INDEPENDENT AUDIT OF LOS ALAMOS NATIONAL LABORATORY FOR COMPLIANCE WITH THE CLEAN AIR ACT, 40 CFR 61, SUBPART H

INTRODUCTION

On January 21, 1997, the U.S. Department of Energy (DOE), Siegfried S. Hecker, and the Concerned Citizens for Nuclear Safety (CCNS) reached an agreement to settle a suit concerning the status of compliance of the Los Alamos National Laboratory (LANL) with 40 CFR 61.90–61.97, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* (see Appendix B to this report). As part of that agreement, referred to as the Consent Decree (see Appendix C to this report), a series of comprehensive technical audits were to be performed. The first audit, covering the year 1996, began in June 1997 and subsequent audits are to be performed in 2000 and 2002. As stated in the Consent Decree, the purpose of these technical audits is to verify whether LANL is in compliance with the Clean Air Act, 40 CFR 61, Subpart H, set forth in the Code of Federal Regulations (CFR). It was agreed in the settlement that *Risk Assessment Corporation (RAC)* would conduct the audits as the independent auditor. Dr. John E. Till, president of *RAC*, assembled a multidisciplinary team of scientists, the Independent Technical Audit Team (ITAT), for this purpose.

The audit was observed and monitored by a separate independent group on behalf of CCNS, the Institute for Energy and Environmental Research (IEER), to ensure the audit was objective and comprehensive. IEER neither performed a separate audit nor were they responsible for the results of the audit. Their role was to monitor the audit for completeness, quality, and thoroughness.

This report has been through a draft form, which was reviewed extensively by all of the interested parties. Although comments to the report are not addressed in a separate document, *RAC* endeavored to treat every comment raised on the draft report. These are treated within the text of the report as appropriate.

This chapter provides background about the lawsuit precipitating this audit, describes the selection of the audit team, summarizes the purpose and scope of the audit, explains how the audit team identified deficiencies, describes the history of the Clean Air Act and the Federal Facilities Compliance Agreement (FFCA), and summarizes the documentation presented by LANL to the U.S. Environmental Protection Agency (EPA) explaining the Laboratory's compliance plan and self-assessment of compliance with 40 CFR 61, Subpart H, for 1996.

Background

The Los Alamos National Laboratory is a Department of Energy facility located in Los Alamos County in north-central New Mexico. The Laboratory is located atop a mesa and is surrounded by canyons, making the topography of the site very complex. The primary mission of this facility has always been research and development in the area of nuclear weapons, including weapons development, fission and fusion, and weapons safety. Along with conducting nuclear weapons research goes the responsibility of maintaining environmental controls to limit the release of radionuclides into the environment. These controls and the practice and procedures that accompany them are some of the questions around which this audit was focused.

Figure 1 is a map of the LANL site. This map indicates some of the major release points to air for offsite dose calculations, the locations of major unmonitored point sources, and the locations of some of the environmental samplers used to demonstrate compliance with the 40 CFR 61, Subpart H, regulations.

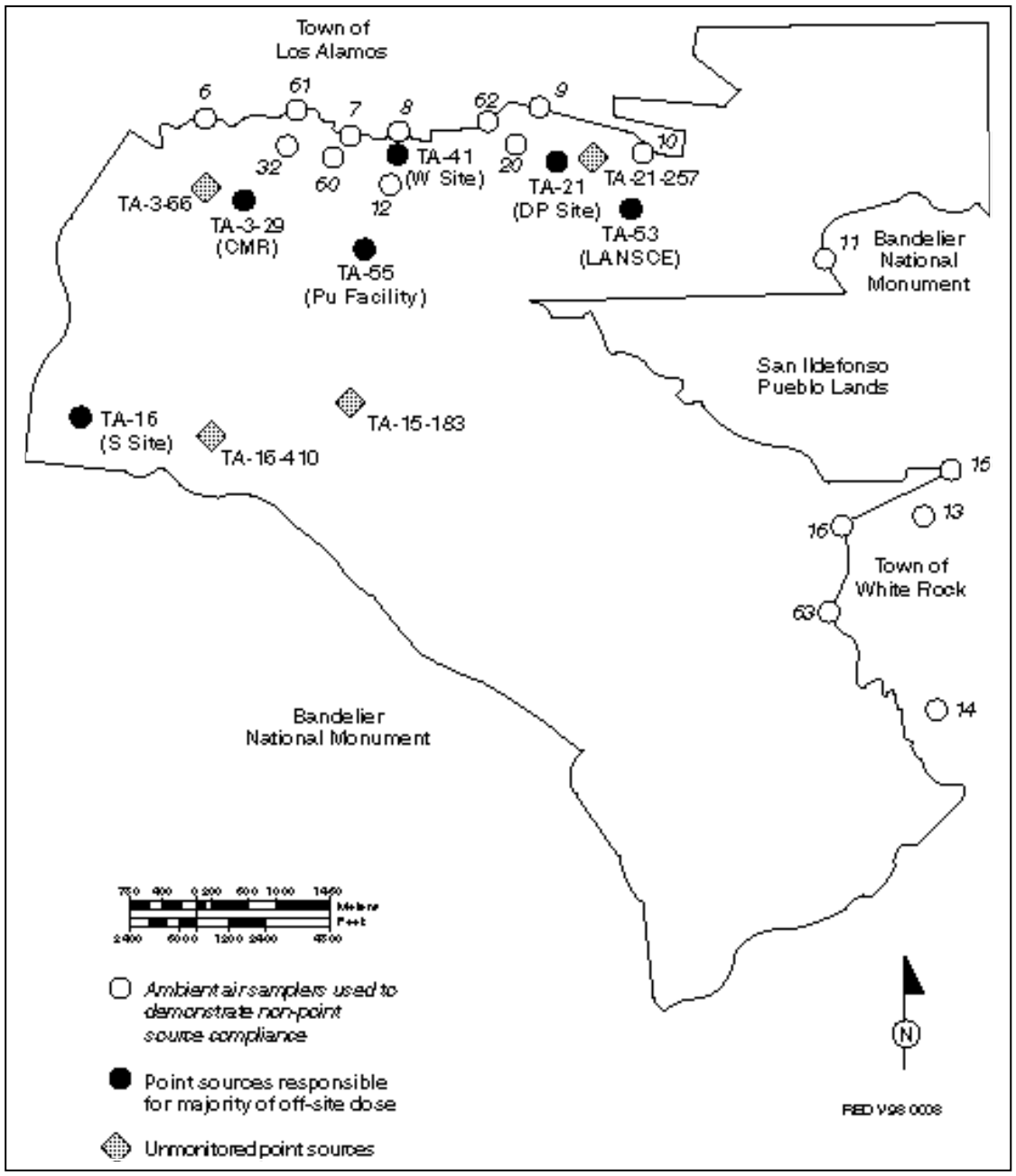

Figure 1. Los Alamos National Laboratory site.

The facilities identified in this figure are the major release points to air, which are discussed at length in the chapter titled "Stack Sampling and Monitoring Evaluation." The Los Alamos Neutron Science Center, or LANSCE, is located at Technical Area (TA) 53 and is the biggest contributor to offsite dose at LANL.

For purposes of compliance, the offsite dose must be calculated at the location of maximum dose where a person could reside. The process of calculating dose is described in more detail in the chapter titled "Dose Assessment Evaluation." The location of maximum offsite dose for 1996 was near the sampler numbered 10 in Figure 1. This is commonly referred to as the MEI, or maximally exposed individual, for LANL.

This audit report raised issues surrounding the calculation of releases from some of these major facilities, releases from less significant facilities, calculation of doses, and environmental sampling of radionuclides. Figure 1 is a reference for spatial locations throughout much of this report.

The Independent Technical Audit Team

Because of the multidisciplinary nature of the audit, the ITAT included scientists with a variety of backgrounds. These scientists had a broad range of skills including effluent monitoring, environmental surveillance, quality assurance, dose assessment and modeling, and source term development. The *curriculum vitae* of key scientists on the ITAT were included in an appendix to the proposal submitted at the beginning of the audit and are available for review. Key scientists on the audit team are listed below along with a description of the areas on which they focused during the audit. Other members of the *Radiological Assessments Corporation* research team also contributed to the audit, but following individuals were the principal contributors:

- John E. Till, audit team leader
- Steven J. Maheras, dose calculations
- H. Justin Mohler, radionuclide inventory and associated emission calculations
- Paul G. Voillequé, stack monitoring and emissions
- Jill Weber Aanenson, environmental monitoring and diffuse source emissions.

Although these audit team members did not have significant previous experience performing an audit of this type, the ITAT included individuals who have had extensive experience with the scientific issues addressed. This scientific experience was important because the key issues in question were technical, not administrative.

Purpose and Scope of Audit

The audit of LANL focused on issues and procedures that demonstrated the Laboratory's state of compliance with the Clean Air Act as presented in 40 CFR 61.90–61.97. In 1994, a memorandum of understanding (MOU) was approved by DOE and EPA addressing the need for facilities to reach an agreement with their regional EPA office on action necessary to achieve compliance. The Federal Facilities Compliance Agreement (see Appendix D to this report) was drafted jointly by DOE and EPA Region VI in an attempt to bring LANL into compliance by

providing some guidance for aspects of the compliance program not well defined in the Clean Air Act.

The scope of work for this technical audit was drafted by *RAC* and agreed upon after discussion and editing by *RAC*, LANL, DOE, CCNS, and IEER. The scope of work stated that:

> It is intended that the audit process will be open, thoroughly documented, and interactive with both DOE and CCNS…Throughout the course of the audit, the team will point out issues relevant to the audit and to the environmental monitoring program that they feel may be of interest to the DOE and to CCNS. Within the technical framework of 40 CFR 61, Subpart H, we will also identify aspects of the LANL compliance methodology which we believe are not appropriately implemented, are not appropriate for demonstrating compliance, or are not considered to be state-of-the-art techniques. In this context we will also evaluate the FFCA. Where possible, we will recommend an alternative methodology to be followed.
>
> It is recognized that this work will be performed independently by the audit team and the full cooperation of LANL and DOE is expected. It should also be understood that this audit is the result of a legal settlement resulting from litigation brought about by CCNS, an environmental organization based in Santa Fe and representing the concerns of citizens residing near the Los Alamos National Laboratory. Therefore to the greatest extent possible, the audit will be an open and fully documented process, providing both the LANL and CCNS information that can be readily understood and traceable. Further, *RAC* recognizes the important role that will be played by IEER, as a separate, independent group, responsible for monitoring the audit as it progresses. Therefore, throughout the course of the audit, we will provide whatever is necessary to allow IEER to fulfill its objectives.

The audit scope included a number of tasks that *RAC* committed to complete. These tasks involved preparing for the audit (selecting team members and establishing the scope); requesting and reviewing documents; and communicating with the public (holding pre- and post-audit workshops and releasing the audit report).

The audit team assessed four technical methods by which LANL demonstrates compliance:

- Radionuclide inventory for unmonitored point sources
- Major release point effluent monitoring
- Environmental compliance sampling for non-point sources
- Dose calculation.

The audit team also reviewed the quality assurance (QA) plan to examine how the QA plans were implemented for the procedures that affect the compliance calculations. Therefore, QA procedures were assessed by each member of the ITAT, and the assessments are presented in their respective report chapters. One universal QA issue is discussed in the "Quality Assurance Evaluation" chapter of this report.

The quality assurance, radionuclide inventory, effluent monitoring, environmental sampling, dose calculation, and FFCA evaluation chapters of this report present conclusions drawn by the audit team about LANL's compliance status.

One of the primary reasons for an independent scientific audit was to ensure that it addressed issues of scientific and technical merit as they applied to the compliance regulations. This audit was designed not to only verify compliance with regulations but also to assess whether the methodology chosen by LANL to demonstrate compliance was adequate and defensible.

The scope of the audit did, as agreed upon by all parties, cover the validity and technical merit of the FFCA. The FFCA has become an issue of technical merit and DOE credibility in the eyes of some concerned members of the public. The FFCA, including its purpose and history, is explained and assessed in the "Federal Facility Compliance Agreement Evaluation" chapter of this report.

The scope of this audit did not cover neutrons or neutron radiation. Although members of CCNS and IEER thought it desirable for the ITAT to evaluate neutron emissions, the ITAT determined that neutron emissions are specifically exempt from coverage under the Clean Air Act. This was confirmed through questions referred to the EPA, outlined in Appendix F to this report.

Compliance as Defined by This Audit

The regulations dictate many levels of compliance. The first level is whether a facility achieves a dose to the maximally exposed individual below 10 millirem per year (mrem yr^{-1}). The regulations also contain many requirements, such as measurement methods, procedures, and documentation, that must be met for a facility to be in compliance.

Each evaluation chapter of this audit report presents deficiencies in the LANL methodology in three categories: (1) regulatory deficiencies, (2) technical or scientific deficiencies, and (3) additional observations. Not all technical evaluation chapters identify deficiencies for each category and some categories contain multiple deficiencies.

In this report, a regulatory deficiency is a finding that tracks directly to a regulation or requirement that was not met by the Laboratory for the year 1996. This report cites and paraphrases the regulation, identifies the application to the LANL procedure, and assesses the compliance status.

Technical or scientific deficiencies are problems with the Laboratory's compliance program that are not specifically noted in the regulation but are implicit to having a valid and defensible compliance program. Although not specifically outlined in 40 CFR 61, Subpart H, these technical issues directly affect the Laboratory's ability to demonstrate compliance.

Additional observations point out practices that the ITAT determined to be questionable. These issues are not noted or implied in the regulation, but relate to good scientific practice and need to be addressed by the Laboratory.

A complete list identifying all deficiencies and observations is included in Appendix A.

History and Summary of 40 CFR 61, Subpart H

In 1977, Congress amended the Clean Air Act to address airborne emissions of radionuclides. Before 1977, these emissions were either regulated under the Atomic Energy Act or unregulated. Section 112 of the Clean Air Act required that the EPA determine whether emissions of radionuclides cause or contribute to air pollution that may reasonably be expected to endanger public health.

On December 27, 1979, the EPA listed radionuclides as a hazardous air pollutant under Section 112 of the Clean Air Act. The EPA then initiated studies to determine what source categories emit radionuclides to the air in quantities sufficient to warrant establishing a National Emission Standard for Hazardous Air Pollutants (NESHAP). The NESHAP was developed to limit emissions of radionuclides to levels providing an ample margin of safety for public health protection.

On June 16, 1981, the Sierra Club filed suit in the U.S. District Court for the Northern District of California pursuant to the citizens' suit provision of the Clean Air Act. The suit alleged that the EPA had a nondiscretionary duty to propose emission standards for radionuclides within 180 days after listing them as hazardous air pollutants. On September 30, 1982, the Court ordered the EPA to publish proposed regulations establishing emission standards for radionuclides.

On April 6, 1983, the EPA proposed standards for radionuclide emissions from four source categories and announced its finding that standards were not required for seven of the source categories that it had investigated. Standards were proposed for emissions of radionuclides from elemental phosphorus plants, DOE facilities, U.S. Nuclear Regulatory Commission (NRC) licensed facilities and non-DOE federal facilities, and underground uranium mines. Standards were not required for coal-fired boilers, the phosphate industry, other mineral extraction industries, uranium fuel cycle facilities, uranium mill tailings, high-level radioactive waste facilities, and low energy accelerators.

On February 17, 1984, the Sierra Club filed suit in the U.S. District Court for the Northern District of California to compel the EPA to take final action on the proposed standards. The EPA was subsequently ordered by the Court to promulgate final standards or to find that radionuclides are not hazardous air pollutants.

On October 31, 1984, the EPA withdrew the proposed emission standards for elemental phosphorus plants, DOE facilities, NRC-licensed facilities, and non-DOE federal facilities, finding that the control practices already in effect for these source categories protected the public from exposure to radionuclides with an ample margin of safety. The EPA also withdrew proposed standards for underground uranium mines, published advanced notices of proposed rulemaking for radon-222 emissions from underground uranium mines and licensed uranium mills, and decided to further study phosphogypsum stacks to determine the need for an emission standard.

The decision to withdraw the proposed standards was immediately challenged in court, and on December 11, 1984, the U.S. District Court for the Northern District of California found the EPA in contempt of its earlier order to promulgate final standards or to find that radionuclides were not hazardous air pollutants. On February 6, 1985, the EPA complied with the court order by issuing standards for elemental phosphorus plants, DOE facilities, and NRC-licensed facilities and non-DOE federal facilities. Two additional radionuclide standards, covering radon-222 emissions from underground uranium mines and licensed uranium mills, were issued on April 17, 1985, and September 24, 1986, respectively.

The Environmental Defense Fund, the Natural Resources Defense Council, and the Sierra Club filed petitions with the court to review the final decisions not to regulate underground uranium mines per the February 1985 and the April 1985 standards. The April 1985 standard for underground uranium mines was also challenged by the American Mining Congress. In November 1986, the American Mining Congress and the Environmental Defense Fund filed petitions challenging the standard for licensed uranium mills.

On July 28, 1987, while these petitions were pending, the U.S. Court of Appeals for the District of Columbia remanded to the EPA an emission standard for vinyl chloride (a nonradioactive hazardous air pollutant), which had also been promulgated under Section 112 of the Clean Air Act. The court concluded that the EPA had improperly considered cost and technological feasibility without first making a determination based exclusively on risk to health.

In light of that decision, the EPA concluded that its radionuclide standards should also be reconsidered and on November 16, 1987, petitioned the court for a voluntary remand of the standards. In its petition, the EPA also moved that the pending litigation on all issues relating to its radionuclide standards be placed in abeyance during the rulemaking and agreed to reexamine all issues raised by the parties to the litigation. On December 8, 1987, the Court granted the EPA motion for voluntary remand and established a time schedule for the EPA to propose regulatory decisions for all radionuclide source categories. On March 17, 1988, the court granted a subsequent EPA motion and modified the order to require proposed regulatory decisions by February 28, 1989, and final action by August 31, 1989.

On April 1, 1988, the EPA also requested a remand for its standard for licensed uranium mills. On August 3, 1988, the Court granted the EPA motion and put the licensed uranium mill standard on the same schedule as the other radionuclide standards.

On March 7 1989, the EPA published proposed standards, which described four possible policy approaches for regulating emissions of radionuclides. On July 14, 1989, the Court granted an EPA request for an extension until October 31, 1989, for final action. The final radionuclide standards were published on December 15, 1989. The radionuclide emission standard for DOE facilities was established as 10 mrem yr^{-1}, that is, emissions must be such that resulting dose to any member of the public is less than this amount. The standard was codified in 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* (see Appendix B to this report).

The regulatory guidance in 40 CFR 61, Subpart H, is designed to provide the rules that facilities must follow and guidance for the techniques that might be used to achieve compliance. These rules do have some flexibility because the EPA can grant prior approval for alternative methodologies that the facility intends to use.

Summary of Federal Facilities Compliance Agreement

In 1991, the EPA conducted an audit of LANL's compliance status with 40 CFR 61, Subpart H. This audit concluded that LANL was not in compliance with the 10 mrem yr^{-1} standard. In 1994, the MOU drafted between DOE and EPA addressed the need for DOE facilities to reach an agreement with regional EPA offices on the following:

- Actions necessary to achieve compliance
- Approval of use of engineering calculations to comply with the periodic confirmatory measurement requirement
- Use of different monitoring procedures
- Use of environmental monitoring for demonstrating compliance.

This MOU and the EPA audit findings brought about the development of the FFCA (see Appendix D to this report) between LANL and the EPA.

In 1996, LANL and DOE negotiated the FFCA, which was submitted to and approved by the EPA. This document provides more explicit guidance for the methodology to be used by LANL to implement their compliance programs. In some cases, the FFCA constitutes prior approval for LANL to use alternate methodologies. In other cases, it simply identifies a more detailed discussion of the prescribed techniques identified in 40 CFR 61, Subpart H. The existence of the FFCA does not constitute compliance; but it provides LANL more detailed direction on methods to achieve compliance.

The FFCA consists of a number of sections that discuss the implementation and legal impacts of the compliance plan. The detailed compliance plan is Appendix A of the FFCA. Three supplements (1, 2a, and 2b) provide more information on important new aspects of that plan. The compliance plan identifies the methodology for source evaluation and emission measurement, modeling and dose determination, and quality assurance, as well as information on reporting and implementation. The supplements discuss point source evaluation, non-point source assessment methods, and the environmental sampler siting analysis needed to adapt the environmental sampling network for compliance purposes.

Part of the impetus of the lawsuit that initiated this audit process were disagreements that the Concerned Citizens for Nuclear Safety had with the FFCA. Although a public comment period followed the release of a draft version of the FFCA, there was little opportunity for public input into the creation of the FFCA. In the eyes of certain members of the public, the credibility of the FFCA was compromised by not including the public in the process of drafting the FFCA.

Nonetheless, the FFCA is an important part of the compliance process. Regulatory guidance is very limited for certain release scenarios that are important at LANL. The Laboratory needed a framework for assessing the environmental impacts of releases for which compliance procedures either did not exist or were unclear. The FFCA provides this framework.

Although the FFCA was approved by the EPA for use at LANL, the ITAT determined that a review of the FFCA was an appropriate audit function. The ITAT carefully evaluated the technical merit of procedures identified in the FFCA and assessed the scientific assumptions that underlie these procedures.

1996 Radionuclide NESHAP Report

Since the focus of the independent audit was on LANL's compliance with 40 CFR 61, Subpart H, for 1996, the ITAT conducted a thorough review of the 1996 Annual Report, *U.S. Department of Energy 1996 LANL Radionuclide Air Emissions*, LA-13353-ENV, 1997 (see Appendix E to this report). The following items that must be contained in the annual report are identified in § 61.94:

- The results of monitoring and dose calculations
- The name and location of the facility
- A list of the radioactive materials used at the facility
- A description of the handling and processing that the radioactive materials undergo at the facility
- A list of the stacks or vents or other points where radioactive materials are released to the atmosphere

- A description of the effluent controls that are used on each stack, vent, or other release point and an estimate of the efficiency of each control device
- Distances from the points of release to the nearest residence, school, business, or office and the nearest farms producing vegetables, milk, and meat
- The values of all other user-supplied input parameters for the computer models and the source of these data
- A brief description of all construction and modifications that were completed in the calendar year.

According to the 1996 Annual Report, the effective dose equivalent for 1996 was 1.93 mrem yr^{-1}. In addition, the annual report stated that LANL achieved compliance with 40 CFR 61, Subpart H, on June 3, 1996. On June 13, 1996, the FFCA was approved by EPA Region VI. The purpose of this agreement was to resolve the issues of noncompliance described in two Notices of Noncompliance issued to the DOE by the EPA and to assure compliance by the DOE with the Clean Air Act and its implementing regulations (40 CFR 61, Subpart H). The FFCA addressed only the compliance violations noted in the Notices of Noncompliance. The FFCA contains a compliance plan designed to bring LANL into compliance with 40 CFR 61, Subpart H, as soon as practicable.

AUDIT PROCESS

The ITAT conducted this audit using techniques not ordinarily employed by auditors, for example, visiting the site a number of times over an extended period. The following sections discuss how *RAC* works in general and how its method of doing business was applied to this audit. The audit included site visits and tours, document review and retrieval, and interviews. Information retrieved in tours, document review, and interviews were carefully logged in the researchers' personal notes. The ITAT believed this approach allowed it to thoroughly evaluate relevant aspects of LANL's compliance-related programs. Additionally, this evaluation was more detailed than a typical audit because the scientific and technical merit of each element of the program was closely examined.

The Independent Technical Audit Team

The ITAT was comprised of scientists who are members of the *RAC* research team. *RAC* focuses on research related to risk associated with chemicals and radionuclides released to the environment. Although *RAC's* headquarters are located in South Carolina, *RAC* team scientists live in different parts of the country, and each team member operates as an independent consultant.

Dr. Till organizes and manages the activities of the *RAC* team largely through regular personal contact. *RAC* researchers communicate with each other via telephone and conference calls, e-mail and fax messages, electronic bulletin board and Internet server data transfers, and subgroup and group meetings. Overall, *RAC* team projects are completed by many supporting independent professionals who contribute to, or take the lead in, project tasks appropriate to their skills and in close communication with other *RAC* team members.

For the LANL audit, the ITAT used a combination of different methods to gather and analyze information. The audit team visited Los Alamos, New Mexico, on a number of different occasions, touring facilities, talking with the LANL staff, and reviewing records. The ITAT performed independent calculations to verify dose estimates and to determine the validity of assumptions made. Although some work was carried out at the site, most analyses and reviews of documentation were performed at the individual offices of audit team members. In many cases, records to review were identified and sent to ITAT project leader, Ms. Jill Weber Aanenson, for further distribution to the *RAC* team. A complete list of all documents is included as Appendix G. To keep the IEER scientists informed of materials the ITAT was requesting from LANL, Laboratory staff sent a duplicate copy of each document to CCNS, who forwarded that copy to IEER. At the same time, questions raised by IEER distributed to *RAC*, and an attempt was always made to be certain that LANL personnel also received a copy. A complete list of all IEER, CCNS, and public issues is included in Appendix H. The audit team worked to keep all parties informed of issues it was reviewing at every step of the audit.

During visits to the site, the audit team held frequent meetings with LANL staff and IEER to discuss plans for the visit and to summarize findings at the end of each visit. These meetings were open to any individuals who wished to attend. LANL and IEER personnel accompanied the audit team members when they visited a facility. Although some of the visits to LANL have required considerable preparation on the part of the Laboratory to meet security requirements, the ITAT did not believe the security associated with conducting the audit affected the performance of

objectives. Considerable credit is given to DOE and LANL staff for their cooperation in this regard.

During the audit process, the audit team worked to substantiate all of its findings through facts discovered during its review of records, interviews, and facility tours documented in this report. This report also cites regulations and the specific requirements not met by the Laboratory. In some cases, the regulations are not entirely clear with regard to specific issues that affect the audit. In these cases, the ITAT used judgment and attempted to be fair and unbiased, relying on the "spirit of the regulation." The ITAT identifies where the regulations are not clear and forwarded the issues to the Environmental Protection Agency for clarification in future revisions of the regulations. The communication that the ITAT had with the EPA is shown in Appendix F, with ITAT response to the comments of the EPA.

It is important to note that as the ITAT reached a decision regarding compliance for 1996, the audit team was confronted with a dilemma about how to proceed. Although the audit team reached the conclusion that LANL was not in compliance with 40 CFR 61, Subpart H, for 1996, the audit team recognized it had neither finished looking at all of the audit issues nor had it responded fully to the questions asked by IEER. The ITAT felt a responsibility to make this decision of noncompliance known as soon as possible. Making the noncompliance decision known, even though there were still questions that had not been answered, allowed the audit team to continue to seek answers to IEER's questions while giving LANL the earliest opportunity to correct deficiencies, some of which the ITAT believed were serious and needed immediate attention. The ITAT continued to perform the audit until contract resources were exhausted.

The dilemma described above was not easily resolved. The audit team policy was to be as open as possible with all parties, including DOE, CCNS, LANL, and IEER. The openness applied to discussion as well as written materials prepared throughout the evaluation. As the audit team shared information with all parties, that information also became public, in the spirit of openness the ITAT believed was integral to the success of the audit. As the ITAT began to document its findings, it realized that it was not possible to distribute the draft report that described audit conclusions without making the conclusions public. At the same time, the ITAT also felt a strong commitment to fully explain its results and conclusions in a public forum after they were documented. Therefore, in a meeting held on April 13, 1998, in Santa Fe, New Mexico, the audit team asked and received agreement from all parties to deliver a draft partial report on May 12, 1998. The ITAT also agreed to make the report available to the public on May 15, 1998. The draft partial report was available at that time for comment, comments were received and integrated, and additional information was included in this final report as resources allowed. Although detailed responses to comments were not prepared, the ITAT attempted to respond to every comment received on the draft report and integrate that information into this final report as much as possible.

In spite of the issuance of a draft report, the ITAT did not anticipate changing the conclusions with regard to compliance, nor did they make significant changes in the findings in this final report. The audit team believed substantive information on which the decision of noncompliance was based was missing and could not be created.

Layout and Purpose of Site Visits

The ITAT planned and coordinated site visits through a joint effort with LANL, CCNS, and IEER. The audit team generally visited the site for three days at a time to gather information and visit facilities. Although different members of the ITAT concentrated on different issues during the audit, site visits were planned to accommodate the interests of all concerned parties. Schedules for the visits were arranged and distributed to the appropriate people before the visits.

The only time that scheduling was not detailed in advance occurred when members of the ITAT visited the site for document review. In those cases, the visit was announced and members of the LANL staff were alerted to be available to answer questions as they arose for the audit team.

Site visits served as the primary information gathering mechanism for the audit team. Relevant documents were identified, interviews were conducted, and facilities were toured. A number of processes and procedures were observed. Through the site visits, the ITAT gained a good knowledge of the methods by which LANL demonstrates compliance. More conventional audits are generally conducted with a single site visit and observational time. The ITAT felt that scheduling multiple site visits with a chance to work, digest information, and read documents between the visits enhanced the value of the time spent at LANL. This type of schedule streamlined the entire process and contributed to a more productive team effort and a more thorough audit.

At no point during the audit were members of the audit team denied access to facilities that we thought it necessary to visit. We did encounter some difficulty gaining access for members of the public to some facilities because of classification issues, but these issues were resolved to everyone's satisfaction and members of the audit team had appropriate clearances and were able to view documents or visit facilities as necessary.

