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2018 LANL Radionuclide Air Emissions Report

Documenting compliance with 40 CFR 61, Subpart H, the Radionuclide NESHAP

Site Name: Los Alamos National Laboratory
Location: County of Los Alamos, New Mexico

DOE Offices Information:

Office: Los Alamos Field Office (NNSA)	**Office:** Los Alamos Field Office (EM-LA)
Address: U. S. Department of Energy National Nuclear Security Administration Los Alamos Field Office 3747 West Jemez Road Los Alamos, NM 87544	**Address:** U. S. Department of Energy Environmental Management Los Alamos Field Office 1900 Diamond Drive Los Alamos, NM 87544
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Site Information:

Primary Operator (NNSA): Triad National Security, LLC (Triad)	**Secondary Operator (EM):** Newport News Nuclear BWXT - Los Alamos (N3B)
Address: Los Alamos National Laboratory P. O. Box 1663 Los Alamos, NM 87545	**Address:** N3B Los Alamos 600 Sixth Street Los Alamos, NM 87544
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Compliance Assessment:

2018 Off-Site Effective Dose Equivalent: **0.35 mrem**

Executive Summary

This report describes the emissions of airborne radionuclides from operations at Los Alamos National Laboratory (LANL) for calendar year 2018 and the resulting off-site dose from these emissions. This document fulfills the requirements established by the National Emissions Standards for Hazardous Air Pollutants in 40 CFR 61, Subpart H – Emissions of Radionuclides other than Radon from Department of Energy Facilities, commonly referred to as the Radionuclide NESHAP or Rad-NESHAP. [1] Compliance with this regulation and preparation of this document is the responsibility of LANL's Rad-NESHAP compliance program, which is part of the Environmental Protection and Compliance Division. The information in this report is required under the Clean Air Act and is being submitted to the U.S. Environmental Protection Agency (EPA) Headquarters and EPA Region 6.

The highest effective dose equivalent (EDE) to an off-site member of the public was calculated using procedures specified by the EPA and described in this report. LANL's EDE was 0.35 mrem for 2018. The annual limit is 10 millirem per year, established by the EPA in 40 CFR 61 Subpart H. All measured air emissions are modeled to a single location, known as the Maximally Exposed Individual (MEI).

During calendar year 2018, LANL continuously monitored radionuclide emissions at 27 "major" release points, or stacks. The Laboratory estimates emissions from an additional 58 "minor" release points using radionuclide usage source terms in lieu of stack monitoring. Also, LANL uses an EPA-approved network of air samplers around the Laboratory perimeter to monitor ambient airborne levels of radionuclides. To provide data for dispersion modeling and dose assessment, LANL maintains and operates meteorological monitoring systems. From these measurement systems, a comprehensive evaluation is conducted to calculate the MEI dose for the Laboratory.

The MEI can be any member of the public at any off-site location where there is a residence, school, business, or office. In 2018, this MEI location was a business at 2470 East Road, located in the eastern end of Los Alamos town site. The primary contributors to the off-site dose at this location were radioactive gas emissions from sources at the LANSCE accelerator complex. Overall, the MEI dose in 2018 is similar to levels in recent years, and is well below the EPA's 10 millirem per year limit. Doses reported to the EPA for the past 10 years are shown in Table E1. In that table, note the elevated releases

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[1] *Code of Federal Regulations*, Title 40, Part 61.90, Subpart H, 1989. "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," promulgated by the U. S. Environmental Protection Agency.

associated with the remediation of legacy waste disposal at Materials Disposal Area B (MDA-B) in 2011, as described in that year's annual report.

Table E1. Ten-Year Summary of Rad-NESHAP Dose Assessment for LANL

Year	EDE (mrem)	Highest EDE Location
2009	0.55	2470 East Road ("East Gate")
2010	0.33	2201 Trinity Drive, Airnet Station 257
2011	3.53	278 DP Road, Airnet Station 317
2012	0.58	2201 Trinity Drive, Airnet Station 257
2013	0.21	2101 Trinity Drive, Airnet Station 324
2014	0.24	95 Entrada Drive
2015	0.13	2470 East Road ("East Gate")
2016	0.12	2470 East Road ("East Gate")
2017	0.47	2101 Trinity Drive, Airnet Station 324
2018	0.35	2470 East Road ("East Gate")

2018 Noteworthy Events

Several events that took place in 2018 are worth discussion in this Executive Summary; they are divided into administrative events, dealing with execution of the compliance program at LANL, and facility operational events, pertaining to changes at LANL's air emissions sources.

Administrative & Programmatic Events

LANL prime contract separation.

In December 2017, the Department of Energy announced the new contractor that has since taken over certain LANL operations that are managed by the DOE Environmental Management office. The new contractor, Newport News Nuclear BWXT Los Alamos, LLC, referred to as "N3B," assumed control of these operations on April 30, 2018. Up-to-date information on the new Environmental Management field office can be found on their website.[2]

N3B manages legacy waste operations, primarily at the Technical Area (TA-) 54 waste disposal facility and the TA-21 legacy cleanup site, along with other environmental cleanup sites

[2] EM-LA website: https://www.energy.gov/em-la/environmental-management-los-alamos-field-office

around LANL and the nearby community. There are three LANL monitored stacks at TA-54 affected by this transition, along with several minor point sources and eight on-site Airnet stations which are part of the on-site surveillance network. All other LANL operations (24 monitored stacks and all compliance Airnet stations) will remain under the DOE National Nuclear Security Administration (NNSA) Management & Operating (M&O) contract, currently with Triad National Security, LLC (Triad).

The current operational strategy is to continue all site-wide operations under a single Rad-NESHAP compliance program, managed by the NNSA contractor (Triad). This makes operational sense due to the small program on the EM side in comparison with the larger NNSA program and also meets the desire of EPA Region 6 to keep a single point of contact for the radionuclide operations at LANL. Applications for Pre-Construction Approval for new emissions sources will be routed to EPA Region 6 through the appropriate DOE Field Office, the EM office (EM-LA) for activities within the legacy cleanup areas and the NNSA office (NA-LA) for other sites.

Transitioning the M&O contract at LANL.

During 2017 and 2018, the Department of Energy's National Nuclear Security Administration (NNSA) worked with organizations bidding on the M&O contract at LANL. Most of the radionuclide emissions sources at LANL are managed under this contract, as discussed above. There were several bids entered for the new contract, and the successful contractor, Triad National Security, LLC (Triad), was announced June 8, 2018. The M&O contract with LANS was scheduled to expire on September 30, 2018 but was extended to allow for a full four month transition period. Triad successfully took over operations of LANL on November 1, 2018. More details are available on the NNSA's contract transition website[3] as well as on Triad's website.[4] Rad-NESHAP compliance operations and personnel under the Triad contract remain unchanged from the prior contract.

[3] NNSA contract transition website: https://www.energy.gov/nnsa/los-alamos-mo-contract-competition
[4] Triad management transition website: https://www.triadns.org/triad-national-security-llc-begins-management-transition-at-los-alamos-national-laboratory/

Plutonium tracer availability at analytical laboratory.

In early 2018, the off-site analytical laboratory used for Rad-NESHAP samples notified the Laboratory of an issue with plutonium tracer availability. Tracer nuclides are used to quantify the amount of radionuclides that exist in samples undergoing radiochemical separation. The plutonium tracer used by the analytical laboratory is Pu-242, and is usually obtained from the National Institute of Standards and Technology (NIST), who in turn receives material from sources within the DOE Complex. However, NIST ran out of the Pu-242 stock solution and there were no other suppliers which could provide this tracer solution with sufficient purity. An alternative supplier was identified, but the tracer solution had slightly elevated plutonium and americium contamination relative to the NIST solution. As a result, the analytical laboratory had to develop more sophisticated background subtraction methods for radiochemical separation methods. This resulted in delayed analysis and receipt of analytical data for both stacks and Airnet well beyond normal turnaround time. Overall, the data set has higher uncertainties for plutonium isotopes than usual, but the data are still useful for compliance calculations.

EPA site visit to LANL.

In August 2018, LANL hosted a visit by two personnel from EPA Region 6. The Regional Health Physicist and the Solid Waste & Underground Storage Tank Section Chief received an overview of the program, ongoing activities, and recent construction. The visit was focused on planning for venting legacy tritium waste drums at TA-54, the Flanged Tritium Waste Containers (FTWCs). The Pre-Construction approval request for this operation was submitted to EPA shortly after the visit. Other facilities visited included the new Transuranic Waste Facility and the new Low-level Liquid Waste facility, both discussed later. LANL Environmental Protection & Compliance management also met with the EPA personnel to discuss the contract transitions at LANL, discussed above. A variety of other ongoing LANL operations were viewed and discussed as well.

Facility Operational Events

Installation of new sampling systems at TA-55 PF-4.

In June 2017, LANL installed new shrouded probes into exhaust ducts at the TA-55 plutonium facility, building 4 (PF-4). There are two stacks which vent PF-4 operations, both of which are monitored release points and considered major sources. Current emissions monitoring is on the roof of PF-4, using multi-point samplers ("rakes"). Use of these multi-point samplers is discouraged by the applicable ANSI standard[5], and moving to more efficient single-point shrouded probes is required when facilities change operations or bring new operations on board. While the PF-4 mission remains unchanged, the installation of shrouded probe technology allows flexibility in operations for the future.

The new samplers are located in the basement of PF-4, where the exhaust flow meets acceptable criteria for single-point sampling. Samplers are located in the "Zone 1" exhaust ducts, which provide exhaust for significant radiological operations in PF-4. There are areas within PF-4 which are not ventilated by the Zone 1 system, and potential emissions from these areas will be evaluated for monitoring and/or tracked as minor sources in the Radioactive Materials Usage Survey. The new basement duct samplers went into operation for the 2018 reporting year. LANL is concurrently operating both the old rooftop samplers and the new basement duct samplers to compare measurements. For the 2018 reporting year, we are treating the basement Zone 1 samplers as R&D systems until we can incorporate a full inspection and maintenance program on these samplers. Also, we want to have more data points to compare performance of the two systems. The data in this 2018 report are from the rooftop samplers.

Low-Level Liquid Waste facility construction.

Major construction was completed in 2018 on the Low-Level Liquid Waste facility at TA-50 Building 230, designed as the first phase of replacing the aged Radioactive Liquid Waste Treatment Facility (TA-50 Building 1). Throughout 2018 and into 2019, the LLW facility has been going through a series of operational readiness activities. We anticipate radiological operations to commence later in 2019. This summer, the Rad-NESHAP team will conduct commissioning tests on the stack sampling system at LLW in preparation for these operations.

Unplanned releases from the LANSCE accelerator.

The Los Alamos Neutron Science Center (LANSCE) is a proton accelerator that performs a variety of national security and basic science experiments. Beam operations can result in the buildup of radioactive air in the tunnels, which are normally held stagnant or exhausted out monitored stacks. During 2018, a ventilation fan failure in one experimental area resulted in

[5] American National Standards Institute, "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities." ANSI N13.1-1999, reaffirmed in 2011.

pressurization of an adjacent beam tunnel, forcing the radioactive air that had built up in the tunnel out through a non-monitored pathway.

This issue was discovered essentially simultaneously through both off-site radiation detectors and also by facility experimenters who noted elevated background radiation levels. To address this issue, the facility installed air pressure instrumentation that will cease beam operations if a similar situation develops again and is currently in the process of installing improved ventilation barriers to prevent this type of scenario in future years.

For this 2018 report, we calculated a bounding level of emissions that could have come from this unplanned release and are including these emissions as a new diffuse emissions source, dubbed 53DIF03N (TA-53, diffuse emissions from Building 3, Sector N). More information is available later in this report, in the section on Unplanned Emissions.

<u>Extended down time at two monitored stacks</u>.

There were two stack monitoring systems at LANL that experienced extended downtime in 2018. One was at the TA-48 radiochemistry facility and one at the TA-54 waste management facility. Each system had about 80% uptime; the goal for LANL monitoring systems is 85% or more, per the Rad-NESHAP quality assurance project plan.

The TA-48 radiochemistry facility lost electrical power to a portion of the facility in early 2018. This affected the stack sample system for one area, and resulted in a system uptime of only 80%. The source in question, 48000160 (TA-48, Building 1, stack 60) is a stack that exhausts a small portion of the building hot cell wing. This source did not meet criteria to be a major source in recent years; the potential emissions for this stack in the 2017 review was less than 0.0002 millirem. This low potential dose, combined with the operational difficulty of supplying auxiliary power to this sample system, led to the programmatic decision to wait for the facility to repair the affected electrical system and simply scale up measured emissions to account for the down time.

The sample pump at stack 54041299 (TA-54, building 412, stack 99) failed in early October 2018. As part of the N3B takeover of the TA-54 facility, no operations were taking place at TA-54 for most of the year, including maintenance activities. The pump was repaired in early December, before any radiological operations took place. The overall uptime was 82% for the year.

Emissions reported in this document for 48000160 and 54041299 are scaled up to reflect the downtime. A review of operations indicate no unusual operations taking place during this down time, so this standard correction method is adequate. It should be noted that except for these two systems, all other stacks at LANL all had operational uptime of over 97%. The overall system uptime for 2018 was 98.8% for all stacks. For both affected systems, the ambient air monitoring stations downwind of these stacks were operational for the duration of the down time.

New facilities design & construction.

As described in the reports for prior years, the Transuranic Liquid Waste (TLW) facility is undergoing design. This facility is the second phase of replacing the aged Radioactive Liquid Waste facility and will process liquid waste contaminated with actinides at higher concentrations than the LLW facility. Design activities on TLW paused during the final phases of LLW construction and commissioning but are planned to resume in 2019.

Other facilities discussed in prior years did have construction activities take place. Operational scope from the Chemistry and Metallurgy Research facility are moving to TA-59 Building 1. Ventilation and exhaust improvements in preparation for this activity have been installed, but no operations have transferred yet. This stack is currently planned to be a minor source; it will not require monitoring for several years. However, the new exhaust system is being designed to accommodate monitoring if operational scope increases to major source levels.

Measurement of depleted uranium at ambient air monitoring stations.

LANL's ambient air monitoring network (Airnet) measures air concentrations of various radionuclides at public receptor locations, as well as at selected operational locations around the Laboratory. In 2018, we measured depleted uranium (U-238) at locations around the Area G waste management facility, as well as one off-site location in White Rock (station 119, Rocket Park). These measured doses are quite low; the station 119 value is 0.02 millirem, as shown in Table 9 of this report. Nevertheless, it is slightly higher than what we normally see for depleted uranium. We are investigating the source of the emissions and will provide information to Region 6 regarding any results.

2018 LANL Radionuclide Air Emissions Report

Abstract

The emissions of radionuclides from Department of Energy Facilities such as Los Alamos National Laboratory (LANL) are regulated by the 1990 Amendments to the Clean Air Act, National Emissions Standards for Hazardous Air Pollutants (40 CFR 61 Subpart H). These regulations established an annual dose limit of 10 mrem to the maximally exposed member of the public attributable to emissions of radionuclides from LANL. This document describes the emissions of radionuclides from LANL and the dose calculations resulting from these emissions for calendar year 2018, meeting reporting requirements established in the regulations. For 2018, the effective dose equivalent received by the maximally exposed individual member of the public was 0.35 millirem.

Section I. Facility Information

61.94(b)(1) Name and Location of Facility

Los Alamos National Laboratory (LANL or the Laboratory) and the adjacent residential areas of Los Alamos and White Rock are located in Los Alamos County in north-central New Mexico, approximately 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe. Figure 1 illustrates the Laboratory's location with respect to the nation, state, and county.

61.94(b)(2) List of Radioactive Materials Used at LANL

Since the Laboratory's inception in 1943, its primary mission has been nuclear weapons research and development. Programs include weapons development, stockpile stewardship, nonproliferation, magnetic and inertial fusion, nuclear fission, nuclear safeguards and security, isotope production, and laser isotope separation. There is also research in the areas of physics, chemistry, and biology.

The primary facilities involved in the emissions of radioactivity are outlined in this section. The facility locations are designated by technical area (shown in Figure 2) and building. For example, the facility designation TA-3-29 is Building 29 at Technical Area (TA-) 3. Potential radionuclide release points are listed in Table 1, with supporting information in later tables and in Section II of this report. Some of the sources described below are characterized as non-point (diffuse and fugitive) emissions. Off-site doses resulting from non-point emissions of radioactive particles and tritium oxide (tritiated water vapor or HTO) are measured and calculated using LANL's ambient air sampling network (Airnet).

