5

Air Monitoring

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Introduction

Air surveillance monitoring is performed to evaluate compliance with local, state, and federal laws and regulations and to ensure that human health and the environment are protected from hazardous and radioactive air emissions. Federal environmental air quality laws and DOE regulations include 40 CFR 61, the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) section of the Clean Air Act, and DOE Orders 5400.1, *General Environmental Protection Program,* and 5400.5, *Radiation Protection of the Public and the Environment*. The *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991) provides the guidance for implementing DOE Orders 5400.1 and 5400.5. Other laws governing air quality include 22 CCR 67264.700 and 66265.710, Environmental and Compliance Monitoring, and the California Air Toxics "Hot Spots" Information and Assessment Act of 1987 (AB2588). In general, the constituents that LLNL analyzes (in order to determine environmental impact) are at levels far below the regulatory standards.

LLNL conducts surveillance monitoring of ambient air to determine if airborne radionuclides or hazardous materials are being released by Laboratory operations, what the concentrations are, and what the trends are in the LLNL environs. In the air monitoring program, particles are collected on filters and vapor is chemically trapped on a collection medium. Concentrations of various airborne radionuclides (including particles and tritiated water vapor) and beryllium are measured at the Livermore site, Site 300, at off-site locations throughout the Livermore and Tracy Valleys. In addition, some point sources and diffuse, or nonpoint sources, are monitored to fulfill NESHAPs requirements (Gallegos et al. 1998a).

Methods

Several monitoring networks are established for surveillance of air particulates in the environs of LLNL and Site 300, as well as in the surrounding Livermore Valley and Tracy. The sampling locations for each monitoring network are listed in **Table 5-1**. All monitoring networks use continuously operating samplers located as shown in **Figures 5-1, 5-2,** and **5-3.** The radiological sampling networks utilize glass fiber filters,

the high volume beryllium networks use cellulose filters, and the low volume network uses Millipore AW-19 filters.

Table 5-1. Sampling locations listed by monitoring network.

High volume radiological (glass fiber filters)	High volume beryllium (cellulose filters)	Low volume gross alpha and beta (millipore filters)	Tritium (silica gel)
Livermore site locations			
SALV CAFE VIS COW MET MESQ B531[a] CRED[a]	SALV CAFE VIS COW MET MESQ		SALV CAFE VIS COW MET MESQ POOL B292[a] B331[a] B514[a] B624[a]
Livermore Valley locations			
FCC FIRE HOSP CHUR[b] RRCH[b] PATT ZON7 TANK ALTA[c] LWRP		FCC HOSP	ZON7 ALTA FIRE XRDS VET HOSP
Site 300			
801E ECP EOBS GOLF NPS WCP WOBS	EOBS GOLF 801E		
Site 300 off site			
TFIR PRIM	TFIR		PRIM

[a] These locations are in areas of diffuse sources and are monitored to fulfill NESHAPs requirements.

[b] Location CHUR replaced RRCH in May of 1997.

[c] Location ALTA was removed from service in April 1997. It will be replaced by a new location in 1998.

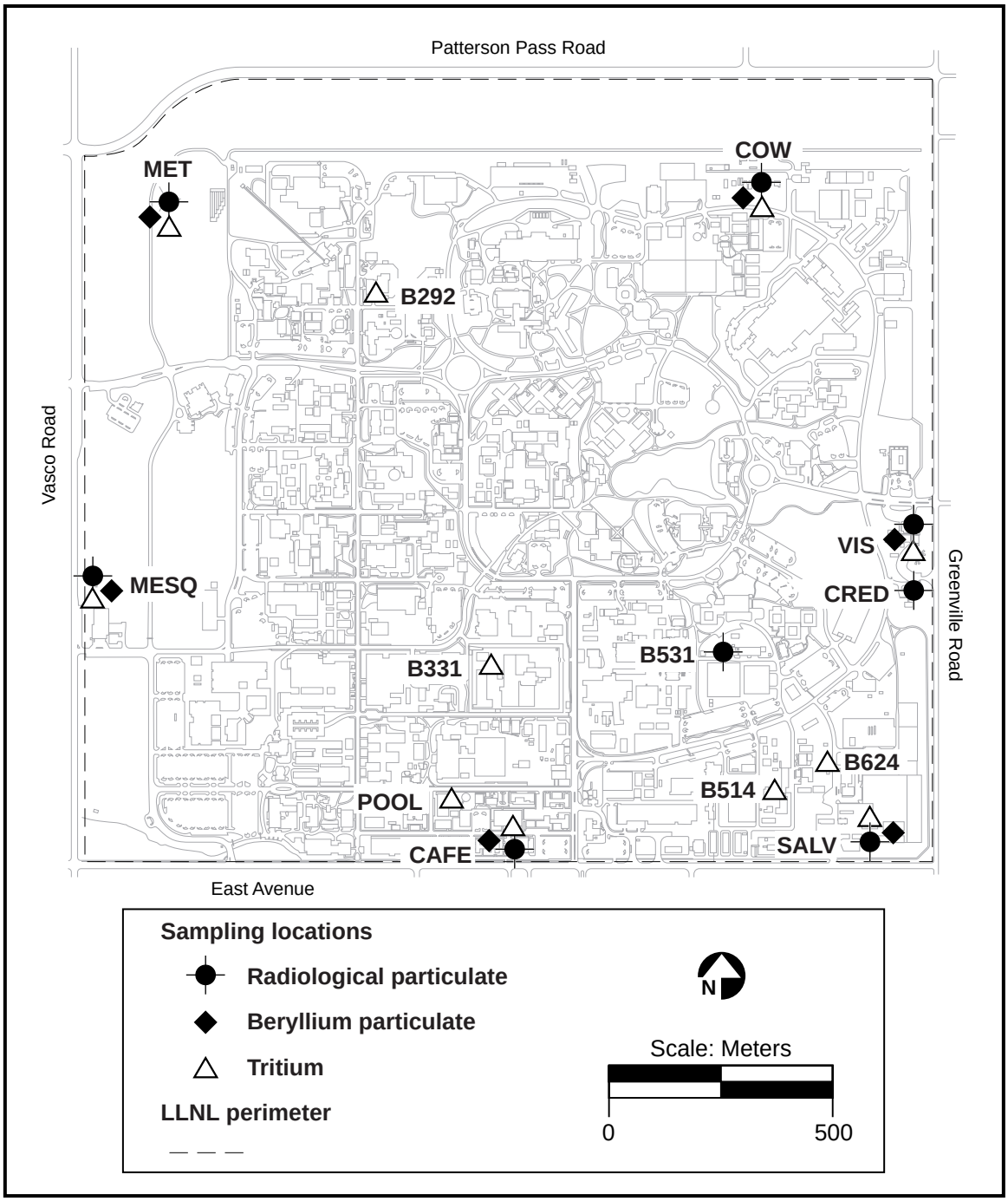

Figure 5-1. Air particulate and tritium sampling locations on the Livermore site, 1997.

