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Environmental Protection Department

Operations and Regulatory Affairs Division

LLNL NESHAPs 1997 Annual Report

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Comparison of 1997 Modelling Results with Surveillance Monitoring Data 38

Figure 6. Tritium air-surveillance sampling locations 39

Figure 7. Comparison of measured and modelled tritium concentrations, 1997 40

Status of the NESHAPs QA Program 41

Quality Control (QC) for 1997 Radiological Inventory Update and Modeling 42

Radiological Inventory Update QC 42

Modeling QC 43

EPA Compliance Evaluation Investigation 43

Attachment 1. 1997 LLNL NESHAPs Annual Report Spreadsheet 44

Guidance for Interpreting Attachment 1 44

Radionuclides 44

Radionuclide Inventories with Potential for Release 44

Physical-State Factors 45

Stack Parameters 45

Emission-Control Devices 45

Control-Device Abatement Factors 45

Estimated Annual Emissions 45

10 mrem/y Site-Wide Dose Requirement 46

0 1 mrem/y Monitoring Requirement 46

Source Categories. 47

Below Appendix E Quantity 47

Attachment 2. Surrogate Radionuclides List 64

Lawrence Livermore National Laboratory NESHAPs 1997 Annual Report

This annual report is prepared pursuant to the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) 40 CFR Part 61, Subpart H, Subpart H governs radionuclide emissions to air from Department of Energy (DOE) facilities.

SYNOPSIS

NESHAPs limits the emission of radionuclides to the ambient air from DOE facilities to levels resulting in an annual effective dose equivalent (EDE) of 10 mrem (100 μSv) to any member of the public The EDEs for the Lawrence Livermore National Laboratory (LLNL) site-wide maximally exposed members of the public from 1997 operations were

- Livermore site. 0 097 mrem (0 97 μSv) (80% from point-source emissions, 20% from diffuse-source emissions),
- Site 300 0 014 mrem (0 14 μSv) (38% from point-source emissions, 62% from diffuse-source emissions)

The EDEs were generally calculated using the EPA-approved CAP88-PC air-dispersion/dose-assessment model Site-specific meteorological data, stack flow data, and emissions estimates based on radionuclide inventory data or continuous-monitoring systems data were the specific input to CAP88-PC for each modeled source

SECTION I. Facilities Information

Site Description

The University of California operates LLNL for DOE LLNL was established in 1952 to conduct weapons research and development LLNL's mission is to serve as a national resource in science and engineering, with a special responsibility for nuclear weapons Laboratory activities focus on global security, energy, global ecology, biomedicine, economic competitiveness, and science and mathematics education. The Laboratory's mission is dynamic and has been broadened over the years to meet new national needs LLNL consists of two sites—the main laboratory site located in Livermore, California (Livermore site), and the Experimental Test Facility (Site 300) located near Tracy, California Figure 1 shows the locations of the sites

Livermore site: LLNL's Livermore site occupies an area of 3 3 km^2 located about 60 km east of San Francisco, California, adjacent to the City of Livermore in the eastern part of Alameda County. More than 6 million people live within 80 km of LLNL, approximately 65,000 of them live in the City of Livermore

The Livermore site is located in the southeastern portion of the Livermore Valley, a topographical and structural depression oriented east-west within the Diablo Range of the California Coast Range Province. The Livermore Valley forms an irregularly shaped lowland area approximately 26 km long and an average of 11 km wide The floor of the valley slopes from an elevation of approximately 200 m at the eastern end to approximately 90 m at the southwest corner

The climate of the Livermore Valley is characterized by mild, rainy winters and warm, dry summers The mean annual temperature is about 15°C Temperatures typically range from –5°C during some pre-dawn hours in the winter, to 40°C on a few summer afternoons The 1997 annual wind data for the Livermore site are shown in Table 1 and displayed as a wind rose in Figure 2. Although winds are variable, the prevailing wind direction is from the southwest, especially during the summer However, during the winter, the wind often blows from the northeast Most precipitation occurs as rain between October and April with very little rainfall during the summer months. In 1997, the Livermore site received 282 mm of precipitation

Site 300: Site 300, LLNL's Experimental Test Site, is located 24 km east of the Livermore site in the Altamont Hills of the Diablo Range and occupies an

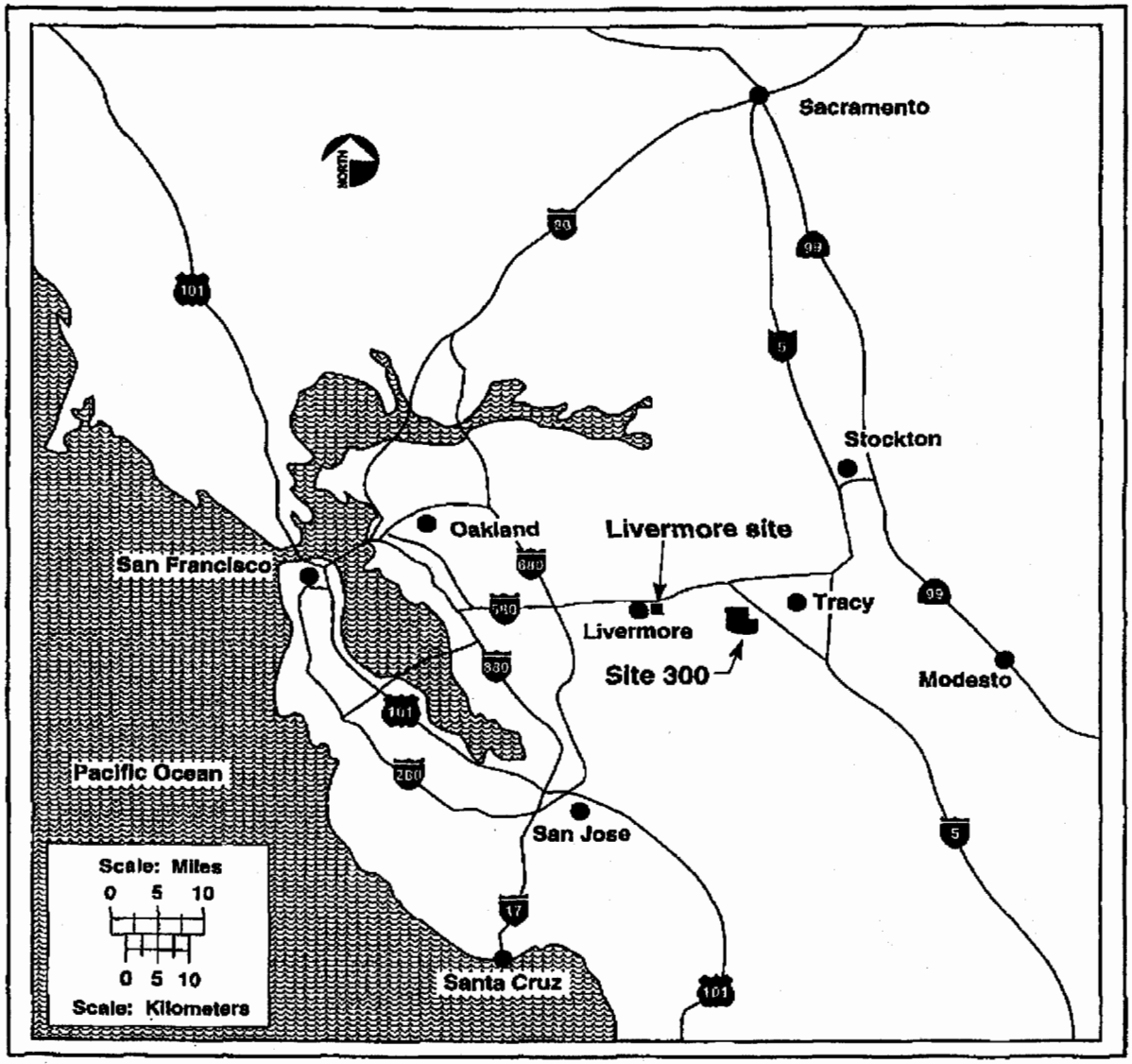

Figure 1. Locations of LLNL Livermore site and Site 300

area of 30 3 km^2 It is close to two other explosives-testing facilities, one operated by Primex Physics International, the other by SRI International A State of California vehicular-recreation area is located nearby, and wind-turbine generators line the surrounding hills The remainder of the surrounding area is in agricultural use, primarily pasture land for cattle and sheep The nearest residential area is the City of Tracy (population approximately 45,000), located 10 km to the northeast

Table 1. Wind rose for LLNL's Livermore site at the 10-m level for 1997 Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding.

	Wind Speed Range (m/s)					
Direction	0 0-0 40	0 50-2 90	3 00-4 90	5 00-6 90	=>7 00	Total
NNE	0 05	2 65	1 73	0 58	0 55	5 56
NE	0 05	3 17	2 72	0 29	0 15	6 38
ENE	0 05	3 80	0 29	0 00	0 00	4 14
E	0 05	3 63	0 02	0 00	0 00	3 70
ESE	0 05	4 31	0 00	0 00	0 00	4 37
SE	0 05	2 92	0 00	0 00	0 00	2 98
SSE	0 05	2 62	0 08	0 00	0 00	2 74
S	0 05	5 49	0 74	0 44	0 41	7 12
SSW	0 05	6 27	2 02	0 72	0 23	9 28
SW	0 05	7 35	7 41	2 56	0 84	18 20
WSW	0 05	7 49	5 87	1 35	0 11	14 86
W	0 05	4 52	6 80	2 29	0 05	13 70
WNW	0 05	1 71	0 69	0 22	0 00	2 67
NW	0 05	1 18	0 09	0 00	0 00	1 31
NNW	0 05	1 20	0 31	0 09	0 00	1 65
N	0 05	0 50	0 26	0 25	0 26	1 32
Total	0 72	58 81	29 05	8 79	2 61	100 00

Table 2. Wind rose for LLNL's Site 300 at the 10-m level for 1997. Values are frequency of occurrence (in percent). Columns and rows may not exactly sum to the listed totals due to rounding

	Wind Speed Range (m/s)					
Direction	0 0-0 4	0 5-4 9	5 0-6 9	7 0-10 9	≥11 0	Total
NNE	0 12	1 31	0 00	0 00	0 00	1 44
NE	0 12	2 06	0 00	0 00	0 00	2 19
ENE	0 12	1 61	0 00	0 00	0 00	1 74
E	0 12	1 83	0 02	0 02	0 00	1 99
ESE	0 12	1 69	0 09	0 02	0 00	1 92
SE	0 12	1 79	0 30	0 27	0 00	2 48
SSE	0 12	2 02	0 06	0 15	0 09	2 44
S	0 12	3 16	0 31	0 19	0 18	3 96
SSW	0 12	1 76	0 02	0 03	0 00	1 93
SW	0 12	1 44	0 47	0 85	0 86	3 74
WSW	0 12	2 87	6 62	20 29	4 11	34 01
W	0 12	3 84	4 51	2 11	0 02	10 60
WNW	0 12	3 32	1 57	0 54	0 00	5 56
NW	0 12	4 91	2 21	2 45	0 47	10 16
NNW	0 12	4 50	3 09	3 19	1 68	12 58
N	0 12	1 43	0 82	0 63	0 30	3 30
Total	1 86	39 54	20 11	30 74	7 73	100 00

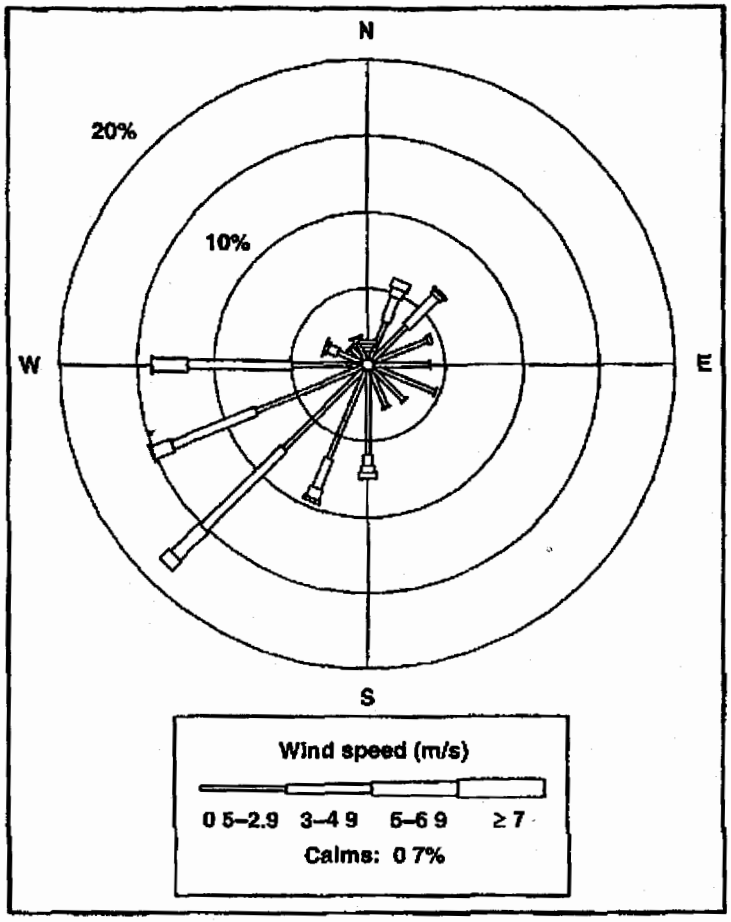

Figure 2. Wind rose showing the average annual wind speed, frequency of occurrence, and direction at the Livermore site, 1997