Radioactive materials used at LANL include weapons-grade plutonium, heat-source plutonium, enriched uranium, depleted uranium, and tritium. Also, a variety of materials are generated through the

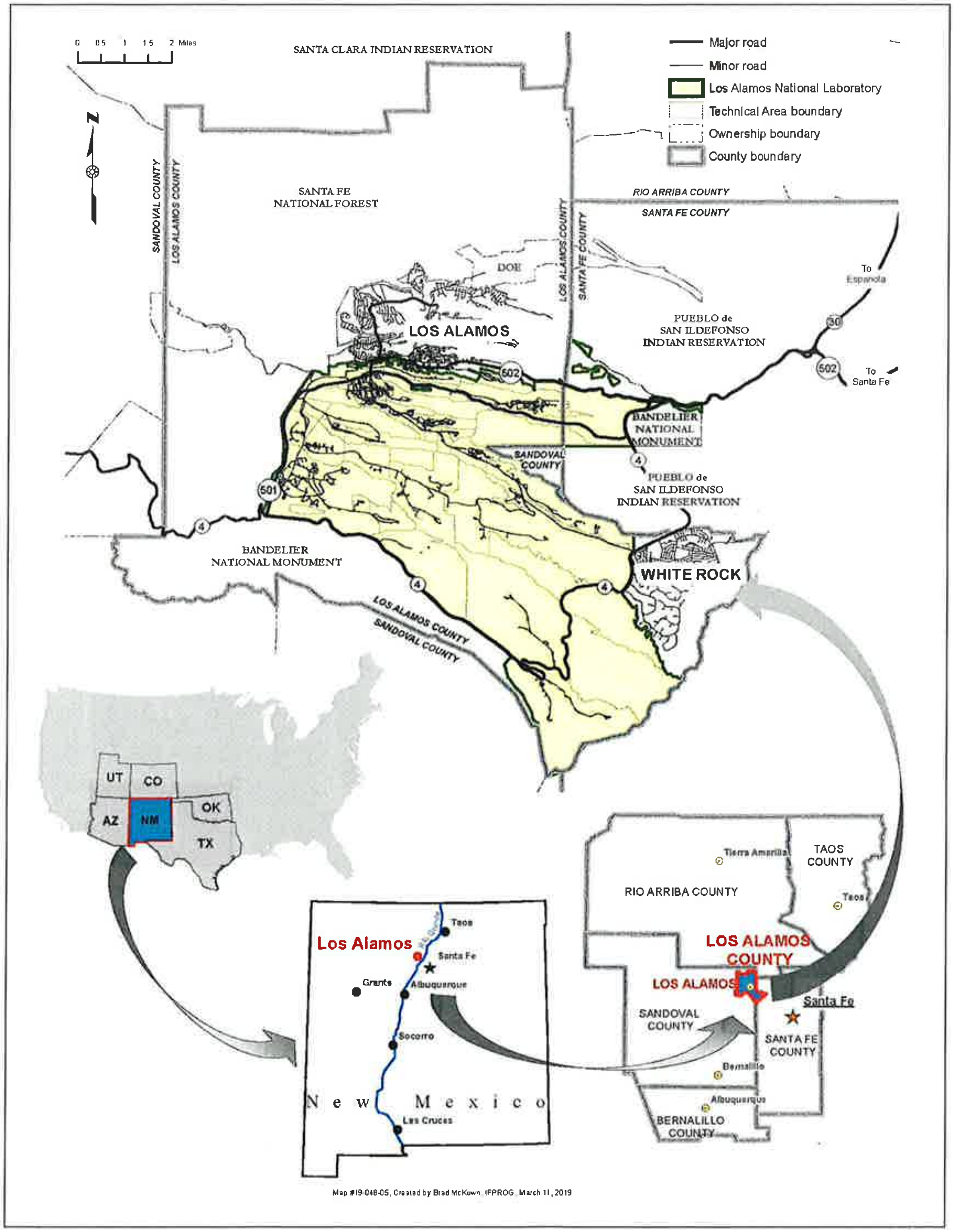

Figure 1. Location of Los Alamos National Laboratory.

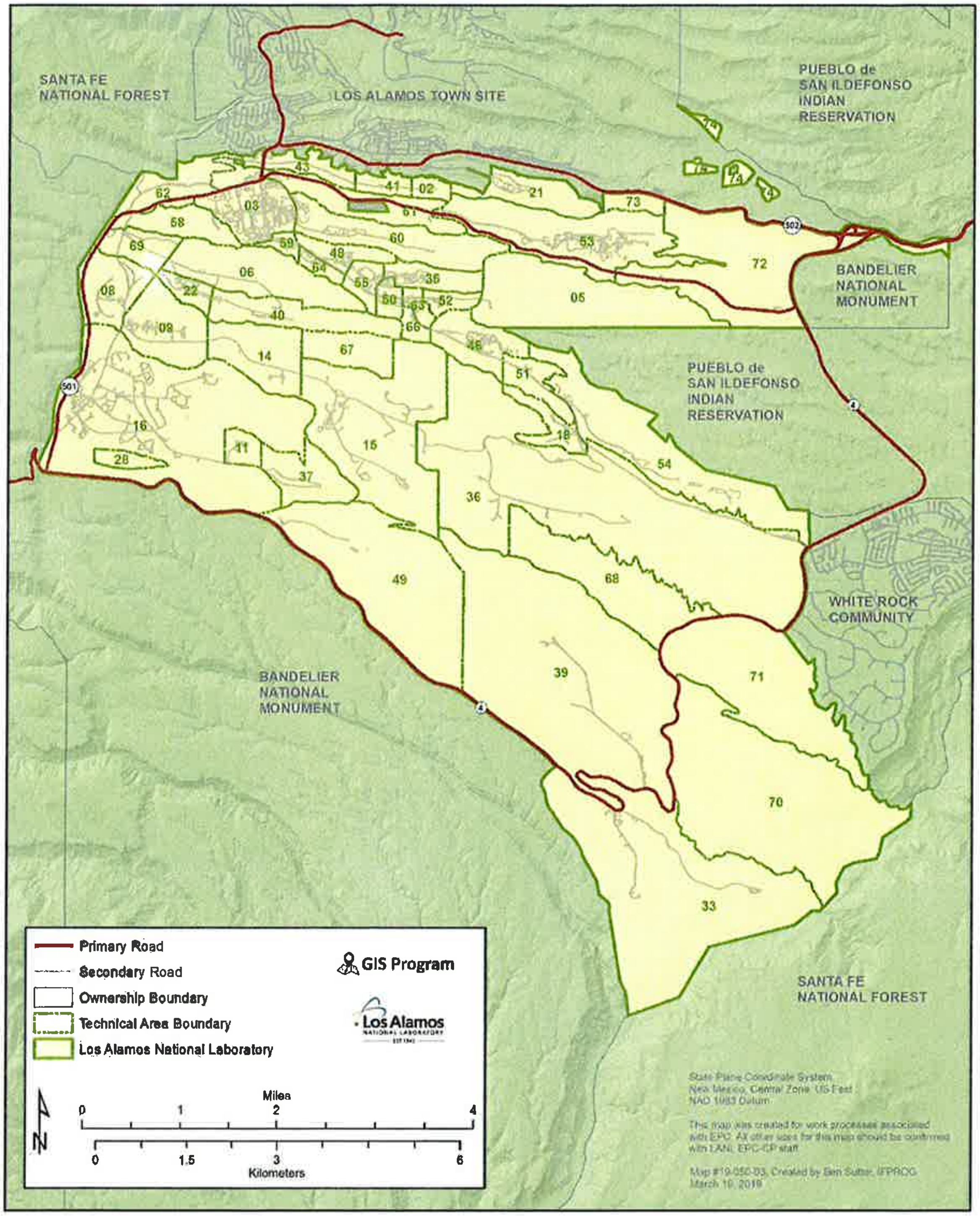

Figure 2. Los Alamos National Laboratory technical areas by number.

process of activation; consequent emissions occur as gaseous mixed activation products (GMAP) and other particulate or vapor activation products (P/VAP).

The radionuclides emitted from monitored point sources at LANL in calendar year 2018 are listed in Table 2. Tritium is released as either tritiated water vapor (called HTO) or elemental tritium gas (HT). Plutonium-239 can also contain Pu-240; the two isotopes are virtually indistinguishable by alpha spectroscopy but have similar off-site dose conversions. Reported emissions of Pu-239/240 are simply referred to as Pu-239 for brevity. GMAP emissions include ^{41}Ar, ^{11}C, ^{13}N, ^{14}O, and ^{15}O. Various radionuclides such as ^{197m}Hg, ^{68}Ge, and ^{82}Br make up the majority of the P/VAP emissions.

61.94(b)(3) Handling and Processing of Radioactive Materials at LANL Technical Areas

LANL technical areas and operations summaries are listed below. Additional descriptions of LANL technical areas can be found in the Annual Site Environmental Report for LANL.[6] More thorough descriptions of LANL operations can be found in the Annual Site-Wide Environmental Impact Statement Yearbooks, the most recent addressing LANL operations in 2017.[7] A complete list of non-monitored sources and activities is found in the Radioactive Materials Usage Survey (RMUS), described in the next section.

The primary facilities responsible for radiological airborne emissions are as follows:

TA-3-29: The Chemistry and Metallurgy Research (CMR) facility conducts chemical and metallurgical research. The principal radionuclides used are isotopes of plutonium and other actinides. There are a variety of activities involving plutonium and uranium, which support many LANL and other U.S. Department of Energy (DOE) programs. As mentioned in prior years' reports, work has been consolidated from six wings down to just three wings; these three wings will remain active for a few more years, when operations are planned for phase-out in this facility. In late 2012, one stack fan was shut down (ES-37) and the associated sampling system turned off. Stack sampling in remaining wings is ongoing, due to the potential for radionuclide emissions from duct holdup. Sampling systems and fans may be shut down in coming years as operations dictate. In 2018, one stack (ES-24) had not operated for several months and the facility indicated it would not be repaired; we therefore ceased sampling at the end of March. The fan was subsequently restarted in May 2018, so we resumed sampling.

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[6] Los Alamos National Laboratory, "Los Alamos National Laboratory 2017 Annual Site Environmental Report," LA-UR-18-28565, December 2018.
[7] Los Alamos National Laboratory, "SWEIS Yearbook 2017," LA-UR-19-20119, February 2019.

TA-3-66: The TA-3-66 Sigma facility is used for a variety of nuclear materials work. Primary materials are metallic and ceramic radionuclides, including depleted uranium. The uranium foundry is located in this building. In recent years, research and development work with low-enriched uranium (LEU) fuels used in research reactors has been performed in this facility. The stacks at Sigma are considered "minor" sources under 40 CFR 61 Subpart H and are not monitored.

TA-3-102: This machine shop is used for the metalworking of radioactive materials, primarily depleted uranium. The monitored stack at this facility (ES-22) was shut down in 2011; only minor operations are performed in this facility, and these operations do not meet requirements for a monitored stack.

TA-3-1698: This facility is the Materials Science Laboratory. The building was designed to accommodate a wide variety of chemicals used in small amounts that are typical of many university and industrial labs conducting research in materials science. Small amounts of radioactive materials are used in experiments on materials properties (e.g., stress/strain measurements).

TA-15 and TA-36: These facilities conduct open-air explosive tests involving depleted uranium and weapons development testing. One building, TA-36-99, houses a "gas gun" focused explosive experiment that is ventilated through a non-monitored stack.

TA-15-312: This is the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility. DARHT conducts high-explosive-driven experiments to investigate weapons functions and behavior during nonnuclear tests using advanced radiography. Starting in 2007, explosive operations at DARHT are conducted in containment vessels. Use of these vessels virtually eliminates air emissions from these operations. Following explosive operations, containment vessels undergo cleanout in building 15-534 and if needed, repair in building 15-285. Both of these latter two buildings are non-monitored point sources tracked in the RMUS.

TA-16-205 and -450: This is the Weapons Engineering Tritium Facility (WETF). Buildings 205 and 450 were specifically designed and built to process tritium safely. The operations at WETF are divided into two categories: tritium processing and activities that support tritium processing. Examples of tritium-processing operations include repackaging of tritium into different quantities and the packaging of tritium and other gases to user-specified pressures. Other operations include reacting tritium with other materials to form compounds and analyzing the effects of tritium. WETF operations have historically been housed in building 205, while building 450 was built for other tritium activities. Expansion of WETF into building 450 began in 2007. As part of this expansion, exhaust ducts were reconfigured so that emissions from TA-16-205 were routed into the TA-16-450 ES-05 stack. Therefore, the TA-16-205 stack ES-04 is discontinued as a point source and TA-16-450 ES-05 is the emissions point source for both buildings. The older emissions sampling system for building 205 is located in the exhaust duct coming out of building 16-205, and this system remains operational and able to measure emissions from that building. The new stack sampling system in stack ES-05 was certified to measure emissions from building 450, whenever that portion of the complex becomes active. This system will also measure emissions from building 205 operations, but it was not certified for these operations under ANSI/HPS N13.1-1999 criteria. As discussed in the 2009 emissions report, the ES-05 stack monitor experienced technical problems, and its operations were discontinued in June 2009. Since significant tritium operations have not commenced in 16-450, this stack system is not needed for compliance purposes. Reported emissions for 2018 are measured with the 16-205 duct monitor but exhausted through and modeled from the 16-450 ES-05 stack.

TA-21: The great majority of buildings at this decommissioned radiochemistry site have been decontaminated and demolished. The tritium operations in TA-21 were relocated in 2006 to other LANL sites, primarily WETF. In 2009, demolition of office and support buildings began. Radiological process buildings were demolished in 2010, and only isolated structures remain at TA-21. Final remediation of these structures, building foundations, subsurface equipment, and legacy disposal areas will take place in coming years. The plans for these operations were discussed with EPA Region 6 during the August 2014 site visit. The MDA-B legacy waste disposal site is also considered part of TA-21. Excavation of MDA-B was completed in 2011; removal of excavation structures was achieved in late 2012.

TA-41-4: This building was formerly used as a tritium-handling facility. The tritium sources were removed in 2002. Most of the process buildings have been demolished. Diffuse tritium emissions could result from residual tritium contamination and cleanup operations.

TA-48: The principal activities carried out in this facility are radiochemical separations and hot cell operations supporting the medical radioisotope production program, the Yucca Mountain program, nuclear chemistry experiments, and geochemical and environmental research. These separations involve nanocurie to curie amounts of radioactive materials and use a wide range of analytical chemical separation techniques, such as ion exchange, solvent extraction, mass spectroscopy, plasma emission spectroscopy, and ion chromatography. Besides the hot cell operations, the building also houses the Actinide Research Facility (ARF) and includes the other radiochemical operations described above. Building 1 at TA-48 contains the majority of operations, exhausted through three monitored stacks and several non-monitored stacks. Smaller (non-monitored) operations take place in other buildings around TA-48-1. Building 1 of TA-48 was the first to adopt SD 1027G radionuclide inventory thresholds as described in the prior annual reports. While a larger number of isotope processing operations may theoretically result in increased air emissions, this trend has not been significant in recent years. The facility did perform a "one-off" plutonium experiment in 2017 that vented through ES-45 at TA-48-1, a minor (unmonitored) source; potential emissions from this activity approached the 0.1 millirem/year limit, but did not exceed it. Future operations of this type will be evaluated to determine if they can continue in areas vented through the minor source ES-45 or if they should move to an area vented through a monitored stack, e.g. the ARF.

TA-50-1: This waste management site consists of an industrial low-level radioactive liquid waste treatment facility, RLWTF. Transuranic liquid waste is also treated in this building. The building has one monitored stack (ES-2) and other smaller non-monitored point sources. Two small cooling towers described in the 2010 executive summary had been used for non-radiological purposes in the past. These cooling towers operated briefly to evaporate treated radiological effluent from RLW in 2010 but have not operated since 2010, and that practice has been discontinued. A new fuel-fired evaporator (described in the 2011 report) started radiological operations in 2011 and is being tracked as a non-monitored source. Use of solar evaporative tanks for evaporation of treated effluent have been built but their operations have not commenced. Over time, operations in TA-50-1 will be transitioned to the new Low-level Liquid Waste (LLW) facility at TA-50-230 and to a transuranic liquid waste (TLW) facility, still in the design phase.

TA-50-37: Currently there are no operations involving radioactive material in this building; plans for future radiological operations have not come to fruition. Stack sampling took place due to legacy contamination issues. In September 2013, potentially contaminated ventilation duct components were removed to eliminate sources of emissions from this building. Emissions measurements continued through June 2014. With no detectable emissions in the first half of 2014 and no radiological operations or source term present, the monitoring system was shut down in late September 2014. The building is now used exclusively for non-radiological operations.

TA-50-69: This waste management site consists of a waste characterization, reduction, and repackaging facility. Waste drums are repackaged for on-site or off-site disposal. There is one monitored stack, ventilating the primary drum processing glove box, and three non-monitored sources at this building. The operations were suspended in 2016 pending administrative review. This suspension was lifted in 2017, and processing of drums resumed in 2018.

TA-53: This technical area houses the Los Alamos Neutron Science Center (LANSCE), a linear particle accelerator complex. There are two monitored stacks (on buildings TA-53-3 and TA-53-7) and several sources tracked in the non-monitored stacks program. The accelerator is used to conduct research in stockpile stewardship, radiobiology, materials science, and isotope production, among other areas. LANSCE consists of the Manuel Lujan Neutron Scattering Center, the Proton Storage Ring, the Weapons Neutron Research (WNR) facilities, the Proton Radiography facility, and the high-intensity beam line (Line A). The facility accelerates protons and H- ions to energies of 800 MeV into target materials such as graphite and tungsten to produce neutrons and other subatomic particles. The design current of the accelerator is approximately 1000 microamperes, but most operations take place at beam currents of 120 microamperes or less. Airborne radioactive emissions result from proton beams and secondary particles passing through and activating air in target cells, beam stop, and surrounding areas, or activating water used in target cooling systems. The majority of the emissions are short-lived activation products such as ^{11}C, ^{13}N, and ^{15}O. Most of the activated air is vented through the main stacks; however, a fraction of the activated air becomes a fugitive emission from the target areas.

As a by-product of accelerator operations, cooling water can contain trace amounts of radionuclides. Two solar evaporative tanks were constructed and began operation in 1999 to evaporate this wastewater from the accelerator. Evaporation of water from these open-air tanks can result in a diffuse source of airborne tritium and other particulates. To support other Laboratory operations, these tanks can be used for evaporation of water from other LANL facilities.

In 2004, the Isotope Production Facility (IPF) began operations as part of the LANSCE facility. IPF uses a portion of the LANSCE beam to irradiate a variety of targets for different medical research and treatment uses. After irradiation, targets are processed at LANL hot cells at TA-48 or CMR. IPF has two stacks which are managed as part of the minor (non-monitored) source program.