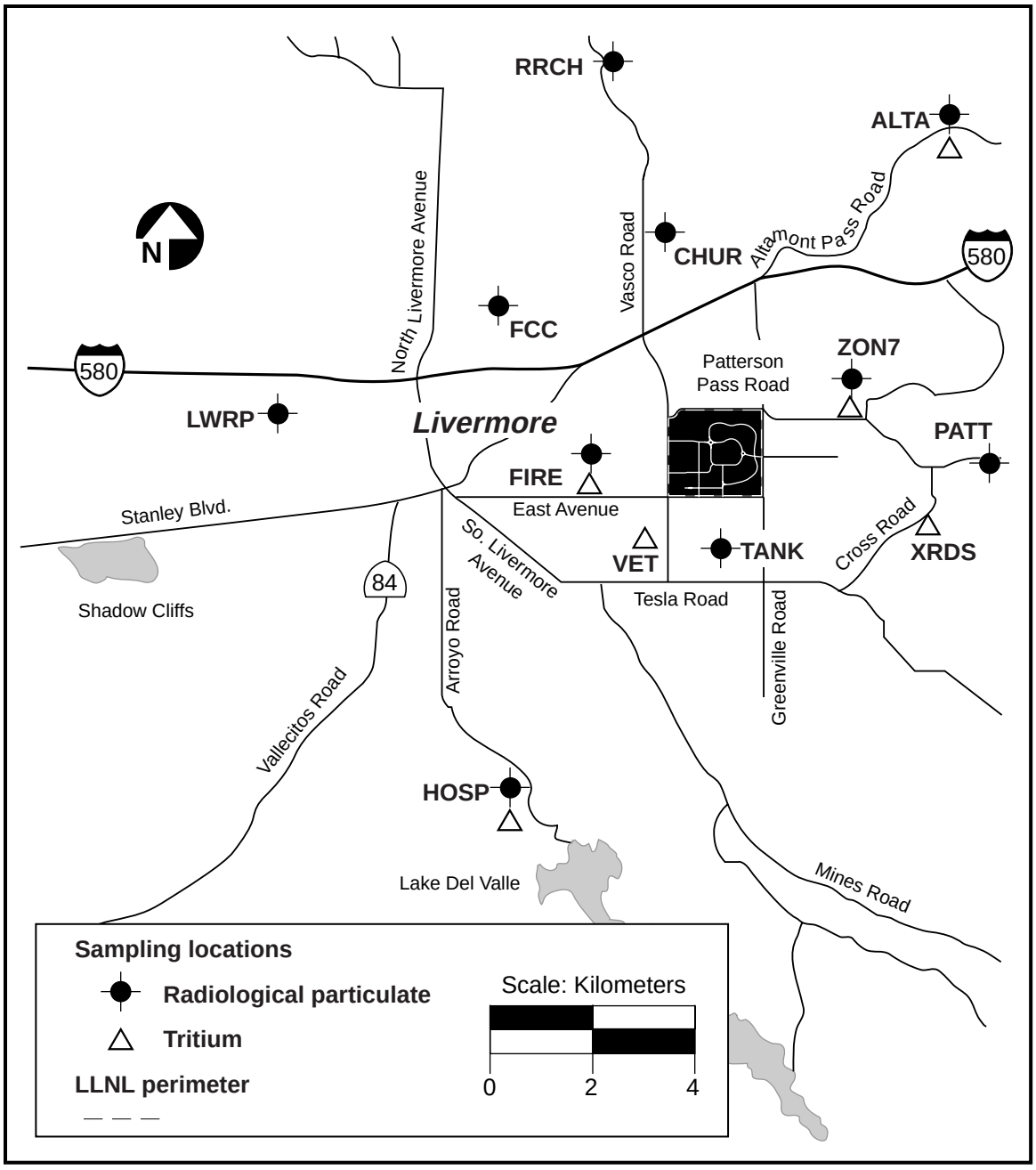

Figure 5-2. Air particulate and tritium sampling locations in the Livermore Valley, 1997.

The Livermore site radiological air particulate networks consist of six samplers at the perimeter. In addition, two areas of special interest (B531 and CRED) are monitored for plutonium only. The Livermore Valley network consists of air samplers located in all compass directions. For the purposes of data analysis, five samplers located in the least prevalent wind directions (FCC, FIRE, HOSP, RRCH, and CHUR) are considered to be

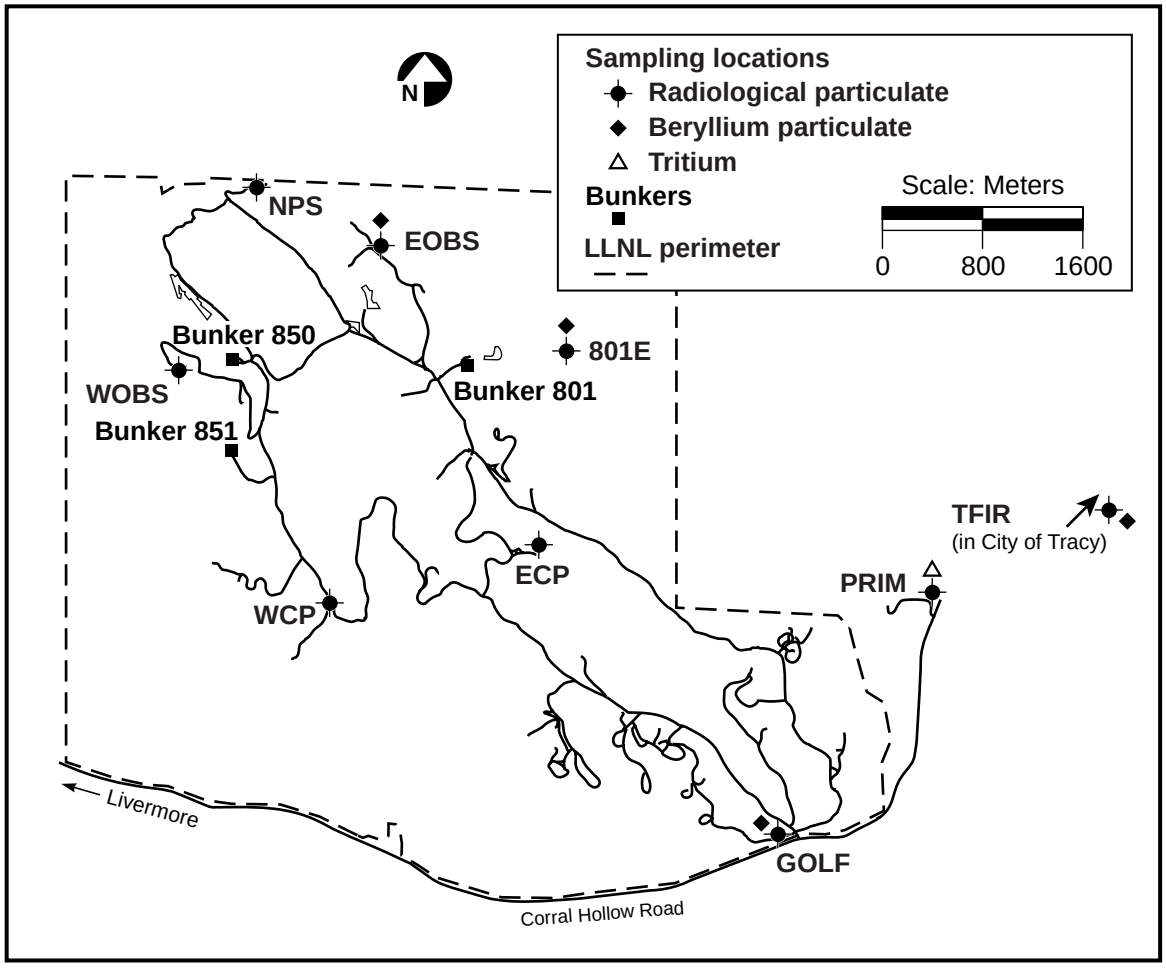

Figure 5-3. Air particulate and tritium sampling locations at Site 300, 1997.

