6. Surface Water Monitoring

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Introduction

Lawrence Livermore National Laboratory performs surface water monitoring at the Livermore site, in surrounding regions of the Livermore Valley, and at Site 300 and vicinity in the nearby Altamont Hills. At the first two locales, LLNL monitors reservoirs and ponds, the LLNL swimming pool, rainfall, tap water, and storm water runoff. At Site 300 and vicinity, surface water monitoring encompasses rainfall and storm water runoff. Results for the spring at Site 300 are reported in Chapter 7 (Routine Ground Water Monitoring) because the spring water is more representative of its ground water source than it is of surface water. The water samples are analyzed for radionuclides, explosives, total organic carbon, total organic halides, total suspended solids, conductivity, pH, chemical oxygen demand, oil and grease, metals, minerals, anions, and a wide range of organic compounds.

Surface water monitoring is driven by the requirements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991) and DOE Orders 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment*. LLNL also complies with the Federal Clean Water Act and changes in Section 402 of this Act, which led to LLNL's revision of the storm water monitoring program during 1993.

Rainwater monitoring is called for in DOE Order 5400.1, which states:

> Representative meteorological data are required at DOE facilities to support environmental monitoring activities. This information is essential to characterize atmospheric transport and diffusion conditions in the vicinity of the DOE facility and to represent other meteorological conditions (e.g., precipitation, temperature, and atmospheric moisture) that are important to environmental surveillance activities such as air quality and radiation monitoring.

Water Sampling Methods

A description of water sampling methods for surface water and rainfall follows.

Surface Water

Surface and drinking water near the Livermore site and in the Livermore Valley (**Figure 6-1**) are sampled according to procedures EMP-W-L and EMP-W-S

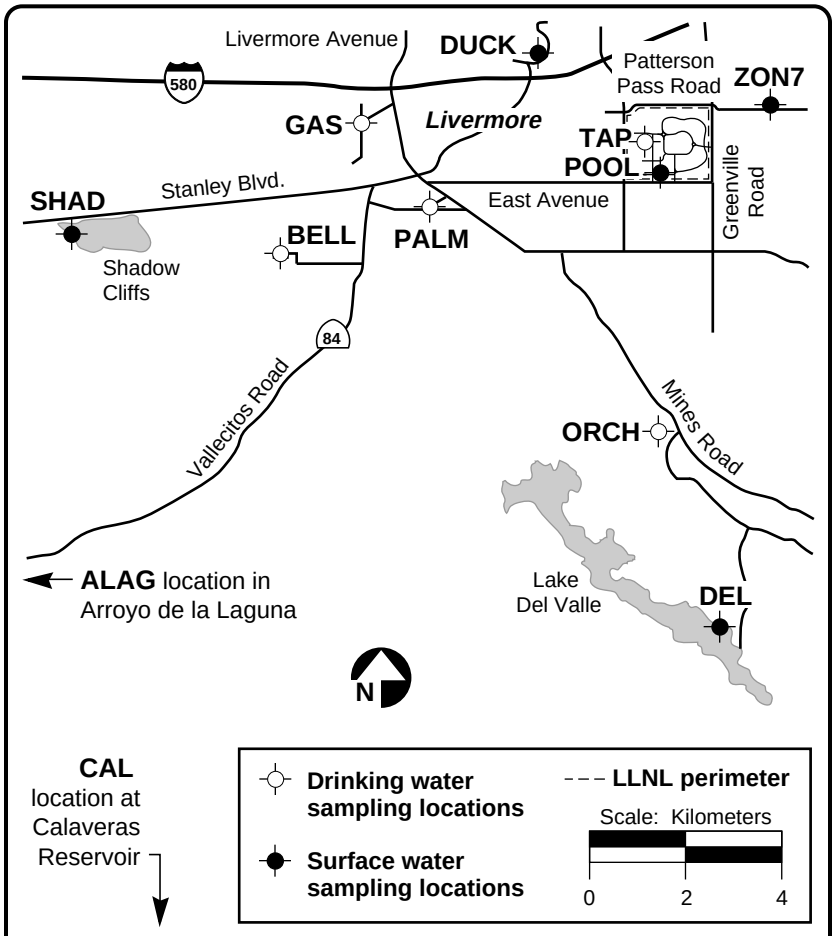

Figure 6-1. Surface and drinking water sampling locations, Livermore Valley, 1994.

