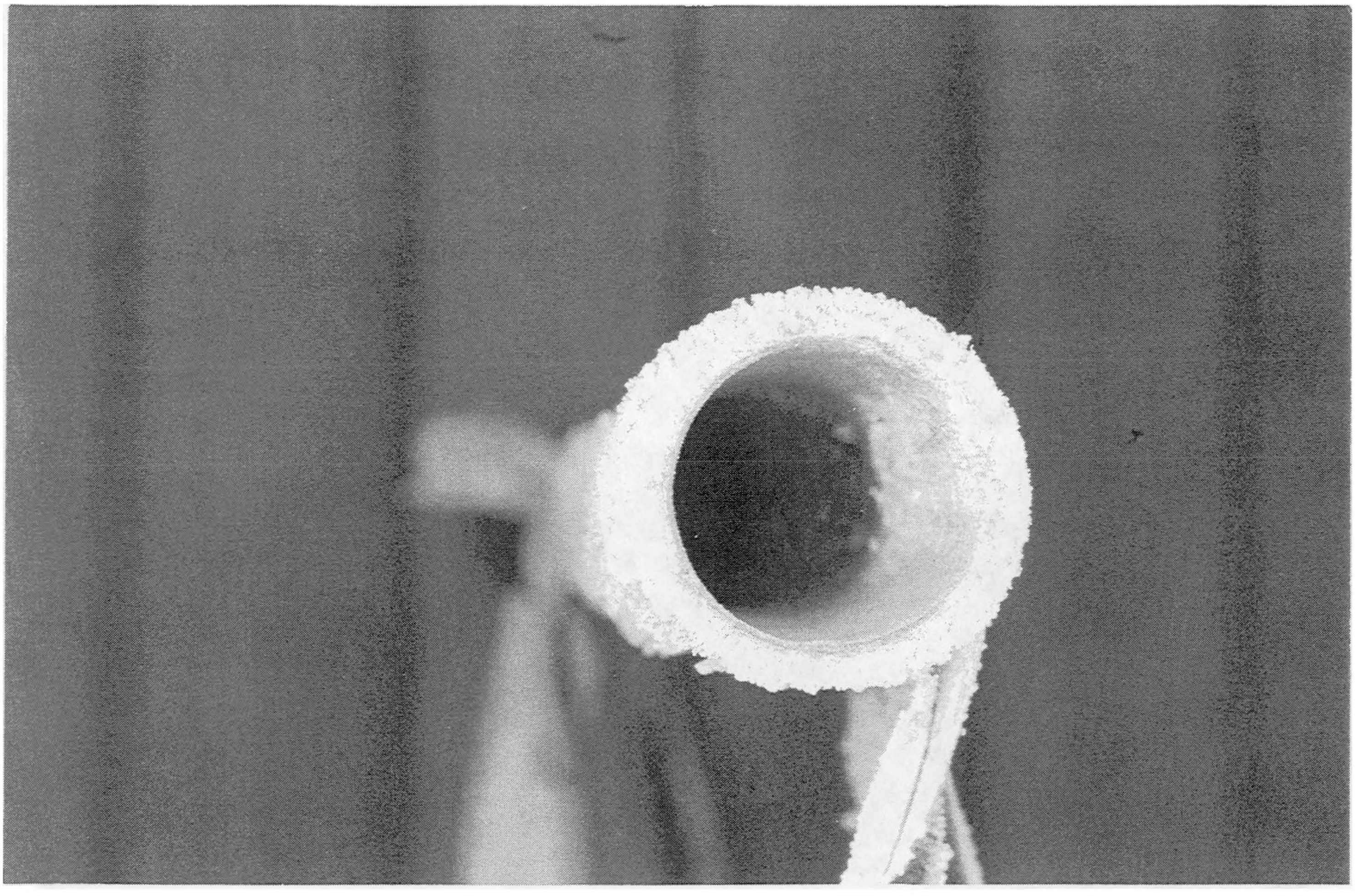

Figure 9. CAM 121 Sample Line Penetration at S1600 and E300

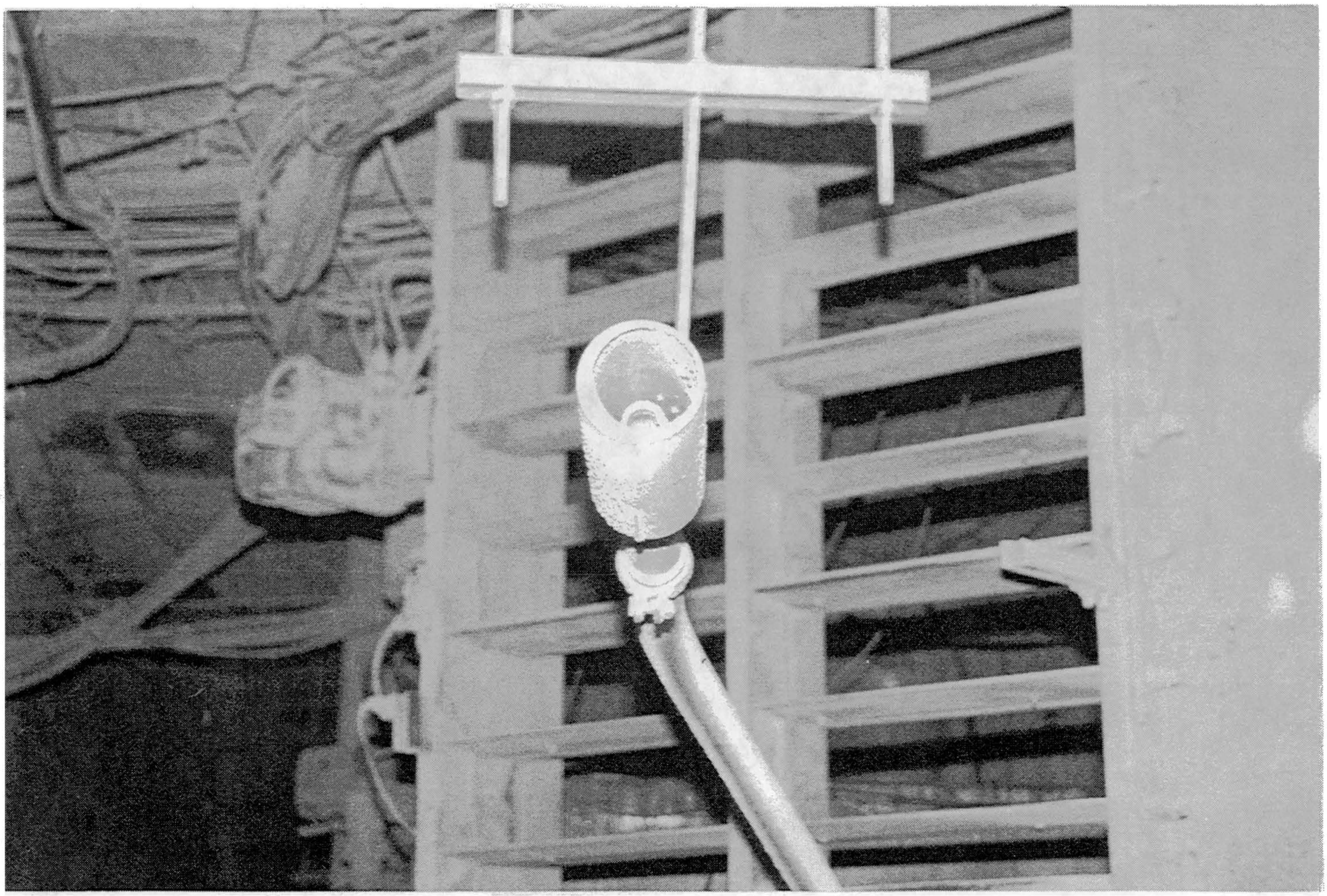

Figure 10. CAM 127/128 Station D Sampling Probe

sensitivity for acute releases. The referenced ITRI study did not consider the synergistic effects of salt, plutonium, and radon/thoron progeny on CAM measurements, but rather measured the burial depth of plutonium in the absence of radon/thoron progeny. As discussed in Section 7.8, detector efficiency is significantly affected by high-salt loading. In addition, the effects of filter salt buildup on CAM measurement of acute radioactive releases remains untested.

EEG QUESTION

6. Effluent Monitor System

   a. A formal report showing calculations of doses to WIPP site workers as a result of radioactive releases at or below proposed Station A alarm levels. Calculations should take into account puff releases, fumigation of the site when wind direction opposes the direction of stack effluent releases, and the effect of inversion condition (which are prevalent during the winter months).

   b. Data indicating the sensitivity of fixed air sampling (FAS) systems, including the following details:

      (1) Radon progeny background (^{222}Rn and ^{220}Rn) found typically at Stations A and B, and other LCO monitoring locations.

      (2) Time of decay of radon progeny to produce an acceptable lower limit of detection (LLD) measurement.

      (3) Type of analysis and equipment routinely used to analyze FAS filters.

      (4) Type of filters used.

      (5) Formal report, or acceptance information, showing calibration of equipment used for FAS filter analyses. Sensitivity of equipment and traceability to NIST.

      (6) Reference to any approved procedures.

   c. Batch sampling methods. Please describe the methodology, sensitivity to radionuclides listed as part of the FSAR inventory, and time duration to complete measurement. This is an alternative provided in the FSAR which needs to be characterized.

DOE RESPONSE

6a. The EEG requested "a formal report showing calculations of doses to WIPP site workers as a result of ..." a specific set of very interesting conditions. Attached to this response is a copy of the report dated January 17, 1991, "Verification of the Station A Alpha CAM Alarm Set Point at the Waste Isolation Pilot Plant," prepared by the S. M. Stoller Corporation. This release modeling was performed using CAP-88 Ver. 1.01, an air dispersion and dose/pathway modeling code accepted by the EPA and the DOE, and meets the DOE 5400.5 requirements. This analysis shows that the 40 cpm alpha CAM alarm limits the maximum individual at risk (MIR) to exposures of less than 10 mrem per year, and that the maximum on-site workers and visitors will be limited to less than 9 mrem per year. Since the WIPP is a clean facility, an individual (Station A) alarm will indicate a release capable of providing less than 0.1 percent of the yearly allowable dose. In addition, the DOE shared with the EEG at the March 19, 1992, meeting that there is work in progress to provide additional confirmation of these assessments. That work is progressing. It is being completed in a carefully planned way; and when the reports are completed, approved, and accepted for publication, they will be offered to the EEG for information.

6b. The sensitivity of "fixed air sampling (FAS) systems" as requested, is as such: the lower limit of detection (LLD) of activity on a filter collected from a FAS is 1.77×10^{-14} μCi/ml based on a 24-hr. sample at 2 CFM, Radon decayed for 36 hrs, and counted for 10 min.

(1) Data on radon progeny background is not collected or maintained. Therefore, this information is not available.

(2) Per the enclosed procedure WP 12-508 (Enclosure 13), radon progeny are allowed to decay at least 36 hours before counting.

(3) FAS filters are routinely counted on the WIPP's Canberra Model 2400 alpha/beta counting systems, per the enclosed procedure WP 12-516 (Enclosure 14).

(4) The type of filter used in the WIPP CAMs are copolymer-supported, pore-type (Versapor) filters with a nominal pore size of 3 micrometers.

(5) One Canberra system as calibrated 4/21/92 as follows:
Sources used: Sr/Y 90 #S3401
64995 dpm (decay corrected)
20916 cpm (measured)

Pu 239 #511/88
18800 dpm
2174 cpm (measured)

The other system was calibrated 12/9/91 as follows:
Sources used: Sr/Y 90 #P674
214863 dpm (decay corrected)
68628 cpm (measured)

Pu 239 #90PU4703969
133195 dpm
31849 cpm (measured)

All sources used are NIST-traceable. Source-certification sheets, entitled "Certificate of Calibration," for these sources are provided as Enclosure 10.

(6) Procedure WP12-516, "Operation and Calibration of the Canberra Model 2400 Alpha/Beta Counting Systems" is provided as Enclosure 14.

6c. The EEG's letter requests additional information on the methodology, sensitivity to radionuclides, and time duration to complete measurement for the batch sampling option provided for in the WIPP FSAR. It is important to note that the WIPP FSAR does not make batch sampling a requirement, but it is established as an option.

Section 10.3.1.2 of the WIPP FSAR requires that either the effluent monitors be working at Stations A, B, and C or there be termination of waste handling activities for a period of time. If the resumption of monitoring is not achieved (through repair of in-situ monitors or use of portable monitors) within one hour, it would then be necessary to shift exhaust air to filtration, or to suspend exhaust. The WIPP has chosen the options of additional operating CAMs so that malfunction or failure does not eliminate a required CAM. This was the logic used when two sets of simultaneously operating CAMs were put into service at Station A (i.e., should one CAM become inoperable, the WIPP will be able to continue normal operation because we have an identical unit up and running).

The potential for batch sampling, while provided for in the FSAR, is not planned for use at the WIPP. Its use is obviated by the presence of the simultaneously-operating CAMs. As such, though the EEG has requested the "methodology" for batch sampling, it cannot be provided since no formal procedure for batch sampling at the WIPP exists. If ever invoked, batch sampling could be undertaken by collecting the station's FAS filter and counting it immediately in a portable Alpha 6A CAM using a radiation work permit.

EEG CONCLUSION (6.)

The answer to 6.a. is considered non-responsive. An EEG review of the Stoller report is provided in Section 5.20 of this report. The report's deficiencies were brought to the DOE's attention at the February 14, 1991 Quarterly Meeting of the DOE and the EEG.

Although the DOE stated it was planning to publish a theoretical report on loss of particles in the underground, there is sufficient empirical data to indicate that significant particle transport to the environment will occur. As suggested at numerous meetings, collection and analysis of the FAS and CAM gravimetric data would provide empirical rather than theoretical data on particle transport in the underground.

The answer to 6.b. appears to be in error. The referenced FAS LLD was 1.77×10^{-14} μCi/ml. A standard formula for LLD is as follows:

$$LLD = 4.66\ (\sigma^2)^{1/2}$$

where σ^2 = variance of the background

When alpha disintegrations are measured on a FAS filter, there is a significant radon and thoron progeny background. After 36 hours the radon series count rate should be small because of the 26.8 minute Pb^{214} half-life, but the thoron series is dominated by a 10.64 hour Pb^{212} half-life. After 36 hours, significant thoron progeny remain. There must be an understanding of the magnitude and contributions to the variance, σ^2, before an LLD can be calculated.

The EEG Station A filters, collected in the week of August 3, 1992, were measured with a 23% efficient alpha scintillator at post-28 hours and greater collection times. The following results were obtained:

Decay Time (hrs)	Counts / 10 minutes (gross)
28	193
55	38
78	18
102	2

A back calculation of the WIPP variables indicates less than 15 counts per 10 minutes are required to achieve the referenced LLD. Both the empirical and theoretical data indicate greater than 72 hours to achieve the LLD. Other variables which must be considered are:

- variations in radon/thoron background
- linkage to meteorological conditions, especially in the times when inversion conditions are prevalent
- corrections for salt attenuation
- filter/electroplate source correction
- instrument experimental error

WP 12-516, Rev.2, was reviewed and an error was found in the use of the LLD (MDCR - minimum detectable count region) in Attachment 3 of the procedure. The MDCR was improperly divided by 10 to obtain CPM. The statistic was based on a 10 minute count, not a one minute count. The stated LLD sensitivity appears to be an order of magnitude too optimistic.

There appears to be a mistake in the documented detector efficiencies for ^{239}Pu, one source being about 23% and the other about 12%. There is either an error in deriving these numbers or very poor linearity in the instrument.

The WIPP response indicates that the optional effluent batch monitoring method, described in the FSAR, is not important. This method is needed as part of the contingency planning. During the first week of August 1992, both Station A alpha CAM systems failed. The safety analysis was predicated on an alternative method, and a batch method is required.

EEG QUESTION

7. Other Research

A review of data provided indicates that negative excursions and degraded spectra continue to be an alpha CAM system problem. Although detector failure because of salt corrosion may be a major complication, there are other possible contributing factors which should not be ruled out. These problems are not "fail-safe," as the systems are presently designed. We would recommend that other systems or methods be considered which would key algorithm corrections to the peak centroid rather than to fixed regions-of-interests now used in the spectrometry system. Such an approach would compensate for quality assurance concerns and help correct drift caused by salt or electronic problems. The present plans for enhancement of electronic circuitry based upon the region-of-interest approach may not be appropriate.

DOE RESPONSE

7. Item 7 suggests research into "Methods be considered which would key algorithm corrections to the peak centroid rather than to fixed regions-of-interest now used in the spectrometry system." This concept has been suggested by Mr. John Rodgers of LANL and is being worked on jointly with Canberra Nuclear along with a radon progeny filtering CAM design. This work is in a very preliminary stage of development. Only a prototype CAM has been built, and the new "Peak Centroid" algorithm is as yet unproven. It is inappropriate to limit further development on the "fixed regions of interest" approach (a tested and proven method) in favor of the conceptual, untested, and unproven approach suggested by the EEG. At this time, the WIPP is unique, having over six CAM-years of

recorded operational data using the most completely test, microprocessor-based, spectrum-stripping alpha CAM. For purposes of the EEG evaluations in the near future, the EEG can safely assume that the WIPP will utilize the presently installed and operationally proven region-of-interest algorithms.

The WIPP will continue to incorporate current and emerging expertise into its CAM systems. Suggestions from organizations such as the EEG will always be carefully considered.

EEG CONCLUSION (7.)

The referenced Canberra Nuclear equipment is available for sale, not in a very preliminary stage of development. Our comment was not an endorsement of Canberra, but a suggestion that new technology be considered. We hope that our suggestions were carefully considered and that the DOE will incorporate emerging technology. The DOE statements about the WIPP alpha CAM experience and testing appear to be exaggerations.

EEG QUESTION

8. Salt Aerosol Concentrations. At the December 17, 1991 Quarterly Meeting, EEG requested that expected air salt concentrations be provided for typical underground maintenance procedures (i.e., roof bolting, resuspension by equipment, etc.). To date no information has been provided.

DOE RESPONSE

8. The EEG states that they requested specific information on salt aerosol concentration for roof bolting operations, underground maintenance procedures, resuspension by equipment, etc. As has been explained previously in other fora, the WIPP makes use of operational procedures and management controls to ensure the proper functioning of the total WIPP system. Operational controls provide an extra margin of safety in situations where high airborne salt concentrations may degrade CAM sensitivity. It is recognized that operations such as roof bolting are not compatible with waste hauling and placement. In addition, the WIPP is investigating both airborne salt monitoring systems (to give us better operational control) and new approaches

to minimizing airborne salt dust. Please note, the EEG presently collects salt-density data on a periodic basis from the FAS provided to the EEG at Station "A".

Finally, a study was undertaken by ITRI earlier in the WIPP's history that characterizes the sizes and concentrations of salt particles in the WIPP underground associated with a variety of underground work activities. A copy of this ITRI report entitled "Aerosol Measurements in the Partially Completed Underground Waste Isolation Pilot Plant: Final Report" is provided as Enclosure 15.

EEG CONCLUSION (8.)

The historical data published by the ITRI were obtained under different ventilation conditions and the aerosol was generated under a different set of conditions 9 years ago. Even so, the referenced report concluded:

> If a 5.16 MeV alpha particle has a maximum range in NaCl of ≈ 30 μm, then in a relatively short sampling period sufficient mass could be collected so that the alarm level for a slow plutonium release would be compromised.

As explained in a June 9, 1992 meeting with the DOE and the WID, the intent of the question was to determine how newly-planned operations in Room 1, Panel 1 would affect alpha CAM measurements. The data might indicate a better environment for alpha CAM measurements. The reluctance to generate meaningful empirical data for health and safety measurements is counterproductive. Even gravimetric analysis of underground CAM or FAS filters would be useful.

The DOE should know that the EEG's gravimetric data at Station A are representative of the entire mine, not a specific operation or area. The EEG's evaluation of operational data will be presented in the next section where Station A gravimetric data are published. The EEG data indicate very high salt aerosol concentrations at Station A.

7.0 CAM DATA

In January 1991, the EEG began receiving computer-archived operational data for the alpha CAMs 27, 153, and 121. In November 1991, similar data were provided when CAM 157 was installed as a backup alpha CAM at Station A.

7.1 Data Format

The CAM operational data are on floppy disk files in a format compatible for use with personal computer spreadsheet software programs. The data files are imported into the software Quattro Pro[7] where simple analyses and graphing are possible.

The data include a listing of all plutonium channel counts per minute (CPM) and accumulated hourly alpha spectra. The plutonium channel counts are listed as 60 one-minute counts per column and 12 columns per page. This format allows a quick review of 12 hours of plutonium channel count data. The hourly spectra are printed as graphs, with 6 hourly spectra per graph. As shown in Figure 11, each hourly spectrum is an accumulation of counts since the last filter change. When a filter is changed, the spectrum is zeroed and the accumulation begins again.

7.2 Data Interpretation

The following kinds of information can be derived from graphs of accumulated alpha spectra:

(1) The relative magnitude of the radon and thoron progeny background counts as shown in Figure 11. Figure 11 data are from CAM 27 which is in the clean,

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[7] Quattro Pro is produced by Borland International, Inc., Scotts Valley, CA.

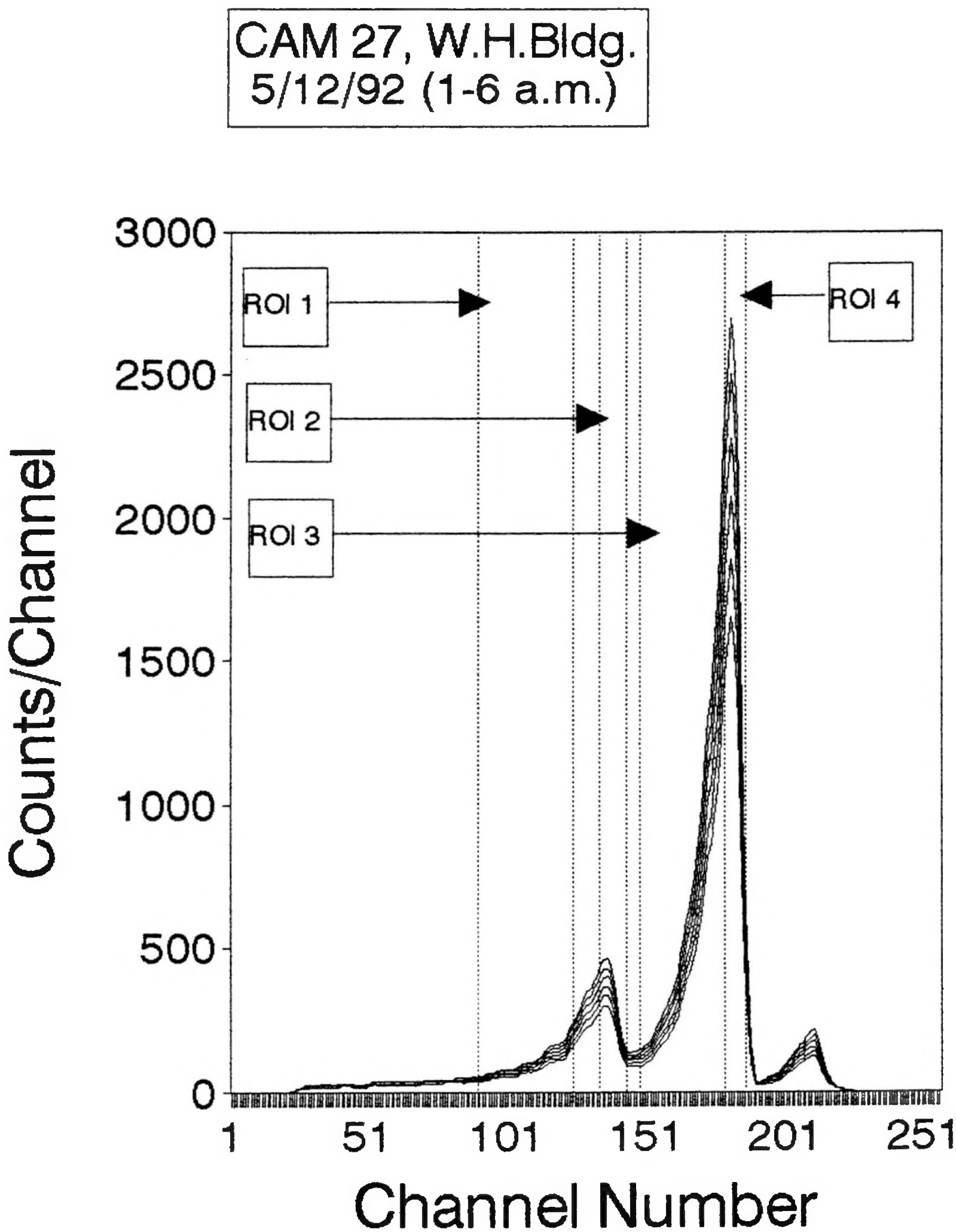

Figure 11. Alpha Spectra

air-conditioned environment of the Waste Handling Building. The large central peak indicates ^{214}Po (Ra C'). The Ra C' has an effective half-life of 19.7 minutes because it is in secular equilibrium with ^{214}Bi. The peak to the right is ^{212}Po (Th C'), and it has an apparent half-life of about 10 hours because of transient equilibrium between ^{212}Pb and ^{212}Bi. The peak to the left is a composite of ^{218}Po (Ra A) and ^{212}Bi (Th C).

(2) A derived k-factor can be determined by summing counts in the ROIs and entering the values in the formula shown in Section 3.6.

(3) Alpha spectra can be visually rated. This qualitative technique for determining if an alpha CAM is used to determine operational status.

(4) Performance trends are based on the number of degraded spectra. The DOE has objected to this method because it does not take into account "red-tagged" (out-of-service) equipment, although out-of-service data have not been provided.

(5) CAM 153 and 157 sample the same air flow (background source term) at Station A. Data from the two identical systems can be compared to determine relative efficiencies. This comparison is particularly important because daily efficiency measurements are not made.

In addition to spectral data, the minute-by-minute plutonium counts are formatted, printed and reviewed. If the algorithm works properly, then the plutonium counts will be at or near zero (Figure 12). Detector or equipment problems often result in excessive negative counts in the plutonium channel. If a

CAM 27 (Data are average CPM of last 5 minutes)

05/12/92 (Date, time in row below)

23:50	00:50	01:50	02:50	03:50	04:50	05:50	06:50	07:50	08:50	09:50	10:50
2	3	3	2	5	3	1	2	2	1	5	2
3	3	2	1	3	4	1	1	2	1	3	3
3	3	1	2	1	4	0	2	1	1	4	3
2	2	-1	1	3	2	2	0	0	2	3	1
1	2	1	1	2	4	2	0	0	3	4	1
3	2	1	2	2	3	2	1	-1	4	3	1
2	1	2	2	2	2	3	2	0	2	5	0
1	2	5	2	5	2	3	0	-1	2	3	2
2	3	6	4	4	3	4	2	1	3	5	1
3	4	5	5	5	3	5	2	2	3	2	1
0	4	5	3	3	2	4	2	3	2	4	3
1	4	5	3	4	4	3	1	4	4	1	3
2	3	3	2	2	2	2	2	5	4	2	2
4	4	2	1	2	2	3	1	4	4	0	2
3	2	2	3	1	3	2	1	3	4	3	2
3	2	2	4	2	4	2	1	2	4	2	0
2	2	1	4	2	5	1	3	0	4	3	1
3	4	1	6	3	5	3	3	2	4	4	1
1	1	2	6	3	3	0	3	1	2	4	2
1	2	2	5	3	2	2	4	1	3	3	1
2	1	3	5	4	1	2	4	3	3	3	2
1	1	4	3	4	-1	4	4	2	4	3	2
1	0	3	2	3	-1	2	4	2	2	2	2
3	1	3	1	2	2	3	5	3	3	3	2
3	2	2	2	3	2	0	6	3	4	3	3
2	1	1	3	3	3	2	5	4	4	5	3
4	2	1	4	3	2	1	4	3	3	4	3
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0	3	2	5	3	2	3	3	5	2	4	2
1	2	1	4	2	1	3	1	5	0	3	3
1	3	3	3	2	1	2	2	3	0	2	2
1	2	3	4	3	2	3	3	5	0	2	4
1	2	3	4	2	2	1	4	5	1	2	3
3	2	2	3	3	3	3	2	4	2	2	2
3	4	2	4	4	2	4	4	2	3	4	2
2	3	2	3	4	1	4	3	2	1	5	3
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3	3	2	4	4	2	1	2	4	2	4	1
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1	4	3	3	3	2	2	2	6	2	3	4
2	3	5	4	4	2	1	2	5	1	2	4
2	4	3	4	3	0	2	4	4	0	3	4
3	5	3	1	3	1	2	3	2	0	3	4
4	3	4	1	4	0	2	0	0	1	2	3
3	3	3	1	4	0	2	-1	1	1	3	4
5	3	2	2	5	0	3	1	3	3	4	3
4	3	4	1	6	1	2	2	2	2	2	4
3	2	2	3	6	1	3	1	4	2	1	3
2	3	2	3	6	2	2	3	3	2	1	4
1	3	2	2	4	1	3	4	2	3	1	2
-1	2	2	1	3	1	3	4	1	1	1	3
0	3	2	3	1	1	2	2	2	3	2	2
1	3	3	4	3	0	3	3	1	4	2	4
1	3	3	5	2	0	4	3	1	4	4	2
2	2	2	5	2	0	3	2	0	4	3	3

Figure 12. Plutonium Channel Counts Corresponding to Figure 11 Spectra

spectrum is degraded, an over subtraction in ROI-1 counts occurs, resulting in a non-conservative measurement. Negative plutonium counts directly increase the effective alarm setting.

7.3 Data Analyzed

Data from February through June 1992 are emphasized in this report because these data best reflect the current CAM operational status at the time of the drafting of this report. Some 1991 data are used for trend analyses. For clarity, the location of each alpha CAM is again documented:

Designation:	Location:	Condition:
CAM 27	Waste Handling Building	Clean Area
CAM 121	Underground, S1600 Drift	Salt Aerosol
CAM 153	Station A, LCO, directly above underground exhaust shaft (See Figure 3)	Salt Aerosol
CAM 157	Station A, Backup Monitor	Salt Aerosol

7.4 Data Availability

Figure 13 is a bar graph indicating the availability of CAM data from February to June 1992. Each bar on the chart represents a single day's data. Blank regions indicate days or portions of days when data were not available.

The DOE has not been able to provide specific reasons for lack of data, but general statements have been made that no data could mean that the computer archiving may have failed, plant power outages may have occurred, maintenance activities required interruptions, or possibly detector/equipment failures.

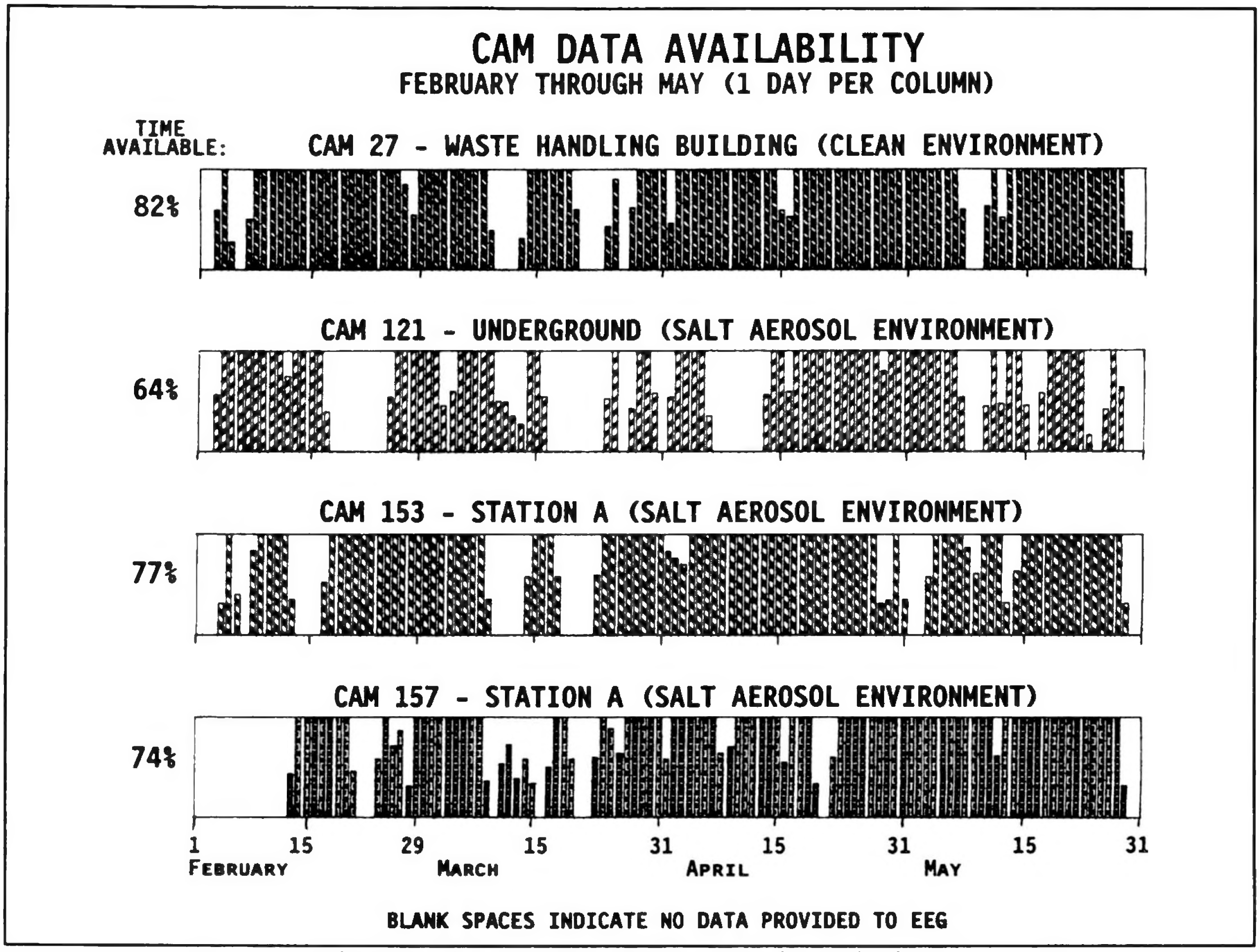

Figure 13. CAM Data Availability

7.5 Evaluation of Spectra

The DOE states that technicians can determine the operational status based upon the quality of the spectra. No evaluation method was found in the WIPP procedures; therefore, the EEG developed a qualitative method to review data as shown in Appendix F-1.

Each EEG spectral graph is typically a composite of six hourly spectra. The total number of counts on each graph varies because of radon/thoron variation. The maximum range is from a few hundred counts to thousands of counts. If a filter is not changed over a week-end period, total counts may be very high.

Degraded spectra infer salt attenuation or detector malfunction. Spectra selected were near "no-data" regions (shown in Figure 13) to determine if there was any correlation between loss of data and CAM performance (see Appendix F-2 to F-9).

CAM 27 is located in the clean, air conditioned environment of the Waste Handling Building. CAM 27 spectra are almost always classical in appearance and are usually rated as "ideal" (Figure 11 and Appendix F-2). Generally speaking, CAM 27 appears to have a high level of reliability and spectra are usually well-defined radon/thoron peaks. CAM 27 no-data regions in Figure 13 probably result from maintenance or secondary consequences.

CAM 121 is the only underground CAM for which data are provided. Data are frequently not available, and spectra are often degraded. Many of the example spectra are rated as poor or unusable (Figure 14 and Appendix F-3 to F-5).

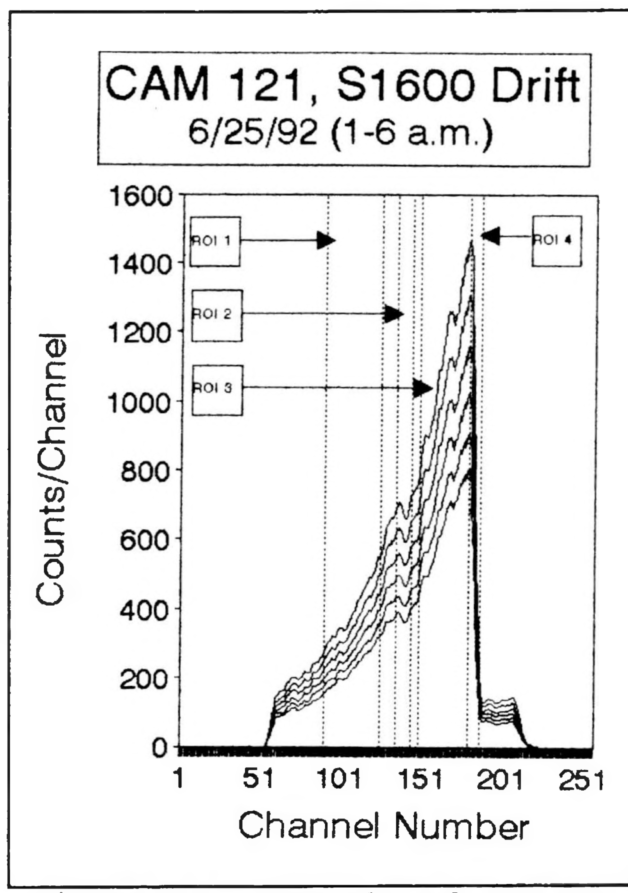

Figure 14. Example of CAM 121 Degraded Spectrum

CAM 153 and CAM 157 sample the same air flow, and both systems appear to have fewer degraded spectra than CAM 121. One example is shown when both 153 and 157 had unusable spectra (Figure 15 and Appendix F-6 to F-9).

Because no gravimetric data are available from underground stations, filter salt-loading comparisons between the underground CAM 121 system and Station A (CAM 153 and 157) are not possible.

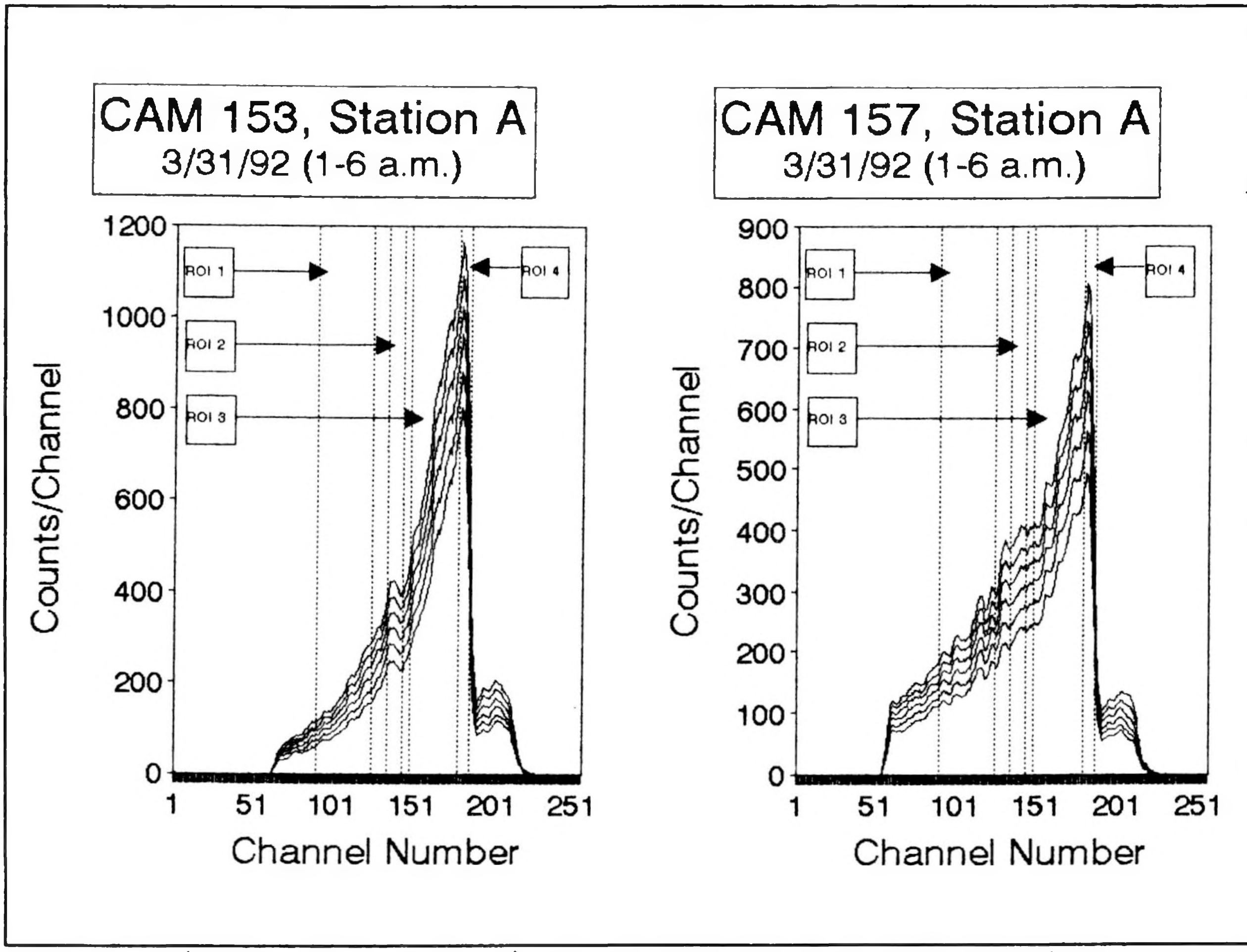

Figure 15. Comparison of CAM 153 and 157 Spectra

Gravimetric data would be useful in determining the difference in sampling conditions. CAM 153 is an LCO system and receives higher maintenance priority. This may account for CAM 153 performance being better than CAM 121.