upwind or representative of background locations and four samplers located in the most prevalent downwind directions (PATT, ZON7, TANK, and ALTA) are considered most likely to be impacted by Laboratory operations. An additional sampler is located in another area of special interest, the Livermore Water Reclamation Plant (LWRP), because of a plutonium release to the sanitary sewer system in 1967 with subsequent soil contamination and potential resuspension (see Results section below). A technical assessment of the beryllium monitoring locations at Site 300 was conducted in 1997. There is no requirement to sample for beryllium at Site 300; however, LLNL has decided to continue beryllium monitoring at three locations on site and at TFIR in the city of Tracy. These air samplers are positioned to provide reasonable probability that any significant concentration of radioactive particulate or beryllium effluents from LLNL operations will be detected should it occur. The geographical details of the particulate sampling locations are outlined in a procedure in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995).

Two sampling systems were added in July 1997 as part of the new low-volume air surveillance sampling network. The samplers are situated at the FCC and HOSP locations, sites which are generally upwind of the Livermore site. The results are used to establish background levels of gross alpha and beta activity for direct comparison to results from the air effluent samplers. The sampling systems are very similar to the air effluent samplers used in facilities, including sampling system design, sampler operation, sample tracking, sample analysis, and processing of results.

LLNL also maintains 11 continuously operating airborne tritium samplers on the Livermore site (**Figure 5-1**), 6 samplers in the Livermore Valley (**Figure 5-2**), and 1 sampler near Site 300 (**Figure 5-3**). Four of the Livermore site locations (B331, B292, B514, and B624) monitor diffuse tritium emissions. The tritium sample locations are detailed in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995).

Particulate filters (glass fiber, cellulose, and Millipore) are changed each week at all locations, and tritium samples are changed every two weeks. Duplicate quality control samplers are operated for 2 months in parallel with the permanent sampler at a given site, and samples are analyzed to confirm results.

As outlined in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991), gross alpha and gross beta air filter results are used as trend indicators; specific radionuclide analysis is done for plutonium, uranium, and gamma emitters. All analytical results are reported as a measured concentration per volume of air, or at the minimum detection limit (MDL) when no activity is detected. In all cases, the MDL is more than adequate for demonstrating compliance with the pertinent regulatory requirements for radionuclides that may be or are present in the air sample and for evaluating LLNL-induced environmental impacts. Particle size distributions are not determined because the estimated effective dose equivalent to the maximally exposed individual is well below the 0.01 mSv (1 mrem) allowable limit as discussed in the above mentioned *Environmental Regulatory Guide.* Further details of the surveillance monitoring methods are included in the Data Supplement, Chapter 5.

Results

This section discusses the air monitoring results at the Livermore site and at Site 300.

In April 1997, the filter media changed from cellulose to glass fiber for all radiological particulate sampling. Blank glass-fiber filters contain detectable amounts of some naturally occurring radiological isotopes. Of those radiological isotopes that LLNL

monitors, detectable amounts of ^{235}U, ^{238}U, ^{40}K, ^{228}Ra, and ^{228}Th are found on the blank filters. A full investigation of the radioactive content on glass fiber filters used by LLNL is in progress. The measured concentrations of these isotopes were adjusted according to EPA procedures (EPA 1976). This procedure simply subtracts the appropriate blank filter content from the gross analytical result to obtain a corrected net result.

Livermore Site

Airborne Radioactivity

Table 5-2 summarizes the monthly gross alpha and gross beta results for the LLNL perimeter, Livermore Valley, and Site 300 sampling locations. Medians, interquartile ranges (IQR), and maximum values for each network are included. (See Data Supplement, Tables 5-1 and 5-2a and b for detailed location results for all high-volume networks for gross alpha and gross beta concentrations.) The monthly median gross alpha and gross beta concentrations are plotted in **Figures 5-4** and **5-5**, respectively. The gross beta results follow a similar pattern to previous year's data. The gradual increase in beta activity throughout the summer is due to an increase in resuspension of soils that occurs during the dry season.

The gross alpha data are much more variable because of the nature of the standard analytical method capabilities, and most of the data are very close to the minimum detection limit of the method.

Typical gross alpha activity (median value) for the LLNL perimeter network is 1.6×10^{-11} Bq / mL (4.4×10^{-22} Ci / mL); for the upwind Livermore Valley stations the value is 1.4×10^{-11} Bq / mL (3.4×10^{-22} Ci / mL); and for the downwind Livermore Valley stations the value is 1.6×10^{-11} Bq / mL (4.4×10^{-22} Ci / mL). Negative values occur when the activity of the analytical background filters is higher than the activity on the filters being analyzed. Typical gross beta activity (median value) for the LLNL perimeter is 5.1×10^{-10} Bq / mL (1.4×10^{-20} Ci / mL); for the upwind Livermore Valley stations the value is 5.7×10^{-10} Bq / mL (1.4×10^{-20} Ci / mL); and for the downwind Livermore stations the value is 4.9×10^{-10} Bq / mL (1.3×10^{-20} Ci / mL). These values are similar to those obtained from previous monitoring data during the past several years. The primary sources of the alpha and beta activities are the naturally occurring radioisotopes of uranium and thorium, and any residual fallout from atmospheric weapons testing and the Chernobyl reactor accident in 1986.

Table 5-2. Gross alpha and gross beta in air particulate samples summarized by month, 1997.[a]

	Gross alpha (10^{-12} Bq/mL)			Gross beta (10^{-12} Bq/mL)		
	Median	Interquartile range	Maximum	Median	Interquartile range	Maximum
LLNL perimeter						
Jan	23.5	78.8	107	185	407	784
Feb	–4.74	49.6	85.1	278	146	412
Mar	28.8	66.9	138	297	220	605
Apr[b]	25.3	22.7	136	476	98.4	661
May	18.4	32.2	89.5	513	114	661
June	7.66	31.2	57.3	415	96.3	595
July	23.8	32.2	77.0	558	212	891
Aug	18.2	37.1	74.3	533	125	778
Sept	–0.422	36.0	40.9	726	364	1350
Oct	11.2	40.7	64.6	1090	672	1470
Nov	8.64	38.2	57.2	521	223	989
Dec	–11.5	24.6	69.8	856	324	1220
Livermore Valley upwind						
Jan	31.2	76.3	155	280	315	645
Feb	26.9	53.2	122	274	130	424
Mar	26.7	36.5	70.8	292	129	550
Apr[b]	16.5	32.2	89.0	450	87.3	637
May	22.6	30.8	83.0	578	147	636
June	0.477	35.5	33.0	417	58.1	505
July	21.9	26.7	52.8	567	163	727
Aug	17.5	33.7	83.5	524	170	736
Sept	–2.96	31.4	59.0	661	428	1270
Oct	17.4	32.4	37.1	1220	761	1550
Nov	–1.23	36.1	77.0	579	374	1060
Dec	–5.76	42.9	39.5	843	415	1330

Table 5-2. Gross alpha and gross beta in air particulate samples summarized by month, 1997[a] (concluded).