Interviews

Throughout the audit, interviews were conducted with Environmental Safety and Health personnel, facility managers, and other people responsible for compliance activities at LANL. Interviews were generally planned ahead of time and usually involved one or more members of the audit team, IEER, CCNS, LANL, and other interested parties. In keeping with the policy of openness, anyone could be a part of any interview. However, if either IEER or LANL wanted to be involved in an interview and was unable to attend, an interview was rescheduled until all interested parties directly involved in the audit could attend. It is a credit to the groups involved that this procedure worked well.

Members of the ITAT led interviews, and the interviews focused on procedures relevant to compliance issues. Interviews became increasingly specific as the audit progressed and more knowledge was gained about the particular strengths and weaknesses of the program.

The team read affidavits from whistle blowers and had discussions with one individual who wanted to share information believed to be relevant to the audit. It is stressed that information of this nature is difficult to use directly because it is based more on personal observation of workers. However, such discussions could be helpful in identifying areas that might not have been considered in developing our original approach to the audit. Much of what we learned from the

individual we interviewed and the affidavits we read appeared to be outside of the scope of our work.

Document Retrieval

It was necessary for the audit team to obtain a large number of documents from LANL to support their research of compliance activities. After each site visit, a document request was drafted and sent to the Air Quality Group of the Environmental, Safety, and Health Division at LANL (ESH-17) document control. This request was filled and sent to a central document control person on the audit team, with a copy of every document sent to CCNS, per the consent decree requirements. Documents were also requested between site visits. A copy of every document request was sent to all parties involved in the audit process so that all could be aware of ongoing research and information needs.

The audit team stored all documents at a central location, and copies of necessary documents were distributed to researchers. Documents were tracked through a database, and a report was printed from that database with vital document information, including title, document number, author, and date (see Appendix G).

Appendix G also lists documents that the ITAT obtained on their own to assist in gaining the appropriate knowledge and background to conduct the audit. Because these documents were not received from LANL, they were not widely distributed to all the parties of the audit. Most of these documents are easily obtained from DOE or EPA web sites or document libraries. The database contains approximately 250 documents.

Working with LANL Staff

One of the most vital aspects of the audit was the cooperation of LANL and DOE. All audit visits and requested interviews were arranged by LANL staff. Document copying and shipping was usually completed with reasonable timeliness. The staff was always available for phone calls or to answer electronic messages regarding questions or concerns. For the most part, the audit ran smoothly, and the ITAT credits the cooperation of LANL and DOE for making this possible.

QUALITY ASSURANCE EVALUATION

Quality assurance (QA) was an important focus of this audit. Quality assurance encompasses all those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. (International Organization of Legal Metrology. *Vocabulary of Legal Terms*, Paris; 1976. Cited on page 699 *of The Health Physics and Radiological Health Handbook*, 1992). The group filing the lawsuit raised the concern that QA may have been documented but not implemented. The ITAT assessed QA issues as they applied to various procedures at the Laboratory (e.g., inventory estimates and stack sampling). These issues are discussed in each chapter of this report to address any identified deficiencies. However, the chapters addressing unmonitored point sources and diffuse sources include a more detailed discussion because the regulatory QA requirements are not designed to address the procedures used to evaluate these sources.

It is important to note here that the ITAT reviewed only ESH-17 QA procedures. Certainly QA procedures are important at all LANL facilities; however, limited resources required us to focus on those procedures used directly by ESH-17. Additionally, the ITAT believed that an audit of this type fell outside the scope of this audit. A laboratory wide QA evaluation would require a separate contract and funding specifically designated for that. Our budget simply did not allow us to evaluate QA across the laboratory.

In addition to reviewing QA documentation, the ITAT also carefully evaluated implementation of that documentation in the ESH-17 setting. As QA is discussed throughout the course of this report, deficiencies in the implementation are noted if they occur, but if implementation was determined to be adequate by the audit team, then either a brief statement indicating adequacy is made or no deficiencies are noted.

Most of the QA issues are specific to each segment of the evaluation, but the ITAT felt it necessary to also address one QA issue in a separate chapter in this report. The primary QA concern is the ESH-17 practice relating to the conduct of audits. This is a very important concern because audits are the principal means of checks and balances within any technical program. An inadequate or inappropriate audit plan could seriously compromise the integrity of the program.

Audits of ESH-17

Summary of LANL Methodology

LANL is required, by 40 CFR 61, Subpart H, and the FFCA, to ensure that both internal and external audits are conducted on the Rad-NESHAP project within the Air Quality Group of Environmental, Safety, and Health Division at LANL (ESH-17). To meet QA requirements, it is also required that ESH-17 audit the contracted analytical laboratories annually and ensure that the laboratories conduct themselves within the boundaries of LANL QA requirements as defined by 40 CFR 61, Subpart H. These audits are discussed in a later section of the report.

During 1996, ESH-17 participated in three audits, designated by LANL as an external audit, an internal audit, and a management assessment.

It is important to note that the internal assessment process at ESH-17 appeared to the ITAT to be well maintained and documented. The working relationships of the staff enhance the ability to detect errors within their own system. They willingly accept constructive criticism from one

another and seem to make changes in procedures and the appropriate documentation whenever it becomes apparent that it is required. There is a long trail of documentation of revisions to procedures and notification of problems. The ESH-17 group leader is very actively involved in the every day mechanics of his division and is very aware of problems that exist and need to be corrected.

One important internal assessment mechanism that seems to be missing in a formal fashion is peer review. This is dealt with in more detail in later sections of the report, but it is important to note that there is no documented peer review system in place at ESH-17.

Technical or Scientific Deficiencies

Audits of programs or procedures should not be carried out by a person who could be perceived to be responsible for audited programs. Internal audits, contrary to the implication of their name, should be completed by someone who is external to the program being audited.

The ITAT had determined that the definition of "external to the program" refers to someone external to ESH-17. The auditor selected to conduct the 1996 internal audit of ESH-17 was a contractor to and a part of the ESH-17 group for some time. That association was revealed in the introduction to the report prepared for the designated 1996 internal audit.

ESH-17 asserted that the auditor did not have responsibility for any of the programs that were audited. For this reason, this deficiency was not classified as a regulatory deficiency, since regulations require that the auditor meet only this single criterion. However, the ITAT is convinced that an audit would be more credible if it were conducted by a person who has no association with the program.

The ITAT defines the three types of audits required as follows:

- External audit: Conducted by someone external to, and not involved with, LANL, DOE, the University of California, or any of its contractors. ESH-17 had an audit conducted in 1996 that fit this category.
- Internal audit: Conducted by someone external to the ESH-17 group, but the auditor may be internal to LANL. There were no audits in 1996 that fit this category, as defined by the ITAT.
- Internal assessments: Internal to the ESH-17 group; conducted to increase the technical substance of the programs. This type of audit cannot replace an internal audit. There were two audits in 1996 that fit this category.

The ITAT views an internal audit by someone within the group to be a serious compromise of integrity because the audit might provide biased results or fail to reveal significant findings. Required internal audits should be contracted out to an uninvolved party to ensure the greatest degree of completeness. However, recommendations and evaluations of individuals who are most familiar with day-to-day activities are very important to the evolution of a quality program and are certainly encouraged.

This point also relates to credibility of program compliance as perceived by the public. If ESH-17 met all requirements of the regulations but had a person internal to their group conducting annual audits, the public credibility of their program would be compromised. A system of checks and balances makes QA work, and LANL needs to ensure that those balances are in place.

This issue was forwarded to the EPA for clarification. This text appears in Appendix F to this report.

RADIONUCLIDE INVENTORY EVALUATION FOR UNMONITORED POINT SOURCES

As specified in 40 CFR 61, Subpart H, emissions must be estimated for all facilities with the potential to discharge radionuclides into the air. This includes all facilities conducting operations using radionuclides in an environment that discharge effluents through a forced ventilation system via a single exhaust stack or point source. This emission estimate is used to determine monitoring requirements for all point sources at each facility. The requirements outlined in § 61.93 (b) state the following:

> Radionuclide emission rates from point sources (stacks or vents) shall be measured in accordance with [the following requirements] or other procedures for which EPA has granted prior approval.

The procedures outlined in 40 CFR 61, Subpart H, however, do not explicitly define the method to be used for estimating potential emissions from unmonitored point sources. In May 1996, the EPA and the DOE established the FFCA to provide further guidance to LANL with regard to such point source potential emission determinations. The FFCA effectively served as prior EPA approval regarding methods of estimating potential emissions and consequent doses from unmonitored point sources for comparison to the 10 mrem yr^{-1} standard specified in 40 CFR 61, Subpart H. It also established accepted methods for determining monitoring requirements as well as verifying continued low emissions.

A number of methods for estimating emissions were outlined in the FFCA. They included the use of historical stack sampling data, 40 CFR 61, Appendix D methodology, duct holdup studies, engineering estimates and judgments, and the need for operational flexibility. Where facility operations are relatively stable, historical stack sampling data are considered the most accurate method for determining potential emissions. Appendix D methodology was originally designed to estimate emissions for new construction or modifications and changes to existing sources, but LANL has relied heavily on this methodology for estimating potential emissions and determining monitoring requirements based on respective facility radionuclide inventories. For determining monitoring requirements, estimated radionuclide release rates are based on the discharge of the effluent stream that would result if no pollution control equipment existed, but the facility operations were otherwise normal.

Any point source with the potential to emit radionuclides in quantities that could cause any member of the public, or maximally exposed individual (MEI), to receive a potential effective dose equivalent (PEDE)[a] in excess of 1% of the standard (0.1 mrem yr^{-1}) is defined as a major point source and requires continuous monitoring. Point sources with a radionuclide emission potential and consequent dose of less than 1% of the standard are defined as minor point sources. Minor point sources may be evaluated for compliance with the standard by estimating the potential for emission during the year in question by one or a combination of the methods outlined in the FFCA. For demonstrating compliance with the standard, the FFCA specifies the filtration factors for pollution control equipment specified in Appendix D of 40 CFR 61 may be

[a] For readability, the precise technical term potential effective dose equivalent is usually replaced with the general term dose in this document. However, the reader should be reminded that this is a possible dose and not an actual measured value that a member of the public received.

applied. Additionally, periodic confirmatory measurements are required to verify continued low emissions from unmonitored facilities. The FFCA (Section 2.1.3) specifies that these confirmatory measurements may be based upon facility radionuclide inventories or other methods outlined in Section 2.1.1.

A defensible and credible inventory of radionuclides is clearly an integral part of demonstrating compliance as specified in 40 CFR 61, Subpart H. It not only serves as the basis for the accepted method of determining monitoring requirements and verifying continued low emissions, but it is also used to directly estimate releases and consequent doses for unmonitored (minor) point sources. The ITAT's efforts focused on evaluating the accuracy and adequacy of the inventories and associated emission estimates reported for 44 unmonitored point sources at 31 facilities that had a potential for radionuclide release during 1996.

A complete and thorough evaluation of LANL's methodology for inventory compilation, emission determinations, and consequent dose calculations in 1996 involved assessing the adequacy and appropriateness of the procedures in place at that time. This included evaluating the accuracy and completeness of the reported inventory and associated emission estimate calculations for a number of facilities. These evaluations were completed through facility visits and personnel interviews.

Additionally, several unmonitored point sources in 1996 were monitored at some time between 1990 and 1995. Comparisons were made between doses calculated in 1996 based on estimated emissions and doses calculated between 1990 and 1995 based on measured emissions to assess whether the methodology for estimating emissions has been appropriately conservative.

Radionuclide screening factors (*Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground,* NCRP-123) were used to prioritize facilities and individual radionuclides with the potential to create the largest dose based on release of the entire inventory of radionuclides contained in that area. Tables 1 and 2 list the facilities (technical area and building) and individual radionuclides with the potential to create the largest dose based on emission of the entire 1996 inventory. Facility visits and verification efforts focused on these facilities and radionuclides as well as those unmonitored point sources with the largest calculated doses in 1996. Figure 1 shows the location on the site of some of the most significant unmonitored point sources.

Table 1. Facilities with the Potential to Create the Largest Dose, Based on the 1996 Reported Inventory

Technical Area	Building
03	0066[a]
16	0410
15	0183
21	0257
48	0001[b]
21	0150
03	0016
21	0005
18	0168
33	0086
03	0034
59	0001

[a] TA-3-66 is divided into nine separate exhaust stack units.

[b] TA-48-1 is divided into six separate exhaust units.

Table 2. Individual Radionuclides with the Potential to Create the Largest Dose, Based on the 1996 Reported Inventory

Facility	Building	Room	Radioactive material	Amount (Ci)
03	0066	B3 (1)	D-38[a]	8.20
16	0410	All	D-38	8.88×10^{-1}
03	0066	R100	D-38	6.60×10^{-1}
03	0066	B3 (2)	D-38	6.57×10^{-1}
03	0066	B100 (1)	D-38	6.57×10^{-1}
03	0066	B100 (2)	D-38	4.40×10^{-1}
15	0183	131	D-38	3.07×10^{-1}
03	0066	B101	D-38	2.20×10^{-1}
21	0257	106	Am-241	2.50×10^{-2}
21	0150	ALL	Pu-239	1.58×10^{-2}
03	0066	B107	D-38	3.30×10^{-2}
21	0257	106	Pu-239	9.30×10^{-3}
48	0001	308	Cs-137	2.55×10^{-2}
48	0001	WING 300	Pu-239	3.85×10^{-3}
21	0257	106	Pu-238	4.20×10^{-3}

[a] D-38 = depleted uranium.

The following sections describe the methodology LANL employed to

- Compile inventory information
- Estimate potential emissions
- Identify new or modified procedures that may involve emission of radionuclides
- Adopt the QA program with respect to unmonitored point sources.

The following sections explain regulatory deficiencies, technical or scientific deficiencies, and other observations noted by the ITAT for each process description. They also discuss any changes LANL made to address concerns raised during the audit process and as part of the Laboratory's periodic procedure revision system. Finally, they compare the 1996 estimated emissions and 1990 through 1995 measured emissions for facilities that were unmonitored in 1996 but were monitored at some time between 1990 and 1995.

While the majority of the ITAT's efforts were focused on evaluating 1996 methodology, LANL has implemented a number of procedures or changes to address concerns raised throughout the audit process. Admittedly, this has made our evaluation regarding 1996 methodology more difficult, but LANL's responses were appropriate and necessary under the circumstances. It should be understood that many of the deficiencies and observations identified during the course of this audit have been or are being addressed by LANL and are discussed below in the sections titled "Changes Made by LANL."

Inventory Compilation

Summary of LANL Methodology

The radionuclide inventory serves as the primary basis for determining potential emissions from unmonitored point sources. Monitored point sources, the major source of offsite dose from Los Alamos, will be discussed in the following chapter titled "Stack Sampling and Monitoring Evaluation." This inventory was compiled by LANL for calendar year 1994 and again for calendar year 1996. LANL uses these inventory compilations as the periodic confirmatory measurements required to demonstrate continued low emissions from unmonitored point sources. Appendix D of 40 CFR 61 outlines the general methodology used by LANL to estimate potential emissions based on facility inventories. The FFCA describes other methods that may be used to estimate emissions, such as historical stack sampling data, duct holdup studies, survey data, and engineering estimates and judgments applied to detailed operational information.

In February 1996, ESH-17, the Air Quality Group of the Environmental, Safety, and Health Division at LANL, distributed a memorandum requesting an update of 1994 radionuclide inventories to all facilities conducting operations using radioactive materials. ESH-17 distributed a separate memorandum to all other facilities to identify any facility not previously included in the inventory that currently (at that time) conducted or had plans to conduct operations using radioactive materials during calendar year 1996. For classified quantities, ESH-17 requested conservative but reasonable estimates of amounts used and associated processes. A single point of contact for each Facility Management Unit was also established for any necessary follow-up interviews. ESH-17 personnel conducted extensive follow-up interviews, primarily through telephone and e-mail correspondence, to obtain more detailed process information for point sources with initial estimated emissions exceeding 0.01 mrem. Additionally, ESH-17 personnel visited at least one facility in December 1996 (TA-3-66) to evaluate the reported inventory and the operational processes resulting in radionuclide emissions. ESH-17 documented this visit in the inventory file for TA-3-66 that they maintained.

Instructions for completing the 1996 inventory were provided to all personnel identified as either radionuclide users (referred to as custodians by ESH-17) or responsible for a facility, building, room, or hood that contained radioactive materials. These people were responsible for

providing updated (1996) information regarding the radioactive materials used, their chemical form, the amount in curies, the physical state, primary containment, source type, and summary information that detailed operations and processes. ESH-17 explicitly requested information regarding all processes and operations that were conducted or planned during 1996, as well as usage information regarding any heating (including maximum heating temperatures) of radioactive materials. Because the inventory update was initiated in February 1996, an estimate of radionuclide quantity usage was required for some part of the year depending on when facilities completed the update.

Regulatory Deficiencies

The requirements outlined in § 61.95 state the following:

> All facilities must maintain records documenting the source of input parameters including the results of all measurements upon which they are based, the calculations and/or analytical methods used to derive values for input parameters, and the procedure used to determine effective dose equivalent. The documentation should be sufficient to allow an independent auditor to verify the accuracy of the determination made concerning the facility's compliance with the standard. These records must be kept at the site of the facility for at least five years and, upon request, be made available for inspection by the Administrator, or his authorized representative.

Because LANL evaluates unmonitored point sources for compliance, determines monitoring requirements, and performs periodic measurements to verify continued low emissions using the radionuclide inventory, the requirements quoted above necessarily apply to the estimation of inventory values. A defensible and substantiated inventory is of primary importance. The ITAT attempted to verify the reported 1996 inventory primarily through visits to facilities and interviews with personnel. Because most facilities do not have static inventories, the radionuclide sources present during our visits in 1997 did not necessarily reflect the 1996 inventory. Therefore, whenever possible, the ITAT attempted to interview those individuals directly responsible for compiling and reporting the 1996 inventory. Unfortunately, these people were not always available. Consequently, adequate facility radionuclide inventory documentation would have been essential for an external audit team, such as the ITAT, to assess the accuracy and completeness of each facility inventory.

In general, record keeping and supporting documentation at several LANL facilities were insufficient in 1996 to accommodate a thorough verification of the reported inventory. In many cases, particularly at TA-48-1, this information is contained in personal experimental logbooks containing research information that was the property of individual scientists. To protect these data, the logbooks were cleared before being released for review to ensure that proprietary information was not being distributed. An attempt was made to identify and copy only the information the ITAT needed from the logbooks; however, it was very difficult and time-consuming to extract and clear sufficient information to evaluate yearly usage of radionuclides. This made verification of the 1996 inventory difficult, if not impossible. The ITAT reviewed copies of experimental logbooks and inventory lists for Rooms 430 and 414 at TA-48-1 and attempted to correlate the information with the reported 1996 inventory. However, much of the

information provided for Room 430, an experimental laboratory, was not included in the 1996 inventory (discussed below in "Changes Made by LANL"). Additionally, the information related to those values that were reported for Room 430 in 1996 was insufficient to determine annual radionuclide usage amounts. The implementation of a simple facility inventory tracking procedure would eliminate inefficient reliance on experimental logbooks for determining radionuclide usage and solve the problem related to releasing proprietary information to external evaluators.

The information provided for Room 414, a repository where radionuclide tracers are maintained in a safe, was provided in two inventory lists: one was apparently two or three years old, and one was updated on September 22, 1997. While this information was useful for establishing the radionuclides that are present in the safe at a given time, it was not particularly useful for verifying the 1996 reported values. The ITAT requested 1996 inventory lists for Rooms 308 and 309, but the inventory lists were not available.

The procedures outlined in ESH-17-102, R0, were written to evaluate the current active inventory. Because most facilities do not have a static inventory, this methodology may omit radionuclides that were used during the year but were not present at the time the inventory was compiled. However, the memorandum distributed to facility managers (previously discussed) requested information regarding all radionuclide usage throughout the calendar year. It is clear that annual dose calculations should require an evaluation of all activities throughout the calendar year. Documentation must be sufficient to verify *usage* amounts throughout a given year in order to accomplish this. The fact that the above information, which consisted of several copied pages from experimental logbooks and safe inventory lists, was either received more than four months following the initial request or was unavailable in any form clearly demonstrates the need for an established procedure for radionuclide usage tracking.

Furthermore, the method of inventory tracking within individual rooms and laboratories was inconsistent and, particularly at TA-48-1, sometimes incomprehensible to an external evaluator. Because of a lack of facility documentation, it was also sometimes not apparent to the ITAT or to LANL exactly what the reported inventory values represented. For example, at TA-3-16, the individual responsible for the inventory was no longer employed at LANL, and it was not clear whether the values represented a snapshot of the inventory at a given time or usage throughout the year. At other facilities, such as TA-21-257 and TA-18-168, it was relatively clear how the inventory was calculated and what the reported values represented. The ITAT was able to sufficiently verify the accuracy of reported inventory values at TA-3-66, TA-16-410, and TA-15-183 because of the procedures designed to track special nuclear materials in place at these facilities.

The ITAT determined that a lack of documentation regarding facility inventories severely precluded a thorough evaluation regarding the quality and completeness of the reported 1996 inventory. Therefore, it is the ITAT's conclusion that LANL was out of compliance in 1996 with regard to the "Recordkeeping requirements" specified in § 61.95. Because LANL evaluates potential doses (and ultimately compliance with the 10 mrem yr^{-1} standard) from unmonitored point sources based on the facility inventory, this requirement necessarily applies to the procedures involved with inventory compilation.

A question related to this issue and the regulatory intent was forwarded to the EPA for clarification. The question, EPA response, and ITAT reaction to that response is shown in Appendix F to this report.

Technical or Scientific Deficiencies

With the exception of one visit to TA-3-66, it is not apparent that ESH-17 personnel visited facilities to verify the accuracy of information provided by the facilities. Such visits are necessary to ensure the quality of the inventory values and ultimately the quality of the potential dose estimates. Future verification efforts should include some method to ensure the quality of reported inventory values.

During the course of the audit, LANL initiated a process of verifying the inventory reported for several facilities. This is noteworthy and is a process that should become an integral part of future inventory compilations. However, this verification process was not a documented part of the 1996 inventory compilation but rather was initiated to retroactively address the ITAT's concern regarding inventory documentation.

Additional Observations

The method of tracking must be sufficient "at the site of the facility" to accommodate any necessary inspection for a period of "at least five years," as specified in 40 CFR 61, Subpart H. A facility is defined in § 61.91 as "all buildings, structures, and operations on one contiguous site." Based on this definition, LANL is considered a facility, and all associated technical areas qualify as "buildings, structures, and operations on one contiguous site." Therefore, at LANL's option, documentation of inventory values may be maintained at any location within LANL. However, for the purpose of maintaining verifiable documentation, the ITAT recommends that such supporting documentation be kept at each technical area or individual laboratory. This would facilitate not only future audit activities but also inventory verification efforts carried out by ESH-17. An understandable and consistent method of inventory tracking at each respective facility and/or in individual laboratories is essential to achieve a credible and defensible inventory.

The need for an established procedure for inventory tracking and documentation is very apparent, particularly given the proprietary nature of some experimental information as well as the dynamic nature of some of the more complex facilities, such as TA-48-1. Furthermore, because researchers change positions or jobs, it is imperative that documentation of inventory estimates, which should reflect *usage* throughout the calendar year, be adequately maintained to support future audits. Initial information supplied by each facility to ESH-17 should be sufficient to significantly reduce the time spent obtaining more detailed operational information. Implementation of such a Laboratory-wide protocol would greatly improve inventory accountability as well as decrease the time and effort required by ESH-17 to compile inventory information. Some method of continuous tracking would also allow inventories to be reported later in the year, and estimates of usage throughout the remainder of the year could be replaced by actual usage amounts. Because LANL relies almost entirely on facility inventories for monitoring requirement determinations and for potential dose estimates for unmonitored facilities, it is clear that a procedure should be written to document radionuclide inventories and associated annual usage, which can be verified by an independent auditor.

A question related to this issue was also forwarded to the EPA. The question focused on the definition, in the opinion of the EPA, of usage and documentation. The EPA's response and the ITAT's evaluation are included in Appendix F to this report.

During the course of the audit, some concerns were raised about the informal methods used to estimate radionuclide amounts (e.g., eye-balling the amount of material in a bottle), particularly at TA-48-1. ESH-17 has established conversion factors that permit a quick estimation of the potential consequences of emissions from TA-48-1. LANL calculated these factors using an EPA-approved computer code, CAP-88. These factors allow for conversion from emission amount (curies) to potential dose (millirem). The ITAT evaluated the entire inventory associated with unmonitored point sources at this facility using these conversion factors. This allowed the ITAT to evaluate the adequacy of inventory estimations at this facility.

If the entire radionuclide inventory reported for 1996 at TA-48-1 is assumed to be released during the course of one year from the unmonitored point sources at this facility, which is highly unlikely, the resultant potential dose is 0.8 mrem. It should be noted that this dose was calculated for an individual who represents a potential resident located such that he/she is maximally exposed to releases from this particular facility, the facility maximally exposed individual (MEI). The dose at the location where the MEI for the entire site resides, the LANL MEI, would likely be an order of magnitude or more below this value. While this calculation is of limited technical use, it serves to demonstrate the relative magnitude of the unmonitored inventory at this facility. It is clear that doses based on potential emissions from the unmonitored point sources at this facility are small, a fact that is supported by historical stack sampling (see Appendix I). There is little evidence to suggest that the sometimes informal method by which inventories are estimated is likely to significantly underestimate dose that might impact monitoring requirements or regulatory compliance. Furthermore, the uncertainties associated with the final dose estimate far outweigh the uncertainties associated with these types of informal measurement techniques. However, LANL personnel should take steps to ensure that the method by which radionuclide quantities are determined is clearly documented.

There was also some concern regarding reported quantities of ^{235}U, which were apparently based on gross alpha measurements. Labeling of this material as entirely ^{235}U is somewhat misleading considering that the majority of radioactivity in highly enriched uranium results from the presence of ^{234}U. Reported ^{235}U quantities for 1996 are quite small for all facilities, and most of this material resides at TA-48-1. Based on the conversion factors for TA-48-1 discussed above, the individual ^{235}U source with the greatest potential for delivering a dose to an offsite receptor is a 0.2 mCi solid source. If all of this material were assumed to be released, which is highly unlikely, the facility MEI would receive a dose of 0.014 mrem. The individual source with the second greatest potential for delivering a dose to an offsite receptor is a 6.25 μCi gaseous source, also at TA-48-1. If all of this material were assumed to be released, the resulting dose to the facility MEI would be 0.0003 mrem.

It is clear that the quantities of reported ^{235}U are highly unlikely to result in an appreciable offsite dose. However, LANL should take steps to ensure that the actual composition of the radioactive material is clearly identified. This step is important as much for public credibility as it is for accuracy of the offsite dose calculations.

Other concerns raised during the audit included the potential importance of duct hold-up in unmonitored facilities as well as the status of sealed or unopened sources. It is the ITAT's opinion that duct hold-up is not an important issue at any unmonitored facility. LANL combines all the sealed sources for a given point source into one item and lists the amount and type as "various". This applies to all type 4 and 5 sources, which encompass any radionuclide in an enclosed container that remains unopened for the entire year and does not leak and also all sealed

calibration sources. The ITAT looked at sealed sources in Rooms 415 and 414 to confirm their sealed status. It is the ITAT's opinion that if radionuclide sources were improperly classified as sealed or unopened in 1996, it is unlikely that the misclassification significantly impacted facility emissions.

Changes Made by LANL

LANL is currently in the process of taking steps to ensure that future documentation will be "sufficient to allow an independent auditor to verify the accuracy of the determination made concerning the facility's compliance with the standard," as specified in 40 CFR 61, Subpart H. Greater emphasis is now being placed on face-to-face communication with radionuclide users in lieu of telephone and e-mail communication. In addition, a full-time employee was hired in June 1997 to visit some of the more complicated facilities, TA-48-1 in particular, to speak with custodians and users personally. Future assessments by LANL regarding the validity of inventory information provided by facility and operational personnel will include visits to selected facilities and spot checks of reported information. This procedure has been documented in ESH-17-UMS, R2 (draft), "Quality Assurance Plan for Unmonitored Point Source Activities."

ESH-17 is currently compiling 1997 interim inventory estimates and updates for those facilities with a 1996 potential dose greater than 0.005 mrem (or $1/20^{th}$ of the annual dose limit). This includes effluent stacks (ES) at TA-48-1 (ES 11, 15, and 45/46), TA-3-66 (ES 1 and 8), TA-48-45, and TA-59-1. Future inventories will be compiled annually for any point source with an estimated dose exceeding 0.005 mrem. For point sources with doses less than 0.005 mrem, inventories will be updated biannually. The next complete inventory update is scheduled for 1998. This procedure has been documented in ESH-17-UMS, R2 (draft).

The Air Quality Group at LANL also has implemented an assessment process that involved obtaining more detailed information regarding reported radionuclide usage and inventories in 1996. This process was carried out between August and October 1997 for four facilities (including TA-48-1, TA-48-45, TA-46-154, and TA-3-40) and was apparently initiated to address the ITAT's concerns regarding the informal method by which inventories were documented and tracked at various facilities. The assessors discovered radioactive material use not identified in 1996 as well as several rooms with radiological operations not identified in 1996. Also identified were sealed or unopened sources that were originally classified as active point sources. The doses were recalculated based on the updated information, which resulted in lower doses for three point sources at TA-48-1, an increase in the dose for TA-48-45, and no change in dose for the other two facilities.