(Tate et al., 1995). Sampling locations DEL, ZON7, DUCK, ALAG, SHAD, and CAL are surface water sources; BELL, GAS, PALM, and ORCH are drinking water outlets. LLNL samples these locations quarterly for gross alpha, gross beta, and tritium. The on-site swimming pool and drinking water source (POOL and TAP; **Figure 6-1**) are also sampled, as described above, for gross alpha, gross beta, and tritium. POOL is sampled monthly, TAP quarterly.

Rainfall

Rainfall is sampled according to written procedures EMP-RA-L and EMP-RA-S (Tate et al. 1995). The tritium activity measured in Livermore Valley rainfall results primarily from atmospheric emissions of tritiated water vapor (HTO) from stacks at LLNL's Tritium Facility (Building 331), and Sandia National Laboratories, California's (Sandia, California's) former Tritium Research

Laboratory. No experiments using tritium were conducted at either of these facilities during 1994. HTO emissions resulted from continuing cleanup activities at both locations. The total measured atmospheric emission of HTO from these facilities in 1994 was 6.2 TBq (168 Ci). Of this amount, LLNL released 2.8 TBq (76 Ci).

The rain sampling station locations are shown on map in **Figure 6-2**. The fixed stations are positioned around the two main HTO sources so as to record a wide spectrum of tritium activities in rainfall, from the maximum expected down to background levels. Previous analyses of tritium activity at 19 rain sampling locations, covering 53 rain events from October 1990 through December 1992, showed that activity levels decreased to background levels beyond 4 kilometers from the two main sources. Therefore, in 1993, as a cost-cutting measure, eight of the more distant background locations were eliminated from the 19-station network.