In 2014, two new sources were identified at the LANSCE facility. The first is a diffuse source at the IPF building. An improvement to the air emissions detection system resulted in measurements of trace radioactive gases in the high bay area around the IPF target and in the equipment aisle above the IPF beam tunnel. This air is the result of migration of beam tunnel air through drains and cable penetrations up into worker occupied spaces, and then vented to the environment as a diffuse/non-point source. For 2018, radionuclide air concentrations are continuously measured at the most conservative location within the equipment aisle, and these measurements are used to calculate emissions from this diffuse source.

The second new source was from the WNR facility, Target 4. Air from around the WNR Target 4 is normally exhausted by vacuum pump into the WNR Target 2 area, which in turn is exhausted by the Building 7 stack fan. However, the vacuum pump discharge line was discovered to be cracked in late 2014, so all air from Target 4 was released directly to the atmosphere. These emissions calculations were discussed in the 2014 annual report. The pump discharge pipe was fixed in late 2014, returning air into the building for eventual exhaust through the monitored stacks. No radionuclide emissions evaluation from this discharge point was required for 2018.

As described in the executive summary and in more detail in the Unplanned Released section, a new radioactive air emissions source was found in 2018 when a fan malfunction resulted in pressurizing the beam tunnel in one of the LANSCE areas. Radioactive air in the tunnel, normally held stagnant or exhausted out a monitored stack, was instead pushed out from TA-53 Sector N as a fugitive release. The issue was detected and addressed late in the 2018 run cycle and addressed prior to 2019 beam operations to prevent a repeat of this event.

TA-54: This waste management site consists of active and inactive shallow land burial sites for solid waste and is the primary storage area for mixed and transuranic radioactive waste. Waste characterization and processing operations also take place at TA-54 to prepare waste for shipment to the Waste Isolation Pilot Plant (WIPP). Shipments of transuranic waste for disposal at WIPP began in 1999. Characterization work includes analysis of headspace gases and radiography of waste drum contents; processing includes sorting, segregating, size-reduction, and repackaging of waste.

MDA G at TA-54 is also a known source of diffuse emissions of tritium vapor and direct radiation from above-ground storage of radioactive waste. Resuspension of soil contaminated with low levels of plutonium/americium has also created a diffuse source. Point sources at Area G include operations involving characterization, processing, or repackaging of waste containers. Two new monitored point sources came on-line in 2010, at Building 412 and Dome 231. These two sources are waste processing facilities, where drums are repackaged, inspected, and otherwise prepared for off-site disposal. The Dome 231 processing facility was expanded in 2012 to increase throughput capacity of the dome. In March 2014, a new building (Dome 375) began radiological operations to process larger waste containers. Non-monitored (minor) sources of emissions at TA-54 include drum characterization work at Building 33 and Dome 224 as well as air sample management work outside of Area G in Building 1001.

Note that after the WIPP radiological release in February 2014 was tracked back to a waste drum originating at LANL, air monitoring around TA-54 was increased. Drums which contained waste similar to that in the drum involved in the WIPP release were isolated in Dome 375. Other waste drums of concern were stored at Dome 231. Most waste handling activities at TA-54 were reduced while the facility dealt with storing and treating these Remediated Nitrate Salt (RNS) drums in recent years; now that the RNS processing was completed in 2017, routine waste drum handling operations began ramping up again. Also, the additional air monitoring (real-time environmental continuous air monitors) ceased operations after the RNS drums were moved out of Dome 375.

TA-54 building 1028 houses four legacy tritium waste containers, referred to as Flanged Tritium Waste Containers (FTWCs). These units are high-pressure tritium containers and were originally packed with small amounts of lead waste, making these FTWCs mixed-waste items. To address these issues, LANL will be venting any tritium in the headspace and then moving the FTWCs to the TA-16 tritium facility for further waste processing. This venting operation will be a new major source of emissions, and an application pre-construction approval[8] was submitted and approved in 2018. Programmatic delays have pushed this operation to the summer of 2019. The venting is expected to take less than a week once operations begin.

TA-55-4: Building 4 of the Plutonium Facility (PF-4) provides a pit manufacturing capability and continues the role of providing the capability for research and development applications in chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides. A wide range of activities (e.g., heating, dissolution, forming, and welding of special nuclear materials) are also conducted. Additional activities include investigating the means to safely ship, receive, handle, and store nuclear materials and to manage wastes and residues from TA-55. Limited-scope tritium operations also take place in certain areas of TA-55. There are two monitored stacks at TA-55 Building 4. In 2017, new samplers were installed in the "Zone 1" ventilation system for each operational area of PF-4; these new systems use shrouded probe technology to provide state-of-the-art sampling for the nuclear facility. These new systems went operational for the 2018 calendar year, but are still being treated as R&D systems until we can establish a full maintenance and inspection program for the new sample systems and until a full comparison can be made to evaluate these new systems with the current stack monitoring systems.

Building 2 of TA-55 houses associated support facilities for operations in PF-4, including the radiological sample analysis laboratory. Operations from this laboratory are tracked as part of LANL's non-monitored source program.

TA-55-400: Building 400 at TA-55 is the Radiological Laboratory / Utility / Office Building (RLUOB), the first phase of the project to replace capabilities in TA-3 Building 29. A Congressionally approved line-item project may eventually include a nuclear facility to replace remaining capabilities

[8] LA-UR-18-26283, rev.1. Application for Pre-Construction Approval under 40 CFR 61 Subparts A and H for Venting of Flanged Tritium Waste Containers (FTWCs) at TA-54. Submitted to EPA Region 6 by memo EPC-DO-18-281, August 8, 2018. Approved by EPA Region 6 on September 25, 2018. Due to project delays, this Application was re-submitted in May 2019.

from TA-3 Building 29. Design of a CMR Replacement (CMRR) nuclear facility was underway but the Administration announced its intent to delay construction for at least five years. RLUOB is designed to perform materials characterization work and actinide chemistry research. While the RLUOB stack became active in November 2012, radiological operations did not commence until late 2014. Although this facility was originally constructed as a radiological facility, DOE has commissioned a review to evaluate increasing the operations level to that of a limited-scope Category 3 nuclear facility. This move was approved[9] in July 2018, allowing RLUOB to maintain inventory of up to 400 grams of Pu-239 or equivalent. At the present time, RLUOB is still operating under the EPA-approved throughput of up to 3000 grams of Pu-239 equivalent per year, approved in the original Pre-Construction Application. Prior to any operational changes beyond this level, LANL will evaluate the implications of such a change and will communicate appropriately with EPA when the final decisions are made.

Section II. Air Emissions Data

61.94(b)(4) Point Sources

Monitored and non-monitored release points at LANL are listed in Table 1. The point sources are identified using an eight-digit identification number for each exhaust stack (StackID); the first two digits represent the LANL technical area, the next four the building, and the last two digits the stack number. Also listed in Table 1 are type, number, and efficiency of the emissions control systems used on the release points. More information on these emissions control systems appear below.

LANL has 48 buildings in which radiological operations can take place and be vented through a point source, as listed in Table 1. In these buildings, there are 27 sources that are monitored ("major") point sources and 58 non-monitored ("minor") release points. Under 40 CFR 61.93(b)(4)(i), sampling of these minor release points is not required because each release point has a potential effective dose equivalent (PEDE) of less than 0.1 mrem/year at the critical receptor. However, in order to verify that emissions from non-monitored point sources remain low, LANL conducts periodic confirmatory measurements in the form of the annual *Radioactive Materials Usage Survey for Unmonitored Point Sources*.[10] The purpose of this survey is to collect and analyze radioactive materials usage and process

[9] United States Department of Energy, "Finding of No Significant Impact for the Environmental Assessment of Proposed Changes for Analytical Chemistry and Materials Characterization at the Radiological Laboratory/Utility/Office Building, Los Alamos National Laboratory, Los Alamos, New Mexico," July 25, 2018.

[10] R. Sturgeon, "2018 Radioactive Materials Usage Survey for Unmonitored Point Sources." EPC-CP internal memo, pending final publication at time of report development.

information for the non-monitored point sources at LANL. In alternate years, the survey is expanded to review monitored sources and ensure proper emissions monitoring is taking place at these facilities. For 2018, the most significant minor sources were analyzed, the evaluated sources were those designated "Tier III" whose potential emissions exceed 0.001 millirem but fall below the 0.1 millirem per year threshold at which continuous monitoring is required. For 2017, all minor sources were evaluated; Tier III sources as above and Tier IV sources which have potential emissions below 0.001 millirem per year. A full description of which sources are analyzed in each year is included in the RMUS report.

The distance between each of the release points and the critical receptor for each facility is provided in Table 1. The critical receptor can be a residence, school, business, or office. In this report, the critical receptor is defined as the member of the public (at a fixed structure location) most significantly impacted by a given release point. Air dispersion modeling is taken into account to determine the most critical receptor location; the nearest public receptor is not always the critical receptor if the nearest location is upwind from a source.

In compliance with Appendix D to 40 CFR 61, we have used data collected from the facilities in conjunction with engineering calculations and other methods to develop conservative emissions estimates from non-monitored point sources. Estimated PEDEs are calculated by modeling these emissions estimates using EPA-approved CAP88 dose modeling software. Version 4 of CAP88-PC has been used to determine offsite dose consequence from LANL emissions sources since 2014. The Laboratory has established administrative requirements to evaluate all potentially new sources. These requirements are established for the review of new Laboratory activities and projects, ensuring that air quality regulatory requirements will be met before the activity or project begins.[11]

Non-point Sources

There are a variety of non-point sources within the 111 km^2 of land (43 square miles) occupied by LANL. Non-point sources can occur as diffuse or large-area sources or as leaks or fugitive emissions from facilities. Examples of non-point sources of airborne radionuclides include surface impoundments, evaporative tanks and basins, shallow land burial sites, open burn sites, live firing sites, outfalls, container storage areas, unvented buildings, waste treatment areas, solid waste management units, and tanks. Additionally, LANL considers a building to be a non-point source if there is no active process exhaust

[11] LANL Environmental Protection and Compliance Division – Compliance Programs Group, Functional Series Document, "Air Quality Reviews," EPC-CP-FSD-002, October 2017. Replaced LANL procedure of the same name, P408, in 2017.

(e.g., no fume hood, glove box, etc.); no forced air exhaust to the environment; or is equipped with only standard heating/ventilating/air conditioning systems (e.g., occupational comfort cooling or heating).

LANL determines the potential impacts of non-point sources by measuring air concentrations of significant radionuclides at ambient air-sampling sites at locations of public receptors surrounding the Laboratory and at selected locations on Laboratory property. This network of ambient air sampling stations is called Airnet. The LANL Airnet system was originally approved for use in monitoring LANL's non-point radioactive air emission sources in 1996 and reaffirmed as part of the Airnet system re-evaluation in 2015.[12] New activities are reviewed to ensure adequate Airnet coverage exists for new sources, or if additional stations are required. As described in the 2015 annual report, modifications to LANL's ambient air monitoring program were proposed in 2014, and approved by EPA Region 6 in early 2015. This updates the siting of Airnet stations to reflect current LANL operations and the locations of public receptors and also updates other operational parameters of the Airnet program. The overall intent and general operational scope of the program remains unchanged, to measure air concentrations of significant LANL radionuclides at public locations.

Radionuclide Emissions

Table 2 lists the radionuclides released from monitored point sources, along with the annual emissions in curies for each radionuclide. For a source with no detectable emissions, the term "none" appears in the radionuclide column. Extensive notes appear at the end of the source term table. A map showing the general locations of the facilities continuously monitored for radionuclide emissions is shown in Figure 3.

[12] U.S. Environmental Protection Agency emailed approval, George Brozowski to Tony Grieggs, February 18, 2015. Approval and concurrence of proposals in "Update to the Ambient Air Sampling Network (Airnet) at LANL," document ID LA-UR-15-21001, transmitted to EPA via memo ENV-DO-15-0046, February 17, 2015.

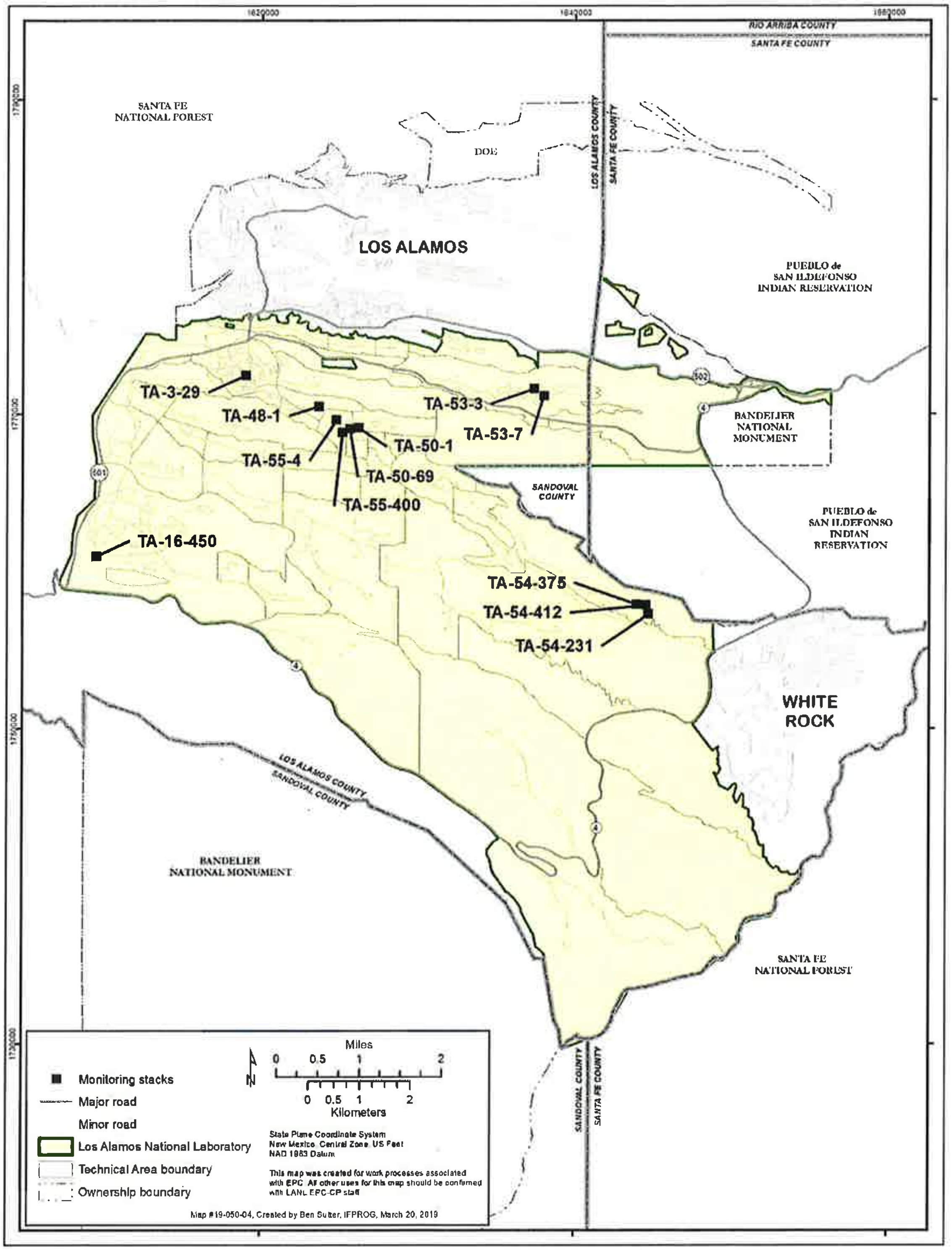

Figure 3. Location of facilities with continuously operated stack-sampling systems for airborne radionuclide emissions.

Emission Controls

The most common type of filtration for emission control purposes at LANL is the high-efficiency particulate air (HEPA) filter, as noted in Table 1. HEPA filters are constructed of sub-micrometer glass fibers that are pressed and glued into a compact, paper-like, pleated media.

At LANL, each HEPA filter system that is credited for performance on active operational sources is tested at least once every 12 months. The nominal performance criteria for HEPA filter systems are a maximum penetration of 5×10^{-4} for one stage (99.95% removal) and maximum penetration of 2.5×10^{-7} for two stages in series (99.999925% removal). In these quoted values, filter penetration and percent removal are defined below.

$$\text{Penetration} = (\text{downstream concentration}) / (\text{upstream concentration})$$

$$\text{Removal} = [1 - (\text{penetration})] * 100\%$$

Note that in recent years, changes to HEPA filter testing methods and equipment at LANL have resulted in limitations in the ability to certify very high levels of aerosol removal. Therefore, LANL is now only certifying filters at the "single stage" penetration & removal criteria, regardless of the number of filter bank stages installed at the facility. Table 1 lists the number of filter banks installed at the facility and the nominal removal efficiency, not the certified tested removal efficiency.

Other types of filters used in ventilation systems are Aerosol 95; RIGA-Flow 220, 221, and 222; and FARR 30/30. These units are typically used as pre-filters in HEPA filtration systems. These filters are significantly less efficient than HEPA filters and are typically used for removing gross particulate matter larger than 5 μm.

The above-mentioned filters are only effective for particles. When the contaminant of concern is in the form of a gas or vapors, activated charcoal beds can be used. Charcoal beds collect the gas contaminant through an adsorption process in which the gas comes in contact with the charcoal and adheres directly to the surface of the charcoal. The charcoal can be coated with different types of materials to make the adsorption process more efficient for specific types of contaminants. Typically, charcoal beds achieve an efficiency of 98% capture. Efficiency of a charcoal filter can vary with different chemical pollutants in the exhaust air stream. Activated charcoal filters are currently in use at one stack, the hot cell stack (ES-7) at TA-48-1.