The fact that this assessment process resulted in lower potential doses at three point sources at TA-48-1 indicates that the methodology used to estimate emissions in 1996 was conservative for these exhaust stacks. However, a slightly higher dose was calculated for TA-48-45, so it is possible that emission estimates for some facilities may not be sufficiently conservative. Based on the assessment report, facility personnel were often unaware of compliance requirements and occasionally assumed small quantities need not be reported. The findings of this assessment process further demonstrate the need for complete facility documentation of radionuclide inventories as well as thorough communication between ESH-17 and facility representatives to achieve a defensible and credible inventory.

LANL is currently developing a Space Hazards Inventory Program to track real time radionuclide inventory and usage in a computer database. Initial implementation of this program is focused on the facility management unit that includes TA-48-1. Following an evaluation of the success of this program, LANL may expand it to include other facility management units. This program is a chemical inventory system, developed using Microsoft Access™, designed to track usage of a variety of materials at LANL. Radioactive material attributes and other specific items are recorded in this database, including such information as material identification, quantity, location, source classification, physical state, and containment.

Additionally, ESH-17-UMS, R2 (draft), "Quality Assurance Project Plan for Unmonitored Radioactive Air Emissions," references ESH-17-126, R0 (draft), "Performing a Radionuclide Point Source Inventory Interview," as the method by which inventory information is collected. This document outlines the procedure that is used by ESH-17 personnel to perform an interview to determine the radionuclide inventory for a given point source. Inventory forms are included as attachments to this document to assist with compiling inventory usage and process information. These forms will assist in obtaining relevant information including the radioactive material, associated quantities and the method by which the quantities were determined, annual usage as well as the basis for the usage amounts, and the physical form and containment of each source. It will also be noted whether the inventory is a snapshot of the materials in use at that time or if it reflects the total inventory for the calendar year.

ESH-17 is currently identifying additional information that will be part of the next official inventory. The next complete inventory update is scheduled for 1998, but a 1997 interim inventory is currently being compiled for effluent stacks at TA-48-1 (ES 11, 15, and 45/46); TA-3-66 (ES 1 and 8); TA-48-45; and TA-59-1. The additional information should include not only the facility inventory values but also the estimated potential emissions (modeled inventory) and the modeled physical state.

Potential Emissions Calculations

Summary of LANL Methodology

The steps taken by ESH-17 during 1996 for determining the dose for unmonitored release points are outlined in ESH-17-102, R0, "Determination of Release Point Potential Effective Dose Equivalent." The document describes procedures for dose determinations based on the current active inventory, duct holdup, and historical emissions (when the currently unmonitored sources were monitored).

ESH-17 based the majority of its potential dose estimates in 1996 on facility inventories. The procedures outlined in ESH-17-102, R0, were geared toward evaluating the current (at the time of inventory compliation) active inventory. Appendix D guidance was used for dose calculations based on facility inventories.

ESH-17 also considered potential duct holdup as part of the inventory for several facilities. Duct holdup is the phrase used to define the retention of radioactive material in a ventilation duct. This material can build up and become a source of emissions that would not be documented in a room-by-room facility inventory. Procedures for estimating inventories based on duct holdup include the use of previous duct holdup estimates as well as an evaluation of other reasons that may warrant a duct holdup review. Final determination of whether a duct holdup review is

necessary was based on professional judgment by the person responsible for the emissions estimate. In 1996, duct holdup estimations were based on values provided in *Special Nuclear Material Holdup Assessment of Los Alamos Exhaust Ducts* (LA-12700), radiological smear data, and historical measured emissions.

Determining the dose based on historical emissions, as specified in ESH-17-102, R0, involved selecting the highest calculated historical dose from the past four years, if the operations have been stable, or the dose from the past four years that best represented future operations if operations had changed significantly. After selecting the appropriate dose, the effect of filtration was removed by dividing by high-efficiency particulate air (HEPA) filter and non-HEPA filter penetration factors (0.0005 and 0.2, respectively). This method of dose determination was apparently not used during 1996.

After compiling inventory data, emission estimates were made based on reported usage/process information. ESH-17 has maintained complete and thorough documentation of these calculations. The initial calculations were based on guidance provided in 40 CFR 61, Appendix D, and the methodology was consistently conservative. If information regarding the physical state and usage (e.g., heating or milling) was available, appropriate Appendix D emission reduction factors were used. If no physical state or usage information was available, the material was assumed to be a gas, the entire inventory was assumed to be emitted, and the result was modeled using CAP-88. The "enhanced 100°C rule," as described in the FFCA (Section 2.1.1.2) was used once for determining the 1996 potential dose for TA-3-66, ES 8, where depleted uranium is heated to 400°C. This appeared to be a realistic assumption, and the application of this rule in this case did not deviate from the conservative methodology used by LANL for dose estimates.

Determining an inventory estimate for a contaminated room involved using survey data and conservatively assuming uniform contamination of the highest count rate recorded for an individual swipe. In some cases, a single source was effectively emitted more than once because it may have been used in different rooms (e.g., TA-3-66, ES 25 and 26). While this is a conservative methodology, it does not realistically represent potential emissions, and it should be avoided.

If the estimated dose did not exceed 0.01 mrem, the estimated emissions were officially modeled using CAP-88. If the calculated dose exceeded 0.01 mrem, the inventory and emission estimates were further refined using good engineering judgment calculations and guidance provided in 40 CFR 61, Subpart H and Appendix D. The individual radionuclides that dominated the dose estimate were identified and prioritized, and more detailed usage and process information was obtained from the facility manager. This iterative process continued until the dose fell below 0.01 mrem or until all relevant usage and process information had been obtained. ESH-17 personnel conducted follow-up interviews with radionuclide users into June 1997 as part of this process. If the final estimated dose exceeded 0.1 mrem, the stack required continuous monitoring as specified in 40 CFR 61, Subpart H.

Regulatory Deficiencies

The ITAT did not identify any regulatory deficiencies.

Technical or Scientific Deficiencies

ESH-17 personnel have maintained very thorough documentation of all calculations and assumptions made throughout the process of estimating emissions. This enabled the ITAT to conduct a complete review of the emission estimate calculations for a number of unmonitored point sources, including all facilities listed in Table 1. The primary deficiency in this process was the apparent lack of a formalized QA procedure to review the emission estimate calculations. The requirements specified in 10 CFR 830.120(c)(iv) state the following: "Records shall be specified, prepared, reviewed, approved, and maintained." Although this regulation is one that LANL must comply with, it is admittedly not required by 40 CFR 61. This lack of review procedures cannot be a regulatory deficiency, but it certainly serves to undermine the credibility of the compliance program, so the ITAT has classified it as a technical or scientific deficiency.

It is clear that the regulations require review and approval by individuals other than those performing the work. Procedure ESH-17-UMS, R1, did describe a quality control process that included review by different qualified persons. This review process was apparently rather informal in 1996. The ITAT requested documentation of the peer review process a number of times throughout the course of the audit, but ESH-17 did not maintain documentation of any reviews performed.

It is not apparent that comparisons were made between historical sampled emissions and estimated emissions for any facility. During interviews, LANL personnel maintained that this was primarily due to the generally low potential emissions from the majority of unmonitored sources. Because the FFCA (Section 2.1.1.1) explicitly defines historical stack sampling data to be the most accurate method for determining potential emissions where facility operations are relatively stable, the ITAT elected to classify this as a technical deficiency. It should be noted that the historical stack sampling did not meet 40 CFR 61 requirements; therefore, the accuracy of the historical data is in question. However, these comparisons are the only means of establishing some measure of the accuracy of the emission estimates based on the reported radionuclide inventories. The ITAT suggested to the LANL Radionuclide NESHAP Project Leader that the Process Verification methods outlined in ESH-17-UMS, R2 (draft), be amended to include the use of historic stack sampling data to verify emission estimates whenever possible.

Changes Made by LANL

A procedure that involves maintaining complete documentation of peer review and verification activities has been documented in ESH-17-UMS, R2 (draft). Future process verification will include peer review of selected documentation to ascertain that calculations are accurate, assumptions are conservative, and estimates are valid.

ESH-17 is also in the process of completing ESH-17-102, R1 (draft), "Radiological Point Source Emissions Estimates and Monitoring Requirements." This document details the procedures used to develop radionuclide inventories based on duct holdup, residual contamination, and material usage. Material usage information is collected using the procedures described in ESH-17-126, R0 (draft), and reflects annual usage (previously discussed). For monitoring requirement emissions estimates, which do not account for pollution control equipment, initial dose values that exceed 0.005 mrem will be further refined using more detailed

process information. If the calculated dose value is less than 0.005 mrem, the estimated emissions will be officially modeled using CAP-88.

ESH-17-102, R1, also describes the procedures for calculating dose values to demonstrate compliance with the 10 mrem yr^{-1} standard. The estimated emissions are calculated by applying HEPA penetration factors (0.0005) or penetration factors for any other type of filter (0.2) to the uncontrolled emission estimates used for determining monitoring requirements. *However, the FFCA clearly stipulates that Appendix D filtration factors are to be used (Section 2.1.1.2). This document should be revised to reflect the methodology described in the FFCA.*

Identification of New or Modified Sources

Summary of LANL Methodology

Procedures for addressing the potential impact on air emissions from new operations or modifications to existing sources during 1996 are outlined in LS104-01.0, "Air Pollution Control," effective September 7, 1995. As specified in this document, line management was responsible for notifying ESH-17 if new operations resulted in the emission of any radionuclides or if modifications to existing sources were made. ESH-17 was then responsible for performing an air quality review to ensure compliance with the regulations and to evaluate potential impacts to air emissions.

Additionally, ESH-17-UMS, R1, "Quality Assurance Project Plan for Unmonitored Point-Source Radioactive Air Emissions," effective July 5, 1996, describes methods or administrative controls to ensure operational changes that could impact stack monitoring requirements are promptly identified. The first and most important administrative control involves the Environmental Safety and Health Identification (ESH-ID) process, which identifies any new or modified operations that could increase radioactive material emissions in an existing or new facility. The ESH-ID process is administered and coordinated by ESH-3, the Facilities Review Section of the ESH Division, and was adopted in 1994 to replace AR 1-10, "Environmental, Safety, and Health Questionnaire," effective August 30, 1991. The ESH-ID questionnaire template used during 1996 was quite lengthy, and an online version of the process was constructed in August 1996 at the address: http://drambuie.lanl.gov/~esh3/eshid/eshid.html to streamline the process. Other administrative controls to ensure prompt identification of operational changes include conservative potential and annual emission estimates as well as the AIRNET environmental monitoring network.

Several facilities were listed as minor unmonitored point sources in 1996 and were not identified as either monitored or unmonitored point sources in 1995, including TA-3-1698, TA-9-32, and TA-50-2. Additionally, TA-54 Transuranic Waste Inspection/Isolation Storage Project (TWISP) was scheduled to become active in February 1997. Air quality reviews or pre-construction approvals for these facilities should have been completed before initiating any operations with the potential to emit radionuclides, unless an exemption could be identified.

The radioactive material reported in 1996 for TA-9-32 and TA-50-2 consisted entirely of legacy (residual) contamination that had not been identified during compilation of the 1994 inventory. This does not appear to qualify as a new or modified source and a new source review is deemed unnecessary.

TA-54 TWISP activities received EPA approval in March 1994, and operations began on March 27, 1997. LANL is required to report the start-up of operations between 30 and 60 days prior to start-up. All of these activities would have taken place in 1997; therefore, this was outside the scope of the ITAT audit, designated to evaluate only 1996 activities.

The TA-3-1698 inventory (a few hundred grams of depleted uranium) was relocated from another facility. Based upon the regulatory guidance provided in § 61.97, LANL is exempt from the reporting requirements of § 61.10, which specifically direct the Laboratory to report modification or relocation of sources. The ITAT noted this regulatory exemption.

Regulatory Deficiencies

The ITAT did not identify any regulatory deficiencies.

Technical or Scientific Deficiencies

LANL identified the ESH-ID process as the first and most important administrative control that ensured prompt identification of operational changes that could impact stack monitoring requirements. However, during interviews with ESH-17 personnel, it was clear that this method of identifying changes was voluntary and geared primarily toward evaluating new work for which additional funding was required. This deficiency was also identified during an Independent Program Management Assessment conducted at LANL October 30 through November 1, 1996, by a team from Northern Arizona University. In addition, the Northern Arizona University assessment team indicated that "an effective procedure to assess and monitor whether line management is complying with LS104-01.0 should be established." The assessment process (previously discussed) carried out at TA-48-1 demonstrates the need for adequate communication between ESH-17 and facilities to ensure that operational changes are identified and evaluated by appropriate qualified personnel. It is important for Laboratory personnel to understand that all radionuclide usage, regardless of the amount, must be evaluated regarding its potential to impact monitoring requirements.

Changes Made by LANL

The corrective actions taken by ESH-17 to address these concerns are outlined in LANL ID#: 96-51, "Action/Implementation Plan to the Independent Program Management Assessment of the Air Quality Program at LANL." ESH-17 has removed the dependence of air quality reviews on the voluntary ESH-ID process and is working to make the review mandatory through the Laboratory Implementation Requirement process. The procedure for new project review is in the process of being documented in LIR 404-10-01.0 (draft), "Air Quality Reviews." This document outlines specific requirements describing when and by whom air quality reviews will be performed. In additional, ESH-17 has documented a specific procedure for air quality reviews in ESH-17-103, R0, "Review of New or Modified Radioactive Air Emission Sources." Both of these documents include detailed flow charts directing the sequence of responses depending on the scope and nature of the specific project in question. A qualified air quality reviewer will review all future new or relocated radionuclide sources.

ESH-17 is also in the process of developing guidance cards to assist in complying with LS104-01.0. The guidance cards are described in LANL ID#: 96-51. The estimated completion date on these cards was December 1997, with scheduled availability to facility and division managers in January 1998. After receipt of the cards, LANL managers will be informed of the need to incorporate these guidance cards to comply with LS104-01.0. The ITAT requested a copy of the guidance cards; however, the cards had not yet been completed.

LANL Quality Assurance Plan

Summary of LANL Methodology

The QA requirements for compliance-related programs are outlined in 40 CFR 61, Appendix B, Method 114. The QA guidelines are specifically directed toward assuring the quality of radionuclide emission measurements. Because emission measurements are not made for unmonitored point sources, these QA guidelines are not directly applicable. However, since LANL primarily determines monitoring requirements and evaluates unmonitored point sources for compliance by compiling a radionuclide inventory and estimating potential emissions, some means of assuring the quality of these estimates is necessary. The implementation of these QA procedures was carefully investigated throughout the course of this audit. Any deficiencies associated with the implementation of this program are discussed at the end of this section or may be addressed in more detail in another section. If no deficiencies are identified, the ITAT determined that the implementation of the QA program was adequate.

ESH-17 originally produced a QA project plan, ESH-17-UMS, R0, "Quality Assurance Project Plan for Unmonitored Point-Source Radioactive Air Emissions," which became effective June 12, 1995. The first revision of this document, ESH-17-UMS, R1, became effective July 5, 1996. These two documents are essentially the same, with some slight differences, particularly in Section 4.3. These plans were developed to follow the requirements outlined in 40 CFR 61, Appendix B, Method 114, as closely as possible.

Section 4.1 and the appendix of both of these documents clearly define the organizational structure of ESH-17 and identify the individuals responsible for various aspects of the unmonitored emissions program.

Section 4.2 describes the administrative controls in place to promptly identify any operational changes that might impact stack monitoring requirements. These operational changes were identified primarily through the ESH-ID process and the conservative method by which potential emissions were estimated (both discussed previously). In addition, the AIRNET environmental monitoring network data was used to detect any significant expected or unexpected emissions from unmonitored sources.

Section 4.3 outlines the methods used to identify and determine which point sources do not require continuous monitoring as well as their contribution to the calculated LANL airborne emission dose. These methods have been discussed previously and are outlined in ESH-17-102, R0. Additionally, the ESH-ID process was considered the primary method by which the unmonitored point source list is updated. The ITAT evaluation of the adequacy of this process has been previously discussed.

Potential dose estimates used to set triggers, above which further process information was to be obtained, are also defined in Section 4.3. ESH-17-UMS, R1, specified that if the calculated

dose was below 0.01 mrem yr^{-1}, no additional follow-up was required. If the calculated potential dose exceeded 0.01 mrem yr^{-1}, the adequacy of the dose calculation was further evaluated through follow-up interviews with respective facility personnel. ESH-17-UMS, R0, specified additional follow-up only if the initial calculated potential effective dose was above 0.1 mrem yr^{-1}, which is the dose above which continuous monitoring requirements are imposed. This follow-up was performed through site visits and telephone calls to designated contacts. After evaluating the adequacy of the potential dose calculation and obtaining additional process and usage information, point sources were officially classified as either monitored (major) or unmonitored (minor), and potential doses were calculated using CAP-88.

40 CFR 61, Subpart H, requires periodic confirmatory measurements of unmonitored point sources to verify continued low emissions. However, the regulation does not define the term periodic. LANL defines periodic in ESH-17-UMS, R1, Section 4.3, to be whenever there was reason to believe the dose for an unmonitored source may change enough to possibly alter the point source classification. The updated radionuclide inventory and associated dose calculations served as the periodic confirmatory measurements for 1996.

Section 4.4 describes data quality objectives for ensuring the quality of emissions estimates for unmonitored point sources. In summary, the objectives are to maintain a comprehensive list of unmonitored point sources, classify stacks conservatively, ensure that classification changes are identified and made, determine inventories and emissions conservatively, determine doses using approved methods, and maintain complete documentation of calculations. This was facilitated through distribution of the memorandum regarding inventory updates in February 1996 and through the methods defined in ESH-17-102, R0.

Section 4.5 outlines quality controls for assuring the quality of emissions estimates. These controls included having inventory, emissions, assumptions, dose calculations, and other data prepared and reviewed by different qualified persons as well as cross-checking inventories with various independent information sources, such as historic emissions measurements. AIRNET was also assumed to provide an independent method for detecting significant emissions from unmonitored sources.

Section 4.6 describes the records management procedures for ESH-17. Records are to include the unmonitored stack list, inventory reports, emissions measurements or determinations, CAP88 dose determinations, audit reports, corrective action documents, and NESHAP reports.

Section 4.7 describes audits that are used to ensure the quality of emissions estimates for unmonitored point sources. ESH-17 conducts internal audits in accordance with requirements in the ESH-17 Quality Management Plan and ESH-17-029. An assessment of the effectiveness of the compliance program and associated unmonitored point source activities is performed annually. An audit external to the lab is conducted every two years, and was first carried out in June 1996 as a program management assessment of the Federal Facilities Compliance Agreement by Northern Arizona University.

Section 4.8 describes corrective actions that will be used to document and correct any problems associated with emissions estimates for unmonitored point sources. Corrective actions are carried out according to ESH-17-026, “Deficiency Tracking and Reporting,” and include any issues that affect the identification of point sources requiring monitoring or that result in an underestimation of the cumulative dose to the LANL MEI from all unmonitored point sources. Individual employees are responsible for deficiency reporting; however, there is no punishment associated with such reporting in an effort to maximize its effectiveness.

Section 4.9 describes the reports that will be issued regarding the performance of emissions estimates for unmonitored point sources. These include the annual NESHAP report and any audits and corrective action reports.

The QA project plan for unmonitored point sources was documented in 1996 as ESH-17-UMS, R0, and ESH-17-UMS, R1. This plan adequately addressed the relevant QA requirements specified in 40 CFR 61, Subpart H.

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies in the area of QA as it applies to inventory compilation and associated emissions estimates.

Technical or Scientific Deficiencies

A technical or scientific deficiency associated with Section 4.2 was identified and is discussed in the section of this chapter titled "Identification of new or modified sources."

Inventory documentation was not maintained at the facility level, and this was identified as a regulatory deficiency in the section titled "Inventory Compilation." This deficiency is associated with Section 4.4.

Because 40 CFR 61, Subpart H, does not explicitly prescribe an accepted QA plan for unmonitored point sources, LANL has developed its own plan, which was documented in 1996 as ESH-17-UMS, R0, and ESH-17-UMS, R1. The quality control procedures outlined in Section 4.5 were not sufficiently documented to ensure that they actually occurred. Documentation of peer review was not maintained, and the use of historic stack sampling data was not considered in all cases for which data were available. LANL responses to these concerns have been previously discussed.

Changes Made by LANL

A procedure that involves maintaining complete documentation of peer review and verification activities is documented in ESH-17-UMS, R2 (draft). Future process verification will include peer review of selected documentation to ascertain that calculations are accurate, assumptions are conservative, and estimates are valid.

ESH-17-UMS, R2 (draft), also outlines internal and external audit activities to be carried out for ESH-17. *However, the internal management assessments discussed in the Management Assessment chapter do not meet the requirements for internal audits as specified in 40 CFR 61, Subpart H, unless the group leader (designated in this document as the individual responsible for performing the assessment) does not have any responsibility for performing any of the operations being audited.* Particularly since the project leader reports directly to the group leader, this requirement should be met by an organization external to ESH-17, such as the LANL QA Support Group, which conducts an annual audit of ESH-17. It is essential that ESH-17 clearly defines and differentiates between management assessments and audits. By nature, an audit must be conducted by an entity external to the organization being audited.

The trigger dose value above which further process information is to be obtained has also been reduced to 0.005 mrem. This procedure is documented in ESH-17-102, R1 (draft), and has already been discussed.

Comparing Historical Measured Emissions and 1996 Estimated Emissions from Thirteen Point Sources

Thirteen point sources were monitored at some time between 1990 and 1995 and were reclassified as minor or unmonitored point sources in 1996 (TA-3-66 [ES 1, 8, 9, 25, and 26]; TA-21-5 [ES 7]; TA-21-150 [ES 1]; TA-21-257 [ES 4]; TA-48-1 [ES 11-14, 15, 45/46, and 51]; and TA-54-2 [ES 1]). The ITAT compared the facility doses that were calculated in 1996, which were based on estimated emissions, with facility doses calculated from 1990 through 1995, which were based on measured emissions, to examine whether the methodology used for estimating emissions for unmonitored point sources was sufficiently conservative in 1996. Comparisons for each of the thirteen point sources are illustrated as Figures I-1—I-13, included as Appendix I. These comparisons were particularly useful given the difficulties that the ITAT encountered while attempting to verify reported inventory information. As mentioned previously, the historical stack sampling did not meet 40 CFR 61 requirements; therefore, the accuracy of the historical data is in question. However, these comparisons are the only means of establishing some measure of the accuracy of the emission estimates based on the reported radionuclide inventories.

Throughout this section, the word dose is used to designate the potential effective dose equivalent (PEDE) to a potentially exposed individual at an offsite location resulting from a particular release of radionuclides from a defined point source. This refers to the whole-body dose that would be delivered to an individual, given a particular release of radionuclides. This individual is often referred to as the maximally exposed individual (MEI) because the potential exposure location is designated at the offsite location at which the maximum dose could be delivered during a particular set of meteorological conditions. The potential doses discussed in this section are to the individual facility MEI or the sitewide LANL MEI. The facility MEI location is designated based on emissions for that facility only, and the sitewide MEI is designated based on emissions from all LANL facilities. It is important to understand that this is a hypothetical dose and not an actual measured dose. The assumption that a receptor (or person) resides at the maximally exposed location throughout the year is often a very conservative one and generally yields calculated doses that overestimate the actual maximum dose to a member of the public.

The operations and general layout of facilities at LANL result in the sitewide MEI being designated as the MEI for the Los Alamos Neutron Science Center (LANSCE), a monitored point source. Emissions from LANSCE historically dominate emissions from all other sources (monitored and unmonitored), and there is little evidence to suggest that operations at any of the unmonitored point sources in 1996 would result in a facility dose exceeding or even approaching the dose calculated for LANSCE. Because the highest dose at LANL has historically been for the LANSCE facility MEI, contributing doses from other facilities must be calculated for this receptor location. Therefore, it is actually most appropriate to evaluate potential doses from unmonitored point sources at the LANSCE facility MEI.

To understand the potential impacts of underestimating potential emissions for unmonitored facilities, it is helpful to examine the doses that have been calculated based on both actual and potential measured emissions. This enables the estimated potential doses from unmonitored facilities in 1996 to be put into perspective relative to the 10 mrem yr^{-1} standard specified in 40 CFR 61, Subpart H. For facilities equipped with effluent filtration, potential measured emissions refer to emissions that could occur if all filtration equipment failed. Such emissions are calculated by dividing actual measured emissions by an appropriate penetration factor (e.g., 0.0005 for single-stage HEPA filtration).

The 13 point sources that were monitored from 1990 through 1995 and unmonitored in 1996 comprise 84% of the total summed estimated facility dose for all unmonitored sources in 1996 (0.142 out of 0.169 mrem). If the facility doses based on the maximum measured emissions between 1990 and 1995 for each of these sources are summed, the resultant dose is 0.004 mrem. If potential emissions are used, the resultant summed dose is 1.45 mrem. In other words, in the unlikely event that all pollution control equipment failed, and emissions from these facilities were at their highest level at any time during 1990 through 1995, a total dose of 1.45 mrem for all facilities would result. The maximum dose resulting from emissions from a single point source during this time period, TA-3-66, ES 26, was 0.86 mrem in 1990, and most activities generating emissions from this point source were discontinued in 1994. While this calculation is of little technical use, it demonstrates the relative magnitude of maximum historical emissions from the facilities that comprise the majority of the estimated dose for *unmonitored* point sources in 1996.

This calculation provides a rough estimate only, but it is sufficient to establish the relative magnitude of potential doses from the unmonitored facilities at LANL during 1996. It should be noted that these numbers were derived using maximum measured emissions for each point source throughout the six-year period from 1990 through 1995. Figure 2 shows the sum of facility doses that were derived from measured emissions from 1990 through 1995 and from estimated emissions in 1996 for these 13 point sources. Estimated doses in 1996 appear generally consistent with doses based on potential measured releases from 1990 through 1995 and adequately conservative relative to doses based on actual measured emissions. The relatively high dose based on potential measured emissions in 1990 was dominated by the dose calculated for TA-3-66, ES 26 (0.86 out of 1.12 mrem), a point source for which most operations were terminated in 1994.

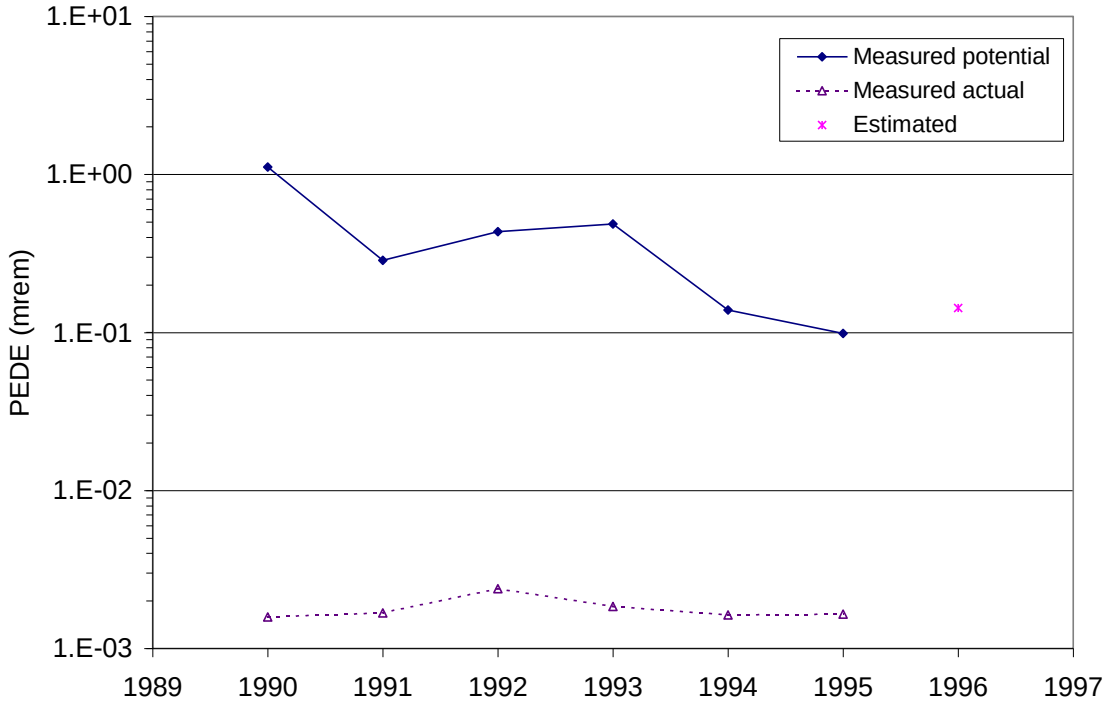

Figure 2. Sum of PEDEs for 13 facilities based on actual and potential measured emissions (1990 through 1995) and estimated emissions (1996).

The summed doses discussed above are for facility MEIs, and the dose for the LANL (or sitewide) MEI would be much smaller. In fact, if the doses based on potential measured emissions at the LANL MEI (instead of facility MEI) for these 13 sources are summed, the resultant dose is 0.09 mrem (compared to 1.45 mrem for facility doses). If the actual measured emissions (compared to potential emissions, which are based on measured emissions divided by a HEPA penetration factor) are used, the resultant dose is 0.0005 mrem (compared to 0.004 mrem for facility doses) for the LANL MEI. Conversions of dose for facility MEI to LANL MEI were accomplished using 1995 facility doses (discussed below) and 1995 LANL doses provided in ESH-DO-96: 206 for each facility. Dividing the sitewide LANL dose by the facility dose enabled calculation of an estimated conversion factor for each facility.