The topography of Site 300 is much more irregular than that of the Livermore site, it consists of a series of steep hills and ridges, which are oriented along a generally northwest/southeast trend, separated by intervening ravines. The elevation ranges from approximately 540 m in the northwestern portion of the site to 150 m at the southeast corner The climate at Site 300 is similar to that of the Livermore site, with mild winters and dry summers The complex topography of the site significantly influences local wind and temperature patterns, making the temperature range somewhat more extreme than at the Livermore site. The 1997 annual wind data for Site 300 are shown in Table 2 and displayed as a wind rose in Figure 3 Prevailing winds are from the west-southwest As is the case at the Livermore site, precipitation is highly seasonal, with most precipitation occurring between October and April. The average

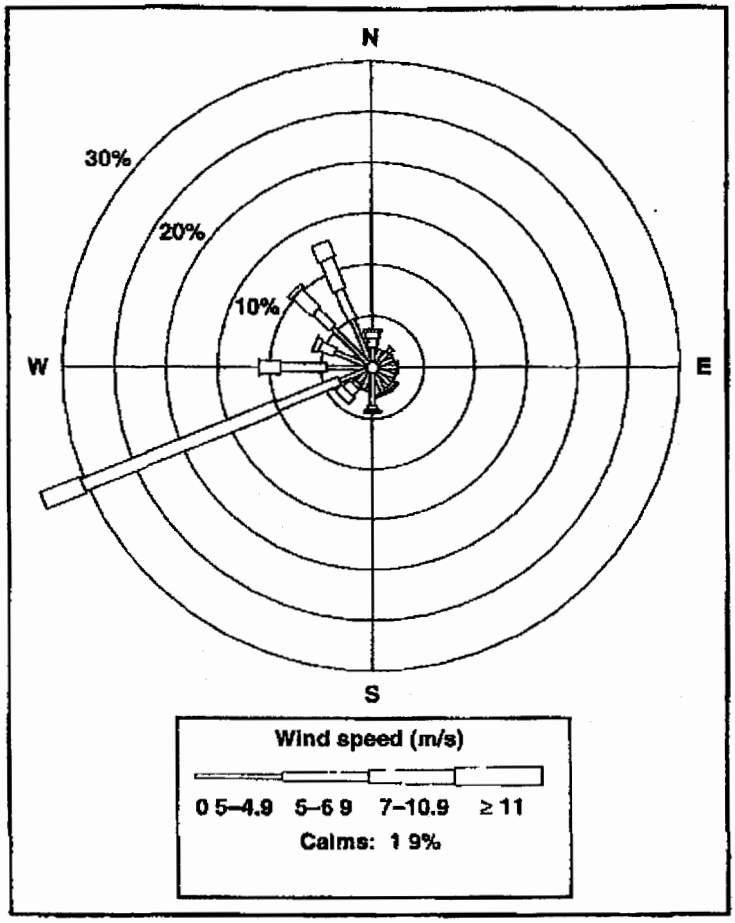

Figure 3. Wind rose showing the average annual wind speed, frequency of occurrence, and direction at Site 300, 1997

annual rainfall over the past 20 years was 257 mm, Site 300 received 193 mm of precipitation during 1997

Source Description

Many different radioisotopes are used at LLNL for research purposes, including transuranics, biomedical tracers, tritium, mixed fission products, and others (Table 3) Radioisotope-handling procedures and work enclosures are determined for each project, depending on the isotopes, the quantities being used, and the types of operations being performed. Radioisotope handling and working environments include glove boxes, exhaust hoods, and laboratory bench tops Exhaust paths to the atmosphere range from triple-HEPA (High-Efficiency-Particulate-Air)-filtered stacks, to roof vents and stacks

lacking abatement devices, to direct dispersal of depleted uranium during explosives testing at Site 300, to a variety of diffuse-area sources

Table 3. Radionuclides used at LLNL during 1997

^{3}H	^{63}Ni	^{109}Cd	^{154}Eu	^{228}Ac	^{239}Pu
^{7}Be	^{75}Se	^{110m}Ag	^{155}Eu	^{228}Ra	^{239}U
^{13}N	^{85}Kr	^{115}Cd	^{160}Tb	^{228}Th	^{240}Pu
^{14}C	^{85}Sr	^{124}Sb	^{182}Ta	^{229}Th	^{241}Am
^{15}O	^{88}Y	^{125}I	^{192}Ir	^{230}Th	^{241}Pu
^{22}Na	^{89}Sr	^{125}Sb	^{195}Au	^{231}Pa	^{242}Am
^{32}P	^{90}Sr	^{131}I	^{203}Hg	^{232}Th	^{242m}Am
^{33}P	^{90}Y	^{133}Ba	^{207}Bi	^{232}U	^{242}Cm
^{35}S	^{90}Zr	^{134}Cs	^{208}Tl	^{233}U	^{242}Pu
^{40}K	^{91}Y	^{137}Cs	^{209}Po	^{234}Th	^{243}Am
^{46}Sc	^{94}Nb	^{138}Cs	^{210}Pb	^{234}U	^{244}Am
^{51}Cr	^{95}Nb	^{140}Ba	^{210}Po	^{235}U	^{244}Cm
^{54}Mn	^{95}Zr	^{141}Ce	^{212}Bi	^{236}Pu	^{245}Cf
^{55}Fe	^{99}Mo	^{144}Ce	^{212}Pb	^{236}U	^{249}Cf
^{56}Co	^{99}Tc	^{146}Gd	^{214}Bi	^{237}Np	^{252}Cf
^{57}Co	^{102}Rh	^{147}Pm	^{214}Pb	^{237}U	
^{58}Co	^{103}Rh	^{149}Eu	^{223}Ra	^{238}Pu	
^{59}Ni	^{106}Rh	^{151}Sm	^{226}Ra	^{238}U	
^{60}Co	^{106}Ru	^{152}Eu	^{227}Th	^{239}Np	

SECTION II. Air-Emission Data

Sources

At LLNL, areas where radioactive materials are used or stored, or where activation products occur, are called Radioactive Materials Management Areas (RMMAs) Detailed information is given in Attachment 1 for point-source emissions from the Livermore-site RMMAs in which radiological operations took place during 1997 Building 514 and five other Livermore-site sources external to buildings (including the RMMA at the Building 612 Hazardous Waste Management Yard) are treated as diffuse-area sources

Similarly, detailed information is given in Attachment 1 for experiments at two Site 300 explosives-testing facilities (Buildings 850 and 851 and their associated firing tables) Site 300 is also treated as a diffuse-area source of residual tritium and depleted uranium contamination

1997 Inventory Update and Effective Dose Equivalent (EDE) Calculations

For this year's report, covering activities in 1997, we updated the radionuclide inventories in all facilities Radionuclide inventory forms, with guidance for completing them, were sent to the unmonitored facilities The forms were completed by experimenters, and certified by facility managers Radionuclide inventories for all Site 300 explosives experiments and assessments of source terms for known diffuse sources at both sites were also updated

Dose-assessment modeling runs were conducted for all diffuse sources and for all point sources using actual radionuclide releases to air, or potential releases based on radionuclide inventory data The model used was CAP88-PC (see Section III), we incorporated 1997 on-site meteorological data (wind, precipitation, and temperature) along with the 1997 radionuclide inventory or monitoring data Annual dose is reported as whole-body EDE expressed in units of mrem (followed by μSv) When reasonable to do so, modeling runs were combined by building, rather than a separate model run for each stack or room This is permitted by the 1995 Memorandum of Understanding between the U S EPA and the DOE concerning radionuclide NESHAPs

A generalized description of each facility and its operations is provided in Attachment 1. The following information is shown for each listed emission point or stack

radionuclides to estimate EDEs. Attachment 2 shows the surrogate radionuclides used in CAP88-PC In selecting the surrogates, the most-restrictive lung class (whether clearance from the lungs takes place in days, weeks, or years) was used. When possible, a surrogate radionuclide with similar chemistry and similar values for "annual limits of intake via inhalation and derived air concentration," as specified in the EPA's Federal Guidance Report No. 11 was used In some cases, experimenters did not have isotopic analyses of mixtures of radionuclides and could only identify their radionuclide inventory as "gross alpha," "gross beta," "gross gamma," or "mixed fission products" (MFP) In these cases, ^{239}Pu was used as the surrogate for gross alpha, ^{137}Cs was used as the surrogate for gross gamma, and ^{90}Sr was used as the surrogate for gross beta and mixed fission products to provide conservative dose estimates

Population Inputs: Population distributions centered on the two LLNL sites were compiled from 1990 census data The population data files (distribution of population with distance and direction) used in the 1997 modeling effort are described in Section VI under "Collective Effective Dose Equivalent "

Land-Use and Agricultural Inputs: Options for model inputs regarding agricultural characteristics and land use are established by the EPA, and the particular designation selected can strongly influence the ingestion dose received by the population being evaluated Following our investigation in 1995 into the use of the various options, the "user entered" option was again selected foı the CAP88-PC modeling effort foı 1997 The values entered corresponded to the "local agriculture" option (i e , everything is home produced), with one exception—all milk consumed was assumed to be imported The assumption that all milk comes from local cows is not supported by the agricultural activities conducted in the area. A detailed discussion of how the dose from tritium is calculated by CAP88-PC is presented in the LLNL NESHAPs 1995 Annual report (Gallegos et al , 1996, Lawrence Livermore National Laboratory, UCRL-ID-113867-96)

Emission Source Terms: The source term(s) from each emission point in the calculations was determined by one of two methods For continuously monitored sources, the sampling data (curies released per unit time) for each radionuclide were used directly For unmonitored facilities, the radionuclide inventories, together with the EPA-specified fractions for potential release to air of materials in different physical states (solid, liquid, powder, or gas), in accordance with 40 CFR Part 61, Appendix D were used The state-dependent release fraction was used to adjust (by multiplication) the total annual

inventory to yield the potential annual release to air. If the material was an unconfined gas, then the fraction 1.0 was used; for liquids and powders, 1.0×10^{-3} was used; and for solids, 1.0×10^{-6} was used. In 1996, U.S EPA granted approved alternative emissions factors for elemental uranium as follows· an emission factor of 1×10^{-6} can be used for elemental uranium heated at temperatures below 1100°C, an emission factor of 1×10^{-3} can be used for elemental uranium heated at temperatures below 3000°C, and an emission factor of 1 shall be used for temperatures greater than 3000°C These factors are allowed provided that the uranium is not intentionally dispersed to the environment and that the processes do not alter the chemical form of the uranium In addition, emission-control abatement factors (40 CFR 61, Appendix D), when applicable, were applied. Each HEPA filter stage was given a 0 01 factor, electrostatic precipitators, as well as venturi scrubbers, were each given a 0 05 factor, and each activated-charcoal filter was given a 0.1 factor (However, abatement factors were not used to evaluate compliance with the 0 1 mrem standard that determines the need for continuous monitoring at a facility) The use of actual monitoring data is much more direct, and presumably more accurate, than using assumptions based on inventory, release fractions, and emission-control factors

Site-Wide Maximally Exposed Individual: For LLNL to comply with the NESHAPs regulations, the LLNL site-wide maximally exposed individual cannot receive an EDE greater than 10 mrem/y (100 μSv/y) The site-wide maximally exposed individual (SW-MEI) is defined as the *hypothetical* member of the public at a single residence, school, business, or office who receives the greatest LLNL-induced EDE from the combination of all radionuclide source emissions

To determine the location of the 1997 SW-MEI, CAP88-PC results from multiple sources were combined Sources were selected to include those expected to give significant contributions to the EDE These included Building 331 point and area sources, Building 514 Tank Farm, and Building 612 area source Because EDE results from CAP88-PC are relative to the location of the specified source, direct summing of results from multiple sources can only be accomplished using an interpolation method To do this, the location of each selected source relative to a common location (the Livermore-site center) and a set of receptor locations (where the combined EDEs from the selected sources were to be evaluated), also relative to the site center, were specified in the modeling efforts that supported determination of the SW-MEI The receptor locations included 48 equally spaced directions from the site center and 4 additional receptor locations along the eastern and