Tritium effluent controls are generally composed of a catalytic reactor and a molecular sieve bed. Tritium-contaminated effluent is passed through a catalyst that converts gas-phase or elemental tritium (HT) into tritiated water vapor (HTO). This HTO is then collected as water on a molecular sieve bed.

This process can be repeated until the tritium level is at, or below, the desired level. The effluent is then vented through the stack.

A delay system is used to reduce some of the short-lived radionuclides generated by activation at LANSCE. Emissions from a concentrated source of activated gas (the off-gas system for the 1L target cooling system) are directed into a long transport line. The transit time through this system allows short-lived gaseous radionuclides to decay before being emitted from the stack. This delay system is used to provide a reduction in radionuclide emissions from the 1L target area exhausted through stack 53000702.

Compliance with Maintenance and Inspection Requirements under the Revised Rad-NESHAP

The 2003 revisions to 40 CFR 61 Subpart H established several inspection and maintenance requirements for monitored stacks. These requirements are based on American National Standards Institute/Health Physics Society N13.1-1999, *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities*. Annual visual inspection of particulate monitoring systems is a component of the Laboratory's program to comply with these requirements.[13] In 2018, we performed stack inspections and/or cleaning operations on 27 monitored stacks.

Cleaning activities were performed on 8 of these systems in 2018 to remove trace particulate within the sample systems noted in the previous year. Of the inspections performed in 2018, sample systems on 4 stacks showed evidence of particulate deposition in the sampler or transport line. These systems will be addressed as part of the current year's sampler inspection cycle, along with systems which are cleaned each year. In 2018, no radiological material was measured on inspection or cleaning equipment. Therefore, no additions to the source term are required from this pathway for this year.

For the tritium sampling systems at TA-16 and TA-55, a visual inspection of the system piping was conducted in 2018. Internal sampler inspections with a borescope is not possible on tritium systems. Particulate deposition on these gas/vapor systems are not critical to sampler performance as long as flow is maintained through the sampler.

Section III. Dose Assessment

61.94(b)(7) Description of Dose Calculations

Effective dose equivalent (EDE or dose) calculations for point sources, unmonitored point sources, and non-point gaseous activation products from LANSCE were performed with the CAP88 code.

[13] Procedure ENV-ES-QP-142, "Inspecting Stack Sampling Systems." Results documented in internal memo, Richard Sturgeon to David Fuehne, Dec 21, 2018.

LANL had used the original mainframe version of CAP88 (version 0) through the 2005 report; CAP88 version 3 was used for 2006-2012 reports; and CAP88 version 4 was adopted for use in the 2013 annual report and all subsequent dose assessments. Verification of the CAP88 code is performed by running the EPA test case before performing the dose calculations.

Development of Source Term

The 2018 source term for radionuclide air emissions is fully documented in a LANL internal memorandum[14] and full explanations of methods are provided in that document. A summary appears below.

Tritium emissions

Tritium emissions from the Laboratory's tritium facilities are measured using a collection device known as a bubbler. This device enables the Laboratory to determine not only the total amount of tritium released but also if it is in the chemical form of elemental tritium (HT) or tritiated water vapor (HTO). The bubbler operates by pulling a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that is part of a water molecule (tritium oxide, or HTO). After bubbling through these three vials, essentially all water vapor (including HTO) is removed from the air, leaving elemental tritium, or HT. The sample air stream is then passed through a palladium catalyst that converts the HT to HTO. The sample is pulled through three additional vials containing ethylene glycol, which collects the newly formed HTO. The amount of HTO and HT is determined by analyzing the ethylene glycol for the presence of tritium using liquid scintillation counting. Since different chemical forms are collected in different vials, the system will discriminate HTO vapor from HT gas, allowing separate dose assessment with CAP88-PC versions 3 and 4. Bubblers are in use to measure tritium emissions from TA-16 (WETF) and TA-55 PF-4's south stack, 55000416.

Tritium emissions from LANSCE do not require monitoring under 40 CFR 61.93(b)(4)(i). The primary source for airborne tritium emissions at LANSCE is activation of water vapor in air and activation and subsequent evaporation of water in the cooling system of beam targets. Because of the low contribution of tritium to the off-site dose at LANSCE, formal monitoring for tritium was discontinued

[14] Memo EPC-DO-19-150, "2018 Annual Source Term for Radionuclide Air Emissions," David P. Fuehne to Rad-NESHAP Project Files. May 28, 2018.

after July 2001. Tritium emissions at LANSCE continue to be calculated based on the rate of generation measured in 2001, using representative parameters.

In past years, very low-level tritium operations also took place from TA-55 Building 4, in the northern portion of the building exhausted through ES-15. While the southern stack ES-16 is monitored for tritium emissions, at ES-15, tritium is not a pollutant of concern and falls well below the ten percent of the PEDE criteria at which monitoring is required. Similarly, the WCRR waste repackaging facility at TA-50-69 occasionally processes waste drums containing trace amounts of tritium. No tritium operations took place in either of these facilities in 2018. If tritium operations had occurred at these facilities, the potential upper bound limit of emissions would be included in the Table 2 source term. Calculations and user estimations would be used to determine this upper bound, adequate for a non-significant radionuclide at these sources.

Radioactive particulate emissions

Emissions of radioactive particulate matter, generated by operations at facilities such as the CMR facility (TA-3-29) and the Plutonium Facility (TA-55), are sampled using a glass-fiber filter. A continuous sample of stack air is pulled through the filter, where small particles of radioactive material are captured. These samples are analyzed weekly using gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, LANL composites these stack samples for subsequent analysis at an off-site laboratory. These composite samples are analyzed to determine the total activity of materials such as ^{234}U, ^{235}U, ^{238}U, ^{238}Pu, ^{239}Pu, and ^{241}Am. These semiannual composite data are then combined with estimates of sampling losses and stack and sample flows to calculate emissions. Short-lived progeny are assumed to be emitted in secular equilibrium with their long-lived parent nuclides. For example, we measure for the presence of ^{90}Sr and assume that an equal amount of the progeny ^{90}Y is emitted as well.

Vapor form emissions

Vapor emissions, generated by LANSCE operations and by hot-cell activities at TA-3-29 and TA-48, are sampled using an activated charcoal filter cartridge. A continuous sample of stack air is pulled through a charcoal filter upon which vaporous emissions of radionuclides are adsorbed. The amount and identity of the radionuclide(s) present on the filter are determined through the use of gamma spectroscopy. These analytical results are used in conjunction with facility information to calculate emissions. Examples of radionuclides of this type include ^{68}Ge and ^{76}Br.

Gaseous mixed activation products (GMAP)

GMAP emissions resulting from activities at LANSCE are measured using real-time monitoring data. A continuously-operating air flow-through ionization chamber is operated in series with a high-purity germanium (HPGe) detector and data acquisition system. A sample of stack air is pulled through the ionization chamber to measure the total amount of radioactivity in the sample, while the specific radioisotope composition is identified through the use of gamma spectroscopy and decay curve analysis with the HPGe system. This information is then used to calculate emissions. Radionuclides of this type include ^{11}C, ^{13}N, and ^{15}O.

Summary of Input Parameters

The effective dose equivalent to potential receptors was calculated for all radioactive air emissions from sampled LANL point sources. The radionuclide emissions (source term) for the monitored point sources are provided in Table 2. Input parameters for these point sources are provided in Table 3. The geographic locations of the release points, given in New Mexico State Plane coordinates, are provided in Table 4. Table 5 shows the distance and direction from each of the LANL monitored stacks to the LANL-wide highest receptor location for this report year. Other site-specific parameters used in CAP88 and the sources of these data are provided in Table 6.

LANL operates an on-site network of meteorological monitoring towers. Data gathered by the towers are summarized and formatted for input into the CAP88 program. For 2018, data from three different towers were used for the air-dispersion modeling; the tower data that are most representative of the release point are applied. Copies of the meteorological data files used for the annual 2018 dose assessments are provided in Appendix A at the end of this report. There are three files included in Appendix A, detailing wind speed and direction information from the TA-6, TA-53, and TA-54 meteorology towers.

The Laboratory also enters population array data into the CAP88 program. The data file represents a 16-sector polar-type array, with 20 radial distances for each sector. Population arrays are developed for each release point using U.S. Census data, and the population files used at LANL were updated in late 2012 using 2010 census data[15]. Different population files are used depending on where the dominant LANL source is located in a given year. A full description of the population dose assessment calculation appears later in this document. Note this population dose does not include

[15] LA-UR-12-22801, "Population Files for use with CAP88 at Los Alamos. M. McNaughton and B. Brock. January 2012.

potential emissions from non-monitored sources but is solely based on measured emissions in Table 2. For agricultural array input, LANL is currently using the default values in CAP88 for the state of New Mexico. For conservatism, the "local" option is used for the "food source" determination.

Public Receptors

Compliance with the annual dose standard is determined by calculating the highest EDE to any member of the public at any off-site point where there is a residence, school, business, or office. The Laboratory routinely evaluates public areas to assure that any new residence, school, business, or office is identified for the EDE calculation. As per EPA guidance,[16] personnel that work in leased space within the boundaries of the Laboratory are not considered members of the public for the EDE determination. Personnel of this type are considered to be subcontractors to DOE, similar to security guards and maintenance workers.

Point Source Emissions Modeling

The CAP88 version 4 program was used to calculate doses from both the monitored and unmonitored point sources at LANL. The CAP88 program uses on-site meteorological data to calculate atmospheric dispersion and transport of the radioactive effluents. CAP88 version 4 includes all radionuclides for which there are dose conversion factors in the EPA's Federal Guidance Reports.[17,18,19] In 2018, all monitored radionuclides were included in CAP88 for the monitored stacks source term. Some minor sources (non-monitored stacks) used exotic radionuclides (usually very short-lived) not in the CAP88 version 4 library; these were addressed per LANL procedure.[20] Updates of "non-CAP88

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[16] Frank Marcinowski, Acting Director, Radiation Protection Division, "Criteria to Determine Whether a Leased Facility at Department of Energy (DOE) is Subject to Subpart H," Office of Radiation and Indoor Air, U. S. Environmental Protection Agency, March 26, 2001.

[17] K. F. Eckerman, A. B. Wolbarst, and A. C. B. Richardson, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Office of Radiation Programs, U.S. Environmental Protection Agency, Washington, D.C., 1988.

[18] K. F. Eckerman and J. C. Ryman, Federal Guidance Report No. 12, "External Exposures to Radionuclides in Air, Water, and Soil Exposure-to-Dose Coefficients for General Application," U.S. Environmental Protection Agency, Washington, D.C., 1993

[19] K. F. Eckerman, R. W. Leggett, C. B. Nelson, J. S. Puskin, and A. C. B. Richardson, Federal Guidance Report No. 13, "Cancer Risk Coefficients for Environmental Exposure to Radionuclides," U.S. Environmental Protection Agency, Washington, D.C., 1999

[20] LANL procedure EPC-ES-TP-512, R4, "Dose Factors for Non-CAP88 Radionuclides," December 2018.

nuclides" for monitored and non-monitored point sources were described in previous memos to EPA Region 6, most recently in a 2011 memo.[21]

LANSCE Diffuse / Fugitive Emission Modeling

Some of the GMAP created at the accelerator target cells or at other accelerator beam line locations migrate into room air and into the environment. These diffuse or fugitive sources are continuously monitored throughout the beam-operating period. In 2018, approximately 82 Ci of ^{11}C and 34 Ci of ^{41}Ar were released from LANSCE as fugitive emissions. These sources were modeled as area sources using CAP88 version 4, and the specific input parameters are provided in Table 8. The dominant fugitive emissions source was the Building 984 source.

Environmental Data Used for Non-point Source Emission Estimation

The Airnet system of ambient air sampling stations is shown in Figure 4 (Los Alamos County only) and Figure 5 (Los Alamos and Northern New Mexico). These stations represent compliance stations and some LANL facility surveillance stations.

The net annual average ambient concentration of airborne radionuclides measured at air sampling stations is calculated by subtracting an appropriate background concentration value.[22] The net concentration at each air sampler is converted to the annual effective dose equivalent (EDE) using Table 2 of Appendix E of 40 CFR 61 and applying the valid assumption that each Table 2 value is equivalent to 10 mrem/year from all appropriate exposure pathways (100% occupancy assumed at the respective location). Dose assessment results from each air sampler are given in Table 9 of this document. The operational performance and analytical completeness of each air sampler is provided in Table 10.

[21] WES-EDA-11-0023, "Documentation of Dose Calculation Methods for Radionuclides Not Included in CAP88 Version 3." M. McNaughton memo to G. Brozowski, December 21, 2011.
[22] LANL procedure EPC-CP-QP-502 R5, "Air Pathway Dose Assessment," July 2018.

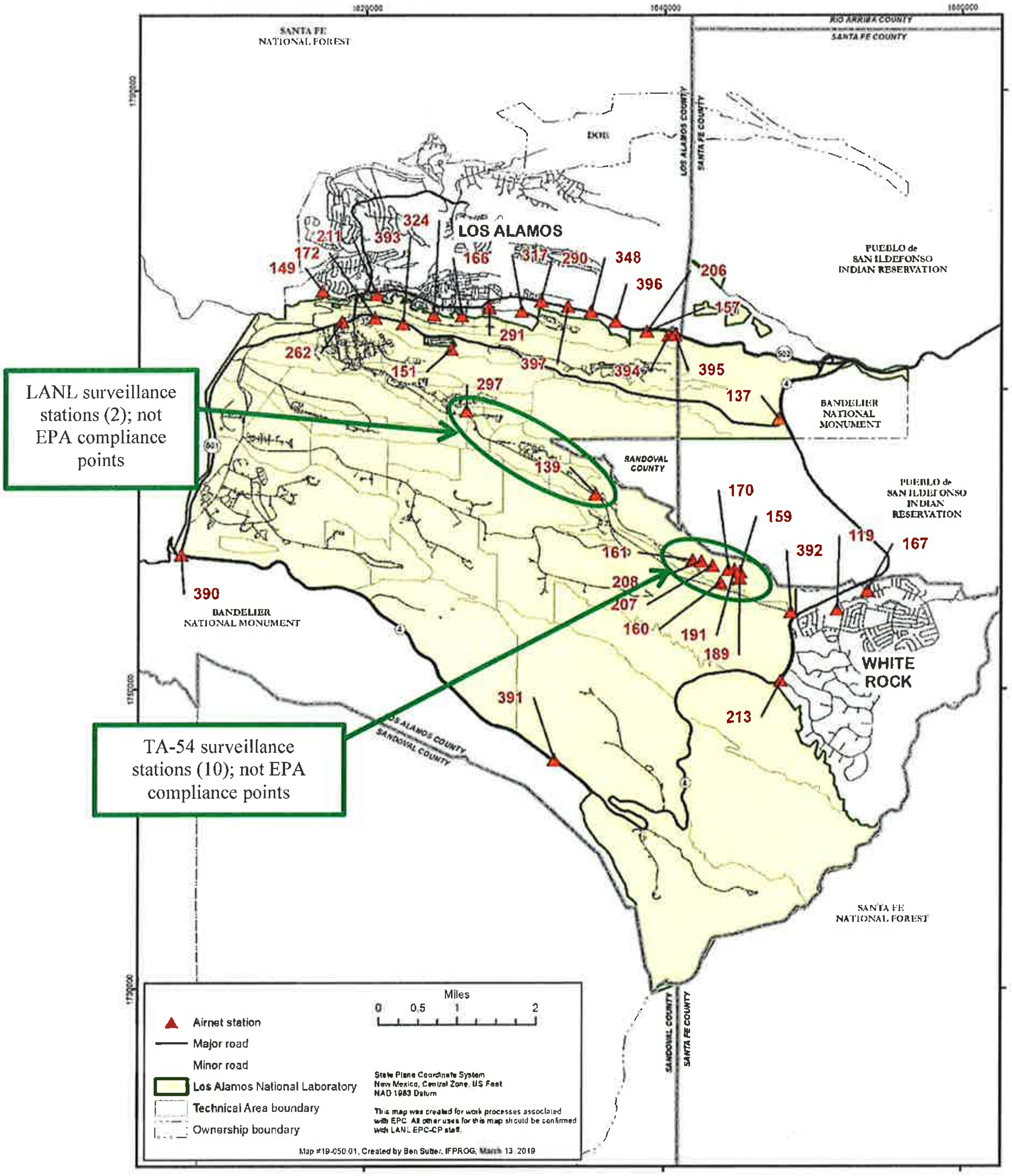

Figure 4. Locations of air sampling stations around Los Alamos County. Stations that are not EPA Compliance points are indicated.