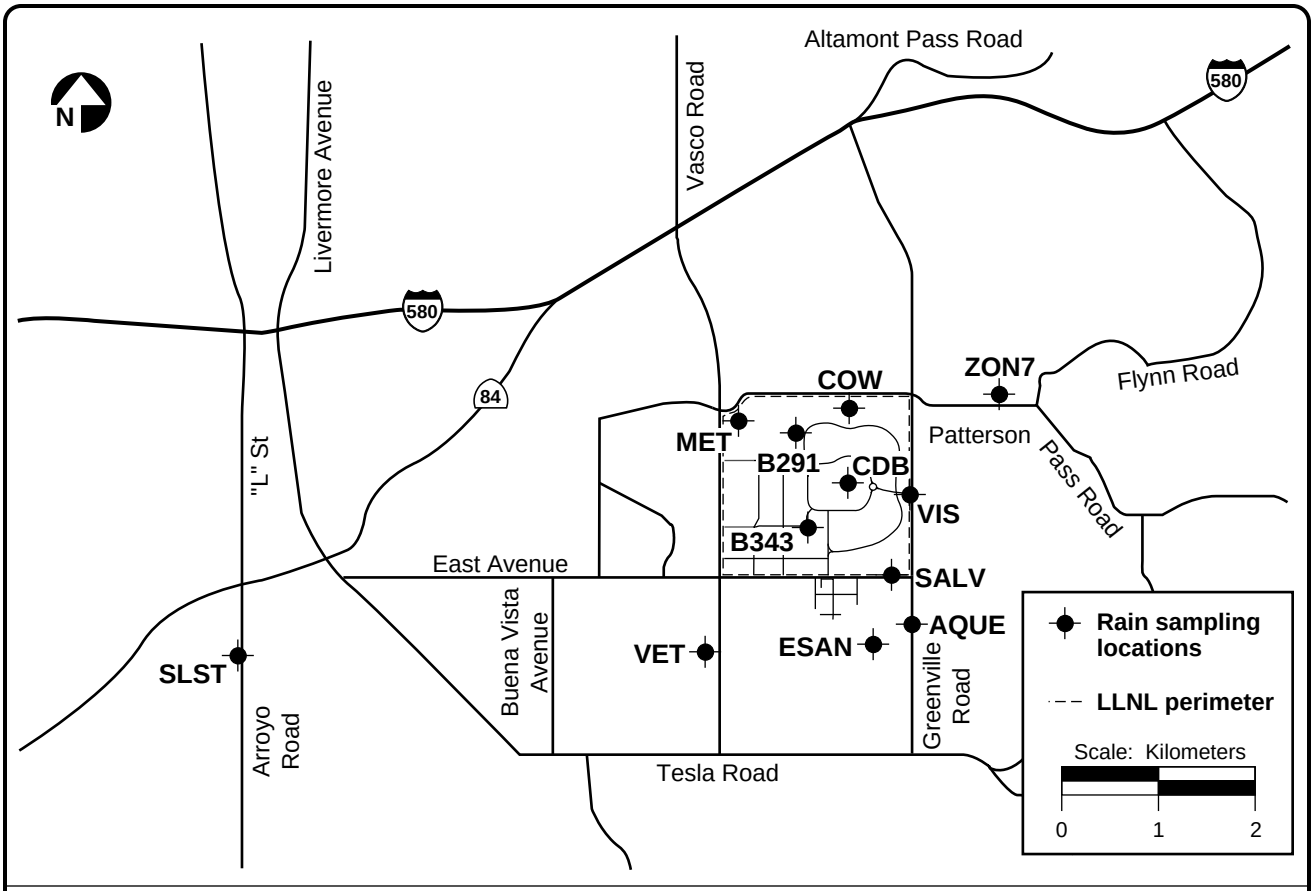

Figure 6-2. Rain sampling locations, Livermore site and Livermore Valley, 1994.

Winds measured at LLNL during rain events are predominantly from the southwest quadrant and totaled 49% of the 1994 wind field. Winds from the northwest, northeast, and southeast quadrants accounted for 16%, 21%, and 14%, respectively, during rain events. One station, located west-southwest of LLNL, is used to determine upwind background levels of tritium activity in rainfall. This station is identified as SLST on **Figure 6-2**. ZON7 is the most distant downwind station. Nine additional rain sampling locations were designed to monitor rainfall close to the primary sources. Stations were placed at various compass directions to provide adequate coverage of wind directions expected during rain events. However, in October 1994, a new rain sampling station (VET) was established southwest of LLNL to fill a potential directional gap in rain-sampling coverage (**Figure 6-2**).

One central location is used to collect rainfall for tritium activity measurements at LLNL's Experimental Test Site (Site 300; **Figure 6-3**). Rain samples are collected monthly from Site 300 during the rainy season. Over the past 23 years, 151 measurements of rainfall samples collected at this location give a maximum tritium activity of only 9.1 Bq/L (246 pCi/L), a median of 2.3 Bq/L (62 pCi/L), and an interquartile range of 2.2 Bq/L (60 pCi/L). The tritium activity measured in rainfall at Site 300 is not distinguishable from atmospheric background over the past 23 years.

Storm Water

Storm water runoff monitoring provides a broad measure of the efficacy of LLNL operational procedures that prevent, contain, and remediate inadvertent spills of hazardous wastes or products onto the ground at the Livermore site and Site 300. LLNL first monitored storm water runoff at the Livermore site in 1975. This monitoring network, originally designed to detect pesticides, expanded in 1990 to cover new locations and additional water quality parameters (i.e., radioactivity, metals, and additional organic compounds). Additional changes during 1993 complied with the National Pollutant Discharge Elimination System General Industrial Activities Storm Water Permit (NPDES General Permit). In October 1993, also in response to the NPDES General Permit, LLNL established a new storm water monitoring program at Site 300. The current list of analyses requested for storm water samples is given in **Table 6-1**. A wide range of activities is conducted at the Livermore site so it is necessary to monitor storm water for the potential impacts of these activities. In addition, due to flow patterns at the site, storm water at sampling locations includes components from other sources, such as neighboring agricultural land, parking lots, and landscaped areas. Therefore, it is necessary to analyze storm water for a wide range of constituents at the Livermore site. In contrast, storm water at Site 300 is sampled at locations that target specific activities, and a smaller range of analyses is needed.