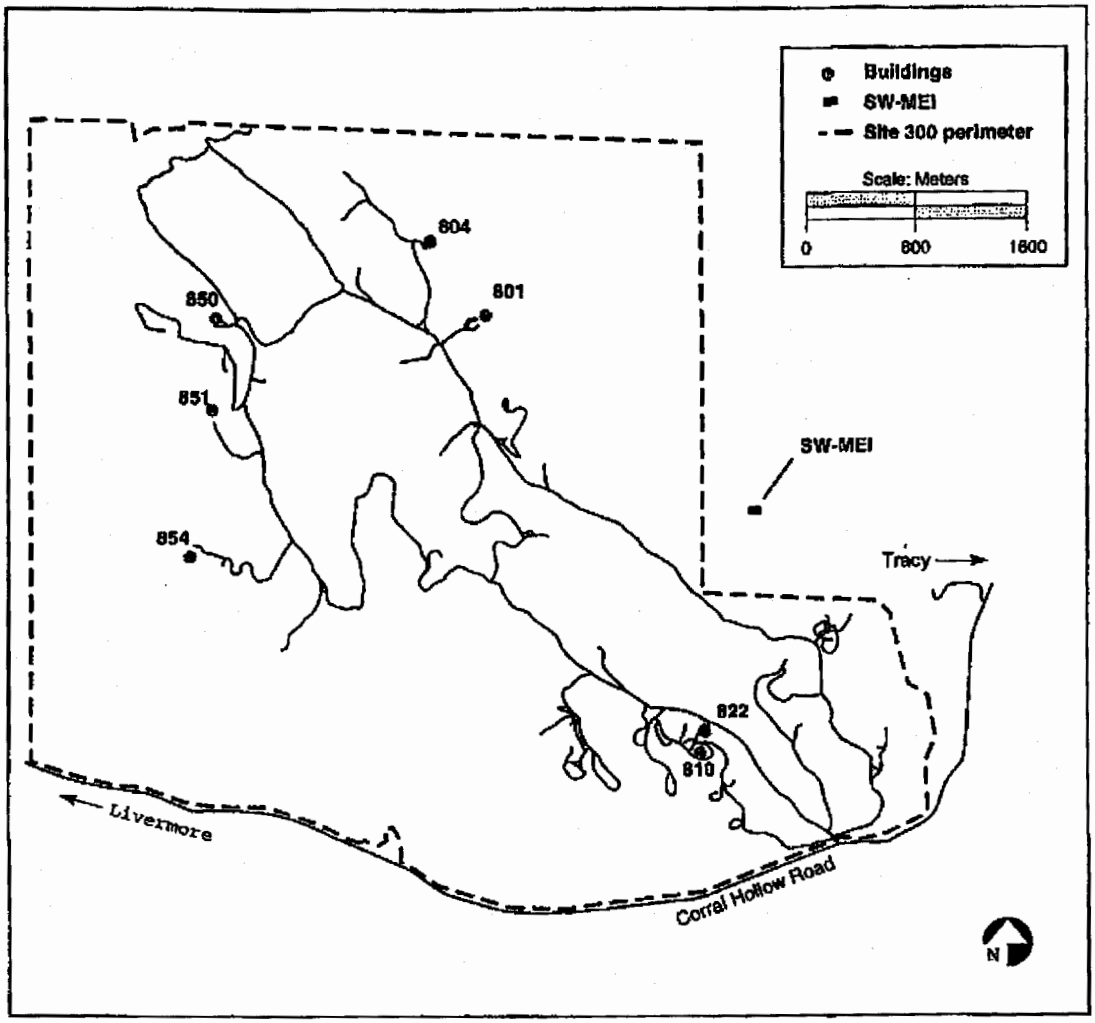

Figure 5. Location of Site-Wide Maximally Exposed Individual (SW-MEI) at Site 300, 1997

At Site 300, the 1997 SW-MEI was located in an experimental area termed "Bunker 2" operated by Primex Physics International Bunker 2 lies about 300 m outside the east-central boundary of Site 300, as shown in Figure 5 This bunker is approximately 4 km east of the firing tables at Buildings 850 and 851

In Attachment 1, the distance and direction to the respective SW-MEI are shown for each facility at each site Doses to the site-specific SW-MEIs were evaluated for each source and then totaled for site-specific evaluations against the 10 mrem/y dose standard (see "Total Dose Estimate" in Section IV)

powerful laser beams onto a BB-sized capsule of deuterium and tritium, forcing the two heavy isotopes of hydrogen to combine through compression and heating, producing ignition and self-sustained fusion burn The NIF construction project began in 1996 and will end in 2003 with initial operations beginning in 2001. It is being designed, built and operated by a team from Lawrence Livermore, Los Alamos and Sandia National Laboratories and the University of Rochester Site preparation for NIF has been completed, and construction of the steel frame of the building has begun.

Unplanned Releases

There was one unplanned atmospheric radionuclide release from the Livermore site in 1997 Waste shredding operations were resumed in Building 513 in 1997 During those operations, on July 2, 1997, an incorrectly labelled HEPA filter containing curium (^{244}Cm) in excess of the administrative limit for the process was shredded This activity resulted in the contamination of four workers and the release of small amounts of the material to the environment The U.S EPA was briefed on the incident in September 1997 The range of doses calculated to the SW-MEI was 2.3×10^{-5} to 2.1×10^{-4} mrem (2.3×10^{-4} to 2.1×10^{-3} μSv), and the range of doses to the MEI was 5.5×10^{-4} to 5.4×10^{-3} mrem (5.5×10^{-3} to 5.4×10^{-2}μSv) This is not a significant contribution to dose at the SW-MEI and does not trigger the requirement for continuous monitoring

Modelers took three approaches to evaluating the ^{244}Cm emissions and subsequent doses from the incident As is shown below, the three approaches resulted in a reasonably narrow range of estimated emissions and subsequent doses from the incident. This modeling information was previously provided to the U S EPA in response to its specific questions about the Building 513 shredder unit operations (See EPA Compliance Investigation, below)

Evaluation of the off-site doses generated by the curium incident presented a significant modeling challenge Difficulties in the assessment included (1) the amount of curium in the HEPA filter suspected of causing the incident was not accurately known, (2) the time-line of the incident was imprecisely known and difficult to match up with dynamic meteorological data; (3) the shredder room was not completely closed off from the rest of the building or from the outside environment, and the passive building ventilation dynamics could not be measured because access to the building was restricted due to contamination, (4) immediate swipe sampling indicated no significant contamination outside the building which called into question the need for further environmental

evaluations, and (5) the low-level nature of the curium release, while desirable from an impact point of view, made environmental evaluations difficult

The paucity of data and the difficulties mentioned above required some modeling assumptions One assumption common to the three approaches was that the ^{244}Cm release occurred over a relatively short time period, all the approaches assumed the ^{244}Cm was released mostly during the first day and that nearly all of it was released during the first week following the incident Such an assumption is supported by environmental monitoring data collected in the area following the incident Another common assumption was that ^{244}Cm was the only radionuclide released in the incident This assumption was supported by analytical data provided by the LLNL Hazards Control Department following analysis of respirator cartridges worn by the workers who were inside Building 513 during the incident A third assumption common to all modeling was that any release of ^{244}Cm was unabated because the operational status of the HEPA-filtered ventilation system during the incident was unknown, it was conservatively assumed that any releases to the environment during the incident escaped out of the passive vents in Building 513 Estimates of the amount of ^{244}Cm released during the incident were assumed to be actual, and doses to any hypothetical individuals (MEI or SW-MEI) calculated from air dispersion and dose assessment models did not allow credit to be taken for abatement devices, as is the case when using radiological inventories to estimate emissions

Two of the modeling approaches used surveillance air monitoring data from continuously operating high-volume ambient air samplers that were operating at LLNL the day of the incident The routine air surveillance filters for the period July 1–7, which included the day of the incident, from three locations in general proximity to Building 513, designated SALV (237 m SE of Building 513), CRED (579 m NE), and B531 (389 m NNW), were analyzed An additional filter, from a background location designated FCC (about 6 kilometers NW of Building 513) also was submitted for analysis All filters were submitted to the LLNL Chemistry and Materials Sciences Environmental Services analytical laboratory for low-level ^{244}Cm analysis by alpha spectroscopy.

Original analyses did not detect any ^{244}Cm on the filters above normal detection limits, but the analytical laboratory went to extraordinary lengths, including multiple long counts of the activity, in an attempt to measure any ^{244}Cm on these filters In the end, very small positive detections, barely above detection limits, were reported In general, the levels detected were consistent with what is known about the incident and the prevailing meteorological

^{244}Cm measured at the three on site surveillance air sampler locations (SALV, CRED, and B531). The total estimated release (Ci) of ^{244}Cm from the incident was determined to be the largest value for which the calculated concentrations using the air dispersion modeling equations agreed with the mean concentrations (plus the 2σ measurement uncertainty) exhibited by the air samplers

Among the set of representative scenarios considered, the one deemed to be most plausible featured a stack-type release from the passive vent above the shredder room into an atmosphere characterized by stability class C, with low speed winds (1 3 m/s), and no pronounced directionality for the wind For this basic scenario, the air-dispersion modeling calculation yielded a release of about 400 nanocuries (nCi, 1 nCi = 1 x 10^{-9} Ci), which produced ^{244}Cm concentrations at the locations of the air surveillance samplers that were consistent with their measured one-week-average values (plus 2σ) for July 1–7, 1997 Using the 400 nCi source term CAP88-PC yielded calculated doses of 2 9 x 10^{-3} mrem to the MEI, and 1 2 x 10^{-4} mrem to the SW-MEI at the UNCLE Credit Union

While a single modeling run leading to definite numerical answers is emphasized here, note that modeling gives a *range* of credible values caused by making different, but still plausible assumptions concerning the conditions of the release Parameter studies carried out in our modeling runs indicate that the total amount of ^{244}Cm that escaped from Building 513 most likely ranged from a few hundred to a thousand nCi, the 400 nCi result above is not a precisely known value Nevertheless, the small nature of the release can be appreciated by considering the mass of material The specific activity of ^{244}Cm is 80 9 Ci per gram, so a release of 400 nCi amounts to only about 5 nanograms (5 x 10^{-9} g) of this substance

Approach 3: Model development was based on air concentration measurements made at different times and locations within Building 513 on the day of the incident These measurements include initial ^{244}Cm air concentrations estimated from respirator cartridge activity and worker breathing rates, continuous air monitor data from inside the shredder room, and high volume air sampler data collected inside Building 513 following the incident This model used the fluid dynamics principle for steady state flow conditions to estimate the ventilation dynamics responsible for contamination transfer and release Monte Carlo simulation techniques were used to explore the range of model input parameters that would satisfy the monitoring data This was accomplished by varying the building intake velocity plus the fractional deposition in the shredder room and the remainder of the building

calculate the total tritium emissions from the area, using a conservative approach that assumed the source to be 60 m south-southwest of the air sampler With this assumption, a diffuse source emission of 4.2 Ci/y (1.5×10^{11} Bq/y) was required to produce the concentrations measured at the air sampler. This source term produced a calculated 1997 dose to the SW-MEI from the Building 612 Yard of 1.6×10^{-2} mrem (1.6×10^{-1} µSv)

Waste Accumulation Area Drum Sampling: Waste Accumulations Areas (WAAs) are maintained by the LLNL programs as storage areas for waste prior to the transfer of the waste to Hazardous Waste Management Before the wastes are transferred, the waste drums are sampled by Hazardous Waste Management Because this sampling represents a potential for exposure to the atmosphere, estimates of the potential dose from this activity are provided The waste areas are maintained at various locations around the LLNL Livermore Site, so the potential emissions were modeled from the center of the site This source term produced a calculated 1997 dose to the SW-MEI from the Waste Accumulation Areas (listed under Diffuse Sources, B612 in Attachment 1) of 1.6×10^{-6} mrem (1.6×10^{-5} µSv)

Southeast Quadrant: The Southeast Quadrant of the Livermore site has elevated levels of ^{239}Pu in the surface soil (from historic waste-management operations) and air (presumably from resuspension) A high-volume air-particulate sampler is located adjacent to the UNCLE Credit Union (the location of the SW-MEI) to monitor the ^{239}Pu levels in this area Monitoring data from this air sampler were used as a direct measurement of potential dose via the air pathway. The median annual concentration of ^{239}Pu in air of 1.2×10^{-19} µCi/mL (4.4×10^{-15} Bq/mL), the dose-conversion factor of 3.08×10^{5} mrem/µCi (8.33×10^{-5} Sv/Bq) from Federal Guidance Report No 11, EPA-520/1-88-020, U S Environmental Protection Agency (1988) for ^{239}Pu, and the standard-man breathing rates of 8.4×10^{9} mL/y were used to calculate the estimated EDE of 3.1×10^{-4} mrem (3.1×10^{-3} µSv) for 1997