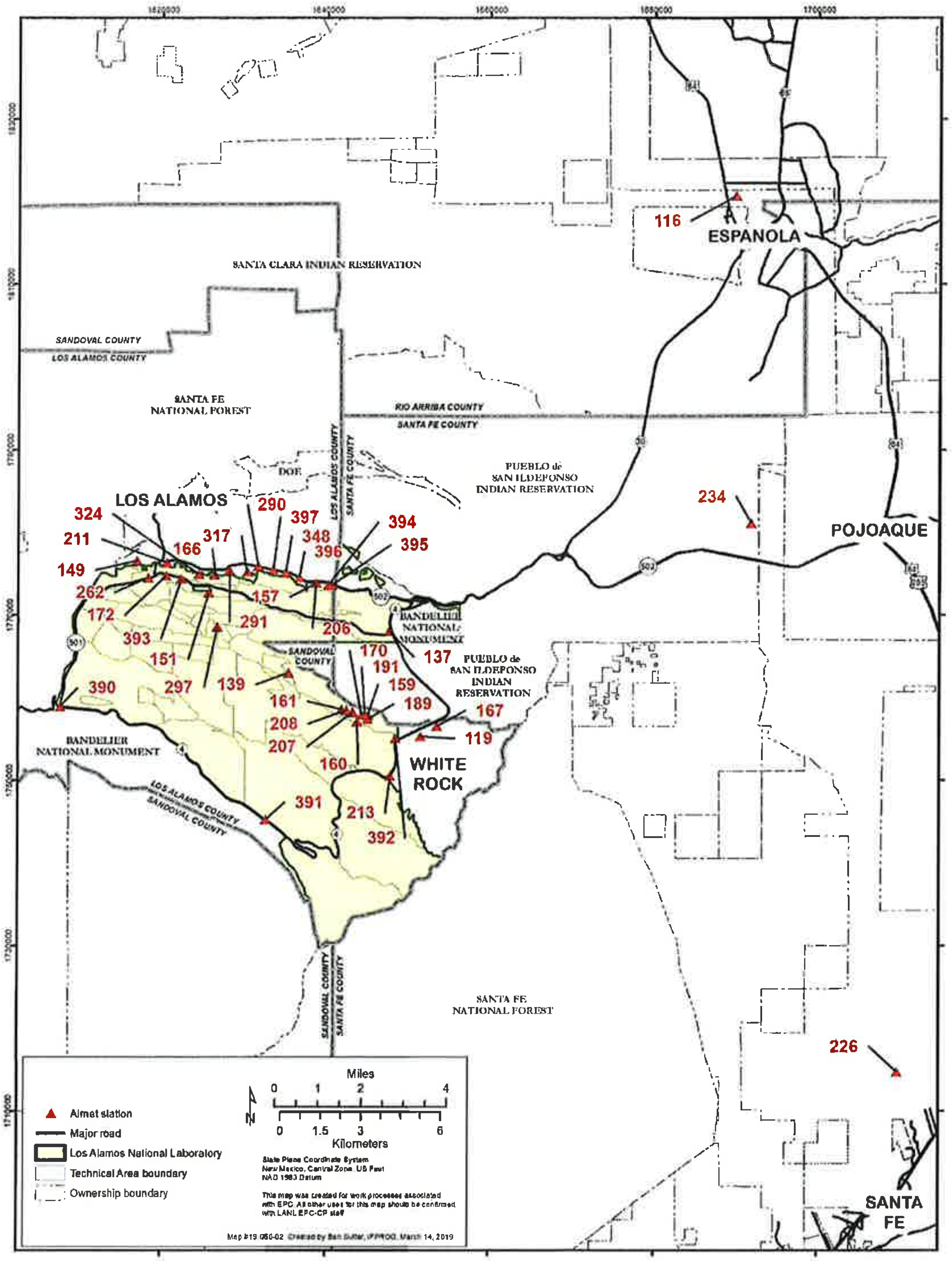

Figure 5. Locations of air sampling stations around Los Alamos County and also regional Northern New Mexico stations. Not all are EPA Compliance points; some are for facility environmental surveillance. See Figure 5 for more details.

LANSCE Monthly Assessments

The Laboratory evaluates and reports the dose from short-lived radioactive gases released from LANSCE exhaust stack 53000702 on a monthly basis. This is performed to track and trend the emissions throughout the year and identify any operational issues that may need addressing. The doses from these monthly emissions are calculated with CAP88 using actual meteorology for the month and are shown in Table 11. For 2018, the Laboratory also evaluated this stack's total gaseous emissions for the year in a single CAP88 run and compared the results to the sum of monthly values. When evaluated to the LANSCE facility critical receptor at East Gate, the sum of monthly doses is a dose of 0.0536 mrem, and the annual total single analysis result is 0.0540 millirem, a difference of 0.7% (see Table 11 for details). These differences are due to meteorological parameters modeled by monthly runs (e.g., wind speed and direction, atmospheric mixing height) for the specific months of interest as opposed to those factors representing the entire calendar year. For conservatism, LANL uses the maximum value of either the annual evaluation or the sum of the monthly doses for EPA reported doses.

Because there was a potential for the White Rock Pajarito Road receptor, the Entrada Drive receptor, and the East Gate Tank receptor to be the MEI in 2018 (see the next section), this same comparison was repeated for stack GMAP emissions from 53000702 to those locations. When emissions are modeled to the White Rock Pajarito Road receptor, the sum of monthly analyses is 0.000469 millirem and a single annual analysis is equal to 0.000433 millirem. This difference is 8.1%. When emissions are modeled to the Entrada Drive receptor, the sum of monthly analyses is equal to 0.0151 millirem and a single annual analysis is equal to 0.0155 millirem. This difference is 2.7%. Finally, when emissions are modeled to the East Gate Tank receptor, the sum of monthly analyses is 0.0323 millirem and a single annual analysis is equal to 0.0312 millirem. This difference is 3.6%.

Aside from these monthly assessments of GMAP emissions from 53000702, all other CAP88 assessments are performed using annual source term and annual meteorological inputs. The summary of off-site dose analyses from the LANSCE facility to the facility critical receptors at East Gate and Entrada Drive are included in Table 11.

Highest EDE Determination

Historically, the maximally exposed individual (MEI) location has been at 2470 East Road, usually referred to as "East Gate." The dose was primarily a result of LANSCE stack emissions. Emissions reduction efforts in place at LANSCE since 2005 have resulted in very low off-site doses from these stacks. Emissions were further reduced by improvements made in the new beam

Target/Moderator/Reflector System (TMRS) that was installed in early 2010. Because the LANSCE emissions are so low in recent years, the location of the MEI is not as readily apparent as in the past and requires more detailed evaluation, as follows.

The dose from LANSCE stack and diffuse emissions can be significant contributors at receptor locations at East Gate and at Entrada Drive, but much less so at other possible MEI locations. To evaluate different MEI locations, LANL first calculates doses from LANSCE stacks and diffuse emissions sources to the East Gate and Entrada Drive receptor locations. These CAP88 sums are then combined with the ambient air doses measured at Airnet stations at these locations to establish dose comparison points. The doses measured at other Airnet locations are examined to see if there are any sites which could be candidates to match or exceed these dose comparison points at East Gate and Entrada Drive. CAP88 is used to model the LANSCE facility emissions and other significant stack sources to these locations, and the results are shown in Table 11. The Airnet measured dose is added to the stack modeled doses to determine the total LANL dose consequence at each location, keeping in mind that the MEI location must be a school, business, residence, or office.

In 2018, the dominant Airnet measured dose location was Station 392, located at the bottom of Pajarito Road in White Rock. This site's Airnet dose and dose from LANSCE stacks modeled to Station 392 were then compared to the dose comparison points from three receptors near LANSCE. Results are shown below, with doses in millirem.

- East Gate: LANSCE = 0.155 mrem; Airnet #157 = 0.0092 mrem; Total = 0.164 mrem
- Entrada Drive: LANSCE = 0.070 mrem; Airnet #396 = 0.027 mrem; Total = 0.096 mrem
- East Gate Tank: LANSCE = 0.082 mrem; Airnet #395 = 0.041 mrem; Total = 0.123 mrem
- WR Pajarito Road: LANSCE = 0.0017 mrem; Airnet #392 = 0.096 mrem; Total = 0.098 mrem

For the East Gate location, the maximum Airnet dose of two stations at that site is used. For 2018, the primary East Gate station (#157) is the conservative value at 0.0092 mrem as opposed to the East Gate Duplicate station (#206) which measured 0.00055 mrem in 2018.

Based on the list above, the MEI for 2018 is East Gate. Emissions from the remaining monitored stacks were modeled from their sources to this location. The total MEI dose at this location is shown in Table 12. The overall dose is the sum of the following sources:

- emissions from all LANL stacks (major sources), modeled by CAP88 to this location;
- emissions from LANSCE diffuse sources, modeled by CAP88 to this location;
- the dose measured at the nearby Airnet station; and

- the sum of all minor sources potential emissions, modeled by CAP88 to each source's critical receptor.

61.92 Compliance Assessment

The highest EDE to any member of the public at any off-site point where there is a residence, school, or business was 0.35 mrem for radionuclides released by LANL in 2018. This dose was calculated by adding up (1) the dose contributions for each of the monitored point sources at LANL, modeled to the MEI location; (2) the diffuse/fugitive gaseous activation products from LANSCE modeled to this MEI location; (3) the dose measured by the ambient air sampler in the vicinity of the public receptor location; and (4) the potential dose contribution of 0.188 mrem from non-monitored stacks (minor sources). Because the emissions estimates from non-monitored stacks do not account for pollution control systems, the actual dose from these minor sources is significantly less than the reported potential dose value. Table 12 of this report provides the compliance assessment summary, broken down by stack. The location of the Maximally Exposed Individual (MEI) from LANL operations is a business at 2470 East Road, locally known as East Gate, and close to Airnet Stations 157 and 206. The EDE for this year is well below the EPA limit of 10 millirem per year.

Section IV. Construction and Modifications

61.94(b)(8) Constructions, Modifications, and 61.96 Activity Relocations

A brief description of construction and modifications that were completed in the past year and for which the requirement to apply for approval to construct or modify was waived under section 61.96 is typically provided in this section. Items below are identified with their Air Quality Review (AQR) number or Permit Requirements Identification (PR-ID) number for tracking. There was only one activity that met this requirement in 2018.

<u>Air Quality Review 17A-0005-V00 – Actinide Radiochemistry Operations at TA-53-0015</u>

This project involved the preparation and testing of depleted uranium samples, using a high-speed counter-current chromatography instrument. This instrument uses liquid extraction techniques to enable chemical separation of analytes and subsequent analysis.

These operations commenced in March 2018, using depleted uranium in small quantities, 10 grams per sample. Later in the year, the operations increased to 100 grams of depleted uranium per sample. A bounding estimate of processed amounts and potential emissions indicated off-site doses will be less than 1.2E-5 millirem per year. This activity is included in the Radioactive Materials Usage Survey as a minor source of radionuclide emissions.

Section V. Additional Information

This section is provided pursuant to DOE guidance and is not required by Subpart H reporting requirements.

Unplanned Releases

There was an unplanned release from LANSCE in 2018, as mentioned earlier in this report. The LANSCE facility operates experimental stations along different accelerator beam lines. The Ultra-Cold Neutron (UCN) experiment hall is in TA-53, building 3, Sector N. The Proton Radiography (P-Rad) experiment hall is in TA-53, building 3, Sector P. Ion beams to these experimental areas come down a common tunnel, dubbed "Line X," which then splits into Line B and Line C. Line B delivers beam to the UCN experiment area in Sector N while Line C delivers beam to P-Rad in Sector P. The P-Rad operations have a dedicated fan system in Sector P, which provides supply and exhaust air to Sector P for personnel comfort and equipment cooling. At times, these fan systems operate while beam is being delivered down Line B to the UCN experiment. This dedicated system in Sector P is not a monitored exhaust point.

The main monitored stack for building 3 has exhaust vents in Line B, as well as Sectors N and P, which provide a slight negative pressure on the area. These vents to the monitored stack act to control radioactive air buildup in the Line B tunnel, but do not provide significant air changes in these areas.

In October 2018, it was noted that the fan on the Sector P dedicated exhaust system had lost a belt, causing it to fail. The supply fan for Sector P was still operating, however. This resulted in positive pressure within Sector P, extending down the Line C and Line B beam tunnels, into Sector N. This positive pressure resulted in radioactive air migration from Line B into Sector N, the UCN experiment hall. This radioactive air was released as a fugitive (diffuse) emission from Sector N.

This issue was identified late in October 2018. Experimenters in Sector N had noticed an elevated background reading on their experiments. Also late in the month, scientists in Environmental

Protection & Compliance monitoring the NEWNET system[23] noticed very slight elevated gamma readings in off-site radiation monitors, indicating a plume of emissions from LANSCE. It took some time to determine the common cause of these issues, but the situation was resolved in early November.

To address these issues, we first installed air pressure relays which will turn off beam operations if there is a similar pressure imbalance between Line B and Sector N (the UCN hall) or Line B and Sector P (P-Rad). This corrective action was installed in November 2018. During the maintenance outage in 2019, a ventilation barrier is being installed in Line B to prevent air migration from one experimental area to the next. This has been installed, prior to beam operations in June 2019.

To determine emissions from this 2018 event, we looked at the emissions from the monitored stack in at TA-53 building 3; this stack exhausts the areas affected by this issue along with other areas. We assumed the entire emissions source term for September, October, and November 2018 was also emitted as a diffuse emission from Sector N. We corrected these emissions for decay of these short-lived radioactive gases to account for air migration times from these experimental areas to the main stack. The end result of this calculated emission agreed with data measured off-site at the NEWNET station. The emissions are included in this report as a diffuse emission from source 53DIF03N.

Environmental Monitoring

In addition to the Airnet monitors identified in this report, additional environmental monitoring stations are operated at LANL and include several environmental monitoring stations located near the LANSCE boundary inhabited by the public. Measurement systems at these and other stations include thermoluminescent dosimeters, continuously operated air samplers, and in-situ high-pressure ion chambers. The combination of these measurement systems allows for monitoring of radionuclide air concentrations and the radiation exposure rate. Results for air sampling associated with NESHAP compliance are included in this document, while results for all monitoring data are published in the Annual Site Environmental Report for compliance with DOE Orders.

[23] NEWNET is the Neighborhood Environmental Watch NETwork, a system of ion chambers and wind stations around LANL which can help determine public exposure to gamma-emitting radionuclides emitted from LANL or other locations. NEWNET is publicly available at https://envweb.lanl.gov/newnet/

Other Supplemental Information

The following information is included for completeness, but not directly required under 40 CFR 61 Subpart H regulations.

- 80-km collective effective (population) dose for 2018 airborne releases: **0.09 person-rem.**
  To calculate this dose, the source term (Table 2) from all Laboratory monitored stacks and LANSCE diffuse sources were modeled in two CAP88 files from each emissions source. The source term from all TA-53 sources was modeled as being emitted from the 53000702 stack using the population array for TA-53 sources; the total dose in this evaluation is 0.0559 person-rem. The remainder of the LANL monitored stacks source term was modeled as being emitted from the 48000107 stack using the general LANL-area population file, resulting in a dose of 0.0341 person-rem. All other CAP88 parameters were identical to the individual dose calculations for each stack. The population dose from the two CAP88 analyses are summed together to obtain the reported population dose above.
- Compliance with Subparts Q and T of 40 CFR 61—Radon-222 Emissions.
  These regulations apply to ^{222}Rn emissions from DOE storage/disposal facilities that contain by-product material. "By-product material" is the tailings or wastes produced by the extraction or concentration of uranium from ore. Although this regulation targets uranium mills, LANL has likely stored small amounts of by-product material used in experiments in the TA-54 low-level waste facility, MDA G; this practice makes the Laboratory subject to this regulation. Subject facilities cannot exceed an emissions rate of 20 pCi/m^2 s of ^{222}Rn. In 1993 and 1994, LANL conducted a study to characterize emissions from the MDA G disposal site.[24] This study showed an average emission rate of 0.14 pCi/m^2 s for MDA G. The performance assessment for MDA G has determined that there will not be a significant increase in ^{222}Rn emissions in the future.[25]
- Potential to exceed 0.1 mrem from LANL sources of ^{222}Rn or ^{220}Rn emissions: not applicable at LANL.
- Status of compliance with EPA effluent monitoring requirements as of June 3, 1996: LANL is in compliance with these requirements as put forth in the Federal Facility Compliance Agreement.

The following pages contain Tables 1 through 12 as referenced in the previous sections.

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[24] Bart Eklund, "Measurements of Emission Fluxes from Technical Area 54, Areas G and L," Radian Corporation report, Austin, Texas, 1995

[25] Los Alamos National Laboratory, "Performance Assessment and Composite Analysis for Los Alamos National Laboratory Materials Disposal Area G," LA-UR-97-85, 1997.