Doses for these facilities from 1990 through 1994 were taken from Supplement 1 to the FFCA. Doses for 1995 were derived by ESH-17 from measured emissions in 1995, which were reported in ESH-DO-96: 206 (see document database). The CAP88 conversion factors supplied in Supplement 1 to the FFCA were used to convert measured emissions in 1995 to potential dose for each facility. Because specific isotopes were not measured in stack emissions until 1995, these conversion factors were apparently for the most conservative alpha or beta-gamma emitter with the potential to be released from each stack. To estimate potential dose for each facility in 1995, alpha and beta-gamma emissions were summed separately, and the results were converted to dose with the same conversion factors that were used from 1990 through 1994. Evaluations of emission estimates (i.e., conservative or not conservative) based on these comparisons necessarily assume no significant operational changes during this time period.

Based on measured emissions and associated doses from 1990 through 1995, 1996 doses for 7 of the 13 unmonitored point sources appear to have been conservatively calculated (TA-3-66 [ES 1, 8, and 25]; TA-21-257 [ES 7]; and TA-48-1 [ES 11-14, 15, and 45/46]). That is, the estimated emissions in 1996 resulted in a calculated dose that exceeded the dose that was calculated based on measured emissions from 1990 through 1995.

Estimated doses for the remaining six unmonitored point sources were consistent with or exceeded doses that were calculated based on actual measured emissions (TA-3-66 [ES 9 and 26]; TA-21-5 [ES 4]; TA-21-150 [ES 1]; TA-48-1 [ES 51]; and TA-54-2 [ES 1]). However, five of these sources had emissions that were controlled through the use of single stage HEPA filters. The estimated emissions in 1996 for these five sources were not conservative when compared to potential emissions based on measured emissions from 1990 through 1995. Potential emissions refer to those resulting from failure of air pollution control equipment and are calculated by dividing actual emissions by a HEPA filtration factor of 0.0005. The one other source for which estimated emissions appeared to not be conservative (TA-3-66 [ES 9]) does not have any pollution control equipment.

ESH-17 indicated that review of historical emissions was generally not carried out for facilities with very low historical emissions. This suggests that potential emissions from these facilities may not have been calculated using appropriately conservative methodology, which may have resulted from a failure to review historical emissions for these facilities or identify and quantify duct holdup appropriately (e.g., using Appendix D filtration factors instead of actual filter penetration factors). ESH-17 is in the process of documenting detailed procedures for estimating duct holdup and residual contamination in ESH-17-102, R1 (draft).

The relative magnitude of potential dose from these 13 unmonitored point sources, which comprise 84% of the summed doses calculated for all unmonitored point sources in 1996, is quite small. It is clear, though, that historical measurements have not been used by LANL to verify estimated potential emissions for all unmonitored point sources. This is evident for at least six point sources which had doses based on estimated potential emissions in 1996 that were significantly less than doses based on historical potential emissions. However, the potential doses from these facilities are small, and the fact that LANL may have underestimated potential emissions does not appear to have a significant impact on compliance with the 10 mrem yr^{-1} standard or their classification as unmonitored. It is possible that potential emissions from 1990 through 1995 from TA-21-5 and TA-21-150 are sufficient to warrant monitoring, but these facilities are inactive and are currently being decommissioned. In the future, historical emissions should be examined whenever possible, particularly because the FFCA defines historical stack sampling to be the "most accurate for determining potential emission rates where facility operations are stable and the effluent is filtered."

It was not possible to complete a thorough evaluation of the reported 1996 inventory. However, historic stack sampling data were very useful for establishing the relative magnitude of potential emissions from the most important unmonitored point sources in terms of potential dose to the nearest receptor. Comparisons between measured and estimated emissions facilitated an evaluation of the conservative approaches that LANL maintains have been used for emission estimates. These comparisons also allowed the ITAT to form a conclusion with regard to compliance with the 10 mrem yr^{-1} standard as well as point source classification for monitoring requirements.

The relative magnitude of potential emissions from unmonitored point sources appears to be very insignificant relative to potential LANSCE emissions. It is the ITAT's opinion that the shortcomings related to unmonitored point source estimated emissions that have been identified during the conduct of this audit are not sufficient to alter LANL's compliance with the 10 mrem yr^{-1} standard. Based on historical emissions, it also does not appear that LANL has underestimated potential emissions from any unmonitored point sources to the extent that their classification as unmonitored is inappropriate.

It should be understood that the compiled inventory list and associated emission estimate calculations by LANL in 1996 were the second such compilations. The creation of a combination of procedures that addresses the requirements as specified in 40 CFR 61, Subpart H, is an ongoing process that is continuously modified based on experience. These procedures must be sufficient to satisfy the requirements but not so cumbersome that they hinder researchers' ability to focus on their work. It is the ITAT's opinion that the recommendations made to LANL regarding its unmonitored point source radionuclide inventory, associated emission calculations, new source identification, and QA procedures allow for creating a credible and defensible radionuclide inventory without imposing unreasonable expectations on researchers.

STACK SAMPLING AND MONITORING EVALUATION

This chapter addresses point sources of radioactive releases to the atmosphere at the Los Alamos National Laboratory that are monitored. Unmonitored point sources were discussed in the previous chapter and non-point sources are discussed in the next chapter of this report.

Methods for monitoring, sampling, and analysis of effluents are specified in 40 CFR Part 61, § 61.93. Section 61.93 provides specific requirements that apply to monitoring or continuous representative sampling of discharges. Appendix B, Method 114, of 40 CFR Part 61 focuses on the requirements for sample collection, various types of analytical measurements made on collected samples, and real-time monitoring for radioactive gases discharged from stationary sources, such as stacks and building vents. The requirements of § 61.93 and Method 114 apply to the LANL effluent discharges that must be measured to comply with 40 CFR 61, Subpart H. Those discharges are measured, either continuously or real-time by sequential collection and analysis of effluent samples.

This audit focused on evaluating the continuous effluent monitoring, sampling protocols, and analytical methods for locations that were estimated to be the primary contributors to the offsite dose. Table 3 shows the estimated dose contributions from measured radionuclide releases to the atmosphere by technical area (TA) during the year 1996 (K. W. Jacobson, 1997, U.S. Department of Energy Report, *1996 LANL Radionuclide Air Emissions*).

Table 3. Estimated Offsite Doses in 1996 from Monitored or Sampled Airborne Releases

Technical area	Estimated effective dose equivalent (mrem)[a]	Percent of total	Principal radionuclides released
TA-53 (LANSCE)	1.62	99.1	^{15}O, ^{11}C, ^{10}C, ^{16}N, ^{41}Ar
TA-21 (DP Site)	0.012	0.73	^{3}H
TA-41 (W Site)	0.0010	0.061	^{3}H
TA-3-29 (Chemical and Metallurgical Research Facility)	0.00076	0.046	^{234}U, ^{238}Pu, ^{239}Pu
TA-16 (S Site)	0.00044	0.027	^{3}H
TA-55 (Plutonium Facility)	0.00036	0.022	^{3}H, ^{239}Pu, ^{241}Am
Total[a]	1.63	100	

[a] This table does not include estimates of doses from all sources, only the six TAs where the highest airborne radionuclide releases were measured. The number of significant figures shown does not reflect uncertainties associated with the dose estimates.

Table 3 shows that in 1996, TA-53, the Los Alamos Neutron Science Center (LANSCE), was the principal source of offsite radiation dose resulting from releases of radionuclides to the atmosphere. Releases from the LANSCE facility have been the predominant source of offsite doses during other recent years as well. The principal radionuclides released from the LANSCE facility are short-lived radionuclides produced by activation of elements in air.

Other radionuclides contributing to offsite doses were tritium (^{3}H) and isotopes of uranium (U) and the transuranic elements plutonium (Pu) and americium (Am). In 1996, releases from two facilities, LANSCE and DP Site, were responsible for nearly all of the estimated offsite effective dose equivalent due to measured releases.

Reliable estimates of the amounts of radionuclides released in effluents depend on knowledge of the effluent flow rate and the concentration of radionuclides in the effluent air. The quantity of radionuclides released is the product of its concentration in the airstream and the flow rate of the air out of the stack or vent. To measure the radionuclide concentration properly, it is necessary to obtain a representative sample from the effluent stream, to collect the radionuclides present in the sample, and to measure the amounts of radioactivity collected. An alternative approach, used at the LANSCE facility, is to install instrumentation that can analyze the radionuclide concentrations and estimate releases in real time. In either case, estimation of the release is a multistep process, and there are EPA requirements related to each of the steps involved.

The following sections discuss the requirements that are most generic and apply to all sampling locations. These are the procedures for effluent flow measurements, selection of effluent sampling locations, extraction of effluent air samples, and transport of the sample to the collection device or measurement point. Subsequent sections address collection and measurement of radionuclide concentrations in effluent samples. Some measurement methods apply to more than one facility; such as the technique used to collect tritium from air samples and to quantify the amount collected. Each section includes a discussion of the applicable regulatory requirements, LANL methodology, regulatory deficiencies (if any were identified), technical or scientific deficiencies (if any were identified) and any related technical issues that were identified.

Effluent Flow Rate Measurements

Knowledge of the rate of discharge of effluent air is essential to accurately estimate radionuclide discharges. Because it is equally important for other pollutants regulated under the Clean Air Act, methods for measurements of the amount of air flowing in a stack or vent had been established by the EPA before the time that radionuclide releases were regulated. 40 CFR 61.93 (b), specifies that Reference Methods 2 or 2A of Appendix A of 40 CFR 60 (or another method for which EPA has given prior approval) be used to measure effluent flow rates in large stacks and vents or in pipes and small vents, respectively.

Summary of LANL Methodology

LANL used the methods specified by the EPA, Reference Methods 2 or 2A of 40 CFR 60, Appendix A, to measure effluent air flow. Measured stack flow rates can differ from time to time because of changes in fan operation and effluent filtration units. For example, some stacks have both a primary exhaust fan and a back-up exhaust fan whose discharge flow rates may differ. To ensure that effluent releases are not underestimated, it has been LANL policy to use the highest flow rate measured during the previous three years in the release calculation. This approach leads to estimates of the amounts of radionuclides released that generally exceed those that actually occurred.

Regulatory Deficiencies

The ITAT did not identify regulatory deficiencies in records examined.

Technical or Scientific Deficiencies

The ITAT did not identify technical or scientific deficiencies in records examined. The ITAT determined that the EPA methods used by LANL have a firm basis and provide reliable information.

Selection of Effluent Sampling Locations

Because it is essential that collected samples of the air being discharged represent the properties of that effluent, it is important that the location for the sample be chosen carefully. As was the case for effluent flow measurements, this issue is one that arose in regulation of other pollutants before EPA established 40 CFR 61, Subpart H. Subpart H employs previously established guidance and specifies in § 61.93 (b) (2) that Reference Method 1 of 40 CFR 60, Appendix A, (or other method for which EPA has given prior approval) be used to select sampling sites. Reference Method 1 relies upon a rule of thumb to avoid disturbances of the effluent flow that could cause samples to be nonrepresentative; namely, that the location should be at least eight duct diameters downstream and at least two duct diameters upstream of a major flow disturbance.

Summary of LANL Methodology

The preferred method used by LANL is an alternative method that has received prior approval from the EPA. Beginning in 1993, DOE requested EPA approval of a method of sampling point selection for all DOE facilities based upon quantitative measurement rather than the rule of thumb (letter dated August 23, 1993, from Raymond F. Pelletier, Director, Office of Environmental Guidance, DOE-HQ to J. Wm. Gunter, Director, Criteria and Standards Division, EPA). It is known from measurements of trace gas concentration profiles that sample location based upon the rule of thumb does not guarantee that the effluent will be well mixed. The goal of the approach proposed by the DOE was to identify a location where the effluent is well mixed, to sample at that location using a single highly efficient sample extraction method (the shrouded probe) to collect the sample, and to transport the sample to the collector using an optimized line. The sample extraction and transport line aspects are discussed in a later section.

Following agreement on the Clean Air Act Memorandum of Understanding (MOU) between the EPA and DOE in the fall of 1994, the EPA gave approval to use an alternative method for selecting sampling locations (letter dated November 21, 1994, from Mary D. Nichols, Assistant Administrator for Air and Radiation, EPA to Raymond F. Pelletier, DOE-HQ). The approval letter states the following regarding sampling location:

> The sampling locations must be selected to ensure that the flow profiles are well characterized and that sampling is representative of all stack effluents. The measurement site must be qualified for a single point representative sampling by demonstrating complete mixing across the entire flow profile by:

i) measuring the velocity profile;
ii) measuring for complete mixing with an appropriate tracer gas; and
iii) measuring for complete mixing of tracer particulates in stacks where particulate contaminants could be present

The coefficient of variation of the velocity profile and test tracers each must not be greater than ± 20% over the central 2/3 of the area of the duct. Over the complete profile, the tracer gas concentration must not be greater than ± 30% of the mean concentration across the duct. EPA 40 CFR 60, Appendix A, Method 1 must be used to determine the number of measurement points in each sampling grid.

In instances where all of these criteria are not satisfied initially, exhaust stream mixing must be enhanced by appropriate measures, e.g. installing mixing elements, adding elbows, rearranging entrances in different planes, and preventing the introduction of lateral flows flush with the side wall of the receiving duct. The objective of such modifications is to avoid particle stratification, ensuring complete mixing, minimizing particle entrapment in flow boundary layers, and avoiding regions of unusually high concentrations. Following these modifications, the system must be tested again to verify that all standards and criteria are met.

The approval letter permits DOE to request approval from the appropriate EPA Regional Office for deviations from the specified conditions as provided in § 61.93 (b) (3). Modification of the conditions in the last paragraph was requested by DOE (letter dated April 12, 1995 from Larry D. Kirkman, P.E., Acting Area Manager, DOE-LAAO to Lynda F. Carroll, Acting Director, Air, Pesticides and Toxics Division, EPA Region VI). The DOE proposal was conditionally approved by EPA Region VI (letter dated June 21, 1995 from Jane N. Saginaw, EPA Regional Administrator (6A), to Larry Kirkman, P.E., Acting Area Manager, DOE-LAAO). The approach proposed by the DOE is given here:

In instances where this criterion cannot be satisfied, one of the following courses of action will be taken before single point sampling can be employed:

(a) The exhaust stream mixing will be enhanced by appropriate measures (e.g., installing mixing elements, adding elbows, etc.) to achieve a coefficient of variation that is not greater than 20%, or
(b) A single nozzle probe will be placed in accordance with the velocity and test tracer profiles such that the probe is sampling at a point of above average test tracer concentration.

The following paragraph provides the condition that the EPA placed upon approval of the DOE proposal:

CONDITION

> If a Coefficient of Variation ≤ 20% is not achieved by measures described in option (a) above and the alternative option (b) is employed, the probe shall be placed such that test tracer concentrations are above average for all test particles over the entire design envelope range 3–15 µm aerodynamic equivalent diameter, and this must be documented.

When single point sampling using a shrouded probe is not feasible at a location because conditions listed above or others given below are not met, the approach of Reference Method 1 is employed. Because needs for effluent monitoring were not given adequate attention during design, there are some stacks at LANL for which application of Reference Method 1 is impractical. Sampling locations for those stacks are selected under the provisions of § 61.93 (b) (3), which provides for prior EPA approval of documented procedures that will not significantly underestimate emissions.

Regulatory Deficiencies

The ITAT did not identify any regulatory deficiencies.

Technical or Scientific Deficiencies

The ITAT did not identify any technical or scientific deficiencies. The approach that DOE proposed to EPA and that EPA approved yields effluent sampling locations that are known to be satisfactory and is an improvement over the rule of thumb that is part of Reference Method 1.

Sample Extraction Techniques

The requirement that the effluent sample represent the properties of the air being discharged also affects the method of withdrawal of the sample from the airstream. In § 61.93 (b), the requirement states:

> Representative samples of the effluent stream shall be withdrawn continuously from the sampling site following the guidance presented in American National Standards Institute (ANSI) N13.1-1969 ‘Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities’ (including the guidance presented in Appendix A of ANSI N13.1).

Appendix A of the ANSI guide deals specifically with sampling ducts and stacks. Briefly, the approach recommends sampling isokinetically (the condition when the air velocity entering the probe is the same as the air velocity in the stack) at several points in the cross-section of the stack to ensure that the total sample collected represents a possibly nonuniform concentration of radionuclides in the air being discharged. As for other methods presented in § 61.93 (b), alternative techniques may be used if prior approval is received from the EPA.

Summary of LANL Methodology

The preferred method used by LANL is an alternative method that has received prior approval from the EPA. As discussed above in the section on sampling location, the DOE requested and received prior approval for a technique that identifies a location where the effluent is well mixed and obtains samples at that location using a single highly efficient sample extraction probe. This procedure employs a probe, called the shrouded probe, that intentionally avoids isokinetic sampling to reduce deposition of particles in the inlet of the sampling probe. The alternative method of sampling using a single shrouded probe was approved by the EPA in November 1994 (letter dated November 21, 1994, from Mary D. Nichols, Assistant Administrator for Air and Radiation, EPA to Raymond F. Pelletier, DOE-HQ). The approval letter states the following regarding use of the shrouded probe:

> For each release point under consideration, the shrouded probe must be designed to meet all expected stack operating specifications, including exhaust velocity and sampling flow rates over the range of anticipated conditions. The shrouded probe must be designed for and operated at a qualified sampling location in a well-mixed and stable effluent flow profile. Each use of a shrouded probe must satisfy the following conditions:
>
> i) The transmission ratio of the probe must be between 0.80 and 1.3 for 10 μm aerodynamic diameter aerosol particles, where the transmission ratio is defined as the ratio of the particulate concentration delivered by the probe at the entrance of the sample transport line to the free-stream particulate concentration;
> ii) The overall frontal area of the probe must not exceed 15% of the duct or pipe's internal cross-sectional area;
> iii) The use of the probe must be limited to pipes and ducts with an internal diameter of ≥ 3 inches;
> iv) For cyclonic or swirling flows, use of the probe must be limited to pitch and yaw angles of ≤ 20 degrees in accordance with 40 CFR Part 60, Appendix A, Method 1;
> v) The sampling flow rate must be maintained at ± 25% of design specifications over the range of anticipated conditions; and
> vi) The probe is used at a sampling site where the particle size, as determined by either direct measurements or analytical means, is within the range for which the probe was calibrated.
>
> The specifications of each shrouded probe must be fully documented, starting with the initial design requirements, manufacturing, and testing, and installation at the point of use. Each probe must be stamped with the following information: model number, serial number, and nominal and range of operating conditions. The documentation package must provide all information necessary to identify the original requestor *[sic]* and the probe manufacturer, to address all design requirements, manufacturing, and testing. The testing criteria for each new probe must be ± 7% of mean value (of the

transmission ratio) between the wind tunnel test results and model calculations for the nominal operating conditions with 10 μm aerodynamic equivalent diameter particles."

The November 1994 approval letter from EPA permits DOE to request approval from the appropriate EPA Regional Office for deviations from the specified conditions as provided in § 61.93 (b) (3). Modification of item (vi) was requested by DOE (letter dated April 12, 1995 from Larry D. Kirkman, P.E., Acting Area Manager, DOE-LAAO to Lynda F. Carroll, Acting Director, Air, Pesticides and Toxics Division, EPA Region VI). The concern was that the words "range for which the probe was calibrated" implied that the probe would have to be tested with particles of many sizes, from extremely small to very large, that could possibly be present. In the request, the suggested language was, "The performance of the shrouded probe will be demonstrated for particles ranging from 1–10 μm." A similar request was apparently made from DOE-HQ because modification of item (vi) was approved by changing the word "calibrated" to the word "qualified" (letter dated June 15, 1995 from Lawrence Weinstock, Acting Director, Criteria and Standards Division, EPA to Raymond F. Pelletier, Director, Office of Environmental Policy and Assistance [EH], DOE-HQ). [The author or typist of this letter apparently transposed the "i" and "v" and the text mistakenly refers to "criterion iv"].

When single point sampling using a shrouded probe is not feasible at a location because either a sample location condition or a shrouded probe condition is not met, LANL employs the approach of the American National Standards Institute in their method ANSI N13.1, which includes multiple sample extraction probes. LANL also uses sampling rakes with multiple probes to sample effluents from stacks for which Reference Method 1 cannot be used to select a sampling location.

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies.

Technical or Scientific Deficiencies

The ITAT has not identified any technical or scientific deficiencies. The approach that DOE proposed to EPA and that EPA approved yields effluent sampling locations that are known to be satisfactory and is an improvement over the rule of thumb that is part of Reference Method 1.

Sample Transport Lines

Transport lines carry sampled air from the outlet of the sampling probe to the point of sample collection or location of a continuous monitoring system. There is a potential for loss of particulate radionuclides from the sampled airstream because of deposition on the walls and in bends of the line. Therefore, transport lines should be kept as short as is feasible given the conditions at the sampling location. Appendix A of the ANSI N13.1 guide, which is included by reference in § 61.93 (b), deals specifically with sampling ducts and stacks. Appendix B of ANSI N13.1, which discusses particle deposition in sampling lines, is not included by reference in § 61.93 (b).

Summary of LANL Methodology

The preferred method used by LANL is an alternative method (single point sampling of a well-mixed effluent using the shrouded probe and an optimized transport line) that has received prior approval from the EPA. As part of the DOE request (Pelletier to Gunter, August 1993) for EPA approval to use the alternative method, DOE proposed using the DEPOSITION computer code to optimize the transport line and to estimate transmission losses. This computer code was developed at Texas A & M University and had been accepted by the Nuclear Regulatory Commission for estimation of losses in transport lines. In the approval letter (Nichols to Pelletier, November 1994), the following statement was made:

> The design of the sample transport lines must be optimized to reduce the number of bends, elbow, long horizontal and vertical runs, and total run lengths from the probe to the sample collection medium for the designed sampling flow rate. Transport line diameters must also be optimized. The DEPOSITION computer code must be used to estimate particulate deposition in the line between the shrouded probe and the collection device and to account for line losses in the calculation of the source term. (Other methods or computer codes which are shown to be equivalent to or better than the DEPOSITION code may be used to assess the overall performance of the system with the prior approval of EPA.) The following specifications must be met:
>
> i) The overall performance of the system, from the sampling probe to the sample collection medium, must be shown by the DEPOSITION code to be ≥ 50% for 10 μm aerodynamic equivalent diameter aerosol particles at the nominal sampling flow rate and free stream velocity;
> ii) For sampling conditions within the range of 0 to 50 degrees C., Version 2.01 or newer of the DEPOSITION code must be used. For temperature conditions outside of this range, Version 2.02 or newer, must be used; and
> iii) For gas mixtures other than air, the DEPOSITION code cannot be used unless adjustments are made for the given mixture."

For sampling locations that meet the requirements for use of the shrouded probe, LANL uses the DEPOSITION code to optimize the sampling line by selecting a line diameter that minimizes deposition for the flow rate needed for sampling. For these lines, LANL also uses the DEPOSITION code to estimate transmission losses in the probe and sample transport line.

When single point sampling using a shrouded probe is not feasible at a location because either a sample location condition or a shrouded probe condition is not met, LANL employs the approach of ANSI N13.1, with multiple sample extraction probes. These sampling probe arrangements (called ANSI rakes) are also used to sample effluents from stacks for which Reference Method 1 cannot be used to select a sampling location. Probe and sampling line deposition losses are not formally estimated for these sampling locations; however, test data on the losses during sample extraction are available for some Kurz probes.

Regulatory Deficiencies

The regulation, in § 61.93 (b), requires that representative samples be collected. Section 4.2.2 of the ANSI N13.1 guide, incorporated by reference into the regulation, describes mechanisms that can cause samples to be non-representative. Particle deposition in sample transport lines is one of those mechanisms. To assure that the samples collected are representative, it is necessary to assess the losses of particles during transport of the samples from the point of extraction to the filter. The ITAT determined that LANL has failed to analyze such losses in transport lines for three sampling systems that do not employ shrouded probes.

Technical or Scientific Deficiencies

Estimates of sampling losses in both extraction probes and transport lines should be used to adjust estimates of releases from LANL stacks. Such estimates may come from calculations or from aerosol challenge measurements that have been made for some stack sampling systems. Correction of the estimated release rates of particulate radionuclides is the logical consequence of having estimated the bias due to losses that occur during extraction and transport of the sample.

As was just demonstrated, it is simple in principle to decide that a correction for losses during sampling should be made. However, establishing the appropriate correction is more problematic. For building exhausts that are treated with one or more sets of HEPA filters, the effluent is *expected* to consist primarily of those small particles (with aerodynamic diameters roughly in the range 0.1–0.5 μm) for which HEPA filter retention is poorest. Sampling losses for such particles are much lower than those for larger particles (with aerodynamic diameters roughly in the range from 1 to 10 μm) that *might be* present at some time during routine operations. The correction factor for a particular sampling system could vary from <10% to perhaps 400%, depending upon the assumed distribution of effluent particle sizes. Measurements of effluent particle size at the discharge point are difficult to obtain because the concentrations of radionuclides have been greatly reduced by the HEPA or other filtration systems. As a result, there is rarely definitive information on effluent particle size that can be used to guide the choice.

Using the highest correction factor estimated for a worst-case distribution of particle sizes would be an approach that might be attractive to some because it is very cautious. Table 3 shows that multiplying the CMR and Plutonium Facility dose estimates by a factor of 4 would have had no impact on the question of compliance with the 10 mrem dose standard of 40 CFR 61, Subpart H, in 1996. However, extreme bias in the estimation of releases is not required, and it confuses comparisons that may be made between estimated and measured environmental concentrations. The ITAT recommends selecting an intermediate best estimate correction factor for sample losses in a sampling system, using it with documentation, and periodically reviewing its basis.

Collection and Analysis of Tritium Samples from Facilities Located in TA-16, TA-21, TA-41, and TA-55

The techniques used for collection and analysis of tritium (^{3}H or T) in airborne effluents from stacks and vents at the TA-16, TA-21, TA-41, and TA-55 locations are similar. For that reason, the tritium sample collection and analysis procedures for all these facilities are discussed together.

The requirements of 40 CFR 61, Appendix B, Method 114, Section 2.2.1 describes appropriate methods for collecting tritium from effluent samples. Section 2.2.1 also provides the method for oxidizing tritium gas, followed by bubbler collection of the resulting water vapor. Liquid scintillation counting, 40 CFR 61, Appendix B, Method B–5, is identified as a method that is most applicable to low-energy beta-emitters such as tritium.

Summary of LANL Methodology

Weekly samples of tritium in effluents are collected using ethylene glycol bubbler-type collectors. Three bubblers are used in series to collect tritium present as tritiated water vapor (HTO or T_2O) in the sampled air stream, which is trapped as the air bubbles through the ethylene glycol collectors. The second and third bubblers provide back-up capability to collect the sample. Tritium that is present as hydrogen gas (HT or T_2) in the sampled air stream passes through those three bubbler collectors. It is converted to tritiated water vapor as the sampled air stream flows through a heated bed of palladium metal that catalyzes the oxidation of the hydrogen gas. The air stream that leaves the catalytic converter flows through a second series of three ethylene glycol bubbler collectors, which trap the HTO or T_2O containing tritium originally present as hydrogen gas. The collected samples are analyzed by liquid scintillation counting and the results are used to estimate the releases of tritiated water vapor and tritiated hydrogen gas.

LANL performs a test of the catalytic conversion process in the sampling system and the overall sample collection efficiency for HT periodically. In this procedure, a known amount of HT is released into the stack over approximately a four-hour period. The ethylene glycol bubbler samples for HT are collected and analyzed. A second procedure then begins to measure the release of HT from the stack as the result of facility operations during most of the following day. Care is taken to detect any disturbances that would affect this measurement, which serves as a background release estimate for the test period. The HT concentration measured during the background period is subtracted from the value measured during the test and the net response of the sampling system is compared with that expected from the known release. In nearly all cases, the amount estimated by the sampling system exceeds, usually by 10–20%, that predicted from knowledge of the release. In that case, no correction is made to release estimates for HT. When the amount estimated by the sampling system is less than the expected value (one value of 0.84 was seen in the records) the release estimates of HT are corrected by an appropriate factor.

Duplicate aliquots of ethylene glycol are taken from the bubbler vials and analyzed by the Health Physics Analytical Laboratory together with a standard and blanks of unexposed ethylene glycol. Although there is normally little difference between the duplicate samples, the higher of the two is used to estimate releases. LANL uses the totals of the three highest estimates (one for each bubbler) for HTO and for HT to estimate the releases. As noted earlier, the highest flow during the previous three years is also used in the calculation. Spot checks of the calculations showed that they were performed correctly.

Regulatory Deficiencies

The ITAT did not identify any regulatory deficiencies.

Technical or Scientific Deficiencies

Heat tracing was not installed on some lines used to transport samples from the outside of a tritium facility exhaust stack or duct to the building housing the sample collection system. This could result in a temporary loss of sample for HTO that condensed on the wall of the sampling line. In the worst, but unlikely, case, the line might be plugged by ice. As a matter of good scientific practice, LANL should heat trace sample transport lines to avoid condensation of water vapor.

Collection and Analysis of Airborne Particles Released from the Chemical and Metallurgical Research Facility (TA-3-29) and the Plutonium Facility (TA-55)

Several radionuclides, primarily alpha emitters, are released in the form of particles from 13 different stacks at the Chemical and Metallurgical Research Facility, TA-3-29 and from two stacks at the Plutonium Facility located in TA-55. Sample collection and analysis methods and the procedure for source term estimation for these radionuclides are the same and are discussed together in this section.

The requirements of 40 CFR 61, Appendix B, Method 114, describe sample collection and analysis methods for radionuclides present in particulate form:

> The extracted effluent stream is passed through a filter media to remove the particulates. The filter must have a high efficiency for removal of sub-micron particles. The guidance in ANSI N13.1–1969 shall be followed in using filter media to collect particulates.