Site 300 Diffuse Sources

Diffuse sources at Site 300 involve tritium and uranium During remediation efforts at Site 300, LLNL completed a contaminant screening to identify potential routes of migration from soil to air and other environmental media of these radionuclides and other contaminants (Final Site Wide Remedial Investigation Report, Webster-Scholten, Ed , 1994, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-108131) Tritium and ^{238}U were identified as contaminants of potential concern

Tritium Migration and Evaporation at Site 300: Tritium gas and solid tritium (Li^3H) were components of explosives assemblies tested on the firing tables during past experiments Most of the gaseous tritium escaped to the atmosphere during the tests, but some of the solid Li^3H remained as residue in the firing table gravel Rainwater and dust-control rinse water percolated through the gravel, causing the tritium to migrate into the subsurface soil and, in some cases, eventually to the ground water. Tritium-contaminated gravel was removed from the firing tables in 1988 and disposed in the Pit 7 landfill Tritium in landfills, firing-table soils, and ground water are source terms for diffuse emissions of tritium to the atmosphere at Site 300 The tritium contamination at these locations was characterized at Site 300 in 1994 Since that time, natural processes including rainfall and evapotranspiration acted on the locations characterized, but new data have not been collected Because it is becoming less likely that the 1994 data are representative of current conditions, LLNL personnel installed a tritium sampler at a location (designated PRIM) that represents the SW-MEI, and doses from diffuse tritium sources for 1997 are estimated based on the monitoring data for that sampling location The median annual concentration of tritium in air of 0 21 pCi/m^3 ($7\ 8 \times 10^{-3}$ Bq/m^3), the dose-conversion factor of $6\ 4 \times 10^{-8}$ mrem/pCi ($1\ 73 \times 10^{-11}$ Sv/Bq) from Federal Guidance Report No 11, EPA-520/1-88-020, U.S Environmental Protection Agency (1988) for tritium, and the standard-man breathing rates of $8\ 4 \times 10^3$ m^3/y were used to calculate the estimated EDE of 1.1×10^{-4} mrem ($1\ 1 \times 10^{-3}$ µSv) for 1997

Resuspension of Depleted Uranium at Site 300: Like tritium, depleted uranium has been used as a component of explosives-test assemblies It remains as a residue in surface soils, especially near the firing tables. Because surface soil is subject to resuspension by the action of wind, rain, and other environmental disturbances, the collective effects of surface soil uranium residuals on off-site doses were evaluated

For the 1995 NESHAPs annual report, we developed calculations to separate the contribution to measured uranium activities from naturally occurring uranium (NU) (Gallegos et al , 1996, Lawrence Livermore National Laboratory, UCRL-ID-113867-96) We base our dose estimate for resuspended depleted uranium (DU) on the measured environmental surveillance monitoring total concentration in air of uranium-238, subtracting out the part contributed by NU, from the following equation

$$\mu = \frac{0\ 00726 + 0\ 99274 \dfrac{M(CU-235)}{M(CU-238)}}{0\ 00526 \dfrac{M(CU-235)}{M(CU-238)} + 0\ 00526},$$

where μ is the fraction (by weight) of uranium contributed by operations, CU is composite uranium (both DU and NU), M(CU-235) the mass of U-235 in the composite (measured) uranium, and M(CU-238) the mass of U-238 in the composite (measured) uranium (For derivation of the equation see the 1995 NESHAPs annual report, referenced above) This equation is used for those months in which explosives shots were not conducted

Using these calculations to apportion the M(CU) for 1997, and excluding the appropriate months, we obtain an annual average concentration of DU in air from resuspension of $2\ 36 \times 10^{-11}$ g/m^3 Using the fractions 0 998, 0 002, and 0 000005 to represent the amounts of ^{238}U, ^{235}U, and ^{234}U; specific activities of $3\ 32 \times 10^{-7}$, $2\ 13 \times 10^{-6}$, and $6\ 16 \times 10^{-3}$ Ci/g for ^{238}U, ^{235}U, and ^{234}U, a yearly inhalation rate of 8400 m^3/y, and dose conversion factors from EPA Regulatory Guide 11 of $1\ 18 \times 10^{11}$, $1\ 23 \times 10^{11}$, and $1\ 32 \times 10^{11}$ mrem/Ci, we obtain a total dose for resuspended DU of 8.7×10^{-3} mrem for 1997 This increase is due to high measured uranium concentration in February 1997, $18\ 1 \times 10^{-11}$ g/m^3, which raised the average for the year. Although this measurement is not consistent with experimental or construction activity, it is used in this calculation provide a conservative estimate of dose

Total Dose Estimate and Comparison with Previous Years' Data

For the Livermore site, the dose calculated for the SW-MEI from diffuse emissions in 1997 was 0 019 mrem (0 19 μSv) When point and diffuse sources were combined, the total annual dose was 0 097 mrem (0 97 μSv) Therefore, the relative contributions to the total were 20% from diffuse sources and 80% from point source emissions The total dose to the Site 300 SW-MEI from Site 300 operations in 1997 was 0 014 mrem (0 14 μSv) Point-source emissions from firing-table explosives experiments accounted for 0 0054 mrem (0 054 μSv), or 38%, of this total, while 0 0088 mrem (0.088 μSv), or 62%, was contributed by diffuse sources Table 5 presents the facilities or sources that account for 90% or more of the doses for the Livermore site or Site 300 SW-MEI

Comparison of the 1997 total dose estimate with that of previous years can be made by reviewing the information presented in Table 6 No diffuse

emissions were reported at Site 300 for years before 1993, so comparison for total dose can only be made with the values for 1993, 1994, 1995, and 1996; in addition, diffuse source doses were not reported separately from the total dose for the Livermore site for 1990 and 1991

Table 5. List of facilities or sources whose emissions account for 90% or more of the doses for the Livermore site and Site 300 SW-MEI.

Facility or Source	Dose (mrem)	Percent Contribution to Total Dose
Livermore site		
Building 331 (point source)	0 075	78%
Building 612 Area Source (diffuse source)	0 016	17%
Site 300		
Uranium resuspension (diffuse source)	0 0087	61%
850 Firing Table (point source)	0 0028	20%
851 Firing Table (point source)	0 0026	18%

Table 6. Doses (in mrem) calculated for the Site-Wide Maximally Exposed Individual for the Livermore site and Site 300, 1990 to 1997

Year	Total Dose	Point Source Dose	Diffuse Source Dose
Livermore site			
1997	0 097	0 078	0 019
1996	0 093	0 048	0 045
1995	0 041	0 019	0 022
1994	0 065	0 042	0 023
1993	0 066	0 040	0 026
1992	0 079	0 069	0 010
1991	0 234	—a	—a
1990	0 240	—a	—a
Site 300			
1997	0 014	0 0054	0 0088
1996	0 033	0 033	0 00045
1995	0 023	0 020	0 003
1994	0 081	0 049	0 032
1993	0 037	0 011	0 026
1992	0 021	0 021	—b
1991	0 044	0 044	—b
1990	0 057	0 057	—b

[a]Diffuse source doses were not reported separately from the total dose for the Livermore site for 1990 and 1991

[b]No diffuse emissions were reported at Site 300 for years before 1993

SECTION V. Certification

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

Name: Ray Corey
Deputy Manager, Livermore Site
U.S. Department of Energy
Livermore Site Office
7000 East Avenue, L-293
Livermore, CA 94550

Signature: _____ **Date:** 6/24/98
Ray Corey

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Name: Dennis K. Fisher
Associate Deputy Director for Operations
Lawrence Livermore National Laboratory
7000 East Avenue, L-005
Livermore, CA 94550

Signature: _____ **Date:** 6-14-98
Dennis K. Fisher

SECTION VI. Supplemental Information

Collective Effective Dose Equivalent

Population doses, or collective EDEs, for both LLNL sites were calculated out to a distance of 80 km in all directions from the site-centers using CAP88-PC As noted earlier, CAP88-PC evaluates the four principal exposure pathways ingestion through food and water consumption, inhalation, air immersion, and irradiation by contaminated ground surface

In 1996, we reconstructed the population distributions centered on the two LLNL sites These population distributions, as were the previous distributions, are based on 1990 census data However, the 1996 distributions were developed using commercially available, computer-map-based population data and the geographic information system software, ArcView© The population for each sector segment was determined by selecting census block level data for that segment In 1997, we further improved the estimates of the population distribution by refining the location of the centers of the grids and by using curved arcs rather than straight lines to define the sector segments Key population centers affected by LLNL emissions are the relatively nearby communities of Livermore and Tracy, and the more distant metropolitan areas of Oakland, San Francisco, and San Jose, as well as the San Joaquin Valley communities of Modesto and Stockton Within the 80 km outer distance specified by the EPA, there are 6 3 million residents included for the Livermore site collective dose determination, and 5 4 million for Site 300 Our population data files (distribution of population with distance and direction) are shown in Tables 7 and 8 for the Livermore site and Site 300, respectively

For the evaluation of the population dose, as distinct from the individual dose, all food (and in particular milk) was assumed to be produced locally This decision was made because, although there are no commercial dairy animals within the distances used to evaluate individual doses, many dairy animals live within 80 km of the Livermore site and Site 300

The collective EDE, which is the sum of the individual doses to all 6 3 million people within 80 km of the Livermore site, due to 1997 Livermore-site operations was 1 5 person-rem (0 015 person-Sv) This number can be compared to the collective EDE from natural background radioactivity for 6 3 million people of 1.88×10^6 person-rem (1.88×10^4 person-Sv) The 1997 collective EDE value is similar to the 1996 value of 1 1 person-rem

(0.011 person-Sv) The values ar similar because the stack releases from Building 331 (the Tritium Facility) were similar both years.

The corresponding collective EDE from Site 300 operations in 1997, 3 6 person-rem (0 036 person-Sv), was due to point-source emissions. The total collective EDE value for Site 300 is also similar to the 1996 value of 10 0 person-rem (0.10 person-Sv). The difference in EDE value is the result of differences in the amounts of high explosives and depleted uranium used each year in explosives experiments

The larger value for Site 300 compared to the Livermore site is traceable primarily to the highly conservative assumptions about the Site 300 explosives experiments, especially regarding the fraction of radioactive material that is aerosolized and the height and trajectory of the explosive-debris cloud This conservative modeling methodology over-predicts the quantity of radionuclides released to air by at least a factor of five, we believe, and over-estimates the long-range dispersal of material in these experiments In 1992, we submitted to EPA a modeling protocol designed to treat the transient explosive experiments more realistically than does CAP88-PC, but this protocol was not accepted

Compliance with 40 CFR 61 Subpart H (61.93)

Calculations of effective dose equivalents for all Livermore-site and Site 300 facilities having the potential to release radionuclides to the atmosphere have been completed Annual doses from actual total emissions of all facilities during 1997 were found to be well below the 10 mrem (100 μSv) NESHAPs dose standard Tritium accounted for most of the Livermore-site calculated dose, while at Site 300 practically the entire calculated dose was due to the isotopes ^{238}U, ^{235}U, and ^{234}U, in depleted uranium

Based on potential emissions without control devices and EPA agreement, 17 emission points in three facilities at the Livermore site will maintain continuous monitoring systems in compliance with NESHAPs requirements Continuous monitoring will be maintained in Building 332 and the seismically hardened area of Building 251 instead of a modeling or measurement effort to demonstrate the actual need for monitoring Continuous monitoring is being continued at Building 331 even though the EDEs that result from measured emissions do not require monitoring under 40 CFR 61 93(b).

Several other Livermore-site facilities (Buildings 175, 251 unhardened, 490, and 491) also will maintain continuous-monitoring systems, however, calculations using unabated potential emissions resulted in EDEs of less than 0 1 mrem/y (1 μSv/y) for the emissions from each of these facilities While this monitoring also will be continued, it is not required under NESHAPs

For facilities having discharge points without continuous monitoring, the requirement for continuous monitoring was individually evaluated The evaluation was based on unabated emissions, even if emission-control systems existed No additional facilities at either LLNL site were found to require continuous monitoring.

Status of compliance with 40 CFR 61 Subpart Q - National Emission Standards for Radon Emissions from Department of Energy Facilities

LLNL does not have storage and disposal facilities for radium-containing materials that would be a significant source of radon

Status of compliance with 40 CFR 61 Subpart T - National Emission Standards for Radon Emissions from the Disposal of Uranium Mill Tailings

LLNL does not have or store any uranium mill tailings

Information on Radon-220 and Radon-222 Emissions

Radon emissions occur naturally by emanation from the earth Radon-222 emissions that were reported in past NESHAPs annual reports from research experiments at the Livermore site did not occur in 1997

Continuous Monitoring: In the beginning of 1997, there were nine buildings (Buildings 166, 175, 231, 251, 331, 332, 419, 490, and 491) at the LLNL site that had radionuclide air-monitoring systems These buildings are listed in Table 9, along with the number of samplers, the types of samplers, the analytes of interest, and the number of monitored discharge points at the building. Many would operate from emergency power systems if normal power were lost

During 1997, sampling at locations in Buildings 166, 231 and 419 was discontinued For Buildings 166 and 419, sampling was discontinued because the operations originally requiring sampling ceased The sampler at the

Table 9. Air-effluent sampling locations and systems.