Table 1. 40-61.94(b)(4-5) Release Point Data

Stack ID	Location TA-Bldg	Effluent Controls	# of Effluent Controls*	Control Efficiency*	Monitored Stack?	Nearest Receptor (m)	Receptor Direction
03002913	TA-03-29-1	unknown	0	0%		859	NNE
03002914	TA-03-29-2	HEPA	2*	99.95% each*	X	733	NE
03002915	TA-03-29-2	HEPA	2*	99.95% each*	X	734	NE
03002919	TA-03-29-3	Aerosol 95	1	80%	X	838	NNE
03002920	TA-03-29-3	Aerosol 95	1	80%	X	837	NNE
03002923	TA-03-29-4	FARR 30/30	1	20%	X	618	NNW
03002924	TA-03-29-4	FARR 30/30	1	20%	X	618	NNW
03002928	TA-03-29-5	HEPA	2*	99.95% each*	X	938	NE
03002929	TA-03-29-5	HEPA	2*	99.95% each*	X	939	NE
03002932	TA-03-29-7	HEPA	2*	99.95% each*	X	858	NNE
03002933	TA-03-29-7	HEPA	2*	99.95% each*	X	857	NNE
03002944	TA-03-29-9	RIGA-Flow	1	80%	X	939	NNE
03002945	TA-03-29-9	RIGA-Flow	1	80%	X	941	NNE
03002946	TA-03-29-9	RIGA-Flow	1	80%	X	940	NNE
03003299	TA-03-32	unknown	0	0%		641	NNE
03003400	TA-03-34	none	0	0%		668	NNE
03006601	TA-03-66	none	0	0%		695	N
03006602	TA-03-66	none	0	0%		709	N
03006603	TA-03-66	none	0	0%		708	N
03006604	TA-03-66	none	0	0%		708	N
03006605	TA-03-66	none	0	0%		714	N
03006606	TA-03-66	none	0	0%		670	N
03006626	TA-03-66	HEPA	1	99.95%		618	N
03006654	TA-03-66	HEPA	1	99.95%		665	N
03006699	TA-03-66	none	0	0%		669	N
03010225	TA-03-102	HEPA	1	99.95%		772	N
03014101	TA-03-141	None	0	0%		658	NNE
03169800	TA-03-1698	none	0	0%		717	NNE
09002103	TA-09-21	none	0	0%		3044	NE
09003499	TA-09-34	none	0	0%		2879	NE

Table 1 (Continued) Release Point Data

Stack ID	Location TA-Bldg	Effluent Controls	# of Effluent Controls	Control Efficiency*	Monitored Stack?	Nearest Receptor (m)	Receptor Direction
15028599	TA-15-285	HEPA	1	99.95%		3719	NNE
15053401	TA-15-534	HEPA	1	99.95%		3250	NNE
16020299	TA-16-202	none	0	0%		1185	S
16020599	TA-16-205	none	0	0%		752	SSW
16045005	TA-16-450	none	0	0%	X	772	SSW
35000200	TA-35-2	none	0	0%		1294	NNW
35021305	TA-35-213	none	0	0%		1010	N
35045599	TA-35-455	Unknown	0	0%		1055	N
36000104	TA-36-1	unknown	0	0%		5379	SE
39006999	TA-39-69	unknown	0	0%		3071	ENE
43000100	TA-43-1	none	0	0%		122	NNE
46002499	TA-46-24	none	0	0%		2887	N
46003100	TA-46-31	none	0	0%		2792	N
46015405	TA-46-154	none	0	0%		2769	N
46015899	TA-46-158	none	0	0%		3053	N
46020099	TA-46-200	none	0	0%		2743	N
48000107	TA-48-1	HEPA/Charcoal	2*	99.95% each*	X	754	NNE
48000111	TA-48-1	none	0	0%		874	NNE
48000115	TA-48-1	none	0	0%		764	NNE
48000135	TA-48-1	none	0	0%		797	NNE
48000145	TA-48-1	none	0	0%		884	NNE
48000154	TA-48-1	HEPA	2*	99.95% each*	X	756	NNE
48000160	TA-48-1	HEPA	1	99.95%	X	769	NNE
48000166	TA-48-1	HEPA	2*	99.95% each*		867	NNE
48000167	TA-48-1	HEPA	2*	99.95% each*		897	NNE
48000168	TA-48-1	none	0	0%		874	NNE
48000171	TA-48-1	none	0	0%		883	N
48004500	TA-48-45	none	0	0%		742	N

Table 1 (Continued) Release Point Data

Stack ID	Location TA-Bldg	Effluent Controls	# of Effluent Controls	Control Efficiency*	Monitored Stack?	Nearest Receptor (m)	Receptor Direction
50000102	TA-50-1	HEPA	1	99.95% each*	X	1185	N
50000299	TA-50-2	none	0	0%		1215	N
50006901	TA-50-69	HEPA	1	99.95%		1199	N
50006902	TA-50-69	HEPA	1	99.95%		1188	N
50006903	TA-50-69	HEPA	2*	99.95% each*	X	1187	N
50006999	TA-50-69	unknown	0	0%		1190	N
50025799	TA-50-257	none	0	0%		1201	N
53000116	TA-53-1	unknown	0	0%		1061	NE
53000303	TA-53-3	HEPA	1	99.95%	X	806	NNE
53000702	TA-53-7	HEPA	1	99.95%	X	957	NNE
53000799	TA-53-7	None	0	0%		926	NNE
53001599	TA-53-15	none	0	0%		1096	NNE
53001899	TA-53-18	none	0	0%		1019	NNE
53036899	TA-53-368	none	0	0%		1000	NNE
53098401	TA-53-984	none	0	0%		965	NNE
53109099	TA-53-1090	none	0	0%		1009	NNE
53130299	TA-53-1302	None	0	0%		1024	NNE
54003399	TA-54-33	None	0	0%		2058	ESE
54022499	TA-54-224	None	0	0%		2246	ESE
54023199	TA-54-231	HEPA	1	99.95%	X	1480	SE
54037599	TA-54-375	HEPA	1	99.95%	X	1783	SE
54041299	TA-54-412	HEPA	1	99.95%	X	1660	SE
54100199	TA-54-1001	None	0	0%		4999	ESE
55000201	TA-55-2	None	0	0%		1111	NNE
55000415	TA-55-4	HEPA	4*	99.95% each*	X	1018	NNE
55000416	TA-55-4	HEPA	4*	99.95% each*	X	1091	NNE
55040099	TA-55-400	HEPA	1	99.95%	X	1318	NNE
59000100	TA-59-1	None	1	0%		1104	N

Notes: * As described in the main text, LANL only tests HEPA filter banks down to 0.0005 penetration & 99.95% removal.
This table reports the actual number of installed HEPA bank stages and nominal/design removal efficiencies, not tested efficiencies.

Table 2. 40-61.94(b)(7) User Supplied Data—Radionuclide Emissions

StackID	Nuclide	Annual Emission (Ci)
03002914	Pu-238	3.77E-09
03002914	U-234	4.90E-08
03002915	U-235	1.36E-08
03002915	U-238	1.44E-08
03002915	Pa-234m (p)	1.44E-08
03002915	Th-234 (p)	1.44E-08
03002919	Am-241	7.84E-08
03002919	Pu-238	5.26E-08
03002919	Pu-239	3.02E-07
03002920	Am-241	6.56E-09
03002920	Pu-238	1.22E-09
03002920	Pu-239	1.48E-08
03002920	U-234	1.94E-08
03002923	Pu-238	6.44E-08
03002923	Pu-239	5.99E-09
03002923	Th-230	2.97E-08
03002923	U-234	1.79E-06
03002923	U-235	7.12E-08
03002923	U-238	6.96E-08
03002923	Pa-234m (p)	6.96E-08
03002923	Th-234 (p)	6.96E-08
03002924	Am-241	9.82E-09
03002924	Pu-238	3.61E-08
03002924	Pu-239	4.34E-08
03002924	Sr-90	2.14E-08
03002924	Y-90 (p)	2.14E-08
03002924	Th-228	1.70E-08
03002924	U-234	8.97E-07
03002928	Pu-238	7.30E-09
03002928	Pu-239	3.55E-09
03002928	Th-230	2.26E-08
03002929	U-234	4.15E-08
03002932	U-238	6.21E-08
03002932	Pa-234m (p)	6.21E-08
03002932	Th-234 (p)	6.21E-08
03002933	None	0.00E+00
03002944	Am-241	9.05E-09
03002944	U-234	2.11E-08
03002945	Am-241	1.68E-08
03002946	Pu-239	2.03E-08
03002946	U-234	6.02E-08
16045005	H-3(Gas)	6.52E+00
16045005	H-3(HTO)	1.74E+01
48000107	As-73	6.03E-06
48000107	As-74	3.97E-07
48000107	Br-77	1.59E-04
48000107	Ge-68	3.26E-03
48000107	Ga-68 (p)	3.26E-03
48000107	Hg-197m	5.65E-05
48000107	Hg-197 (p)	5.65E-05
48000107	Se-75	1.61E-05
48000154	Pu-238	4.19E-10
48000154	U-234	3.78E-09
48000154	U-235	2.44E-09
48000160	As-73	5.49E-08
48000160	Br-77	3.85E-06
48000160	Ge-68	8.68E-07
48000160	Ga-68 (p)	8.68E-07
48000160	Se-75	2.62E-05
50000102	Pu-238	1.46E-08
50000102	Pu-239	1.64E-08
50000102	U-234	8.41E-08
50000102	U-235	5.74E-08
50006903	Pu-238	2.87E-11
50006903	U-234	6.73E-10
53000303	Ar-41	2.18E+00
53000303	Be-7	4.27E-05
53000303	Br-77	3.14E-06
53000303	Br-82	7.22E-05
53000303	C-11	5.24E+01
53000303	H-3(HTO)	1.87E+01
53000303	Na-24	3.78E-06
53000702	Ar-41	1.22E+01
53000702	Br-76	8.96E-05
53000702	Br-82	2.45E-03
53000702	C-10	4.18E-01
53000702	C-11	8.39E+01
53000702	H-3(HTO)	4.67E+00

StackID	Nuclide	Annual Emission (Ci)
53000702	Hg-197m	1.72E-04
53000702	Hg-197 (p)	1.72E-04
53000702	N-13	3.39E+01
53000702	N-16	6.85E-01
53000702	Na-24	5.25E-05
53000702	O-14	8.05E-01
53000702	O-15	4.87E+01
54023199	Sr-90	1.87E-09
54023199	Y-90 (p)	1.87E-09
54023199	U-234	4.81E-09
54037599	None	0.00E+00
54041299	U-238	2.40E-09
54041299	Pa-234m (p)	2.40E-09
54041299	Th-234 (p)	2.40E-09
55000415	Pu-238	2.75E-10
55000415	Pu-239	3.34E-10
55000415	Th-230	2.07E-09
55000415	U-234	1.89E-08

StackID	Nuclide	Annual Emission (Ci)
55000415	U-235	4.10E-09
55000416	H-3(Gas)	3.12E-01
55000416	H-3(HTO)	1.16E+00
55000416	Pu-239	1.47E-09
55000416	Th-230	4.98E-09
55000416	U-234	2.09E-08
55000416	U-235	1.02E-08
55040099	U-234	5.28E-08
Diffuse (Non-Point) Emissions		
53DIF1LS	Ar-41	7.79E-01
53DIF1LS	C-11	1.87E+01
53DIF3SY	Ar-41	1.15E+00
53DIF3SY	C-11	2.75E+01
53DIF984	Ar-41	3.05E+01
53DIF984	C-11	5.38E+00
53DIF03N	Ar-41	1.28E+00
53DIF03N	C-11	3.07E+01

Table 2 Notes:

Stacks at the Chemistry & Metallurgy Research (CMR) facility identified as 03002914 through 03002933 are recorded in the RADAIR database as N3002914 through N3002933, to indicate measurements made with the New sampling systems, effective 2001.

Starting in 2006, particulate emissions from TA-55 stacks 55000415 and 55000416 are measured from new sample systems, which consist of four independent sample systems on each stack. The four samplers are identified as 5500415A, -B, -C, and -D; and 5500416A, -B, -C, and -D. Stack emissions data reported in this table represent average emission values measured from these four samplers. In the RADAIR database, these average emissions are given the stack ID 5500415X and 5500416X, with the "X" indicating the calculated average value from the four samples. The emissions of tritium (H-3, both HT and HTO forms) from the ES-16 stack use a different sample system, and references remain unchanged in the database.

Starting in 2018, particulate emissions from TA-55 stacks 55000415 and 55000416 are also measured from basement samplers in addition to the rooftop sample systems. There are four zones that are being sampled from and are identified as 55410015, 55420015, 55430016, and 55440016. The RADAIR database then sums the emissions from the sample systems for each stack and gives the resulting emissions the stack ID 5500415Z and 5500416Z, where "Z" indicates the calculated value from the sampled zones. We are currently treating the "Z" sample systems as R&D systems, pending formal comparison between the basement samplers and rooftop samplers. Until these new sample systems can be proven to report representative emissions similar to the rooftop samplers, the results of 5500415X and 5500416X will be reported.

Radionuclides with the designator "(p)" are short-lived progeny in secular equilibrium with their parent radionuclide; e.g., "(p) Ga-68" (progeny) is in equilibrium with "Ge-68" (parent).

The term "None" in the Nuclide column indicates that there were no detectable emissions from this source for this calendar year.

Stack 16045005 (ES-5) exhausts buildings TA-16-450 and TA-16-205. The ES-5 stack sampler was not operational, so reported emissions are measured by the sampler in the exhaust duct from 16-205, designated 16020504. That sampler captures all emissions from the facility, as 16-450 operations have not commenced.

Non-point emissions sources 53DIF3SY, 53DIF1LS, and 53DIF984 are separated from the main source term table because they are addressed in different sections of the annual emissions report.

53DIF03N is included with the Diffuse Emissions Sources because it is a non-point emission source. However, 53DIF03N is included as the result of an unplanned release. This location is not tracked since operations are not normally run in this location during beam operation. The results shown here are hand-calculated results based on measured emissions from stack 53000303, corrected for decay.

Table 3. 40-61.94(b)(7) User-Supplied Data—Monitored Stack Parameters				
StackID	**Height (m)**	**Diameter (m)**	**Exit Velocity (m/s)**	**Nearest Meteorological Tower**
03002914	15.9	1.07	6.8	TA-6
03002915	15.9	1.05	11.1	TA-6
03002919	15.9	1.07	18.7	TA-6
03002920	15.9	1.07	0.0*	TA-6
03002923	15.9	1.07	16.6	TA-6
03002924	15.9	1.06	0.0*	TA-6
03002928	15.9	1.05	18.4	TA-6
03002929	15.9	1.07	16.0	TA-6
03002932	15.9	1.07	13.9	TA-6
03002933	15.9	1.06	15.0	TA-6
03002944	16.5	1.52	1.3	TA-6
03002945	16.5	1.52	7.0	TA-6
03002946	16.5	1.88	10.5	TA-6
16045005	18.3	1.18	13.5	TA-6
48000107	13.4	0.30	18.8	TA-6
48000154	13.1	0.91	5.2	TA-6
48000160	12.4	0.38	8.1	TA-6
50000102	15.5	1.82	12.4	TA-6
50006903	10.5	0.31	5.6	TA-6
53000303	33.5	0.91	10.1	TA-53
53000702	13.1	0.91	8.6	TA-53
54023199	0.61	0.61	0 vertical 9.3 horizontal	TA-54
54037599	0.76	0.90	0 vertical 7.5 horizontal	TA-54
54041299	0.61	0.61	0 vertical 1.6 horizontal	TA-54
55000415	9.5	0.93	7.8	TA-6
55000416	9.5	0.94	10.2	TA-6
55040099	26.0	1.88	10.3	TA-6

* Exhaust fans operated only intermittently for stacks 03002920 and 03002924. Emissions were calculated using 3-year historical maximum flow rates, and doses modeled using 0.0 m/s stack velocity. These two assumptions result in conservative off-site doses.

Table 4. 61.94(b)(7) User-Supplied Data—Monitored Stack Parameters—NM State Plane Coordinates (NAD '83)

StackID	Easting	Northing
03002914	1,619,176	1,772,806
03002915	1,619,171	1,772,805
03002919	1,619,252	1,772,350
03002920	1,619,257	1,772,352
03002923	1,618,691	1,772,719
03002924	1,618,686	1,772,718
03002928	1,618,774	1,772,265
03002929	1,618,767	1,772,265
03002932	1,619,268	1,772,267
03002933	1,619,272	1,772,269
03002944	1,618,987	1,772,121
03002945	1,618,977	1,772,120
03002946	1,618,982	1,772,121
16045005	1,609,426	1,760,910
48000107	1,623,591	1,770,693
48000154	1,623,744	1,770,650
48000160	1,623,613	1,770,638
50000102	1,626,157	1,769,086
50006903	1,625,579	1,769,065
53000303	1,638,133	1,771,546
53000702	1,638,057	1,771,054
54023199	1,644,758	1,757,255
54037599	1,644,020	1,757,838
54041299	1,644,568	1,757,946
55000415	1,624,870	1,769,742
55000416	1,624,675	1,769,550
55040099	1,624,983	1,768,754

Table 5. 40-61.94(b)(7) User-Supplied Data—Highest Off-Site Dose Location for Monitored Release Points

StackID	Associated Meteorological Tower	Distance to LANL Highest Dose Location (m)	Direction to LANL Highest Dose Location
03002914	TA-06	6002	E
03002915	TA-06	6003	E
03002919	TA-06	5990	E
03002920	TA-06	5988	E
03002923	TA-06	6151	E
03002924	TA-06	6153	E
03002928	TA-06	6137	E
03002929	TA-06	6139	E
03002932	TA-06	5987	E
03002933	TA-06	5986	E
03002944	TA-06	6077	E
03002945	TA-06	6080	E
03002946	TA-06	6078	E
16045005	TA-06	9821	ENE
48000107	TA-06	4758	ENE
48000154	TA-06	4715	ENE
48000160	TA-06	4755	ENE
50000102	TA-06	4152	ENE
50006903	TA-06	4319	ENE
53000303	TA-53	806	NNE
53000702	TA-53	957	NNE
54023199	TA-54	5444	NNW
54037599	TA-54	5203	NNW
54041299	TA-54	5220	NNW
55000415	TA-06	4456	ENE
55000416	TA-06	4530	ENE
55040099	TA-06	4511	ENE

Table 6. 40-61.94(b)(7) User-Supplied Data—Other Input Parameters

Description	Value	Units	CAP88 Variable Name (source code/V0 identifiers)
Annual rainfall rate	45	cm/y	RR
Lid height*	1600	m	LIPO
Annual ambient temperature	9	deg C	TA
Absolute humidity	5.5	g/m^3	
E-vertical temperature gradient	0.02	K/m	TG
F-vertical temperature gradient	0.035	K/m	TG
G-vertical temperature gradient	0.035	K/m	TG
Food supply fraction - local vegetables	1		F1V
Food supply fraction - vegetable regional	0		F2V
Food supply fraction - vegetable imported	0		F3V
Food supply fraction - meat local	1		F1B
Food supply fraction - meat regional	0		F2B
Food supply fraction - meat imported	0		F3B
Food supply fraction - milk local	1		F1M
Food supply fraction - milk regional	0		F2M
Food supply fraction - milk imported	0		F3M
Ground surface roughness factor	0.5		GSCFAC

* Note for the monthly LANSCE runs, the atmospheric lid height used in each monthly run uses the average value for each specific month. The annual average of 1600 meters is used for full-year runs. Procedure 501 has full details[26].