Summary of LANL Methodology

Weekly samples are collected downstream of effluent filtration systems in the several exhaust stacks using LB-5211 filters. When a switch from the HV-70 filter that had been used for many years was considered in the 1980s, LANL evaluated the collection efficiency of the candidate replacement, the LB-5211 filter. Penetration of 0.3–μm unit density particles through the LB-5211 filters was measured and found to 0.04%. This result was the mean of six tests; in individual tests, the measured collection efficiencies ranged from 99.2 to 99.8%.

These samples are counted directly for total activity. The most important isotopes are alpha-emitters (Table 3), and the direct filter (gross alpha) counting result is used to determine the activity in the weekly samples. Half of each filter is included in a quarterly composite sent to an offsite radiochemical laboratory for determination, by alpha spectrometry, of the alpha-emitting radionuclides present in the composite sample. LANL retains the other half of the filter. Gross alpha analysis of the composite samples is also performed at the radiochemical laboratory. For the year 1996, release estimates for the stacks were based upon the weekly gross alpha counting results, with application of a correction for self-absorption of alpha particles. The total release was apportioned among the alpha emitters detected in the composite samples according to the relative amounts found by radiochemical analysis.

Regulatory Deficiencies

The ITAT did not identify any regulatory deficiencies.

Technical or Scientific Deficiencies

Three technical issues are related to the methods of sample analysis. As noted, the release estimates are based upon the results of direct alpha counting of the filters and the analysis of composites of those filters. The following subsections address direct alpha counting as a technique, correction for self-absorption losses during counting, and potential effects of dividing the filters to form composites.

Direct Alpha Counting. Analytical methods are prescribed in 40 CFR 61, Appendix B, Method 114. Four analytical methods that are generally applicable for analysis of alpha-emitting radionculides are listed according to the amount of information that the technique provides. By this measure, Method A–4, direct alpha counting or gross alpha determination, is the least favored of the analysis techniques for alpha-emitters. The following discussions of the principle of the method and its applicability are taken from Appendix B.

> *Principle*. The sample, collected on a suitable filter, is counted with an alpha counter. The sample must be thin enough so that self-absorption is not significant and the filter must be of such a nature that the particles are retained on the surface.
>
> *Applicability*. Gross alpha determinations may be used to measure emissions of specific radionuclides only (1) when it is known that the sample contains only a single radionuclide, or the identity and isotopic ratio of the radionuclides in the sample are well-known, and (2) measurements using either Method A–1, A–2, or A–5 have shown that this method provides a reasonably accurate measurement of the emission rate. Gross alpha measurements are applicable to unidentified mixtures of radionuclides only for the purpose and under the conditions described in section 3.7.

The assumption that self-absorption of the alpha particles emitted from the sample is "not significant" is a central feature of the principle of the method. As can be seen from the discussion in the following section on technical issues, it is not clear that the filters used by LANL yield a sample that is sufficiently thin to meet this goal. The fraction of the emitted particles that are detected was determined for the filter medium being used when it was first adopted in the 1980s. Those measurements show self-absorption losses that range from 36 to 71% with a mean of 58%. These losses are certainly large enough to require a correction factor, which LANL applies, but the magnitude of losses that would be "significant" is not specified in 40 CFR 61, Appendix B.

Radiochemical analysis of composite samples is used to determine the mixture of radionuclides present in the effluents sampled. This procedure satisfies the first requirement of the section on applicability of Method A–4. The second requirement states that there be evidence that the gross alpha counting method provides a "reasonably accurate" estimate of emissions. [Whether this is the case is not clear at this point, because of questions about the information and because we have no definition of what "reasonable" accuracy requires.]

Sample Self-absorption. When air sampling filters are counted directly, a correction must be made for the fraction of the particles emitted by radionuclides collected in the sample that are

absorbed by the sample itself, the filter material, and collected dust. This has been called a correction for self-absorption losses. In LANL documents, the term "depth of burial correction factor" has been used; when exhausts are treated with HEPA filters, most of the counting loss is due to penetration of the small effluent particles into the air sampling filter medium.

If A_T is the true activity on the filter and A_M is the activity measured by direct counting of the filter, then:

$$A_M = A_T f_d \quad \text{which implies} \quad A_T = A_M / f_d \tag{1}$$

where f_d is the fraction of the emitted alpha particles detected during direct counting of the filter. Knowledge of the fraction f_d is essential to determination of the true filter activity.

Because IEER scientists were concerned about disagreements between the results of direct filter counting and those from isotopic analyses, they recommended that the adequacy of the correction for self-absorption be reviewed. The value of f_d (= 0.43) that is employed by LANL is based upon measurements that were performed in the 1980s when LANL changed from HV-70 filter paper to the LB-5211 filter paper, which is still used. The ITAT reviewed information in memoranda and data sheets related to this technique (Scott Miller, Documentation of the Development of the 1996 Stack Source Term, August 26, 1997, Attachment 3). Although the uncertainties associated with individual determinations of the fraction f_d bear further investigation (if possible), the ITAT review indicates that the values of f_d for 25 determinations (11 and 14 for plutonium- and uranium-contaminated filters, respectively) are correct. They range from 0.29 to 0.64 with a mean of 0.42 and a standard deviation of 0.10, but the values are not normally distributed. The distribution of values of f_d is closer to a lognormal distribution but, as Figure 3 shows, it is not truly lognormal.

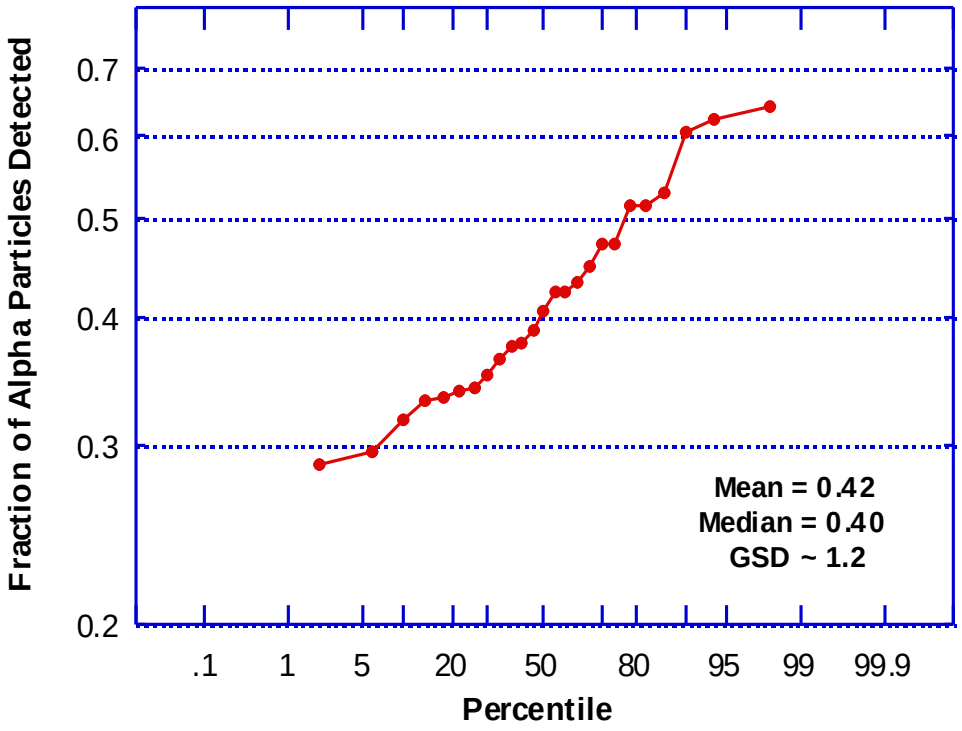

Figure 3. Distribution of the measurements of the fraction of alpha particles emitted from the filter that are detected during direct counting of the filter. The y-axis is a logarithmic scale. The distribution of values would be considered a lognormal distribution if all the data points fell on a straight line.

The broad range of values of f_d (more than a factor of 2) is an important factor related to the differences between the results of direct counting and more sensitive isotopic measurements of the alpha emitters collected on the filter. When making comparisons that employ the results of direct counting of the filters, the relatively large uncertainty in f_d must be remembered.

Dividing the Filters. As noted previously, half of each effluent filter is included in a composite sample submitted for radiochemical analysis to determine the composition of the alpha-emitting radionuclide mix that was released. A natural question, and one raised by IEER scientists, was whether the division of filters would lead to differences in the results for the samples.

If the activity on the filter is due to the collection of a large number of particles, there is no reason to suspect that particles would not be distributed more or less uniformly on the surface of the filter. It is unlikely that all of the particles would preferentially deposit on one half of a filter, and very difficult to predict where the filter would need to be cut in order to produce two filter halves that greatly differed in activity.

However, if the activity on the filter is due to only a few particles then the possibility that counting results for the two halves would differ will increase. In the extreme, if the activity is due to collection of a single particle there will almost certainly be a large difference of activities for the two halves. The solution to the dilemma depends upon the specific radionuclides in the effluent stream, the size of the particles being released, and the chemical form of the material.

The alpha activities of particles of differing sizes for radionuclides of interest are shown in Table 4, which considers only the oxides of the elements plutonium, uranium, and americium. Alpha particle activities of particles containing other chemical forms of these elements would differ in proportion to the differences in density of the various forms and would generally be lower than the values shown Table 4. However, the difference between the activity estimates in the table and those for other pure chemical forms would be less than a factor of 2.

Table 4. Alpha Activities of Spherical Particles Containing Pure Oxides of Plutonium, Uranium, and Americium

Diameter [a] Of particle (μm)		Alpha activity (pCi) contained in one particle of indicated diameter				
D_p	d_{ae}	Weapons grade[b] Pu oxide[c]	^{238}Pu oxide[c]	Depleted (0.2% ^{235}U) oxide[d]	Enriched (93% ^{235}U) oxide[d]	^{241}Am oxide[e]
0.005	0.017	5.4×10^{-8}	1.3×10^{-5}	2.6×10^{-13}	4.7×10^{-11}	2.6×10^{-6}
0.01	0.034	4.3×10^{-7}	1.0×10^{-4}	2.1×10^{-12}	3.7×10^{-10}	2.1×10^{-5}
0.03	0.010	1.2×10^{-5}	2.8×10^{-3}	5.6×10^{-11}	1.0×10^{-8}	5.7×10^{-4}
0.05	0.17	5.4×10^{-5}	1.3×10^{-2}	2.6×10^{-10}	4.7×10^{-8}	2.6×10^{-3}
0.1	0.34	4.3×10^{-4}	1.0×10^{-1}	2.1×10^{-9}	3.7×10^{-7}	2.1×10^{-2}
0.15	0.51	1.5×10^{-3}	3.5×10^{-1}	7.0×10^{-9}	1.3×10^{-6}	7.1×10^{-2}
0.3	1.0	1.2×10^{-2}	2.8×10^{0}	5.6×10^{-8}	1.0×10^{-5}	5.7×10^{-1}
0.5	1.7	5.4×10^{-2}	1.3×10^{1}	2.6×10^{-7}	4.7×10^{-5}	2.6×10^{0}
1	3.4	4.3×10^{-1}	1.0×10^{2}	2.1×10^{-6}	3.7×10^{-4}	2.1×10^{1}
3	10	1.2×10^{1}	2.8×10^{3}	5.6×10^{-5}	1.0×10^{-2}	5.7×10^{2}

[a] Two diameters are shown: the physical diameter (d_p) and the aerodynamic diameter (d_{ae}); for the densities (see below) of materials considered in this table $d_{ae} \sim 3.4\ d_p$.
[b] Weapons grade Pu assumed to contain 93.8% ^{239}Pu and 5.8% ^{240}Pu.
[c] Density of pure oxide particle is 11.5 g cm^{-3}.
[d] Density of pure oxide particle is 11.0 g cm^{-3}.
[e] Density of pure oxide particle is 11.7 g cm^{-3}.

For stacks and vents carrying exhaust gases that have passed through HEPA filters, penetration of large particles is quite unlikely. The particles most likely to penetrate such filters have aerodynamic diameters of about 0.3 μm; the aerodynamic size that is most penetrating varies with operational parameters, but a range of aerodynamic diameters of 0.1–0.5 μm, based upon experimental observations, has been often quoted. For HEPA filtered exhausts, the row for $d_p = 0.1$ μm ($d_{ae} = 0.34$ μm) is perhaps most relevant to the discussion. The ITAT noted that the detection limit for the direct alpha counting analysis is about 6 pCi and estimated the number of pure oxide particles that would produce that activity. For that diameter, about 16 million particles of enriched uranium and 2.9 billion particles of depleted uranium would be required to be detectable. The possibility of developing a bias when halving a sample containing that number of particles is quite low. The situation is similar for weapons grade plutonium, for which about 14,000 0.1-μm particles would be needed to give a total activity of 6 pCi. For ^{238}Pu and ^{241}Am, the numbers are much smaller, 58 and 286 0.1-μm particles, respectively. Plutonium-238, which has the highest specific activity, is clearly the most problematic nuclide in this regard. For

particles with physical diameters of 0.15 μm (d_{ae} = 0.5 μm), only 17 particles of ^{238}Pu would give a total activity of 6 pCi. For unfiltered exhausts, small numbers of particles of ^{238}Pu and ^{241}Am could account for the detected activity and, depending upon circumstances, biases could be introduced when filters were divided.

While gross alpha counting certainly has its uses, prompt assessment of whether releases are unexpectedly high being one of them, other methods that are more reliable should be used to estimate releases of alpha-emitting radionuclides. As discussed above, the uncertainties associated with the self-absorption correction are not small. Analysis of composite samples using alpha spectometry following chemical separations is a more reliable method that has lower analytical uncertainties.

Analysis of Airborne Effluents from the Los Alamos Neutron Science Center (LANSCE)

Evaluation of the real-time monitoring data from the LANSCE facility was not completed during the course of this audit due to time and budgetary constraints. While the preliminary conclusion is that the real-time measurements are reliable and well documented, further evaluation is required.

NON-POINT SOURCE MONITORING EVALUATION

LANL has identified over 1500 potential sources for diffuse, or non-point, emissions within the boundaries of the LANL technical site. To meet the requirements of 40 CFR 61, Subpart H, releases from all sources that have the potential to release radionuclides must be kept below an annual dose limit of 10 mrem to a maximally exposed individual (MEI). These releases include those from point sources as well as the 1500 diffuse sources onsite. Techniques for monitoring releases from point sources are specified in 40 CFR 61, Subpart H, but non-point sources are not explicitly addressed in the prescribed methods. Non-point sources include sources at LANL such as shallow land burials, surface impoundments, firing sites, unvented buildings, open burn sites, and tanks.

One choice for assessment of diffuse releases involves estimating the source term from each identified release site and modeling the dispersion of this source term through the atmosphere to the MEI. For example, these source areas might consist of soil areas or surface water contamination, but the endpoint of interest is the ambient air concentration of radionuclides at a downwind, maximally exposed location. The other option is to use environmental monitoring at the location of the MEI from which the dose can be inferred.

Within the FFCA Supplement 2a, which outlines LANL's proposed methodology for monitoring diffuse releases, LANL assesses the two alternate methods for establishing dose to a receptor for usability with the criteria of accuracy, completeness, and timeliness.

The accuracy of a source term and dispersion calculation is affected not only by the errors involved in using resuspension and atmospheric dispersion modeling, but also in the ability to identify and quantify the source term. Techniques for modeling particle resuspension from area sources are not well established, and atmospheric dispersion modeling is extremely uncertain on rugged terrain such as that at LANL. The majority of atmospheric dispersion models base their code on flat terrain, which is certainly not exhibited at LANL. The site is located on a mesa, and a rather deep canyon separates the site from the neighboring town of Los Alamos. This terrain complication makes the process of modeling the dose with any certainty a problem. LANL never actually modeled dose to a MEI from diffuse locations, but subjectively estimated the uncertainty in modeling dose from these multiple locations based on their experience with conventional source to receptor models.

LANL places confidence in environmental monitoring based upon their ability to understand and control errors in environmental sampling that cannot be controlled in source term modeling. In the FFCA, LANL estimated the uncertainties in doses calculated from diffuse sources using modeling techniques to be greater than 30%. This estimate was not based on actual calculations but rather on professional judgment. In contrast, LANL assumes that the uncertainties in environmental monitoring measurements are much smaller since uncertain parameters are avoided and sampling error can be adjusted for and minimized through quality control.

LANL does recognize that by taking environmental measurements, they are essentially calculating dose from point sources twice: once with the effluent source and modeling techniques (includes both monitored and unmonitored sources) and once by measuring exposure at environmental locations that would also be affected by point sources. They have determined this doubling-up to be negligible because a major portion of the dose to a member of the public at Los Alamos results from immersion dose (dose associated with being immersed in neutron activation products)—not ambient air inhalation dose as measured by environmental samples.

It is difficult to calculate complete and timely dose estimates using modeling techniques because of the number of diffuse source locations at LANL. LANL believes the source term estimates and modeling required to completely account for all diffuse sources would be more rigorous and time consuming and less complete than monitoring the ambient air. LANL used this reasoning to support its decision for using environmental sampling to demonstrate compliance. Assuming that the samplers are properly placed, LANL postulated that the environmental measurements should provide a comprehensive assessment of contamination due to diffuse sources, as well as monitoring any unsuspected contamination. In LANL's judgment, the timeliness of sampling results would be at least as rapid as samples can be analyzed by an analytical laboratory.

Because of constraints related to accuracy, timeliness, and completeness described above, LANL has chosen to use environmental monitoring techniques to assess releases from non-point sources instead of modeling. While environmental monitoring appears to be a reasonable and much simpler technique for accomplishing compliance requirements for diffuse source monitoring, the ITAT assessed whether the system in place at LANL is, in fact, the best one possible and meets all stated and implied requirements of compliance calculations.

For this reason, the ITAT examined the FFCA, by which the EPA preapproved LANL's use of environmental sampling to show compliance with the dose limit for diffuse sources. The FFCA identifies the LANL Radiological Air Sampling Network, or AIRNET, as the primary environmental sampling network for monitoring non-point releases, with the adaptations noted in FFCA Supplements 2a and 2b to be made to the network to ensure complete regulation of dose from these sources. To evaluate LANL's compliance with 40 CFR 61, Subpart H, and the viability of the FFCA and LANL's diffuse source monitoring program, the ITAT needed to understand how the implied guidelines in 40 CFR 61, Subpart H, for the program were implemented and how the program operated at the Laboratory. The ITAT examined the AIRNET system in detail and identified the requirements within LANL documentation that meet applicable 40 CFR 61, Subpart H, regulations.

The AIRNET System

To audit the compliance network, it was necessary to understand the AIRNET sampler network as it existed before the FFCA was implemented as a means of understanding the use and/or adaptation of the samplers to meet compliance requirements.

AIRNET is a system of environmental samplers located around the perimeter of LANL property and in other locations where monitoring the concentrations of radionuclides in air might be important. The AIRNET network had been in operation for over 20 years, long before LANL was legally bound to EPA and DOE requirements. The samplers are located between LANL facilities and potentially exposed members of the public or they encircle areas on the Laboratory property that have the potential to be major sources of diffuse emissions.

The compliance-related sampling network comprises only a small portion of the total AIRNET system. There are a number of AIRNET stations located at other onsite locations as well as a number of offsite locations. When the compliance sampler sites were being established, LANL tried to overlap existing AIRNET sites with compliance sites to avoid duplication.

The compliance network contains a sampler at the location identified for the MEI for the entire site, the LANL MEI, because this is the primary focus of compliance with the EPA's 40

CFR 61, Subpart H, requirement. Other compliance locations were identified by LANL using a sampler siting analysis, which is discussed in detail later in this chapter.

Sample Collection and Handling

Summary of LANL Methodology

Each AIRNET sampler station collects filter samples of airborne particles and silica gel samples of water vapor, including tritium vapor, from ambient air. The filter housing and airflow equipment configuration was designed by LANL from commercially available parts. The filter housing is a weather-tight, louvered design containing a particulate filter assembly, silica gel water vapor absorber, two flow meters, a vacuum pump, various connecting hoses, and a power supply circuit. The vacuum pump must meet the requirements of running constantly and not overheating if the filter paper becomes clogged. Specifications for all parts of the sampling assembly are given on Page 31 of the AIRNET QA document (ESH-17-AIRNET, R5).

The filters and silica gel cartridges are changed out every two weeks (biweekly), using techniques described in ESH-17-202 and 204. The detailed procedures indicate good quality control and complete chain-of-custody documentation requirements.

The filter head design for the samplers was chosen to reduce the possibility of filter contamination when the filters were removed and transferred to the AIRNET laboratory. The filter head, which contains the filter, is removable in its entirety from the airflow system. An identical filter head, containing a clean filter, is readied during filter preparation, and the filter head is clearly marked with the sampler number to which it will be attached. The filter head is then protected from contamination with a plastic cap. The old filter head, already marked with the sampler number, is removed from the airflow system and covered with the cap from the new filter. This new filter is then placed on the airflow system. This process reduces filter contamination during the change-out. The procedures for filter handling after retrieval from the field are rigorous and should also prevent contamination by unknown sources if the techniques are carefully followed.

Silica gels are safe from contamination if the gel beads are not exposed to moisture before being sealed in the casing. LANL procedures are reasonably written and employed to prevent contamination. Once the silica gel is connected to the airflow system, only moisture passing through the system during the two-week sampling period will be collected by the gel. Gel weights have been selected based upon exposure duration and experience with these gels in the field. Silica gel cartridge holders include a mechanism that stops air flow, and thus moisture flow, into the cartridge after it is removed from an airflow system.

During 1996, after the samples were collected, whole filters were face counted for gross alpha and gross beta (gamma spectroscopy was done as well) by the Health Physics Analytical Laboratory onsite at LANL within a few weeks of collection to provide a timely indication of any potential contamination. The filters were then returned to the AIRNET laboratory and split in two. Each half of the filter was added to a quarterly filter composite. Half-filters continued to be added to this composite sample until the quarter was complete. One half-filter composite sample was then sent off to an offsite radiochemical analytical laboratory. These filters were digested and analyzed for isotopes of uranium and plutonium and ^{241}Am.

Silica gel cartridge contents were measured for tritium content at another offsite laboratory. Silica gels were removed from their holders and distilled using a well-documented process. The water that was removed from the gels and put into a small jar was sent to the laboratory for tritium analysis.

A review of non-point sources done by the Radian Corporation in 1993 estimated the total emissions from LANL diffuse sources. In the FFCA, LANL converted these release estimates to dose to the LANL MEI, using methods not presented in the text of the FFCA. As a result of this calculation, specific radionuclides were identified as radionuclides of concern. Isotopes of uranium contributed the highest dose, at about 0.05 mrem, followed by a tritium dose 10 times lower, and a dose from isotopes of plutonium 10 times lower than the tritium dose. Remaining radionuclides fell several orders of magnitude below these doses, so uranium, tritium, and plutonium were considered the nuclides of interest for analysis. The digested filter is analyzed for these nuclides only.

Because of the comprehensive and detailed instructions that accompany the process of filter and silica gel preparation and change-out, samples are not likely to be contaminated by employee mishandling. Cross contamination during filter transport is also limited by the capping procedure that accompanies the quick-connect filter heads. Human error in data entry has been sufficiently reduced by introducing palm top computers, as described in the section of this chapter titled, "Data Validation and Verification." Through this process, the chain of custody is maintained using data sheets that accompany the samples everywhere they go.

The ITAT observed filter and silica gel change-out and sample preparation for analytical counting. All of the procedures discussed in the supporting documentation appear to be followed, and all possible measures are taken to reduce the possibility of any cross-contamination. The area in which the samples are handled was clean and well-maintained. Personnel in charge of AIRNET operations are knowledgeable and responsible.

While the ITAT watched the filter being removed from the filter head, the ITAT noted that when the plastic protective cap is removed, a small vacuum between the filter and the cap results. This results in a small quantity of dust from the filter coming off the filter and being discarded with the plastic cap. AIRNET personnel were questioned about this and remarked that they have taken steps to reduce the suction by poking a small hole in the cap before placing it on the filter head. The discarded dust was only a very small quantity, and in the ITAT's opinion, unlikely to affect the filter concentration significantly.

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies in the area of sample collection and handling.

Technical or Scientific Deficiencies

The samplers used to collect environmental data were produced from commercial parts by LANL staff. It is not uncommon to develop a site-specific sampler, and LANL has chosen to use what they refer to as a mid-volume sampler. The mid-volume samplers were chosen by LANL as a result of excessive dust loading on the high-volume samplers during the two-week sampling period. Mid-volume samplers have an air-flow of only 4 cubic feet per minute (cfm), far below

high-volume sampler rates common for environmental sampling in the range of 34 cfm. These samplers in their current configuration were never tested for particle collection properties and sensitivity according to the requirements of 40 CFR 61, Appendix B, Method 114, Requirement 4.3.3.

> The sample collection and analysis procedures used in measuring the emissions shall be described including a description of any continuous monitoring system used to measure emissions, including the sensitivity of the system, calibration procedures, and frequency of calibration.

No studies have been conducted to assess the sensitivity of the samplers for respirable particle collection. To adequately assess the precision and accuracy of the environmental measurements, a wind tunnel study or a comparison with commercially produced PM-10 monitors and the ambient air sampler should be completed to ensure that the respirable particle fraction is adequately collected by the samplers. At the very least, some evidence should have been collected to support the ability of the low flow rate for adequate particle collection.

The use of these samplers was, however, approved by the EPA via the mention of the sampling flow rate in the FFCA document. Within the FFCA, however, no attention is drawn to the fact that this sampling rate is below typical high volume rates used for environmental sampling. Without having run a test of this sampler or having cited other tests of similar configurations, it is not possible to know the particle collection properties of the sampler.

The ITAT researched the use of sampler flow rates at other facilities and discovered that even lower flow rates have been used at other locations. Although the ITAT does not recommend lowering the flow rate (rather, we postulate that perhaps the flow rate is too low), the ITAT does believe that flow rate examinations should be done to confirm collection of the respirable fraction at the flow rate selected for use by LANL.

The ITAT questioned LANL staff about knowledge of testing done on systems similar to the AIRNET samplers, and staff were not aware of any tests of this sort. The ITAT felt that the use of these samplers without knowledge of particle collection efficiency studies constituted a shortcoming in the environmental sampling program's credibility. It is, however, not a regulatory deficiency because LANL had, in essence, received approval to use the samplers by including their properties in the FFCA. The ITAT identified the use of the mid-volume samplers without adequate testing as a technical or scientific deficiency. The ITAT encourages LANL to research these sampling systems more fully and conduct a sampling study in the Los Alamos environment.

Changes Made by LANL

LANL has made some changes in their sample collection program starting at the beginning of 1997. LANL ceased to use filter face counting for gross alpha and beta determination. Instead, the filter is cut in half immediately after removal from the field and half the filter is sent to the analytical laboratory for digestion and gross alpha and beta counting. The other half is maintained at the AIRNET laboratory for inclusion in the quarterly composite. This procedure eliminates the problem sometimes experienced with filter face counting known as sample self absorption. To correct for this phenomenon, a correction factor, sometimes called the depth of burial correction factor, must be applied to the analytical result to account for the alpha particles that are absorbed

within the thickness of the filter. As discussed in a previous chapter of this report on counting of effluent air filters, the uncertainties associated with this calculation are large. It was in the interest of good analytical results that the AIRNET program discontinued use of filter face counting, and the ITAT commends LANL for this positive change.

It is not clear, however, whether the split sample represents the whole. This was a concern to the ITAT. It is unlikely that a single hot particle could become imbedded on one-half of the sample, throwing the analysis of the other half off, but it is a concern that should be addressed. A gross alpha analysis of the quarterly composite before isotopic analysis could eliminate the concern. Gross alpha analysis of the quarterly composite could then be compared to the sum of the gross alpha measurements of the biweekly samples. If the two are within the limits of statistical variation of one another, then it can be concluded that the half sample represents the whole sample.

In response to the ITAT's concern, the AIRNET staff looked into the possibility of conducting this additional analysis. Wastren informed them that it is not possible. To conduct an isotopic analysis, tracers must be added at the beginning of the filter digestion process. A gross alpha analysis is compromised by adding these tracers, and an isotopic analysis is not possible without the tracers. AIRNET staff have committed to try and resolve this issue.

The AIRNET group has also been looking into the possibility of an alternate method for assessing tritium in the atmosphere. It has been noted that the silica gels are not collecting all of the water vapor from the ambient air sample passed through the gel. The AIRNET group is looking into the possibility of using meteorological humidity data to estimate ambient tritium vapor concentrations. The ITAT has been asked to review this procedure and will advise the AIRNET group as it develops this new program.

The analysis of biweekly filter samples was moved offsite in 1997 to the same laboratory that had been handling the quarterly composite samples. This move was precipitated by a number of factors, primarily a concern about the integrity of the results obtained from the Health Physics Analytical Laboratory. This change is discussed further in the section titled "Auditing the Analytical Laboratory."

Data Validation and Verification

Summary of LANL Methodology

During sample collection, a number of field parameters measured by the equipment in the sampler housing must be collected and recorded. This process was streamlined, beginning in January 1996, with the addition of palmtop computers for use during sample collection. These palmtops accept the information that must be retrieved by technicians in the field and automatically incorporate data protection. Certain nominal ranges for values collected in the field, such as time elapsed and flow rate, have been established through knowledge of the system and continued use. The user of the palmtop computer inputs these values as read from the timer device or flow meter. If the input value is outside the nominal range, the computer indicates a potential error and requires the user to reenter the value. This gives the user a chance to check the value for correctness. If the value entered is correct and outside this range, it is not possible to enter it directly in the data field, it must be entered as a comment. Therefore, no data are entered

into the given field, ensuring that the value will be carefully considered by a validation and verification team. This process has significantly decreased errors in the field data.