Building	Facility	Analytes	Sample type	Number of samplers	Number of discharge points
166	Pyrochemical Demonstration Facility	Gross α, β on particles	Filters	1 [a]	1
175	MARS	Gross α, β on particles	Filters	6	6
231	Vault	Gross α, β on particles	Filter	1 [a]	1
251	Heavy Elements				
	Unhardened area	Gross α, β on particles	Filters	44	55[b]
	Hardened area	Gross α, β on particles	Filters	4	4
	Hardened area	Gross α, β on particles	CAM[c]	4	
331	Tritium	Tritium	Ionization Chamber[c]	4	2
		Gaseous tritium/ tritiated water vapor	Molecular sieves	4	
332	Plutonium	Gross α, β on particles	CAM[c]	12	11
		Gross α, β on particles	Filters	16	
419	Decontamination	Gross α, β on particles	Filters	2 [a]	2
490	USEC Laser Isotope Separation	Gross α, β on particles	Filters	4	4
491	USEC Laser Isotope Separation	Gross α, β on particles	Filters	1	1

Note "CAM" denotes Eberline continuous air monitors

[a] Sampling at these locations was discontinued during 1997 because it was no longer required by the NESHAPs requirement for continuous monitoring

[b] Alternate blower system measured by the same sampler

[c] Alarmed systems

Building 231 vault was removed because operations consist of receipt, repackaging and shipping, and involve only sealed or encapsulated sources Thus, normal operations are not a potential source of emissions nor is the potential exposure to an MEI above 0 1 mrem from these operstions, therefore, continuous sampling is not required according to the NESHAPs regulations

Air samples for particulate emissions are extracted downstream of HEPA filters and prior to the discharge point to the atmosphere Particles are

collected on membrane filters. The sample filters are removed and analyzed for gross alpha and beta activity on a weekly or bi-weekly frequency depending on the facility In most cases, simple filter-type aerosol collection systems are used However, in some facilities, alpha continuous-air monitors (CAMs) are used for sampling In addition to collecting a sample of particles, the CAM units provide an alarm capability for the facility in the event of a release of alpha activity

Detection of gross alpha and beta activity resulting from particles collected on the air filters is accomplished using gas-flow-proportional counters Analysis is delayed for at least four days from the end of sample collection to allow for the decay of naturally occurring radon daughters For verification of the operation of the counting system, calibration sources, as well as background samples, are intermixed with the sample filters for analysis Analysis is performed by the Radiological Measurements Laboratory (RML) in the Hazards Control Department (HCD)

Each stack of the Tritium Facility (Building 331) is monitored for tritium release by both a continuous-monitoring alarm system and continuous molecular-sieve samplers The alarmed samplers, Overhoff ion chambers, provide real-time tritium concentration release levels (HT and HTO) The sieve samplers, which can discriminate between tritiated-water (HTO) vapor and molecular tritium (HT), provide the values used for environmental reporting and are exchanged weekly or bi-weekly depending on the rate of tritium releases expected from planned work Each sieve sampler (unalarmed) is in parallel with an alarmed monitor and consists of two molecular sieves The first sieve collects tritiated water vapor, then a palladium-coated catalyst converts molecular tritium to tritiated water, which is then collected on a second sieve The molecular sieve samples are submitted to the Hazards Control Analytical Laboratory where they are installed into a recovery system for the bake-out of tritiated-water vapor and subsequent condensation and collection of the water The retrieved tritiated water is analyzed by RML using liquid-scintillation counting techniques

Data from air-particulate-sampling filter and molecular-sieve analyses are reviewed by the Hazards Control Department Health Physicist responsible for each facility and an Environmental Protection Department Environmental Analyst

Periodic Confirmatory Sampling: NESHAPs periodic confirmatory sampling was conducted at two facilities in 1997. These were a cleaning operation in Building 322 and a drum crushing operation in Building 612.

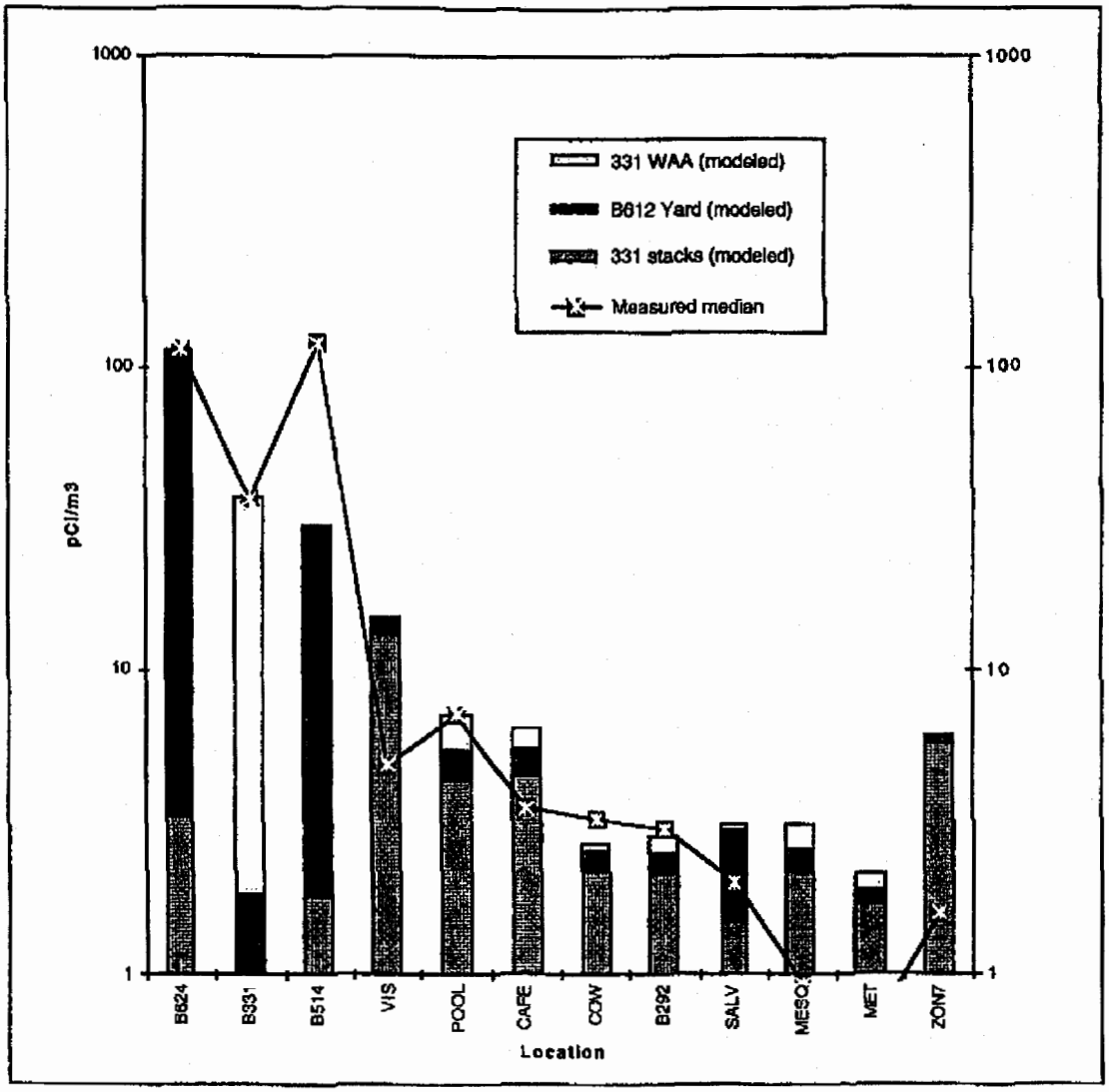

Figure 7. Comparison of measured and modeled tritium concentrations, 1997 Note that the measured median values for MESQ (0.93 pCi/g) and MET (0.67 pCi/g) are below the scale of this figure.

concentrations at the desired locations However, both the B331 WAA and the Building 612 Yard emission rates were not independently measured, but rather were determined from the surveillance tritium air monitor data for the particular monitor in the closest proximity, by requiring that the modelled concentration match the data from that particular monitor The source term for Building 612 Yard was adjusted to give the observed value at the B624 monitor, and the source term for the B331 WAA was chosen to give

625, 804, and 810A An EPD Environmental Analyst contacted the responsible party who signed the NESHAPs Inventory Forms and physically visited and inspected the facilities to verify inventory data The responsible party was asked to demonstrate how he/she arrived at the data submitted on the original inventory form. Stack parameters also were verified The QC data were compared to the original data The accuracy of the inventory data was confirmed

Modeling QC: Fifteen percent of the CAP88-PC modeling runs were selected for validation by a second analyst using a different computer and copy of CAP88-PC The analyst performing this QC effort ran the model following independent gathering of radionuclide inventories and stack data from the NESHAPs Inventory Forms and pertinent distances from site maps The QC modeling verified the values from the original CAP88-PC modeling runs The data that are presented in the attached spreadsheet are as accurate as possible, demonstrating that quality objectives are being met

EPA Compliance Evaluation Investigation

On September 3, 1997, the U S EPA, Region IX conducted a Compliance Evaluation Investigation at Site 300 LLNL personnel made a number of presentations during the course of the inspection including summaries of explosives tests air dispersion modeling assumptions and calculations, diffuse source modeling calculations for Site 300, the planned operations of the Contained Firing Facility, and the Building 513 shredder incident. U S EPA personnel visited several locations at Site 300, including Bunker 801, Bunker 851, and onsite tritium and air particulate monitors By letter report dated September 29, 1997, the U S EPA indicated that the Site 300 facility met the requirements 40 CFR 61 Subpart H, and no additional compliance activities were required.

By a letter dated January 27, 1998, the U S EPA Air Division raised a number of questions regarding the Building 513 shredder unit these questions addressed routine operations as well as the incident in which workers were contaminated with ^{244}Cm On March 4, 1998, LLNL provided a lengthy reply stating that the routine operations of the unit were conducted in accordance with all NESHAPs requirements, and providing the estimates of dose from the incident LLNL has not yet received a response to this letter from the U S EPA

Physical-State Factors: The physical-state factors listed are EPA potential-release fractions from 40 CFR 61, Appendix D, whereby emissions are estimated from radionuclide inventories depending on their physical states for use in dispersion/dose assessment modeling A physical-state factor of $1\ 0 \times 10^{-6}$ is used for solids, 1.0×10^{-3} is used for liquids and powders, and 1 0 is used for unconfined gases In 1996, U.S. EPA granted approved alternative emissions factors for elemental uranium as follows. an emission factor of 1×10^{-6} can be used for elemental uranium heated at temperatures below 1100°C, an emission factor of 1×10^{-3} can be used for elemental uranium heated at temperatures below 3000°C, and an emission factor of 1 shall be used for temperatures greater than 3000°C These factors are allowed provided that the uranium is not intentionally dispersed to the environment and that the processes do not alter the chemical form of the uranium

Stack Parameters: Engineering surveys conducted from 1990 through 1992 form the basis for the stack physical parameters shown, which were checked and validated by facility experimenters and managers for 1994 and 1995 Stack physical parameters for sources evaluated in 1997 were updated, as necessary, by experimenters and managers foı those facilities

Emission-Control Devices: High-Efficiency-Particulate-Air (HEPA) filters aıe used in many LLNL facilities to contıol particulate emissions For some discharge points, scrubbers and electrostatic precipitators aid the control of emissions The operational performance of all HEPA filtration systems is routinely tested. The required efficiency of a single-stage HEPA filter is 99 97% Double-staged filter systems are in place on some discharge points Tıiple-stage HEPA filters aıe used on glove-box ventilation systems in the Building 332 Plutonium Facility and in the hardened portion of Building 251

Control-Device Abatement Factors: Similar to physical-state factors, control-device abatement factors, from Table 1 in 40 CFR 61, Appendix D, are those associated with the listed emission-control devices, and are used to better estimate actual emissions for use in dispersion and dose models By ıegulation, each HEPA filter stage is given a 0 01 factor (even though the required test efficiency that all LLNL HEPA filters must maintain would yield a factor of 0 0003), venturi scrubbers and electrostatic precipitators are each given a 0 05 factor, and each activated-charcoal filter is given a 0 1 factor

Estimated Annual Emissions: For unmonitored and non-continuously monitored sources, estimated annual emissions for each radionuclide aıe