	Gross alpha (10^{-12} Bq/mL)			Gross beta (10^{-12} Bq/mL)		
	Median	Interquartile range	Maximum	Median	Interquartile range	Maximum
Livermore Valley downwind						
Jan	1.90	39.7	83.8	268	318	651
Feb	13.2	31.8	102	297	93.0	399
Mar	9.08	31.2	106	272	143	699
Apr[b]	20.9	18.5	42.4	497	63.3	587
May	17.6	43.2	71.2	564	116	713
June	7.23	17.6	45.1	421	31.7	550
July	22.1	24.7	70.6	553	192	846
Aug	30.8	20.5	50.0	499	127	657
Sept	–7.75	27.7	63.5	700	307	1210
Oct	21.7	25.6	96.5	922	845	1710
Nov	6.04	30.0	64.6	523	483	1080
Dec	15.4	31.7	83.0	814	374	1300
Site 300						
Jan	9.64	57.1	91.1	195	191	808
Feb	1.40	55.4	149	292	138	578
Mar	22.4	50.5	85.2	281	234	518
Apr[b]	20.1	28.5	65.6	496	115	614
May	37.5	32.7	101	643	131	910
June	10.7	21.3	58.5	507	101	671
July	39.3	35.2	97.2	706	185	1010
Aug	33.4	31.8	97.9	636	226	838
Sept	5.68	24.4	89.1	808	458	1310
Oct	21.3	31.7	85.0	884	766	1880
Nov	1.13	46.1	94.1	654	414	1260
Dec	-2.77	53.5	65.1	790	349	1800

a Negative values indicate that at least half of the samples had activity of the background greater than that of the sample.

b Filter media changed from cellulose to glass fiber. Samples from April through December were collected on glass fiber filters.

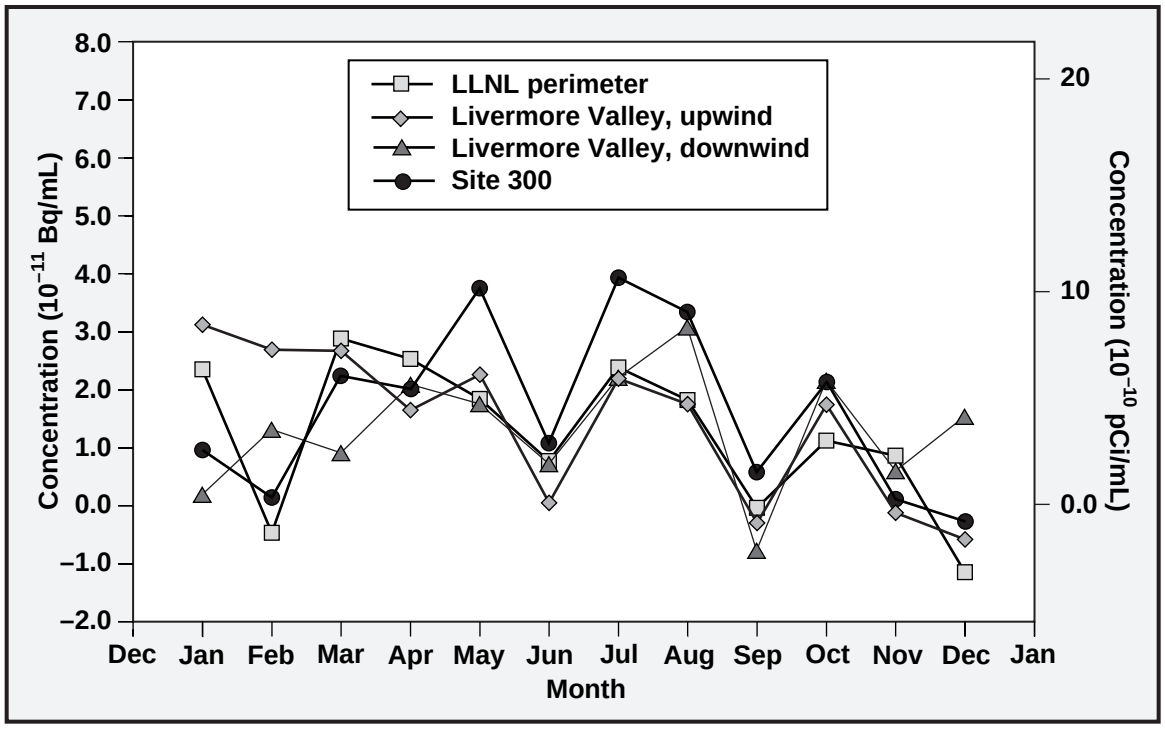

Figure 5-4. Monthly median gross alpha concentrations in particulate air samples from the LLNL perimeter, Livermore Valley and Site 300 sampling locations, 1997.

Gamma-emitting radionuclide concentrations in air that contribute to the activity in the Livermore site perimeter samples are summarized in **Table 5-3**. (See Data Supplement, Table 5-3 for monthly gamma data.) Of the nuclides tabulated, ^{7}Be, ^{40}K, ^{226}Ra, ^{228}Ra, and ^{228}Th occur naturally. The primary source of ^{137}Cs is long-term global fallout and fallout resuspension.

In addition to providing baseline data on global fallout, analysis of these radionuclides enables LLNL to monitor the containment of the small inventories of mixed fission products and radiochemical tracers used at LLNL. The Derived Concentration Guides (DCGs) for these radionuclides are also shown in **Table 5-3**. For air, DCGs specify the concentrations of radionuclides that could be inhaled continuously 365 days a year without exceeding the DOE primary radiation protection standard for the public, which is 1 mSv / y (100 mrem / y) effective dose equivalent (DOE Order 5400.5). (Chapter 12 on Radiological Dose Assessment provides an explanation of this and other units of dose.) Finally, the fraction of the DCGs is presented. These values demonstrate that levels of gamma activity present in air at the Livermore site perimeter are far below the DCGs. Air monitoring data are compared to the DOE DCG in 5400.5, and compliance with the EPA 100 μSv (10 mrem) standard (40 CFR 61) is demonstrated by modeling.