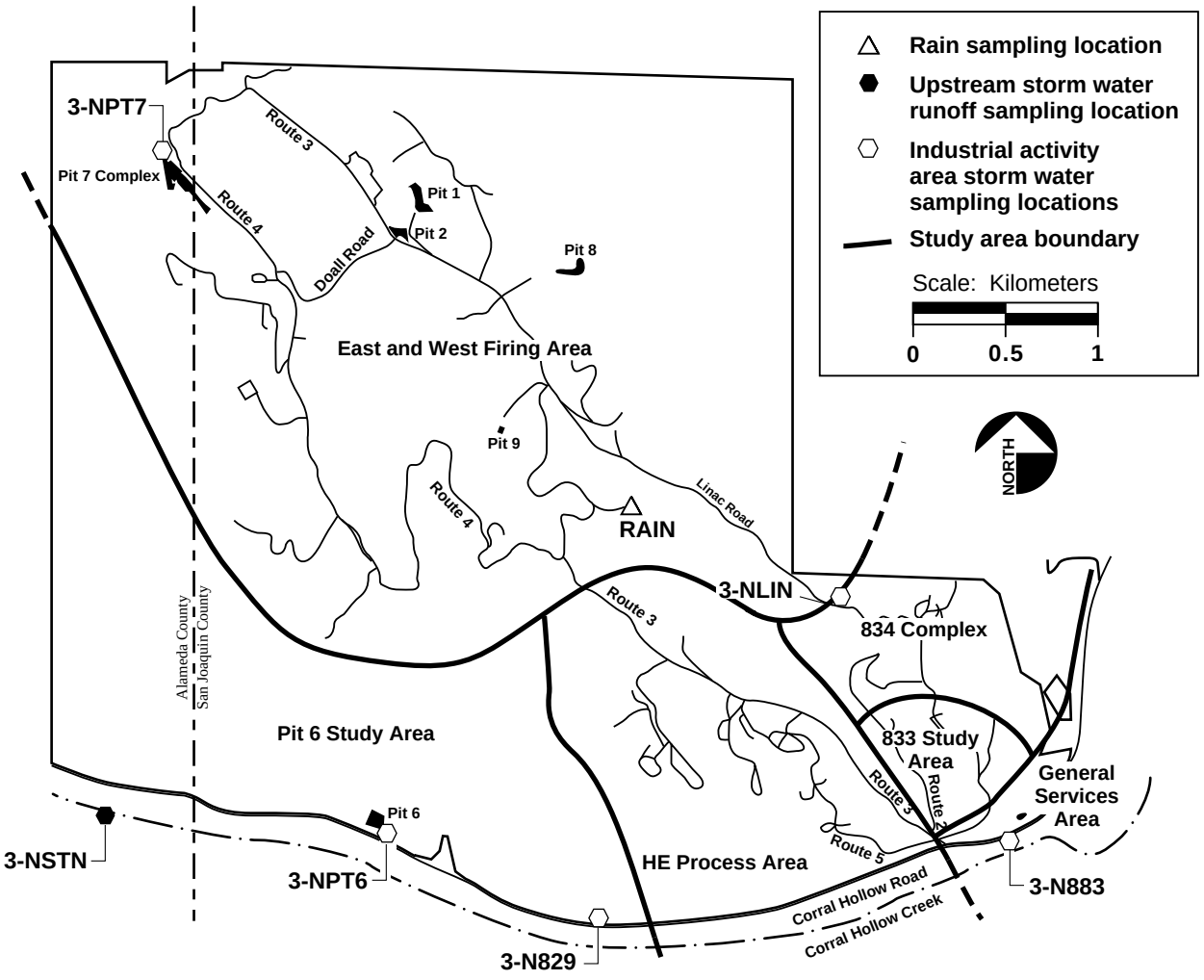

Figure 6-3. Rain sampling location and storm water runoff sampling locations, Site 300 and vicinity, 1994.

About one-fourth of the storm water runoff generated within the Livermore site drains into the Drainage Retention Basin (**Figure 6-4**), a lined depression turned into a man-made lake through the collection of runoff and treated ground water. The remainder of the site drains either directly or eventually into two arroyos by way of storm sewers and ditches. The two arroyos drain from east to west. Arroyo Seco cuts across the southwestern corner of the site. Arroyo Las Positas, diverted from its natural course, follows the northeastern and northern boundaries of the site and exits the site at the northwest corner.

In 1994, the Livermore site storm water sampling network consisted of six locations (**Figure 6-4**). Five locations characterize storm water either entering (influent: ALPE, GRNE, and ASS2) or exiting (effluent: WPDC and ASW) the

Table 6-1. Requested analyses for storm water samples.

Livermore Site	Site 300
pH	pH
Total suspended solids	Total suspended solids
Specific conductance	Specific conductance
Oil and grease	Total organic carbon
Total organic carbon	Gross alpha and beta
Gross alpha and beta	Tritium
Tritium	Uranium
Chemical oxygen demand	Total organic halides
General minerals	Explosives
Anions	
Metals	
EPA Method 624	
EPA Method 625	
Drinking water pesticides	

Livermore site. Location CDB characterizes runoff from the southeastern quadrant of the Livermore site entering the Drainage Retention Basin (DRB).