Attachment 1 - 1997 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem/y)	0.1 mrem/y Maximum Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem/y)	Source Category	Below App. E Quantity
151	2120 (continued)			Eu-152	1.0E-06	1.0E-03						1.0E-11								Y
				Eu-154	1.0E-06	1.0E-03						1.0E-11								Y
				Co-60	1.0E-06	1.0E-03						1.0E-11								Y
				Th-232	1.0E-06	1.0E-03						1.0E-11								Y
				Ra-133	1.0E-06	1.0E-03						1.0E-11								Y
				U-238	4.7E-09	1.0E-03						4.7E-12								Y
				U-235	3.2E-10	1.0E-03						3.2E-13								Y
				U-234	5.1E-09	1.0E-03						5.1E-12								Y
151	2140	FHE-78	Tracer preparation	Pu-238	2.0E-14	1.0E-03	11.9	0.61	3.3	None	1	2.0E-17	1308	E	6.5E-13	584	WNW	2.3E-12	1	Y
				Pu-239	4.0E-14	1.0E-03						4.0E-17								Y
				Pu-240	4.0E-14	1.0E-03						4.0E-17								Y
				Pu-242	3.0E-12	1.0E-03						3.0E-15								Y
				U-232	1.0E-12	1.0E-03						1.0E-15								Y
				U-233	9.0E-13	1.0E-03						9.0E-16								Y
				U-236	1.0E-15	1.0E-03						1.0E-18								Y
				U-238	8.6E-17	1.0E-03						8.6E-20								Y
				U-234	2.0E-15	1.0E-03						2.0E-18								Y
151	2308	FHE-18	Actinide research	Th-232	3.0E-19	1.0E-03	11.9	0.61	2.9	Double HEPA	0.0001	3.0E-17	1308	E	1.4E-09	584	WNW	5.2E-06	1	Y
				Pu-239	1.0E-04	1.0E-03						1.0E-11								Y
				Pu-242	5.0E-07	1.0E-03						5.0E-14								Y
151	2312	FHE-21	Actinide research	Pu-242	2.0E-07	1.0E-03	11.9	0.61	2.9	Double HEPA	0.0001	2.0E-14	1308	E	2.8E-09	584	WNW	1.0E-04	1	Y
				U-233	1.0E-06	1.0E-03						1.0E-15								Y
				Np-237	1.4E-04	1.0E-03						1.4E-11								Y
151	2315	FHE-30	Sample preparation	Pu-242	6.0E-07	1.0E-03	11.9	0.61	2.9	Double HEPA	0.0001	6.0E-14	1308	E	8.0E-12	584	WNW	2.9E-07	1	Y
151	2322	FHE-31	Chemical leaching experimentation	Gross alpha	1.3E-06	1.0E-03	11.9	0.61	3.4	None	1	1.3E-09	1308	E	1.7E-07	584	WNW	5.8E-07	1	NA
				Gross beta	1.2E-09	1.0E-03						1.2E-09								NA
151	2326	FHE-09	Chemical analysis of waste	Gross alpha	2.5E-06	1.0E-03	11.9	0.61	3.0	None	1	2.5E-09	1308	E	3.3E-07	584	WNW	1.3E-06	1	NA
				Gross beta	2.5E-06	1.0E-03						2.5E-09								NA
151	2344	FHE-08	Chemical analysis of waste	Gross alpha	2.0E-06	1.0E-03	11.9	0.61	2.4	None	1	2.0E-09	1308	E	2.6E-07	584	WNW	1.0E-06	1	NA
				Gross beta	2.0E-06	1.0E-03						2.0E-09								NA
Building 166 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC). *Gross alpha and gross beta emissions are continuously monitored at the stack. Monitoring data, rather than the inventory approach, are used to determine emissions. **Because monitoring takes place after HEPA filration, an unabated EDE cannot be determined (see discussion on page 46.)																				
166	Hilltop	Stack	Conversion of uranium to metallic and oxides of uranium	Gross alpha	-	NA	7.9	0.86	3.9	HEPA	0.01	0.0E+00	1291	E	0.0E+00	**	**	**	3	NA
				Gross beta	-	NA						0.0E+00								NA
Building 174 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).																				
174	Annex-1401	Room air	Pulse laser experimentation	U-238	9.0E-06	1.0E-06	NA	NA	NA	None	1	9.0E-16	1440	SSE	1.5E-12	480	W	5.4E-11	1	Y
				U-235	1.2E-06	1.0E-06						1.2E-16								Y
				U-234	6.4E-06	1.0E-06						6.4E-16								Y
Building 175 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC). *Gross alpha and gross beta emissions are continuously monitored at the stack. Monitoring data, rather than the inventory approach, are used to determine emissions. **Because monitoring takes place after HEPA filration, an unabated EDE cannot be determined (see discussion on page 46.)																				
175		5 Stacks	Cleaning and refurbishment of parts	Gross alpha	-	NA				HEPA	1.0E-02	0.0E+00	**	**	0.0E+00	**	**	**	3	NA
				Gross beta		NA						0.0E+00								NA
Building 177 is part of LLNL's Uranium Atomic Vapor Laser Isotope Separation (U-AVLIS) program, now affiliated with The United States Enrichment Corporation (USEC).																				
177	1908	Room Air	Corrosion studies of liquid uranium	U-238	6.0E-03	1.0E-03	N/A	N/A	N/A	None	1	6.0E-06	1350	SSE	9.4E-09	615	WNW	2.2E-03	1	Y
				U-235	6.1E-05	1.0E-03						6.1E-08				658	W			Y
				U-234	4.7E-04	1.0E-03						4.7E-07								Y
177	1914	FHE-10	Examination/cleaning of apparatus contaminated by uranium	U-238	3.3E-05	1.0E-03	6.8	0.41	2.4	HEPA	0.01	3.3E-10	1350	SSE	1.2E-08	615	WNW	2.5E-05	1	Y
				U-235	1.5E-06	1.0E-03						1.5E-11								Y
				U-234	3.0E-05	1.0E-03						3.0E-10								Y
177	1918	FHE-07	Preparation and examination of metallographic samples	U-238	9.0E-06	1.0E-03	7.9	0.56	12.9	HEPA	0.01	9.0E-13	1350	SSE	2.9E-11	784	NNE	2.9E-08	1	Y
				U-235	4.8E-08	1.0E-03						4.8E-14								Y
				U-234	1.1E-04	1.0E-03						1.1E-12								Y

Attachment 1 - 1997 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 meaning Site-Wide Dose Assessment: Distance to SAMEL (m)	Direction to SAMEL	MEI (mrem)	0.1 meaning Maximum Dose Assessment: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Subpt. H App. E Quantity
177	1021	FHE-94, 95	Sample preparation	U-238	1.7E-04	1.0E-03	11.0	0.41	7.8	HEPA	0.01	1.7E-06	1350	SW	6.0E-05	784	NNE	8.0E-05	1	Y
				U-235	8.0E-06	1.0E-03						8.0E-10								Y
				U-234	2.1E-04	1.0E-03						2.1E-08								Y
Building 194 is operated by N-Division for the Physics and Space Technology Directorate. The facility houses a high-energy linear accelerator (LINAC) and research laboratories.																				
The accelerator beam can produce small quantities of short-lived air activation products.																				
194	B122	TE-PE4 (Target Exhaust)	Linac accelerator vault	C-14	6.0E-06	1.0E+00	39.6	1.37	4.5	None	1	6.0E-06	1535	SW	8.4E-06	928	NE	5.3E-04	1	NA
				H-3	1.1E-01	1.0E+00						1.1E-01								NA
194	B194	TE-PE4	Storage	Na-22	3.0E-06	1.0E-03						3.0E-09								Y
				U-233	1.2E-03	1.0E-04						1.2E-11								Y
				U-234	6.0E-07	1.0E-04						6.0E-10								Y
				U-235	1.0E-07	1.0E-04						1.0E-10								Y
				U-236	3.3E-08	1.0E-04						3.3E-12								Y
				U-238	1.0E-04	1.0E-04						1.0E-10								Y
	B130	TE-PE4	Positron beam generation	O-15	5.5E-01	1.0E+00				None	1	5.5E-01								NA
				N-13	1.1E+00	1.0E+00						1.1E+00								NA
194	1131	Room Air	Positron materials science experiments	Na-22	3.0E-05	1.0E-03	NA	NA	NA	None	1	3.0E-09	1525	SE	1.3E-09	412	NNE	4.6E-08	1	Y
Building 212 is administered by the Physics and Space Technology Directorate (formerly the Physical Sciences Directorate) for miscellaneous physics experiments.																				
The current radionuclide emissions are due to contamination from past operations of the existing target neutron source, which is no longer in operation.																				
212	174	FHE-7	Contamination	H-3	1.7E-02	1.0E-03	4.5	0.6	0.5	None	1	1.7E-06	1278	ENE	6.8E-12	38	SW	2.4E-10	1	Y
212	164	Room Air	Contamination	H-3	1.0E-03	1.0E-00	NA	NA	NA	None	1	1.0E-09	1278	ENE	4.0E-13	38	SW	1.4E-11	1	Y
Building 222 is part of the Chemistry and Material Sciences Directorate. Many of the laboratories either store or used depleted uranium.																				
The depleted uranium usually exists as a solid, either as metal plates or in chemical reagents such as white powders. The other source of radionuclides in Building 222 is from analysis of hazardous waste samples.																				
222	1106	Room Air	Analysis of waste samples	Gross alpha	3.0E-14	1.0E-00	NA	NA	NA	None	1	3.0E-17	1230	ENE	7.3E-16	191	SSW	1.0E-13	1	NA
				Gross beta	3.0E-10	1.0E-03						3.0E-10								NA
				Gross gamma	3.0E-10	1.0E-03						3.0E-10								NA
				H-3	7.5E-13	1.0E-03						7.5E-16								Y
222	1406	Room Air	Chemical analysis	U-238	4.0E-13	1.0E-03	NA	NA	NA	None	1	4.0E-16	1239	ENE	3.0E-14	191	SSW	5.0E-13	1	Y
				U-235	8.3E-15	1.0E-03						8.3E-18								Y
				U-234	4.0E-14	1.0E-03						4.0E-17								Y
				H-3	1.1E-11	1.0E-03						1.1E-14								Y
222	1511B	FHE-113	Chemical analysis	U-234	1.0E-16	1.0E-00	5.5	0.10	6.0	HEPA	0.01	1.0E-18	1239	ENE	1.0E-16	191	SSW	1.3E-15	1	Y
																283	SW			Y
				U-235	4.4E-19	1.0E-00						4.4E-20								Y
				U-238	9.0E-17	1.0E-00						9.0E-19								
222	1511B	Room Air	Chemical analysis	U-234	5.1E-14	1.0E-03	NA	NA	NA	None	1	5.1E-17	1239	ENE	7.7E-16	191	SSW	1.1E-13	1	Y
				U-235	2.2E-15	1.0E-03						2.2E-18								Y
				U-238	4.7E-14	1.0E-03						4.7E-17								Y
222	1514	Room Air	X-ray fluorescence analysis	U-238	9.0E-11	1.0E-03	NA	NA	NA	None	1	9.0E-17	1239	ENE	8.0E-15	191	SSW	1.1E-13	1	Y
				U-235	1.3E-12	1.0E-03						1.3E-15								Y
				U-234	9.3E-12	1.0E-03						9.3E-15								Y
222	1534C	FHE 87	Sample digestion	Gross alpha	6.0E-10	1.0E+00	6.1	0.20	6.7	None	1	6.0E-10	1239	ENE	1.3E-07	191	SSW	8.3E-07	1	NA
				Gross beta	9.3E-10	1.0E+00						6.0E-10								NA
The 231 complex houses research and development activities conducted by the Chemistry and Materials Science Directorate, Engineering, Weapons Engineering, and Safeguards and Security Materials Management Division.																				
Management oversight for Building 231 is provided by the Engineering Directorate through the Engineering Sciences Division.																				
*Gross alpha and gross beta emissions are continually monitored at the stack. Monitoring data, rather than the inventory approach, are used to determine emissions.																				
**Because monitoring takes place after HEPA filtration, an unabated EDE cannot be determined (see discussion on page 48.)																				
231	1128	FHE-84-1,2	Storage of radionuclides	Gross Alpha	*	NA	12.2	0.41	13.0	HEPA	0.01	0.0E+00	1167	E	0.0E+00	**	**	**	3	NA
231	1407	Room Air		U-238	4.1E-08	1.0E-00	NA	NA	NA	None	1	4.1E-09	1167	E	2.2E-07	439	SSW	1.4E-06	1	Y
				U-235	5.2E-06	1.0E-00						5.2E-11								Y
				U-234	3.3E-04	1.0E-00						3.3E-10								Y
231	1737	FOBE-8	Storage area	U-238	1.0E-07	1.0E-06	10.1	0.46	1.5	HEPA	0.01	1.0E-16	1167	E	1.2E-13	723	WNW	4.0E-11	1	Y
				U-235	2.5E-09	1.0E-06						2.5E-17								Y
				U-234	1.0E-08	1.0E-06						1.0E-16								Y
231	1737A	FHE-94	Electron beam welding	U-238	3.0E-05	1.0E-06	10.1	0.46	1.5	HEPA	0.01	3.0E-18	1167	E	2.3E-11	723	WNW	8.1E-09	1	Y
				U-235	4.0E-07	1.0E-06						4.0E-19								Y
				U-234	3.3E-06	1.0E-06						3.3E-18								Y