The first step in data validation and verification is conducted by the AIRNET staff. This group works most intimately with the AIRNET program and is usually the best judge of the cause of a missing data point. The AIRNET staff might notice that a breaker was thrown, a pump failed, or power was cut off for a limited time. They are best able to assess a reasonable estimate of what the timer reading might be, for instance, when power fails for only a few minutes out of the entire sampling period.

The next step in data validation and verification is taken by the health physics team, which might use gross beta analysis information to infer something about the representativeness of the sample reading. Gross beta readings have historically remained relatively constant throughout the year and across the site. A gross beta reading similar to that registered at the sampler historically would indicate that regardless of sampler downtime, the filter measurement could still be used.

The ITAT concluded that the process of data verification and validation appeared to be reasonable and well-enforced. The palmtop computer indicates when data values need to be more closely examined, for example, following pump or timer failure or when data may be suspect. It is in the interests of ESH-17 to validate as much of the data as possible to achieve 95% completeness of sampler operation, as stated in the FFCA. The ITAT reviewed a number of memoranda drafted by the health physics team regarding data validation and verification activities and determined that data validation and verification provides a sound method for retrieving data points that might otherwise have been lost as a result of minor equipment failure. The health physics team has read-only access to the data, and they must submit a memo to the AIRNET QA officer if they intend to suggest any changes in the status of the data from "rejected" to "qualified."

Data validation and verification is carried out for 100% of the hand-entered data in the database and for 10% of the data downloaded from the palmtop computers. The 10% are randomly selected.

The ITAT obtained an entire database listing the field data results for 1996 and compared this data listing to the original data sheets for 20% of the biweekly data and 25% of the quarterly data, selected at random. The ITAT found that the data were transferred completely and accurately from the data sheets or palmtop computers to the database.

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies.

Technical or Scientific Deficiencies

The ITAT did not find any technical or scientific deficiencies. Data validation and verification appear to be complete and comprehensive.

Action Levels

Summary of LANL Methodology

After data validation and verification is completed, the data are assessed for comparison with action levels. Two different types of action levels have been set by LANL: investigation and alert.

Investigation levels for gross alpha, gross beta, and isotopes are determined using historical AIRNET data. A set of stations is established (e.g., perimeter stations and Area G stations), and data are collected for the entire set of stations for the previous year. A typical set contains 10 stations. All of the gross alpha, gross beta, and isotopic data are sorted categorically by magnitude, and the 95% level of the data is calculated. This level is set as the investigation level. When an analytical result exceeds this level, it is a flag to alert personnel that the station is showing higher than historically normal readings and to prompt an investigation into the cause.

Alert levels are determined differently for alpha and beta measurements than they are for isotopic measurements. For alpha and beta measurements, the alert level is determined again from historical AIRNET data. The alert level is set at three standard deviations above the historical mean level, or at the 99% level. In comparison, the investigation level is set at two standard deviations above the historical mean value, i.e., the 95% level.

For individual radionuclides determined by isotopic analysis, the alert levels are calculated as concentrations in air that are some fraction of the dose limit given in DOE Order 5400.5 (see document database). The annual dose limit for this DOE order is 100 mrem, an order of magnitude higher than the dose limits given in 40 CFR 61, Subpart H. The alert level is 0.5% of the DOE dose limit for onsite, perimeter, and regional stations, and 2.5% of the dose limit for waste sites at the laboratory (ESH-17-201). For the perimeter compliance stations, the alert level is set at 0.5 mrem, which is 5% of the 10 mrem EPA standard.

The ITAT reviewed a printout of the alert and investigation levels for 1996, accompanied by biweekly and quarterly results for comparison with action levels. For 1996, there were some values that exceeded investigation and alert levels for several quarterly composites. None of the exceedances were at offsite compliance stations, and all but one could be logically explained based upon activities at LANL. An example of an exceedance during 1996 include an elevated concentration at Area G, the waste disposal facility, as the result of road work in the vicinity of the sampler. No other samplers exhibited high concentrations, either in Area G or at the compliance stations. Other elevated air concentrations in 1996 were investigated and reported in the annual environmental report for 1996.

LANL examines the alert and investigation levels after each biweekly sample package and each quarterly composite package is returned. LANL carefully evaluates any values that exceed the investigation or alert levels, and the Laboratory reports these results and a description of what caused the elevated values in the annual environmental surveillance report. The action levels for the AIRNET stations are used to identify unusually high concentrations, and the ITAT determined that the identification process is sound. The ITAT concludes that the process of action level determination, comparison, and evaluation of elevated samples was acceptable in 1996.

The Air Quality Group has prepared a report describing the evaluation of data and a list of procedures to follow when an investigation or alert level is exceeded (ESH-17-201). Each action level procedure concludes with delivery of the information to the appropriate project or group leader. There is no indication within the documentation of how quickly after the collection and

receipt of analytical data they are evaluated for the various action levels. It is specified that data must already have been through the analytical chemistry quality assessment and data review and the biweekly AIRNET data evaluation.

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies in alert level determination.

Technical or Scientific Deficiencies

Prompt response to any action level exceedances is a very important issue, and is required by 40 CFR 61, Appendix B, Method 114, Requirement 4.2. This requirement states that "Administrative controls shall be prescribed to ensure prompt response in the event that emission levels increase due to unplanned operations." Action level assessment of environmental data is the only means available to assess unplanned releases from diffuse source areas. The ITAT reviewed AIRNET data for 1996 and examined the elapsed time between collection of filters and evaluation of the data for action levels. At the beginning of 1996, it took as long as 11 months to evaluate the data against action levels. The ITAT does not consider 11 months a prompt response.

As the year progressed, the time elapsed gradually decreased. By July, data turnaround was down to 6 months, and by December, three months. The ITAT determined that by the end of 1996, ESH-17 was far more responsible about prompt response than at the beginning. The reason for the increased degree of action appeared to be a shift in management and the acquisition of a new QA officer.

Given the lack of any unusual data results during 1996, the ITAT determined that the significant elapsed time between sampler collection and data review did not result in any regulatory problems. Additionally, any lack of prompt response was corrected throughout the course of 1996. For these reasons, this has been classified as a technical or scientific deficiency, and the ITAT encourages LANL to continue the trend of prompt response to AIRNET action level assessments.

Changes Made by LANL

The ITAT acquired AIRNET data collected the week of July 7, 1997. These data indicate that the filters were sent to Wastren in Grand Junction, Colorado, by overnight delivery on July 10 or 11, 1997. Presumably, the samples, which were held until July 11, needed the additional day to allow for decay of short-lived radionuclides. Tritium silica gel samples were sent to Wastren on July 17, 1997. A memo dated July 31, 1997, to project leaders presents the results of air concentration calculations made from the filter analysis and notes that the data were compared with action levels and not found to exceed them. A similar memo dated August 28, 1997, presents the results of the tritium analysis and compares them to action levels. Given the amount of data to be handled and the analysis of the data by the outside laboratory, this response seems timely. By far, the largest contributor to elapsed time between collection and reporting is the analysis time by the outside laboratory. It appears that ESH-17 has limited the time on their end as much as possible. The ITAT concludes that the response of the ESH-17 group to action level requirements

and the swiftness with which the data are retrieved and handled has improved and management would be promptly informed of any unusual environmental results.

Auditing the Analytical Laboratory

Summary of LANL Methodology

The outside laboratories that perform sample analyses for LANL are audited annually. A qualified assessor, from either the ESH-17 group or from the audits and assessments team at LANL, undergoes ISO 9000 training, and laboratories are held to standards such as DOE Order 5700.6C; EPA QUAMS 004-005; EPQ QA R5; and 40 CFR 61, Appendix B, Method 114. LANL also considers analytical chemistry experience crucial for a lead assessor, so the auditor is aware of the vulnerabilities of an analytical laboratory. Lead auditors of the analytical laboratories are trained in all of these areas.

LANL has identified the primary parameter of interest during an audit to be how the outside laboratory manages links between different levels of data and sample handling. These interfaces are common points of trouble, and miscommunication can be detrimental to an analytical laboratory's quality program. Information management, including software control, is an important aspect of quality control. Codes that govern calculations should remain the sole responsibility of information management and should not be accessible by analytical laboratory personnel. The same is true of spreadsheet values. Spreadsheets that contain analytical results are examined by LANL during these external laboratory audits to determine how well the spreadsheets are maintained as locked and unchangeable.

The use of corrective action is also very important to LANL in their assessment of an analytical laboratory. How a laboratory uses corrective action and how it is documented are key issues. Quality control training, as well as analytical requalification, are records that should be carefully tracked and easily accessible. With the exception of the stringent rules in 40 CFR 61, Appendix B, Method 114, audits of outside laboratories are performance based; that is, ESH-17 is interested in obtaining optimal performance from the laboratory.

The ITAT concluded that the procedures by which LANL assesses an analytical laboratory are sound, provided that they are employed uniformly for every laboratory.

Laboratory audit reports are compiled by the lead assessor after an audit visit and sent to the audited laboratory for response before being more widely publicized. This procedure ensures that misunderstandings did not exist and allows any errors to be corrected.

The ITAT reviewed an October 6–7, 1997, ESH-17 assessment of the offsite laboratory used for filter analysis. The scope was sample management, radiochemistry, inorganic analysis, laboratory information management, and QA. ESH-17 used interviews, document review, and observations of work in progress to assess these parameters. Before traveling to Wastren for the audit, a document package was selected at random from ESH-17 files. The package was presented to the Wastren employees, and they were able to rapidly present all supporting documentation for the record.

ESH-17's conclusions following this audit were generally positive, with minor suggestions for improvement. A major source of concern, however, was the imminent personnel change in the QA program. The current quality program was good, and ESH-17 was concerned that this level

be maintained. A change in personnel could compromise the QA level, and ESH-17 was committed to ensure that data quality continues at its current level.

LANL audited all appropriate external analytical laboratories during 1996. The ITAT determined that these audits were thorough and conducted by appropriate personnel. Problems identified during the 1996 audits were followed up by ESH-17 the following year to ensure that they had been resolved.

Interlaboratory comparison programs are used as a part of the LANL audit and assessment process. Comprehensive results from interlaboratory comparison tests are required for an outside laboratory to remain the laboratory of choice for the AIRNET program. Results of the interlaboratory tests are provided to agencies that sponsor the tests. ESH-17 obtains the test results from the sponsoring agency and inserts them into a database for analysis. Criteria are established as follows: an acceptable rating is within two standard deviations (<95%) of the agency value, a warning rating is between two (95%) and three (99%) standard deviations, and an unacceptable rating is outside three standard deviations (>99%). A laboratory that does not participate regularly in the national performance ratings would raise an alert to the QA officer. If a laboratory receives a warning or unacceptable rating, a phone call to the analytical laboratory manager may follow, and consideration would be given to switching laboratories or at least making provisions for a backup analytical laboratory to verify any suspicious results.

During 1996, the Health Physics Analytical Laboratory participated in only one interlaboratory comparison study for tritium in water. They did not participate in studies for the media they analyze for the AIRNET group. Because this was unacceptable to LANL, analysis was moved to another organization in 1997, as described below.

The offsite laboratory responsible for the analysis of tritium samples participated in a number of comparison studies, including three that looked at tritium in water samples. Of these three studies, they received an acceptable rating for only one, and a warning rating for the other two. For the warning ratings it received, the laboratory result was lower than the actual concentration in the solution provided by the testing group. This laboratory received more favorable ratings for the rest of the radionuclides for which it tested.

The offsite laboratory contracted to analyze filters participated in many of the same studies. For alpha activity in air filters, they received one acceptable rating and one warning rating. For the warning value, the number they measured was higher than the true value. For isotopes of plutonium and uranium during 1996, the laboratory received acceptable ratings for all studies in which they participated.

The AIRNET QA officer determined all of the laboratories were within the bounds of acceptability. To further evaluate the analytical laboratories, LANL recently began sending Paragon spiked samples with the tritium samples. This gives the AIRNET group another means of evaluating the adequacy of the analytical laboratories.

The ITAT emphasized that auditing of outside laboratories is a huge quality control issue. Lack of quality in procedures or practices of an analytical laboratory used by ESH-17 could completely compromise the quality of their program. The ESH-17 auditing process for analytical laboratories appears to be intact.

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies in auditing of analytical laboratories.

Technical or Scientific Deficiencies

The ITAT did not discover any technical or scientific deficiencies. The auditing process for AIRNET external laboratories is adequate.

Additional Observations

The ITAT was concerned about 1996 AIRNET data analyses conducted by the Health Physics Analytical Laboratory because of the poor quality control performance of the laboratory throughout the year. The 1996 data were carefully reviewed by the ITAT, and no values of concern were evident. If the analytical laboratory had inadvertently contaminated samples, an unexpected high value in sample results would be likely. Additionally, quarterly samples were maintained at ESH-17 and subsequently sent offsite, so any inconsistencies in results between earlier gross alpha determinations presented by the Health Physics Analytical Laboratory and the offsite laboratory results would have been detected. Based on this evaluation, the ITAT concludes that the 1996 AIRNET data provided by the Health Physics Analytical Laboratory were reliable.

No deficiency was noted here because of the response that ESH-17 had to the inadequacy of the HPAL laboratory. HPAL was not responding to the requirements laid out by the new QA officer at ESH-17, and ESH-17 promptly moved their business elsewhere.

Changes Made by LANL

At the beginning of 1997, because of increasing troubles with the Health Physics Analytical Laboratory, including the possibility of sample contamination and continued lack of participation in national performance studies, the filter gross alpha and beta analysis was moved offsite. Also in 1997, a new sample analysis program was initiated, in which the filters are split immediately after removal from the field, with one-half immediately sent offsite for digestion and analysis for gross alpha and beta. This is a more reliable technique than filter face counting. The other half of the filter is retained and becomes a part of the quarterly composite, which is also sent to the offsite laboratory for digestion and analysis for specific radionuclides. The ITAT concluded that these revisions have significantly improved the sampling and analysis program.

Sampler Siting Analysis

In drafting the FFCA and justifying the use of environmental measurements for compliance purposes, LANL evaluated the existing AIRNET system to identify any deficiencies associated with using this sampler network to monitor doses to potential MEIs. This siting analysis is discussed below, followed by an evaluation of the analysis by the ITAT. A proper siting analysis should address the sensitivity of the sampling grid to possible releases from diffuse sources because these source releases are the compliance endpoint of interest.

Summary of LANL Methodology

LANL based its sampler siting on the existing locations of AIRNET samplers. The LANL siting analysis focused on whether the existing sampler network provided adequate coverage or if new samplers would be required to monitor doses to all potential MEIs.

The siting analysis for samplers described in Supplement 2b of the FFCA was performed assuming that no information about the location of the LANL MEI was available. The ITAT determined that an environmental sampling network must be established so that all potential MEI locations are being sampled. This is the only way that an environmental sampling network could defensibly be used as a compliance substitute.

LANL evaluated most of the existing AIRNET sampler sites considering 22 points within the site boundary that would represent potential diffuse emissions; the sampler sites were not evaluated considering actual diffuse emission locations. The potential locations were selected based on their proximity to existing samplers, with the distance from each sampler to a possible source location determined by calculating maximum, average, and minimum source to receptor distances. These source to receptor distances were calculated using a process described in the following text. Each potential diffuse source location was established based upon the current AIRNET sampler locations rather than known diffuse source locations. The exception to this evaluation was sources identified close to the nearby town of White Rock, where actual sources were used as the evaluation parameter.

A 16-sector polar grid was established to evaluate the coverage of the sampling network. The source to receptor distances that the grid represents are based upon the minimum and maximum distances between existing AIRNET stations so that the grid represents each theoretical diffuse source location. The maximum source to receptor distance is calculated using a sector angle of 22.5 degrees and the maximum distance between air monitoring stations. A similar calculation provides the minimum value. Figure 4 shows the calculation is a simple trigonometric relationship.

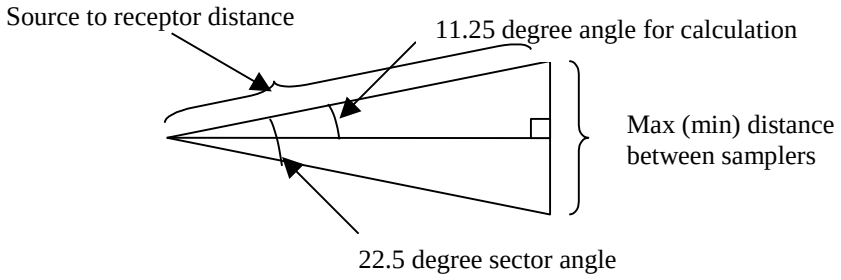

Figure 4. LANL calculational parameters for source to receptor distance used in sampler siting analysis grid.

The grid created by these calculations has two concentric circles with different radii, with the 16 sectors defining the polar segments of the grid (see Figure 5). The inner circle has a radius of 1700 m and the outer a radius of 5500 m. The intermediate circle represents the average source to receptor distance.

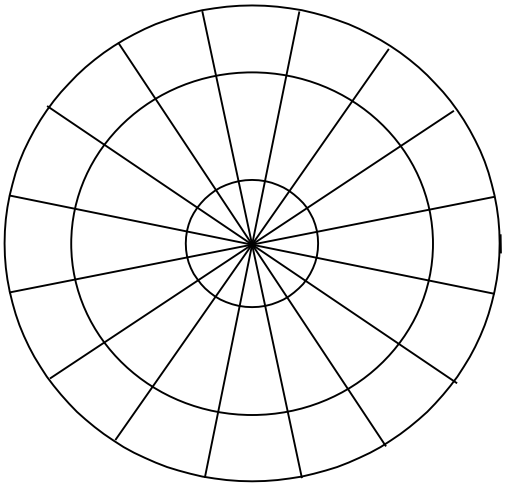

Figure 5. Grid overlay for LANL sampler siting analysis.

The grid represents the range of possible sampler locations based upon the current maximum and minimum source-to-sampler distance. At least one sampler must exist within each polar segment, if a potential receptor exists, to create a representative sampling network.

The next step in the analysis was to place the midpoint between the spokes of each grid arc in Figure 5 at the location of one of the six Los Alamos boundary sampler locations. This was repeated for the maximum, minimum, and average source to receptor distance for each sampler. If a receptor existed within any of the 22.5 degree arcs inside the grid layout, then a sampler must exist there as well. If no sampler was located in a segment where a receptor existed, then for compliance, a sampler location was suggested.

As mentioned, the process used in the White Rock area was somewhat different. In this case, known release locations were used to assess necessary sampler locations. Four sites for potential releases were analyzed; this was considered adequate by LANL because of the buffer zone of no activity 1 to 3 km wide that exists between any technical areas and the LANL boundary at White Rock.

Also governing the placement of samplers are conditions identified by LANL in ESH-17-207 as established by DOE/EH-0173T and 40 CFR 58. These conditions are as follows:

1. Favorable surface characteristics: Ideal sites have little material that has the potential to be suspended into the air stream. This prevents filter loading.
2. Trees acceptable: Samplers must be 10 m from the nearest tree dripline when the tree acts as an obstruction. If the distance is less than 10 m, the distance to the dripline must be greater than two times the height the tree extends above the sampler, or the tree must be located outside a 270 degree arc from the sampler to the source being monitored.
3. Distance to obstructions must be greater than two times the height the obstruction extends above the sampler: This is equivalent to a rise angle from the sampler to the top of the obstruction of 27 degrees.
4. Unrestricted airflow in a 270 degree arc around the sampler: Objects must fall outside the arc as measured from the sampler to the source area.
5. Good topographic location: The surface should be as flat as possible.

LANL has met these requirements for each individual sampler and confirms that the conditions are maintained with regular assessments by responsible personnel and the continued assessment of the samplers during each biweekly visit.

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies.

Technical or Scientific Deficiencies

The LANL analysis of sampling locations was dependent wholly on the locations of existing monitors. The analysis grid was established based upon current monitoring locations and distances between samplers. What the siting analysis should have been based on was actual major diffuse emission sources (that have been identified by LANL and are ringed with air samplers) and potential receptors within sector arcs. The siting analysis continually refers to the selection of representative diffuse source locations, but the locations were chosen solely based on sampler location and the minimum, maximum, and average source to receptor distance, which was also based on existing sampler locations. A network analysis that uses existing samplers as a criterion of correct sampler siting will necessarily produce a result biased toward evaluating the existing sampler locations as appropriate ones. A more independent siting study would center on emission sources, not sampler locations, and would then assess 22.5 degree arcs for potential receptors from these sources to suggest sampler locations. Sampler locations and potential MEIs would be the endpoint of the study, not the starting point. The maximum concentration within these sectors would then represent an appropriate location for a sampler. According to 40 CFR 61, Appendix B, Method 4.3.1.

> The sample collection and analysis procedures used in measuring the emissions shall be described including identification of sampling sites and number of sampling points, including the rationale for site selection.

According to 40 CFR 61, Appendix B, Method 4.3.1, LANL has complied with the regulation by describing the rationale for sampler site selection, but the ITAT concluded that the LANL rationale may not produce optimal results. It is important for LANL to show that the sampler network provides adequate coverage. The existing siting analysis does not do this.

Another concern that the ITAT identified during analysis of the LANL siting procedure was the application of the no receptor exemption to the San Ildefonso Pueblo sacred land. San Ildefonso Pueblo cuts a segment out of the LANL site property. While it is true that there is no identifiable building, school, residence, or business on the land, it is well known that Pueblo members regularly use the land. The ITAT concluded that the lack of a sampler in this location was an omission in the monitoring network. This omission is not regulatory, as the location does not fit the criteria outlined in the regulation, but it is one that should be dealt with. ESH-17 personnel stated that an effort has been made to place a sampler on this land, but issues such as lack of power sources and Pueblo privacy concerns continue to cause difficulty. The ITAT

encouraged ESH-17 to continue to work with members of the Pueblo to overcome these difficulties and place a sampler somewhere on this area.

Other locations identified as exempt with no receptor during the siting analysis were the wellness center and the ski hill onsite at LANL. The wellness center is only accessible to LANL employees, so the exception appears warranted. The ski hill exemption, however, is puzzling. Even with its limited annual operation time, it is still a place of business and would, therefore, fall under the 40 CFR 61, Subpart H, classification of a potential receptor. Additionally, the ski hill restaurant is open for lunch-time business during summer months. For this reason, the ITAT concludes that a sampler location at this site is appropriate.

It is difficult to cite any of these deficiencies as regulatory, as the sampler network has been approved by the EPA for compliance purposes. However, they are important points that should be addressed by LANL to insure network completeness.

Additional Observations

While the FFCA indicates that annual evaluations of AIRNET compliance locations will take place, the ITAT did not find the type of evaluation it expected. The ITAT assumed that the annual sampler evaluation would be similar in content to the original sampler siting analysis. If diffuse sources change from year to year, the ITAT expected to see the location of the samplers reassessed to identify the possible MEI location. Instead, LANL's annual sampler evaluation consists of visiting the sampler site to determine if conditions (such as surface characteristics, trees, potential obstructions, and topography) remain favorable for a sampler. If a tree has grown into a position that obstructs the 270 degree sampling arc, it might be trimmed, or if an obstruction has been placed in the sampling path, the sampler might be moved. Because the initial sampler siting analysis was so generic, ESH-17 assumes that the sensitivity of the sampling network is still sufficient.

In 1996, LANL identified the following four sites as the major diffuse emission sites: LANCE, Area G, the firing sites, and the TA-21 decontamination and decommissioning activities. Decontamination and decommissioning activities occur whenever a building's or a technical area's operations are being shut down. The site is cleaned up and restored to a predetermined level of usability. Assuming that different locations are subject to decontamination and decommissioning activities in different years, a diffuse source resulting from decontamination and decommissioning could change from year to year. If diffuse sources, especially major ones, may potentially change from year to year, the ITAT concluded that LANL should perform either an annual dynamic analysis of sampler locations to evaluate the samplers' ability to detect releases from diffuse sources or a sensitivity analysis of the existing network.

Quality Assurance Evaluation

As provided in 40 CFR 61, Appendix B, Method 114, compliance measurements are subject to strict and specific quality control (QC) and QA guidelines. Although 40 CFR 61, Subpart H, guidelines were developed for stack measurements, they can be easily adapted for non-point measurements, and the requirements do apply to these type of measurements. This methodology is the QA methodology identified by LANL to be used for the AIRNET program. AIRNET QA is

specified in ESH-17-AIRNET, "Quality Assurance Project Plan for the Radiological Air Sampling Network (AIRNET)."

The following sections list the QA guidelines specified in 40 CFR 61, Subpart H, describe the LANL methodology, and point to the document that addresses the details. As necessary, evaluations and suggestions for improvements or deficiencies associated with each requirement are listed. In many cases, QA issues were discussed in previous sections. These sections are noted, and the reader is directed to them for more information.

Each one of these quality assurance requirements was also explored in the field with LANL personnel to assure that quality procedures were followed every step of the way. Unless noted here or referred to as a deficiency in a noted section, the audit team found the application of quality control as it applied to the non-point source measurement and evaluation to be adequate.

QA Requirement #1

The guidelines in 40 CFR 61, Appendix B, Method 114, QA requirement 1 require sites to identify and document organizational structure, levels of authority, and lines of communication.

This directive is met by LANL in the AIRNET QA Project Plan (ESH-17-AIRNET). Pages 5 and 6 of the AIRNET QA Project Plan list the ESH-17 group organization, the AIRNET project organization, supporting organizations, and a list of personnel who must approve all products of the AIRNET program. The project plan provides an organizational list and chart that outline the authority structure within each group.

QA Requirement #2

QA requirement 2 indicates that administrative controls need to be in place to ensure prompt response if emission levels are exceeded because of unplanned operations. Prompt response was discussed and a deficiency noted in the section titled "Action Levels."

The decision-making process and administrative controls are carefully outlined in the project plan (ESH-17-AIRNET). Page 13 identifies the EPA requirement by asking the question: Are diffuse emissions from LANL causing MEI exposure greater than 10 mrem when summed with additional emissions? If the answer is yes, LANL has a series of decisions to make and actions to engage in, outlined on Page 13. The following page of that report identifies the controls in place to keep the levels from reaching critical points. The application of these procedures was also carefully reviewed.

EPA requires action levels to be set as protective measures. Two classes of action levels are identified in the project plan: alert level and investigation level (as described in the section of this chapter titled "Action Levels"). The real question in meeting this QA requirement has to do with whether controls for a prompt response are in place.

A more detailed discussion of this issue can be found in the section in this chapter in the "Action Levels" section, along with a technical or scientific deficiency associated with the requirement.

QA Requirement #3.1

Quality assurance requirement 3.1 states that sampling sites and number of sampling points shall be identified, including the rationale for site selection. Site selection is discussed in detail in this chapter in the section titled "Sampler Siting Analysis." Appendix C of ESH-17-AIRNET identifies sampling sites and provides directions for how to travel to each site.

QA Requirement #3.2

QA requirement 3.2 states that sampling probes and representativeness of samples shall be described.

This QA requirement was designed to apply to the sampling probes placed into the airstream of a stack effluent, and it is somewhat difficult to apply this requirement to environmental sampling. In the same way a small probe pulling a sample of air out of an airstream must represent the entire sample, a series of air samplers located in the environment must represent the potentially exposed population. The sample pulled from the airstream must be similar to air that a person would inhale.

The rules that governed the placement of samplers is discussed in this chapter in the section titled "Sampler Siting Analysis."

The sampling probes are described in this chapter in the section titled "Sample Collection and Handling."

Representativeness is defined as "a measure of the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition" (ESH-17-AIRNET, page 18). In terms of AIRNET, representative data would adequately represent the concentrations in inhalable air at the given receptor locations. Pages 18 and 19 of ESH-17-AIRNET describe how AIRNET meets the goals of representativeness. The following paragraphs summarize these methods.

For the data to have qualities of representativeness, they must reflect environmental conditions and process conditions. This condition is met because the samplers run continuously in the environment and samples are processed in a similar fashion following strict quality guidelines.

Data must also be adjusted for any sampler bias. Sampler bias is inherent to the sampler (such as conditions affecting representative particle size collection) and would not be reflected during analysis processes because all samples would be impacted in the same way. The samplers used at LANL are constructed of commercial parts, but the assembly of these parts as an air sampler is a product of LANL, as described earlier in this chapter in the "Sample Collection and Handling" section. The technical or scientific deficiency associated with the lack of testing of these samplers is also described in the "Sample Collection and Handling" section.

QA Requirement #3.3

Requirement 3.3 indicates that continuous monitoring systems used to measure emissions should be described, including sensitivity of the system, calibration procedures, and frequency of calibration.

The continuous monitoring systems are the air samplers. Sampler media consist of filter paper to collect particulate radionuclides, such as isotopes of uranium and plutonium, and silica gel to collect tritium samples. The filter paper LANL uses is described on page 27 of ESH-17-AIRNET as having the requirement of retaining 99% of particles with a aerodynamic mean diameter of 0.3 μm. The filter paper also needs to have a low uranium content so background concentrations are more easily measured. The commercially produced filter paper is specified in the QA plan, and the manufacturer specifications of that paper contain the detailed information on the collection efficiency of the paper for the particles of interest. Although the manufacturer specifies the efficiency of respirable particle collection, it would be meaningful and logical to do a particle size analysis on a collected filter to ensure that the filter captures particles of the appropriate size.