[26] LANL Procedure EPC-ES-TP-501, "Dose Assessment Using CAP88."

Table 7. 40-61.94(b)(7) User-Supplied Data—Population Arrays
Estimated 2010 Population within 80 km of Los Alamos National Laboratory (revised 2012)

	Table 7.1 Distances from Los Alamos – "LANL Area Source"												
Direction (sector)	250	750	1500	2500	3500	4500	7500	15000	25000	35000	45000	55000	70000
N	4	13	89	231	274	514	1350	16	103	1077	0	945	641
NNW	4	17	102	173	375	282	1299	7	22	291	0	0	528
NW	8	4	58	146	218	266	1030	2	27	56	821	0	1153
WNW	4	19	34	65	115	142	281	0	35	41	0	0	3305
W	0	0	22	26	25	30	18	14	119	575	0	135	257
WSW	0	0	0	0	0	0	2	14	1	696	0	4673	0
SW	0	0	0	0	0	0	5	5	0	0	0	3965	0
SSW	0	0	0	0	0	0	36	6	1766	2392	5674	4591	100236
S	0	0	0	0	0	0	20	9	31	274	0	0	6060
SSE	0	0	0	0	0	0	765	51	406	6811	3328	0	0
SE	0	0	0	0	0	0	5764	1	1318	88346	9870	218	6
ESE	0	0	0	0	0	0	36	14	868	10461	0	803	2430
E	0	0	22	26	25	30	18	1915	5002	511	588	1	598
ENE	4	19	34	65	115	142	281	2600	5419	4317	194	1128	1752
NE	8	4	58	146	218	266	1030	1314	17067	2878	1604	1597	3527
NNE	4	17	102	173	375	282	1299	15	2739	479	3483	0	58

Table 7.2
Distances from Los Alamos – "TA-53 Source"

Direction (sector)	250	750	1500	2500	3500	4500	7500	15000	25000	35000	45000	55000	70000
N	0	50	0	157	184	183	0	16	103	1077	0	945	641
NNW	0	0	0	566	276	397	50	7	22	291	0	0	528
NW	0	0	0	312	647	786	1336	2	27	56	821	0	1153
WNW	0	0	0	38	959	1047	5063	0	35	41	0	0	3305
W	0	0	0	0	161	169	15	14	119	575	0	135	257
WSW	0	0	0	0	0	0	2	14	1	696	0	4673	0
SW	0	0	0	0	0	0	5	5	0	0	0	3965	0
SSW	0	0	0	0	0	0	36	6	1766	2392	5674	4591	100236
S	0	0	0	0	0	0	20	9	31	274	0	0	6060
SSE	0	0	0	0	0	0	765	51	406	6811	3328	0	0
SE	0	0	0	0	0	0	5764	1	1318	88346	9870	218	6
ESE	0	0	0	0	0	0	36	14	868	10461	0	803	2430
E	0	0	0	0	0	0	3	1915	5002	511	588	1	598
ENE	0	0	0	0	0	0	0	2600	5419	4317	194	1128	1752
NE	0	0	0	0	0	0	0	1314	17067	2878	1604	1597	3527
NNE	0	0	0	0	0	0	0	15	2739	479	3483	0	58

Table 8. 40-61.94(b)(7) User-Supplied Data Modeling Parameters for LANL Non-Point Sources

Non-Point Source	Area of Source (m^2)	Height of Source (m)	Radionuclide	Emission (Ci)
TA-53-1L Service Area Stack ID = 53DIF1LS	1.0	0	^{41}Ar ^{11}C	7.79E-01 1.87E+01
TA-53 Beam Switchyard StackID = 53DIF3SY	484	0	^{41}Ar ^{11}C	1.15E+00 2.75E+01
TA-53 Building 984 Stack ID = 53DIF984	200	3.0	^{41}Ar ^{11}C	3.05E+01 5.38E+00
TA-53 Area B, Sector N Stack ID = 53DIF03N	625	0	^{41}Ar ^{11}C	1.28E+00 3.07E+01

Non-Point Source	Distance to Nearest Receptor Location [Critical receptor] (meters)	Direction to Nearest Receptor Location [Critical Receptor]
TA-53-1L Service Area Stack ID = 53DIF1LS	943	NNE
TA-53 Beam Switchyard StackID = 53DIF3SY	774	NNE
TA-53 Building 984 Stack ID = 53DIF984	973	NNE
TA-53 Area B, Sector N Stack ID = 53DIF03N	705	NNE

Non-Point Source	Distance to LANL Maximum Dose Location (m)	Direction to LANL Maximum Dose Location
TA-53-1L Service Area Stack ID = 53DIF1LS	943	NNE
TA-53 Beam Switchyard StackID = 53DIF3SY	774	NNE
TA-53 Building 984 Stack ID = 53DIF984	1220	NE
TA-53 Area B, Sector N Stack ID = 53DIF03N	705	NNE

Table 9. Environmental Data—Compliance Stations
2018 Effective Dose Equivalent measured at air sampling locations around LANL (net millirem)

Site	Site Name	H-3	Am-241	Pu-238	Pu-239	U-234	U-235	U-238	Total (mrem)
119	WR Rocket Park	0.02	0.00	0.00	0.00	0.01	0.00	0.02	0.04
137	Well PM-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
149	48th St	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
151	Royal Crest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
157	East Gate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**
166	McDonalds	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
167	WR Fire Station	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.03
172	LA County Landfill	0.00	0.01	-0.01	0.00	0.03	0.00	0.03	0.06
206	East Gate Backup	0.00	0.01	-0.01	0.00	0.00	0.00	0.00	0.00
211	LA Hospital	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
213	WR Monte Rey	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
262	TA-3 Research Park	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.02
290	Airport Road	0.00	0.00	0.01	0.00	0.01	0.00	0.01	0.03
291	Knights of Columbus	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01
317	DP Road	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.02
324	Hillside 138	0.00	0.00	0.00	0.03	0.01	0.00	0.00	0.04
348	Mid-Runway	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.02
390	West Gate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
391	Bandelier Gate	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01
392	WR Pajarito Road	0.02	0.00	0.00	0.00	0.02	0.00	0.05	**0.10**
393	Transit Mix	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.05
394	East Gate Shed	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
395	East Gate Tank	0.01	0.00	0.00	0.01	0.01	0.00	0.01	**0.04**
396	Co-Op Market (Entrada)	0.00	0.00	0.00	0.00	0.01	0.00	0.01	**0.03**
397	West Runway	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02

Highlights indicate sites that were evaluated for the maximally exposed individual (MEI) location.

Results have been rounded to two digits in this table for clarity.

Table 10. Environmental Data—Compliance Stations
2018 Sampler Operational Completeness and Analytical Completeness

Site #	Site Name	% Run Time	H-3	Am-241	Pu-238	Pu-239	U-234	U-235	U-238
119	WR Rocket Park	99.1%	100%	100%	100%	100%	100%	100%	100%
137	Well PM-1	101.1%	100%	100%	100%	100%	100%	100%	100%
149	48th St	99.6%	100%	100%	100%	100%	100%	100%	100%
151	Royal Crest	100.3%	100%	100%	100%	100%	100%	100%	100%
157	East Gate	100.9%	100%	100%	100%	100%	100%	100%	100%
166	McDonalds	100.9%	100%	100%	100%	100%	100%	100%	100%
167	WR Fire Station	100.6%	100%	100%	100%	100%	100%	100%	100%
172	LA County Landfill	100.4%	100%	100%	100%	100%	100%	100%	100%
206	East Gate Backup	100.0%	100%	100%	100%	100%	100%	100%	100%
211	LA Hospital	100.9%	100%	100%	100%	100%	100%	100%	100%
213	WR Monte Rey	100.2%	100%	100%	100%	100%	100%	100%	100%
262	TA-3 Research Park	100.9%	100%	100%	100%	100%	100%	100%	100%
290	Airport Road	100.9%	100%	100%	100%	100%	100%	100%	100%
291	Knights of Columbus	100.9%	100%	100%	100%	100%	100%	100%	100%
317	DP Road	100.9%	100%	100%	100%	100%	100%	100%	100%
324	Hillside 138	100.8%	100%	100%	100%	100%	100%	100%	100%
348	Mid-Runway	100.9%	100%	100%	100%	100%	100%	100%	100%
390	West Gate	100.5%	100%	100%	100%	100%	100%	100%	100%
391	Bandelier Gate	100.5%	100%	100%	100%	100%	100%	100%	100%
392	WR Pajarito Road	100.5%	100%	100%	100%	100%	100%	100%	100%
393	Transit Mix	100.7%	100%	100%	100%	100%	100%	100%	100%
394	East Gate Shed	100.9%	100%	100%	100%	100%	100%	100%	100%
395	East Gate Tank	101.0%	100%	100%	100%	100%	100%	100%	100%
396	Co-Op Market	100.9%	100%	100%	100%	100%	100%	100%	100%
397	West Runway	100.9%	100%	100%	100%	100%	100%	100%	100%

Table 11. LANSCE Monthly Assessments, Comparison with Annual Analyses, and Facility Dose Summary

Description	StackID	Dose at @ East Gate (mrem)	Dose at @ Entrada Drive (mrem)
LANSCE stack January GMAP	53000702	3.30E-03	1.30E-03
LANSCE stack February GMAP	53000702	None	None
LANSCE stack March GMAP	53000702	None	None
LANSCE stack April GMAP	53000702	None	None
LANSCE stack May GMAP	53000702	1.17E-03	2.68E-04
LANSCE stack June GMAP	53000702	3.37E-03	1.17E-03
LANSCE stack July GMAP	53000702	3.13E-03	9.47E-04
LANSCE stack August GMAP	53000702	8.61E-03	2.44E-03
LANSCE stack September GMAP	53000702	5.81E-03	1.47E-03
LANSCE stack October GMAP	53000702	1.20E-02	2.72E-03
LANSCE stack November GMAP	53000702	1.23E-02	3.40E-03
LANSCE stack December GMAP	53000702	3.95E-03	1.37E-03
Sum of monthly GMAP runs for this stack	53000702	5.36E-02	1.51E-02
GMAP single annual analysis for this stack	53000702	**5.40E-02**	**1.55E-02**
Difference, sum of monthly vs. annual analyses:		*0.7%*	*2.7%*
To be conservative, the **maximum value** of the either the single annual analysis or the sum of monthly analyses will be used for all further reporting of GMAP emissions from the main LANSCE stack 53000702. Reporting values are highlighted above for each receptor location.			
SUMMARY OF LANSCE FACILITY DOSE		**Dose at @ East Gate (mrem)**	**Dose at @ Entrada Drive (mrem)**
LANSCE stack	53000303	1.41E-02	6.12E-03
LANSCE stack GMAP (see above)	53000702	**5.40E-02**	**1.55E-02**
LANSCE stack PVAP	53000702	1.90E-03	6.51E-04
LANSCE Diffuse/Fugitive Emissions – 1L Service Area	53DIF1LS	1.13E-02	3.20E-03
LANSCE Diffuse/Fugitive Emissions – Beam Switchyard	53DIF3SY	2.48E-02	6.92E-03
LANSCE Diffuse/Fugitive Emissions – Building 984	53DIF984	1.53E-02	2.84E-02
LANSCE Diffuse/Fugitive Emissions – Area B, Sector N	53DIF03N	3.33E-02	8.99E-03
2018 LANSCE facility summary:		1.55E-01	6.98E-02

GMAP = Gaseous Mixed Activation products; short-lived radioactive gases (e.g., C-11, O-15, Ar-41).

PVAP = Particulate & Vapor Activation Products (e.g., Na-24, Br-76).

Note: All CAP88 analyses above are annual assessments, with the exception of the monthly GMAP analyses for stack 53000702, as described.

Note: For completeness, the "Summary" portion of this table is reproduced in Table 12, next page, for both the individual facility critical receptors for each source and for the LANL Maximally Exposed Individual (MEI) receptor.

Note: 53DIF984 is about 750 meters west of the other sources at TA-53. As such, the critical receptor for Building 984 is not the East Gate complex, but rather a business on Entrada Drive. Doses in the above table are shown to each location.

Table 12. 40-61.92 Highest Effective Dose Equivalent Summary All LANL Sources			
Description	StackID	Dose for Facility Critical Receptor (mrem)	Dose at LANL MEI receptor – East Gate (mrem)
CMR Stack – Wing 2	03002914	5.46E-07	4.09E-08
CMR Stack – Wing 2	03002915	1.60E-07	1.35E-08
CMR Stack – Wing 3	03002919	2.39E-05	2.37E-06
CMR Stack – Wing 3	03002920	2.05E-06	1.48E-07
CMR Stack – Wing 4	03002923	1.17E-05	1.10E-06
CMR Stack – Wing 4	03002924	1.29E-05	9.69E-07
CMR Stack – Wing 5	03002928	8.30E-07	9.41E-08
CMR Stack – Wing 5	03002929	1.33E-07	1.46E-08
CMR Stack – Wing 7	03002932	2.78E-07	2.74E-08
CMR Stack – Wing 7	03002933	No Emissions	No Emissions
CMR Stack – Wing 9	03002944	6.39E-07	5.59E-08
CMR Stack – Wing 9	03002945	8.23E-07	8.38E-08
CMR Stack – Wing 9	03002946	1.20E-06	1.34E-07
WETF Stack – new	16045005	2.86E-03	4.37E-04
Radiochemistry Stack	48000107	3.25E-03	3.62E-04
Radiochemistry Stack	48000154	8.25E-08	8.71E-09
Radiochemistry Stack	48000160	1.31E-05	1.37E-06
Waste Management Stack	50000102	1.51E-06	4.04E-07
Waste Management Stack	50006903	3.70E-09	8.41E-10
LANSCE-Stack	53000303	1.41E-02	1.41E-02
LANSCE-Stack – GMAP (See Note 1)	53000702	5.40E-02	5.40E-02
LANSCE- Annual – Partic/Vapor	53000702	1.90E-03	1.90E-03
LANSCE Fugitive – 1L Service Area	53DIF1LS	1.13E-02	1.13E-02
LANSCE Fugitive – Beam Switch Yard	53DIF3SY	2.48E-02	2.48E-02
LANSCE Fugitive – Building 984	53DIF984	2.84E-02	1.53E-02
LANSCE Fugitive – Area B, Sector N	53DIF03N	3.33E-02	3.33E-02
Waste Processing Stack	54023199	3.20E-08	5.01E-10
Waste Processing Stack	54037599	No Emissions	No Emissions
Waste Processing Stack	54041299	1.03E-08	2.06E-10
Plutonium Facility Stack	55000415	1.94E-07	3.16E-08
Plutonium Facility Stack	55000416	4.46E-04	8.71E-05
Radiological Lab/Utility/Office Bldg	55040099	8.71E-08	2.48E-08
Minor Sources (Unmonitored) (See Note 2)	99000000	1.88E-01	1.88E-01
Air Sampler Net Dose @ MEI location	99000010	N/A	9.20E-03
Total dose to off-site maximally exposed individual (mrem)			**0.353 = mrem** **Reporting value: 0.35 mrem**

Note 1: As described in Table 11, the reporting value for GMAP emissions from 53000702 is the maximum value of either the annual GMAP dose assessment or the sum of monthly GMAP dose assessments. Data for TA-53 sources here is reproduced from Table 11.

Note 2: The doses above for Minor Sources (Unmonitored) reflect calculated potential emissions, with no credit for emission controls. The summed dose from all minor sources to each source's MEI is shown in this table.

61.94(b)(9) Certification

Owner – Department of Energy Office – National Nuclear Security Administration

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

Signature: WSGoodrum Date: 6-25-19

Owner: William S. Goodrum
Manager
National Nuclear Security Administration
Los Alamos Field Office
U. S. Department of Energy

61.94(b)(9) Certification

Owner – Department of Energy Office – Environmental Management

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

Signature: Douglas E. Hintze Date: 17 June 2019
Owner: Douglas E. Hintze
Manager
Environmental Management
Los Alamos Field Office
U. S. Department of Energy

61.94(b)(9) Certification

Operator – Triad National Security, LLC

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

Signature: _______________ Date: 11 June 19

Operator: Michael W. Hazen
Associate Laboratory Director
Environment, Safety, Health, Quality, Safeguards, and Security
Triad National Security, LLC
Los Alamos National Laboratory

61.94(b)(9) Certification

Operator – Newport News Nuclear BWXT-Los Alamos, LLC (N3B)

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. See 18 U.S.C. 1001.