The Site 300 storm water sampling network, begun in 1994, also consisted of six locations (**Figure 6-3**). One location (NSTN) was selected to characterize storm water runoff typical of the region, unaffected by Site 300 activities. The remaining five locations were selected to characterize storm water runoff potentially affected by specific Site 300 activities.

Storm water sampling occurred on seven dates during 1994. LLNL obtained samples from all six Livermore site locations on January 24, April 25, and November 5. Samples were collected from some Site 300 locations on February 7, May 5 and 6, and December 14. Typically, a given storm will not produce runoff at all Site 300 locations because Site 300 receives relatively little rainfall and is largely undeveloped. Therefore, at many locations, a series of large storms is required to saturate the ground before runoff occurs.

Results

This section presents the monitoring results for radioactivity and other constituents in surface water, drinking water, and storm water at the Livermore site, Livermore Valley, and Site 300 and vicinity.

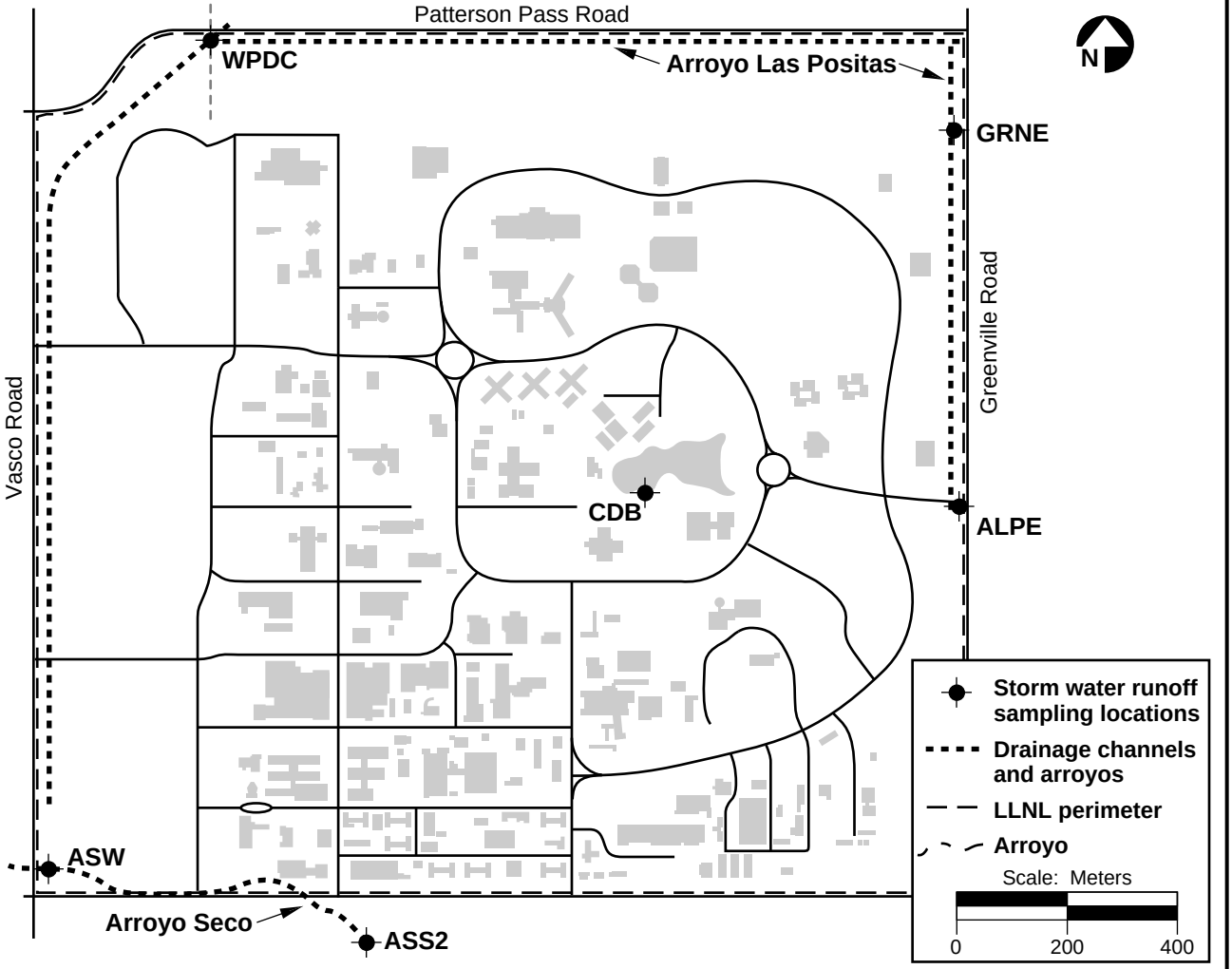

Figure 6-4. Storm water runoff sampling locations, Livermore site and vicinity, 1994.