Attachment 1 - 1997 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 meaty Site-Wide Dose Predictions: Distance to (MWEI) (m)	Direction to MWEI	0.1 meaty Monitoring Requirement: ISE (mrem)	Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below App. E Quantity
252	1734 (continued)			Y-90	9.5E-12	1.0E+00						9.5E-12								Y
				Cs-137	3.9E-12	1.0E+00						3.9E-12								Y
				Th-230	5.3E-13	1.0E+00						5.3E-13								Y
				Pu-239	7.8E-12	1.0E+00						7.8E-12								Y
				Gross alpha	1.4E-13	1.0E+00						1.4E-13								NA
				Gross beta	2.1E-13	1.0E+00						2.1E-13								NA
253	1734	FHE-11	Acid digestion for sample analysis	H-3	9.8E-09	1.0E+00	10.4	0.30	18.3	None	1	9.8E-09	1122	ESE	5.3E-08	798	WNW	2.2E-08	1	Y
				Pu-239	5.3E-11	1.0E+00						5.3E-11								Y
				Sr-90	3.8E-10	1.0E+00						3.8E-10								Y
				Y-90	2.8E-12	1.0E+00						2.8E-12								Y
				Np-237	5.1E-12	1.0E+00						5.1E-12								Y
253	1916	FHE-22	Preparation of calibration standards	H-3	9.0E-11	1.0E-03	7.9	0.20	5.2	None	1	9.0E-14	1122	ESE	1.3E-15	738	W	1.2E-14	1	Y
				C-14	1.4E-11	1.0E-03						1.3E-14				798	WNW			Y
				P-32	1.8E-10	1.0E-03						1.3E-13								Y
Building 254 is run by Hazards Control for the purpose of conducting bioassays and providing analytical services.																				
254	113	FHE-100F	Analysis of urine for radionuclides	Am-241	5.6E-14	1.0E-03	8.2	1.07	5.3	None	1	5.6E-17	1058	ESE	1.1E-11	649	WNW	8.1E-13	1	Y
				Am-243	2.7E-12	1.0E-03						2.7E-15								Y
				C-14	7.0E-11	1.0E-03						7.0E-14								Y
				Cf-252	8.4E-12	1.0E-03						8.4E-15								Y
				Cm-242	9.1E-13	1.0E-03						9.1E-16								Y
				Cm-244	5.6E-10	1.0E-03						5.6E-21								Y
				Cf-249	6.7E-13	1.0E-03						6.7E-16								Y
				Gross gamma	1.4E-11	1.0E-03						1.4E-14								NA
				H-3	1.2E-10	1.0E-03						1.2E-13								Y
				I-125	3.4E-10	1.0E-03						3.4E-13								Y
				Np-237	1.1E-10	1.0E-03						1.1E-13								Y
				Np-239	5.2E-10	1.0E-03						5.2E-13								Y
				P-32	5.6E-10	1.0E-03						5.6E-13								Y
				P-33	2.2E-09	1.0E-03						2.2E-12								Y
				Pu-238	7.1E-15	1.0E-03						7.1E-18								NA
				Pu-239	4.6E-13	1.0E-03						4.6E-16								Y
				Pu-240	2.9E-12	1.0E-03						2.9E-15								Y
				S-35	2.3E-10	1.0E-03						2.3E-13								Y
				Sr-90	2.7E-10	1.0E-03						2.7E-13								Y
				Th-230	9.4E-12	1.0E-03						9.4E-15								Y
				U-232	9.4E-13	1.0E-03						9.4E-16								Y
				U-233	2.9E-14	1.0E-03						2.9E-17								Y
				U-234	1.1E-12	1.0E-03						1.1E-15								Y
				U-235	3.6E-14	1.0E-03						3.6E-17								Y
				U-238	6.7E-12	1.0E-03						6.7E-15								Y
				U-238	2.8E-15	1.0E-03						2.8E-18								Y
				Y-90	2.7E-10	1.0E-03						2.7E-13								Y
Building 255 is operated by Hazards Control and houses a radiation calibration and standards laboratory. Many operations involve the use of sealed sources.																				
255	185	FHE-4	Analysis of urine for radionuclides	Am-241	3.8E-15	1.0E-03	6.9	0.30	6.1	None	1	3.8E-18	1058	E	7.4E-12	790	W	1.3E-11	1	Y
				Am-243	1.0E-14	1.0E-03						1.0E-17								Y
				Cm-244	3.8E-14	1.0E-03						3.8E-17								Y
				I-125	2.3E-09	1.0E-03						2.3E-12								Y
				I-131	7.2E-09	1.0E-03						7.2E-12								Y
				Np-237	5.7E-14	1.0E-03						5.7E-17								Y
				Pu-239	1.8E-14	1.0E-03						1.8E-17								Y
				Pu-242	1.9E-15	1.0E-03						1.9E-18								Y
				Th-230	5.7E-14	1.0E-03						5.7E-17								Y
				Th-232	1.0E-16	1.0E-03						1.0E-19								Y
				U-233	1.0E-11	1.0E-03						1.0E-14								Y
				U-238	1.3E-16	1.0E-03						1.3E-19								Y
255	190	FHE-2	Tritium gas monitor calibrations	H-3	2.5E-02	1.0E+00	8.1	0.31	5.2	None	1	2.5E-02	1056	E	9.8E-08	850	WNW	3.9E-06	1	Y
Building 281 is part of the Chemistry and Materials Sciences Directorate. In rooms 1311 and 1315, there are a number of sources, both as solids and in solution, which are kept and used in glove boxes. There are HEPA filters between the glove boxes and the vent stack. Room 1325 is used for collection of Nuclear Test Site groundwater samples. These samples contain some tritiated water.																				
281	1174	FHE-13	Yucca Vent	C-14	3.0E-06	1.0E-03	6.7	0.30	4.1	None	1	3.0E-09	1338	ESE	1.8E-11	570	NNE	2.9E-10	1	Y
281	1307	FHE-4	Tracer Vent	Ni-63	1.0E-06	1.0E-03	6.4	0.61	3.7	None	1	1.0E-09	1338	ESE	1.7E-12	570	NNE	2.8E-11	1	Y
				Ni-59	3.5E-10	1.0E-03						3.5E-13								Y

Attachment 1 - 1997 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Standard Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Appl. E Quantity
281	1311	FHE-12	Sample preparation	U-233	4.9E-11	1.0E-05	6.1	0.41	4.0	None	1	4.9E-14	1332	SSE	8.8E-13	579	NNE	1.5E-11	1	Y
281	1311A	FHE-5	Sample preparation	Th-232	2.0E-10	1.0E-03	4.9	0.25	10.3	None	1	2.0E-13	1332	SSE	4.0E-10	579	NNE	4.5E-09	1	Y
				Pu-242	1.0E-09	1.0E-03						1.0E-11								Y
281	1311B	FHE-6	Sample preparation	Pu-242	4.0E-09	1.0E-03	4.9	0.25	10.3	Double HEPA	0.0001	4.0E-15	1332	SSE	1.9E-13	579	NNE	3.9E-08	1	Y
281	1316	FHE-1	Sample preparation	Th-232	3.0E-09	1.0E-03	5.2	0.28	8.2	Double HEPA	0.0001	3.0E-17	1332	SSE	4.9E-10	579	NNE	8.0E-05	1	Y
				Np-237	7.0E-09	1.0E-03						7.0E-18								Y
				Pu-242	5.0E-03	1.0E-03						5.0E-14								Y
281	1327	FHE-1	Radioactivity migration studies	U-233	2.7E-09	1.0E-03	6.7	0.30	6.1	None	1	2.7E-12	1332	SSE	1.8E-08	579	NNE	2.8E-06	1	Y
				Np-237	9.0E-08	1.0E-03						2.2E-11								Y

Building 292 is administered by the Environmental Programs Directorate. Residual contamination exists throughout the facility from the past operation of a stationary target neutron source, that is no longer in operation.
Also, neutron mass experiments have not been conducted since 1993.

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Standard Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Appl. E Quantity
292	1200,1202	Room Air	Contamination	H-3	1.8E+00	1.0E-03	NA	NA	NA	None	1	1.8E-03	1380	SSE	1.8E-07	456	N	4.6E-06	1	Y
292	1204	Room Air	Contamination	H-3	2.3E+01	1.0E-03	NA	NA	NA	None	1	2.3E-02	1380	SSE	2.3E-06	456	N	5.9E-05	1	Y
292	1402, 1402A 1404, 1406 1407	Room Air	Contamination	H-3	1.8E+00	1.0E-03	NA	NA	NA	None	1	1.8E-03	1380	SSE	1.8E-07	456	N	4.6E-06	1	Y

Building 298 is part of the Laser Fusion Program. Small amounts of tritium are used in the facility in conjunction with laser target research and development.

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Standard Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Appl. E Quantity
298	183	FEV-1	Laser testing	U-238	9.0E-09	1.0E-06	6.5	0.83	15.9	HEPA	0.01	9.0E-13	1398	SE	1.1E-11	344	NE	8.8E-08	1	Y
				U-235	1.2E-08	1.0E-06						1.2E-14								Y
				U-234	8.0E-08	1.0E-06						8.0E-14								Y
298	189	FHE-14	Laser beam target testing	U-238	4.5E-04	1.0E-06	8.4	0.83	15.1	HEPA	0.01	4.3E-12	1398	SE	5.3E-11	344	NE	2.0E-07	1	Y
				U-235	6.0E-06	1.0E-06						6.0E-14								Y
				U-234	4.0E-05	1.0E-06						4.0E-13								Y
298	Vestibule	Room Air	Laser beam target research and development	H-3	4.0E-02	1.0E+00	NA	NA	NA	None	1	4.0E-02	1456	SE	3.3E-06	384	NNE	2.7E-04	1	Y

Buildings 321, 321A, 321B, and 321C are the Material Fabrication Shops and are part of the Mechanical Engineering Department. Operations in this complex include milling, shaping and machining of depleted uranium.
Uranium pieces may be worked on in a single location, or may be moved from machine to machine. In addition, depleted uranium parts occasionally undergo heat treatment. The amount of depleted uranium that is handled depends on programmatic demands and varies from month to month. NOTE: Machining only occurs in 321C.
*Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding.

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Standard Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Appl. E Quantity
321A	1901A	FHE-24	Machining and manufacturing	U-234	7.5E-04	1.0E-06	9.7	0.46	2.0	HEPA	0.01	7.5E-12	1031	SSE	8.90E-08	252	SSW	5.2E-06	1	Y
				U-235	1.0E-04	1.0E-06						1.0E-12								Y
				U-238	6.1E-03	1.0E-06						6.1E-11								Y
321C	All*	FHE-9	Machining and manufacturing	U-234	3.2E-09	1.0E-06	9.5	0.31	16.1	HEPA	0.01	3.2E-08	1033	SSE	3.1E-06	262	SSW	6.4E-08	1	Y
		FHE-11		U-235	4.0E-02	1.0E-06	12.5	0.60	6.0	HEPA	0.01	4.0E-10								Y
		FHE-18		U-238	3.0E-01	1.0E-06	11.3	0.23	13.4	HEPA	0.01	3.0E-09								Y
		FEV-1000					11.3	0.65	6.6	HEPA	0.01									

Building 322 is operated by the Mechanical Engineering Department.

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Standard Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Appl. E Quantity
322	109	FHE-1	Cleaning and plating of depleted uranium	U-234	5.1E-07	1.0E-06	7.9	0.36	1.0	None	1	5.1E-13	930	ENE	4.3E-10	314	SSW	1.1E-09	1	Y
				U-235	4.3E-06	1.0E-06						4.3E-14								Y
				U-238	3.3E-05	1.0E-06						3.3E-13								Y

Building 327 is operated by the Mechanical Engineering Department.