CAM 153 and 157 spectral data provide an indication of the relative efficiencies. At selected times in March and April of 1992, the peak height of the RaC' peak was estimated from the spectral graphs and the results are shown in Table 7 below. CAM 153 and 157 filter changes occurred near the same time, and therefore peak height differences are not caused by different sampling accumulation times.

Table 7. Variation in Relative Detector Efficiency

Date	CAM 153	CAM 157	Relative Efficiency (%) (CAM153/CAM157)*100
3/7/92	2800	3150	89
3/24/92	3300	2700	122
3/31/92	1400	1000	140
4/28/92	3150	4800	66

There are significant differences in relative efficiency. The differences can not be explained because of the lack of supporting data from the DOE. The variation in efficiency phenomenon is treated in more detail later.

Because CAM 153 is the only LCO system that monitors underground exhaust, the spectra were examined in more detail. A bar graph indicates CAM 153 overall performance from January 1991 to September 1992 (Figure 16). Figure 17 uses the same data as Figure 16, but the data is displayed as a month-to-month bar graph. The month-to-month data indicate that performance improved in early 1992, but in July problems were again obvious.

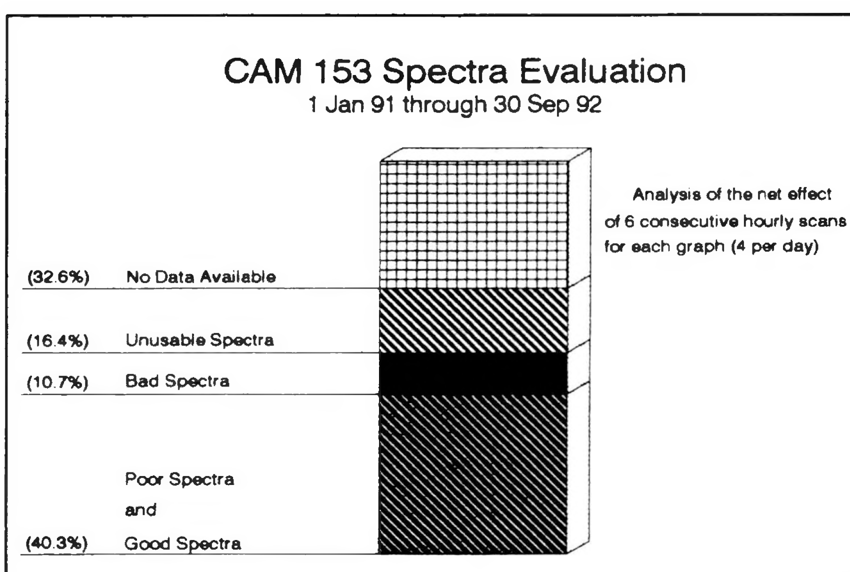

Figure 16. CAM 153 Spectra Evaluation, Combined

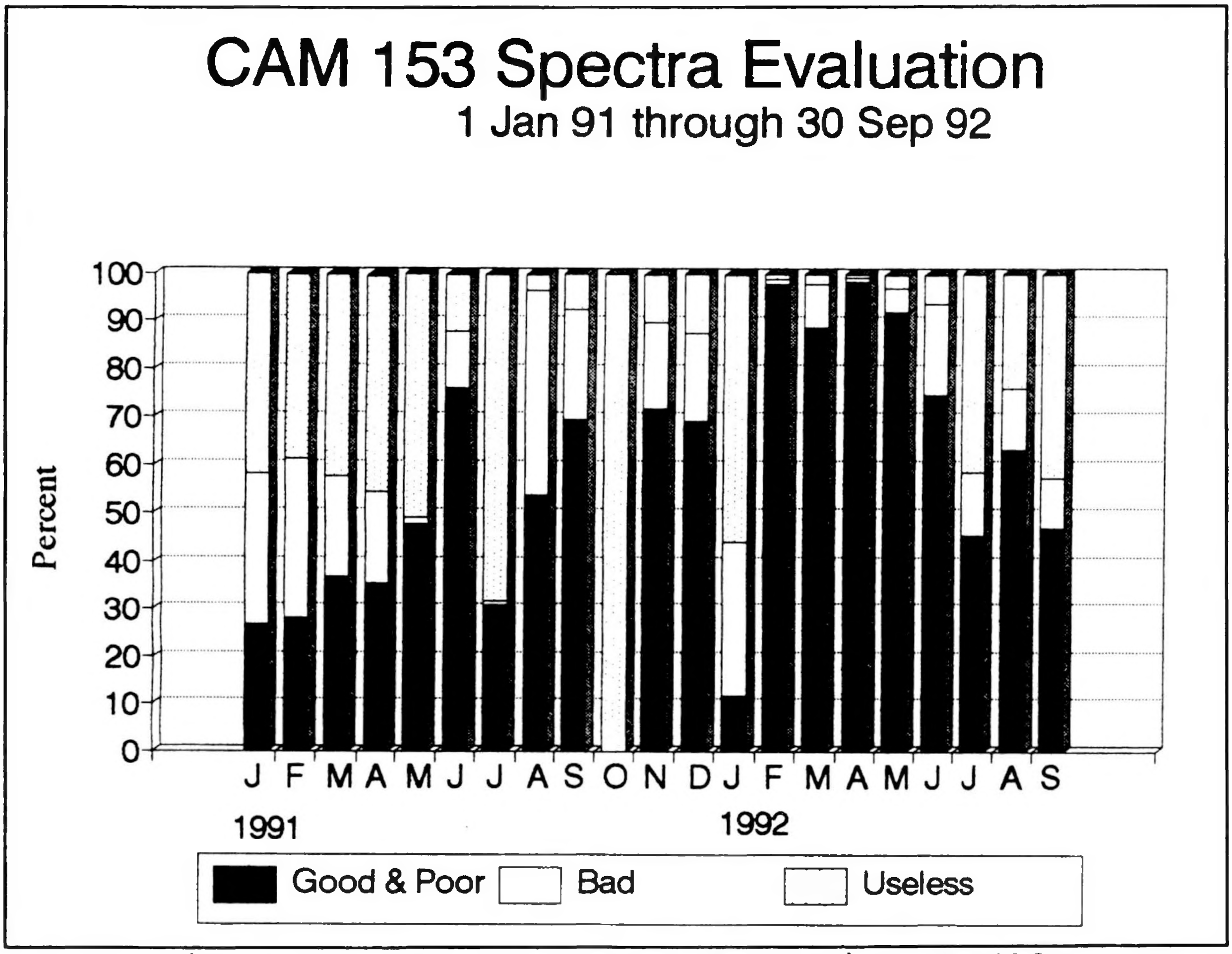

Figure 17. CAM 153 Spectra Evaluation, Monthly

7.6 Station A Gravimetric Data

The EEG Station A gravimetric data are shown in Figure 18 and Appendix F-10 to F-13. The EEG air sampler has the same sample flow rate, sampling probe system, filter medium, and location as CAM 153. The EEG data indicate the average salt aerosol concentration (mg/m^3) at Station A over a 24 hour (week day) or 72 hour (week end) period.

The reference line is the concentration limit suggested in the CAM Expert Panel report (Carter et al. 1991). Even though there have been significant efforts to reduce salt aerosol, the suggested limit has been exceeded numerous times.

The EEG receives a record of flow rate at the Station A fixed air sampler. The EEG sampler is regulated at 2 CFM. On 5/15/92, the filter apparently became clogged with salt and the flow rate was reduced to 0.25 CFM at the 5/18/92 morning filter change. Flow rate was also reduced from 2 CFM to 0.76 CFM in the 5/18/92 to 5/19/92 period. Presumably high salt loading caused a reduction in flow rate during these two periods.

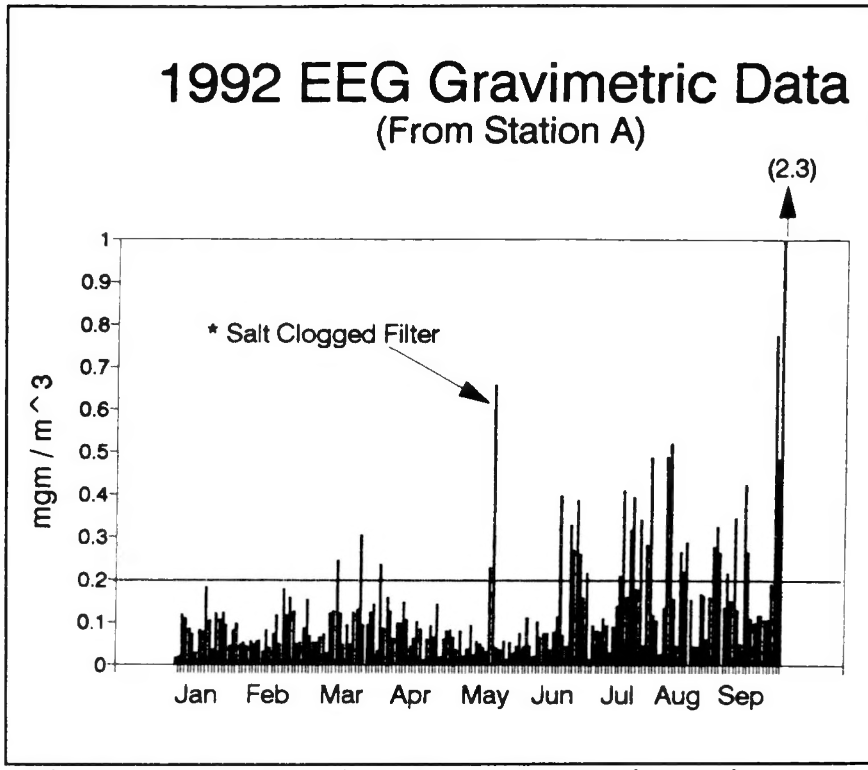

Figure 18. Station A 1992 Gravimetric Data

7.7 <u>High Salt Loading Anomalies</u>

High filter salt loading can cause degraded spectra and negative plutonium channel counts. CAM 157 and 153 spectra were selected from 6/18/92 when filter salt loading was abnormally high (0.39 mg/m^3), and the spectra were significantly degraded (Figure 19 and Appendix F-15). On 6/17 and 6/19, the salt loading was much lower (0.011 and 0.070 mg/m^3, respectively), and the spectra were relatively good. The spectra on 6/18 are particularly revealing because both CAM 153 and 157 spectra are similarly degraded, and on the days before and after 6/18, spectra are reasonably good.

During the first six hours of 6/18, the CAM 153 plutonium channel count average was a negative 12 CPM. During this same time

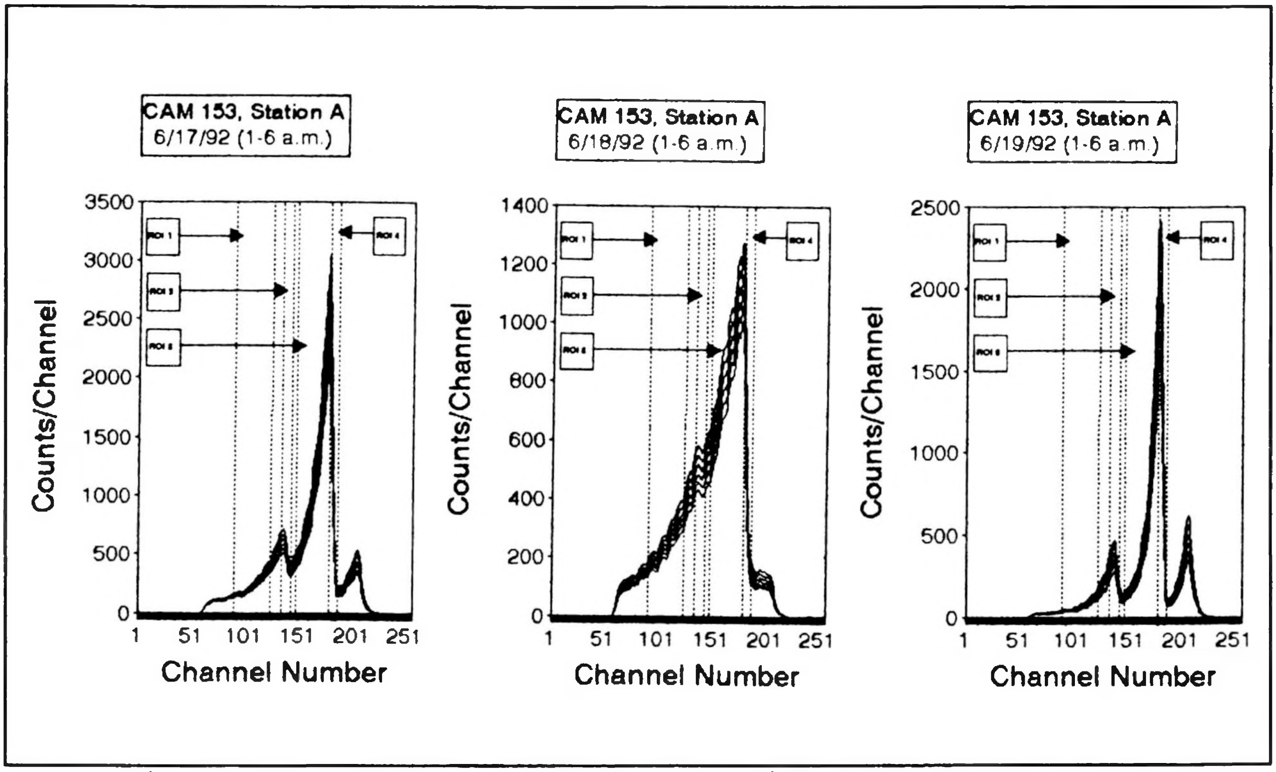

Figure 19. Degraded Spectra on High Salt Aerosol Day

period, the CAM 157 plutonium channel count average was a negative 1.4 with the range extended to as low as -22 CPM. Complete minute-by-minute plutonium channel counts for these time periods are in Appendix F-19 to F-20.

When plutonium channel counts are negative, the effective alarm level is increased. The stated WIPP effluent alarm level is 40 CPM, but Figure 20 data indicate that the effective alarm level is higher than 40 CPM when negative excursions and range variations are considered. When errors caused by the wide range of allowed detector efficiencies, reproducibility of the measurements, or other system errors are considered, the effective alarm level may be much higher than the actual setting.

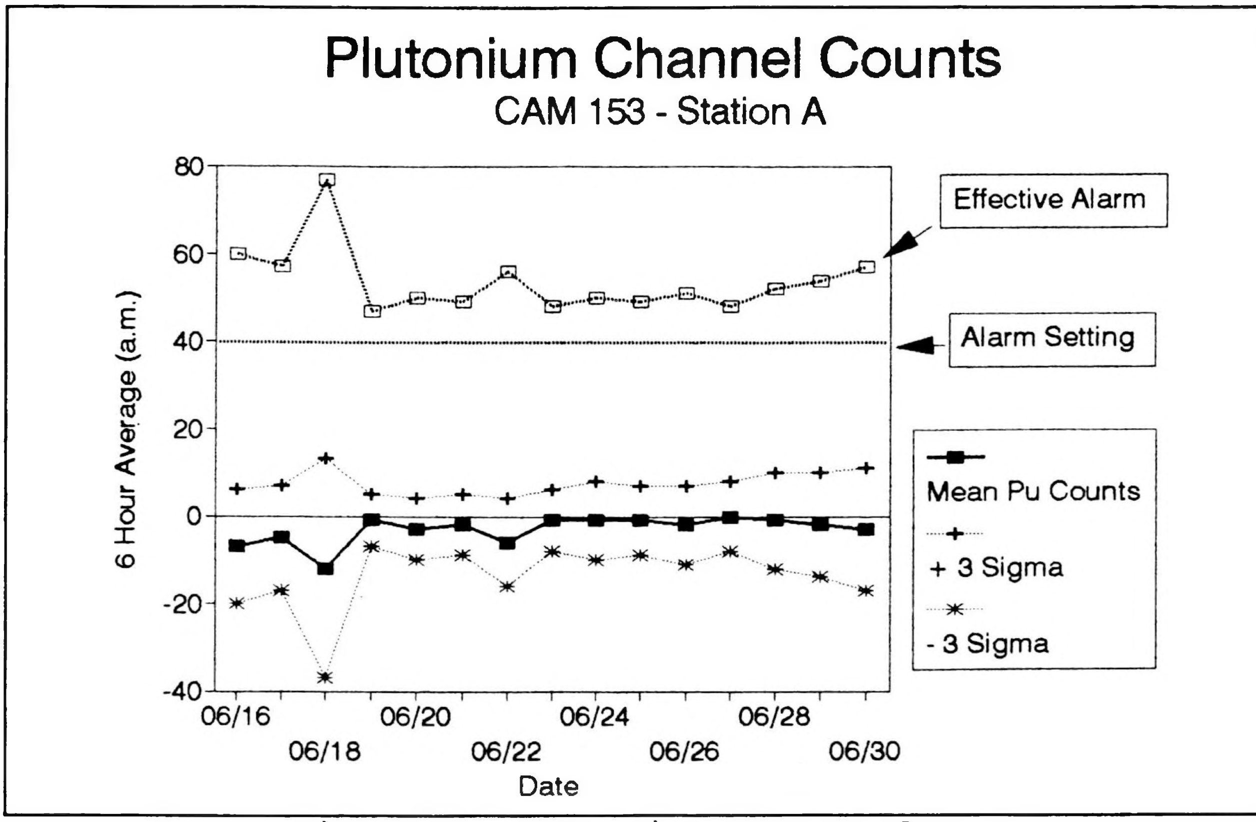

Figure 20. Effective CAM-153 Alarm

7.8 <u>Salt Loading Efficiency</u>

According to procedures provided to EEG, the CAM detector efficiency is not routinely determined. Because CAMs 153 and 157 sample the same Station A airstream, the measurements from these CAMs can be compared to determine relative efficiency. Relative efficiency was evaluated during a three day period (6/17-19/92), and the data are shown in Table 8 and Appendix F-15. On 6/18/92 the filter salt loading was high, and the RaC' peak height was significantly lower than on either the day before or the day after the 6/18/92.

The EEG collects a daily filter at Station A and measures radon/thoron progeny by gamma spectroscopy and L x-ray analyses (Bartlett 1992). The EEG measurements indicate that ^{212}Pb (238 keV peak) counts were only slightly lower on 6/18/92. The decrease in RaC' counts appears to be related to loss of detector efficiency during a high salt loading period, rather than an unusually low radon/thoron progeny background (Table 8).

Table 8. Loss of Detector Efficiency with Salt Loading

Date	Approx. RaC' Peak CAM 157	Approx. RaC' Peak CAM 153	^{238}Pb Counts Net Hourly	Ave. Conc. mg/m^3	Salt Load mg/cm^2
6/17	3500	3000	753	.114	.751
6/18	1300	1300	541	.396	2.123
6/19	3000	2500	621	.070	.426

These data were compared to Figure 10 in the ITRI report (Newton et al. 1990) which showed about 30% loss of plutonium counts by burying ^{239}Pu with 2 mg/cm^2 of salt. The ITRI loss of counts estimate was based on burial of a source by layers of salt. The RaC' source in Table 8 is assumed to be distributed in the salt. Because the RaC' is distributed and the RaC' alpha is higher energy than the ^{239}Pu, loss of counts would be expected to be much lower than 30%. Table 8 data indicate about 48 to 57% loss of RaC' peak counts.

Other high salt loading days were selected from data shown in Figure 18. On nine days the average salt concentration was greater than 0.15 mg/m^3. In each case, the CAM data were not available or it could not be confirmed that detectors were working before and after the day in question.

7.9 Detector Efficiency without Salt Aerosol

CAM 153 and 157 performances were evaluated when salt aerosol was low. Three different examples were chosen. For each condition, spectra, total detector count rate, ROI detector count rate, and plutonium channel counts were reviewed.

In the first example (11/22/91 to 11/25/91), the CAM 157 detector was non-operable as evidenced by the degraded spectra (Appendix F-21). A graph of counts in all four ROIs (Figure 21) indicates the CAM 157 detector efficiency was about 30% less than CAM 153. Graphs of each ROI count rate (Appendix F-22) indicate that ROI 3 and 4 relative efficiencies vary significantly. The change in relative detector efficiency was expected, but plutonium channel minute-by-minute counts do not indicate a detector efficiency problem (Appendix F-23 and F-24).

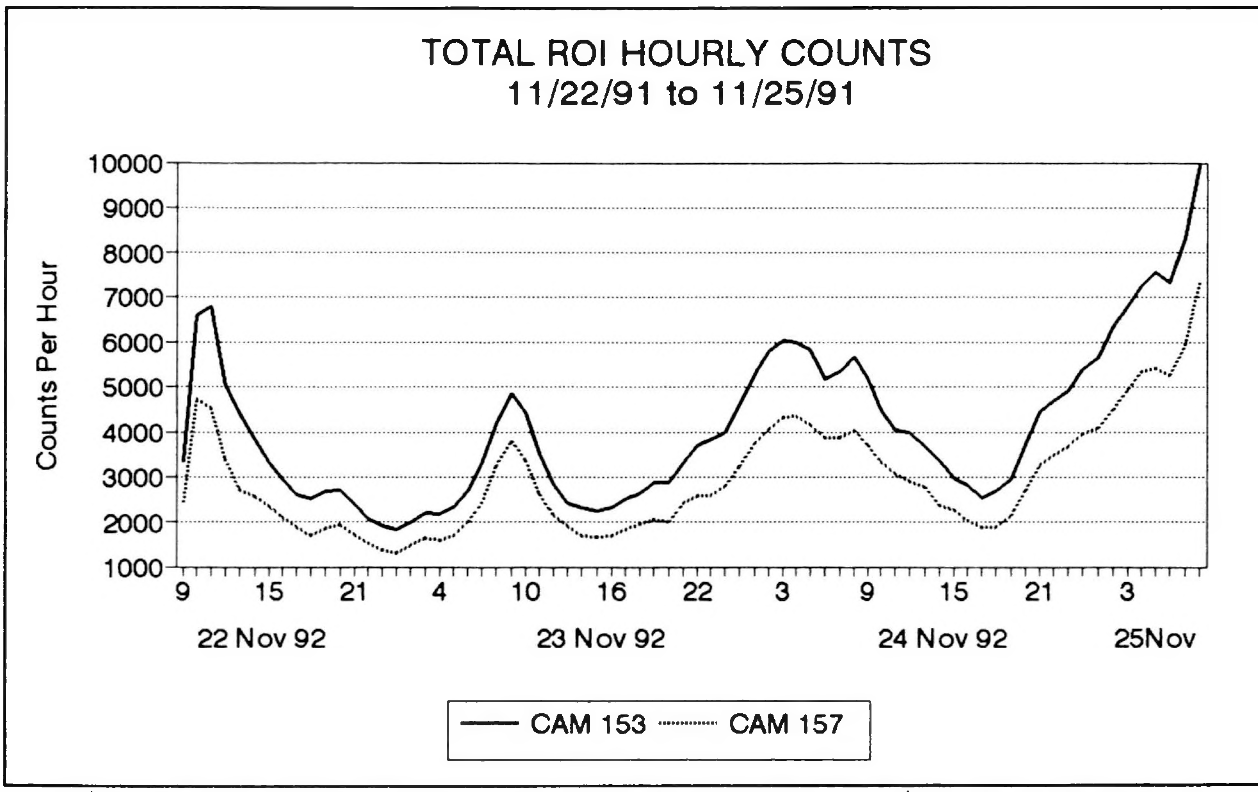

Figure 21. Comparison of CAM Count Rates with One Detector Malfunctioning

In the second example (3/6/92 to 3/9/92), a week-end (72 hour) sampling period, the average salt loading on filters was very low (0.028 mg/m^3). The CAM 153 and 157 spectra are relatively good (Appendix F-25). The graph of total detector count rate indicates that CAMs 153 and 157 efficiencies track very well

(Figure 22), but graphs of each ROI count rate (Appendix F-26) indicate that ROI 1 and 2 have significantly different count rates. There is an apparent tailing effect in the CAM 157 spectrum (Appendix F-25). The tailing effect may result from detector or detector/filter spacing, but the more likely cause is amplifier non-linearity. Severely degraded CAM 157 spectra on 3/9/92 indicated that the CAM 157 detector failed. Like the 11/22-25/92 example, the plutonium channel minute-by-minute counts do not indicate a detector efficiency problem (Appendix F-27 to F-28).

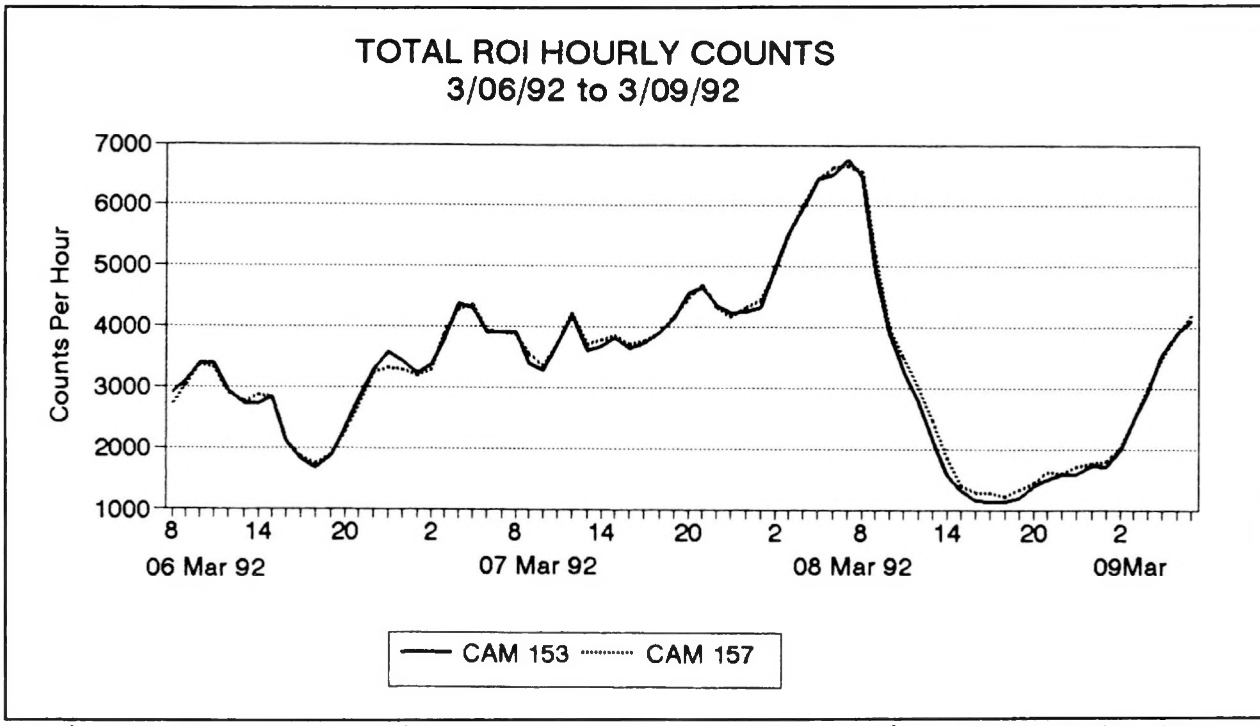

Figure 22. Comparison of CAM Count Rates with Both Detectors Appearing Normal

In the third example (4/10/92 to 4/13/92), average salt filter loading was low (0.042 mg/m^3). Both CAM 153 and 157 spectra were good (Appendix F-29), but total detector count rate indicated significant tracking problems when count rate was increased (Figure 23). This phenomenon was also apparent in the ROI count rate graphs (Appendix F-30). Plutonium minute-by-minute channel data (Appendix F-32) indicate that CAM 157 began having significant negative excursions on 4/11/92, even though CAM 153 was normal (Appendix F-31). This case, like the 3/6/92 example, seems to be the result of poor amplifier performance, although other causes are not ruled out.

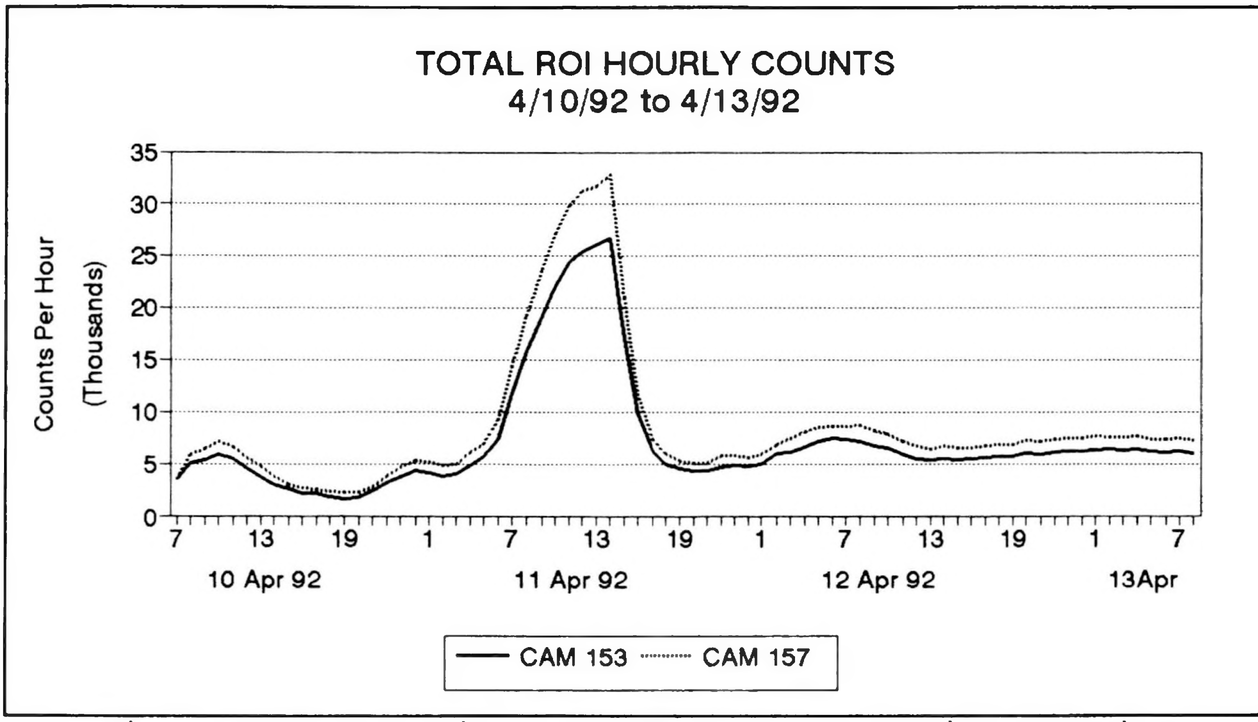

Figure 23. Comparison of CAM Count Rates with Changing Efficiencies

Operability checks based on evaluation of spectra qualitative or plutonium channel counts are not conclusive evidence of normal detector performance. The manufacturer claims an operating temperature of 0°C to 40°C (32°F to 104°F). The EEG's observation is that Station A is not heated or cooled by a central system, and equipment may be subjected to the extremes of the temperature performance range, especially during the summer months. Figure 17 data indicate that CAM 153 performance was poor during the summer. The quantitative influence of temperature, salt aerosol, radon/thoron progeny, and other environmental variables on equipment remains unknown.

7.10 Causes of Anomalous Data

CAM 153 spectral data (May 1992 through October 1992) were reviewed because there were times when filters had high salt loading, and it appeared that there was a correlation between quality of spectra and salt loading. CAM spectral data were from 24 hour accumulations corresponding to the 24 hour cycle of EEG fixed air sampler filter data.

The CAM RaC' peak was divided into two arbitrary regions of interest. One region included the main peak while the other region included most of the peak tail. Figure 24 is a graph of the percent of counts in the tail portion of the RaC' peak versus filter salt loading. A logarithmic least squares analysis of the data indicated an upward sloping line with an r^2 fit of 0.67. High variability was expected because of natural variation in radon/thoron levels. The analysis indicates that more RaC' counts were found in the peak tail as the salt loading increased. It was reported that as much as 90% of the plutonium ROI counts can be lost by 2.0 mg/cm^2 salt loading on a filter (Newton et al. 1990). This reported loss of counts is consistent with the observation that filters with high salt loading typically have more poor or unusable spectra.

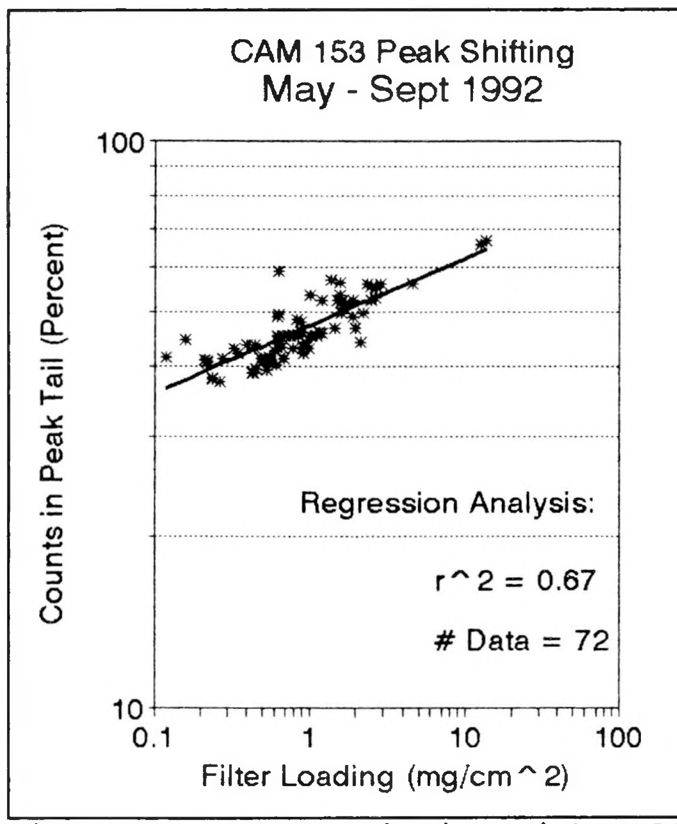

Figure 24. Peak Shifting with Salt Loading

To establish the possible cause of spectral degradation, filters from Station A sampling were selected and photographed with the light and scanning electron microscopes.[8] The filters used by both EEG and WID are Versapor-3000. According to Fisher Scientific,[9] the filter is a membrane of an acrylic copolymer on a nonwoven nylon substrate with a nominal 3μm pore size, and the filter has a diameter of 47 mm and is approximately 191 μm thick.[10]

Figures 25 and 26 are light micrographs made at approximately 320X magnification. Figure 25 shows a relatively smooth surface with markings caused by the nonwoven nylon substrate. Figure 26 is a filter with a salt loading of 1.27 mg/cm^2, and the filter surface is completely covered with salt. What is not obvious in Figure 26 is the depth of the salt loading; although the irregular surface indicates a composite structure. Careful viewing with the light microscope indicated that particles were in a stacked matrix which extended well above the filter surface with large gaps between the tree-like structures.

Filter samples were viewed with a scanning electron microscope in order to improve resolution. As part of the sample preparation, the filter surface was sputter coated with platinum. The coating process and vacuum of the sample chamber appeared to change the electrostatic properties of the salt matrix. Even so, the electron micrographs provided significant information about the surface structures.

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[8] Photographs provided by the Department of Biological Sciences, Texas Tech University, Lubbock, Texas.

[9] The Fisher Catalog, Fisher Scientific Headquarters, 711 Forbes Ave, Pittsburgh, Pa 15219.

[10] A micron is the unit 10^{-6} meters and the designations μm (micrometer) and μ (micron) are the same unit and are used interchangeably.

Figures 27 and 28 are electron micrographs of a clean filter at 800 (7.9 μ/cm) and 4000 (1.6 μ/cm) magnification. Although the manufacturer suggested that pore size is 3 μ, pore sizes appear to consistently range as high as 5 to 7 μ. The filter is designated as a water filter, but there is in-air filtration of 0.2 μ particles at 1.8L/min./cm^2 or about 1 CFM.[11] Flow rates at WIPP are typically 2 CFM.

Figures 29 and 30 are electron micrographs of a filter with low salt loading (0.17 mg/cm^2) at 800 (7.9 μ/cm) and 4000 (1.6 μ/cm) magnification. The salt particles appear to be agglomerations electrostatically attached to the surface and ranging in size from 2 to 7 μ. Smaller particles are not as evident and may be lodged deeper in the filter.

Figures 31 and 32 are electron micrographs of a filter with high salt loading (1.60 mg/cm^2) at 800 (7.9 μ/cm) and 4000 (1.6 μ/cm) magnification. The visible structures are the salt matrix above the surface level of the filter and do not include the filter surface. Larger salt particles appear to attract and build one upon another leaving numerous 5 to 10 μ gaps and crevices. There appears to be a wide range of particle sizes in the picture.

In Figures 33 and 34, a filter with 1.36 mg/cm^2 was placed in a container with 95% humidity for 3 days. As in other electron micrographs, the pictures are at 800 (7.9 μ/cm) and 4000 (1.6 μ/cm) magnification. These conditions are not necessarily comparable to the collection of particles at high humidity, but the experiment was performed to determine the effect of humidity on the filter surface matrix. In Figure 33, the tree-like structures have collapsed and formed a flat surface with fewer openings. In Figure 34, the salt appears striated and solid. This surface is opposite of the electrostatically bound matrix of particles found in other samples.

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[11] 1 CFM ≈ 15.9 cm^2 (surface area) X 1.8 L/min/cm^2 (flow rate) / 28.3 L/CF.

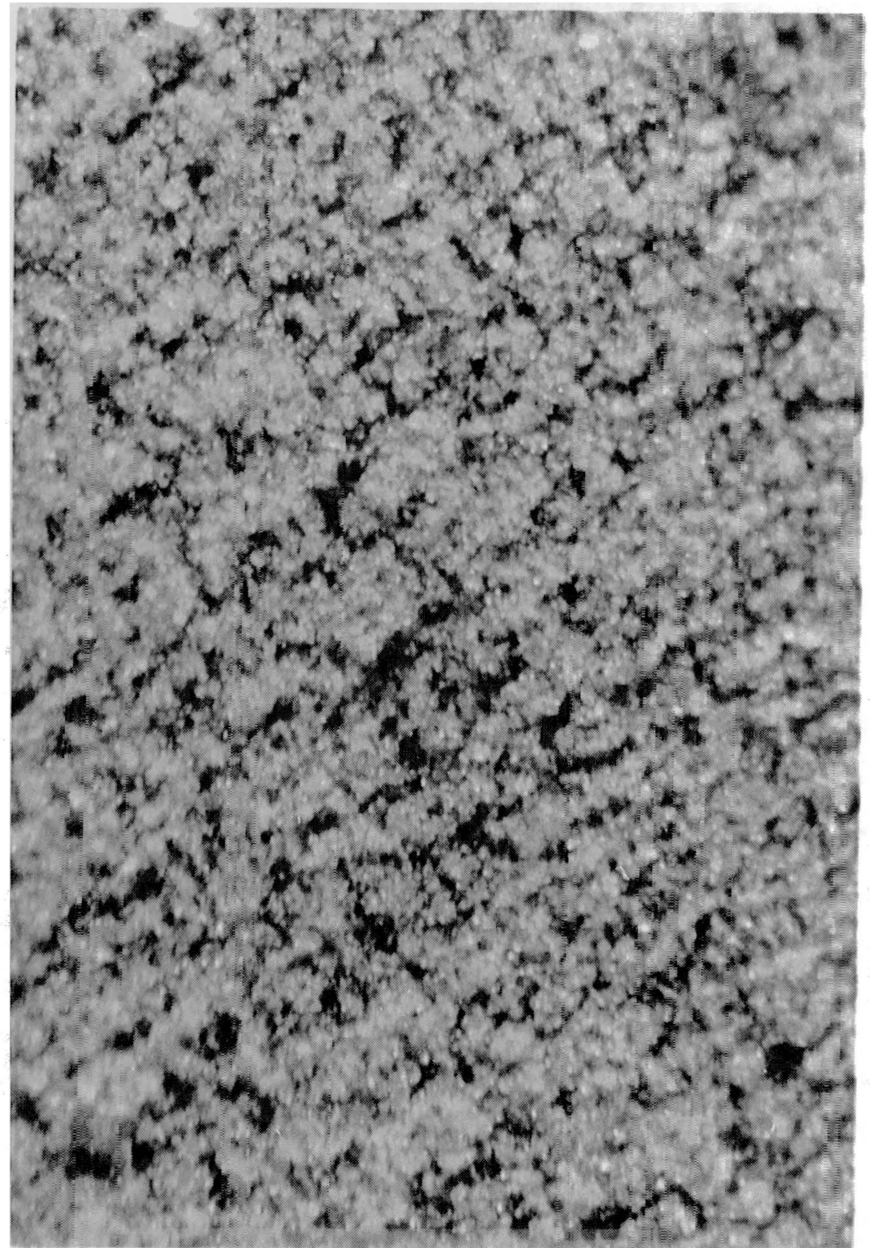
Figures 35 through 38 were taken with the sample tilted at a 75° angle. Figure 35 shows a clean filter with the knobbed ended filter fibers protruding 1 to 2 μ above the surface. Figure 36 shows a group of salt particles extending about 10 μ above the surface with a piece of butterfly wing as a contrasting background. Although the contrast is poor, Figure 37 has a tree-like structure extending about 70 μ above the surface. In Figure 38 the contrast is improved, and a 30 μ high structure is shown at the edge of the filter with a white backdrop. These feathery, tree-like structures uniformly covered the salt-laden filter before sputtering. After sputtering, most of the structures are lost.