Livermore Site and Livermore Valley Radioactivity in Surface Water

Gross Alpha and Gross Beta

Median activities for gross alpha and gross beta radiation in surface water samples (detailed data are in Table 6-1, Volume 2) are generally less than 10% of the drinking water maximum contaminant levels (MCLs; 0.56 Bq/L or 15 pCi/L, gross alpha; 1.85 Bq/L or 50 pCi/L, gross beta); however, the maximum activity detected for gross alpha (0.3 Bq/L; 8.2 pCi/L) was over 50% of its MCL.

Three of the initial analyses for gross beta radiation resulted in activities above the MCL of 1.85 Bq/L. Of those, the analyses for DUCK and PALM during the

Table 6-2. Annual statistics for radioactivity in surface and drinking waters (in Bq/L).

Summary Statistics	Tritium	Gross Alpha	Gross Beta
Maximum Contaminant Level (MCL) Bq/L	740	0.56	1.85
All locations, including POOL			
Number of samples	56	56	56
Minimum	0.414	–0.121	0.014
Maximum	5.957	0.303	10.027 (0.11)
Median	1.093	0.027	0.120
Interquartile range	1.928	0.075	0.121
All locations, except POOL			
Number of samples	44	44	44
Minimum	0.414	–0.121	0.014
Maximum	2.982	0.303	10.027 (0.11)
Median	0.803	0.028	0.109
Interquartile range	0.718	0.072	0.079
POOL only			
Number of samples	12	12	12
Minimum	3.182	–0.047	0.02
Maximum	5.957	0.295	0.326
Median	4.514	0.021	0.197
Interquartile range	1.658	0.127	0.107
Surface waters only			
Number of samples	24	24	24
Minimum	0.503	–0.121	0.014
Maximum	2.982	0.303	6.068 (0.017)
Median	1.215	0.026	0.119
Interquartile range	1.333	0.069	0.100
Off-site drinking waters only			
Number of samples	16	16	16
Minimum	0.414	–0.009	0.062
Maximum	1.395	0.266	0.223
Median	0.753	0.041	0.096
Interquartile range	0.337	0.110	0.048
On-site TAP only			
Number of samples	4	4	4
Minimum	0.507	0.007	0.028
Maximum	0.855	0.06	2.209 (0.021)
Median	0.736	0.033	0.08
Interquartile range	0.126	0.028	0.615

Note: Values in parentheses are the results of recounts for original sample results that gave values inconsistent with historical data.

second quarter resulted in gross beta activities of 6.1 and 10.0 Bq/L (164 and 271 pCi/L), respectively. Upon recounting, the analytical laboratory arrived at activities of 0.017 and 0.11 Bq/L (0.45 and 2.9 pCi/L), respectively. Likewise, the original fourth quarter analysis at TAP (LLNL's on-site drinking water) resulted in an activity of 2.2 Bq/L (60 pCi/L), slightly above the MCL for gross beta radiation; recounted activities for gross beta were 0.021 Bq/L (0.58 pCi/L).

LLNL is now in the process of auditing and checking the quality of the analytical laboratory to see if samples could be contaminated from higher level samples; however, this process is not yet complete. Historically, gross alpha and gross beta radiation have fluctuated generally around laboratory detection limits and display no apparent trends (**Figures 6-5 and 6-6**).