The ITAT held a discussion with AIRNET personnel concerning a document brought to the audit team's attention by IEER, the monitoring group. This document discussed filter collection efficiency and noted that for ^{7}Be, filter collection efficiency is quite poor. IEER's concern was addressed by the AIRNET staff. Since it is formed cosmogenically, ^{7}Be particles tend to form very small aggregates, the largest being around 0.1 μm. In fact, most ^{7}Be aggregates are much smaller than this, and the small particle sizes have the ability to pass through filter paper. AIRNET staff estimate that their filter paper collects 0.1 μm particles at about 90% efficiency, but many commercially produced filter papers would not do this well. The issue was sufficiently solved by the explanation of the AIRNET staff.

Silica gel collects tritium in the form of water vapor. LANL has chosen not to collect elemental tritium because even though release quantities may actually be higher than tritiated water, the dose conversion factor is considerably lower, and elemental tritium will contribute very little to the population dose. The silica gel grade and quantity are chosen so that there is sufficient silica gel to collect all the water vapor without resulting in saturation.

Preparation of both the filter and silica gel samples for transport and placement in the environment was discussed in this chapter in the "Sample Collection and Handling" section. Sample blanks are prepared with every set of filters and gels, and these blanks are carried along during sample change-out to ensure that environmental samples are not contaminated in transport. If samples are contaminated, the sample blanks should also indicate that contamination.

Filter holders are cleaned at each sample change-out (every two weeks). Pump maintenance is conducted both through preventative means, with equipment checks done biweekly for any obvious breaches, and through routine maintenance, conducted on the pumps every six months. Calibration of the air pumps is done every six months upon replacement of the pumps in the field and return of the older pumps for maintenance. The pumps are returned to the manufacturer for recalibration annually. Balances are used to weigh the silica gel before and after collection. This balance is calibrated annually by an onsite calibration group. All of these procedures are well documented in the AIRNET QA plan and in other individual plans (ESH-17-AIRNET, ESH-17-205, and ESH-17-206). These procedures were witnessed by the audit team and the ITAT confirmed that quality requirements are met.

QA Requirement #3.4

Requirement 3.4 discusses the need to define the sample collection system, including frequency of collection, calibration procedures, and frequency of calibration. This issue was fully treated in this chapter in the "Sample Collection and Handling" section.

QA Requirement #3.5

A description of laboratory analysis procedures for each radionuclide, including frequency of analysis, calibration procedures, and frequency of calibration is required by QA requirement 3.5. Procedures for preparation of samples for analytical work were described in the section of this chapter titled "Sample Collection and Handling." Auditing of the out-sourced laboratories was described in this chapter in the section titled "Auditing the Analytical Laboratory." The out-sourced laboratory audits were found to be adequate and fulfilled the quality requirements.

QA Requirement #3.6

QA requirement 3.6 requires sample flow rate measurement procedures be described, including calibration and frequency of calibration.

Sample flow rate is controlled in the air monitors by a vacuum pump. The measurement procedures are detailed in ESH-17-202, and they consist of taking a flow rate measurement immediately after the placement of a new filter and immediately before the removal of that filter two weeks later. These two values are averaged to determine the flow rate during the sampling period.

A program is being developed at the site that will continuously monitor airflow through the samplers. This will remove the uncertainty introduced by taking only two measurements of airflow. It will also alert personnel when something may be wrong with a sampler (e.g., pump failure or filter clogging), allowing for an increase in the run time and percent of useable data.

The automated process is already in place and being tested. Data from the stations are downloaded to the AIRNET laboratory area every 15 minutes. If a major change in a sampling parameter is seen, the AIRNET personnel can respond immediately.

The process currently in place for evaluating flow rate is not as desirable as a continuous monitoring program, but it is actually quite rare to see a huge change in the sample flow rate during a sampling period. A change of any significant magnitude would alert ESH-17 personnel to a possible deficiency in the vacuum pump and would lead to an investigation. Data would be identified as qualified or rejected and would be evaluated by the health physics team for usability. This process was confirmed to be in place and actively used by AIRNET personnel.

QA Requirement #3.7

The description of the effluent flow rate measurements, including calibration and frequency of calibration required by QA requirement 3.7, is not applicable to environmental monitoring.

QA Requirement #4

QA requirement 4 indicates that objectives of the QA program need to be documented and that they need to state the required precision, accuracy, and completeness of the emission measurement data, including a description of procedures used to assess these parameters.

Accuracy is the degree of agreement of a measurement with a true or known value. Precision is a measure of the agreement among individual measurements of the same parameters under similar conditions. Completeness is a measure of the amount of valid data obtained compared to the amount expected under normal conditions.

Completeness of data is measured by taking the number of useable biweekly concentrations at each sampler and dividing by the total number of sampling periods. Multiplying by 100 gives the percent completeness of the data. Runtime completeness for compliance samplers must be at least 95%; that is, samplers must operate at least 95% of the time. Completeness of AIRNET sampling data must be greater than 80% to provide valid data for dose calculation.

There are situations that may cause a sampler to run only for a part of the time during a sampling period, such as a power outage or pump failure. Professional judgment is used to determine if that sample represents data historically collected and whether it can be used as a biweekly sample. That sample could then be counted toward data completeness, but the downtime of the sampler would not count toward runtime completeness.

Calculation of completeness is documented in both the AIRNET QA document and in ESH-17-208, which discusses the analysis of biweekly samples. Health Physics evaluations of biweekly samples that were qualified data were carefully reviewed. Efforts to meet the completeness criteria are well documented and the ITAT concluded that they were adequate.

Precision is a measure of agreement among individual measurements of the same property. Precision of a single sample is required within 20%. Precision of a sample is generally affected most strongly by statistical properties that limit the detection of certain elements of the radionuclide concentration calculation within boundaries. Examples of these elements are flow meter calibration, sample counting error, flow meter reading, timer reading, collection efficiency of filters and silica gels, and other analytical processes. Counting error varies with the sample count rate. For high-count rates, counting error is low; for low count rates, counting error could well dominate the uncertainty for the calculation.

Accuracy is defined as the degree of agreement between a measurement and a true or known value. The very nature of AIRNET makes it impossible to truly determine the accuracy of the samples because it is not possible to know the true value for air concentration at a sampler location. Measurement is the only option for determining concentration values. Any sources of sample bias would affect the accuracy of a sample. As discussed under QA requirement 3.2, bias in the sampler configuration may exist, but this bias is currently unknown until an appropriate study is conducted. To fulfill the conditions of this requirement, sampler bias needs to be evaluated.

Regulations require that monitoring systems be able to readily detect a dose of 1.0 mrem above background. LANL has taken that dictum and used it to define their required precision level for AIRNET data as well as their uncertainty estimate for counting error. If two standard deviations above background are assumed to be 1 mrem, then one standard deviation is 0.5 mrem, which is designated as the minimum acceptable precision for decision making. Since LANL recognizes that environmental concentrations are low, they set the target precision at 0.1 mrem.

LANL has calculated hypothetical uncertainty for a ^{239}Pu measurement of 10 mrem because it is at this dose level that uncertainty of 20% is required, and ^{239}Pu has one of the lowest acceptable concentration levels in Appendix E (ESH-17:95-759). The ITAT reviewed this calculation and it was found to be sound. The estimated counting uncertainty at this dose level is 1%. When combined with other potential sources of uncertainty, such as timer error, filter collection efficiency, and other uncertainties, it appears that LANL meets the 20% uncertainty requirement when doses are as high as 10 mrem.

Additional Observations. It is quite easy to confuse this issue of precision and accuracy in the context of the true properties of environmental measurements. Most environmental sampling results are so near the background concentrations that the counting uncertainty is commonly as large or larger than the sampler result. While LANL clearly meets the requirements laid out by the regulations, the documentation that supports this is not at all clear. It would be in the best interests of LANL, as part of their effort to increase public credibility, to rewrite some of the supporting documentation that describes precision calculations. This documentation should carefully outline the difficulty in dealing with environmental levels, being forthright about defining real counting uncertainty, and then explaining their techniques for calculating uncertainty of measurements that would be in the range of the dose limits imposed by 40 CFR 61, Subpart H.

QA Requirement #5

QA requirement 5 states that a program needs to be established to track and evaluate the quality of emissions measurement data under preset criteria. This program should include a system of replicates, spiked samples, split samples, blanks, and control charts. The number and frequency of such samples should be identified.

Quality of emissions measurements is tracked at LANL through two sets of collocated samplers that provide replicate samples; two sample blanks submitted with each set of biweekly samples; splitting each of the biweekly samples for gross contamination and specific radionuclide analysis; and the occasional spiked sample sent to the analytical laboratory. Frequency of replicates, blanks, and split samples is biweekly, matching the frequency of the routine air monitoring. The implementation of these QA procedures is discussed in ESH-17-208.

New Mexico Environment Department samplers are collocated with a few of the AIRNET regional samplers (these AIRNET samplers are not used for compliance). The New Mexico Environmental Department independently analyzes their filter samples, providing another system of replicates. At least one of the regional pueblos, with more to come, also operate independent but collocated samplers. These samplers consistently register similar readings as LANL samplers, helping confirm the LANL measurements.

On a regular basis, the New Mexico Environmental Department sampler analysis shows higher uranium levels than do the LANL sampler results. Unfortunately, this is a result of type of filter paper used. The New Mexico Environmental Department previously used a glass fiber filter paper, which contains a much higher level of natural uranium. This is reflected in the results. They have since switched filter paper types, and results compare more favorably with LANL results.

Analytical laboratories conducting analyses for AIRNET are also required to participate in interlaboratory comparison programs and meet acceptable standards. The documents detailing the

participation in these programs have been reviewed and discussed in this chapter in the "Auditing the Analytical Laboratory" section.

The sample measurement quality program was carefully reviewed for 1996. The implementation of the requirements was in place and carefully monitored.

QA Requirement #6

QA requirement 6 states that a tracking system shall be established to provide positive identification of samples and data through all phases of sample collection, analysis, and reporting. Sample handling and preservation procedures should be established to maintain the integrity of samples during collection, storage, and analysis.

The chain-of-custody procedures for AIRNET samples appear to be carefully and universally enforced. As recently as 1995, however, the chain of custody of any given sample was difficult to track. Improvements appeared by the third quarter of 1995, with custody papers kept together more regularly. The program continued to become more comprehensive as time went on. Chain-of-custody documentation for any given sample is now retained on a single sheet, which also contains the field data. When the sample is shipped off for analytical procedures, ESH-17 requests a letter from the analytical laboratory stating receipt of the samples. The analytical laboratory is also required to maintain the chain of custody of the sample, as ensured by the annual audit of the remote laboratory. It is quite straightforward to go through current documentation and trace the sample from field to AIRNET laboratory to shipping to the analytical laboratory.

The integrity of the samples is maintained, as discussed in this chapter in the section titled "Sample Collection and Handling."

QA Requirement #7

Periodic internal and external audits are necessitated by QA requirement 7. Audits were discussed in a previous chapter of this report titled "Quality Assurance Evaluation." This chapter discussed global scale QA for the Air Quality Program that was not specific to any segment. A technical or scientific deficiency was noted in that section, and that section should be referenced for further information.

QA Requirement #8

QA requirement 8 requires a corrective action program to be established, including criteria for when a corrective action is needed, what actions will be taken, and who will be responsible.

The deficiency reporting and correcting procedure outlined in ESH-17-026 has been established to manage this QA requirement. ESH-17 has committed to tracking results of all audits and any other deficiencies noted during normal operations through this procedure. Deficiencies for the more general purposes of ESH-17 are performance-based, not compliance-based, in an effort to minimize deficiencies and identify recurring problems.

Deficiency reporting is a process for which each ESH-17 employee is responsible. If a deficiency of any sort is noted, in a procedure, a piece of equipment being inoperable, or a calculation, it is the responsibility of employees to note it and file a report. Employees do not risk

punishment for these deficiencies, making the reporting of them more likely to occur and minimizing ongoing problems. This process allows ESH-17 to spot trends and recurring problems in an effort to have the highest quality program possible.

The reporting procedure involves a single deficiency report with many different parts and documents the steps of implementing a deficiency report and completing a corrective action.

A number of deficiency reports relating to AIRNET were requested and reviewed. At least one of the requested reports, ESH-17-DR-91, indicates that deficiency reporting is a process that ESH-17 personnel participate in freely. An employee reported the loss of a tritium sample that she was responsible for handling. The door to the handling room was left open, and a person entered the room, distracting the employee and causing her to lose track of where she was in the sample processing. As a result, the sample was lost. Instead of fearing punishment for the mishap, the employee documented the deficiency, and steps were taken to prevent a similar incident from occurring again. The ITAT concluded that the process by which deficiencies are reported and logged is sufficient.

QA Requirement #9

QA requirement 9 requires facilities to prepare periodic reports for responsible management on the performance of emissions measurements programs. These reports should assess the quality of the data, provide results of audits, and describe corrective actions.

AIRNET reports are issued annually or as-needed. These reports include a list of items identified on page 54 of the AIRNET QA project plan, including air concentrations, evaluations of validity and completeness, summary of deficiencies and audit results, and many more issues. The reports appear as different documents throughout the year. Quarterly reports of air concentration, sample volume, radionuclide count data, and analytical chemistry data are sent to CCNS and the Los Alamos reading room. Annual Radionuclide-NESHAP reports are issued and sent to the appropriate recipients. The AIRNET program is also addressed in part in the annual environmental surveillance report.

QA Requirement #10

According to QA requirement 10, The QA program must be documented in a QA project plan that addresses each of the above requirements.

This requirement is met through the publication of ESH-17-AIRNET, "The Quality Assurance Project Plan for the Radiological Air Sampling Network (AIRNET)." A number of supporting documents also exist, which were cited here as they apply to QA.

Summary of AIRNET Program Evaluation

In general, it is the ITAT's opinion that the AIRNET system of sampling at LANL is comprehensive and well managed. The ITAT did not identify any regulatory deficiencies in the AIRNET program, but it did discover several technical deficiencies that require the attention of LANL staff. These deficiencies have the combined effect of undermining the defensibility of the program and should be carefully considered by LANL as a mechanism for increasing public credibility.

Weldon Spring is the only DOE facility to have been approved for environmental monitoring used for compliance prior to LANL's approval. Weldon Spring is a facility that has very little radionuclide contamination and never sees environmental samples above local background. The ITAT obtained more information from Weldon Spring as a means of comparison to the LANL program.

The Weldon Spring site has a plan for monitoring radionuclides other than radon (DOE/OR/21548-127). This plan was reviewed for comparison to some of the questionable areas of the LANL plan. The ITAT concentrated on the following key areas of the plan: sampler air flow and sampler siting analysis.

Weldon Spring Sampling Program

Weldon Spring has chosen to use both high-volume and low-volume sampling for purposes of compliance. The high-volume (~34 cfm) sample filters are collected weekly and composited quarterly for analysis of isotopes of thorium, total uranium, and two isotopes of radium because these are the only radionuclides released from the facility. Low-volume (~1.5 cfm) sample filters are collected weekly and composited annually for analysis of total long-lived gross alpha.

The logic that Weldon Spring cites for using high-volume samples for isotopic analysis includes the increase in the number of data values, improved detection limit, more timely estimates of airborne radionuclides, and decrease in the impact of an inadvertent contamination of a single filter sample. These are all valid points and they have something to offer the LANL compliance program. With filter concentrations so close to the detection limit, using a higher flow rate to increase the air volume sampled will decrease the counting error in the environmental samples. The ITAT recognizes LANL's problem with filter loading, and encourages LANL to explore the best possible solution in light of the unusual conditions.

Weldon Spring Sampler Siting Analysis

The Weldon Spring siting analysis for environmental samplers is less comprehensive than the LANL siting analysis. The Weldon Spring site was mapped, and nearby critical receptors were identified. Perimeter samplers were installed, and additional samplers were located at the critical receptors. The result covers all potential MEI receptors at Weldon Spring.

This sampler siting analysis demonstrates that there is no preferred method for conducting an analysis of this type.

As far as the ITAT knows, no other DOE site has been approved for compliance measurements and calculations of this sort. We repeat our recommendation that LANL revisit its approach to sampler location, starting from first principles and focusing on actual emissions and receptors, to make sampler siting logic more understandable to the outside observer.

DOSE ASSESSMENT EVALUATION

40 CFR 61, Subpart H, contains relatively few requirements for performing the dose assessments that are required for demonstrating compliance. For example, EPA-approved computer codes must be used. 40 CFR 61.93 specifically allows the use of CAP-88,[b] AIRDOS-PC, and COMPLY. The EPA has also granted approval for the computer codes CAP88-PC and MICROAIRDOS. In addition, other computer codes or procedures could be used with prior approval by the EPA.

40 CFR 61, Subpart H, requires that doses are to be estimated at offsite points where there is a residence, school, business, or office. The highest dose to a member of the public at these locations is used to demonstrate compliance with the 10 mrem yr^{-1} standard contained in § 61.92. It should be noted that 40 CFR 61, Subpart H, is not an unrestricted area standard (see *Comments and Responses to Comments, NESHAPS for Radionuclides*, EPA 520/1-89-031,1990). This means that doses are to be estimated at fixed locations where members of the public are actually located and doses do not have to be estimated at locations such as roads to which members of the public merely have access for short periods of time. The ITAT confirmed this interpretation of 40 CFR 61, Subpart H, with EPA staff in writing, and the communication is outlined in Appendix F. Additionally, short-term, episodic releases were discussed with EPA staff, who reiterated the requirement that these releases must be included in the inventory of releases for the year and modeled using an EPA-approved computer code such as CAP-88 (see also *Comments and Responses to Comments, NESHAPS for Radionuclides*, EPA 520/1-89-031,1990). EPA staff also indicated that short-term, episodic releases do not have to be modeled using the specific meteorological conditions that existed at the time of the release. Again, see Appendix F for the question and comment related to this issue, as well as the ITAT response to the EPA.

40 CFR 61.94 also contains reporting requirements. For example, the distances to the nearest residence, school, business, or office and the distances to the nearest farms producing vegetables, milk, and meat are to be included in the annual report submitted to the EPA. All user-supplied input data and the source of these data also are to be included in the annual report.

In addition to the requirements contained in 40 CFR 61, Subpart H, LANL is also subject to the requirements contained in other federal regulations (e.g., 10 CFR 830) and DOE orders. The application of 10 CFR 830 under the auspices of 40 CFR 61 was questioned, so the ITAT forwarded the question to the EPA. Appendix F contains the details of the question and response to this issue. The specific DOE orders that are applicable to LANL are listed in Appendix G of the University of California LANL contract with DOE. The order with the most impact on performing dose assessments is DOE Order 5400.5, *Radiation Protection of the Public and Environment*. According to Appendix G, LANL is subject to Chapter II, *Requirements for Radiation Protection of the Public and the Environment*.

LANL also has internal procedures that apply to dose assessments. Of particular interest is "Dose Assessment Using CAP88," ESH-17-501, R1.

The approach used to conduct the dose assessment portion of the audit started with a thorough evaluation of the dose assessments performed by LANL for the 1996 Annual Report. The ITAT examined electronic copies of the CAP-88 input and output files using a checklist to

[b] Throughout this section, the term CAP-88 is used to refer to the mainframe version of the computer code CAP-88 used by LANL.

ensure that all items were covered for each set of files. Items included in the checklists were the radionuclide source term; stack parameters (e.g., the stack height, diameter, and flow); receptor location; and meteorological data. The ITAT checked radionuclide source terms against the original data sources and the data listed in the 1996 Annual Report. The ITAT also checked the dose listed in the CAP-88 output file against the dose listed in the 1996 Annual Report to verify correctness.

The ITAT discussed discrepancies identified in the CAP-88 files with LANL staff and subcontractors. These discussions took the form of personal interviews, telephone conversations, and electronic mail. Often, a discrepancy resulted in modifications of the CAP-88 input files and reruns of CAP-88 by LANL staff to resolve the discrepancy. Interviews unrelated to specific discrepancies also were conducted with LANL staff and subcontractors, largely to understand the structure of the 40 CFR 61, Subpart H, program at LANL. The ITAT conducted facility visits to gain a better understanding of the facilities and environment (e.g., receptor locations) at LANL.

Based on the results presented in the 1996 Annual Report, releases from LANSCE accounted for the vast majority of the dose from LANL emissions. Because of the importance of LANSCE, the ITAT performed independent computer code analyses using CAP88-PC to verify the doses that were calculated by the LANL staff.

Summary of LANL Methodology

The process used by LANL staff for performing CAP-88 dose assessments is described in LANL procedure ESH-17-501, R1, "Dose Assessment Using CAP88." This procedure covers the development of CAP-88 meteorological data, population data, and source term data; the use of CAP-88; record keeping; and dose assessments for radionuclides not included in the CAP-88 data libraries. Dose assessments for most emission points at LANL are conducted annually. However, for LANSCE, dose assessments are conducted monthly and reported to the EPA. The process used for LANSCE dose assessments is described in "1996 RADNESHAP Dose Summary for the Los Alamos Meson Physics Facility," ESH-17:97-493, October 30, 1997.

Location of Receptors

Regulatory Deficiencies

40 CFR 61.94(a) states that:

> Compliance with this standard shall be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business or office.

The ITAT reviewed the CAP-88 input and output files for 1996 and conducted interviews with LANL staff responsible for CAP-88 dose assessments. The ITAT observed that only one receptor location was evaluated in LANSCE dose assessments and other possible receptor locations were not evaluated. By not evaluating other possible receptor locations, the highest dose may not have been calculated. There is no way for LANL to verify that they have calculated the

highest effective dose equivalent without evaluating the dose annually at other sector locations that could represent the MEI.

Technical or Scientific Deficiencies

The ITAT did not note any technical or scientific deficiencies.

Changes Made by LANL

LANL is planning to perform an annual survey of potential receptor locations. In addition, LANL is planning to modify CAP-88 population data files to allow for additional receptor locations.

Evaluation of CAP-88 Dose Assessments

Regulatory Deficiencies

As with all organizations involved in compliance activities, LANL has an obligation to provide information that is accurate and complete. The ITAT reviewed CAP-88 input and output files for 1996 and also conducted interviews with LANL staff responsible for CAP-88 dose assessments. During the course of these reviews and interviews, a number of errors were identified. These errors are regulatory deficiencies, as LANL did not meet the requirement to provide accurate and complete information.

Additionally, the ITAT determined that there was no systematic process for technical peer review to verify the accuracy of the dose calculations. Although the errors identified did not result in a significant dose discrepancy, the fact that such a long list of errors occurred indicates inadequate peer review. The lack of peer review issue was referred to the EPA for comment. The EPA comment and the ITAT response appear in Appendix F. Nonetheless, the errors identified made up a regulatory deficiency since they represent errors in the 1996 Annual Report. The identified errors are listed below.

1. For stack number 48000160, the dose in the 1996 Annual Report was listed as 5.78×10^{-11} mrem yr^{-1}. However, the dose calculated using the atmospheric concentration from the CAP-88 output file (3.4×10^{-9} pCi/m^3) and the concentration listed in 40 CFR 61, Appendix E, Table 2 (1.7×10^{-13} Ci/m^3) for ^{75}Se was 2.0×10^{-7} mrem yr^{-1}.

2. In ESH-17-501, R1, "Dose Assessment Using CAP88," the procedure states that releases from TA-21 should be modeled using meteorological data from TA-6 (see table on page 7 of 16). However, for stacks 21015505 and 21020901, the meteorological data from TA-53 were used.

3. In ESH-17-501, R1, "Dose Assessment Using CAP88," the procedure states that releases from TA-41 should be modeled using meteorological data from TA-6 (see table on page 7 of 16). However, for stacks 41000104 and 41000417, the meteorological data from TA-53 were used.

4. For stack number 03002915, ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997, lists the ^{238}Pu and ^{239}Pu source terms as 6.26×10^{-8} Ci and 1.89×10^{-7} Ci, respectively. However, the CAP-88 output file lists two source terms for ^{239}Pu, 6.30×10^{-8} Ci and 1.90×10^{-7} Ci, and does not contain a ^{238}Pu source term.

5. For stack number 03002919, ^{241}Am (9.37×10^{-7} Ci) is listed in the source term (see ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997). However, ^{241}Am is not present in the source term used in CAP-88.

6. For stack number 03002944, ^{75}Se (1.7×10^{-5} Ci) is listed in the source term (see ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997). However, ^{75}Se is absent from the CAP-88 source term.

7. For stack number 03002945, ^{75}Se (9.6×10^{-6} Ci) is listed in the source term (see ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997). However, ^{75}Se is absent from the CAP-88 source term.

8. For stack number 03002945, the CAP-88 source term for ^{137}Cs/^{137m}Ba is 5.46×10^{-9} Ci. However, in ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997, the ^{137}Cs/^{137m}Ba source term is listed as 2.46×10^{-7} Ci.

9. For stack number 03014106 and 50006903, the CAP-88 source term includes ^{234}U. However, ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997, does not list ^{234}U in the source term for stacks 03014106 and 50006903. In addition, ESH-17-501, R1, "Dose Assessment Using CAP88," states that ^{234}U is to be included in the source term only if it is measured (see attachment 1, page 2 of 3).

10. For stack number 48000107, the CAP-88 source term for ^{68}Ge is 5.0×10^{-6} Ci, while in ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997, the ^{68}Ge source term is listed as 5.04×10^{-5} Ci.

11. For stack number 48000107, the dose listed in the 1996 Annual Report was listed as 2.46×10^{-5} mrem yr^{-1}. However, based on the CAP-88 output files and 40 CFR 61, Appendix E, Table 2, the dose was calculated to be 2.24×10^{-5} mrem yr^{-1} (using a release of 5.0×10^{-5} Ci for ^{68}Ge).

12. The meteorological data used for stack number 53000702 June 1996 gaseous mixed activation product releases is identical to the meteorological data used for stack 53000702 August 1996 gaseous mixed activation product and particulate and vapor activation product releases, and stack 53000303 August 1996 gaseous mixed activation product and particulate and vapor activation product releases.

13. There is no ^{3}H in the stack 53000702 CAP-88 source term for January through June and December 1996. However, ^{3}H is reported for these time periods in the monthly reports on tritium discharges from stack 53000702 (see letters ESH-1-96:TA-53:81, ESH-1-96:TA-53:98, ESH-1-96:TA-53:123, AOT-FM:96-047, AOT-FM:96-054, AOT-FM:96-095, and AOT-FM:97-014).

14. There is no ^{3}H in the stack 53000303 CAP-88 source term for January through June and December 1996. However, ^{3}H is reported for these time periods in the monthly reports on tritium discharges from stack 53000303 (see letters ESH-1-96:TA-53:82, ESH-1-96:TA-53:99, ESH-1-96:TA-53:122, AOT-FM:96-048, AOT-FM:96-053, AOT-FM:96-096, and AOT-FM:97-015).

15. For stack number 41000417, the dose was calculated using a stack diameter of 1.0 m, not a stack diameter of 1.5 m, the stack diameter listed in Table 4 of the 1996 Annual Report.

16. For stack number 03002945, the source term listed in the 1996 Annual Report and ESH-17:97-399, *Documentation of the Development of the 1996 Stack Source Term*, August 26, 1997 included ^{125}Sb. However, ^{125}Sb was not listed in the CAP-88 output file for 03002945.

17. For stack number 55000416, the CAP-88 output file included duplicate entries for ^{234}Th.

18. For stacks 53000702 and 53000303, a deposition velocity of 1.81×10^{-13} m s^{-1} was used for ^{14}O. In addition, in ESH-17-501, R1, "Dose Assessment Using CAP88," the sample PREPNPT input file lists a deposition velocity of 1.81×10^{-13} m s^{-1} for ^{14}O and ^{16}N (see attachment 4, page 1 of 1). A more reasonable value for the deposition velocity is 1.80×10^{-3} m s^{-1}, which is used as the default value of deposition velocity for ^{13}N and ^{15}O in CAP-88.

19. For stack number 53000303, the dose for the December 1996 other particulate and vapor activation product emissions was calculated using a stack height of 13.0 m, not a stack height of 30.5 m, the stack height listed in Table 4 of the 1996 Annual Report.

20. For stack number 53000303, the October 1996 other particulate and vapor activation product source term includes ^{77}Br. However, ^{87}Br was used in the CAP-88 source term.

Technical or Scientific Deficiencies

The ITAT did not note any technical or scientific deficiencies.

Changes Made by LANL

LANL procedure ESH-17-501, R1, "Dose Assessment Using CAP88," is being modified to state that meteorological data from TA-53 should be used for releases from TA-21 and TA-41. Previously, the procedure stated that data from TA-6 should be used. In addition, the deposition velocity of 1.81×10^{-13} m s^{-1} will no longer be used for ^{14}O and ^{16}N.

As part of the process used to conduct the independent audit, The ITAT discussed discrepancies identified in the CAP-88 dose assessments with LANL staff and subcontractors. Often, a discrepancy resulted in modifications of the CAP-88 input files and reruns of CAP-88 to resolve the discrepancy and determine the effect of a discrepancy on the dose. Table 5 presents the effects on the dose of the discrepancies that have been resolved and rerun to date. All errors (except numbers 13 and 14) identified in CAP-88 output have been recalculated by LANL staff at this point in the audit. It should be noted that recalculations with CAP-88 do not map one-to-one with the discrepancies noted above because more than one discrepancy was often corrected with a single CAP-88 recalculation. In cases such as these, when more than one discrepancy applies to a single stack, those discrepancies are combined in the table for that stack. One exception is noted. Overall, the effect of recalculation has been to reduce the dose slightly.