Signature: ______________________ Date: 6/6/2019
Operator: Frazer Lockhart
Regulatory & Stakeholder Interface Manager
Newport News Nuclear BWXT-Los Alamos
Los Alamos National Laboratory

Appendix A – Meteorology Data

Required by 40-61.94(b)(7) User-Supplied Data—Wind Frequency Arrays
Table A1: TA-6 meteorological tower data, 2018
Table A2: TA-53 meteorological tower data, 2018
Table A3: TA-54 meteorological tower data, 2018

Table A1
CAP88 Input Data for 2018 TA-6 Meteorological Tower
(99% Data Completeness)

```
  N A 0.000820.000290.000000.000000.000000.00000
NNE A 0.001640.000560.000000.000000.000000.00000
 NE A 0.002400.001320.000000.000000.000000.00000
ENE A 0.005070.001790.000000.000000.000000.00000
  E A 0.004130.002930.000000.000000.000000.00000
ESE A 0.003750.002670.000000.000000.000000.00000
 SE A 0.003370.002550.000000.000000.000000.00000
SSE A 0.001910.002460.000000.000000.000000.00000
  S A 0.001200.001320.000000.000000.000000.00000
SSW A 0.000650.001140.000030.000000.000000.00000
 SW A 0.000410.000470.000000.000000.000000.00000
WSW A 0.000470.000440.000000.000000.000000.00000
  W A 0.000290.000180.000000.000000.000000.00000
WNW A 0.000150.000320.000030.000000.000000.00000
 NW A 0.000440.000180.000000.000000.000000.00000
NNW A 0.000670.000230.000000.000000.000000.00000
  N B 0.000410.000120.000060.000000.000000.00000
NNE B 0.000260.000670.000030.000000.000000.00000
 NE B 0.000790.001350.000000.000000.000000.00000
ENE B 0.001350.002140.000060.000000.000000.00000
  E B 0.001200.003080.000000.000000.000000.00000
ESE B 0.000850.002900.000000.000000.000000.00000
 SE B 0.000970.002790.000000.000000.000000.00000
SSE B 0.000560.002870.000030.000000.000000.00000
  S B 0.000320.001910.000000.000000.000000.00000
SSW B 0.000210.000700.000090.000000.000000.00000
 SW B 0.000150.000500.000060.000000.000000.00000
WSW B 0.000090.000440.000060.000000.000000.00000
  W B 0.000030.000650.000060.000000.000000.00000
WNW B 0.000030.000290.000120.000000.000000.00000
 NW B 0.000150.000320.000000.000000.000000.00000
NNW B 0.000000.000210.000090.000000.000000.00000
  N C 0.000230.000530.000030.000000.000000.00000
NNE C 0.000670.001580.000180.000000.000000.00000
 NE C 0.000910.004600.000260.000000.000000.00000
ENE C 0.001500.005690.000150.000000.000000.00000
  E C 0.001700.007010.000150.000000.000000.00000
ESE C 0.001500.006710.000260.000000.000000.00000
 SE C 0.001380.008060.000410.000000.000000.00000
SSE C 0.000700.010820.001760.000000.000000.00000
  S C 0.000500.005780.002810.000030.000000.00000
SSW C 0.000350.002460.001520.000060.000000.00000
```

(Table continued next page)

Table A1 (continued)

```
 SW C 0.000260.001080.000730.000000.000000.00000
WSW C 0.000210.000820.001030.000000.000000.00000
  W C 0.000210.001060.001200.000000.000000.00000
WNW C 0.000180.001290.001550.000090.000000.00000
 NW C 0.000150.000790.001320.000030.000000.00000
NNW C 0.000350.000560.000500.000030.000000.00000
  N D 0.004720.006270.002370.000590.000060.00000
NNE D 0.004130.007950.003690.000910.000030.00000
 NE D 0.003810.006360.002610.000180.000000.00000
ENE D 0.003960.004280.001110.000030.000000.00000
  E D 0.003750.004400.000530.000060.000000.00000
ESE D 0.002640.006070.000760.000060.000000.00000
 SE D 0.003230.009590.004050.000210.000060.00000
SSE D 0.004220.017300.016890.001940.000320.00000
  S D 0.005390.022870.035040.009270.000090.00000
SSW D 0.005190.019700.029140.008710.000500.00000
 SW D 0.004600.011430.020700.009620.001200.00012
WSW D 0.003870.009090.015450.008300.001610.00026
  W D 0.003720.009380.018820.010060.002230.00009
WNW D 0.003310.008880.017470.012290.002080.00038
 NW D 0.004220.008530.014220.005720.000530.00000
NNW D 0.004340.006270.004720.001110.000000.00000
  N E 0.002350.004050.001260.000000.000000.00000
NNE E 0.001670.003140.000500.000000.000000.00000
 NE E 0.001110.001640.000180.000000.000000.00000
ENE E 0.000820.001000.000090.000000.000000.00000
  E E 0.001060.000440.000030.000000.000000.00000
ESE E 0.001060.000820.000030.000000.000000.00000
 SE E 0.000910.000910.000000.000000.000000.00000
SSE E 0.001290.002260.000060.000000.000000.00000
  S E 0.002580.008030.001000.000000.000000.00000
SSW E 0.002430.015860.002110.000000.000000.00000
 SW E 0.002370.015360.010820.000000.000000.00000
WSW E 0.002790.008970.006010.000000.000000.00000
  W E 0.002580.006690.002790.000000.000000.00000
WNW E 0.001910.007770.003490.000000.000000.00000
 NW E 0.002230.008390.003640.000000.000000.00000
NNW E 0.002400.004870.001110.000000.000000.00000
  N F 0.005980.005010.000180.000000.000000.00000
NNE F 0.003110.001320.000000.000000.000000.00000
 NE F 0.002290.000350.000000.000000.000000.00000
ENE F 0.001260.000150.000000.000000.000000.00000
  E F 0.001140.000090.000000.000000.000000.00000
ESE F 0.000910.000150.000000.000000.000000.00000
 SE F 0.001030.000180.000000.000000.000000.00000
SSE F 0.001230.000260.000000.000000.000000.00000
  S F 0.002320.001440.000260.000000.000000.00000
SSW F 0.004020.003580.000290.000000.000000.00000
 SW F 0.006190.013520.001200.000000.000000.00000
WSW F 0.007180.028970.002140.000000.000000.00000
  W F 0.006360.023870.001170.000000.000000.00000
WNW F 0.005280.017530.001610.000000.000000.00000
 NW F 0.005830.021550.000530.000000.000000.00000
NNW F 0.006980.011900.000150.000000.000000.00000
```

Table A2
CAP88 Input Data for 2018 TA-53 Meteorological Tower

(99% Data Completeness)

N	A	0.001050.000290.000000.000000.000000.00000
NNE	A	0.002150.000380.000000.000000.000000.00000
NE	A	0.003540.001160.000000.000000.000000.00000
ENE	A	0.004850.002870.000030.000000.000000.00000
E	A	0.004730.003750.000000.000000.000000.00000
ESE	A	0.003570.003370.000000.000000.000000.00000
SE	A	0.002990.002760.000000.000000.000000.00000
SSE	A	0.002410.002350.000000.000000.000000.00000
S	A	0.001800.001830.000000.000000.000000.00000
SSW	A	0.001050.000960.000000.000000.000000.00000
SW	A	0.000460.000580.000000.000000.000000.00000
WSW	A	0.000290.000200.000000.000000.000000.00000
W	A	0.000120.000230.000030.000000.000000.00000
WNW	A	0.000260.000150.000000.000000.000000.00000
NW	A	0.000320.000260.000000.000000.000000.00000
NNW	A	0.000410.000320.000000.000000.000000.00000
N	B	0.000090.000170.000000.000000.000000.00000
NNE	B	0.000520.000440.000060.000000.000000.00000
NE	B	0.000760.001600.000060.000000.000000.00000
ENE	B	0.001220.002640.000000.000000.000000.00000
E	B	0.001050.002960.000000.000000.000000.00000
ESE	B	0.001020.002470.000000.000000.000000.00000
SE	B	0.000730.002530.000000.000000.000000.00000
SSE	B	0.000320.002700.000000.000000.000000.00000
S	B	0.000460.002760.000000.000000.000000.00000
SSW	B	0.000090.000760.000030.000000.000000.00000
SW	B	0.000150.000410.000000.000000.000000.00000
WSW	B	0.000000.000290.000030.000000.000000.00000
W	B	0.000170.000170.000060.000000.000000.00000
WNW	B	0.000000.000170.000000.000000.000000.00000
NW	B	0.000060.000200.000030.000000.000000.00000
NNW	B	0.000030.000230.000060.000000.000000.00000
N	C	0.000580.000440.000170.000000.000000.00000
NNE	C	0.000840.001280.000170.000030.000000.00000
NE	C	0.001220.003950.000380.000000.000000.00000
ENE	C	0.002060.005840.000320.000000.000000.00000
E	C	0.001420.007200.000200.000000.000000.00000
ESE	C	0.001250.006770.000090.000000.000000.00000
SE	C	0.000780.005460.000150.000000.000000.00000
SSE	C	0.000670.006530.000900.000000.000000.00000
S	C	0.000410.006160.001250.000000.000000.00000
SSW	C	0.000170.002030.000670.000000.000000.00000
SW	C	0.000120.001220.000780.000000.000000.00000
WSW	C	0.000060.000810.000640.000000.000000.00000
W	C	0.000170.001220.000840.000000.000000.00000
WNW	C	0.000090.000640.000290.000000.000000.00000
NW	C	0.000200.000320.000260.000030.000000.00000
NNW	C	0.000060.000440.000120.000000.000000.00000

(Table continued next page)

Table A2 (continued)

N	D	0.005370.008970.006270.001050.000170.00000
NNE	D	0.005260.011330.009060.002120.000230.00003
NE	D	0.005080.009730.004530.001050.000060.00000
ENE	D	0.004240.008770.002730.000200.000000.00000
E	D	0.003660.008450.001630.000120.000000.00000
ESE	D	0.002790.005400.001310.000090.000000.00000
SE	D	0.002350.005460.002120.000290.000060.00003
SSE	D	0.002820.009260.010690.004150.000700.00026
S	D	0.002900.017830.034090.018760.001540.00003
SSW	D	0.002240.015710.037370.028460.003170.00052
SW	D	0.001770.011760.025990.012140.001510.00017
WSW	D	0.002090.006850.016410.008570.002240.00038
W	D	0.002060.006710.018410.010510.002270.00026
WNW	D	0.002850.005140.010220.008130.001540.00006
NW	D	0.003140.003050.005630.005690.000550.00000
NNW	D	0.003980.004180.004790.002180.000260.00000
N	E	0.004990.009210.001740.000000.000000.00000
NNE	E	0.004730.007230.001570.000000.000000.00000
NE	E	0.002580.003780.000760.000000.000000.00000
ENE	E	0.002210.002380.000490.000000.000000.00000
E	E	0.001710.001800.000120.000000.000000.00000
ESE	E	0.001390.000990.000000.000000.000000.00000
SE	E	0.001310.001680.000230.000000.000000.00000
SSE	E	0.001160.002270.000670.000000.000000.00000
S	E	0.001360.005920.003630.000000.000000.00000
SSW	E	0.001390.014140.028840.000000.000000.00000
SW	E	0.001770.021810.017570.000000.000000.00000
WSW	E	0.001890.011820.016260.000000.000000.00000
W	E	0.001830.009580.011410.000000.000000.00000
WNW	E	0.001770.008160.005140.000000.000000.00000
NW	E	0.002900.005750.002350.000000.000000.00000
NNW	E	0.004760.007670.003020.000000.000000.00000
N	F	0.003980.001050.000000.000000.000000.00000
NNE	F	0.004150.000870.000090.000000.000000.00000
NE	F	0.004180.000900.000030.000000.000000.00000
ENE	F	0.002990.000580.000000.000000.000000.00000
E	F	0.001830.000170.000000.000000.000000.00000
ESE	F	0.002320.000150.000000.000000.000000.00000
SE	F	0.002500.000640.000030.000000.000000.00000
SSE	F	0.002380.001280.000000.000000.000000.00000
S	F	0.002990.003020.000090.000000.000000.00000
SSW	F	0.003830.007320.000840.000000.000000.00000
SW	F	0.003340.003310.000380.000000.000000.00000
WSW	F	0.002290.007000.002580.000000.000000.00000
W	F	0.003190.007700.004090.000000.000000.00000
WNW	F	0.003510.006300.000730.000000.000000.00000
NW	F	0.003540.002440.000550.000000.000000.00000
NNW	F	0.003920.001950.000550.000000.000000.00000

Table A3
CAP88 Input Data for 2018 TA-54 Meteorological Tower
(99% Data Completeness)

```
  N A 0.000430.000170.000000.000000.000000.00000
NNE A 0.001070.000460.000000.000000.000000.00000
 NE A 0.001820.001420.000000.000000.000000.00000
ENE A 0.004110.001910.000000.000000.000000.00000
  E A 0.007670.003240.000000.000000.000000.00000
ESE A 0.005960.002340.000000.000000.000000.00000
 SE A 0.003650.002050.000000.000000.000000.00000
SSE A 0.001910.001880.000000.000000.000000.00000
  S A 0.001390.001970.000000.000000.000000.00000
SSW A 0.001190.000750.000000.000000.000000.00000
 SW A 0.000610.000380.000030.000000.000000.00000
WSW A 0.000550.000200.000000.000000.000000.00000
  W A 0.000380.000200.000000.000000.000000.00000
WNW A 0.000230.000060.000000.000000.000000.00000
 NW A 0.000410.000260.000000.000000.000000.00000
NNW A 0.000320.000230.000000.000000.000000.00000
  N B 0.000060.000260.000000.000000.000000.00000
NNE B 0.000320.000550.000000.000000.000000.00000
 NE B 0.000230.001560.000000.000000.000000.00000
ENE B 0.000690.001560.000000.000000.000000.00000
  E B 0.001850.003070.000000.000000.000000.00000
ESE B 0.000900.002200.000000.000000.000000.00000
 SE B 0.000490.001220.000000.000000.000000.00000
SSE B 0.000320.001710.000060.000000.000000.00000
  S B 0.000230.002110.000000.000000.000000.00000
SSW B 0.000060.001220.000000.000000.000000.00000
 SW B 0.000090.000550.000000.000000.000000.00000
WSW B 0.000060.000290.000030.000000.000000.00000
  W B 0.000060.000260.000030.000000.000000.00000
WNW B 0.000030.000260.000030.000000.000000.00000
 NW B 0.000030.000060.000000.000000.000000.00000
NNW B 0.000030.000090.000000.000000.000000.00000
  N C 0.000290.000430.000090.000000.000000.00000
NNE C 0.000350.001680.000090.000000.000000.00000
 NE C 0.000610.003440.000140.000000.000000.00000
ENE C 0.001360.005240.000140.000000.000000.00000
  E C 0.002260.006690.000200.000000.000000.00000
ESE C 0.000900.003390.000140.000000.000000.00000
 SE C 0.000580.002600.000090.000000.000000.00000
SSE C 0.000520.003940.000260.000000.000000.00000
  S C 0.000550.005670.000840.000030.000000.00000
SSW C 0.000260.003730.000960.000000.000000.00000
 SW C 0.000120.001360.000580.000030.000000.00000
WSW C 0.000140.000810.000690.000000.000000.00000
  W C 0.000170.000380.001100.000000.000000.00000
WNW C 0.000030.000430.000840.000000.000000.00000
 NW C 0.000000.000290.000320.000000.000000.00000
NNW C 0.000140.000230.000090.000000.000000.00000
```

(Table continued next page)

Table A3 (continued)

N	D	0.005010.004050.002430.001010.000140.00000
NNE	D	0.004520.009290.010160.003500.000230.00006
NE	D	0.003880.014990.009640.001190.000030.00000
ENE	D	0.003820.008680.002430.000200.000030.00003
E	D	0.003150.005670.000810.000060.000030.00000
ESE	D	0.002080.002580.000610.000060.000000.00000
SE	D	0.001710.001820.001130.000410.000030.00000
SSE	D	0.000980.003990.004800.004430.001530.00069
S	D	0.001740.008220.021450.018440.005090.00038
SSW	D	0.002290.014100.045270.040230.008570.00087
SW	D	0.002490.011610.024660.018870.002950.00038
WSW	D	0.002460.007410.009810.006600.001480.00006
W	D	0.002980.006570.010300.005530.000780.00000
WNW	D	0.003300.005040.009520.004110.000230.00000
NW	D	0.004370.005440.005880.002840.000000.00000
NNW	D	0.004200.005210.002660.000610.000030.00000
N	E	0.003390.003880.002520.000000.000000.00000
NNE	E	0.002230.003820.002490.000000.000000.00000
NE	E	0.001650.002430.000810.000000.000000.00000
ENE	E	0.001160.001740.000170.000000.000000.00000
E	E	0.000810.001330.000090.000000.000000.00000
ESE	E	0.001070.000670.000030.000000.000000.00000
SE	E	0.000780.000490.000120.000000.000000.00000
SSE	E	0.000640.001100.000670.000000.000000.00000
S	E	0.000900.002690.002630.000000.000000.00000
SSW	E	0.001270.005670.010740.000000.000000.00000
SW	E	0.001740.010620.016410.000000.000000.00000
WSW	E	0.002660.008190.004340.000000.000000.00000
W	E	0.003210.009750.002840.000000.000000.00000
WNW	E	0.003940.011980.003560.000000.000000.00000
NW	E	0.004250.008510.001970.000000.000000.00000
NNW	E	0.004460.005730.001040.000000.000000.00000
N	F	0.005620.010800.000780.000000.000000.00000
NNE	F	0.005070.006250.000430.000000.000000.00000
NE	F	0.002750.002030.000000.000000.000000.00000
ENE	F	0.001770.000430.000000.000000.000000.00000
E	F	0.000690.000060.000000.000000.000000.00000
ESE	F	0.000640.000000.000000.000000.000000.00000
SE	F	0.000580.000170.000000.000000.000000.00000
SSE	F	0.000520.000290.000000.000000.000000.00000
S	F	0.001130.001270.000060.000000.000000.00000
SSW	F	0.001710.004860.001190.000000.000000.00000
SW	F	0.002780.019070.007840.000000.000000.00000
WSW	F	0.003760.025530.008280.000000.000000.00000
W	F	0.005590.026510.004830.000000.000000.00000
WNW	F	0.007550.017480.000960.000000.000000.00000
NW	F	0.009320.034910.001190.000000.000000.00000
NNW	F	0.007500.017830.002870.000000.000000.00000