Storm water gross alpha and gross beta samples are listed in **Table 6-3**. Because there were only three storm events sampled at each site in 1994, the entire data set is presented. Storm water gross alpha and gross beta were well below MCLs, except for samples collected November 5 at GRNE. Because GRNE is an influent location, the gross alpha and gross beta sources were upstream and off the

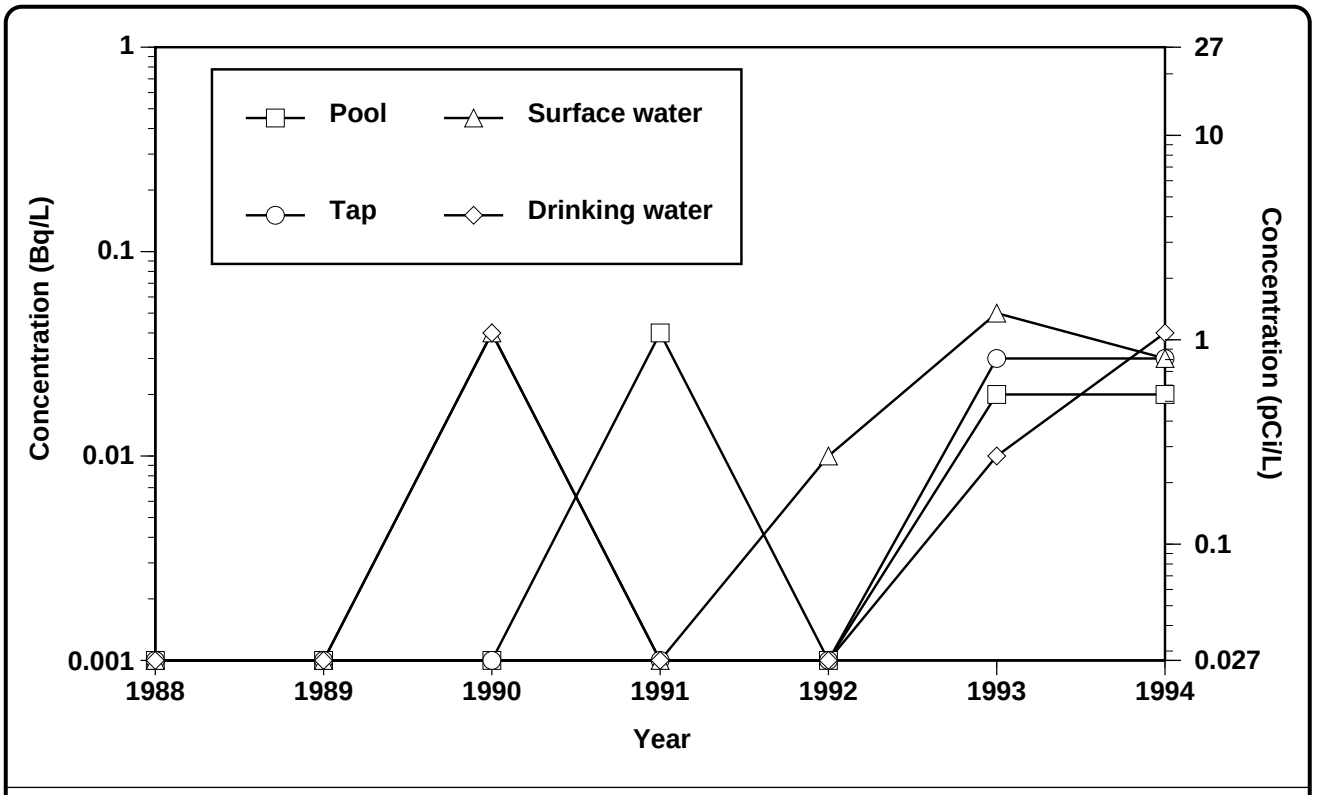

Figure 6-5. Annual median gross alpha in surface and drinking water, 1988 to 1994.