The above referenced pictures clearly show that particles do not collect in layers, but rather the particles form a fibrous surface matrix. The samples shown were randomly selected from the daily-collected EEG FAS Station A filters. The particle collection mechanism appears to be electrostatic, and the surface of salt-laden filters is <u>not</u> uniform. Additional work is needed to determine how deeply particles, particularly small particles, penetrate the salt matrix and/or the filter medium. The desiccated Versapor-3000 filter average weight was found to be 7.67 +/- 0.44 mg/cm^2. A 25% particle penetration into the filter matrix is sufficient to achieve the 90% plutonium alpha measurement loss reported in the ITRI burial experiments (Newton et al. 1990).

Additional sampling problems are caused by the hygroscopic salt environment and WIPP's normally dry arid climate. Controlled experiments are needed to further investigate the competing influence of collection rate, air velocity, and humidity. If alpha monitoring is to be used at WIPP, then correction factors for salt buildup must be empirically derived under conditions identical to the conditions found at WIPP.

(mm) 0 0.1 0.2 0.3 0.4 0.5

Figure 25. Light Microscope View of Clean Filter Surface (~320X)



(mm) 0 0.1 0.2 0.3 0.4 0.5

Figure 26. Light Microscope View of Filter With 1.27 mg/cm^2 of Salt Loading (~320X)

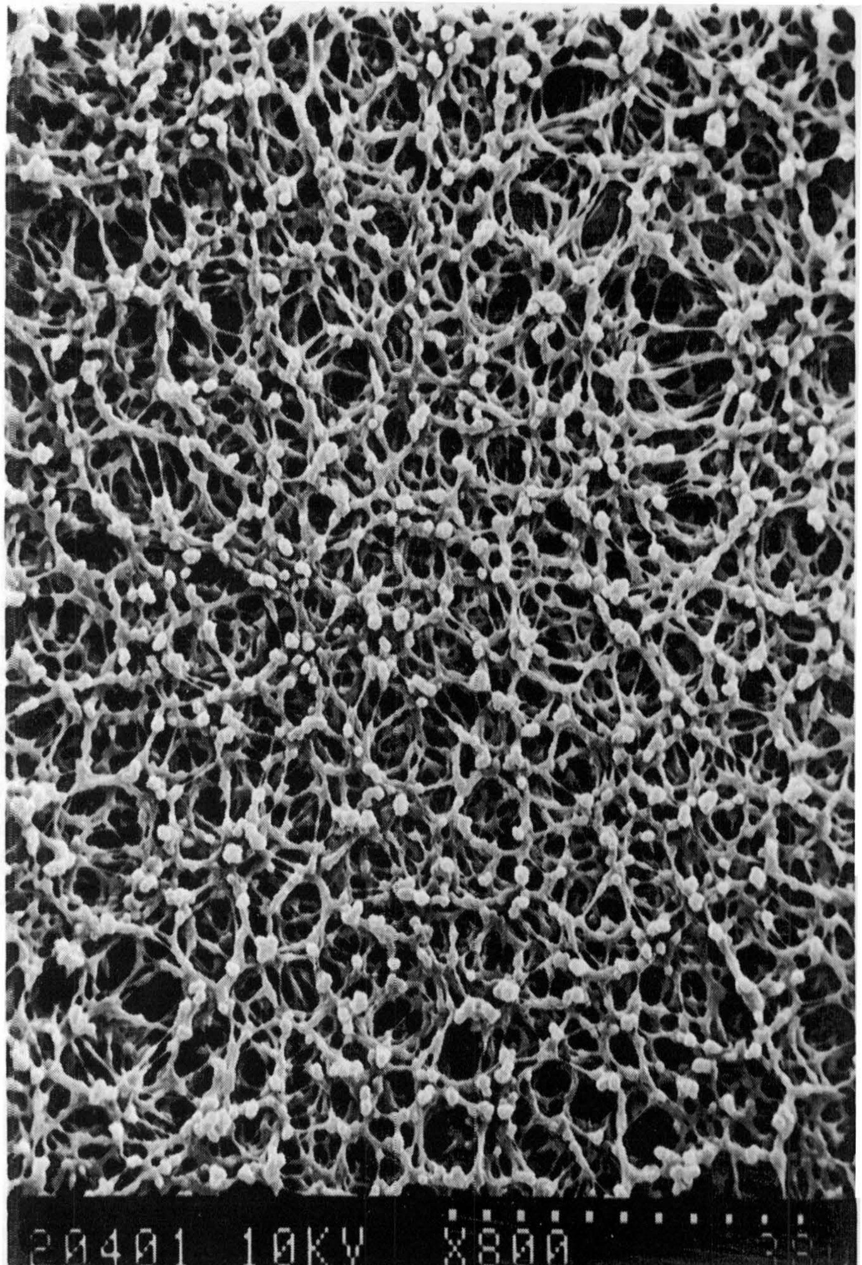


Figure 27. SEM of Clean Filter at 800X (38μ/4.8cm)

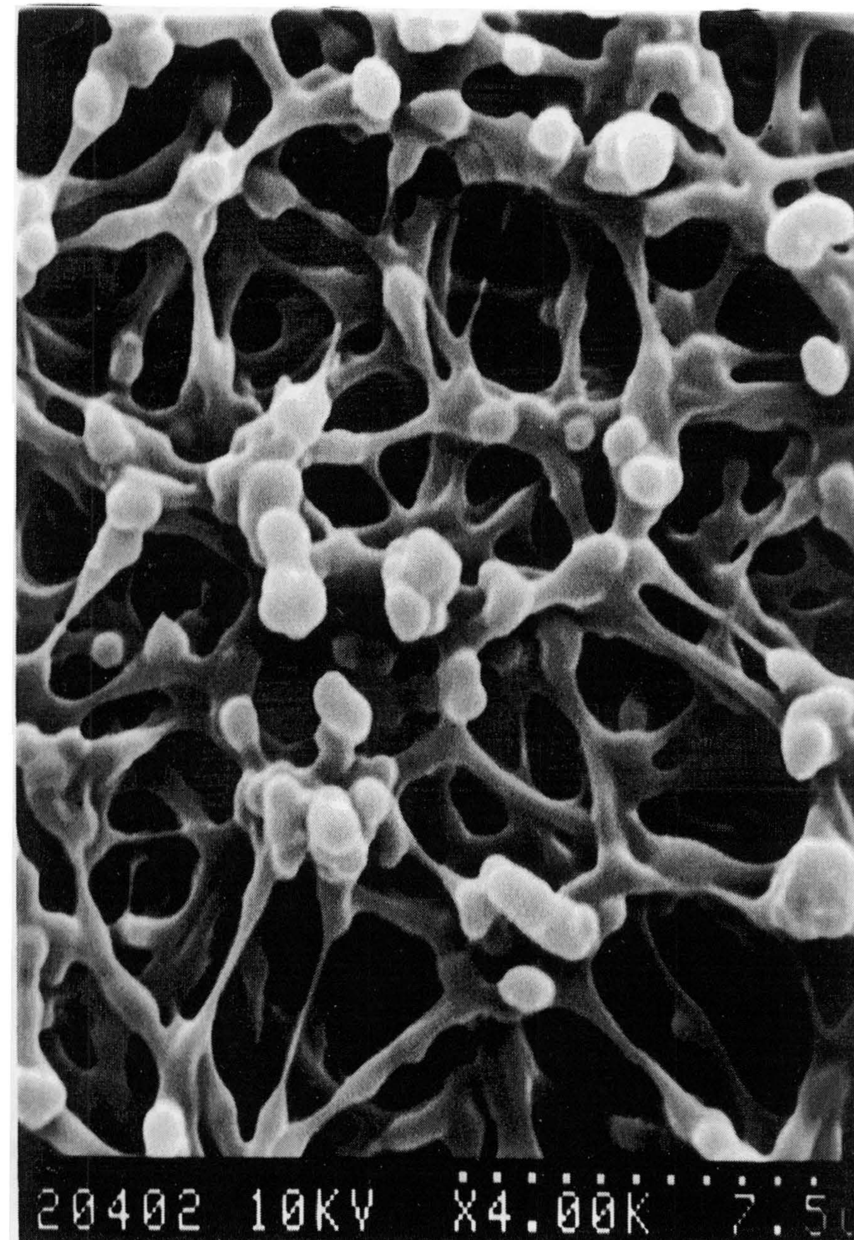


Figure 28. SEM of Clean Filter at 4000X (7.5μ/4.8cm)

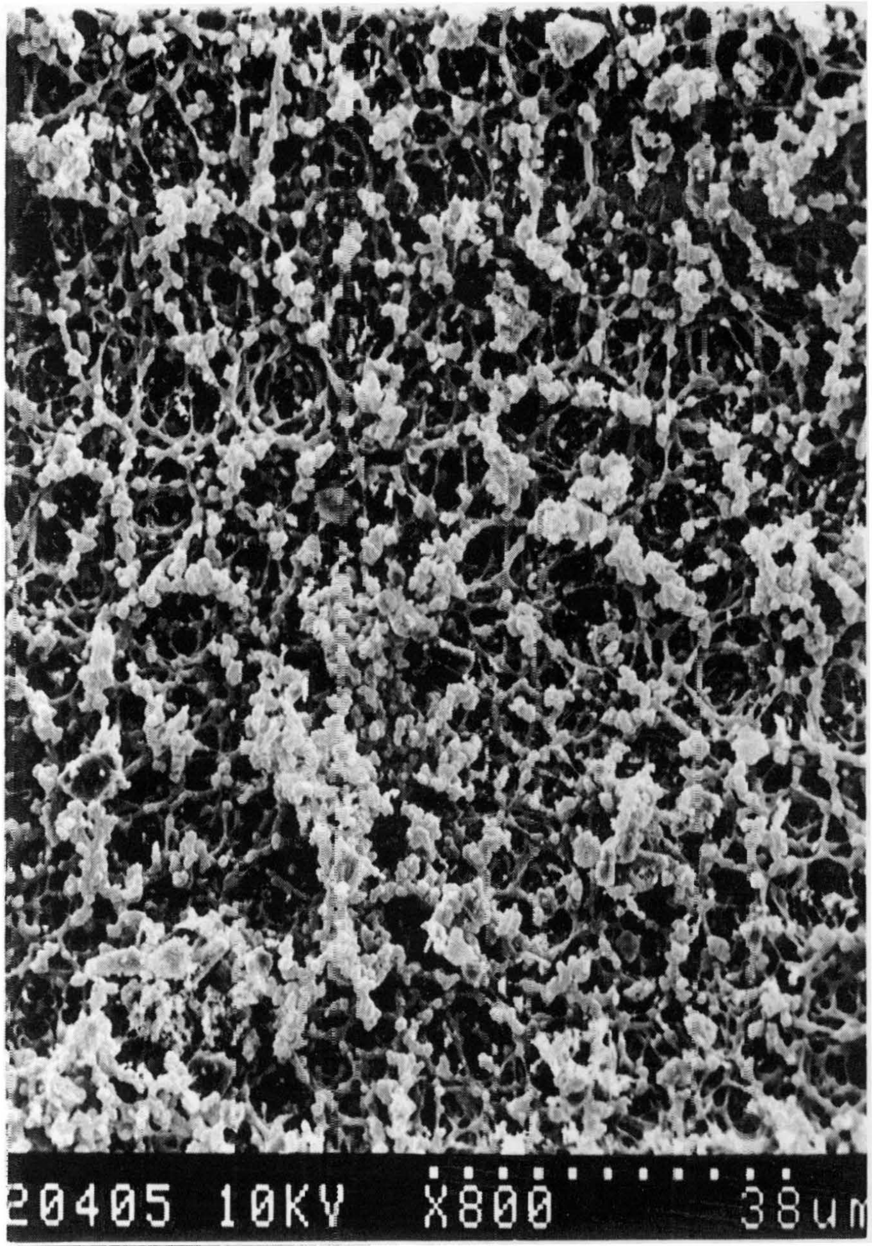


Figure 29. SEM of Filter with 0.17 mg/cm^2 at 800X ($38\mu/4.8cm$)

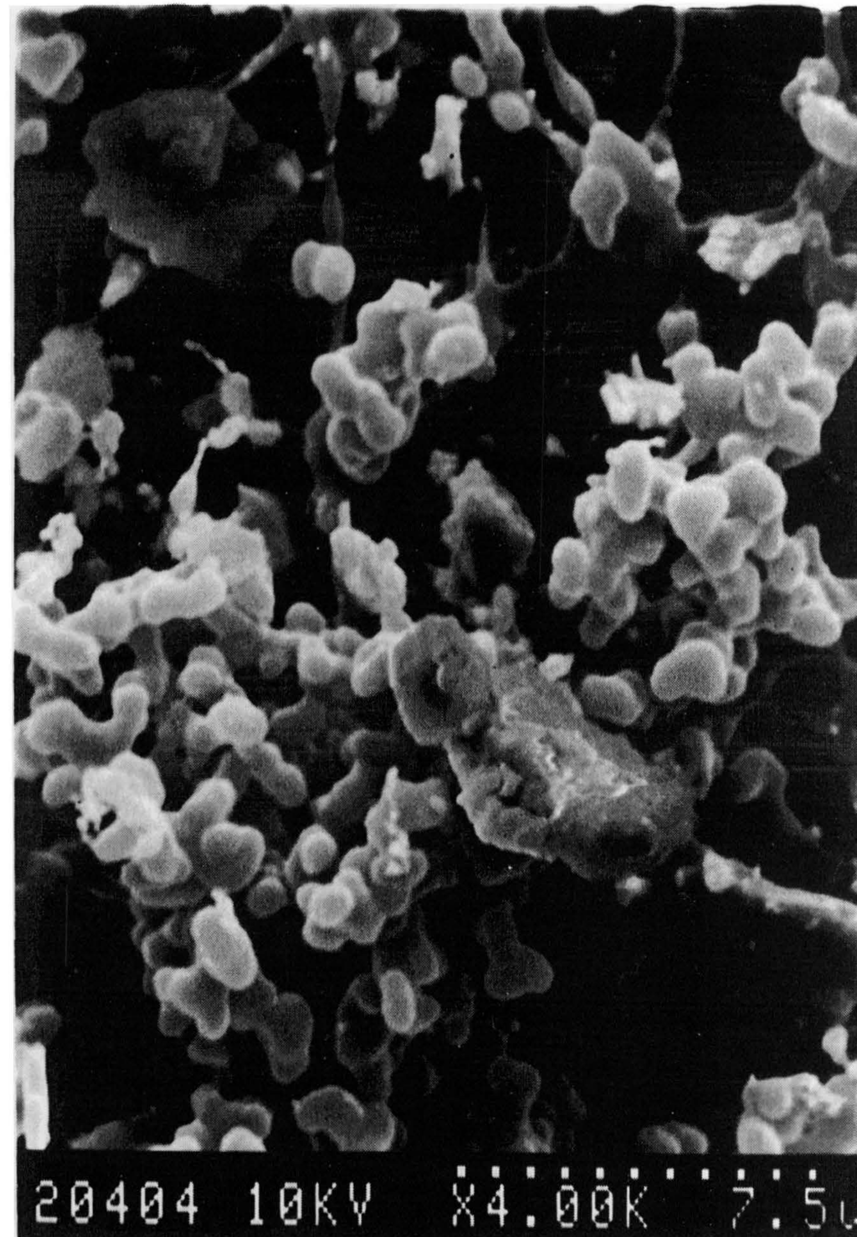


Figure 30. SEM of Filter with 0.17 mg/cm^2 at 4000X ($7.5\mu/4.8cm$)

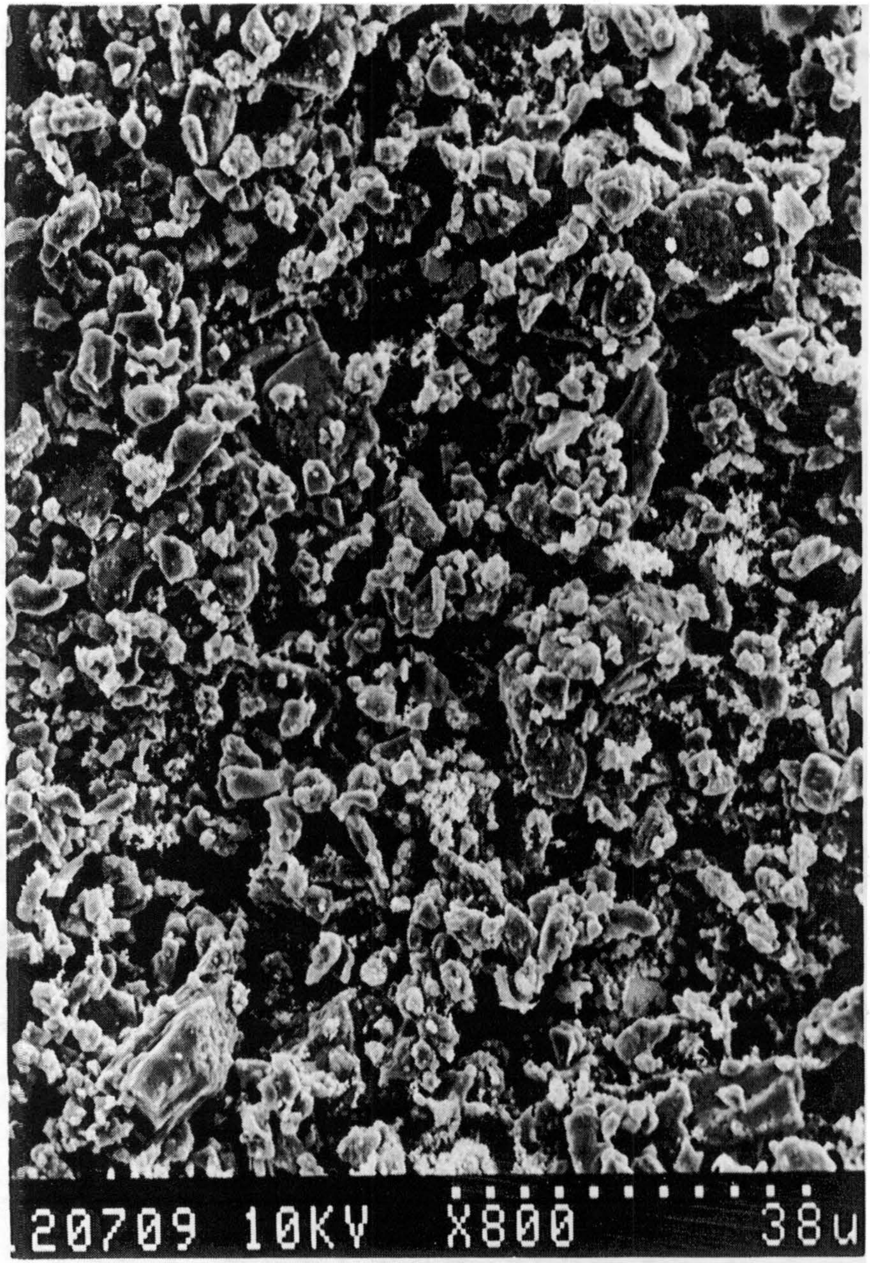


Figure 31. SEM of Filter with 1.60 mg/cm^2 at 800X ($38\mu/4.8cm$)

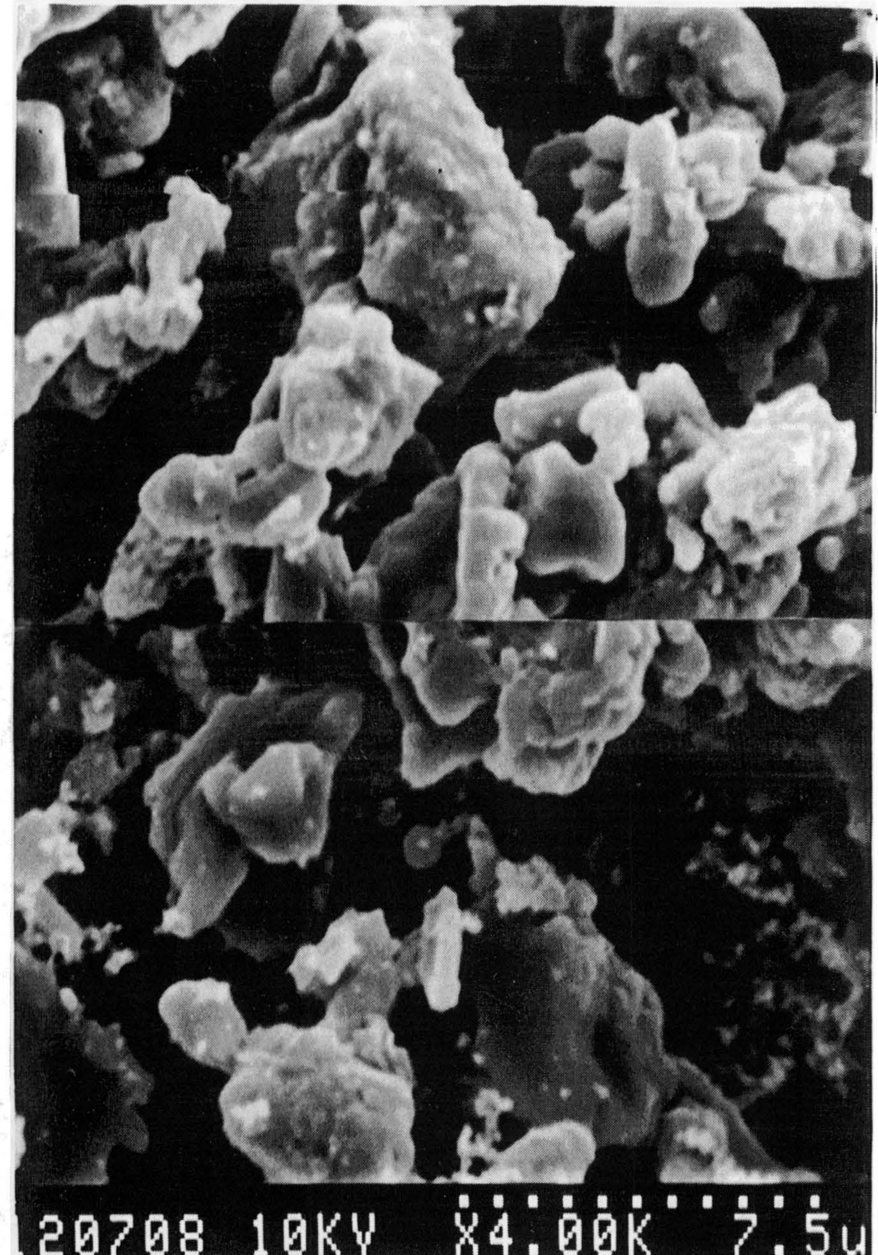
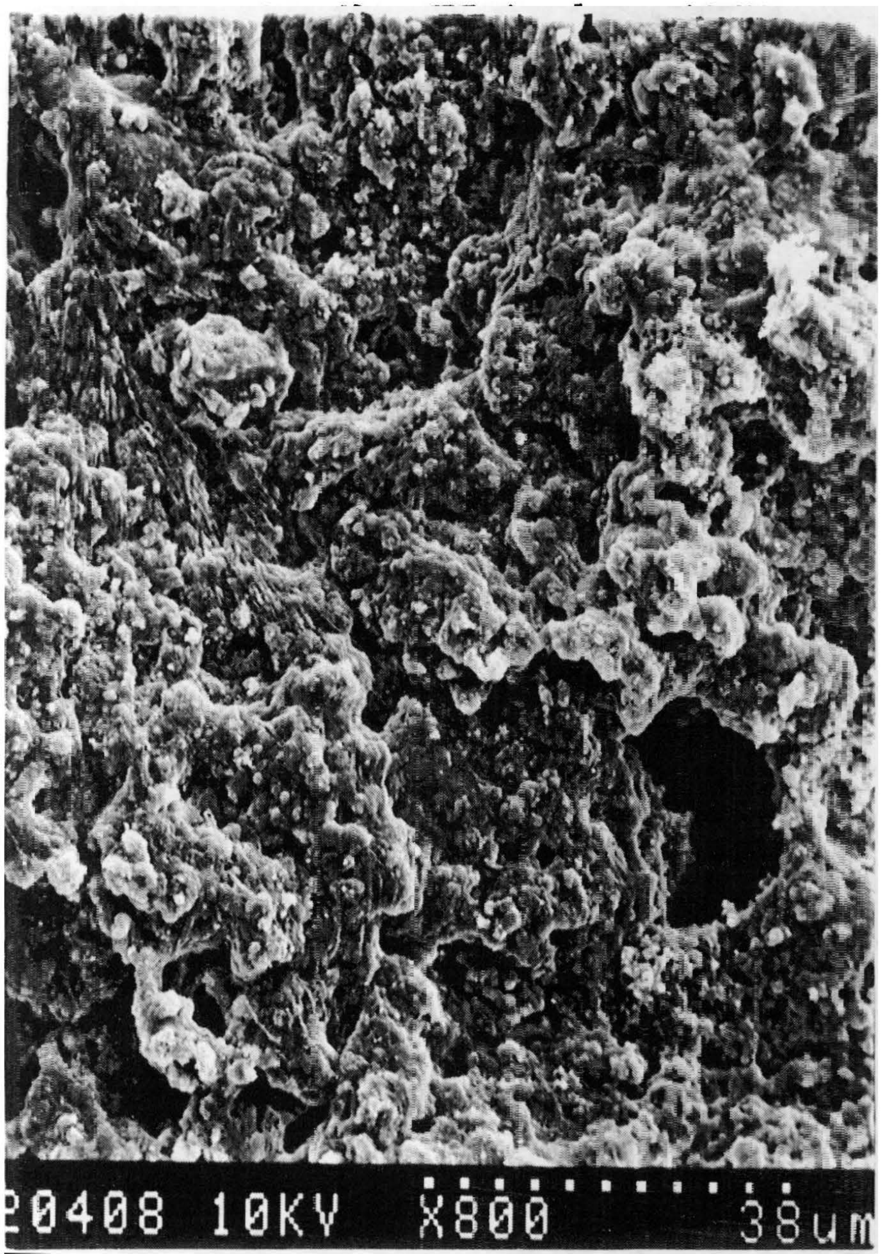


Figure 32. SEM of Filter with 1.60 mg/cm^2 at 4000X ($7.5\mu/4.8cm$), Dual Exposure



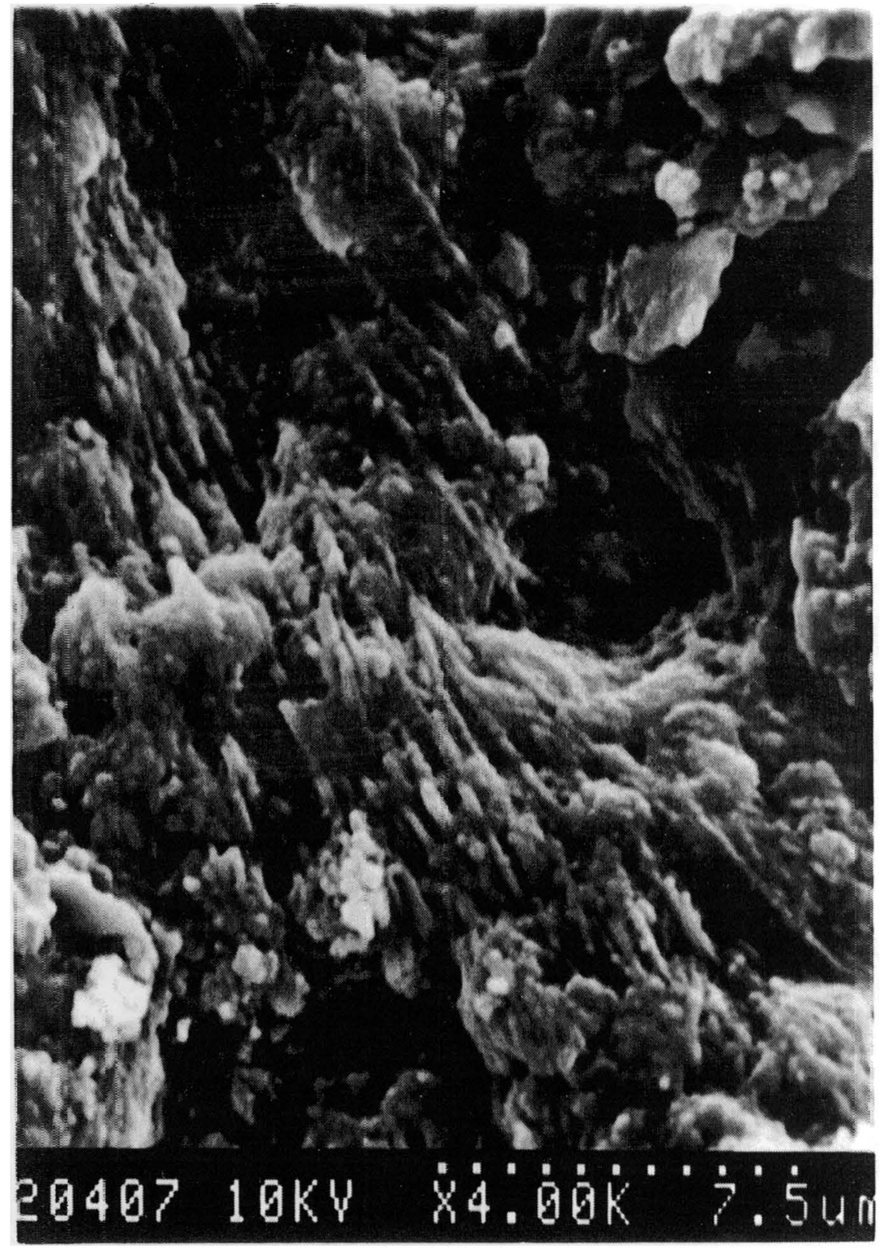


Figure 33. SEM of Hydrated Filter with 1.36 mg/cm^2 at 800X (38μ/4.8cm)

Figure 34. SEM of Hydrated Filter with 1.36 mg/cm^2 at 4000X (7.5μ/4.8cm)

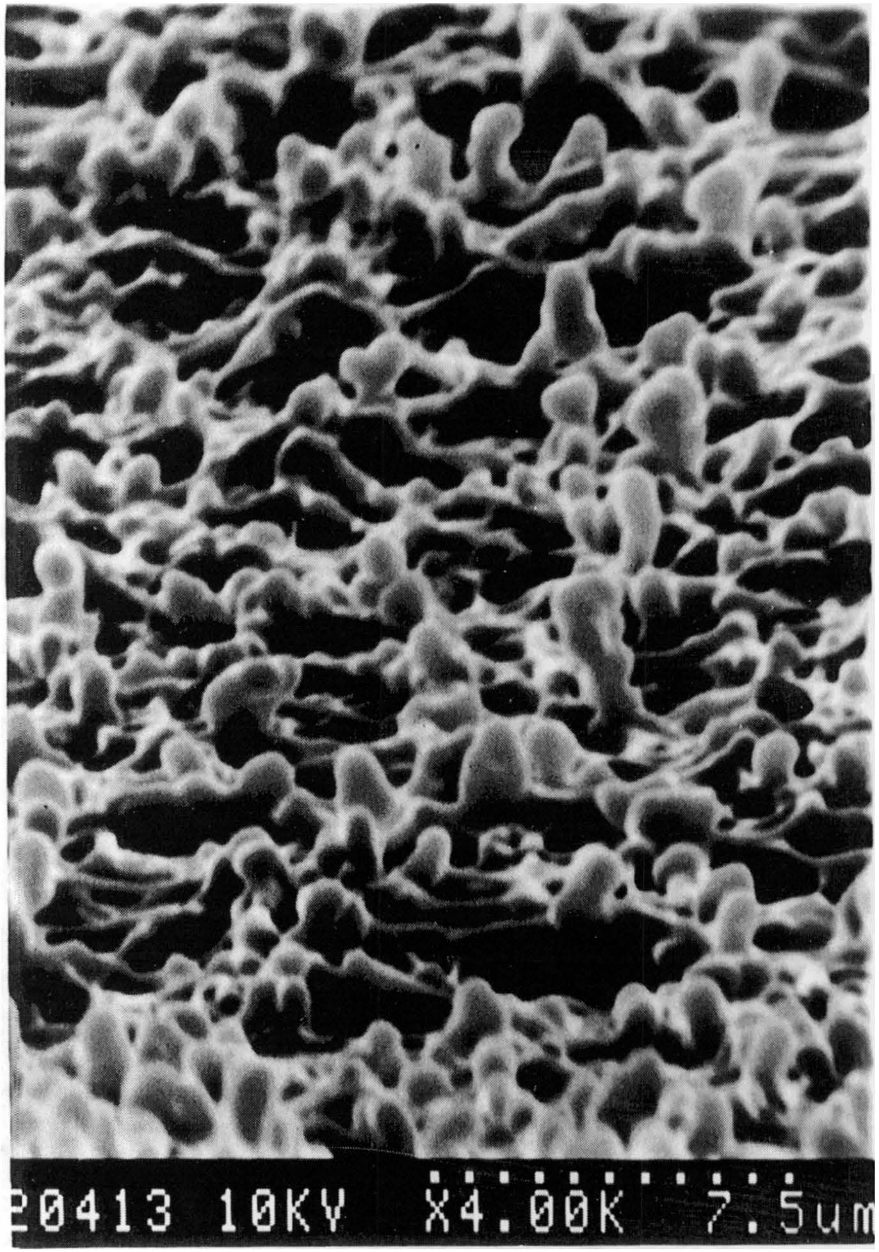


Figure 35. SEM of Clean Filter at 75° Tilt at 4000X (7.5μ/4.8cm)

Figure 36. SEM of Filter with 0.88 mg/cm^2, 75° Tilt at 2500X (12.0μ/4.8cm), with butterfly wing part in center

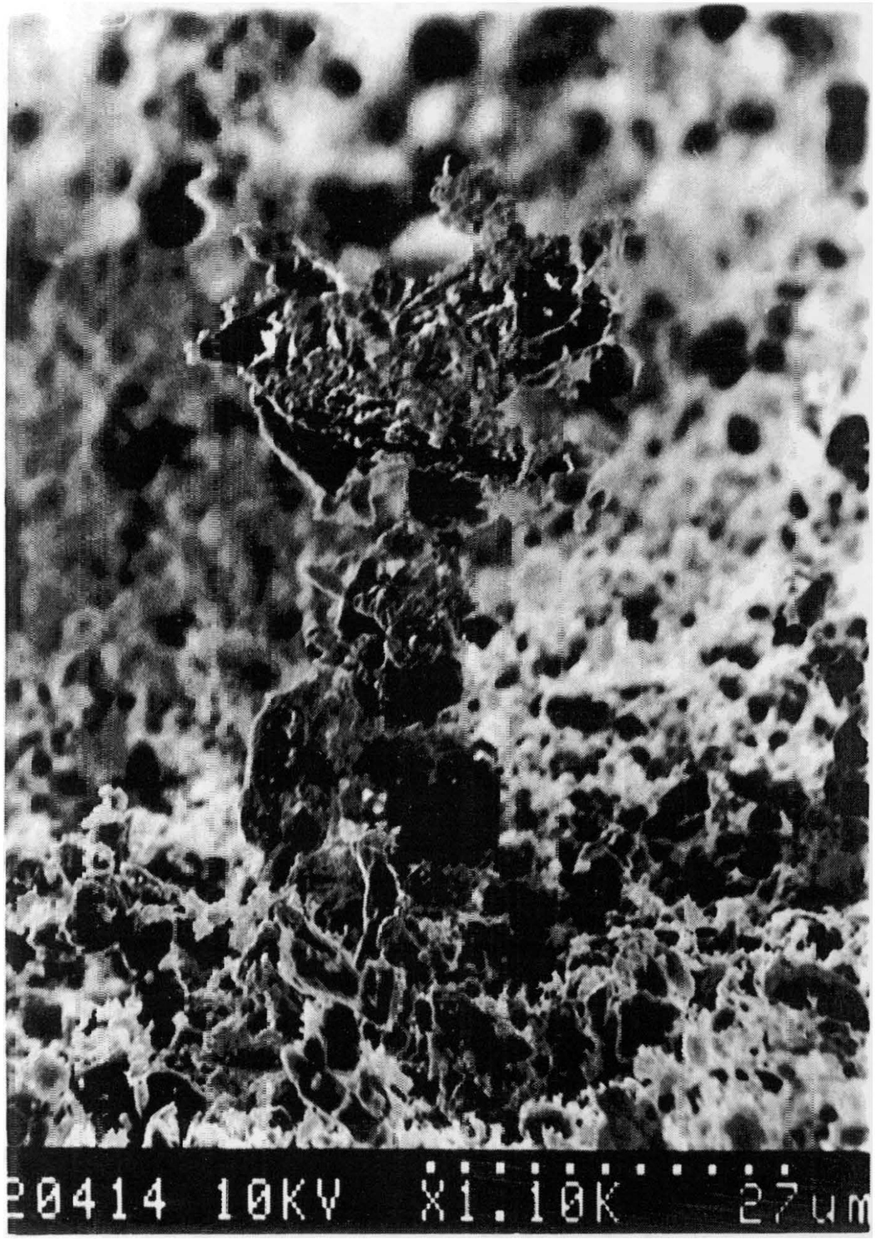


Figure 37. SEM of Filter with 0.17 mg/cm^2, 75° Tilt at 1100X (27μ/4.8cm), with ≈ 70μ High Tree-like Structure

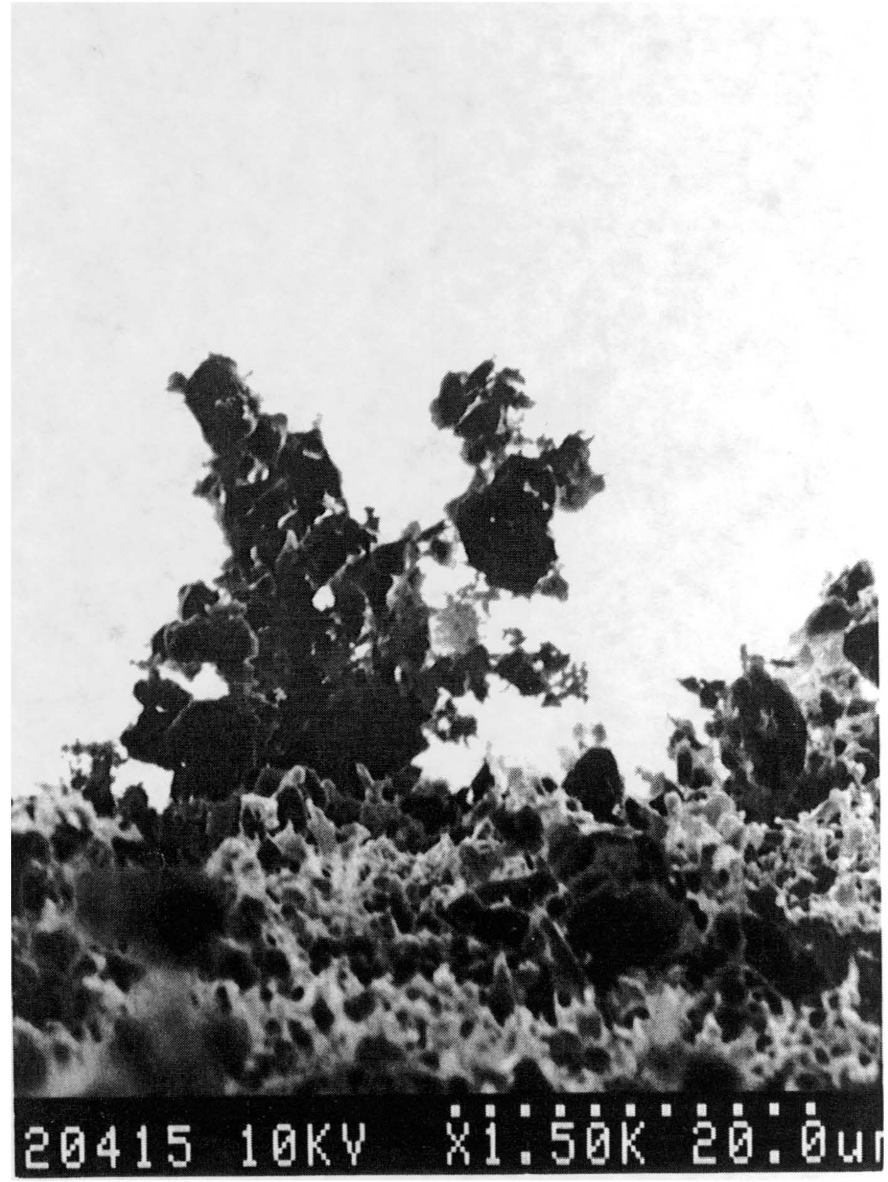


Figure 38. SEM of Filter with 0.17 mg/cm^2, 75° Tilt at 1500X (20μ/4.8cm), with ≈ 30μ High Tree-like Structure

8.0 FINDINGS AND DISCUSSION

The following 39 categorical findings need to be clearly and candidly addressed by the DOE. The lack of information, and frequency and similarity of findings form the basis of the EEG's concern that the CAMs are not properly qualified as effluent monitors.