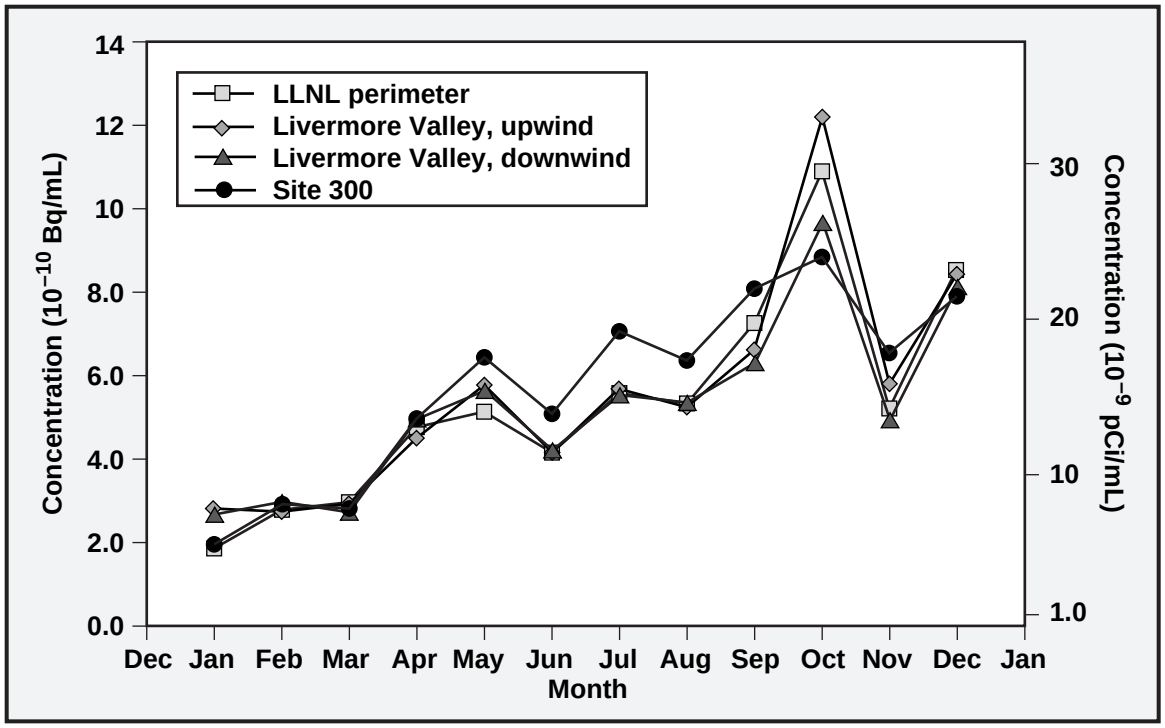

Figure 5-5. Monthly median gross beta concentrations in particulate air samples from the LLNL perimeter, Livermore Valley and Site 300 sampling locations, 1997.

Table 5-3. Gamma activity in air particulate samples, Livermore site perimeter and Site 300, 1997.

	^{7}Be	^{40}K	^{137}Cs	^{22}Na	^{226}Ra	^{228}Ra	^{228}Th
	(10^{-9} Bq/mL)	(10^{-12} Bq/mL)					
Livermore perimeter							
Median	3.4	23	<0.2	<0.3	<3.7	1.9	<1.1
Interquartile range	1.0	—[a]	—[a]	—[a]	—[a]	1.5	—[a]
Maximum	6.5	62	<0.3	0.7	<7.1	4.1	3.3
Median fraction of DCG[b]	2.2×10^{-6}	7.0×10^{-7}	$<1.2 \times 10^{-8}$	$<6.6 \times 10^{-9}$	$<1.0 \times 10^{-4}$	1.7×10^{-5}	$<7.1 \times 10^{-4}$
Site 300							
Median	4.2	23	<0.2	<0.3	<4.5	<1.2	<0.7
Interquartile range	0.9	—[a]	—[a]	—[a]	—[a]	—[a]	—[a]
Maximum	7.0	63	1.0	1.0	<9.0	2.5	3.0
Median fraction of DCG	2.8×10^{-6}	6.9×10^{-7}	$<1.4 \times 10^{-8}$	$<7.3 \times 10^{-9}$	$<1.2 \times 10^{-4}$	$<1.1 \times 10^{-5}$	$<4.8 \times 10^{-4}$
DCG (Bq/mL)	1.5×10^{-3}	3.3×10^{-5}	1.5×10^{-5}	3.7×10^{-5}	3.7×10^{-8}	1.1×10^{-7}	1.5×10^{-9}

a No measure of dispersion calculated. See Chapter 13, Quality Assurance.

b Derived Concentration Guide.

Table 5-4 shows the median, IQR, maximum, and median fraction of DCG for concentration of plutonium on glass fiber air filter samples collected in the Livermore Valley. (See Data Supplement, Table 5-4 for monthly data.) The highest off-site median concentration of ^{239}Pu occurred at the Livermore Water Reclamation Plant (LWRP). Soils near the LWRP contain some detectable plutonium, principally resulting from sludge-spreading operations following an estimated 1.2×10^9 Bq (32 mCi) release to the sewer in 1967 (see Chapter 9, Soil and Sediment Monitoring). Resuspension of these soils probably accounts for the slightly higher median ^{239}Pu in air concentrations observed. However, the median observed value is <0.00001 of the DCG.

Table 5-4 also shows the concentrations of airborne ^{239}Pu on air filters from the LLNL perimeter locations. (See Data Supplement, Table 5-5 for the monthly data by location.) The highest concentration was registered at location SALV in October 1997; the concentration value is reported as 4.9×10^{-14} Bq / mL (1.3×10^{-24} Ci / mL), which represents 0.0001 of the DCG. The median concentration at location SALV is 7.7×10^{-15} Bq / mL (2.1×10^{-25} Ci / mL), which is lower than the previous year.

In June 1991, two air particulate sampling locations (B531 and CRED) were added as part of a special study to investigate the somewhat elevated levels of plutonium in air and surface soil in the southeast quadrant of the Livermore site (see Chapter 9, Soil and Sediment Monitoring, for general background on this study). These sampling locations are now part of our routine monitoring network and provide data for diffuse source dose assessments. **Table 5-4** shows the median concentrations of airborne ^{239}Pu at these two locations. (See Data Supplement, Table 5-6 for monthly data.) The median concentration of 4.7×10^{-14} Bq / mL (1.3×10^{-24} Ci / mL) at location B531 is higher than the median concentration for any of the other air particulate sampling locations, but is still only 0.0001 of the DCG. The higher concentrations have been attributed to historic operations, which included the operation of solar evaporators for plutonium-containing liquid waste (Silver et al. 1974).

Figure 5-6 shows the annual median concentrations of ^{239}Pu for locations SALV (on site) and FCC (off site) from 1982 to 1997. Location FCC represents a typical upwind background location, and SALV represents the perimeter location having the highest annual average for most of this 15-year period. The annual median concentration for FCC was -0.54×10^{-15} Bq / mL (-1.4×10^{-26} Ci / mL). **Figure 5-6** uses a log scale, therefore the positive value closest to the median is plotted. The higher values in the past at SALV may be attributed to historical activities at LLNL; improvements in operational processes in the immediate work area have contributed to the observed downward trend of the data.