Table 5. Effect of Discrepancies on LANL Doses

Emission point	Initial dose (mrem yr^{-1})	Dose after discrepancy resolved (mrem yr^{-1})
48000160	5.78×10^{-11}	2.0×10^{-7}
03002915	9.29×10^{-6}	9.18×10^{-6}
03002919	3.34×10^{-4}	3.62×10^{-4}
03002944	7.69×10^{-6}	1.53×10^{-5}
03002945	1.15×10^{-5}	1.65×10^{-5}
03014106	1.23×10^{-6}	5.80×10^{-7}
48000107	2.46×10^{-5}	2.24×10^{-5}
41000417	1.03×10^{-3}	1.02×10^{-3}
55000416	3.64×10^{-4}	3.64×10^{-4}
53000303[a]	7.01×10^{-4}	3.14×10^{-4}
53000303[b]	1.84×10^{-3}	1.84×10^{-3}
Total	4.32×10^{-3}	3.96×10^{-3}

[a]This discrepancy maps to deficiency number 19

[b]This discrepancy maps to deficiency number 20. The two are separated because the calculations apply to different months (December and October).

Evaluation of 1996 Annual Report

Regulatory Deficiencies

40 CFR 61.94(b)(6) requires that the annual report include the "distances from the points of release to the nearest residence, school, business or office, and the nearest farms producing vegetables, milk, and meat." In addition, § 61.94(b)(7) requires that the annual report include "the values used for all other user-supplied parameters for the computer models (e.g., meteorological data) and the source of these data."

In several instances, these data were either omitted or references were not provided. In several other cases, the data listed in the 1996 Annual Report (the Radionuclide-NESHAP report is attached to this report as Appendix E) did not match other sources of data, such as LANSCE monthly reports or the data used in CAP-88 computer runs. Deficiencies of this type are listed below.

1. The 1996 Annual Report contains user-supplied values for the average rainfall rate, lid height, air temperature, vertical temperature gradient, and the height of wind speed measurement. The sources of these user-supplied input parameters were not presented in the 1996 Annual Report. However, LANL staff responsible for the preparation of the annual report were able to provide references for these data during interviews.

2. For stack 50000101, the stack parameters (height, diameter, and flow) and the distance and direction to the receptor location (i.e., residence, school, business, or office) were not listed in the 1996 Annual Report.

3. Although the 1996 Annual Report states that the nearest farms producing meat and vegetables adjoin the Laboratory's eastern boundary, the distance to these farms was not provided.

4. For stack 53000303, the ^{13}N release is listed in the 1996 Annual Report as 1.8×10^{-3} Ci, while the sum of LANSCE monthly ^{13}N releases is 1.8×10^{3} Ci.

5. For stacks 03002923, 03002929, 03002932, 03002944, 03003501, 03010222, 03010225, 03014106, 03014109, 03014110, 50003701, 50006901, 50006903, and 55000416, ^{234}Pa is listed as being released, but ^{234m}Pa is used in the CAP-88 calculations. (refer to Table 3 of the 1996 Annual Report).

6. For stack 53000702, the ^{10}C release in the 1996 Annual Report was 3.9×10^{1} Ci, while the sum of LANSCE monthly ^{10}C releases is 3.9×10^{-1} Ci.

7. For stack 53000303, the ^{182}Ta release in the 1996 Annual Report was 1.6×10^{-2} Ci, while the sum of LANSCE monthly ^{182}Ta releases is 1.6×10^{-3} Ci.

Technical or Scientific Deficiencies

The ITAT did not note any technical or scientific deficiencies.

Changes Made by LANL

For the 1997 Annual Report, LANL intends to provide more documentation on all user-supplied data.

Prior Approval of Database Modifications

Regulatory Deficiencies

40 CFR 61.93(a) requires that:

> To determine compliance with the standard, radionuclide emissions shall be determined and effective dose equivalent values to members of the public calculated using EPA approved sampling procedures, computer models CAP-88 or AIRDOS-PC, or other procedures for which EPA has granted prior approval.

The ITAT reviewed the CAP-88 input and output files for 1996 and observed that the radionuclides ^{10}C, ^{16}N, and ^{14}O had been added to the CAP-88 database. This was confirmed in interviews with LANL staff responsible for CAP-88 dose assessments. Although the EPA appears to be aware of these modifications, EPA did not grant prior approval for these modifications of the CAP-88 database. The modifications did act to enhance the dose calculations, but should have been previously approved by EPA before their inclusion. This issue was forwarded to the EPA for confirmation. The text of the EPA comment appears in Appendix F.

Technical or Scientific Deficiencies

The ITAT did not note any technical or scientific deficiencies.

Changes Made by LANL

The ITAT has been told that LANL is pursuing EPA approval of the modifications made to the CAP-88 database to include additional radionuclides (e.g., ^{10}C, ^{16}N, and ^{14}O).

Technical Review and Approval of Dose Assessments

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies.

Technical or Scientific Deficiencies

10 CFR 830 is a federal regulation that is applicable to LANL. DOE Order 5700.6C is applicable according to Appendix G of the LANL contract. Both 10 CFR 830 and DOE Order 5700.6C state that LANL must conduct its work according to the criteria listed in 10 CFR 830 and DOE Order 5700.6C. These criteria include requirements for records. Records are required to be reviewed and approved by individuals other than those who performed the work. CAP-88 dose assessments are considered records that are integral to demonstrating compliance with 40 CFR 61, Subpart H.

The ITAT reviewed the CAP-88 input and output files for 1996. In addition, the ITAT conducted interviews with LANL staff responsible for CAP-88 dose assessments and other NESHAP activities and reviewed LANL procedures for performing CAP-88 dose assessments (see ESH-17-501, R1). The audit team observed that there was no documented review of dose assessments by an independent person. In addition, there was no documented approval of dose assessments. Finally, there were no procedures that required review or approval of dose assessments.

This was not noted as a regulatory deficiency because 10 CFR 830 is not specifically referenced in 40 CFR 61 and, therefore, does not apply to compliance with this particular regulation. However, the lack of formal review of these calculations presents an opportunity for error that could impact dose calculations significantly. In fact, the existence of so many errors in the 1996 dose calculations serves to further enforce this point: that lack of peer review leaves far to great a possibility for error.

Application of 10 CFR 860 regulations under the umbrella of 40 CFR 61 compliance was addressed in a question to the EPA. The response is shown in Appendix F to this report.

Changes Made by LANL

LANL is instituting a more formalized peer review process for the dose assessments, which will involve aspects such as review signatures for CAP-88 runs.

Positive Confirmation of Files Used by CAP-88

Regulatory Deficiencies

The ITAT did not note any regulatory deficiencies.

Technical or Scientific Deficiencies

The ITAT reviewed the CAP-88 input and output files, conducted interviews with LANL staff responsible for CAP-88 dose assessments, and reviewed dose assessment procedures (see ESH-17-501, R1). The ITAT observed that the input file assignments used in CAP-88 were not automatically listed in the CAP-88 output file. Input file assignments were instead managed using manual entry of filenames and a naming convention. Because input file assignments were not automatically listed in the CAP-88 output file, there is no positive confirmation of which input files were used to generate which specific output files.

In addition, CAP-88 input files were not appended to the CAP-88 output file. This would also provide positive confirmation of which input files were used in a specific CAP-88 run. Finally, a log of the commands executed during a CAP-88 run is not appended to the CAP-88 output file, which would verify successful execution of CAP-88.

Although this is not a regulatory deficiency, it has the potential to impact the dose calculations significantly, particularly in combination with the lack of peer review. On the whole, this indicates a lack of application of quality control.

Changes Made by LANL

LANL has started to append the CAP-88 input files to the CAP-88 output file, which will improve the traceability of the input files. In addition LANL is planning to run the CAP-88 sample problem on a periodic basis as an in-use test to verify CAP-88. LANL plans to append a portion of the output from the sample problem to the regular CAP-88 output file as documentation of the in-use test. LANL is also implementing a system for the electronic transfer of source term data directly into CAP-88 input files.

Verification of CAP-88 Installation

There does not appear to be a software QA requirement at LANL. For example, DOE Order 1330.1D, *Computer Software Management*, is not an applicable order at LANL according to Appendix G of the LANL contract. However, running the sample problem distributed with a code and comparing the results to the sample problem output distributed with the code is a standard method of verifying the installation of any computer code.

The ITAT requested that LANL run the CAP-88 sample problem to verify the installation of CAP-88 on the LANL CRAY computer. The ITAT compared the results obtained from LANL to the sample problem output and found that the doses calculated were identical within the limits of numerical precision. Differences in dates and times were noted, as well as slight changes in file formats. The differences were not of consequence, leading the ITAT to conclude that CAP-88 was successfully installed on the LANL CRAY.

Verification of Dose Conversion Factors

During interviews with LANL staff responsible for CAP-88 dose assessments, the ITAT was told that the dose conversion factors for ^{10}C, ^{14}O, and ^{16}N were estimated using the DOSFACTOR computer code. To verify that these dose conversion factors were properly calculated and incorporated into CAP-88, the ITAT reviewed the DOSFACTOR output and output from the CAP-88 dosimetric database. The ITAT observed that the DOSFACTOR input data was correct, verified that the calculation of the dose conversion factor for effective dose equivalent was correct, and observed that the values in the CAP-88 dosimetric data base agreed with the DOSFACTOR output, within the limits of numerical precision.

Independent Verification of LANSCE Doses

Releases from LANSCE account for the vast majority of the dose from LANL emissions. Because of the importance of LANSCE, The ITAT performed independent computer code

analyses using CAP88-PC to verify the doses calculated by the LANL staff. Table 6 contains a summary of the results of the verification. The overall percent difference between the LANL-calculated doses and the ITAT-calculated doses was 1.6%. This indicates excellent agreement between the LANL doses calculated using CAP-88 and the ITAT doses calculated using CAP88-PC.

Table 6. Comparison of CAP-88 and CAP88-PC Doses for LANSCE[a]

Emission point	Month/ year	Category[b]	CAP-88 dose (mrem yr^{-1})	CAP88-PC dose (mrem yr^{-1})	Percent difference
53000702	06/96	GMAP	1.03×10^{-3}	1.03×10^{-3}	0.0
53000702	07/96	GMAP	2.44×10^{-2}	2.44×10^{-2}	0.0
53000702	08/96	GMAP	4.06×10^{-2}	4.06×10^{-2}	0.0
53000702	09/96	GMAP	4.95×10^{-2}	4.95×10^{-2}	0.0
53000702	10/96	GMAP	3.20×10^{-2}	3.20×10^{-2}	0.0
53000702	11/96	GMAP	2.65×10^{-2}	2.66×10^{-2}	0.377
53000702	12/96	GMAP	3.69×10^{-2}	3.68×10^{-2}	-0.271
53000702	07/96	PVAP	1.87×10^{-5}	1.93×10^{-5}	3.209
53000702	08/96	PVAP	3.82×10^{-5}	3.93×10^{-5}	2.880
53000702	09/96	PVAP	4.97×10^{-5}	5.16×10^{-5}	3.823
53000702	10/96	PVAP	2.59×10^{-5}	2.64×10^{-5}	1.931
53000702	11/96	PVAP	2.72×10^{-5}	2.76×10^{-5}	1.471
53000702	12/96	PVAP	6.20×10^{-6}	6.20×10^{-6}	0.0
53000303	08/96	GMAP	7.12×10^{-6}	7.13×10^{-6}	0.140
53000303	09/96	GMAP	3.37×10^{-1}	3.35×10^{-1}	-0.593
53000303	10/96	GMAP	8.35×10^{-1}	8.21×10^{-1}	-1.677
53000303	11/96	GMAP	2.38×10^{-1}	2.36×10^{-1}	-0.840
53000303	07/96	PVAP	7.86×10^{-6}	8.26×10^{-6}	5.089
53000303	08/96	PVAP	3.99×10^{-6}	4.20×10^{-6}	5.263
53000303	09/96	PVAP	1.85×10^{-4}	1.90×10^{-4}	2.703
53000303	10/96	PVAP	2.57×10^{-4}	2.69×10^{-4}	4.669
53000303	11/96	PVAP	5.35×10^{-5}	5.48×10^{-5}	2.430
TA-53 diffuse	Annual	GMAP	1.56×10^{-1}	1.56×10^{-1}	0.0
Average					1.6

[a] CAP-88 doses were calculated by LANL. CAP88-PC doses were independently calculated by the ITAT.

[b] GMAP = gaseous mixed activation products.
PVAP = particulate and vapor activation products.

Collecting and Processing Meteorological Data for CAP-88

The ITAT conducted interviews with LANL staff responsible for collecting and processing meteorological data into the format used by CAP-88. The ITAT was told that there were no software QA requirements for the computer code that processes the data from the data loggers. However, there is only one user of the computer code and the computer code is relatively short (614 lines). By comparison, CAP-88 contains about 300,000 lines. In addition, the ITAT was told that output from the computer code was checked against reference data (e.g., wind roses) and the results from other computer codes (e.g., the distribution of stabilities). These checks were performed informally. Based on these inquiries, the ITAT concludes that the collecting and processing of meteorological data into CAP-88 format is done in an acceptable manner.

Applicability of CAP-88 in Complex Terrain

The issue of the applicability of CAP-88 over the complex terrain in the Los Alamos area was raised by the IEER and CCNS during the course of the audit. It is generally true that simpler models, such as the Gaussian plume model employed by CAP-88, result in larger modeled results than more complex models. Indeed, comparisons done by LANL in reports released in 1986 and 1987 showed that hand-calculations of exposure using a straight-line Gaussian plume model at the MEI slightly overpredicted the results (less than a factor of 2) of the CAP-88 model. This indicates that the model probably overpredicts the actual dose to a receptor.

A study done by *RAC* at Rocky Flats showed that a striaght-line Gaussian plume model tended to overpredict concentrations measured in the environment during a tracer study, particularly when the maximum concentrations in the model domain were considered.

Nonetheless, the ITAT forwarded to the EPA a question regarding the application of CAP-88 over complex terrain. The EPA is well aware of the limitations of the Gaussian plume model, and stated that they are working to develop assessment models that provide alternate dispersion models. Until such a time, however, the EPA continues to recommend the CAP-88 and related models. The discussion of this issue appears in Appendix F.

Calculation of Dose to a Transient Receptor

In response to questions raised by the Institute for Energy and Environmental Research, radiation doses to nearby transient receptors from short-term releases were evaluated. It should be stressed that this type of analysis is not required by current regulations.

A 117 μCi puff release from stack 03002924 was modeled, as suggested in a memo from IEER (this memo appears in Appendix H to this report. The 117 μCi release was normalized to the 1996 stack 03002924 activity distribution and was 84% U-234, 8.4% Pu-238, 5.5% Pu-239, 1.8% Am-241, and 0.55% U-235. Distances from stack 03002924 (located at the CMR Building) to a nearby road ranged from 160 m in the NNE direction to 411 m in the SE direction. Atmospheric dispersion analyses were conducted using the puff release model in the GXQ computer code and included momentum plume rise. Atmospheric data collected from 1991 to 1997 at the TA-06 meteorological station were used. Radiation doses were determined for the inhalation pathway using the dose coefficients from Federal Guidance Report No. 11.

In order to provide a reasonable upper bound on the radiation doses, atmospheric conditions that would not be exceeded 95 percent of the time for a given direction were used. When the probability of the wind blowing towards a given direction is included, the probability that the atmospheric conditions would not be exceeded is even higher. It should be noted that the probability of a transient receptor being present during the short-term release was not included in the analysis.

For the 177 μCi short term release from stack 03002924, the radiation doses to a nearby transient receptor ranged from 0.23 to 0.35 mrem. The probability that these doses would not be exceeded was over 99 percent.

FEDERAL FACILITIES COMPLIANCE AGREEMENT EVALUATION

The MOU between DOE and EPA was designed to clarify technical issues associated with implementing the radionuclide NESHAP requirements at DOE facilities. Under this MOU, LANL and all DOE facilities were encouraged to reach an agreement as soon as possible with the appropriate EPA regional office on necessary actions to attain compliance.

The FFCA resulted from seeking such an agreement between LANL and their EPA region office, Region VI. Given the language of the MOU, LANL was well within the boundaries of what was allowed in terms of prior approval for alternate methods of calculation. The FFCA, taken out of the context of the environment in place after drafting this MOU, is much more difficult to understand. To an observer, the FFCA might look like a way for LANL to obtain special treatment under the law, when in fact, agreements of this type were urged by DOE at the time that LANL was attempting to attain compliance.

The FFCA provides helpful technical guidance for LANL in their compliance programs. The question of the scientific merit of the FFCA has been raised, and this was explored by the ITAT.

The MOU between DOE and EPA is very specific about the types of things to which a compliance plan such as the FFCA might apply. The MOU discusses engineering calculations or representative measurements to comply with the requirement of periodic confirmatory measurements for minor release points, continuous monitoring procedures that differ from those referenced in § 61.93 (b) with prior approval, and the use of environmental measurements as an alternate to air dispersion calculations if the criteria of § 61.93 (b) (5) are met. The guidelines for compliance provided in the MOU are precisely what LANL describes in the detailed compliance plan presented in the FFCA.

There are only two portions of the FFCA that the ITAT has found reason to question. These two sections include the sampler siting analysis discussed in Supplement 2b to the FFCA, and the use of the 1000 degree rule, instead of the more common 100 degree rule discussed in the engineering calculations for periodic confirmatory calculations section.

FFCA Sampler Siting Analysis

The sampler siting analysis is detailed in Supplement 2b to the FFCA, and was discussed in the section titled “Sampler Siting Analysis” in the “Non-point Source Monitoring Evaluation” chapter in this report. The ITAT has determined that this methodology necessarily yields results biased toward the existing sampler locations. This assessment is based upon the fact that the starting point for the siting analysis, the existing sampler locations, is also the endpoint that the analysis sought to achieve. An analysis such as this undermines the credibility of the compliance sampling program.

1000 Degree Rule

LANL uses the 1000 degree rule when estimating unabated or potential emissions for determining monitoring requirements [see § 61.93(b)(4)(i) and (ii)]. This rule is discussed in Appendix A, Section 2.1.1.2 of the FFCA between DOE and EPA Region VI.

The 1000 degree rule is a variation of the 100 degree rule contained in 40 CFR 61, Appendix D. The 100 degree rule is used to estimate emissions for applications to construct or modify (see

§ 61.96) and states that if a "nuclide is heated to a temperature of 100 degrees Celsius or more, boils at a temperature of 100 degrees Celsius or less, or is intentionally dispersed into the environment, it must be considered to be a gas." If a radionuclide is treated as a gas, then 100% of the radionuclide inventory must be assumed to be released when estimating emissions for § 61.96, subject to the adjustment factors in Appendix D, Table 1.

The 1000 degree rule states that "a radionuclide that has a boiling point greater than 2000°C and is heated to within 1000°C of its boiling point of higher, or is intentionally dispersed into the environment, must be considered a gas. If the material is not heated to within 1000°C of its boiling point, the material would be considered a solid or liquid depending on its actual physical state at that temperature." The original 100 degree rule applies to all radionuclides with a boiling point less than or equal to 2000°C.

It should be noted that the methods outlined in 40 CFR 61, Appendix D are not required to be used in estimating unabated emissions and there are no methods specified in § 61.93 for determining unabated emissions. Therefore, the use of the 1000 degree rule is not an exemption from an EPA requirement. In addition, the 1000 degree rule contains two safety factors. First, it only applies to materials with boiling points greater than 2000°C. Unabated emissions for materials with boiling points less than or equal to 2000°C would be estimated using the 100 degree rule. Second, the radionuclide must be heated to within 1000°C of its boiling point. This is a considerable margin of safety when the melting and boiling points of elements such as plutonium, americium, and uranium are considered (see Table 7). For these elements, the melting and boiling points are separated by more than 1000°C, so even if these elements were melted, the temperatures would not be within 1000°C of their boiling points.

Based on these considerations, the ITAT finds that the use of the 1000 degree rule is technically valid.

Table 7. Melting and Boiling Points of Actinide Elements

Element	Melting point (°C)	Boiling point (°C)
Actinium	1050	3200
Thorium	1750	4788
Protactinium	1570	4000
Uranium	1134	4100
Neptunium	641	3900
Plutonium	640	3230
Americium	1100	2600

Public Credibility of the FFCA

The final issue surrounding the FFCA was not related to scientific integrity, but rather the public credibility of the document. The process by which the FFCA was written by LANL and approved by the EPA was entirely internal to DOE, LANL, and EPA staff, although LANL had been under increasing public scrutiny with regard to their 40 CFR 61, Subpart H, compliance program. The citizen's group that brought the lawsuit precipitating this audit was already highly

critical of laboratory activities, and yet LANL did not include public opinion into the process of writing and approving the FFCA.

Since 40 CFR 61, Subpart H, and the FFCA outline procedures that directly affect the calculation of doses to the public, it seems reasonable to the ITAT that LANL should have held public seminars and workshops to discuss compliance implementation plans. Without the support of the public on the issue of the FFCA, LANL subjected themselves to further public scrutiny, which eventually resulted in the conduct of this audit.

As LANL considers the issues raised by the ITAT regarding the FFCA, they should consider involving the public in some of the decision making processes. The ITAT does not mean to imply that the public should be involved in the science and calculations that lead to revised methodology, but the methodology should certainly be presented to the public for comment before revisions are submitted to the EPA.

The ITAT suggests some additional possible public involvement ideas in the next section of the report.

RECOMMENDATIONS NOT RELATED TO COMPLIANCE

Suggestions for Public Involvement/Participation

This audit has been historic in the sense that it is the first such audit of compliance with the Clean Air Act for Radionuclides of a DOE facility carried out by an independent team, under the auspices of an independent agency (Department of Justice). The audit team has adopted the policy from the beginning that its work would be open to members of the public throughout its course. Although this policy of openness increased the complexity and cost of the audit, there is no question that it also strengthened its credibility. IEER's role to monitor the audit for thoroughness and to verify the audit's findings was also very helpful. The ITAT believes there are many lessons to be learned as a result of the audit from the vantage point of the structure of the audit and from the standpoint of public involvement in future audits.

Independence of the audit process is critical to its credibility. Therefore, we strongly support the concept of an audit for compliance being carried out by an independent audit team and that financial support for the audit should be arranged through an independent agency. In this situation, the Department of Justice managing resources for the audit has worked well. However, it is not reasonable to expect that Department of Justice would take on this role as an agency to manage resources for independent audits in the future, especially if the audits are initiated voluntarily by DOE and local citizens. Therefore, new mechanisms need to be developed to ensure the independence of funding for audits that will maintain the credibility of the audit process. Possible solutions to this problem include the use of a state agency or a foundation or trust. Another possibility is the involvement of an independent U.S. government agency, such as the Centers for Disease Control and Prevention, which currently has an agreement with DOE to manage environmental studies related to historical dose reconstruction. Regardless of how financial support for an audit is arranged, assuring its independence will be important to its success.

The potential release of radionuclides (or any contaminants) released from a facility that may reach the public offsite, should be of interest to the public, and determining compliance with regulations that control these releases should also be an open public process. It seems reasonable that the more interaction that occurs between LANL and interested citizens, the better the level of understanding that will result. It is important to establish effective involvement of the public in determining compliance with regulations that protect the public. This concept is not one that is commonly practiced by government agencies or private industry. Nevertheless, in the long term we believe it would be very beneficial to have more public involvement in the compliance process and it certainly would enhance a community's understanding of risks and benefits associated with releases of materials to the environment from an operating facility.

At the same time, the ITAT understands the difficulty associated with public involvement in determining compliance and the rights of LANL and DOE to protect information that may be sensitive to national security. Further, scientists who are responsible for compliance have a right to prepare their reports without interference and distractions that may interfere with their work. The ultimate objective should be to develop a good working relationship between interested public, who want to understand how compliance is determined and be heard on this issue, and technical staff who are responsible for making calculations and measurements related to compliance. The relationship should be continuous and open throughout the year.

The ITAT hopes that the key elements that have been introduced during this audit regarding its financial and technical independence, public involvement, openness, and the role of a separate group to verify its work will be evaluated carefully and established for future audits at other sites. We strongly believe these elements have been key to our success and critical to the credibility of the audit.

Issues Raised During the Audit

The audit team has been compiling issues raised, and has completed an assessment of a number of issues as they apply to each technical section of the report. A complete summary of the issues raised appears in Appendix H to this report. The appendix lists the issue, a summary of the issue and the resolution, who raised the issue, and in what section of the report the issue is handled.

CONCLUSIONS

This report documents the results of an independent audit of the Los Alamos National Laboratory performed by *Radiological Assessments Corporation*. The audit focused on the Laboratory's compliance with 40 CFR 61, Subpart H, for the year 1996. The audit was conducted as part of a settlement agreement and consent decree that resolved a lawsuit filed against the U.S. Department of Energy and Los Alamos National Laboratory Director, Siegfried S. Hecker, by the Concerned Citizens for Nuclear Safety and Patrick Jerome Chavez. The audit team divided its work into four areas that addressed the major elements of the regulation. These elements comprise the primary portion of this audit report. The audit team focused on the following four areas:

- **Evaluating the radionuclide inventory for unmonitored point sources**
- **Effluent monitoring of major release points to air**
- **Environmental compliance sampling for non-point sources**
- **Dose calculation**

The audit team also evaluated other areas as it assessed compliance with the regulations. These included traceability of data to their original source, documentation supporting compliance, technical competence, quality assurance, and overall confidence of the audit team in the compliance program. The audit findings were divided into three areas: (1) regulatory deficiencies that can be directly linked to the regulation, (2) technical deficiencies that are not specifically noted in the regulation but are implicit within it, and (3) other observations that are neither noted nor implied in the regulation but are not good scientific practice.

The independent audit team has determined that Los Alamos National Laboratory did not meet certain regulatory and technical requirements and was not in compliance with 40 CFR 61, Subpart H, for 1996.

However, it was the ITAT's considered judgement that the Laboratory did not exceed the 10 millirem per year dose standard prescribed in the regulation. This assessment was based upon an evaluation of radionuclide measurements at monitored release points, the ion chamber exposure rate measurements at the MEI, calculations, and other environmental measurements around the site.

The conclusion reached by the audit team regarding compliance is based on several key regulatory and technical deficiencies that were discovered during the audit. These deficiencies included insufficient inventory documentation, insufficient technical peer review program, and inadequate quality assurance program. Other deficiencies and observations related to compliance with the regulations prescribed in 40 CFR 61, Subpart H, were also identified for 1996. A detailed description of these deficiencies is provided throughout the audit report, and a summary list is attached in Appendix A.

Because the audit was an entirely open process, all parties had access to information being reviewed by the audit team. Los Alamos National Laboratory staff have had an opportunity to implement changes to the compliance program while the audit was being conducted. Therefore, many of the deficiencies noted in this audit report have already been corrected or will be corrected soon. This spirit of cooperation on the part of Los Alamos National Laboratory is extremely encouraging and noteworthy.

This report was initially issued as a draft partial report because the audit had not been completed. However, the audit team felt a responsibility to present its findings, permitting problems related to compliance to be corrected at the earliest possible time. The audit team also believed that its overall conclusion with regard to compliance would not change with the review of additional information, and in fact, that was the case. Key information was missing and procedures that were followed in 1996 cannot be changed. The draft report was reviewed and comments were received. The audit team has included responses to these comments in this final report. As resources permitted, the audit team continued to review several additional areas relevant to compliance and included all findings that it was possible to arrive at within the limitations of time and budget in this final report.

The consent decree requires that the audit will be repeated in the years 2000 and 2002. During future audits, the audit team will evaluate the Laboratory's response to the deficiencies identified during the current audit.

The audit team believes that the public's role in the compliance process is critical. The positive interaction between the audit team, Los Alamos National Laboratory, the Institute for Energy and Environmental Research, and the public confirmed that where regulations related to public exposures are being evaluated, the public can play an important role. The audit team also believes that the Institute for Energy and Environmental Research's role to monitor and verify the audit process was valuable in maintaining this atmosphere of openness. The Institute for Energy and Environmental Research challenged the audit team to conduct a thorough and fair evaluation of compliance.

A number of questions were raised by the Institute for Energy and Environmental Research and the public regarding important issues. Most of these issues were addressed in this final report, but others were unable to be dealt with in light of resource limitations. Several of the questions raised were in reference to issues not clearly defined in the regulations. These questions were important to note because many issues require the audit team to use its best professional judgment to develop an answer. Where important points were raised that are not clearly described in the regulation, the audit team forwarded these issues to the U.S. Environmental Protection Agency for clarification in future revisions to the regulation. The issues and the responses of the EPA are listed in Appendix F. Also in Appendix F is a response of the audit team to the position of the EPA on these very important technical issues.

This was the first audit of 40 CFR 61, Subpart H, to be conducted by an independent audit team working under the auspices of the Department of Justice. This arrangement was critical to guarantee the independence of the audit team. The audit team learned much from the audit process and documented these lessons for future use. The lessons learned during this process should be considered for use at other facilities and this audit should serve as a model for similar reviews at other sites.

It is emphasized that this audit was more rigorous and broader in scope than previous audits conducted for compliance with 40 CFR 61, Subpart H, at Los Alamos National Laboratory and at other Department of Energy sites. The degree of cooperation received from all parties involved was exemplary. The audit team especially commends the Air Quality Group of the Environmental, Safety, and Health Division at Los Alamos National Laboratory because supporting the audit process has required extraordinary effort on their part. The audit team also thanks and commends the U.S. Department of Energy, Los Alamos National Laboratory,

Concerned Citizens for Nuclear Safety, and the Institute for Energy and Environmental Research for their active involvement and support.