In some of the findings, it is obvious that the EEG requests have not been addressed, and a response is needed. In other findings, the information may contradict statements made by the DOE in meetings, and the DOE should provide a written confirmation of their perspective and policy.

For example, the EEG would expect the DOE to concur with Finding (1) or explain why our finding may need to be modified. The EEG concluded that only one alpha and one beta CAM are required to monitor the unfiltered underground exhaust. The implication is these monitors must be operational whenever unfiltered air is released to the environment and that equipment failures must be immediately recognized. Formal testing is needed to prove the performance and sensitivity capabilities. The EEG would prefer that the DOE address the finding directly rather than making unrelated responses, such as in Section 6.0, Response 1a., in which the DOE stated they did not take credit for CAMs in accident assessments. The point here is that CAMs are required and need to be tested. If the DOE believes CAM effluent monitors are not needed, then they should provide appropriate rationale.

FACILITIES

(1) The underground repository operation requires only one operational alpha CAM and one beta CAM to monitor the unfiltered exhaust. The air exhaust is normally unfiltered, but air can be diverted to a high efficiency filtration

system if either CAM signals a possible radiological release. Although there are other CAMs that could monitor the repository exhaust air, these CAMs are not required by the FSAR and do not automatically shift exhaust to filtration. The DOE acknowledges many of the underground CAMs are non-operational a significant percentage of the time (reference Section 2.2, Section 5.24, Appendix D-1). For the EEG to agree that WIPP is operationally ready, the adequacy and reliability of the required alpha and beta CAMs must be proven and documented. If other monitors are to be claimed as part of the air effluent monitoring system, then the specific monitor requirements should be documented in the FSAR, and the results of testing should be available.

(2) The effluent CAM alarm levels should be specified in the FSAR along with the appropriate supporting information and justifications. The WIPP Radiation Safety Manager has the responsibility for establishing effluent CAM alarm levels as stated in the FSAR Chapter 10. The alarm level criteria are not specifically documented and justified in the FSAR with appropriate references to requirements in 40 CFR 61, DOE Order 5480.11, DOE Order 6430.1A, DOE Order 5481.1B, and DOE Order 5400.5 (reference Section 2.2).

(3) The CAM systems should be classified as safety class equipment or the DOE should provide proof-of-design tests and qualification testing of all LCO CAMs to indicate their capability to consistently perform the functions in the environments in which they will be used. The effluent CAMs are not classified as "safety class" equipment in the FSAR. Consequently, a more stringent level of CAM performance testing is not required by DOE. CAM systems must meet Limiting Condition for Operation (LCO) requirements, but there are no quantitative equipment performance requirements listed in the FSAR (reference Section 2.2 and 4.5.4).

(4) If CAMs are not part of the confinement system, then the DOE should clearly state how the facility provides multiple confinement of nuclear wastes at all times. The DOE specifically stated that the Station A effluent CAM systems are not part of the underground facility radiological confinement strategy. In contradiction to this statement, multiple confinement barriers are required in the FSAR Chapter 3.3. Unless effluent is continuously filtered, the underground facility provides no additional confinement to that of the waste container. It is the EEG opinion that the CAM systems are a necessary part of the dynamic confinement system described in the FSAR, because they signal the need to filter air. Without a reliable effluent CAM system, there is no clear method for compliance with the FSAR (reference Section 2.2 and Section 6.0, EEG Response 1a).

INSTRUMENTS

(5) As in Finding (3) above, independent test reports should be available for both alpha and beta LCO CAMs. Although start-up tests are performed to determine if CAM systems are functional, this does not substitute for independent proof-of-design testing previously recommended by the EEG. The testing is necessary to determine the operational limits of both alpha and beta CAMs (reference Section 3.2).

(6) In addition to the information in Finding (5), the EEG is requesting beta CAM basic design and operational descriptions. The EEG has not been provided any basic information on the design, operation or in-situ performance of beta CAMs (reference Section 3.7). The information should include details such as filter/detector spacing, type of sampling probes used, method for subtraction of radon/thoron progeny, expected LLD, beta energy sensitivity, and other appropriate design and operational information.

REGULATIONS

(7) The determination of applicability of the DOE safety regulations resides with the same DOE "chain of command" responsible for management, construction, and fiscal accounting (reference Section 4.1). With regard to compliance with environmental regulations, the responsible individual(s) should be identified.

(8) The operational limitations of workplace CAMs should be documented for all the various environmental conditions found at WIPP. The DOE does not place strict numerical performance requirements on workplace CAMs. An 8 DAC-hr sensitivity is suggested for laboratory conditions (U.S. DOE 1988), but non-laboratory performance criteria are not stated. In effect the role of the workplace CAM is to alert workers to the presence of unusually high concentrations of radioactive aerosols. Other monitoring methods are necessary to prevent chronic exposure to aerosols (reference Section 4.3.2).

(9) All appropriate laboratory analyses and bioassay methods should be available at the WIPP site rather than reliance on capabilities at other DOE or contractor locations. Use of sensitive alternative workplace monitoring methods is important to insure compliance with dose limitations and ALARA regulations. Two alternative monitoring approaches are commonly used, laboratory analysis of air sampling filters and bioassay (reference Sections 4.3.2 and 4.3.3).

(10) There is a need for a lung monitor (bioassay) facility. DOE Order 5480.11 requires an internal dose evaluation program and an ALARA program. These programs are essential in verifying that on-site staff have not had significant uptake of radioactive material and the effluent controls are adequate (reference Section 4.3.2). As in Finding (9),

these capabilities should be available at WIPP. The EEG requests a plan for the procurement of these capabilities.

(11) The DOE needs to provide and justify the necessary calculations to predict on-site and off-site doses. If the codes can not be properly applied, then the DOE should state how it intents to limit releases to the concentration guides found in DOE 5400.5. The data, particularly the meteorological data, used in the calculations should be accurate and obtained in accordance with quality assurance standards.

There are several regulations which apply to routine effluent releases. The NESHAPS regulations, 40 CFR 61, suggest that routine releases may not exceed 10 mrem in a year at an off-site residence. Part 1 of 40 CFR 191 limits whole body dose, off-site, to 25 mrem in a year. DOE Order 5400.5 requires reporting of 10 mrem in a year doses. DOE Order 5480.11 also requires that members of the public be limited to 100 mrem in a year for routine or accidental releases, on-site or off-site (reference Section 4.4).

Verification of these limits is normally based on certified EPA effluent release codes which predict dose at a point based upon meteorological and physical release parameters. If calculational codes are not appropriate, then release point concentration limits, as specified in DOE 5400.5, should be used to restrict releases instead of a calculational approach.

(12) The most effective method to reduce possible radiological releases is by proper facility design. There are conflicting positions within the DOE regarding applicable design regulations. The DOE stated a 6/10/81 version of DOE Order 6430 as applicable to the WIPP, but it appears that the WIPP design was completed after the effective date of 12/12/83 for DOE Order 6430.1. The DOE Albuquerque

Operations Office stated that the DOE complies with the 4/6/89 version, DOE Order 6430.1A, but the WIPP has not strictly followed the provisions of DOE Order 6430.1A.

Regardless of the applicable regulation, it is important to insure compliance with effluent release regulations. The underground facility does not appear to be designed to prevent accidental releases to the environment. In addition, the DOE insists that the CAM is not part of the confinement system strategy, and it remains questionable as to how the underground exhaust filtration building would play a role in mitigating accidental releases without the effluent CAM system (reference Section 4.5). The DOE should review the requirements of DOE Order 6430.1A and document in the FSAR the reasons for deviations from the regulations. If adequate justifications are not available, the facility should be redesigned accordingly.

REPORTS AND COMMUNICATIONS

(13) In 1988, the WIPP followed the suggestions in EEG-38 and replaced the L X-ray CAMs with alpha and beta CAMs. The EEG made a recommendation that a formal test plan be developed and that the EEG be allowed to review the plan. No plan has been provided (reference Section 5.1). The EEG still desires to have such a plan.

(14) There have been numerous WIPP technical studies relating to various aspects of continuous air monitoring. This information has been extremely valuable in the development of the WIPP air monitoring program, and in some instances the WIPP has established state-of-the-art methodologies. The reports reviewed were as follows:

DOE/WIPP 88-027 Design of an aerosol probe

DOE/WIPP 88-024	Testing of Station A sampling systems
ITRI Phase I	An evaluation of the ALPHA-6
ITRI Phase II	ALPHA-6 components and salt burial of plutonium experiment
ITRI Lab Tests	Experience with the ALPHA-6
ITRI In-line Sampler	Studies with an experimental sampling head
CAM Expert Panel	Workplace monitoring recommendations

These reports were not designed as CAM performance test reports (reference Section 5.0). As in Finding (13), the EEG desires to have appropriate performance information.

(15) In February 1989, the EEG recommended that a well-designed, long-term salt aerosol monitoring program be initiated. There has been no response to this recommendation (reference Section 5.6). The EEG would like to have this information.

(16) In December 1989, the ITRI staff recommended that networking of CAM spectral data would help in identifying operational problems. The same recommendation was made in the CAM Expert Panel Report, June 1991. There has been no response to this recommendation (reference Sections 5.8 and 5.23). The EEG would like to be informed on the progress and appropriateness of this task.

(17) In May 1990, the EEG again recommended that a formal performance test program be developed for the CAM systems. There has been no formal response to this presentation (reference Section 5.13). As in Findings (13) and (14), the EEG would like to have this information.

(18) In May 1991, a DOE report referenced problems with the NRC sampler at Station A. No corrective action has been

identified to the EEG (reference 5.17). The EEG would like to have this information.

(19) In May 1991, the ITRI published a report on the feasibility of an in-line sampler. There has been no response to the possibility of using this system (reference 5.19). The EEG would like to be informed as to the status of this project.

(20) In the February 14, 1991 DOE/EEG Quarterly Meeting, the EEG advised the DOE that the Stoller report (Hunt 1991a) did not consider critical variables in the on-site dose calculations. There has been no response to this critique (reference Section 5.20). The EEG believes these calculations do not take into account important variables, and the calculations should be revised accordingly.

(21) In June 1991, the DOE provided a package of procedures describing start-up tests, alarm set-points, and calibration methods. There were significant errors associated with the alarm set-point methodology. Station A is even allowed a temporary setting of 1,040 CPM, 26 times higher than the normal setting of 40 CPM. The detector calibration criterion is a +/- 50% efficiency tolerance which is not considered in relation to alarm level settings. There has been no error analysis to indicate the accuracy of effluent measurements (reference Section 5.22). The EEG requests that the error analysis be performed and that the procedures allowing extraordinarily high alarm settings be revised to allow only a normal alarm setting.

(22) There is no final resolution of the June 1991 Expert Panel recommendations. In March 1992, half of the recommendations were pending (reference Section 5.23). In an October 30, 1992 meeting with the DOE and WID, no additional resolutions were identified. The EEG would like to be advised of the disposition of these recommendations.

PRESENT CAM STATUS

(23) The DOE states that it does not take credit for the operation of the effluent monitoring system as an integral part of the underground confinement strategy. If CAM's are not part of the confinement strategy, then the ALARA considerations in the FSAR should be formally reviewed and revised. Particular attention should be given to the function of the exhaust filtration building (reference Section 6.0, EEG Questions 1a and 1b).

(24) Effluent CAMs are used as facility LCO systems. The measurement accuracy should be well understood. A review of the DOE's technical response indicates that improvements are needed in basic calibration and testing of CAM systems (reference Section 6.0, EEG Questions 2a and 2b).

(25) There is a lack of understanding of CAM detector failure mechanisms. Sufficient data have not been collected to characterize the mechanism of failure, yet qualitative methods are somehow used to make decisions regarding operability. Detector efficiency data need to be systematically collected and used as the basis for operability decisions (reference Section 6.0, EEG Questions 2a - 2d).

(26) New alpha CAM detectors are being procured for use in the WIPP salt environment. The procurement specifications should have a minimum detector efficiency, and the CAM detector and system should be tested as a unit, prior to installation. Detailed EEG recommendations should be considered in developing a performance testing plan (reference Section 6.0, EEG Question 4).

(27) The response of CAMs in a plutonium/salt/radon mixture should be evaluated (reference Section 6.0, EEG Question 5).

(28) The procedures and methods used for fixed air sampler (FAS) systems should be modified. The sensitivity and accuracy do not appear to be compatible with requirements in 40 CFR 61, Appendix B, Method 114 (reference Section 6.0, EEG Question 6).

(29) Additional investigation of commercially available state-of-the-art CAM systems is needed. The study should be formalized and published as at other DOE sites (McIsaac and Amaro 1992), and the particular requirements of the WIPP should be recognized. If CAM deficiencies identified in this report can not be corrected, another CAM system should be considered for effluent monitoring (reference Section 6.0, EEG Question 7).

(30) As in Finding (15) above, no gravimetric data are being collected in underground areas. A similar concern was expressed in the CAM Expert Panel Report. Although there are administrative actions that can be taken when salt aerosol concentrations are high, there is no method to determine when salt concentrations are abnormally high (reference Section 6.0, EEG Question 8). This method should be developed prior to receipt of radioactive wastes at the WIPP.

RESULTS OF CAM DATA ANALYSIS

(31) Technicians are trained to recognize degraded spectra in order to identify detector failures. This method is not quantitative and is not documented in the operability checks procedure WP 12-518, Rev 5 (reference Section 7.5). A quantitative method for operability checks is needed.

(32) Computerized CAM data indicate that CAM 27 which is in a clean, air-conditioned environment performs much better than three CAM systems which monitor salt-aerosol environments (reference Section 7.5). The DOE should provide appropriate explanations for these differences, including theoretical and empirical information on CAM particle collections.

(33) The reliability of the LCO CAM 153 at Station A appeared to improve significantly over an 18 month period, but as recently as 6/92, greater than 20% of the spectra showed degradation. In 7/92, both Station A CAM systems failed for greater than a 2 week period (reference Section 7.5). The DOE should empirically determine the loss of efficiency that occurs when spectra are degraded.

(34) The EEG Station A gravimetric data for the period 1/92 through 6/92 are in Appendix F-10 through F-13. The recommended 0.2 mg/m^3 salt aerosol concentration limit was exceeded numerous times, even when averaged over a 24 hour period (reference Section 7.6). Methods should be developed to prevent excessive salt aerosol concentrations.

(35) The effective alarm level at Station A is raised significantly by negative plutonium channel excursions. Negative plutonium channel counts are directly related to degradation of the spectrum by high salt aerosol concentrations (reference Section 7.7). Negative plutonium channel excursions should be considered a failure mode and equipment should be designed to have a failure alarm. Alarm levels should be adjusted to compensate for possible negative count variability.

(36) The data indicate that high salt loading significantly reduces the efficiency of alpha detectors. The loss of efficiency can not be identified by the present operational validation methods, and salt aerosol concentrations are only

measured retrospectively by analysis of filters (reference Section 7.8). Methods should be available to automatically indicate high salt loading on filters.

(37) The data indicate that detector efficiency also varies significantly when salt aerosol levels are relatively low. This may be the result of other environmental factors, and these factors may affect electronic performance, including amplifier output (reference Section 7.9). The need for comprehensive performance testing is evidenced by these findings.

(38) Observation of the magnitude of plutonium channel counts or spectral displays checks are not conclusive evidence that the CAM systems are performing properly. A quantitative operability check must be developed (reference Section 7.9).

(39) It can not be assumed that salt will be collected as layers on the surface of the CAM filter. If aerosol particles penetrate into the filter or the salt matrix formed on the filter surface, then alpha detector efficiency may be reduced for both chronic and <u>acute</u> radioactive releases. The CAM filter particle collection mechanism appears to be by electrostatic trapping within a highly porous matrix. As shown in Section 7.10, salt collected on filters from Station A tends to form particle matrices with numerous 5 to 10 μ gaps and holes. Additional research is needed to determine the depth of particle penetration into both the salt matrices and the filter medium. The result of this research should be development of quantitative correction factors for the CAM systems.

9.0 CONCLUSIONS

The WIPP design requires that multiple confinement barriers always be between the radioactive waste and the outside environment. If a primary confinement barrier is breached, then a secondary confinement barrier must remain in place to prevent the spread of the radioactive material. Confinement requirements apply to both chronic and accidental releases which must be reduced to negligible levels.

In the Waste Handling Building, air pressure is maintained negative to the outside environment, and all exhaust ventilation air passes through HEPA filters before release to the environment. The waste container is the primary confinement barrier; the negative building pressure and HEPA filtration provide the secondary confinement.

In the underground repository, ventilation air is not filtered before discharge to the environment. If a waste container is breached, air must be diverted to a HEPA filtration building on the surface. The FSAR identifies the HEPA filtration building and associated air monitoring systems as the secondary confinement barrier. Unfiltered exhaust must be continuously monitored to identify possible radiological releases and, if necessary, divert the exhaust to HEPA filtration.

CAMs at the Station A underground air exhaust point are an essential part of the underground repository secondary confinement barrier. Because the CAMs have such a unique role in the confinement strategy, the EEG believes that the Station A CAMs should be classified as safety class equipment with all the prerequisite testing requirements. Regardless of the safety classification, the Station A CAMs must have adequate sensitivity and must operate 100% of the time.

The Station A CAM sensitivity is established by a variety environmental regulations. The two most limiting regulations restrict off-site doses to 10 mrem in a year (40 CFR 61) and on-site doses to 100 mrem in a year (DOE Order 5480.11). The DOE calculations suggest that the on-site and off-site regulatory limits can be satisfied by a Station A alpha CAM alarm setting of 40 cpm. The DOE also states these regulations can be satisfied by retrospective analysis of filters from the Station A fixed air samplers. If the DOE relies on the Station A fixed air sampler filter analyses instead of the CAMs for environmental compliance measurements, then an alternate secondary confinement barrier must be in place.

In the test phase, test bins will be emplaced in the underground repository. Unlike a standard waste drum, the test bins have a secondary confinement system which appears to satisfy the FSAR requirements. If the Station A fixed air sampler filters are used to verify compliance with environmental regulations, then it appears that the Station A CAM confinement and monitoring functions can be replaced by alternative methods.

The EEG reviewed procedures for the collection and analysis of Station A fixed air sampler filters, and the analytical methods do not appear to have adequate sensitivity to satisfy regulatory requirements. The laboratory methods are poorly defined and do not consider salt attenuation or appropriate radon/thoron correction factors.

In addition to confinement and environmental measurement functions, the Station A CAMs are also used to satisfy the LCO requirements specified in the FSAR. LCO CAMs must always be operational during waste operations. If either of the Station A LCO CAMs (alpha or beta) is non-operational for greater than one hour, then the underground exhaust must be stopped or diverted to HEPA filtration.

The sensitivity criteria for the LCO CAMs are not specifically stated in the FSAR, but the WIPP Radiation Safety Manager is delegated the responsibility for determining the alarm levels. As mentioned above, the alarm level should be low enough to limit on-site doses to 100 mrem in a year. The DOE must also satisfy the ALARA regulatory requirements which require as little as 10 mrem in a year to be measured and reported.

CAM operational data show that the effluent alpha CAM system is not fail-safe and does not maintain a 40 cpm alarm sensitivity. There are lengthy, unexplained times in which CAM operational data are not available. Spectra from the Station A LCO alpha monitor appear degraded as much as 25% of the time. On occasion, plutonium counts are negative, indicating a non-conservative measurement. The DOE has not provided similar equipment descriptions or operational data for beta CAMs.

The EEG review indicates that poor CAM performance is linked to high salt-aerosol concentrations. High salt buildup on filters may cause 60% or more reduction in radon alpha counts, and 95% or more reduction in plutonium counts. There are no continuous, real-time methods to measure salt aerosol concentrations or high levels of salt loading on filters.

The daily operational check procedure for CAMs is not quantitative and will not detect loss in detector efficiency. Immediate identification of LCO CAM non-operational status is necessary for waste operations, and adequate methods do not appear to be available to satisfy this requirement.

The EEG evaluated the WIPP effluent dispersion code used for on-site and off-site dose calculations. The code apparently does not account for backwash or building wake effects caused by the unusual design of the underground air exhaust stack. Without an appropriate code or appropriate empirical data, the effluent CAM on-site alarm level can not be established. Even if the

Station A alpha CAM systems are shown capable of reliably measuring 40 cpm, this alarm level will probably not be restrictive enough for on-site monitoring requirements.

REFERENCES

American National Standard, 1969. American National Standard Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities. February 13, 1969. ANSI N13.1-1969, Institute of Electrical and Electronics Engineers, New York.

American National Standard, 1977. American National Standard Radiation Protection Instrumentation Test and Calibration. September 13, 1977. ANSI N323-1978, Institute of Electrical and Electronics Engineers, New York.

American National Standard, 1980a. Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluent. August 15, 1980. ANSI N42.18-1980, Institute of Electrical and Electronics Engineers, New York.

American National Standard, 1980b. Testing of Nuclear Air-Cleaning Systems. May 31, 1980. ANSI N510-1980, Institute of Electrical and Electronics Engineers, New York.

American National Standard, 1989. Performance Specifications for Health Physics Instrumentation - Occupational Airborne Radioactivity Monitoring Instrumentation. September 7, 1989. ANSI N42.17B-1989 (Redesignation of ANSI N13.10), Institute of Electrical and Electronics Engineers, New York.

Arthur, W. J., III, 1992. August 8 letter from the DOE WIPP Project Director to R. H. Neill, EEG Director.

Bartlett, W. T., 1992. "Measurement of Transuranic Radionuclides in a Salt Matrix by L X-ray Spectrometry." Presented at the 37th Annual Meeting of the Health Physics Society, Columbus, OH, June 23, 1992.

Carter, M. W., J. L. McAtee, B. L. Rich, and S. J. Waligora, Jr., 1991. "WIPP Continuous Air Monitoring Program, Report of the External Expert Review Panel, May 13-17, 1991, Carlsbad, NM." (Transmitted by A. Hunt, DOE Project Manager to R. H. Neill, EEG Director, August 22, 1991).

Chase, G. D. and J. L. Rabinowitz, 1968. Principles of Radioisotope Methodology. Burgess Publishing Company, Minneapolis, MN.

Elder, J. C., J. M. Graf, J. M. Dewart, T. E. Buhl, W. J. Wenzel, L. J. Walker and A. K. Stoker, 1986. A Guide to Radiological Accident Considerations for Siting and Design of DOE Nonreactor Nuclear Facilities. LA-10294-MS, Los Alamos National Laboratory, Los Alamos, NM.

Faust, L. G., Chairman, 1988. Health Physics Manual of Good Practices for Plutonium Facilities. PNL-6534, Pacific Northwest Laboratory, Richland, WA.

Guralnik, David B. (ed.), 1976. Webster's New World Dictionary. World Publishing Co., Cleveland, OH.

Hoover, M. D., G. J. Newton, H. Yeh, F. A. Seiler, and B. B. Boecker, 1988. Evaluation of the Eberline Alpha-6 Continuous Air Monitor for the Use in the Waste Isolation Pilot Plant: Phase I Report. Lovelace Inhalation Toxicology Research Institute, Albuquerque, NM.

Hoover, M. D. and G. J. Newton, 1991. Response of the Eberline Alpha-6 to Low Level Releases of Plutonium. ITRI-TR-910602, Lovelace Inhalation Toxicology Research Institute, Albuquerque, NM.

Hunt, A., 1991a. April 4 letter from the DOE WIPP Project Manager to R. H. Neill, EEG Director. Enclosure was a paper (author not identified) prepared by S. M. Stoller Corporation titled "Verification of the Station A Alpha CAM Alarm Set Point at the Waste Isolation Pilot Plant."

Hunt, A., 1991b. May 21 letter from the DOE WIPP Project Manager to R. H. Neill, EEG Director. Enclosure was a paper (author not identified) titled "Operational Sensitivity and Performance of the Eberline Alpha-6 Continuous Air Monitor at the Waste Isolation Pilot Plant," dated January 24, 1991.

Hunt, A., 1991c. June 20 letter from the DOE WIPP Project Manager to R. H. Neill, EEG Director. Enclosures included papers titled "Waste Isolation Pilot Plant Alpha Continuous Air Monitoring System," by K. B. Steinbruegge and "Air Monitoring Philosophy at the WIPP," by T. D. Merkling.

Hunt, A., 1991d. August 30 letter from the DOE Project Manager to R. H. Neill, EEG Director.

International Commission on Radiological Protection, 1977. Radiation Protection. ICRP Publication 26, Pergamon Press, New York.

International Commission on Radiological Protection, 1978. Limits for Intakes of Radionuclides by Workers. ICRP Publication 30, Pergamon Press, New York.

International Commission on Radiological Protection, 1983. Radionuclide Transformations. ICRP Publication 38, Pergamon Press, New York.

Klement, A. W., ed., 1982. Handbook of Environmental Radiation. CRC Press, Boca Raton, FL.

Little, M. S., 1985. Evaluation of the Safety Analysis Report for the Waste Isolation Pilot Plant Project. EEG-29, Environmental Evaluation Group, Santa Fe, NM.

Mishima, J. and L. C. Schwendiman, 1973. Fractional Airborne Release of Uranium (Representing Plutonium) During the Burning of Contaminated Wastes. BNWL-1730, Battelle Northwest Laboratories, Richland, WA.

McFarland, A. R., C. A. Ortiz, M. E. Moore, R. E. DeOtte, Jr., and S. Somasundaram, 1988. A Shrouded Aerosol Sampling Probe. DOE/WIPP 88-027, U. S. Department of Energy, Carlsbad, NM.

McIsaac, C. V. and C. R. Amaro, 1992. Sensitivities of Five Alpha Continuous Air Monitors for Detection of Airborne ^{239}Pu. EGG-WTD-10314, U. S. Department of Energy, Idaho Falls, ID.

Neill, R. H., 1989a. February 17 letter from the EEG Director to J. B. Tillman, DOE Project Manager.

Neill, R. H., 1989b. August 30 letter from the EEG Director to J. B. Tillman, DOE Project Manager.

Neill, R. H., 1989c. November 17 letter from the EEG Director to W. J. Arthur, Acting DOE Project Manager.

Neill, R. H., 1990. December 5 letter from the EEG Director to A. Hunt, DOE Project Manager.

Neill, R. H., 1991a. August 9 letter from the EEG Director to A. Hunt, DOE Project Manager.

Neill, R. H., 1991b. October 24 letter from the EEG Director to A. Hunt, DOE Project Manager.

Neill, R. H., 1992. May 4 letter from the EEG Director to W. J. Arthur, DOE Project Director.

Newton, G. J., Y. Cheng, and B. B. Boecker, 1990. Evaluation of the Eberline Alpha-6 Continuous Air Monitor for use in the Waste Isolation Pilot Plant: Report for Phase II. Inhalation Toxicology Research Institute, Albuquerque, NM.

Newton, G. J. and M. D. Hoover, 1991. Laboratory Tests on the Inline Sampling Head for the Eberline Alpha-6 Continuous Air Monitor. ITRI-TR-910601, Inhalation Toxicology Research Institute, Albuquerque, NM.

Parks, B. S., 1992. User's Guide for CAP88-PC, Version 1.0. EPA 402-B-92-001, U. S. Environmental Protection Agency, Las Vegas, NV.

Rodgers, J. C. and J. W. Kenney, 1988. A Critical Assessment of Continuous Air Monitoring Systems at the Waste Isolation Pilot Plant. EEG-38, Environmental Evaluation Group, Santa Fe, NM.

Seiler, F. A., G. J. Newton, and R. A. Guilmette, 1988. "Continuous Monitoring for Airborne α Emitters in a Dusty Environment." Health Physics, 54 (May): 503-515.

Shleien, B., ed., 1992. The Health Physics and Radiological Health Handbook. Scinta, Silver Springs, MD.

Steinbruegge, K., 1989. "Ventilation System Smoke Tests, CH Bay Area and Underground at the Waste Isolation Pilot Plant." No Report Number Available (Tape delivered to EEG on April 26, 1990).

Tillman, J. B., 1988. November 22 letter from the DOE Project Manager to R. H. Neill, EEG Director.

Turner, W. D., A. R. McFarland, M. G. Glass, C. A. Ortiz, D. L. O'Neal, S. Somasundaram, N. K. Anand, and R. E. DeOtte, Jr., 1988. Tests of Model Waste Isolation Pilot Plant (WIPP) Exhaust Airflow Systems. DOE/WIPP 88-024, U. S. Department of Energy, Carlsbad, NM.

U. S. Code of Federal Regulations, 1990. National Emission Standards for Hazardous Air Pollutants. July 1, 1990. Part 40, Title 61, U. S. Government Printing Office, Washington, DC.

U. S. Code of Federal Regulations, 1992. Standards for Protection Against Radiation. January 1, 1992. Part 10, Title 20, U. S. Government Printing Office, Washington, DC.

U. S. Department of Energy, 1980. Environmental Protection, Safety, and Health Protection Program for DOE Operations. May 5, 1980. DOE Order 5480.1, Washington, DC.

U. S. Department of Energy, 1981. General Design Criteria. June 10, 1981. DOE Order 6430 (DRAFT), Washington, DC.

U. S. Department of Energy, 1983. General Design Criteria. December 12, 1983. DOE Order 6430.1, Washington, DC.

U. S. Department of Energy, 1987. Safety Analysis and Review System. May 19, 1987. DOE Order 5481.1B Chg 1, Washington, DC.

U. S. Department of Energy, 1988. Radiation Protection for Occupational Workers. December 21, 1988. DOE Order 5480.11, Washington, DC.

U. S. Department of Energy, 1989. General Design Criteria. April 6, 1989. DOE Order 6430.1A, Washington, DC.

U. S. Department of Energy, 1990. Radiation Protection of the Public and the Environment. February 8, 1990. DOE Order 5400.5, Washington, DC.

U. S. Department of Energy, 1992. Radiological Control Manual. DOE/EH-0256T, Washington, DC.

U. S. Department of Health, Education and Welfare, 1970. Radiological Health Handbook. U. S. Government Printing Office, Washington, DC.

Weng, P. S. and C. S. Sims, 1987. Dictionary of Radiation Dosimetry and Safety. Nuclear Energy Society of the Republic of China and American Nuclear Society Taiwan Section, LaGrange, IL.

Westinghouse Electric Corporation, Waste Isolation Division, 1990. Waste Isolation Pilot Plant Final Safety Analysis Report. WP 02-9, Rev. 0, Carlsbad, NM.

Westinghouse Electric Corporation, Waste Isolation Division, 1991. Waste Isolation Pilot Plant, Final Safety Analysis Report Addendum, Dry Bin-Scale Test. WP 02-9, Rev. 0, Carlsbad, NM.

White, M. W. and K. V. Manning, 1954. Experimental College Physics. McGraw-Hill, New York.

ACRONYMS

ALARA	As Low As Reasonably Achievable
CAM	Continuous Air Monitor
CFM	Cubic Feet per Minute
CFR	Code of Federal Regulations
CH-TRU	Contact Handled Transuranic (wastes)
CPM	Counts per Minute
DAC	Derived Air Concentration (reference DOE Order 5480.11)
DCG	Derived Concentration Guide (reference DOE Order 5400.5)
DOE	Department of Energy
EEG	Environmental Evaluation Group
EH	Environment Health (reference to an administrative group within the DOE that performs safety inspections)
EPA	Environmental Protection Agency
FAS	Fixed Air Sampler
FSAR	Final Safety Analysis Report
HEPA	High Efficiency Particulate (filter)
ITRI	Inhalation Toxicology Research Institute, Albuquerque, New Mexico
LCO	Limiting Condition for Operation (reference FSAR)
LLD	Lower Limit of Detection
NESHAPS	National Emission Standards for Hazardous Air Pollutants. (40 CFR 61)
NRC	Nuclear Regulatory Commission
PC	Personal Computer
ROI	Region of Interest (See Sections 3.5 and 3.6)
UPS	Uninterruptable Power Supply
WID	Westinghouse Electric Corporation, Waste Isolation Division (WID) at the WIPP
WIPP	Waste Isolation Pilot Plant

DEFINITIONS

Alpha Particles

A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and electrostatic charge of +2 (Shleien 1992).

Beta Particles

A charged particle emitted from a nucleus during radioactive decay... A negatively charged beta particle is identical to an electron (Shleien 1992).

Committed Dose Equivalent

The calculated dose equivalent projected to be received by a tissue or organ over a 50-year period after an intake of radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or sievert) (U.S. DOE 1988).

Committed Effective Dose Equivalent ($H_{E,50}$)

The sum of the committed dose equivalents to various tissues in the body, each multiplied by its weighting factor. It does not include contributions from external dose. Committed effective dose equivalent is expressed in units of rem (or sievert) (U.S. DOE 1988).

Dose (Absorbed Dose, D)

The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad or gray (1 rad = 0.01 gray) (U.S. DOE 1988).

Dose Equivalent

The product of absorbed dose (D) in rads (or gray) in tissue, a quality factor (Q), and other modifying factors (N). Dose equivalent (H) is expressed in units of rem (or sievert) (U.S. DOE 1988).

Mrem

Millirem, or one thousandth of a rem.

Occupation Worker

An individual who is either a DOE or DOE contractor employee; and employee of a subcontractor to a DOE contractor; or an individual who visits to perform work for or in conjunction with DOE or utilizes DOE facilities (DOE 5480.11).

Progeny

Radionuclide decay products, particularly those associated with naturally occurring radon and thoron.

Public Dose

Means the dose received by member(s) of the public from exposure to radiation and to radioactive material released by a DOE facility or operation, whether the exposure is within a DOE site boundary or off-site. It does not include dose received from occupational exposures, doses received from naturally occurring "background" radiation, doses received as a patient from medical practices, or doses received from consumer products (DOE 5400.5).

Radiation Worker

An occupational worker whose job assignment requires work on, with, or in the proximity of radiation producing machines or radioactive materials, and/or who has the potential of being routinely exposed above 0.1 rem (0.001 sievert) per year, which is the sum of the annual effective dose equivalent from external irradiation and the committed effective dose equivalent from internal irradiation (DOE 5480.11).

Radionuclide

Radioactive nuclide. A nuclide is any one of the more than one thousand species of atoms characterized by the number of protons and number of neutrons in the nucleus (Chase and Rabinowitz 1968).

Rem

The special unit of any of the quantities expressed as dose equivalent. The dose equivalent in rem is equal to the absorbed dose in rad multiplied by the quality factor (1 rem = 0.01 sievert) (Shleien 1992).

Source Term

The quantity of radioactive material released to the biosphere, usually expressed as activity per unit time. Source terms should be characterized by the identification of specific radionuclides and their physical and chemical forms (Weng and Sims 1987).

Transuranic

Designation of the elements having atomic numbers higher than that of uranium, as plutonium, prepared by nuclear bombardment (Guralnik 1976).

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APPENDICES

APPENDIX A: November 19, 1990 Neill to Hunt Letter

ENVIRONMENTAL EVALUATION GROUP

AN EQUAL OPPORTUNITY / AFFIRMATIVE ACTION EMPLOYER

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November 19, 1990

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Carlsbad, NM 88221-3090

Dear Mr. Hunt:

We are responding to certain statements in your October 22, 1990 letter that indicate an apparent contradiction in DOE policy. Your public position on numerous occasions has been that WIPP will comply with all applicable regulatory requirements. In our August 10, 1990 technical review, we referred to compliance with DOE Order 6430.1A. Your 10/22/90 response contained the following:

> "The major operational components of the WIPP facility were constructed in accordance with the design criteria of DOE Order 6430 (the draft version of DOE 6430.1). DOE Orders 6430.1 and 6430.1A were issued after the completion of the construction of those portions of the facility; consequently, the design requirements of these orders cannot be strictly applied to the WIPP. Any discrepancies between the original WIPP design and the criteria set out in these DOE orders do not constitute compliance issues but rather provide a framework for facility improvement."

Please advise us of the date of "the completion of those portions of the facility." We were not aware that the WIPP facility construction was completed prior to the 12/12/83 publication of DOE 6430.1.

1. Because the Department is both the regulator and the regulated for WIPP, there should be a clear delineation of responsibility. It is requested that you identify the organization within the DOE that has the responsibility for determining whether or not WIPP will abide by all or part of the DOE regulations. Please identify the DOE person responsible for the specific determination that WIPP does not have to comply with DOE Order 6430.1 or 6430.1A.

Providing an independent technical analysis of the Waste Isolation Pilot Plant (WIPP), a federal transuranic nuclear waste repository.

Mr. Arlen Hunt
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November 19, 1990

For example, if a facility were constructed 30 years ago, it would appear from your letter that there would be no need to determine compliance with current design requirements, as they apply to effluent releases. The site manager could decide if he would like to use current regulations as a framework for facility improvement. If this logic is carried to extreme, then older DOE facilities would not be subject to current environmental laws. Such logic defies your DOE Orders.

2. DOE Order 6430.1A, Section 1324-2.2.1, contains the following statement: (underlining added)

> "For those DOE facilities not regulated by the NRC, the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation shall not exceed 25 mrem (0.25 mSv) to the whole body and 75 mrem (0.75 mSv) to any organ (40 CFR 191.3 (b)). <u>WIPP operations are subject to these dose limits</u>. Section 1300-1.4.3, Routine Releases, provides references for additional limits that are applicable to these facilities."

Section 1300-1.4.2 and 1300-1.4.3 (DOE Order 6430.1A) apply to accidental and routine releases. It is requested that DOE provide a decision on the need for WIPP to comply with these Orders. Please identify the basis of the decision and the individual responsible for making the decision.

Please note that we asked for a review of the DOE Order 6430.1a in our letter 5/22/90. We outlined our concerns in the CAM meeting, 5/30/90. You committed to respond in the Quarterly Meeting, 7/24/90, and in your letter 9/19/90. In our Quarterly Meeting 11/13/90, you claim DOE 6430.1a as the Order applicable to the proposed FSAR Addendum.

3. Please provide a copy of the referenced draft DOE Order 6430. As required under the agreement between DOE and EEG, as well as the C&C Agreement, this document should have been submitted for our comments prior to promulgation by the Department.

4. It is requested that the DOE provide its position on the need to comply with DOE Order 5400.5, dated 2/8/90. Please identify the basis of the decision and the organization responsible for this decision.

Mr. Arlen Hunt
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5. It is requested that DOE advise us of any other applicable regulations requiring WIPP compliance with regard to release of radioactive material to the environment and/or the public.

The above information is essential to our technical review of the adequacy of the WIPP facility for the protection of the public health and safety. We would appreciate a response as soon as possible or at least within 30 calendar days of the date of this letter.

Sincerely,

Robert H. Neill
Director

RHN:WTB:ss:smh:jc:rb

cc: James Bickel
Leo Duffy
Mark Frei
Jill Lytle

Department of Energy
Albuquerque Operations Office
Waste Isolation Pilot Plant Project Office
P. O. Box 3090
Carlsbad, New Mexico 88221

RECEIVED
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ENVIRONMENTAL EVALUATION GROUP

MAR 27 1991

Mr. Robert H. Neill, Director
Environmental Evaluation Group
7007 Wyoming Boulevard, N.E.
Suite F-2
Albuquerque, NM 87109

Dear Mr. Neill:

This letter is in response to your letter of November 19, 1990 in which you raise questions regarding DOE policy concerning applicability of DOE 6430.1A and certain other DOE Orders to the WIPP.

In answer to your questions, we first state categorically that it is the policy of the Department of Energy in general and of the WIPP Project Office (WPO) specifically, that WIPP will comply with all applicable regulatory requirements, which of course includes all applicable DOE Orders. The key word here is "applicable." The determination whether a particular DOE Order or other regulatory requirement applies to WIPP must be determined on a case by case basis.

In the case of DOE Order 6430.1A (United States Department of Energy General Design Criteria), the applicability of the order to a particular facility depends in part upon the relationship between the effective date of the order and the time the design of the facility was completed. It will be instructive at this time to review the history of the evolution of DOE 6430.1A and compare this with the completion dates for design and construction of the WIPP facilities.

DOE 6430.1A became effective on April 6, 1989. It superseded DOE 6430.1, which became effective on December 12, 1983. DOE 6430.1 in turn was preceded by a draft version, DOE 6430., dated June 10, 1981. (It should be noted that there was no final version bearing the designation "DOE 6430."). The design for the Waste Handling Building was formally approved in November 1983. Construction was begun in April 1985 and was completed in May 1987.

In view of the above, the EEG is correct in its observation that the construction of the WIPP facility was completed after the effective date of DOE 6430.1 (but before the effective date of DOE 6430.1A). The quoted paragraph from our October 22, 1990 letter contains an error. It should have stated ". . . DOE Orders 6430.1 and 6430.1A were issued after the completion of the design of those portions of the facility; . . ." The DOE 6430.1 series are design criteria; therefore, the important consideration is when design of

Mr. Robert H. Neill 2 MAR 27 1991

a facility is completed relative to the effective date of the order. As stated in Section 0101-1, "These criteria shall be applied in the planning, design, and development of specifications for facilities, including the preparation of site-specific general design criteria and project-specific design criteria during the project planning phase." The Waste Handling Building was designed in accordance with the requirements of DOE 6430., since that was the version of the General Design Criteria in effect at the time the design of the Waste Handling Building was approved.