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Standard Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Appl. E Quantity
327	1279	Room Air	Non-destructive ultrasonic material evaluation	U-234	1.3E-06	1.0E-06	NA	NA	NA	None	1	1.3E-11	1016	ENE	1.6E-08	321	SSW	7.5E-06	1	Y
				U-235	1.0E-03	1.0E-06						1.0E-12								Y
				U-238	1.4E-04	1.0E-06						1.4E-10								Y

Building 331 is operated by the Defense and Nuclear Technologies Directorate. The building houses the tritium research facility and associated laboratories.
*Tritium HT and HTO emissions are continuously monitored from the two 39 meter tall stacks in compliance with NESHAPs regulations. Monitoring data, rather than the inventory approach, are used to determine emissions.
**Stack emissions have been combined as permitted by the EPA/DOE Memorandum of Understanding.

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Standard Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Monitoring Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Appl. E Quantity
331	All**	Stack 1	Tritium R&D: Decontamination and decommissioning of facility	H-3	*	1.0E+00	30.0	1.22	7.9	None	1	1.0E+01	957	ENE	7.5E-02	957	SSE	7.5E-02	3	NA
		Stack 2		H-3	*	1.0E+00	30.0	1.22	10.3	None	1	8.8E+02								

Attachment 1 - 1997 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclide	Annual Inventory with Potential for Release (Ci)	Physical State Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 meaning Site-Wide Dose Assessment: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Maximum Receptor: Distance to MEI (m)	Direction to MEI	Unmitigated EDE (mrem)	Source Category	Below App. E Quantity
612	102 (continued)			Cd-115	3.2E-11	1.0E-03						5.3E-14								Y
				Ce 141	1.4E-11	1.0E-03						1.4E-14								Y
				Ce-144	4.0E-10	1.0E-03						4.0E-13								Y
				Cl-36	2.0E-10	1.0E-03						2.0E-13								Y
				Cl 252	1.2E-12	1.0E-03						1.2E-16								Y
				Cm 244	1.0E-04	1.0E-03						1.0E-07								Y
				Co 56	1.0E-13	1.0E-03						1.0E-16								Y
				Co-57	3.4E-12	1.0E-03						3.4E-15								Y
				Co-58	1.2E-11	1.0E-03						1.2E-14								Y
				Co-60	1.2E-08	1.0E-03						1.2E-04								Y
				Cr-51	1.0E-11	1.0E-03						1.0E-14								Y
				Cs 134	5.9E-11	1.0E 03						5.9E-14								Y
				Cs 137	8.9E-08	1.0E 03						8.9E 05								Y
				Eu-146	3.2E-12	1.0E-03						3.2E-15								NA
				Eu-152	2.0E-08	1.0E-03						2.0E 08								Y
				Eu-154	3.7E 07	1.0E-03						3.7E 10								Y
				Eu-155	3.3E 08	1.0E-03						3.3E-11								Y
				Fe-55	2.9E-10	1.0E 03						2.9E-13								Y
				Gd 146	1.2E-05	1.0E 03						1.2E-08								NA
				H 3	1.0E-03	1.0E-03						1.0E-06								Y
				Hg-203	1.0E-10	1.0E-03						1.0E-13								Y
				Ir 192	1.0E-13	1.0E-03						1.0E-16								Y
				K 40	6.1E 09	1.0E-03						6.1E-12								Y
				Kr 85	2.0E-10	1.0E+00						2.0E 10								NA
				MFP	6.1E 06	1.0E-03						6.1E-09								NA
				Mn-54	2.3E-10	1.0E-03						2.3E-13								Y
				Mo-99	1.1E-12	1.0E-03						1.1E-15								Y
				Na 22	1.0E-12	1.0E-03						1.0E-15								Y
				Nb 94	3.1E 10	1.0E-03						3.1E-13								Y
				Nb-95	1.2E-10	1.0E 03						1.2E-13								Y
				Np-237	6.0E 06	1.0E 03						6.0E 12								Y
				P-32	1.2E 00	1.0E-03						1.2E 11								Y
				P 33	2.0E-12	1.0E-03						2.0E-15								Y
				Pb-210	2.0E-12	1.0E-03						2.0E-15								Y
				Pm 147	2.7E 12	1.0E-03						2.7E-15								Y
				Po 210	5.1E 17	1.0E 03						5.1E 20								Y
				Pu 238	9.5E 06	1.0E-03						9.5E 09								Y
				Pu 239	1.6E-04	1.0E-03						1.6E-07								Y
				Pu-241	1.3E-03	1.0E-03						1.3E 06								Y
				Pu-242	8.0E 09	1.0E-03						8.0E 11								Y
				Ra-226	1.1E 09	1.0E 03						1.1E-12								Y
				Ra-228	1.7E-10	1.0E 03						1.7E-13								Y
				Rb-102	2.3E-10	1.0E-03						2.3E-13								NA
				Rh-102m	4.7E 13	1.0E-03						4.7E-15								NA
				Ru 106	4.0E-11	1.0E-03						4.0E-14								NA
				S-35	1.0E-07	1.0E 03						1.0E-10								Y
				Sb 124	3.1E-14	1.0E-03						3.1E-17								Y
				Sb 125	8.3E-11	1.0E-03						8.3E-14								Y
				Sc-46	1.0E-11	1.0E-03						1.0E-14								Y
				Se-75	3.3E-11	1.0E 03						3.3E-14								Y
				Sm-151	1.0E-12	1.0E-03						1.0E-15								Y
				Sr 85	1.0E-12	1.0E-03						1.0E-15								Y
				Sr-89	4.5E-12	1.0E-03						4.5E-15								Y
				Sr-90	2.7E 04	1.0E-03						2.7E-07								Y
				Ta-182	1.0E-11	1.0E 03						1.0E 14								Y
				Tb-160	2.0E-13	1.0E-03						2.0E-16								Y
				Tc-99	3.3E-07	1.0E-03						3.3E-10								Y
				Th-228	4.1E-10	1.0E 03						4.1E-13								Y
				Th-229	2.9E-10	1.0E-03						2.9E-13								Y
				Th-232	3.4E-09	1.0E-03						3.4E-12								Y
				Th-234	1.3E-12	1.0E-03						1.3E-15								Y
				U-232	1.0E 09	1.0E-03						1.0E-12								Y
				U-233	2.1E-07	1.0E-03						2.1E-10								Y
				U-234	1.7E-06	1.0E-03						1.7E-09								Y
				U-235	1.7E-07	1.0E-03						1.7E-10								Y
				U-237	7.3E 13	1.0E 03						7.3E-16								Y
				U-238	6.1E 06	1.0E-03						6.1E-09								Y
				U-239	1.1E-11	1.0E-03						1.1E-14								Y
				Y-91	1.3E-11	1.0E-03						1.3E-14								Y
				Zr-93	1.7E-10	1.0E 03						1.7E-13								NA

Attachment 1 - 1997 LLNL NESHAPs Annual Report Spreadsheet

Building	Room/Area	Stack ID	Operation	Radionuclides	Annual Inventory With Potential for Release (Ci)	Physical Susceptibility Factor	Stack Height (m)	Stack Diameter (m)	Stack Velocity (m/s)	Control Device(s)	Control Device Abatement Factor	Estimated Annual Emissions (Ci)	10 mrem/y Site-Wide Dose Requirement: Distance to SWMEI (m)	Direction to SWMEI	EDE (mrem)	0.1 mrem/y Maximally Exposed Requirement: Distance to MEI (m)	Direction to MEI	Unabated EDE (mrem)	Source Category	Below Age E Quantity
Building 625 is operated by the Hazardous Waste Management Division																				
625	All	Room Air	Repackaging of wastes	Am-241	4.1E-07	1.0E-06	NA	NA	NA	None	1	4.1E-13	378	NE	8.4E-09	289	ENE	9.7E-09	1	Y
				Am-243	2.4E-08	1.0E-06						2.4E-14								Y
				Ba-133	4.4E-11	1.0E-06						4.4E-17								Y
				Bi 214	1.4E-10	1.0E-06						1.4E-16								Y
				C 14	1.6E-09	1.0E-06						1.6E-15								Y
				Cd 109	3.07E-10	1.0E-06						3.1E-16								Y
				Ce 141	3.1E-11	1.0E-06						3.1E-17								Y
				Ce-144	7.4E-09	1.0E-06						7.4E-15								Y
				Co 57	2.7E-10	1.0E-06						2.7E-16								Y
				Co-60	4.5E-08	1.0E-06						4.5E-14								Y
				Cs 134	5.2E-09	1.0E-06						5.2E-15								Y
				Cs 137	3.9E-03	1.0E-06						3.9E-14								Y
				Eu 152	2.1E-08	1.0E-06						2.1E-14								Y
				Eu-154	1.2E-08	1.0E-06						1.2E-14								Y
				Eu 155	1.2E-09	1.0E-06						1.2E-15								Y
				H 3	7.0E-03	1.0E-06						7.0E-11								Y
				K-40	4.1E-07	1.0E-06						4.1E-13								Y
				NFP	4.81E-07	1.0E-06						4.8E-13								NA
				Na-84	6.4E-09	1.0E-06						6.4E-15								Y
				U 235	7.4E-06	1.0E-06						7.4E-12								Y
				U 235	7.6E-06	1.0E-06						7.6E-14								Y
				U-234	5.2E-07	1.0E-06						5.2E-13								Y
				Nb 95	6.4E-09	1.0E-06						6.4E-15								Y
				Np-237	1.1E-09	1.0E-06						1.1E-15								Y
				P 32	1.7E-12	1.0E-06						1.7E-18								Y
				Y 90	6.0E-13	1.0E-06						6.0E-19								Y
				Pb 212	1.6E-10	1.0E-06						1.6E-16								Y
				Pb 214	2.3E-11	1.0E-06						2.3E-17								Y
				Th 232	1.1E-09	1.0E-06						1.1E-15								Y
				Th-234	2.3E-06	1.0E-06						2.3E-12								Y
				U 238	1.2E-02	1.0E-06						1.2E-15								Y
				Ra 226	7.1E-04	1.0E-06						7.1E-14								Y
				Pa 238	3.1E-06	1.0E-06						3.1E-12								Y
				Pu 108	3.3E-06	1.0E-06						3.3E-15								Y
				Sb 125	4.0E-09	1.0E-06						4.0E-15								Y
				Sr 90	3.1E-09	1.0E-06						3.1E-14								Y
				Te 228	7.3E-09	1.0E-06						7.3E-15								Y
				Zr-95	1.2E-08	1.0E-06						1.2E-14								Y
625	Tent Enclosure	FEV	Repackaging of wastes	Am 241	9.1E-07	1.0E-06	1.5	0.31	12.4	HEPA	0.01	9.1E-15	378	NE	4.6E-10	289	ENE	5.2E-08	1	Y
				Am 243	1.1E-11	1.0E-06						1.1E-18								Y
				Cm 244	1.1E-11	1.0E-06						1.1E-18								Y
				U 238	3.3E-06	1.0E-06						3.3E-16								Y
				U-235	9.8E-11	1.0E-06						9.8E-18								Y
				U-234	2.7E-10	1.0E-06						2.7E-16								Y
				H 3	1.7E-05	1.0E-06						1.7E-13								Y
				Pa-231	2.3E-10	1.0E-06						2.3E-16								Y
				Pu-238	3.6E-07	1.0E-06						3.6E-13								Y
				Pu-239	1.6E-06	1.0E-06						1.6E-12								Y
				Pu 240	1.8E-06	1.0E-06						1.8E-12								Y
				Pu 241	5.1E-05	1.0E-06						5.1E-11								Y
				Pu-242	2.1E-10	1.0E-06						2.1E-16								Y
				Th-232	2.7E-06	1.0E-06						2.7E-12								Y
SITE 300 POINT SOURCES																				
Site 300 - Explosives tests are conducted on open-air firing tables located at Buildings 801 and 851. These tests have depleted uranium material as part of the material inventory. There are multiple tests per year. A total for 1995 is shown here. The radionuclides in Buildings 804, 810A, 810B, 822B, and 854F are encapsulated or sealed and are not used.																				
810A	133	Room Air	Assembly of peripherals	U-238	9.0E-04	1.0E-06	NA	NA	NA	None	1	9.0E-10	3206	NNE	1.2E-08	844	SSE	7.3E-08	1	Y
				U-235	1.8E-06	1.0E-06						1.8E-11								Y
				U 234	9.4E-05	1.0E-06						9.4E-11								Y
850	Firing Table	None	Explosive tests	U 238	1.7E-02	1.0E+00	NA	NA	NA	None	1	1.7E-02	4208	ESE	2.8E-05	1920	SW	6.5E-03	4	Y
				U-235	2.2E-04	1.0E+00						2.2E-04								Y
				U 234	1.6E-03	1.0E+00						1.6E-03								Y
851	Firing Table	None	Explosive tests	U 238	1.0E-02	1.0E+00	NA	NA	NA	None	1	1.0E-02	3879	E	2.0E-05	1828	SW	6.7E-03	4	Y
				U 235	1.4E-04	1.0E+00						1.4E-04								Y
				U-234	9.8E-04	1.0E+00						9.8E-04								Y