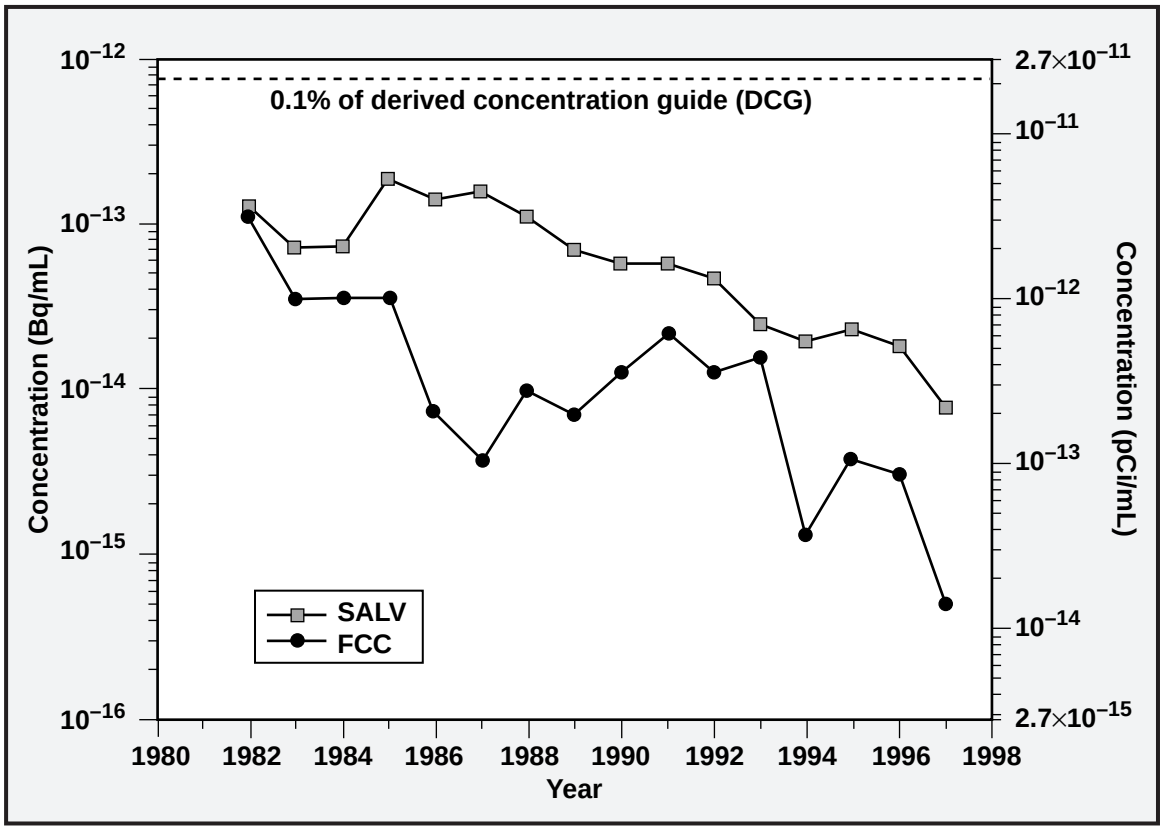

Figure 5-6. Median plutonium concentrations in air particulate samples at two locations, SALV and FCC, 1982 to 1997 (DCG = 7.4×10^{-10} Bq/mL).

The median ^{235}U and ^{238}U concentrations in air samples from the Livermore site perimeter are shown in **Table 5-5**. (See Data Supplement, Table 5-7 for monthly data.) The maximum measured concentration of ^{238}U (at location COW during October) is less than 0.0005 of the DCG. All $^{235}U/^{238}U$ median ratios are as expected for naturally occurring uranium; however, monthly data in the Data Supplement show some unexpected $^{235}U/^{238}U$ ratios, indicating other than natural uranium around the Livermore site perimeter. While no significant environmental impact stems from the observed ratios, their cause is not known but they have occurred sporadically in the past.

Typical gross alpha and gross beta activity from the low-volume sampling locations HOSP and FCC is 1.3×10^{-10} Bq/mL (3.5×10^{-21} Ci/mL) and 7.4×10^{-10} Bq/mL (2.0×10^{-20} Ci/mL), respectively. (See Data Supplement, Tables 5-8 and 5-9 for monthly median data.) These gross alpha values are higher than those reported from the high volume sampling systems. This is probably due to differences in the filter type. A study is being conducted to determine the cause.

Table 5-4. Plutonium activity in air particulate samples (in 10^{-15} Bq/mL), 1997.

Sampling location[a]	Median	Interquartile range	Maximum	Median fraction of DCG[b]
Livermore Valley downwind locations				
ALTA	2.4	5.4	4.7	3.2×10^{-6}
PATT	0.47	5.4	6.6	6.3×10^{-7}
TANK	–0.6	3.4	9.9	—[c]
ZON7	2.3	3.4	12	3.1×10^{-6}
Livermore Valley upwind locations				
FCC	–0.5	5.1	8.9	—[c]
FIRE	3.0	9.1	8.1	4.0×10^{-6}
HOSP	2.1	5.0	13	2.9×10^{-6}
RRCH	–2.8	3.6	7.4	—[c]
CHUR	4.6	6.7	15	6.2×10^{-6}
LLNL perimeter				
CAFE	6.5	5.6	18	8.8×10^{-6}
COW	3.0	8.4	11	4.0×10^{-6}
MESQ	8.8	7.0	17	1.2×10^{-5}
MET	6.7	5.3	12	9.1×10^{-6}
SALV	7.7	11	49	1.0×10^{-5}
VIS	6.2	5.3	15	8.4×10^{-6}
Special interest				
LWRP	11	8.8	24	1.4×10^{-5}
Diffuse sources				
B531	47	59	220	6.4×10^{-5}
CRED	4.5	6.6	29	6.0×10^{-6}
Site 300 on-site				
Site 300	3.6	2.2	17	4.8×10^{-6}
Site 300 downwind				
PRIM	–0.076	2.9	6.4	—[c]
TFIR	2.9	8.1	14	3.9×10^{-6}

[a] See **Figures 5-1, 5-2,** and **5-3** for sampling locations.

[b] Derived Concentration Guide = 7.4×10^{-10} Bq/mL (2×10^{-14} μCi/mL) for ^{239}Pu activity in air.

[c] Median fraction of DCG not calculated when median is a negative value.

Table 5-5. Uranium mass in air particulate samples, 1997.

Sampling location[a]	^{238}U[b] (10^{-5} μg/m^3)	^{235}U[c] (10^{-7} μg/m^3)	$^{235}U/^{238}U$[d] (10^{-3})
LLNL perimeter			
CAFE			
Median	4.85	3.27	6.89
Interquartile range	3.31	2.63	0.45
Maximum	13.2	9.56	NA[e]
Median fraction of DCG	1.6×10^{-4}	7.0×10^{-6}	NA
COW			
Median	5.29	3.71	7.10
Interquartile range	3.05	1.59	0.52
Maximum	16.1	11.6	NA
Median fraction of DCG	1.8×10^{-4}	7.9×10^{-6}	NA
MESQ			
Median	9.68	6.63	7.04
Interquartile range	8.74	6.30	0.63
Maximum	14.6	10.4	NA
Median fraction of DCG	3.2×10^{-4}	1.4×10^{-5}	NA
MET			
Median	2.96	2.21	7.06
Interquartile range	3.32	2.35	0.36
Maximum	8.77	6.21	NA
Median fraction of DCG	9.9×10^{-5}	4.7×10^{-6}	NA
SALV			
Median	3.64	2.42	6.61
Interquartile range	3.41	2.81	1.05
Maximum	11.9	8.54	NA
Median fraction of DCG	1.2×10^{-4}	5.2×10^{-6}	NA
VIS			
Median	3.18	2.11	7.07
Interquartile range	3.87	2.89	0.84
Maximum	9.40	6.80	NA
Median fraction of DCG	1.1×10^{-4}	4.5×10^{-6}	NA
Site 300 (composite)			
Median	4.65	3.41	7.05
Interquartile range	4.49	2.67	1.54
Maximum	18.2	12.8	NA
Median fraction of DCG	1.6×10^{-4}	7.2×10^{-6}	NA

a See **Figures 5-1** and **5-3** for sampling locations.

b Derived Concentration Guide = 0.3 μg/m^3 for ^{238}U activity in air.

c Derived Concentration Guide = 0.047 μg/m^3 for ^{235}U activity in air.

d Naturally occurring uranium has a $^{235}U/^{238}U$ ratio of 7.1×10^{-3}.

e NA = Not applicable.