Since the questions posed in paragraphs 1 and 2 of your letter involve questions of DOE policy, WPO requested a response to them from Albuquerque Operations Office (AL). The response from AL is included herein in its entirety as Enclosure 1.

Enclosure 2 is a copy of draft DOE Order 6430. as requested. Regarding your concern that this document was not submitted to EEG prior to promulgation by the Department, please note that the Agreement for Consultation and Cooperation (C&C), Appendix B of which contains the provisions allowing EEG review of proposed DOE Orders, was signed after the promulgation date for DOE 6430.

DOE Order 5400.5 (February 28, 1990) deals with protection of the public and the environment against undue risk from radiation exposure due to activities of DOE and DOE contractors. The questions that arise with regard to the WIPP are (1) What are the applicable dose limits which govern release of radioactive materials from the WIPP site? and (2) How can the WIPP ensure that it does not exceed these limits?

The primary dose limit expressed in DOE 5400.5 is referred to as the "DOE Public Dose Limit" and requires that the exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem (1 mSv). Members of the public are defined in the order as "persons who are not occupationally associated with the DOE facility or operations; i.e., persons whose assigned occupational duties do not require them to enter the DOE site." However, although this public dose limit does not apply to people who work on the DOE site in question, it does apply to non-employee visitors to the site. This is reflected in the order's definition of "Public Dose," which means "the dose received by member(s) of the public from exposure to radiation and to radioactive material released by a DOE facility or operation, whether the exposure is within a DOE site boundary or off site. It does not include dose received from occupational exposures, doses received from naturally occurring background radiation, doses received as a patient from medical practices, or doses received from consumer products." The public dose is the sum of the effective dose equivalent (or deep dose equivalent, if dosimeter data are used) from exposures to radiation sources external to the body during the year plus the committed effective dose equivalent from radionuclides taken into the body during the year and resulting from all exposure modes that could contribute significantly to the total dose. It should also be noted that the public dose limit refers only to routine operations and does not include accident or off-normal situations.

Chapter II, Paragraph 1.b. of DOE 5400.5 requires that the exposure of members of the public to radioactive materials released to the atmosphere as a consequence of routine DOE activities shall not cause members of the public to receive, in a year, an effective dose equivalent greater than 10 mrem (0.1 mSv). This requirement reflects incorporation of the NESHAPS dose limits of 40 CFR Part 61 into the order. It should be noted that this limit applies only to doses off site where members of the public reside or abide and, therefore, would not apply to the case of nonoccupational visitors on site. As is the case with public dose, this dose limit only applies to routine operations and not to accident situations. Also, this dose limit applies to dose from airborne radioactive emissions only.

Chapter II, Paragraph 1.c. of DOE 5400.5 mandates that the exposure of members of the public to direct radiation or radioactive material released from DOE management and storage activities at a disposal facility for spent nuclear material or for high-level or transuranic radioactive wastes that are not regulated by the NRC shall not cause members of the public to receive, in a year, a dose equivalent greater than 25 mrem (0.25 mSv) to the whole body or a committed dose equivalent greater than 75 mrem (0.75 mSv) to any organ. This requirement is established by Section 191.03(b) of EPA regulation 40 CFR Part 191, Subpart A, "Environmental Standards for Management and Storage," and is incorporated as a part of this order. For purposes of the order, the WIPP is specifically deemed to be a disposal facility.

In addition to the various dose limits described above, which represent maximum allowable levels to which members of the public may be exposed, DOE 5400.5 also contains the requirement that any actual or potential exposure of members of the public as a result of DOE operations which could result in an effective dose equivalent exceeding 10 mrem (0.1 mSv) in a year be reported to the relevant Program Office(s) and the Deputy Assistant Secretary for Environment (EH-20).

The question now becomes which of the above limits are appropriate for application to protect members of the public from airborne radioactivity released from the WIPP. The NESHAPS limit of 10 mrem per year applies to off site exposures and is the most restrictive limit mentioned in DOE 5400.5; therefore, it is appropriate that it be designated as the off site limit for WIPP. Since this limit is more restrictive than either the public dose limit of 100 mrem per year or the 40 CFR 191 limits for dose to the public due to activities associated with a disposal site (25 mrem whole body or 75 mrem to any organ), it obviously also complies with these limits. A more difficult and very important question is which limit to apply to the case of exposures which occur on site to members of the public who are not employed at WIPP; i.e., are not "occupationally associated with the WIPP." The 10 mrem NESHAPS limit specifies that it applies off site only. The 40 CFR 191 limits do not specifically state whether they apply on site as well as off site, but a reading of this section of the order implies that they apply off site only. This is because this is an environmental regulation and because it fails to specifically state that it applies on site as well as off site whereas the order does specify that the public dose (100 mrem) limit applies on site as well as off site. In addition, the specific language of 40CFR Part 191, to which the order refers, implies that this limit applies off site only. 40 CFR 191.03(b) states that activities at disposal facilities shall be conducted such that "the combined annual dose equivalent to any member of the public <u>in the general environment</u> (emphasis added) resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirems to the whole body and 75 millirems to any critical organ." The phrase "in the general environment" indicates that the dose limits stated were intended to apply off site.

DOE 5400.5 must also be interpreted in such a manner as to be consistent with other applicable DOE Orders. DOE Order 5480.11, Paragraph 9.e., states that "the effective dose equivalent received by any member of the public resulting from exposure during direct on site access at a DOE facility shall not exceed a limiting value of 0.1 rem (.001 sievert) per year from the committed effective dose equivalent from internal irradiation plus the effective dose equivalent from any external irradiation. In addition, exposures shall not cause a dose equivalent to any tissue (including the skin and the lens of the eye) to exceed 5 rem (.05 sievert) per year for any member of the public." Therefore, WIPP has adopted the public dose limit of 100 mrem per year to apply to members of the public who receive exposures on site.

There is still one question which has not been answered and that is, what is the appropriate dose limit or limits to apply to the employees at the site who are not classified as radiation workers? This question is not treated in DOE 5400.5, so we must look to other DOE Orders for assistance. DOE 5480.11 (Radiation Protection for Occupational Workers) is the applicable order. This order specifies that doses to occupational workers shall not exceed an annual effective dose equivalent from both internal and external sources of 5 rem (.05 sievert) in any given year for the whole body and shall not exceed 15 rem (.15 sievert) to the lens of the eye or 50 rem (.5 sievert) to any other organ, tissue or extremity of the body. There are also specific defined limits for the case of unborn children, minors, and students. Occupational worker is defined in Paragraph 8.i of the order as "an individual who is either a DOE or DOE contractor employee; an employee of a subcontractor to a DOE contractor; or an individual who visits to perform work for or in conjunction with DOE or utilizes DOE facilities." Please note that DOE 5480.11 does not distinguish between "occupational workers" and "radiation workers" for purposes of annual dose limits. These distinctions only become important for special considerations such as bioassay.

Questions are raised at several places in your letter concerning the identification of the organization within DOE with responsibility for determining the applicability of DOE Orders and other regulations to the WIPP. To answer this question, we direct your attention to the enabling directive which is found at the beginning of each DOE Order. In the case of DOE 6430.1A this information is contained in Paragraph 8, <u>Responsibilities and Authorities</u>. A copy of this section is included for your convenience as <u>Enclosure 3</u>. In addition, Section 0101-2 of DOE 6430.1A states: "DOE organizations with first-line responsibilities for facility projects shall determine to what extent these criteria shall be applied to projects in process under prior issuances of DOE 6430.1." This has been interpreted to

Mr. Robert H. Neill 5 MAR 27 1991

mean that in the chain of command of DOE management for WIPP, a decision can be made as to the applicability of 6430.1A. Such a decision has been made by EM-1 through approval of the FSAR on June 12, 1990. In Chapter 3, page 3.1-1, of the approved FSAR it is stated that "The WIPP facility is designed to Order DOE 6430, General Design Criteria Manual for Department of Energy Facilities, draft, dated June 10, 1981, as specified in Reference 1."

In summary, we want to reiterate that WIPP will comply with all applicable DOE Orders, as well as all applicable environmental rules and regulations. Compliance with environmental rules and regulations will be verified during the Integrated Systems Checkout (ISC) and Operational Readiness Review (ORR). By approving the Safety Analysis Report and the Operational Readiness Review, DOE has made or will make the determination that WIPP appropriately meets DOE requirements. As additional orders, rules and regulations are promulgated, they will be evaluated with respect to their applicability to WIPP and DOE will advise the EEG of its decisions in this area in addition to providing EEG with draft copies of DOE orders for your comment pursuant to the provisions of the C&C Agreement.

Sincerely,

Arlen Hunt
Project Manager

3 Enclosures

cc w/enclosures:
J. Kenney, EEG
C&C File

cc w/o enclosures:
L. Lattman, NM Tech
M. Frei, DOE, HQ
J. Mewhinney, WPO
J. Carr, WPO
A. Stanley, ASI/WPO
R. Farrell, WID

WIPP:JEC E91-0053

DOE F 1325.8

ENCLOSURE I

United States Government

Department of Energy

memorandum

Albuquerque Operations Office

DATE: JAN 8 1991

REPLY TO ATTN OF: WOF:JNB (90-359)

SUBJECT: Environmental Evaluation Group Comments Regarding DOE Order 6430

TO: A. E. Hunt, Project Manager, WIPP

We have reviewed the Environmental Evaluation Group (EEG) comments in their letter to you, dated November 19, 1990 concerning DOE Order 6430 issues. As requested by J. Mewhinney, we are providing input regarding their first two comments.

1. WIPP does comply with DOE Order 6430.1A, as applicable. However, Section 0101-1 of DOE Order 6430.1A states:

   "These criteria apply to any building acquisition, new facility, facility addition and alteration, and leased facility ..... For existing facilities, original design criteria apply to the structure in general; however, additions or modifications shall comply with this Order and the associated latest editions of the references herein."

   As noted in the Hunt/Neil memorandum of October 22, 1990, much of the WIPP was designed and constructed using criteria provided in earlier versions of the 6430.1 Order. In addition to complying with appropriate design and construction criteria, WIPP also complies with current environmental regulations promulgated in DOE Orders 5400.1, 5400.5, etc. Therefore, EEG's attempted linkage between design and construction criteria and environmental laws and effluent release criteria is inappropriate.

2. WIPP does comply with the requirements of DOE Order 6430.1A, Section 1324-2.2.1, in that for normal operations and anticipated operational occurrences, exposures are not expected to exceed the provided criteria for facility discharges. It appears that EEG is misinterpreting Section 1300-1.4.2 as regards accidental releases. At the time DOE developed DOE 6430.1A (4/6/89), it was anticipated that DOE Order 5400.5 (2/8/90) would provide accidental dose criteria for exposures to the public. DOE Order 5400.5 does not provide criteria for accidental releases and states in Chapter II, Section 1.a.(3)(b):

   "The public dose limits do not apply to doses from .... exposures due to accident conditions ...."

It has been recognized within DOE that the wording in Section 1300-1.4.2 could be misinterpreted and changes in the wording have been recommended. Interpretation of 1300-1.4.2 to infer that accidental exposure criteria are the same as the routine release limits in DOE Order 5400.5 is not the intent of DOE Order 6430.1A and is not realistic. This would imply that accidental and routine release criteria are identical and that is certainly not the intent.

For further information, please contact Daryl Mercer at FTS 845-6646 regarding this matter.

L. Douglas Rigdon
Acting Director
Safety Programs Division

cc:
M. W. Frei, EM-34, HQ
J. E. Bickel, OESP, AL

APPENDIX C: Calculation - Underground Stack Air Effluent Velocity

Given (from WID Drawing 54-W-011-W, October 1988, Rev. A):

Effective Stack Radius ≈ 5 feet

Exhaust Flow Rate
425,000 CFM
212,500 CFM/Stack

Approximate Stack Velocity:

Area: $(5')^2 \pi = 78.5 \text{ ft}^2$

Velocity: $\dfrac{212.5 \text{ K CFM}}{78.5 \text{ ft}^2} \approx 2707 \text{ ft/M}$

Metric Vel: $\dfrac{2707 \text{ ft/min}}{3.28 \text{ ft/m}} \approx 825 \text{ m/min}$

$\approx 13.8 \text{ m/sec}$

Vector Analysis at 45° angle:

Velocity $= \sqrt{a^2 + b^2}$

where a = horizontal velocity
b = vertical velocity
a = b

$13.8 \text{ m/sec} = \sqrt{2(a^2)}$

$a = b = 9.7 \text{ m/sec}$

(White and Manning 1954)

WIPP CONTINUOUS AIR MONITOR

OPERATIONAL AVAILABILITY

	1/90 - 4/91			5/91 - 10/91			11/91 - 2/92		
CAM NUMBER	% OK	%OK+NIS	% OOC	% OK	%OK+NIS	% OOC	% OK	%OK+NIS	% OOC
027	92.6	**98.3**	1.7	77.5	**99.4**	0.6	100.0	**100.0**	0.0
029	72.7	**87.6**	12.4	81.6	**100.0**	0.0	95.0	**95.0**	5.0
031	83.5	**98.3**	1.7	81.6	**99.4**	0.6	88.8	**88.0**	12.0
035	84.3	**100.0**	0.0	81.9	**99.4**	0.6	100.0	**100.0**	0.0
053	60.3	**67.7**	32.2	80.0	**99.4**	0.6	70.0	**70.0**	30.0
055	82.6	**86.0**	14.0	77.5	**96.9**	3.1	82.0	**82.0**	18.0
117	65.5	**97.5**	2.5	65.0	**95.6**	4.4	7.0	**57.0**	43.0
119	34.5	**82.7**	17.6	85.0	**88.1**	11.9	65.0	**90.0**	10.0
121	72.3	**79.8**	20.2	58.8	**61.9**	38.1	63.0	**63.0**	27.0
125	27.0	**83.5**	16.5	66.2	**79.4**	20.6	97.0	**97.0**	3.0
127	38.7	**70.6**	29.4	85.0	**81.2**	18.8	87.0	**87.0**	13.0
129	---	**---**	---	---	**---**	---	**	******	**
151	90.1	**97.5**	2.5	98.8	**98.8**	1.2	99.0	**99.0**	1.0
153	98.3	**99.2**	0.8	95.6	**100.0**	0.0	92.0	**92.0**	8.0
155	98.3	**99.2**	0.8	95.6	**100.0**	0.0	99.0	**99.0**	1.0
157	---	**---**	---	---	**---**	---	99.0	**99.0**	1.0

* LCO CAM
** CAM 129 IN S/U MODE

OOC = out of commission
NIS = not in service

APPENDIX D: CAM Operational Data

WIPP LCO CAM CALIBRATION DATA AS OF 06/10/92

CAM #	CPM/DPM	% EFF.	CALIBRATION DUE DATE
029	213.2/1280 5943.8/29400	16.6 20.2 AVE. 18.4	1-22-93
030	14K/65239	21.5	1-22-93
031	204.4/1230 3843/21800	16.6 17.6 AVE. 17.1	5-1-93
032	25.3k/123718	20.4	2-20-93
035	204.7/1280 3847.6/21800	16 17.6 AVE. 16.8	2-10-93
036	28.4/123264	23	5-12-93
151	517/6200 1635.2/18800	8.3 8.7 AVE. 8.5	1-22-93
152	16.6K/65382	25.4	1-22-93
153	545.3/6190 27339.6/288600	8.8 9.5 AVE. 9.2	4-29-93
154	14.1K/65321	21.6	1-30-93
155	528.9/6190 1801.7/20300	8.5 8.9 AVE. 8.7	10-30-92
156	14.9K/65266	23	2-24-93
157	559.6/6190 1875.4/20300	9.0 9.2 AVE. 9.1	4-21-93
158	16.1K/66225	24.3	6-24-92
NE PORTABLE	229.3/1280 4228.4/21800	17.9 19.4 AVE. 18.7	10-10-92
SE PORTABLE	239/1230 6377.6/29400	19.4 21.7 AVE. 20.6	5-19-93
NW PORTABLE	241.5/1230 4601.2/21800	19.6 21.1 AVE. 20.4	9-6-92
SW PORTABLE	229.7/1230 6115.8/29400	18.67 20.8 AVE. 19.7	4-16-93
121 (non-LCO)	374.8/6,190 1321.0/18,800	6.0 7.0 AVE. 6.5	5-14-92

APPENDIX E: May 4, 1992 Neill to Arthur Letter

ENVIRONMENTAL EVALUATION GROUP
AN EQUAL OPPORTUNITY / AFFIRMATIVE ACTION EMPLOYER
7007 WYOMING BOULEVARD, N.E.
SUITE F-2
ALBUQUERQUE, NEW MEXICO 87109
(505) 828-1003

May 4, 1992

Mr. W. John Arthur
Project Director
WIPP Project Integration Office
U. S. Department of Energy
Albuquerque Operations Office
P. O. Box 5400
Albuquerque, NM 87115

Dear Mr. Arthur:

EEG appreciates the DOE/WPSO, Westinghouse (WID), and Inhalation Toxicology Research Institute (ITRI) March 19, 1992 presentations on Continuous Air Monitors (CAMs). There appears to be significant progress over the last several years in making the WIPP CAM systems operational and reliable.

Although DOE/WPSO may classify the CAM systems as operational, EEG believes the CAM systems have significant limitations when used in a salt aerosol. From our perspective, the CAM systems must operate reliably and with adequate sensitivity to fulfill at least three distinct regulatory requirements:

1. Radiation work place monitoring (DOE 5480.11, 12/21/88).

2. Effluent monitoring (DOE 5400.5, 2/8/90).

3. Alarm device for switching to High Efficiency Particulate Filtration (HEPA) mode (FSAR, WP 02-9, Rev. 0, May 1990 and DOE 6430.1a, 4/6/89).

Work Place Monitoring

As a work place monitor, the CAM is part of a comprehensive health physics program. As an example, CAM failure caused by a high salt aerosol would not necessarily preclude radiological operations. Respiratory protection or confinement of the air might serve as acceptable alternatives to air monitoring. The efficacy of each option must be weighed with respect to the regulatory requirements.

Providing an independent technical analysis of the Waste Isolation Pilot Plant (WIPP), a federal transuranic nuclear waste repository.

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Page 2
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Effluent Monitoring

As an effluent monitor, the CAM measures radioactive releases for compliance with DOE 5400.5 environmental and public dose requirements. Fixed air samplers (FAS) also monitor radioactive releases. Although DOE/WPSO staff discussed the FAS method at the December 17, 1991 Quarterly Meeting, lower limit of detection data were not provided. Batch methods are also allowed by the FSAR. The EEG requests for information about the effluent monitor CAMs, the FAS method, and batch sampling methods are attached (see 6.b and C).

If either of the Station A CAMs (alpha or beta) is not operational for greater than one hour, underground ventilation must be stopped or diverted to the filtration system. Similar FSAR requirements apply to other LCO effluent monitors. Our concern is CAM (or detector) failure will not be quickly recognized. In addition, the high salt aerosol presents a potential mechanism of "common mode" failure. We are continuing to review Station A alpha CAM data, and request supporting information as listed in the attachment (see 2). In addition, we request beta LCO CAM operational information be provided (see 2.a).

Alarm Device for Switching

Switching to filtration mode to minimize radiological releases is a facility confinement strategy per DOE 6430.1a. In the FSAR Addendum, WP 02-9, August 1991, the test bins are shown as dual confinement barriers with an internal filtration system. Waste drums provide only one confinement barrier. EEG requests an explanation of the rationale for dual confinement when waste drums are placed underground (see 1.a).

The data provided at the March 19, 1992 CAM meeting indicate that LCO CAM systems are inoperable 1% to 12% of the time, and other CAMs are inoperable a much greater percentage of time. More importantly, detector failure can not be easily identified, and CAM maintenance problems have been sited by auditors in the 1991 ORR audit and the Albuquerque ES&H audit November 18-22, 1991.

In order that EEG can complete an evaluation of the adequacy of the CAMs for radiation protection, we need the specific information listed in the attachment. While the list may appear to be extensive, the following points are to be made:

1. Specific information was formally requested as early as May 30, 1990.

Mr. W. John Arthur
Page 3
May 4, 1992

2. DOE said the information is available (CAM meeting March 19, 1992).

To avoid any unnecessary delays, I suggest that our staffs meet shortly to discuss the specifics so that EEG can complete our commitments.

If you have questions, please contact Dr. William Bartlett at (505) 885-9166.

Sincerely,

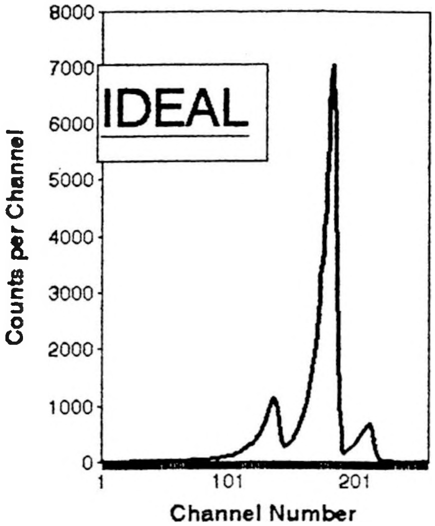
Robert H. Neill
Director

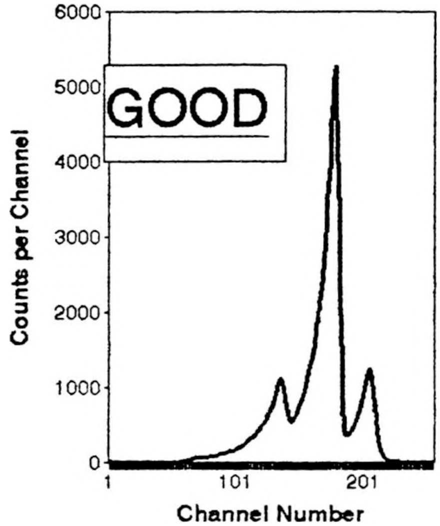
WTB:ss
Enclosure

cc: Mark Frei, WIPP Task Force
James Bickel, DOE/ALO
Arlen Hunt, DOE/WPSO
James Mewhinney, DOE/WPSO

APPENDIX F

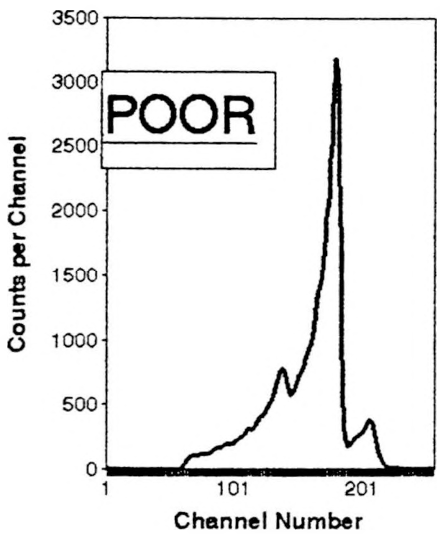
ALPHA SPECTRA RATING SYSTEM



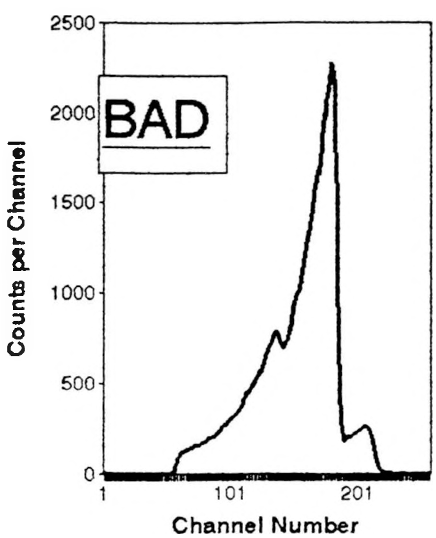


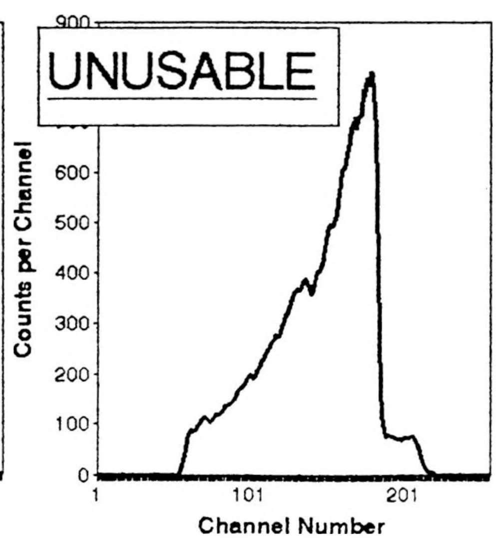
<u>IDEAL</u>
Three Clean Peaks
Consistent Peak Ratios
Distinct Lines

<u>GOOD</u>
Three Peaks
Less Definition



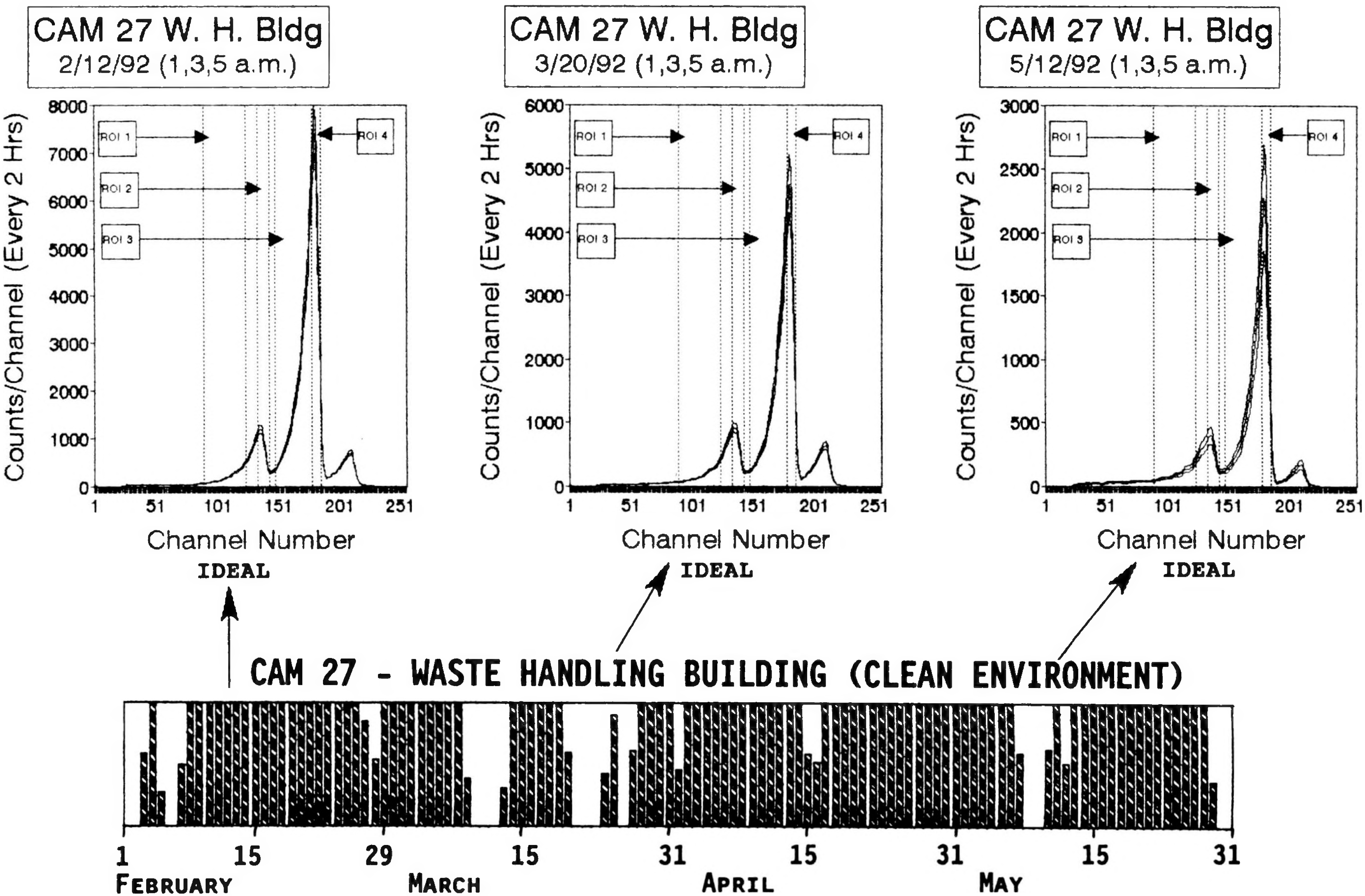
<u>POOR</u>
Peaks Not Clear
Resolution Diminished



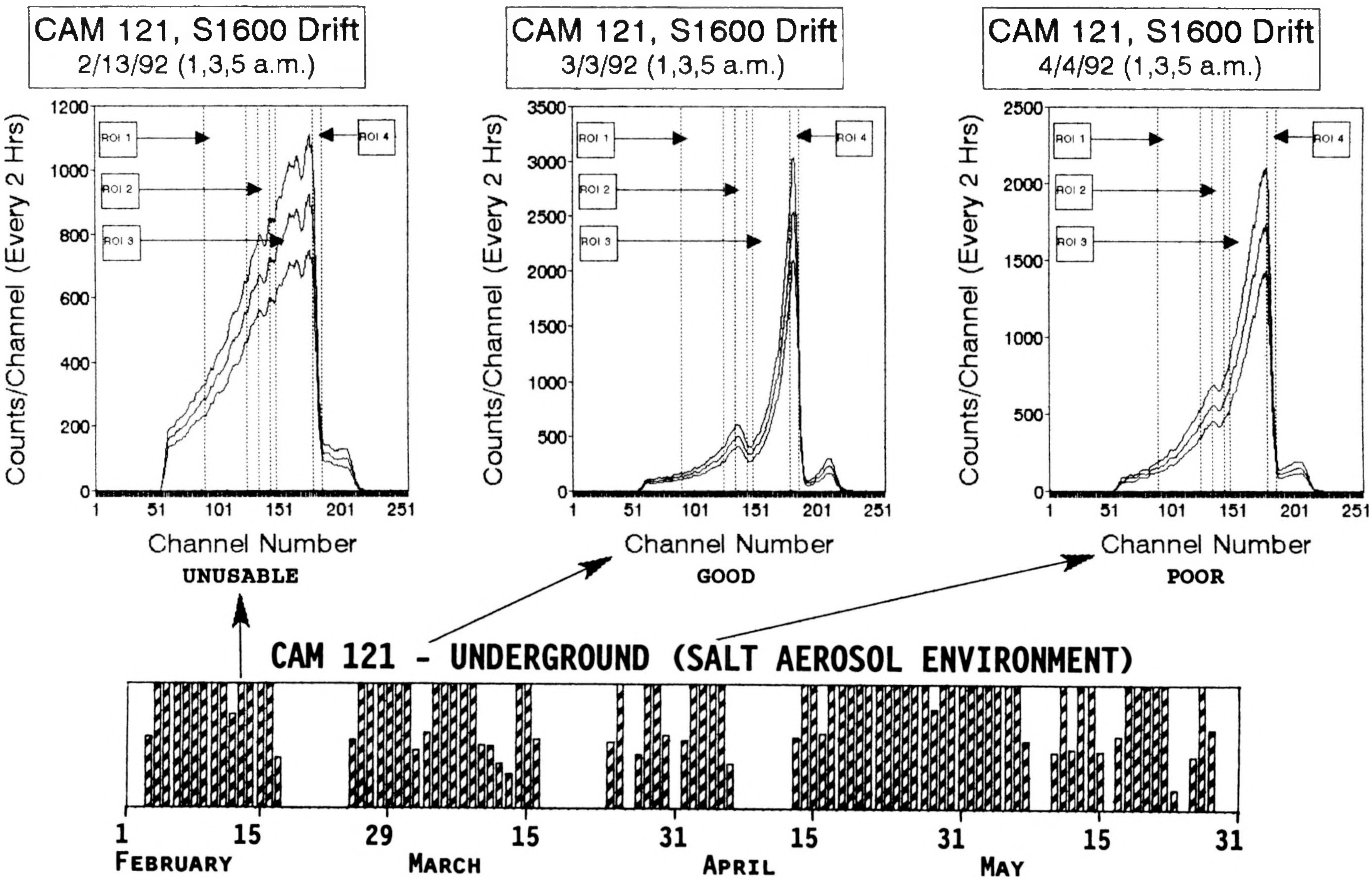


<u>BAD</u>
Peaks Not Defined
Low Energy Peaks Missing

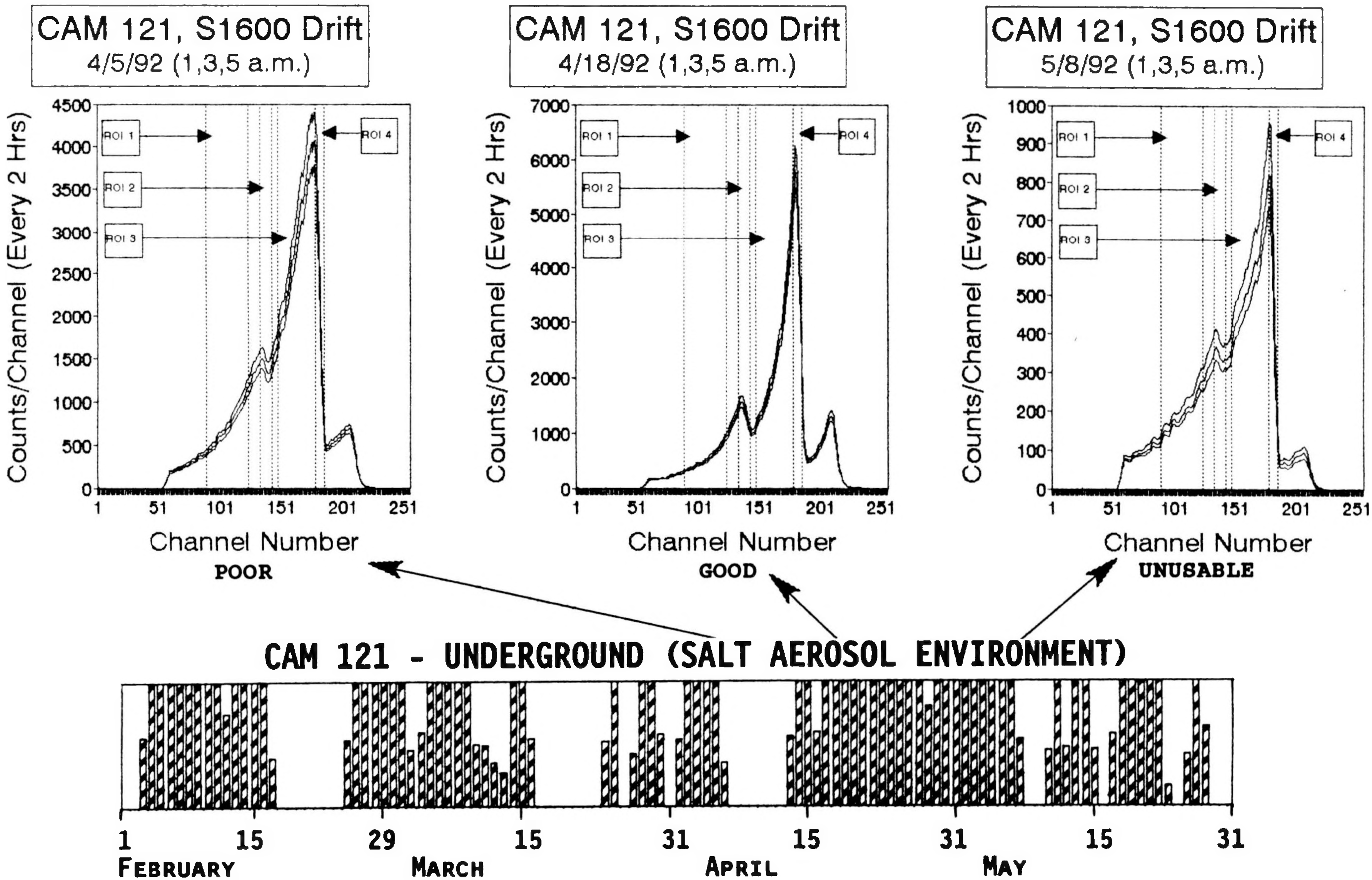
<u>UNUSABLE</u>
Loss of Peak Definition
Irregular Continuum



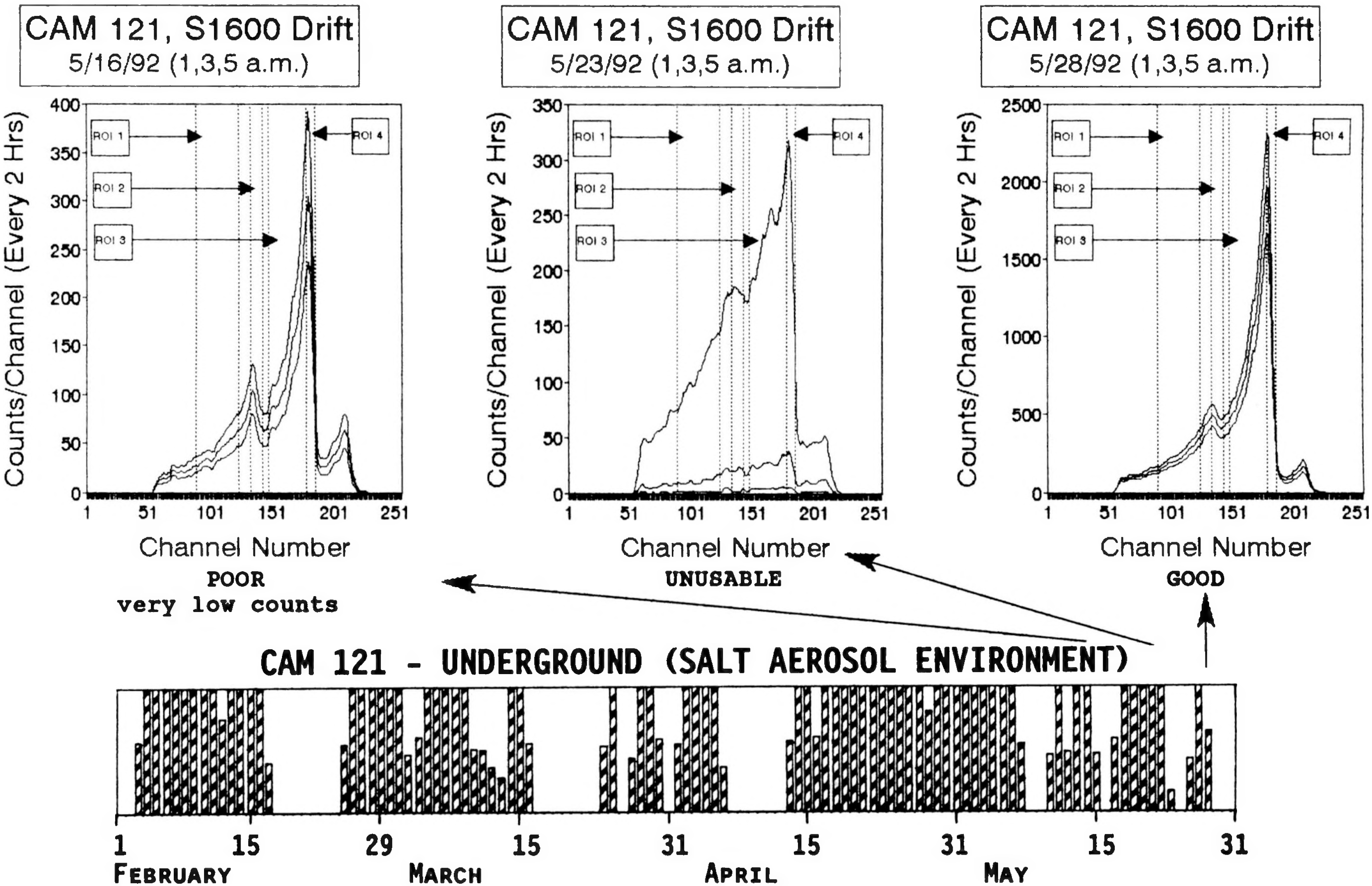
BLANK SPACES INDICATE NO DATA PROVIDED TO EEG



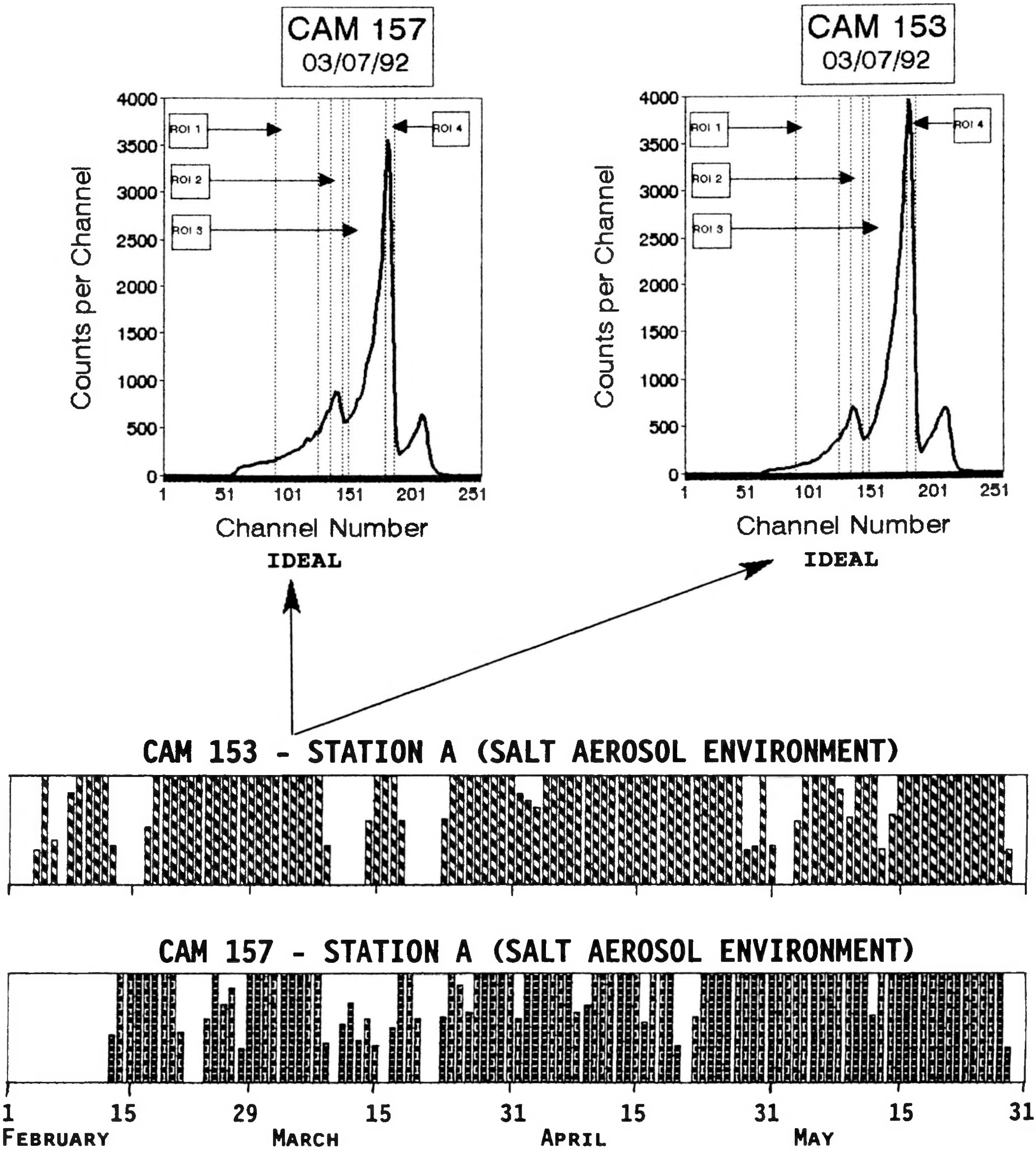
BLANK SPACES INDICATE NO DATA PROVIDED TO EEG



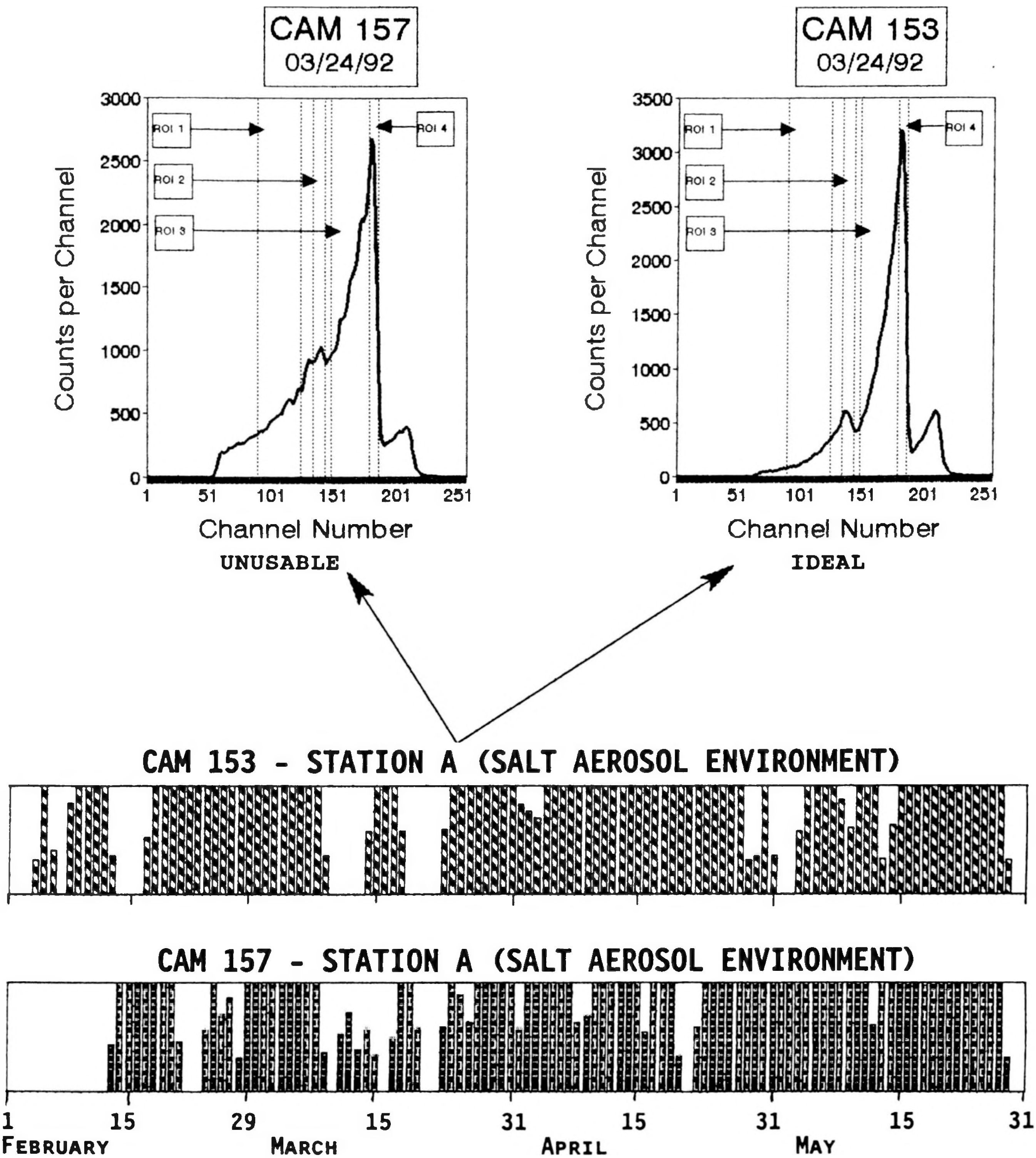
BLANK SPACES INDICATE NO DATA PROVIDED TO EEG



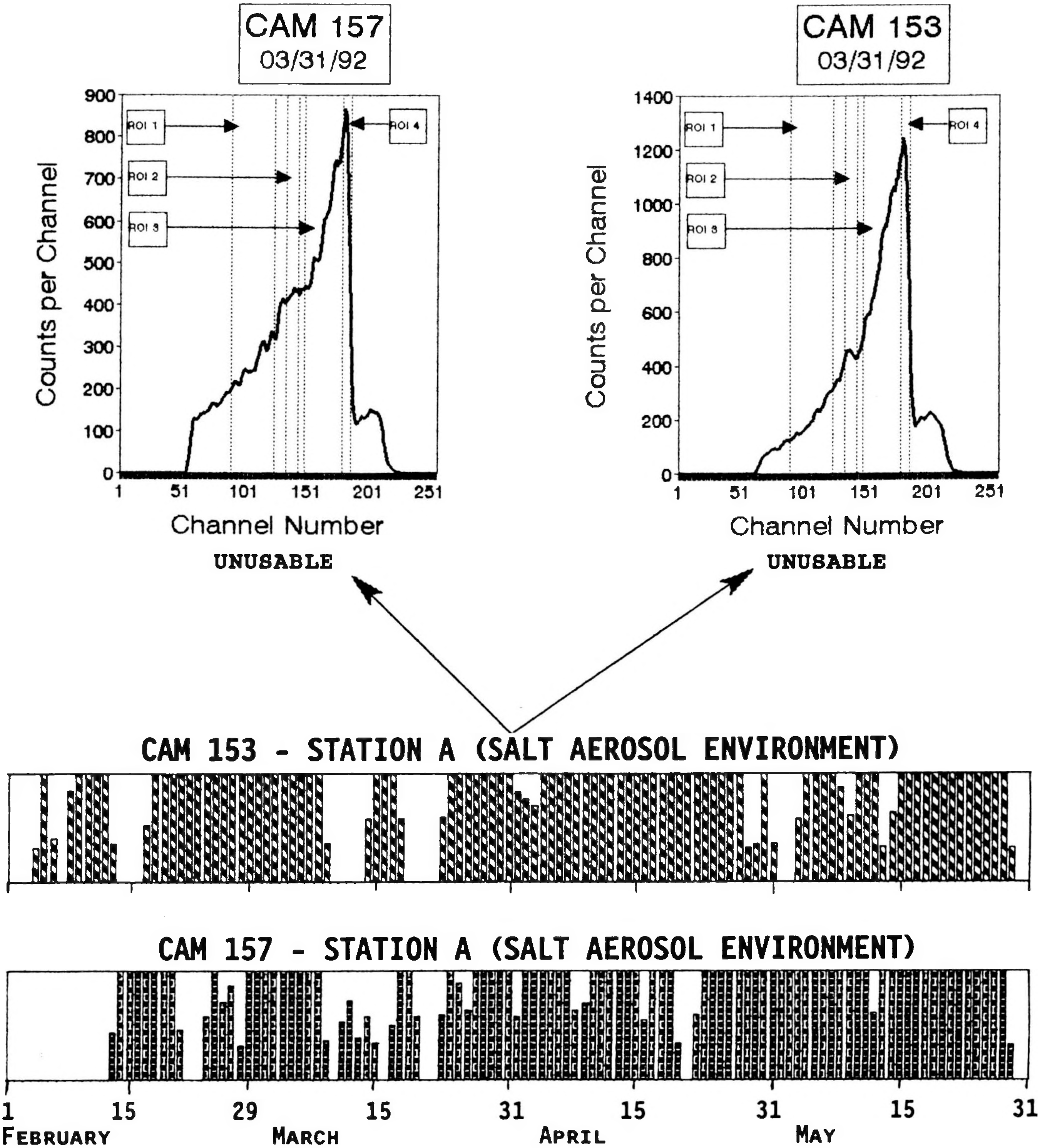
BLANK SPACES INDICATE NO DATA PROVIDED TO EEG



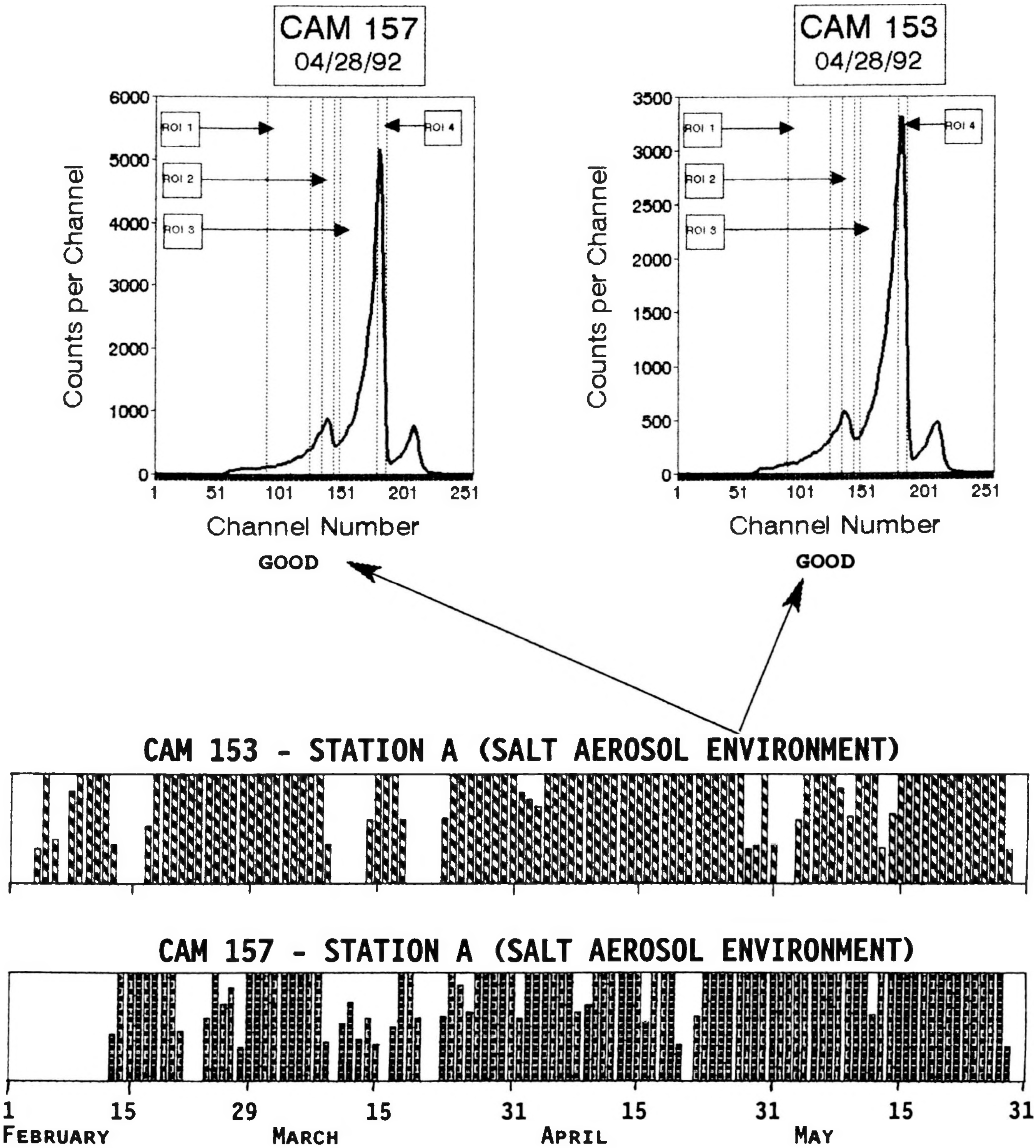
BLANK SPACES INDICATE NO DATA PROVIDED TO EEG



BLANK SPACES INDICATE NO DATA PROVIDED TO EEG



BLANK SPACES INDICATE NO DATA PROVIDED TO EEG



BLANK SPACES INDICATE NO DATA PROVIDED TO EEG

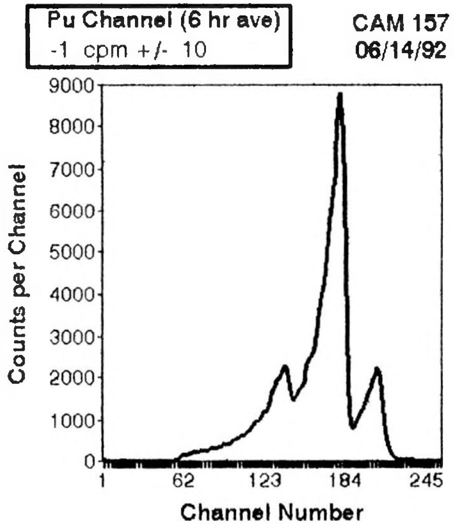
STATION A 1992 FILTER DATA (EEG Skid A-3-1)

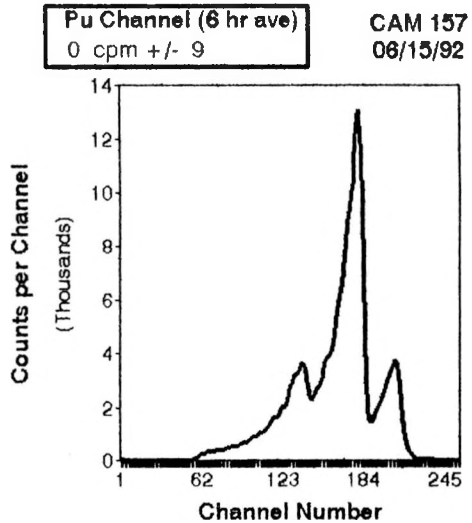
Sample Start (Date)	Sample Stop (Date)	Filter Salt Loading (mg)	Filter Average Salt Loading (mg/cm2)	Salt Aerosol Ave. Conc. (mg/m3)
02-Jan	03-Jan	1.3	0.09	0.016
03-Jan	06-Jan	4.8	0.35	0.019
06-Jan	07-Jan	9.8	0.71	0.117
07-Jan	08-Jan	9.4	0.68	0.108
08-Jan	09-Jan	7.7	0.56	0.085
09-Jan	10-Jan	5.9	0.43	0.072
10-Jan	13-Jan	7.1	0.51	0.029
13-Jan	14-Jan	7.3	0.53	0.083
14-Jan	15-Jan	6.0	0.43	0.077
15-Jan	16-Jan	14.8	1.07	0.182
16-Jan	17-Jan	8.8	0.64	0.105
17-Jan	20-Jan	8.4	0.61	0.034
20-Jan	21-Jan	10.5	0.76	0.121
21-Jan	22-Jan	8.6	0.62	0.105
22-Jan	23-Jan	9.7	0.70	0.124
23-Jan	24-Jan	7.7	0.56	0.095
24-Jan	27-Jan	11.4	0.82	0.046
27-Jan	28-Jan	6.7	0.48	0.081
28-Jan	29-Jan	7.9	0.57	0.097
29-Jan	30-Jan	4.0	0.29	0.048
30-Jan	31-Jan	4.3	0.31	0.053
31-Jan	03-Feb	10.6	0.77	0.042
03-Feb	04-Feb	4.6	0.33	0.056
04-Feb	05-Feb	4.0	0.29	0.048
05-Feb	06-Feb	4.5	0.32	0.055
06-Feb	07-Feb	4.7	0.34	0.057
07-Feb	10-Feb	7.7	0.56	0.031
10-Feb	11-Feb	7.2	0.52	0.082
11-Feb	12-Feb	3.1	0.22	0.040
12-Feb	13-Feb	5.9	0.43	0.072
13-Feb	14-Feb	9.4	0.68	0.115
14-Feb	17-Feb	12.5	0.90	0.050
17-Feb	18-Feb	15.7	1.13	0.177
18-Feb	19-Feb	9.0	0.65	0.117
19-Feb	20-Feb	12.9	0.93	0.157
20-Feb	21-Feb	10.3	0.74	0.125
21-Feb	24-Feb	12.7	0.92	0.051
24-Feb	26-Feb	8.8	0.64	0.052
26-Feb	27-Feb	7.0	0.51	0.087
27-Feb	28-Feb	12.8	0.92	0.152
28-Feb	02-Mar	16.5	1.19	0.067
02-Mar	03-Mar	4.6	0.33	0.052
03-Mar	04-Mar	4.1	0.30	0.052
04-Mar	05-Mar	5.3	0.38	0.065
05-Mar	06-Mar	5.9	0.43	0.072
06-Mar	09-Mar	7.0	0.51	0.028
09-Mar	10-Mar	9.9	0.71	0.120
10-Mar	11-Mar	10.9	0.79	0.125

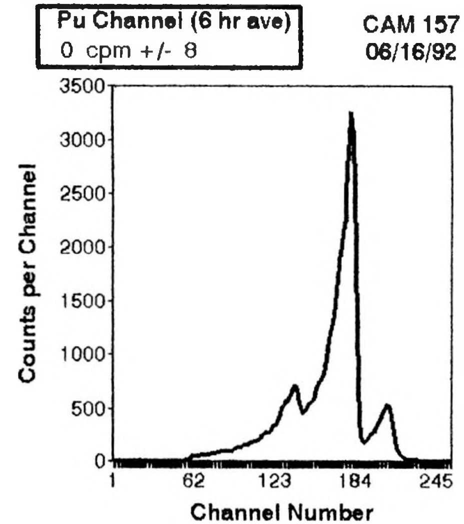
Sample Start (Date)	Sample Stop (Date)	Filter Salt Loading (mg)	Filter Average Salt Loading (mg/cm2)	Salt Aerosol Ave. Conc. (mg/m3)
11-Mar	12-Mar	19.3	1.39	0.244
12-Mar	13-Mar	9.9	0.71	0.121
13-Mar	16-Mar	11.4	0.82	0.047
16-Mar	17-Mar	8.3	0.60	0.095
17-Mar	18-Mar	3.7	0.27	0.048
18-Mar	19-Mar	9.8	0.71	0.123
19-Mar	20-Mar	10.5	0.76	0.127
20-Mar	20-Mar	6.9	0.50	0.304
23-Mar	24-Mar	8.4	0.61	0.095
24-Mar	25-Mar	7.3	0.53	0.095
25-Mar	26-Mar	10.3	0.74	0.124
26-Mar	27-Mar	11.9	0.86	0.143
27-Mar	30-Mar	8.1	0.58	0.033
30-Mar	31-Mar	20.8	1.50	0.237
31-Mar	01-Apr	6.7	0.48	0.085
01-Apr	02-Apr	12.8	0.92	0.158
02-Apr	03-Apr	10.3	0.74	0.125
03-Apr	06-Apr	15.5	1.12	0.063
06-Apr	07-Apr	8.9	0.64	0.100
07-Apr	08-Apr	7.5	0.54	0.096
08-Apr	09-Apr	11.8	0.85	0.147
09-Apr	10-Apr	8.8	0.64	0.107
10-Apr	13-Apr	10.5	0.76	0.042
13-Apr	14-Apr	5.6	0.40	0.063
14-Apr	15-Apr	7.6	0.55	0.100
15-Apr	16-Apr	7.0	0.51	0.084
16-Apr	20-Apr	4.0	0.29	0.012
20-Apr	21-Apr	5.5	0.40	0.061
21-Apr	22-Apr	6.8	0.49	0.091
22-Apr	23-Apr	5.3	0.38	0.065
23-Apr	24-Apr	11.8	0.85	0.142
24-Apr	27-Apr	4.7	0.34	0.019
27-Apr	28-Apr	5.2	0.38	0.059
28-Apr	29-Apr	6.3	0.45	0.080
29-Apr	30-Apr	6.7	0.48	0.083
30-Apr	01-May	5.5	0.40	0.065
01-May	04-May	8.4	0.61	0.035
04-May	05-May	6.9	0.50	0.079
05-May	06-May	1.7	0.12	0.022
06-May	07-May	3.1	0.22	0.038
07-May	08-May	7.5	0.54	0.092
08-May	11-May	5.5	0.40	0.022
11-May	12-May	4.8	0.35	0.055
12-May	13-May	3.9	0.28	0.049
13-May	14-May	3.3	0.24	0.041
14-May	15-May	2.6	0.19	0.031
15-May	18-May	31.3	2.26	0.228
18-May	19-May	41.7	3.01	0.657
19-May	20-May	3.0	0.22	0.040
20-May	21-May	2.9	0.21	0.036

Sample Start (Date)	Sample Stop (Date)	Filter Salt Loading (mg)	Filter Average Salt Loading (mg/cm2)	Salt Aerosol Ave. Conc. (mg/m3)
21-May	22-May	4.6	0.33	0.055
22-May	26-May	4.7	0.34	0.014
26-May	27-May	4.2	0.30	0.053
27-May	28-May	2.2	0.16	0.027
28-May	29-May	3.6	0.26	0.044
01-Jun	02-Jun	6.8	0.49	0.075
02-Jun	03-Jun	3.3	0.24	0.043
03-Jun	04-Jun	9.1	0.66	0.111
04-Jun	05-Jun	3.7	0.27	0.046
05-Jun	08-Jun	5.4	0.39	0.022
08-Jun	09-Jun	8.3	0.60	0.100
09-Jun	10-Jun	5.4	0.39	0.064
10-Jun	11-Jun	6.1	0.44	0.075
11-Jun	12-Jun	6.0	0.43	0.074
12-Jun	15-Jun	8.7	0.63	0.035
15-Jun	16-Jun	6.2	0.45	0.077
16-Jun	17-Jun	10.4	0.75	0.114
17-Jun	18-Jun	29.4	2.12	0.396
18-Jun	19-Jun	5.9	0.43	0.070
19-Jun	22-Jun	10.4	0.75	0.044
22-Jun	23-Jun	29.5	2.13	0.327
23-Jun	24-Jun	20.1	1.45	0.270
24-Jun	25-Jun	31.0	2.24	0.387
25-Jun	26-Jun	21.1	1.52	0.259
26-Jun	29-Jun	37.5	2.71	0.158
29-Jun	30-Jun	19.0	1.37	0.215
30-Jun	01-Jul	1.0	0.07	0.013
01-Jul	06-Jul	38.0	2.74	0.093
06-Jul	07-Jul	6.8	0.49	0.078
07-Jul	08-Jul	6.3	0.45	0.078
08-Jul	09-Jul	8.4	0.61	0.109
09-Jul	10-Jul	7.6	0.55	0.092
10-Jul	13-Jul	6.9	0.50	0.028
13-Jul	14-Jul	7.8	0.56	0.090
14-Jul	15-Jul	10.9	0.79	0.139
15-Jul	16-Jul	16.5	1.19	0.208
16-Jul	17-Jul	34.5	2.49	0.408
17-Jul	20-Jul	38.1	2.75	0.160
20-Jul	21-Jul	26.4	1.91	0.315
21-Jul	22-Jul	32.7	2.36	0.395
22-Jul	23-Jul	14.0	1.01	0.176
23-Jul	24-Jul	27.6	1.99	0.341
24-Jul	27-Jul	10.5	0.76	0.044
27-Jul	28-Jul	23.5	1.70	0.281
28-Jul	29-Jul	36.6	2.64	0.487
29-Jul	30-Jul	8.8	0.64	0.116
30-Jul	31-Jul	8.6	0.62	0.105
31-Jul	03-Aug	6.1	0.44	0.025
03-Aug	04-Aug	11.0	0.79	0.133
04-Aug	05-Aug	37.1	2.68	0.488

Sample Start (Date)	Sample Stop (Date)	Filter Salt Loading (mg)	Filter Average Salt Loading (mg/cm2)	Salt Aerosol Ave. Conc. (mg/m3)
05-Aug	06-Aug	42.0	3.03	0.521
06-Aug	07-Aug	12.7	0.92	0.155
07-Aug	10-Aug	11.3	0.82	0.046
10-Aug	11-Aug	22.4	1.62	0.265
11-Aug	12-Aug	16.6	1.20	0.218
12-Aug	13-Aug	22.3	1.61	0.287
13-Aug	14-Aug	12.0	0.87	0.153
17-Aug	18-Aug	3.6	0.26	0.043
18-Aug	19-Aug	3.6	0.26	0.044
19-Aug	20-Aug	13.8	1.00	0.167
20-Aug	21-Aug	13.6	0.98	0.163
21-Aug	24-Aug	14.7	1.06	0.060
24-Aug	25-Aug	12.8	0.92	0.159
25-Aug	26-Aug	22.7	1.64	0.276
26-Aug	27-Aug	26.7	1.93	0.324
27-Aug	28-Aug	21.8	1.57	0.263
28-Aug	31-Aug	33.1	2.39	0.135
31-Aug	01-Sep	17.6	1.27	0.215
01-Sep	02-Sep	12.3	0.89	0.151
02-Sep	03-Sep	27.3	1.97	0.344
03-Sep	04-Sep	9.6	0.69	0.127
04-Sep	08-Sep	15.8	1.14	0.050
08-Sep	09-Sep	34.2	2.47	0.424
09-Sep	10-Sep	21.8	1.57	0.265
10-Sep	11-Sep	8.8	0.64	0.107
11-Sep	14-Sep	23.9	1.73	0.098
14-Sep	15-Sep	9.6	0.69	0.117
15-Sep	16-Sep	9.5	0.69	0.115
16-Sep	17-Sep	8.6	0.62	0.105
17-Sep	18-Sep	8.7	0.63	0.105
18-Sep	21-Sep	46.6	3.36	0.189
21-Sep	22-Sep	63.6	4.59	0.777
22-Sep	23-Sep	39.9	2.88	0.482
23-Sep	24-Sep	190.1	13.72	2.338
24-Sep	25-Sep	176.3	12.73	2.217
02-Oct	06-Oct	20.1	1.45	0.072
06-Oct	07-Oct	11.9	0.86	0.153
07-Oct	08-Oct	11.6	0.84	0.141
08-Oct	09-Oct	16.0	1.15	0.195
09-Oct	12-Oct	33.5	2.42	0.136
12-Oct	13-Oct	13.1	0.95	0.157
13-Oct	14-Oct	15.2	1.10	0.193
14-Oct	15-Oct	12.5	0.90	0.153
15-Oct	16-Oct	15.1	1.09	0.184
16-Oct	19-Oct	13.2	0.95	0.054
19-Oct	20-Oct	6.4	0.46	0.077
20-Oct	21-Oct	7.8	0.56	0.098
22-Oct	23-Oct	8.1	0.58	0.099
23-Oct	26-Oct	8.4	0.61	0.305
27-Oct	28-Oct	6.2	0.45	0.081



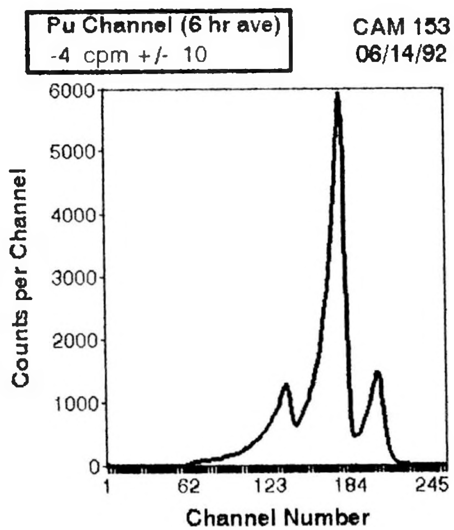


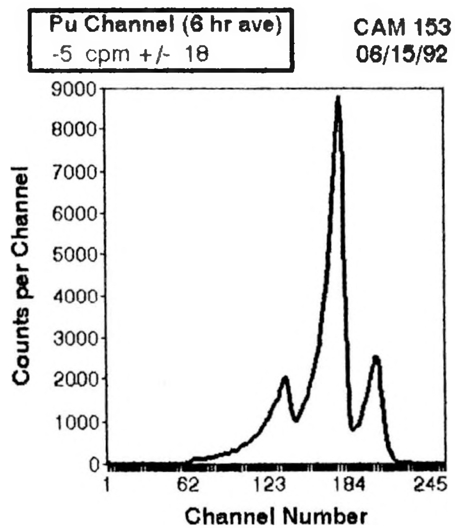


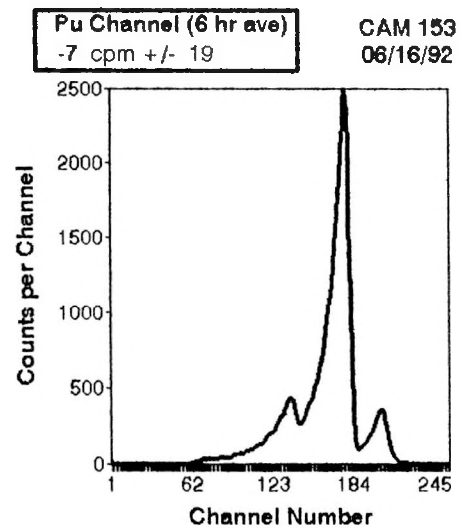
FILTER LOADING = WEEKEND (NO DATA)

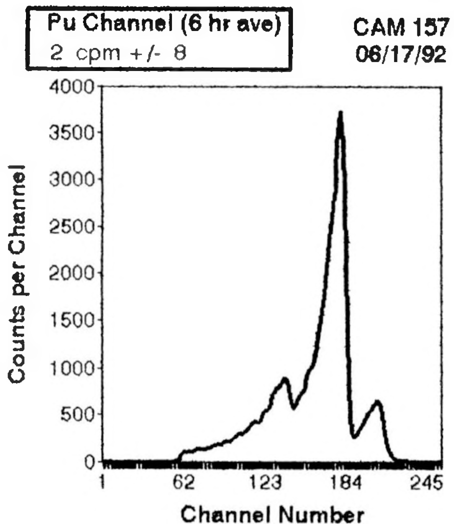
8.7 MG

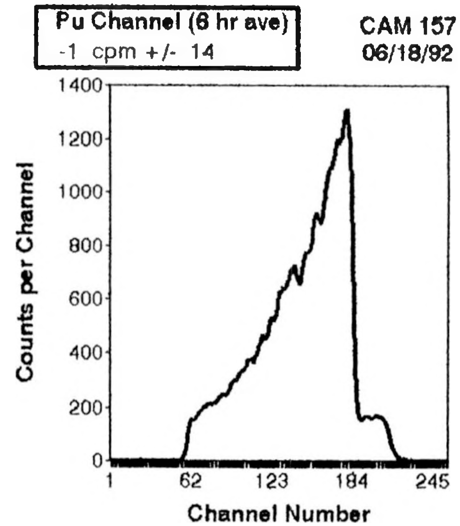
6.2 MG

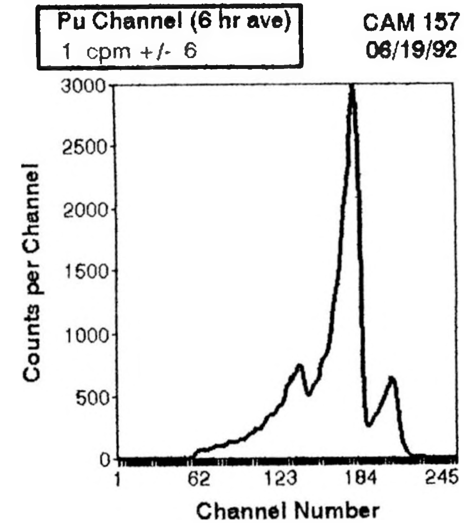




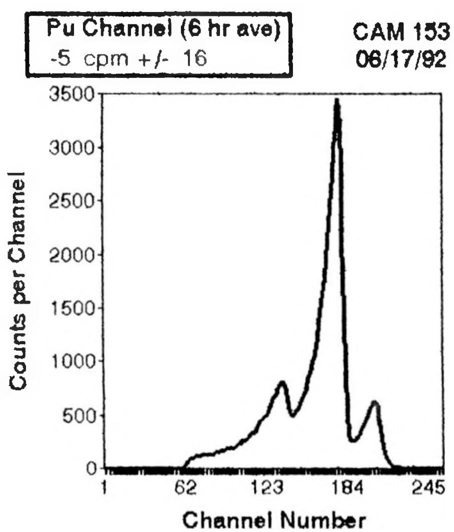


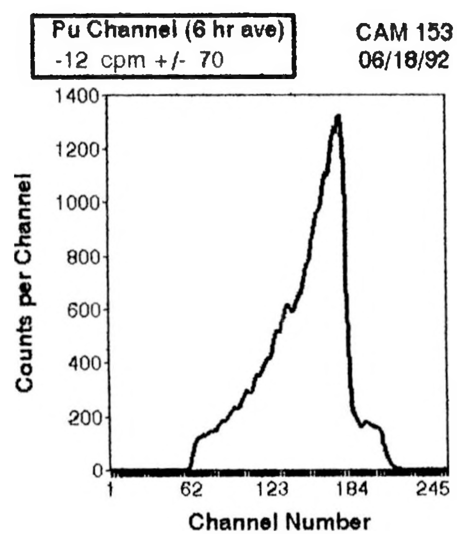


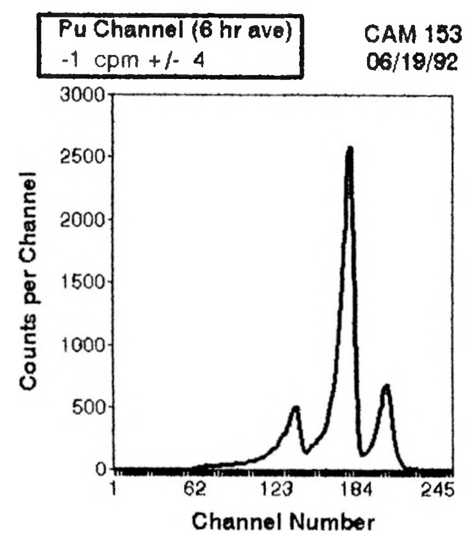


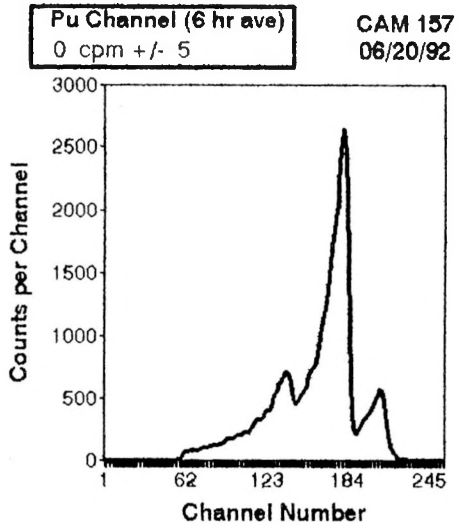


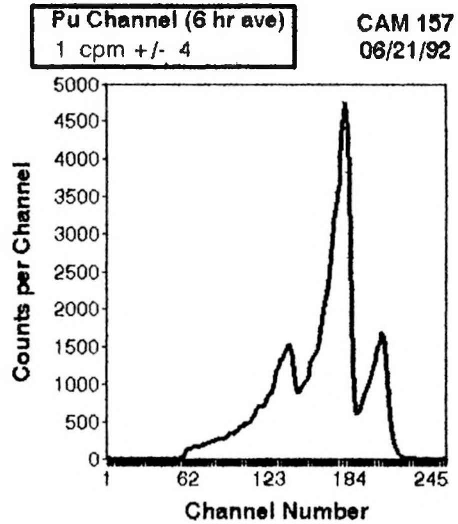
FILTER LOADING = 10.4 MG | **29.4 MG** | **5.9 MG**

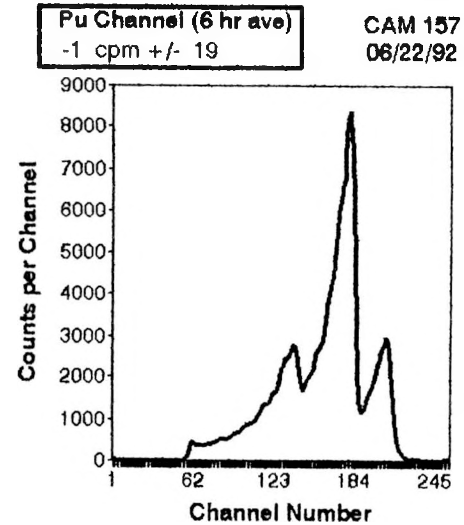








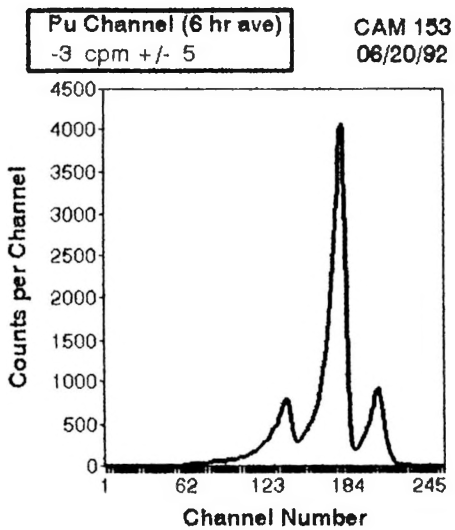


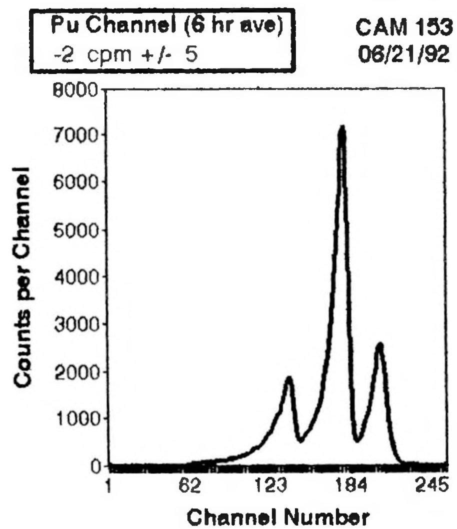


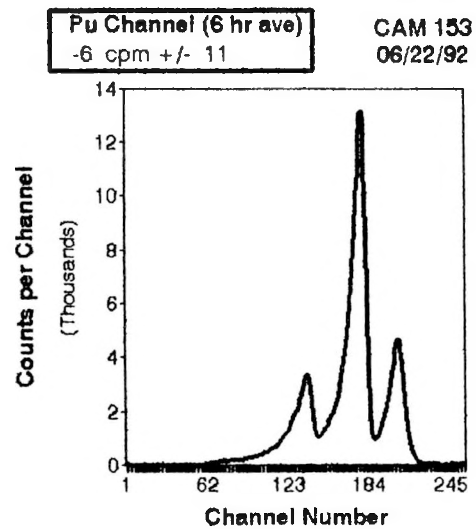
FILTER LOADING = WEEKEND (NO DATA)