Table 5-6 shows the median concentrations of tritiated water vapor for the Livermore Valley sampling locations. (See Data Supplement, Table 5-10 for biweekly data for each location.) The highest annual median concentration was observed at location ZON7. At approximately 5.9×10^{-8} Bq / mL (1.6×10^{-18} Ci / mL), this concentration represents 0.00002 of the DCG. The highest biweekly concentration was observed in October at ZON7. If it were a yearly average, this concentration, 4.9×10^{-7} Bq / mL (1.3×10^{-17} Ci / mL), would be 0.0001 of the DCG. The 1997 tritium values are generally similar to those reported last year.

Table 5-6. Tritium in air samples (in 10^{-9} Bq/mL), 1997.

Sampling location[a]	Detection frequency	Median	IQR[b]	Maximum	Median fraction of DCG[c]	Median dose (mSv)[d]
Livermore Valley						
ZON7	25/26	58.6	64.4	488	1.6×10^{-5}	1.3×10^{-6}
ALTA	6/8	<22.3	—[e]	44.8	$<6.0 \times 10^{-6}$	4.8×10^{-6}
XRDS	17/26	<12.9	—[e]	38.9	$<3.5 \times 10^{-6}$	2.8×10^{-6}
FIRE	15/26	<13.9	—[e]	28.2	$<3.8 \times 10^{-6}$	3.0×10^{-6}
VET	20/25	23.2	—[e]	76.2	6.3×10^{-6}	5.0×10^{-6}
HOSP	7/26	<10.5	—[e]	42.9	$<2.9 \times 10^{-6}$	2.3×10^{-6}
Livermore perimeter						
SALV	24/24	74.6	37.0	403	2.0×10^{-5}	1.6×10^{-5}
MESQ	22/26	34.4	50.9	102	9.3×10^{-6}	7.4×10^{-6}
CAFE	26/26	130	102	522	3.5×10^{-5}	2.8×10^{-5}
MET	21/25	24.8	—[e]	81.4	6.7×10^{-6}	5.3×10^{-6}
VIS	25/26	184	197	707	5.0×10^{-5}	3.9×10^{-5}
COW	26/26	119	88.7	364	3.2×10^{-5}	2.6×10^{-5}
POOL	24/24	267	192	1730	7.2×10^{-5}	5.7×10^{-5}
Diffuse on-site sources						
B292	26/26	112	97.5	796	3.0×10^{-5}	2.4×10^{-5}
B331	25/25	1360	796	9950	3.7×10^{-4}	2.9×10^{-4}
B514	26/26	4370	3780	7730	1.2×10^{-3}	9.4×10^{-5}
B624	26/26	4180	2660	7730	1.1×10^{-3}	9.0×10^{-4}
Site 300 off site						
PRIM	5/24	<7.71	—[e]	10.1	$<2.1 \times 10^{-6}$	1.7×10^{-6}

a See **Figures 5-1**, **5-2**, and **5-3** for sample locations.

b Interquartile range.

c Derived Concentration Guide = 3.7×10^{-3} Bq/mL (1×10^{-7} μCi/mL).

d 1 mSv = 100 mrem.

e Interquartile range not calculated. See Chapter 13, Quality Assurance.

Table 5-6 also shows the median concentrations of tritiated water vapor that were observed at the Livermore site perimeter sampling locations. (See Data Supplement, Table 5-11 for biweekly data.) The highest annual median concentration was observed at location POOL, which was 2.7×10^{-7} Bq / mL (7.3×10^{-18} Ci / mL), or 0.00007 of the DCG.

Diffuse sources of tritium on the Livermore site are monitored at air tritium sampling locations B331, B292, B514, and B624. **Table 5-6** shows the median concentrations of tritiated water vapor for these sampling locations. (See Data Supplement, Table 5-12 for biweekly data.) The highest median concentration was observed at location B514. This concentration was 4.4×10^{-6} Bq / mL (1.2×10^{-16} Ci / mL) and represents 0.001 of the DCG. The highest biweekly tritium concentration, 1.0×10^{-5} Bq / mL (2.7×10^{-16} Ci / mL), was observed in November at location B331. If it were a yearly average, this concentration would represent 0.003 of the DCG.

The B331 location is near the Tritium Facility (Building 331), in which LLNL personnel have reduced operations in recent years and performed significant inventory reduction and cleanup activities. During this process, tritium-contaminated equipment slated for disposal is stored in a waste accumulation area before being sent to Hazardous Waste Management facilities. During 1997, outgassing from such waste processing released an estimated 9.2×10^{10} Bq (2.5 Ci) of tritium to the atmosphere outside of Building 331.

The B624 location is situated in the Building 612 yard, which is dedicated to hazardous waste, radioactive waste, and mixed-waste management activities. The yard consists of several areas where waste containers that are outgassing tritium are stored outdoors.

The B514 sampling location is in a hazardous waste management area where tritium-contaminated waste is treated, and the B292 location is near an underground retention tank that had previously leaked. The concentrations in air at the B514 sampling location are variable because of the changing concentrations of tritium in the waste stream. The 1996 median concentrations at B292 are similar to the median concentrations in 1996.

Beryllium in Air

The median concentrations of airborne beryllium for the Livermore site perimeter sampling locations are shown in **Table 5-7**. (See Data Supplement, Table 5-13 for monthly data.) The highest value of 25.8 pg / m^3 was found in the August composite at location MESQ and was most likely the result of ground moving activities west of LLNL. The median concentration for this location is 0.001 of the monthly ambient concentration guide (ACG) of 10,000 pg / m^3 established by the Bay Area Air Quality Management District (BAAQMD) and the Environmental Protection Agency (EPA).

Table 5-7. Beryllium in air particulate samples (in pg/m^3), Livermore site perimeter and Site 300, 1997.

Sampling location[a]	Detection frequency	Median	Interquartile range	Maximum
Livermore perimeter				
SALV	12/12	5.5	4.8	22
MESQ	12/12	15	16	26
CAFE	12/12	7.9	6.0	14
MET	12/12	6.1	6.3	14
VIS	12/12	5.3	4.4	13
COW	12/12	8.6	7.1	18
Site 300				
EOBS	11/12	3.4	4.8	10
GOLF	12/12	5.3	7.4	14
TFIR	12/12	11	11	20
801E	12/12	10	9.5	17

[a] See **Figures 5-1** and **5-3** for sampling locations. Summary results for sampling locations that were removed in April are not reported. Monthly data are reported in Data Supplement, Tables 5-13 and 5-19.

Figure 5-7 is a plot of the median beryllium concentration at the Livermore site perimeter from 1974 through 1997. The overall median concentration during this time period was calculated to be 0.002 of the ACG. Unless there is a change in LLNL's operations, it is expected that the beryllium levels will remain unchanged.

Site 300

Airborne Radioactivity

Most gross alpha determinations at Site 300 were at or near the analytical limit of detection for the method. **Table 5-2** shows the monthly gross alpha and gross beta median, IQR, and maximum for sampling locations at Site 300. (See Data Supplement, Table 5-14 for monthly data.) The monthly median gross alpha and gross beta concentrations are shown in **Figures 5-4** and **5-5**. The Site 300 gross beta results show a similar pattern to those found at the Livermore site. Typical gross alpha activity is 1.5×10^{-11} Bq / mL (4.0×10^{-22} Ci / mL).

Typical gross beta activity is 5.5×10^{-10} Bq / mL (1.5×10^{-20} Ci / mL). The primary sources of observed gross alpha and gross beta activity are naturally occurring radioisotopes of uranium and thorium and their decay products, and any residual fallout from atmospheric weapons testing and the Chernobyl reactor accident (1986).