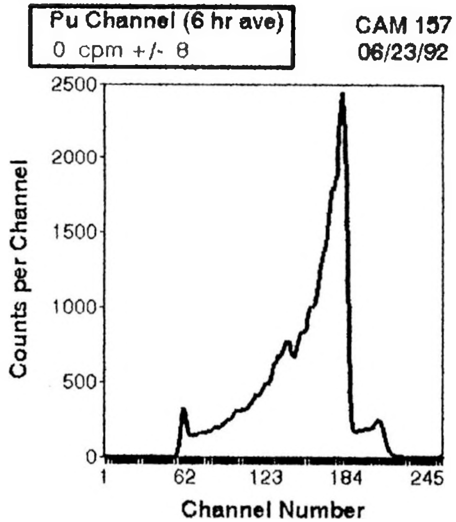
WEEKEND (NO DATA)

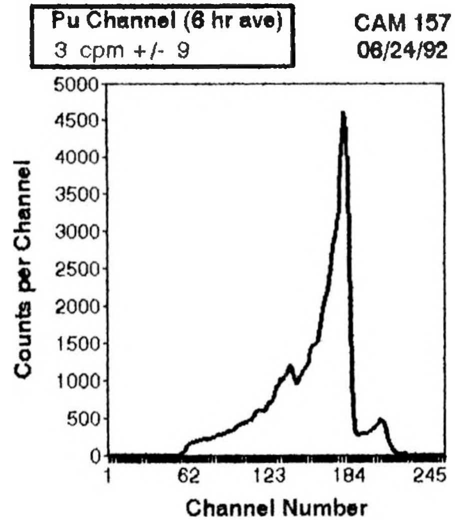
10.4 MG

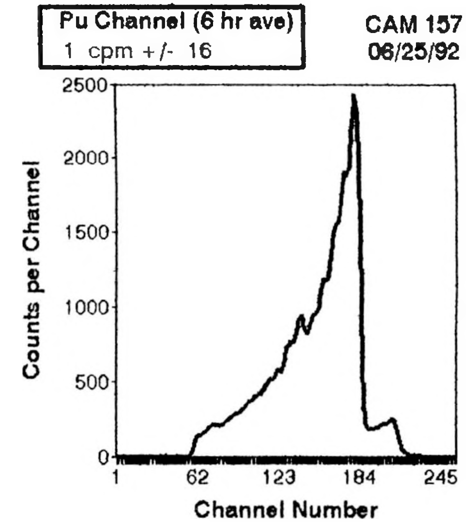




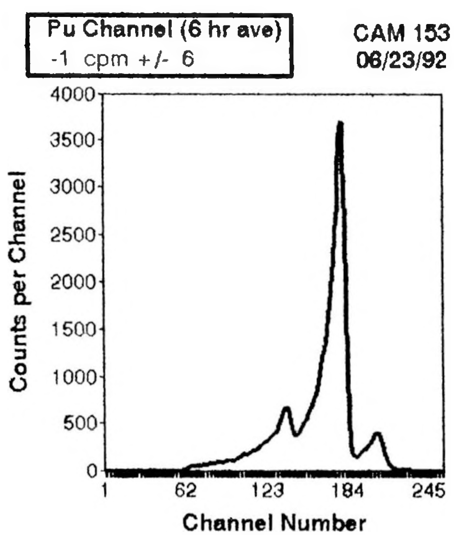


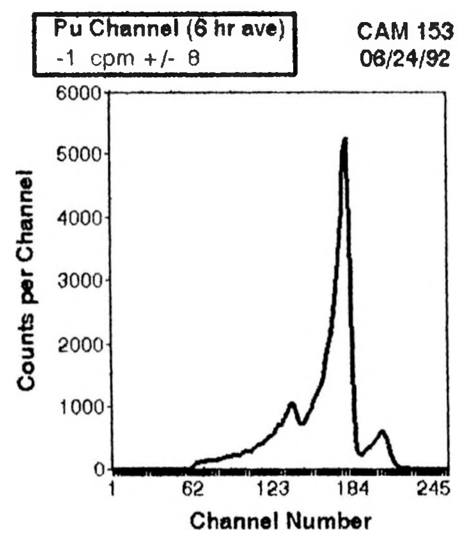


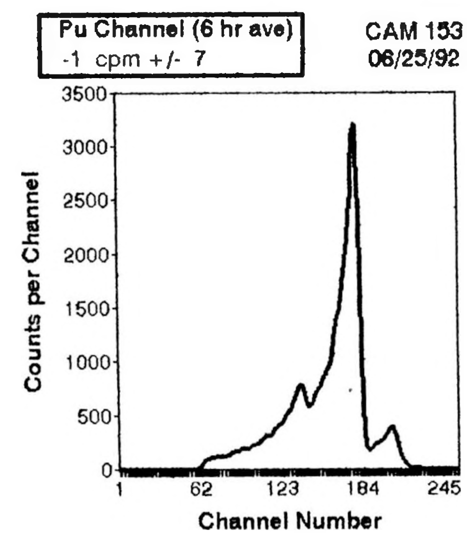


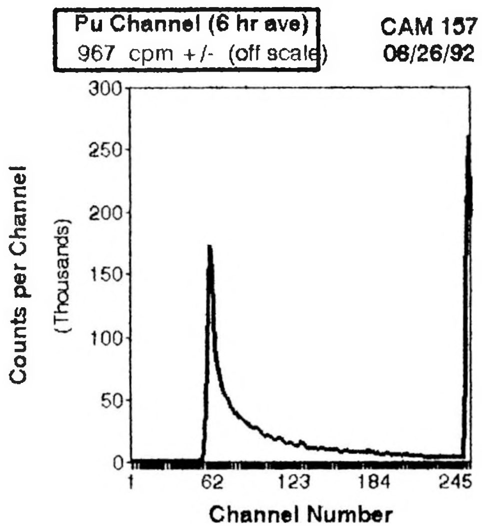


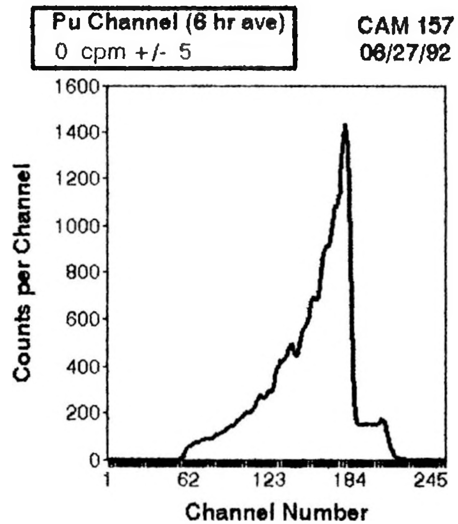
FILTER LOADING = 29.5 MG **20.1 MG** **31.0 MG**

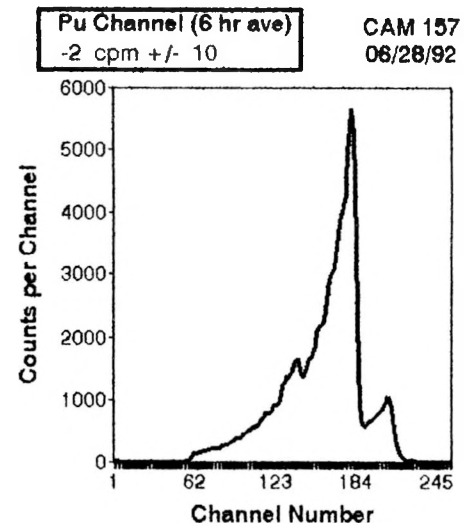








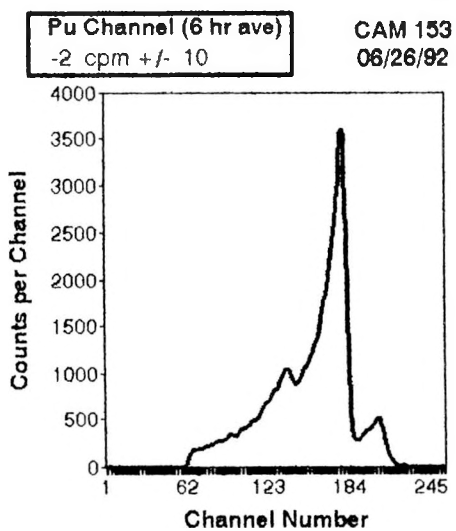


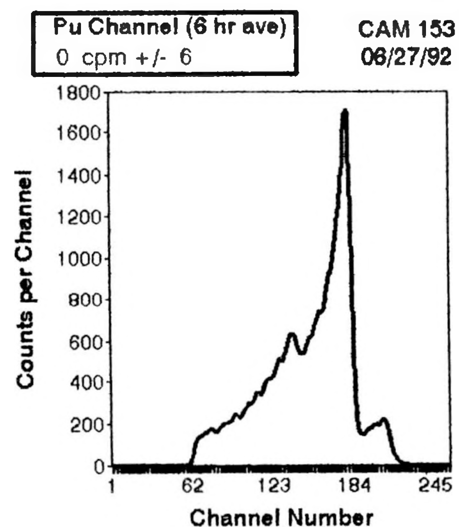


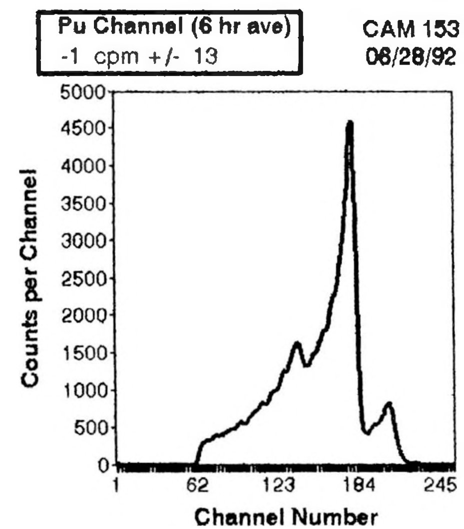
FILTER LOADING = 21.1 MG

WEEKEND (NO DATA)

WEEKEND (NO DATA) 37.5 MG (ON 6/29)







CAM 153 (Data are average CPM of last 5 minutes)

06/17/92 (Date, time in row below)

00:05	01:05	02:05	03:05	04:05	05:05	06:05	07:05	08:05	09:05	10:05	11:05
-7	-10	-8	-1	-8	-5	-5	-8	-4	-1	-15	-9
-12	-12	-6	0	-7	-1	-3	-11	-3	-4	-11	-9
-10	-9	-7	2	-6	0	-4	-8	-6	-6	-4	-6
-9	-4	-7	1	-6	-3	-3	-3	-10	-11	-10	-7
-10	-7	-2	-1	-8	-4	-1	-4	-11	-8	-5	-8
-6	-3	1	1	-6	-6	-3	-2	-13	-5	-6	-10
-5	-3	1	-1	-5	-3	-4	-3	-14	0	-6	-10
-2	1	3	-3	-4	-7	-9	-7	-10	-3	-5	-3
-4	-3	-3	-2	0	-7	-9	-4	-5	-5	-5	-7
0	-1	-8	-1	0	-7	-8	-6	-3	-6	-7	-5
2	-3	-10	-2	-1	-4	-7	-7	-2	-8	-5	-6
0	-4	-7	-3	-2	-11	-3	-1	-2	-7	-7	-9
-4	-7	-9	0	-7	-9	-3	-1	-7	-5	-8	-12
-1	-4	-6	2	-9	-10	-1	-7	-7	-4	-6	-8
-4	-6	-6	-1	-5	-6	-4	-9	-8	-3	0	-7
-10	-5	-1	-1	-5	-10	-4	-10	-8	-7	-3	-6
-3	-1	-6	1	-7	-5	-10	-16	-11	-9	-6	-3
-2	-2	-10	-3	-3	-3	-6	-18	-7	-5	-5	-7
-5	0	-6	-4	-3	-3	-11	-21	-12	-5	-6	-4
-4	1	-4	-3	-7	-4	-12	-17	-15	-8	-14	-4
-4	1	-8	-7	-5	-6	-10	-23	-13	-3	-15	-7
-5	-3	-5	-6	-4	-9	-6	-22	-17	-3	-13	-6
-5	-2	-3	-6	-8	-12	-9	-11	-18	-4	-18	-6
-2	-5	-1	-13	-6	-11	-5	-10	-14	-7	-14	-8
-6	-6	2	-12	-5	-9	-3	-13	-10	-1	-6	-7
-3	-6	1	-9	-8	-6	-3	-6	-9	-4	-4	-1
-4	-3	0	-18	-8	-16	-7	-5	1123 *	-1	-6	-2
-5	-3	0	-11	-5	-17	-4	-9	1126 *	-3	-3	1
-5	-3	-3	-9	-6	-16	-2	-8	1127 *	-5	-3	-5
-3	-3	-8	-7	-8	-17	-4	-8	1127 *	-5	-8	-24
-5	-5	-4	-8	-7	-13	-6	-8	1127 *	-4	-9	-31
-4	-6	-1	0	-5	-6	-6	-4	0	-8	-6	-21
-6	-7	-5	-6	-5	-4	-6	-3	0	-7	-8	-19
-12	-8	-2	-6	-10	-4	-8	-5	0	-4	-8	-14
-12	-7	1	-10	-4	-4	-3	1	1	-4	-8	-9
-10	-10	2	-8	-2	-4	-4	-12	1	-6	-8	-10
-12	-12	-1	-7	-9	-3	-1	-11	1	-3	-7	-8
-5	-11	2	-8	-8	-4	-3	-13	0	-4	-3	-16
-4	-9	3	-8	-8	-2	-1	-12	0	-4	-6	-16
-1	-7	-3	-6	-8	-2	-4	-20	-1	-4	-8	-6
-8	-3	-6	-6	-10	-6	-3	-11	-1	-4	-6	-3
-7	-2	-3	-9	-5	-7	-3	-15	-9	-10	-6	-5
-6	-4	-2	-8	-6	-15	-1	-13	-1	-7	-10	-3
-3	-5	-5	-7	-1	-19	-3	-15	-3	-6	-6	-8
-5	-8	0	-7	-5	-22	-2	-14	-8	-6	-11	-10
1	-9	2	-8	-6	-19	-2	-15	-4	-7	-8	-6
-2	-7	2	-7	-13	-15	-1	-17	-3	-5	-6	-9
-3	-6	0	-5	-12	-4	-5	-14	-4	-8	-6	-3
-8	-4	0	-4	-12	0	-4	-12	-2	-5	-8	0
-11	-4	-2	-3	-9	3	-6	-12	1	-7	-6	-2
-9	-5	-4	-5	-12	0	-7	-10	-5	-7	-8	-7
-8	-6	-7	-3	-4	0	-8	-8	-5	-8	-7	-8
-7	-8	-7	-3	-5	-2	-6	-11	-3	-10	-6	-9
-5	-6	-6	-4	-7	-2	-10	-9	-8	-10	-6	-16
-5	-6	-5	-6	-6	-5	-8	-9	-12	-14	-6	-12
-6	-4	-4	-7	-4	0	-9	-15	-11	-9	-2	-15
-3	-4	-3	-9	-10	-3	-10	-14	-11	-7	-7	-17
-8	1	-3	-8	-9	0	-9	-7	-10	-12	-13	-21
-12	-2	-4	-11	-3	-3	-10	-8	-4	-10	-11	-11
-4	-4	-2	-9	-7	-2	-11	-6	-6	-13	-8	-18

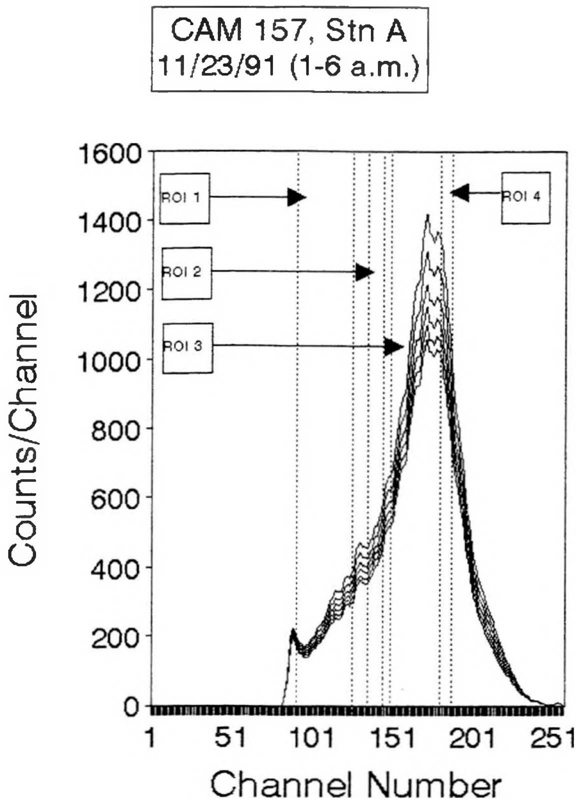
* Filter Change

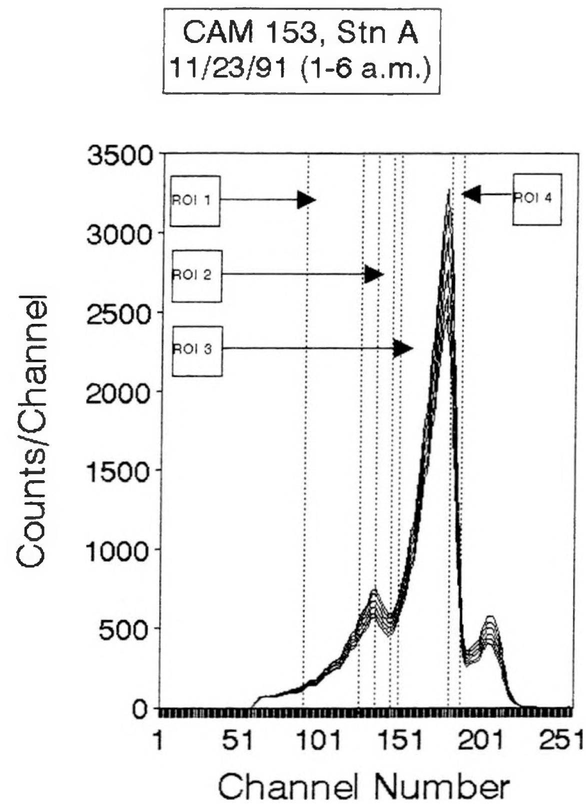
CAM 153 (Data are average CPM of last 5 minutes)

06/18/92 (Date, time in row below)

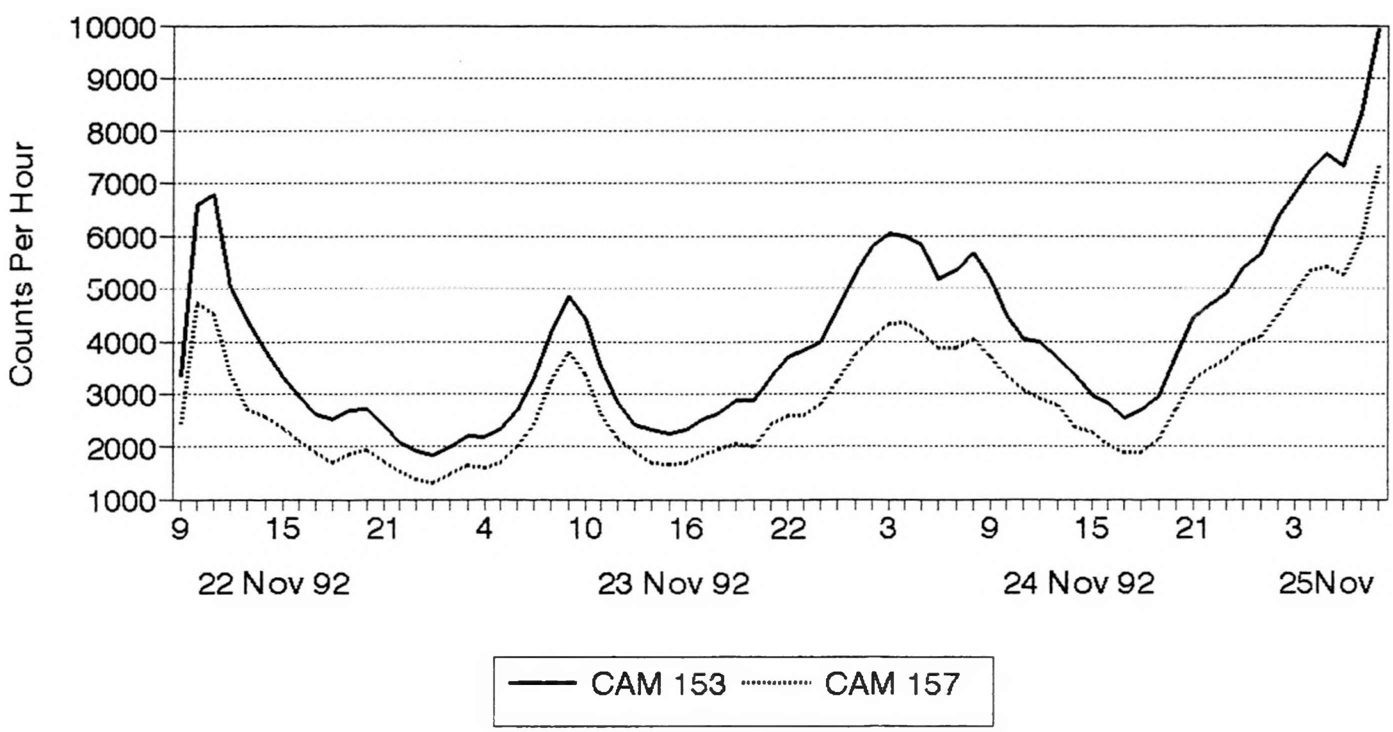
00:05	01:05	02:05	03:05	04:05	05:05	06:05	07:05	08:12	09:17	10:32	11:32
-22	-9	-16	-8	-9	-7	-10	-26	0	0	0	-1
-18	-9	-15	-5	-5	-29	-5	-20	0	0	0	0
-14	-2	-41	0	-4	-16	-3	-32	0	0	0	1
-15	-2	-49	2	-5	-18	-7	-42	0	0	-38	0
-24	-6	-20	3	-3	-24	-12	-17	0	0	-42	-3
-23	-8	-27	-1	-2	-19	-5	-7	0	0	-47	-3
-23	-3	-38	-1	-1	-11	-9	-4	0	0	-49	-1
-26	-10	-22	-7	2	-11	-15	0	0	0	-49	0
-27	-12	-9	-10	0	-8	-11	-1	0	0	-4	2
-24	-4	-13	-7	0	-9	-6	-3	0	0	-4	3
-20	-4	-7	-3	2	-11	-6	0	0	0	-2	3
-22	-10	-4	-6	2	-13	-8	-3	0	0	-3	-1
-29	-18	-10	-1	-1	-17	-3	-2	0	0	-2	0
-26	-22	-17	-2	1	-12	-4	-1	0	0	-2	-2
-20	-35	-20	-14	-7	-9	-5	-2	0	0	10	-2
-31	-29	-16	-21	-7	-7	-2	-2	0	0	4	-1
-22	-26	-13	-16	-7	-7	-5	-5	0	0	-33	-2
-20	-11	-9	-15	-17	-4	-2	-11	0	0	-17	-2
-19	-9	-18	-15	-19	-5	-5	-12	0	0	-11	-2
-22	-7	-12	-16	-10	-12	-8	-13	0	0	0	-1
-15	-6	-6	-5	-7	-15	-16	-14	0	0	-1	0
-12	-11	-5	-9	-12	-10	-6	-3	0	0	-4	1
-5	-20	-11	-11	-15	-18	-10	-6	0	0	-4	2
-6	-10	-6	-10	-12	-25	-15	-4	0	0	-5	1
-3	-9	-13	-8	-12	-14	-9	-2	0	0	-6	1
-7	-23	-26	-14	-23	-10	-11	-3	0	0	-4	1
-11	-21	-10	-13	-19	-7	-12	-6	0	0	-1	1
-7	-11	-8	-15	-15	-11	-11	-5	0	0	0	2
-14	-12	-7	-7	-13	-14	-10	-7	0	0	-1	5
-14	-12	-6	-9	-11	-4	-6	-4	0	0	1	4
-17	-10	-5	-9	-15	-1	-2	-4	0	0	0	3
-11	-4	-9	-8	-20	-7	-6	-6	0	0	-5	0
-27	-13	-11	-13	-14	-6	-8	-4	0	0	-6	-2
-22	-23	-11	-26	-20	-3	-6	-1	0	0	-2	-5
-22	-47	-8	-22	-33	-13	-8	-5	0	0	-3	-2
-19	-34	-12	-26	-18	-32	-8	-5	0	0	-2	-6
-19	-31	-12	-26	-14	-18	-11	-10	0	-32	0	-3
-20	-13	-7	-17	-25	-13	-6	-4	0	1	1	-2
-22	-17	-7	-8	-21	-8	-9	-3	0	8	-1	-1
-19	-13	-12	-9	-9	-5	-14	-5	0	12	-1	-3
-24	-10	-6	-8	-8	-4	-13	-9	0	12	-1	0
-34	-13	-9	-1	-13	-3	-7	-3	0	12	0	0
-22	-14	-9	-4	-6	-3	-15	-3	0	-166	0	1
-22	-6	-9	-4	-4	-7	-11	-8	0	-157	1	0
-42	-9	-7	-5	-8	-11	-6	-7	0	-157	1	0
-21	-8	-7	-5	-3	-12	-6	-4	0	-157	-1	-2
-17	-2	-10	-9	1	-27	-10	-9	0	-180	-1	-3
-9	-4	-6	-9	3	-18	-6	-9	0	12	-1	-9
-12	-9	-6	-14	-5	-11	-9	-9	0	2	1	-9
-9	-2	-6	-19	-4	-8	-22	-16	0	2	2	-8
-7	-2	-13	-19	-10	-4	-20	-5	0	24	1	-6
-8	-4	-8	-12	-11	-3	-12	-5	0	25	3	-7
-17	-9	-21	-10	-16	-1	-11	-9	0	26	3	-6
-10	-5	-18	-8	-5	-3	-9	3377 *	0	19	1	-5
-13	-11	-21	-3	-9	-8	-9	3386 *	0	25	-2	-4
-20	-20	-12	-6	-6	-11	-13	3376 *	0	25	0	-2
-16	-24	-14	-11	1	-10	-32	3381 *	0	28	-2	0
-21	-9	-16	-8	-1	-17	-27	3382 *	0	28	-6	2
-17	-11	-17	-9	-7	-10	-21	0	0	9	-4	1
-13	-15	-10	-6	-2	-5	-17	0	0	0	-1	1

* Filter Change

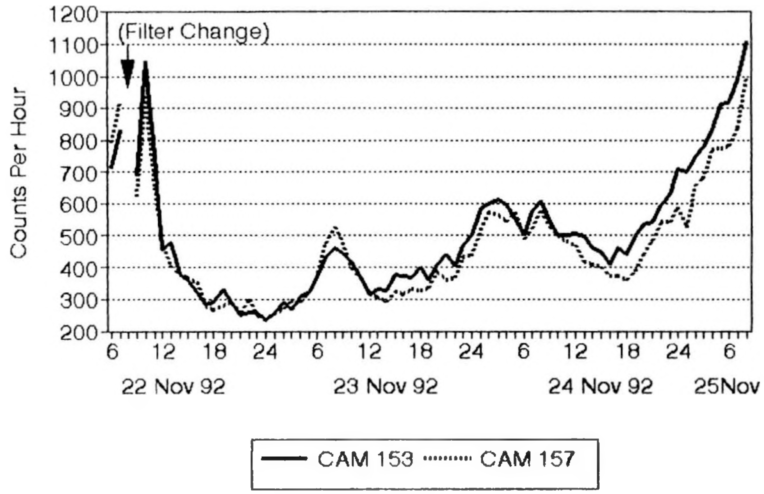




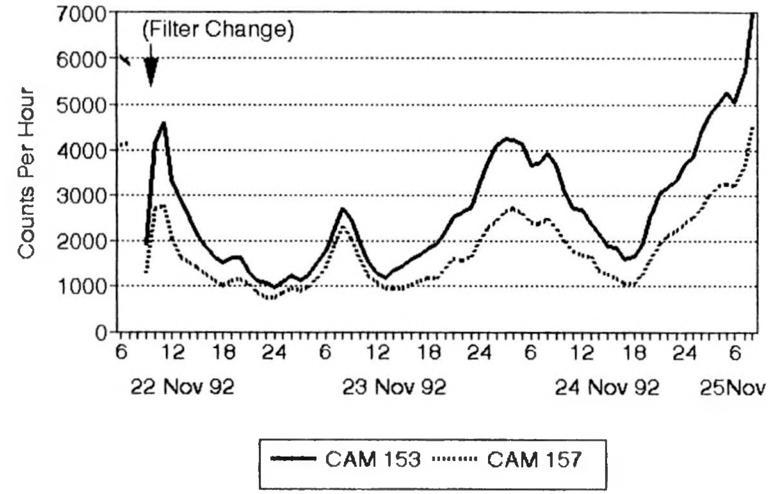
TOTAL ROI HOURLY COUNTS
11/22/91 to 11/25/91



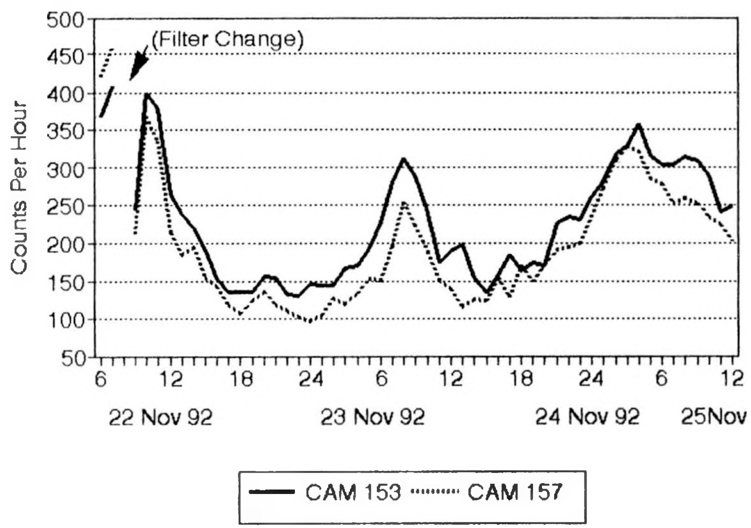
STATION A CAM DATA: ROI 1
11/22/91 to 11/25/91



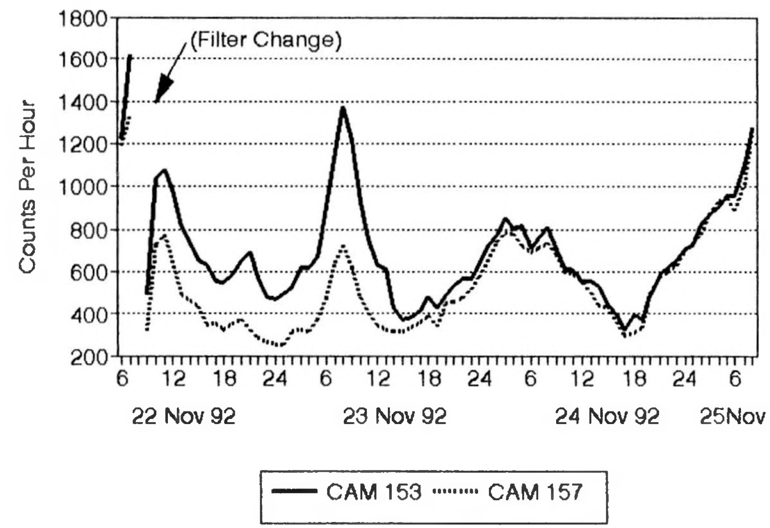
STATION A CAM DATA: ROI 3
11/22/91 to 11/25/91



STATION A CAM DATA: ROI 2
11/22/91 to 11/25/91



STATION A CAM DATA: ROI 4
11/22/91 to 11/25/91



CAM153 (Data are average CPM of last 5 minutes)

11/23/91 (Date, time in row below)

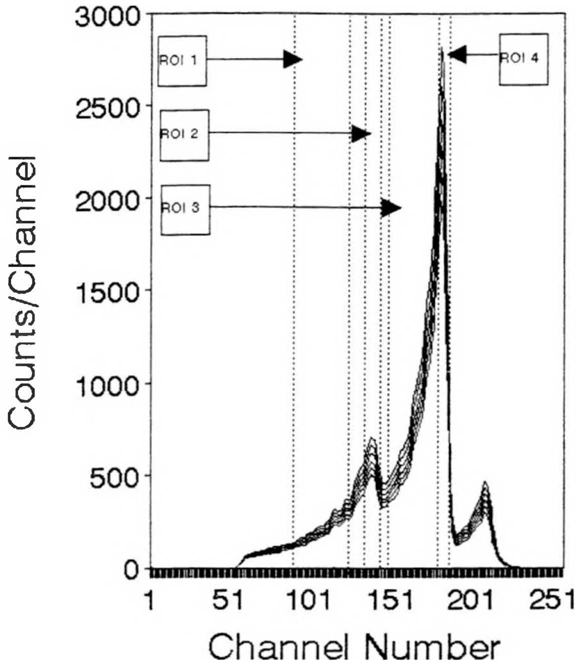
5:34	6:34	7:34	8:34	9:34	10:34	11:34	12:34	13:34	14:34	15:34	16:34
2	0	3	2	3	-1	2	5	3	4	3	1
0	2	2	3	2	-2	2	3	3	3	4	-1
-2	3	0	1	3	0	2	4	2	2	4	2
2	2	0	1	1	1	1	4	1	2	2	1
-1	-1	3	0	3	-2	1	1	0	0	4	-1
-1	-2	-1	3	4	-2	1	0	0	-1	3	-1
3	-4	-1	3	2	-2	-1	1	0	0	1	-1
3	-3	-1	5	1	-4	1	3	0	-1	1	-2
1	-2	-2	5	0	1	3	2	1	0	1	-1
3	1	-2	4	3	0	3	5	4	2	2	1
3	2	0	2	2	3	4	4	3	1	5	1
1	1	1	2	2	3	7	2	2	3	5	3
0	0	1	1	1	3	6	0	2	2	5	5
0	1	2	0	3	0	4	-1	2	2	4	4
0	0	1	-2	1	3	5	0	2	4	1	3
-3	-1	3	0	0	3	4	1	1	4	-4	1
-2	0	3	-1	3	3	2	3	1	3	-2	0
0	0	2	-2	3	4	2	4	1	2	-1	-1
2	0	4	-1	3	4	2	5	1	1	-2	-3
4	0	5	0	3	4	4	2	2	1	1	-1
6	2	1	1	5	2	0	2	4	0	3	4
4	0	1	1	3	1	1	2	5	-2	2	1
2	3	3	1	0	-1	1	2	4	-1	-1	-5
-1	1	1	1	-1	1	2	2	6	1	1	0
-2	1	1	-1	-2	2	1	1	2	-1	-1	0
-1	1	1	-2	-2	1	3	0	2	-2	-4	-1
-1	4	0	3	1	2	3	-2	0	0	-4	-2
0	1	-1	3	2	3	3	-4	1	2	-5	0
2	3	-1	2	2	2	3	-3	0	2	-6	-1
2	4	0	3	2	1	3	-1	2	3	-7	-4
1	3	1	5	3	3	4	1	1	3	-1	-7
2	2	0	1	0	3	4	1	3	3	0	-4
1	1	1	1	1	4	3	3	2	-1	0	-6
0	0	0	3	1	2	4	2	3	-3	2	-4
0	0	0	5	0	2	3	2	1	-1	6	0
-1	-2	-1	4	-2	1	0	-1	-3	-2	0	1
-1	1	3	2	-1	0	-1	-2	-3	-2	2	2
-1	0	3	4	0	-1	1	-2	0	-1	0	3
-1	1	3	3	2	1	1	1	-1	-1	-1	-1
-1	0	5	1	1	0	1	1	0	-2	-2	-4
0	1	5	2	0	2	1	3	1	-3	1	0
1	0	1	3	2	3	3	4	1	-2	0	-2
3	2	0	1	2	3	1	3	2	0	4	1
3	0	0	1	0	1	1	1	1	-1	4	-1
2	1	-3	1	1	5	2	1	2	-1	2	3
3	1	-2	-1	3	2	3	0	3	0	2	1
1	0	0	0	3	1	2	0	1	0	2	-2
2	-2	1	0	2	0	3	1	0	-3	1	-3
0	0	3	2	3	0	2	3	0	0	2	2
1	0	7	1	5	-1	2	5	1	-1	2	-4
0	2	6	1	3	1	1	4	1	2	2	-5
2	2	6	-1	1	3	1	3	2	2	1	-1
1	5	7	-1	3	3	0	2	2	3	-1	-2
1	4	5	-4	2	3	2	1	4	2	-2	-5
2	5	3	-3	0	2	1	0	4	2	2	0
3	4	4	-3	2	4	1	1	3	1	1	-1
1	5	4	-2	4	3	3	2	4	2	2	-1
2	4	3	1	1	3	3	2	4	3	2	-2
2	4	3	4	-2	4	3	1	3	5	2	-5
1	2	4	3	0	4	4	2	3	4	0	-5

CAM157 (Data are average CPM of last 5 minutes)

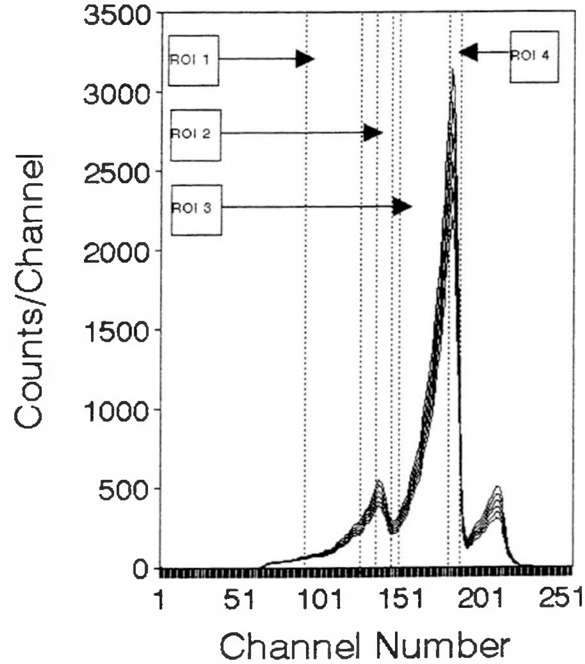
11/23/91 (Date, time in row below)

3:36	4:36	5:36	6:36	7:36	8:35	9:35	10:35	11:35	12:35	13:35	14:35
2	0	0	5	0	2	-5	1	0	-4	2	-1
0	-2	-1	4	0	2	-2	-1	0	0	4	0
0	-1	1	3	4	3	3	0	-1	-2	2	1
1	-1	0	3	2	4	2	2	1	0	2	-1
1	0	-2	2	3	3	3	0	1	0	3	1
2	3	1	1	3	3	4	3	3	2	2	1
2	3	2	3	3	1	2	3	3	2	1	0
3	5	1	1	3	4	0	4	3	4	2	2
1	3	1	2	4	2	0	2	0	3	1	1
0	1	2	3	3	2	-2	3	-1	4	2	1
-1	2	2	4	7	1	-2	-1	-2	3	0	2
1	3	-1	5	8	1	-1	-4	-1	3	1	0
1	1	0	6	5	0	3	-4	0	1	0	1
3	1	2	6	5	-3	2	-6	3	1	-1	3
3	2	-2	5	6	-4	2	-6	3	3	-1	2
2	1	-2	2	3	-2	3	-4	3	4	3	1
3	-1	-1	1	3	0	2	-1	3	3	3	1
2	1	-1	0	3	1	-1	-3	3	5	3	-2
2	2	-2	-1	3	4	0	1	3	3	4	0
2	4	-3	0	1	2	0	2	3	0	3	0
2	6	-1	1	0	2	-2	-1	5	-2	1	-1
-1	6	-3	1	-1	2	-2	-1	3	-2	2	1
0	6	-2	0	1	1	-1	2	2	-5	4	3
2	6	-2	0	-2	1	-2	2	2	-2	4	1
3	2	1	1	0	1	-1	1	2	-3	4	0
4	0	-1	1	2	0	2	3	2	-2	4	1
4	2	0	0	0	-2	3	2	2	1	5	1
3	0	-1	0	-2	-3	1	1	4	2	2	-1
2	-2	1	-2	2	-5	5	-2	2	1	2	2
1	-1	0	-6	3	-2	1	0	3	1	2	3
0	2	0	-5	2	-4	2	1	2	1	4	2
1	0	1	-5	2	1	0	3	2	-2	3	2
0	-1	1	-4	4	1	1	1	1	-2	3	1
-2	0	-1	-1	2	0	-3	4	3	-1	2	-1
-1	-3	-1	2	2	0	1	4	3	-1	2	-2
-2	-6	0	-1	1	2	-1	2	3	0	0	0
-1	-3	2	1	1	1	0	0	3	1	0	0
3	-3	1	0	0	2	-2	3	3	0	0	1
4	-4	1	-3	0	4	-4	2	2	1	1	-1
2	0	2	-4	2	4	-4	1	1	1	1	1
3	1	2	-2	2	2	-3	3	-3	4	3	2
3	1	0	-2	1	2	-1	3	-2	3	0	2
-1	1	1	0	-3	3	3	2	-1	5	2	1
2	2	1	3	-2	4	4	0	-1	4	1	4
2	4	1	6	-6	2	3	2	0	5	1	3
3	2	-1	6	-5	3	3	0	2	2	-1	4
3	0	1	7	-3	4	3	0	3	1	1	4
4	0	1	5	2	4	1	-2	1	1	0	5
3	3	-2	5	5	1	0	-1	2	1	1	4
1	-1	-3	3	5	2	1	-3	2	-1	1	4
1	-2	0	3	6	1	2	-3	2	-2	2	2
2	-4	-2	3	5	0	2	-1	1	-1	1	4
1	-3	0	5	2	-1	0	1	1	-3	0	2
2	-7	1	4	0	0	0	1	-1	0	2	2
4	-3	6	2	2	2	2	1	-1	1	3	1
5	-3	4	3	-2	2	-2	0	-1	1	3	2
5	1	5	2	-3	0	-4	0	-2	-2	3	1
4	1	6	0	-3	-6	0	0	0	1	2	0
4	2	5	1	0	-5	-1	0	0	0	2	1
3	2	4	3	1	-5	-3	0	-1	-1	-3	0

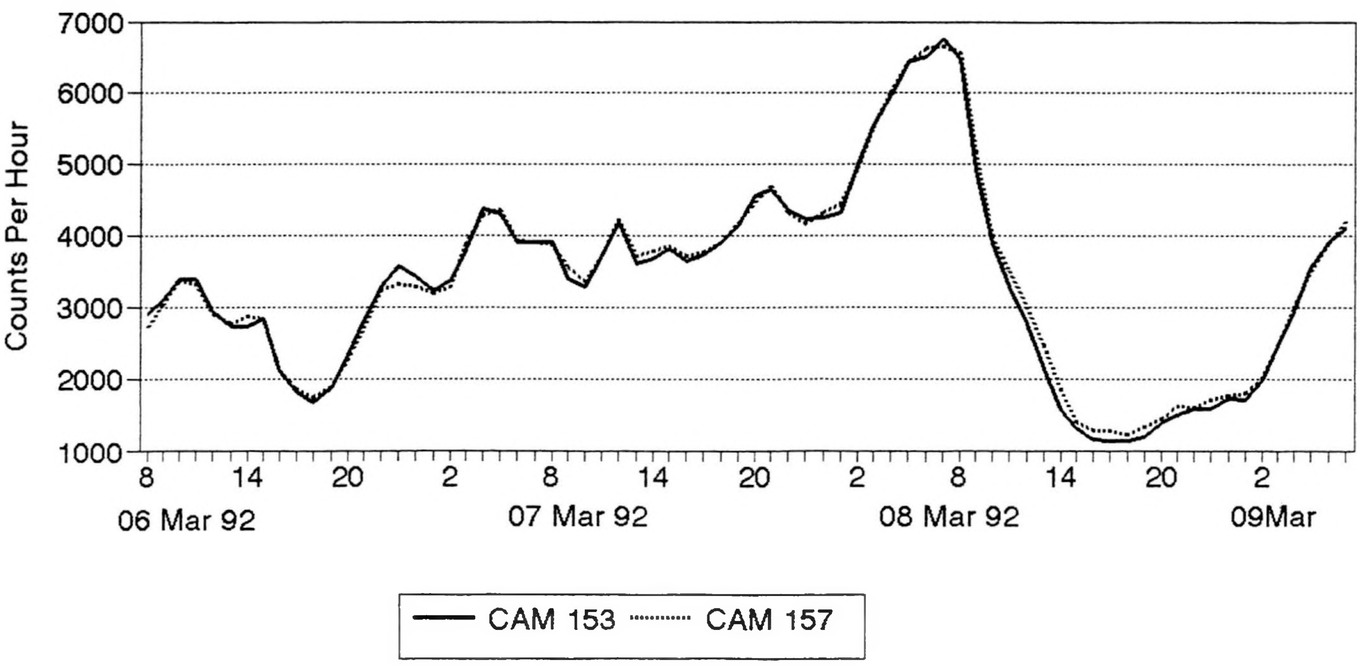
CAM 157, Stn A
3/7/92 (1-6 a.m.)



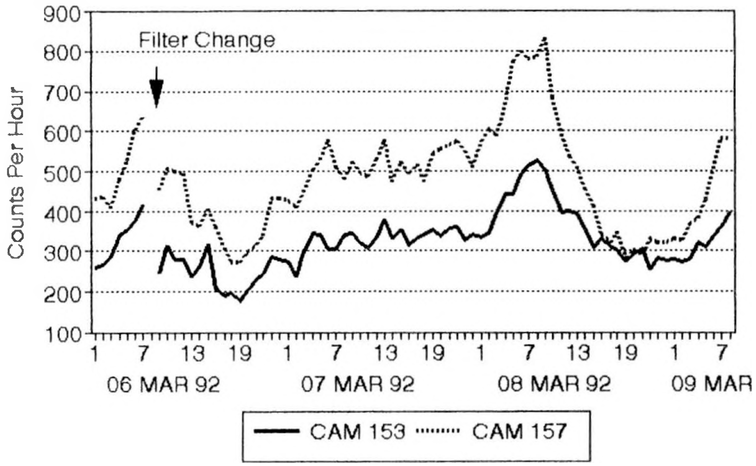
CAM 153, Stn A
3/7/92 (1-6 a.m.)



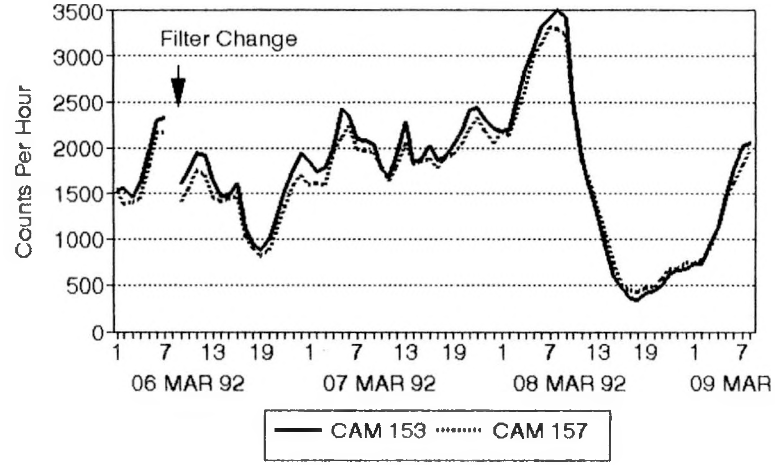
TOTAL ROI HOURLY COUNTS
3/06/92 to 3/09/92



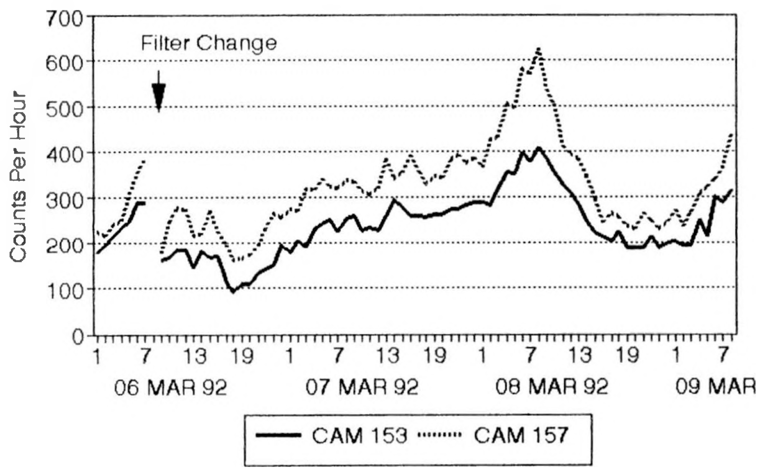
STATION A CAM DATA: ROI 1
3/06/92 to 3/09/92



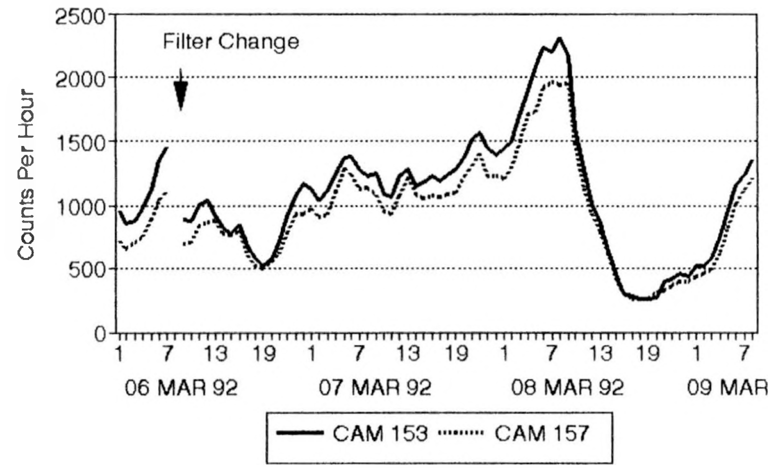
STATION A CAM DATA: ROI 3
3/06/92 to 3/09/92



STATION A CAM DATA: ROI 2
3/06/92 to 3/09/92



STATION A CAM DATA: ROI 4
3/06/92 to 3/09/92



CAM 157 (Data are average CPM of last 5 minutes)

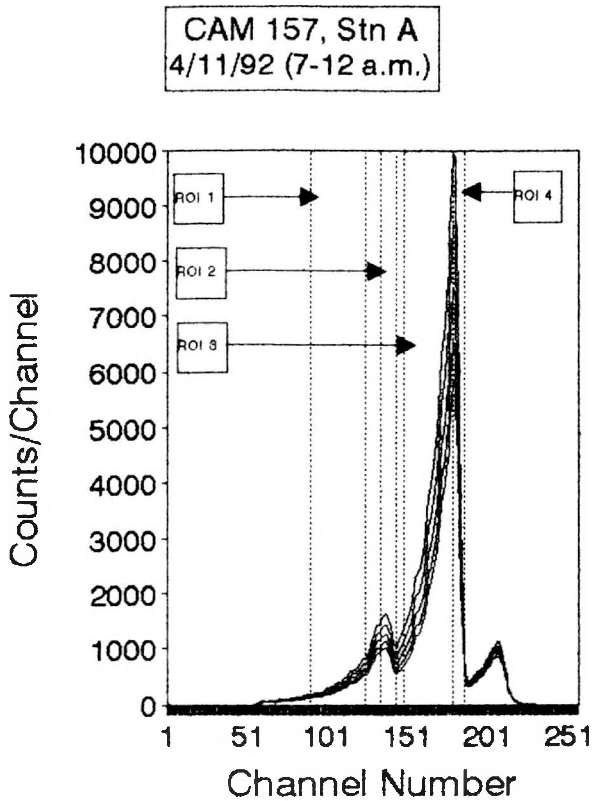
03/07/92 (Date, time in row below)

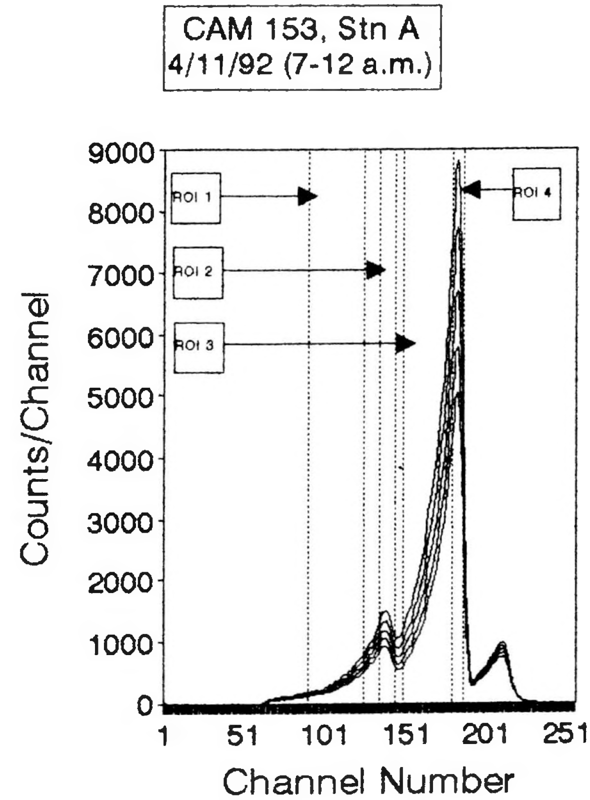
23:51	00:51	01:51	02:51	03:51	04:51	05:51	06:51	07:51	08:51	09:51	10:51
1	-1	2	4	1	6	5	4	0	1	5	2
5	0	2	4	2	5	2	4	0	-2	3	1
4	2	2	1	1	5	0	3	-1	-2	1	2
3	1	1	1	4	6	2	5	-1	1	-2	1
1	3	0	2	3	3	1	5	-2	-1	-2	2
4	1	-1	3	5	2	0	5	-1	1	-2	2
1	1	1	1	5	2	2	5	0	1	-2	2
0	0	3	4	5	2	4	5	0	3	1	1
2	0	2	7	0	1	1	3	0	3	2	2
2	1	2	7	3	3	4	1	3	4	2	2
0	0	2	7	3	1	5	4	2	3	1	1
2	-1	2	8	3	1	4	4	3	3	-1	4
5	0	1	7	4	1	4	4	4	2	0	5
3	0	2	4	6	2	4	3	5	0	3	4
4	-1	2	2	5	2	2	4	1	2	4	6
4	-1	1	0	3	2	2	2	2	3	3	5
3	1	1	1	4	2	2	0	1	3	3	1
1	1	2	0	2	2	2	1	-2	3	1	0
3	2	1	0	0	3	4	0	-2	5	-1	-1
2	4	3	0	-1	1	6	1	0	1	-3	-2
2	6	4	1	1	2	6	-1	-2	1	-2	-1
2	5	3	0	0	2	5	0	-2	3	2	2
3	4	2	-2	0	3	5	3	-1	1	1	3
1	4	3	-2	4	2	4	4	-1	1	2	4
3	3	3	-1	4	4	2	2	0	0	3	3
4	3	3	0	3	5	2	5	1	1	0	4
3	3	3	-2	2	4	3	6	3	1	0	0
4	3	3	-1	1	2	4	4	4	3	2	3
3	2	2	-2	-2	3	2	2	4	4	1	1
3	-1	2	-3	0	3	2	3	4	5	1	3
4	1	2	-2	-1	1	0	2	6	4	5	3
4	1	0	-1	-1	5	2	4	3	2	3	4
2	3	0	-1	0	4	1	2	3	3	3	3
3	4	2	-1	-1	3	2	5	2	1	2	6
1	6	1	-1	-3	1	2	3	3	-1	4	5
-2	4	-1	0	-3	2	5	3	2	-1	1	4
-1	3	0	1	-1	2	5	1	1	2	4	5
-1	4	0	1	-1	3	3	2	0	1	4	0
3	4	-3	3	-2	4	3	0	2	-1	3	-1
2	3	-1	3	-1	4	3	2	2	1	1	-1
3	3	-1	3	-3	4	2	2	3	-1	3	0
3	2	0	3	-3	4	2	1	3	-5	-2	2
2	2	1	0	-2	5	2	3	3	-3	-1	4
-1	2	1	1	-1	3	3	4	1	-1	-1	2
2	0	0	1	-1	5	4	4	0	-1	-3	3
2	3	2	1	-2	3	6	3	-1	2	-2	2
2	4	1	1	-1	3	6	3	2	5	3	2
3	1	1	3	1	0	7	1	2	3	1	2
2	1	3	3	1	0	4	2	4	1	5	3
2	3	2	2	2	-2	2	1	2	1	3	4
2	3	2	1	5	-1	2	0	4	2	5	5
3	2	1	1	6	-2	-1	2	4	0	3	1
1	2	2	-1	4	1	2	2	4	3	6	1
4	2	1	0	5	2	4	2	2	5	3	0
0	2	1	2	5	2	5	3	3	6	4	0
1	0	0	2	5	3	4	2	1	4	2	1
1	1	1	3	5	4	5	1	2	4	3	2
0	1	3	4	6	5	3	2	1	5	0	1
0	2	3	4	5	4	2	-1	0	3	2	1
-1	2	3	2	6	5	3	-2	1	3	3	1

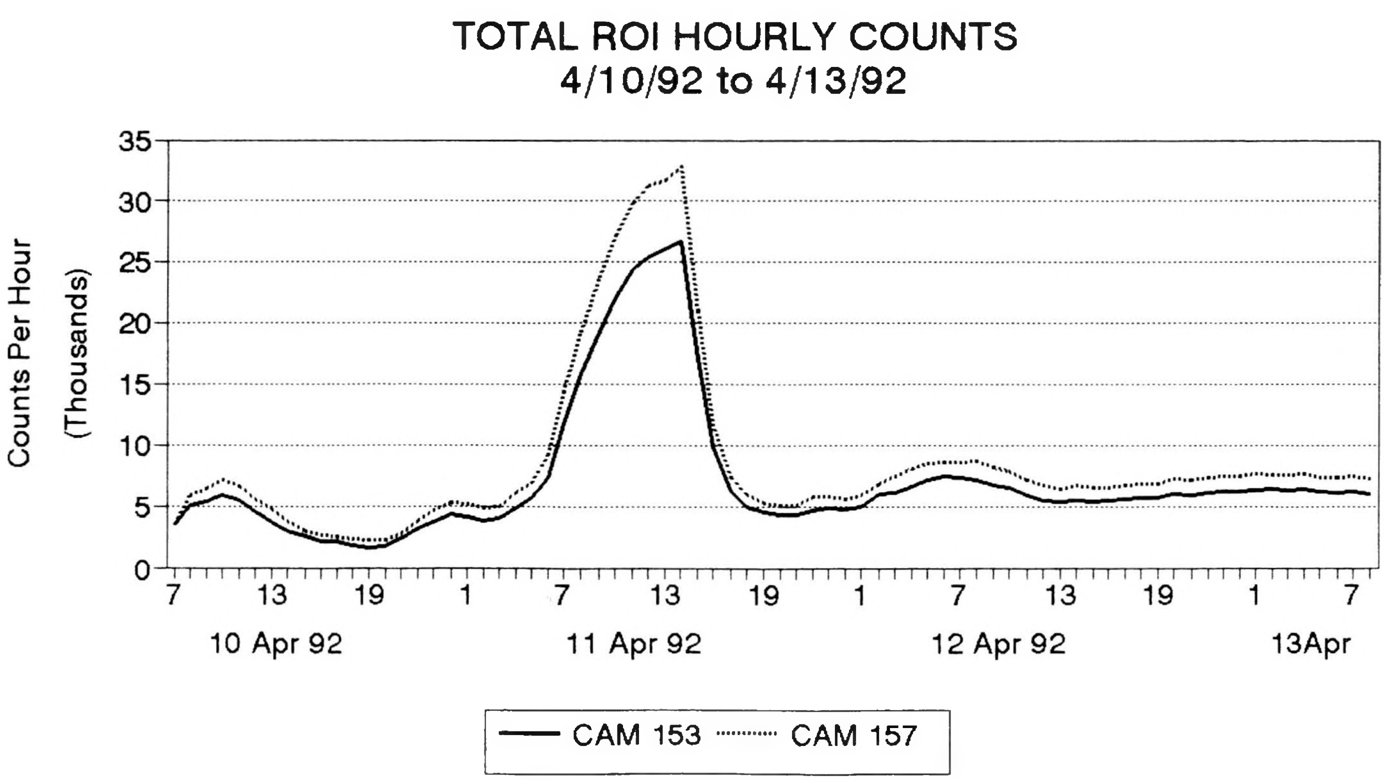
CAM 153 (Data are average CPM of last 5 minutes)

03/07/92 (Date, time in row below)

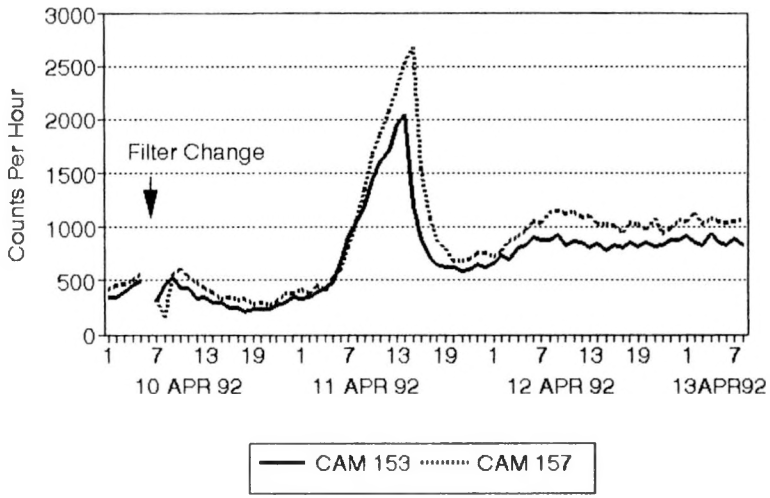
23:55	00:55	01:55	02:55	03:55	04:55	05:55	06:55	07:55	08:55	09:55	10:55
4	4	0	1	2	3	0	-1	0	0	2	3
3	3	0	1	2	0	1	-1	1	0	2	1
1	2	1	3	3	0	0	0	0	0	1	1
0	2	1	3	3	1	-1	-2	0	1	-1	0
3	0	0	3	4	-2	1	-1	1	1	1	2
2	1	0	2	3	-1	1	-2	1	2	1	3
1	0	-2	1	1	1	0	-1	2	3	-1	3
2	2	0	1	1	1	1	1	3	3	0	2
2	2	-1	1	1	-2	0	0	3	4	1	2
-1	2	-2	3	1	0	0	2	3	2	-1	2
1	0	0	1	1	-3	3	2	2	1	0	1
0	1	1	0	2	-4	2	3	4	0	2	-1
-1	1	0	2	3	-2	3	1	3	1	1	1
0	-2	1	1	3	-1	3	2	3	-1	0	-1
1	-1	2	-1	3	1	3	2	2	-1	-1	-1
-1	0	0	0	4	2	1	3	4	1	-2	1
0	0	2	1	4	3	1	2	1	-1	-2	1
1	-1	3	-1	4	4	0	3	1	-1	0	0
1	1	2	0	4	4	1	3	1	-1	1	2
0	1	3	0	3	5	2	3	2	1	2	1
0	3	4	2	3	4	1	2	2	-1	3	0
0	3	2	2	3	5	3	1	2	2	4	1
1	4	2	3	3	5	2	1	1	1	5	1
-1	4	2	3	2	4	0	1	2	1	6	0
1	5	0	4	1	3	0	1	3	1	5	0
0	1	0	3	2	4	1	1	3	1	3	1
-1	1	0	2	2	2	0	1	4	0	2	1
0	0	0	1	2	-1	0	1	4	0	-1	2
4	0	1	2	2	0	0	1	2	0	0	4
3	-1	2	3	3	0	0	-1	2	-1	1	4
3	0	0	2	3	0	-1	-1	2	-1	2	3
4	2	0	2	2	0	0	1	3	0	0	4
4	0	0	2	2	2	0	0	3	-2	3	1
0	1	-1	2	2	2	1	1	4	0	0	2
0	3	-2	2	3	1	2	1	2	-1	0	-1
1	3	1	3	1	2	0	1	2	1	2	-1
-1	3	0	2	2	2	1	-1	2	-1	4	0
1	5	1	2	2	1	0	-1	1	2	2	0
0	4	2	3	2	-1	-2	-1	0	2	3	0
2	3	1	2	2	2	-2	0	0	3	2	1
0	2	-2	2	1	2	0	2	-3	2	0	1
1	2	0	4	2	-1	0	3	-6	4	0	1
1	1	-1	3	2	0	0	5	-4	3	0	2
1	1	-1	1	2	3	3	3	-5	1	3	1
0	2	-1	2	0	-1	2	4	-3	3	4	1
1	1	0	1	2	0	3	2	-1	3	4	0
0	2	-1	0	4	3	1	2	0	0	4	-2
1	2	-1	2	1	4	2	2	1	-1	5	-1
2	1	0	2	2	2	1	3	1	1	1	0
2	1	2	2	2	3	2	2	0	1	1	0
2	2	1	2	2	0	-1	3	1	1	2	1
2	1	2	1	-1	0	-1	3	1	1	1	1
3	1	2	1	0	-1	-1	-1	3	2	1	1
2	3	1	2	-1	0	1	1	1	2	1	1
2	3	1	2	-1	2	-2	1	1	2	0	2
1	3	1	3	0	1	0	0	2	3	1	2
2	4	0	5	2	2	1	-2	1	3	3	3
2	2	0	3	1	2	0	1	-1	4	3	3
2	0	0	3	3	2	0	0	0	4	4	4
3	0	-1	2	4	-1	-1	0	1	4	4	4


CAM 157, Stn A
4/11/92 (7-12 a.m.)
ROI 1
ROI 2
ROI 3
ROI 4
Counts/Channel
Channel Number
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
51
101
151
201
251

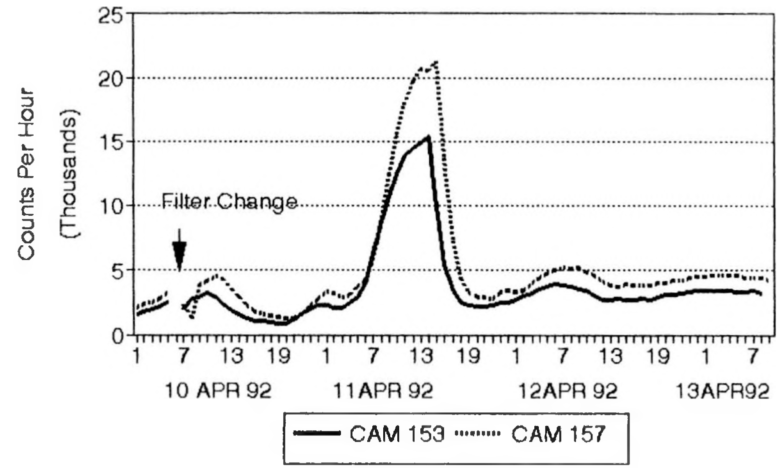

CAM 153, Stn A
4/11/92 (7-12 a.m.)
ROI 1
ROI 2
ROI 3
ROI 4
Counts/Chanel
Channel Number
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
1
51
101
151
201
251


TOTAL ROI HOURLY COUNTS
4/10/92 to 4/13/92
Counts Per Hour
(Thousands)
35
30
25
20
15
10
5
0
7
13
19
1
7
13
19
1
7
13
19
1
7
10 Apr 92
11 Apr 92
12 Apr 92
13Apr
CAM 153
CAM 157

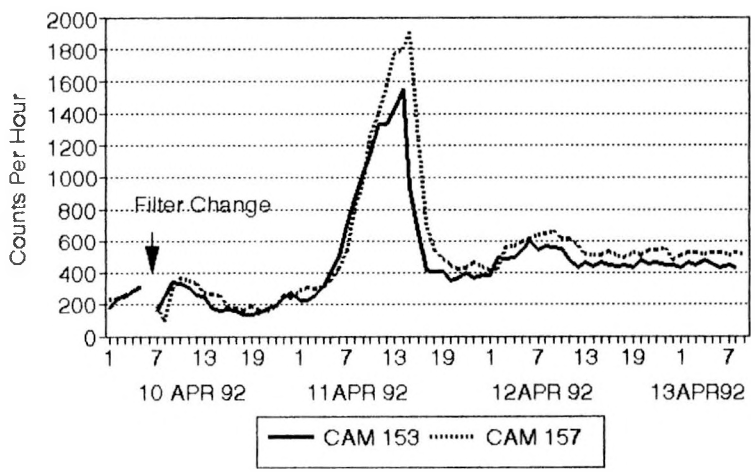
STATION A CAM DATA: ROI 1
4/10/92 to 4/13/92



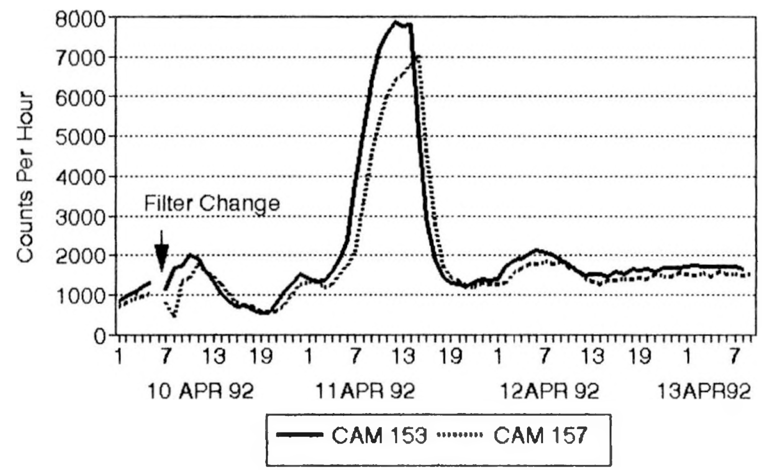
STATION A CAM DATA: ROI 3
4/10/92 to 4/13/92



STATION A CAM DATA: ROI 2
4/10/92 to 4/13/92



STATION A CAM DATA: ROI 4
4/10/92 to 4/13/92



CAM 153 (Data are average CPM of last 5 minutes)

04/11/92 (Date, time in row below)

00:38	01:38	02:38	03:38	04:38	05:38	06:38	07:38	08:38	09:38	10:38	11:38
2	-2	2	2	2	3	2	7	11	0	3	4
3	-1	1	2	3	2	4	7	7	0	2	6
2	1	2	2	4	2	5	3	4	2	-1	3
1	0	3	5	2	2	4	2	5	1	3	4
2	2	3	4	3	3	3	2	8	2	4	2
2	2	2	3	4	1	2	0	5	2	5	3
1	2	2	2	2	3	1	-2	7	2	4	3
3	2	3	3	0	3	0	1	5	-1	7	2
3	2	1	2	2	2	2	1	5	0	4	-1
3	2	0	2	-1	3	4	1	5	4	3	-1
2	2	1	2	-2	3	5	0	7	5	3	-1
1	2	1	3	2	0	5	3	5	3	2	-3
2	4	1	3	2	-4	7	1	7	4	5	1
0	4	2	3	2	-1	6	2	6	1	7	-2
0	2	4	3	3	-3	7	2	4	-2	8	0
0	0	4	4	2	-2	6	1	3	-1	8	1
0	1	5	5	0	-1	6	0	4	0	11	3
1	1	4	3	0	0	4	1	4	2	11	3
2	0	3	3	1	1	4	1	1	3	9	2
3	2	2	3	2	2	4	1	2	5	8	0
4	3	1	3	2	1	4	4	1	4	6	0
3	4	1	3	2	4	3	3	2	2	5	-1
2	3	1	5	3	6	3	1	-1	2	-1	0
4	5	2	4	3	5	1	0	4	3	-2	1
5	2	3	4	3	5	2	2	3	1	-3	4
4	2	4	2	3	5	2	0	2	1	-1	4
5	3	4	2	3	3	3	2	-1	3	-2	4
4	3	4	3	4	0	4	5	2	2	1	1
4	1	3	2	3	0	6	8	0	3	6	-2
1	1	1	3	4	2	2	6	-1	4	1	-1
-1	3	1	3	3	3	4	7	2	5	-1	-4
-1	0	2	1	4	2	5	5	4	6	1	-6
0	0	1	1	4	3	3	3	2	8	0	-4
-1	0	0	0	2	1	1	1	2	4	-5	0
0	1	2	-1	2	-2	5	5	-1	2	0	-5
1	1	0	1	2	-1	3	4	-5	-1	4	-2
3	1	0	2	1	0	1	4	-6	0	1	0
2	2	1	1	1	0	0	5	-7	0	1	-2
4	1	2	1	2	1	2	6	-5	0	0	0
3	2	0	3	3	1	1	2	-1	1	0	3
4	2	0	2	3	2	-1	2	2	2	0	2
2	4	1	2	4	3	-2	4	3	-2	-1	2
1	4	0	2	3	2	1	3	1	-3	0	5
1	5	1	2	3	3	-3	4	2	0	2	4
3	5	2	3	2	3	-3	8	-1	-1	3	6
3	4	3	2	4	2	-2	8	1	0	5	6
2	2	4	2	3	0	0	7	0	0	9	5
4	-1	5	0	3	0	3	8	3	1	8	5
3	0	4	2	5	1	6	6	1	0	6	4
3	-1	4	0	4	1	3	3	3	2	6	-2
2	-1	3	1	2	0	3	3	4	1	1	0
2	2	3	0	1	0	0	4	2	3	0	-1
2	2	3	0	3	3	-1	3	3	4	-2	-2
2	1	2	1	1	3	-2	2	2	5	-1	-1
1	1	3	3	3	6	-2	3	2	6	-3	0
2	2	5	3	1	8	0	1	2	6	-2	-1
2	0	4	2	2	7	1	5	6	6	-3	1
-1	2	4	3	1	5	3	9	3	6	0	1
0	1	3	3	2	5	4	10	6	4	2	0
-2	2	2	2	0	2	5	9	4	3	5	2

CAM 157 (Data are average CPM of last 5 minutes)

04/11/92 (Date, time in row below)

23:37	00:37	01:37	02:37	03:37	04:37	05:37	06:37	07:37	08:37	09:37	10:37
-2	-2	0	-1	2	-7	1	-6	-5	-12	-21	-16
-1	-2	0	-1	0	-5	0	-3	-5	-10	-19	-15
0	-1	-1	-1	-2	-5	-1	-2	-5	-5	-19	-15
0	-1	-1	-2	-4	-3	2	-3	-6	-4	-9	-4
0	-1	-1	-1	-2	-2	0	0	-5	-5	-9	-15
4	0	-2	-1	-4	-2	1	-3	-4	-5	-8	-13
2	1	-3	-2	-4	0	0	-1	-4	-7	-13	-15
0	3	-3	0	-2	1	1	-3	-8	-9	-15	-15
0	0	-3	-1	0	0	1	-2	-8	-10	-22	-20
0	0	-2	-2	1	-1	2	-6	-7	-8	-24	-15
-3	1	-2	1	1	-1	-2	-4	-9	-9	-23	-15
-3	0	-3	3	3	-3	-2	-6	-10	-12	-23	-17
-1	-2	-2	-3	2	-4	-2	-6	-7	-12	-18	-20
1	-1	-3	-4	-1	-4	-4	-6	-7	-15	-19	-23
1	-2	-2	-3	-3	-4	-3	-2	-8	-17	-17	-22
0	-5	0	-5	-4	-4	-5	-1	-10	-14	-17	-31
-1	-6	2	-8	-5	-4	-6	-3	-10	-12	-12	-31
-1	-7	-1	-4	-6	-1	-7	-1	-10	-15	-15	-28
-1	-9	0	1	-4	1	-7	0	-6	-12	-12	-30
-2	-6	-2	-1	-4	3	-10	-1	-10	-13	-13	-24
-1	-3	-3	-1	-2	2	-7	-5	-7	-17	-14	-16
1	-3	-6	-1	-2	1	-4	-4	-9	-19	-21	-17
0	1	-2	0	-2	0	-3	-6	-10	-10	-21	-22
-1	4	-2	-1	-2	-2	-1	-9	-10	-11	-19	-21
-1	2	-3	1	-1	-2	0	-8	-6	-9	-22	-28
0	2	-3	1	-2	-1	1	-6	-10	-8	-24	-30
-1	2	-3	3	0	-1	1	-6	-10	-7	-21	-30
0	1	0	-1	-2	1	0	-2	-8	-14	-21	-26
1	-1	-2	-1	0	-1	2	-2	-10	-11	-23	-28
0	-4	-3	1	-2	-1	1	-2	-15	-11	-22	-24
0	-5	-2	1	0	-1	0	-3	-12	-9	-20	-22
1	-4	0	1	-2	-1	2	0	-10	-10	-20	-28
-1	-7	-2	0	-2	-2	3	-2	-13	-9	-25	-30
-2	-5	-3	1	-1	1	1	-3	-15	-8	-19	-26
-2	-1	-1	1	3	-2	3	-5	-8	-6	-17	-27
-3	-1	-2	-2	1	-3	3	-5	-10	-7	-19	-28
-3	-1	-4	-1	0	-2	1	-2	-7	-8	-14	-22
0	0	-2	1	2	-1	0	-3	-3	-4	-14	-15
0	1	-2	0	-2	-2	-4	-3	0	-7	-28	-16
3	-2	-4	-2	-2	1	-6	-2	-3	-12	-23	-19
3	-2	-2	-1	-1	1	-8	-3	-5	-13	-28	-20
4	0	0	-2	-2	0	-12	-10	-9	-15	-33	-21
2	2	-3	-1	-1	-1	-10	-9	-12	-17	-30	-26
2	-1	0	0	1	0	-5	-6	-15	-21	-18	-28
1	0	2	-2	-2	0	-6	-5	-16	-19	-21	-29
1	1	1	-2	-4	2	-5	-6	-10	-18	-16	-37
0	1	-1	-4	-1	1	-1	-4	-5	-15	-15	-40
1	-4	-1	-5	0	1	-3	-5	-6	-19	-18	-35
4	-4	-1	-5	-2	3	-4	-3	-1	-15	-24	-35
3	2	-4	0	-3	2	-3	-2	-1	-12	-25	-30
2	-2	-4	-2	0	-1	-3	-2	-1	-13	-24	-24
3	-3	-8	0	-5	2	-3	1	-4	-10	-24	-22
3	-1	-7	0	-7	0	-4	-1	0	-2	-22	-24
0	-1	-8	1	-5	0	-4	-4	-1	-3	-22	-20
2	-7	-9	0	-3	-4	-1	-7	-2	-8	-16	-28
0	-7	-6	2	-2	-2	1	-6	-12	-4	-17	-29
-1	-5	-2	4	-3	-4	-3	-7	-11	-7	-15	-25
-2	-3	-2	5	-3	-1	0	-6	-17	-13	-13	-28
-1	-3	-1	3	-5	-5	-1	-7	-18	-18	-16	-29
-3	-2	0	0	-5	-1	-4	-6	-17	-17	-18	-24

Environmental Evaluation Group Reports
(Continued From Front Cover)

EEG-29 Little, Marshall S., Evaluation of the Safety Analysis Report for the Waste Isolation Pilot Plant Project, May 1985.

EEG-30 Dougherty, Frank, Tenera Corporation, Evaluation of the Waste Isolation Pilot Plant Classification of Systems, Structures and Components, July 1985.

EEG-31 Ramey, Dan, Chemistry of the Rustler Fluids, July 1985.

EEG-32 Chaturvedi, Lokesh and James K. Channell, The Rustler Formation as a Transport Medium for Contaminated Groundwater, December 1985.

EEG-33 Channell, James K., John C. Rodgers and Robert H. Neill, Adequacy of TRUPACT-I Design for Transporting Contact-Handled Transuranic Wastes to WIPP, June 1986.

EEG-34 Chaturvedi, Lokesh, (edi.), The Rustler Formation at the WIPP Site, February 1987.

EEG-35 Chapman, Jenny B., Stable Isotopes in Southeastern New Mexico Groundwater: Implications for Dating Recharge in the WIPP Area, October 1986.

EEG-36 Lowenstein, Tim K., Post Burial Alteration of the Permian Rustler Formation Evaporites, WIPP Site, New Mexico, April 1987.

EEG-37 Rodgers, John C., Exhaust Stack Monitoring Issues at the Waste Isolation Pilot Plant, November 1987.

EEG-38 Rodgers, John C. and Jim W. Kenney, A Critical Assessment of Continuous Air Monitoring Systems at the Waste Isolation Pilot Plant, March 1988.

EEG-39 Chapman, Jenny B., Chemical and Radiochemical Characteristics of Groundwater in the Culebra Dolomite, Southeastern New Mexico, March 1988.

EEG-40 Review of the Final Safety Analyses Report (Draft), DOE Waste Isolation Pilot Plant, December 1988, May 1989.

EEG-41 Review of the Draft Supplement Environmental Impact Statement, DOE Waste Isolation Pilot Plant, July 1989.

EEG-42 Chaturvedi, Lokesh, Evaluation of the DOE Plans for Radioactive Experiments and Operational Demonstration at WIPP, September 1989.

EEG-43 Kenney, Jim W., et al., Preoperational Radiation Surveillance of the WIPP Project by EEG 1985-1988, January 1990.

EEG-44 Greenfield, Moses A., Probabilities of a Catastrophic Waste Hoist Accident at the Waste Isolation Pilot Plant, January 1990.

EEG-45 Silva, Matthew K., Preliminary Investigation Into the Explosion Potential of Volatile Organic Compounds in WIPP CH-TRU Waste, June 1990.

EEG-46 Gallegos, Anthony, and James K. Channell, Risk Analysis of the Transport of Contact Handled Transuranic (CH-TRU) Wastes to WIPP Along Selected Highway Routes in New Mexico Using RADTRAN IV, August 1990.

EEG-47 Kenney, Jim W. and Sally C. Ballard, Preoperational Radiation Surveillance of the WIPP Project by EEG During 1989, December 1990.

EEG-48 Silva, Matthew, An Assessment of the Flammability and Explosion Potential of Transuranic Waste, June 1991.

EEG-49 Kenney, Jim W., Preoperational Radiation Surveillance of the WIPP Project by EEG During 1990, November 1991.

EEG-50 Silva, Matthew K. and James K. Channell, Implications of Oil and Gas Leases at the WIPP on Compliance with EPA TRU Waste Disposal Standards, June 1992.

EEG-51 Kenney, Jim W., Preoperational Radiation Surveillance of the WIPP Project by EEG During 1991, October 1992.