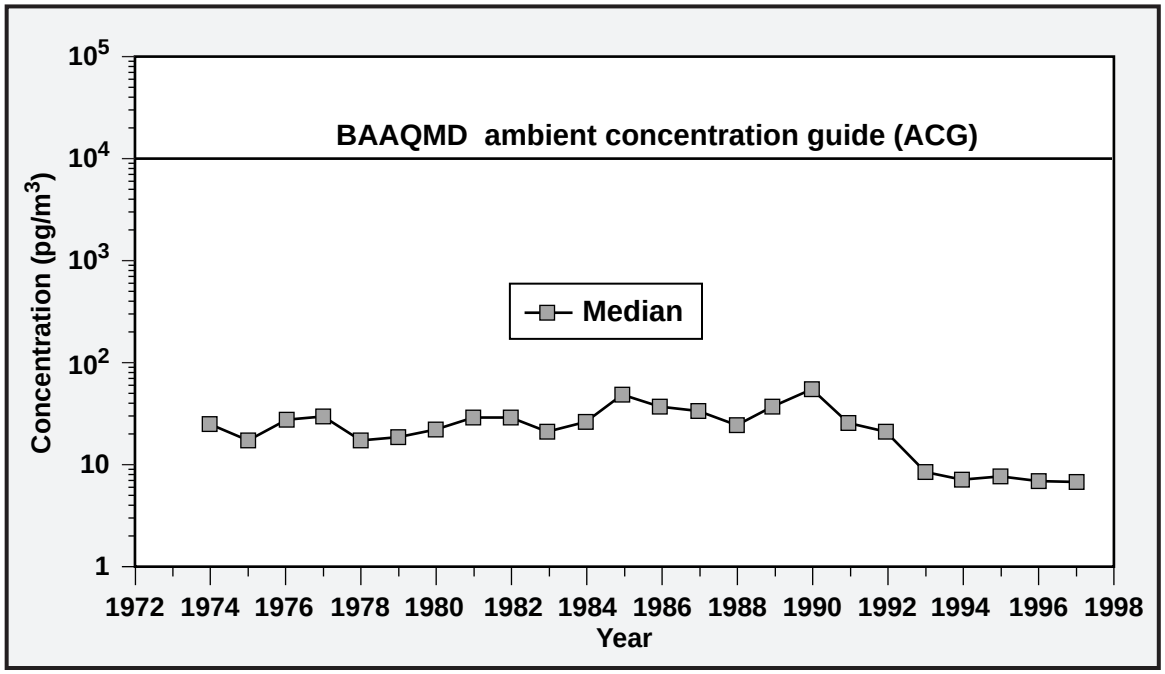

Figure 5-7. Median concentration of beryllium in air particulate samples taken at the Livermore site perimeter, 1974 to 1997.

Table 5-3 lists the annual median activities, IQR, maximum, the fraction of the DCG, as well as the DCG, of gamma-emitting radionuclides in samples from Site 300. (See Data Supplement, Table 5-15 for monthly data.) All these radionuclides were measured at concentrations significantly below the DCGs. Of the nuclides tabulated, ^{7}Be, ^{40}K, ^{226}Ra, ^{228}Ra, and ^{228}Th are naturally occurring. The primary source of ^{137}Cs normally is long-term global fallout and resuspension.

Table 5-4 shows the median concentration of ^{239}Pu on air-filter samples collected from Site 300. (See Data Supplement, Table 5-16 for monthly data.) The highest concentration of ^{239}Pu was observed in the August composite at a level of 1.7×10^{-14} Bq / mL (4.6×10^{-25} Ci / mL), or 0.00002 of the DCG.

Table 5-5 shows the median concentration of ^{238}U, ^{235}U, and the ^{235}U / ^{238}U ratio on air samples from Site 300. (See Data Supplement, Table 5-17 for monthly data.) The highest concentration of ^{238}U was observed in the October composite at a level of 1.8×10^{-4} µg / m^3 (0.0006 of the DCG). The highest concentration of ^{235}U was also observed in the October composite at a level of 1.3×10^{-6} µg / m^3 (0.00003 of the DCG). The overall levels were essentially the same as those reported in previous years.

The ratio of ^{235}U to ^{238}U can be used to identify the source of the uranium. Both ^{235}U and ^{238}U occur naturally in the area, but only 0.7% of the naturally occurring uranium is ^{235}U, and the remainder is almost entirely ^{238}U. Because Site 300 operations use depleted uranium that contains very little ^{235}U, it follows that if the ratio remains constant and near 0.7% (within the limit of sampling and analytical error), then the ^{238}U measured is from natural sources. The $^{235}U/^{238}U$ ratios in January, February, and June are less than expected for natural sources, which indicate some impact from operations at Site 300. The median concentration of ^{238}U for 1997, however, is only 0.0001 of the DCG (DOE Order 5400.5).

Table 5-6 shows the median concentration of tritiated water vapor that was observed at the new sampling location (PRIM) near Site 300. (See Data Supplement, Table 5-18 for biweekly data.) The annual median concentration is $<7.7 \times 10^{-9}$ Bq/mL (2.1×10^{-19} Ci/mL), or 0.000002 of the DCG.

Beryllium in Air

The detection frequency, median, IQR, and maximum concentrations of airborne beryllium for the Site 300 sampling locations are shown in **Table 5-7**. (See Data Supplement, Table 5-19 for monthly data.) The highest beryllium concentration of 19.7 pg/m^3 occurred in September at location TFIR. The median concentration for this location is 0.001 of the federal and state ambient concentration limit, which is 10,000 pg/m^3.

Environmental Impact

The environmental impacts from both radioactive and nonradioactive effluents are described in this section.

Radioactive Materials

LLNL operations involving radioactive materials had little impact on radionuclide concentration in ambient air in 1997. Radionuclide concentrations in air at the Livermore site and in the Livermore Valley are well below levels that would cause concern to the environment or public health according to existing regulatory standards.

The diffuse tritium sources at B292, B331, B514, and B624 have a localized effect; the tritium concentrations in October at all the site perimeter and off-site locations were elevated.

The concentrations of radionuclides measured around Site 300 and in the city of Tracy were well below all standards and, except for uranium isotopes, reflect background or naturally occurring levels of these chemicals. (See Chapter 12, Radiological Dose Assessment, for discussion of estimated dose from these data.) The $^{235}U/^{238}U$ ratios in January, February, and June are less than the ratio of naturally occurring concentrations of these isotopes, which suggests the presence of depleted uranium in Site 300 air samples. This depleted uranium can result from current testing of explosives or resuspension of material left over from testing in previous years.

Nonradioactive Materials

The concentrations of beryllium at both sites can be attributed to resuspension of surface soil containing naturally occurring beryllium. Local soils contain approximately 1 ppm of beryllium, and the air of the Livermore area and Central Valley typically contains 10 to 100 $\mu g/m^3$ of particulates. Using a value of 50 $\mu g/m^3$ for an average dust load and 1 ppm for beryllium content of dust, a conservative airborne beryllium concentration of 50 pg/m^3 can be predicted. The overall annual medians for the Livermore site and Site 300 are 6.6 pg/m^3 and 3.8 pg/m^3, respectively. These data are lower than predicted, well below standards, and do not indicate the presence of a threat to the environment or public health.