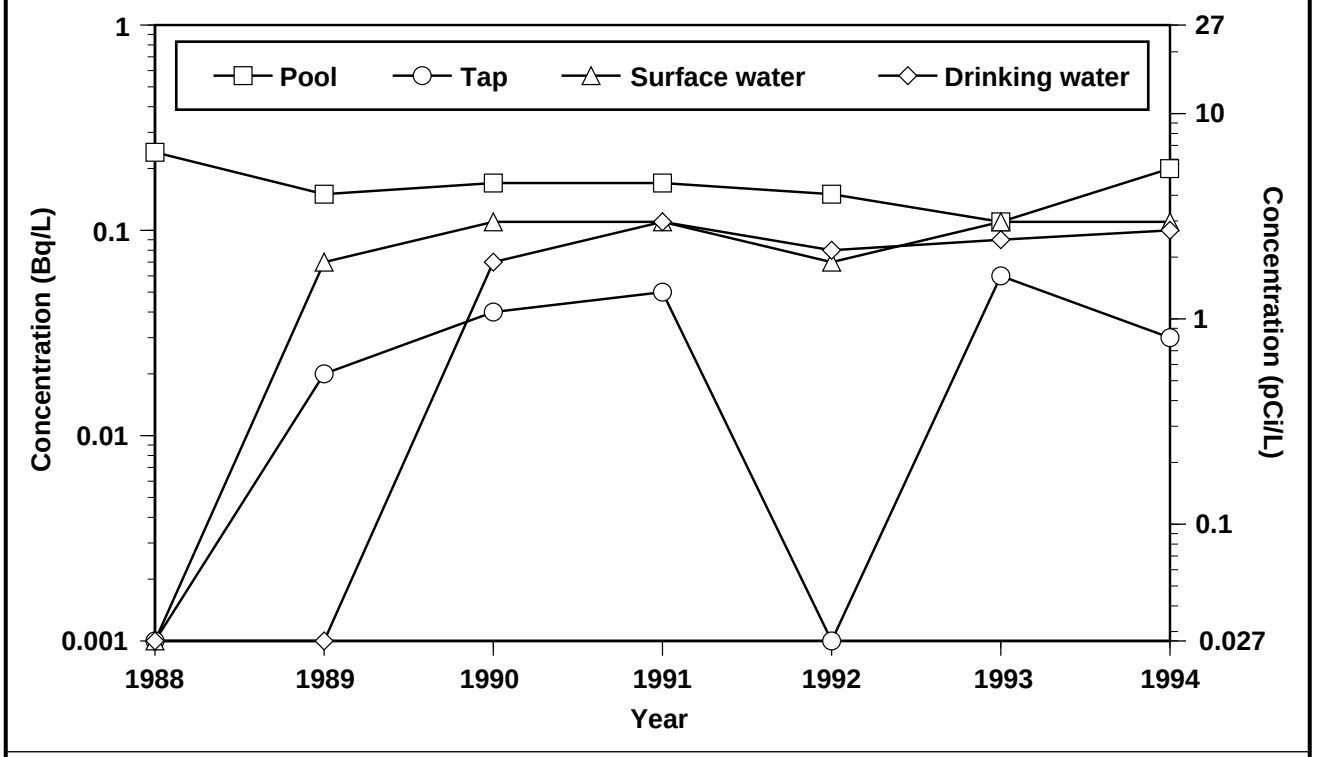

Figure 6-6. Annual median gross beta in surface and drinking water, 1988 to 1994.

Livermore site. The origin of this off-site source is unknown. Because the analytical laboratory did not retain the sample, it was not possible to reanalyze the sample or conduct an isotopic analysis for this event. LLNL procedures have been updated (see below) to ensure that, if another high result is obtained, sufficient sample will be available for further analysis.

In order to investigate possible sources for the November 5 GRNE gross alpha and gross beta, 1994 air particulate gross alpha and gross beta sampling was examined in detail. Air particulate sampling locations ZON7 and PATT are in the area upgradient of storm water location GRNE. If either of these locations exhibited abnormally high gross alpha or gross beta levels, it would indicate a source via the air pathway. **Figure 6-7** compares ZON7 and PATT monthly median air particulate gross alpha with the monthly median for all Livermore Valley locations. All values are very low, near the detection limit of the method. Thus, although the gross alpha level PATT seems high in November, it is within the variation expected at such low levels.

Table 6-3. Radioactivity in storm water runoff at LLNL (in Bq/L), 1994.

Location	Date	Tritium	Gross Alpha	Gross Beta
ALPE	Jan 24	3.522 ± 1.927	0.327 ± 0.113	0.537 ± 0.052
	Apr 25	3.959 ± 2.249	0.063 ± 0.006	0.154 ± 0.020
	Nov 5	2.357 ± 1.845	0.072 ± 0.044	0.160 ± 0.045
ASS2	Jan 24	1.839 ± 1.839	0.070 ± 0.009	0.192 ± 0.011
	Apr 25	2.168 ± 2.168	0.026 ± 0.005	0.044 ± 0.020
	Nov 5	17.945 ± 2.333	0.030 ± 0.027	0.041 ± 0.034
ASW	Jan 24	2.627 ± 1.902	0.081 ± 0.011	0.222 ± 0.012
	Apr 25	2.139 ± 2.139	0.040 ± 0.006	0.137 ± 0.019
	Nov 5	25.530 ± 2.527	0.024 ± 0.027	0.121 ± 0.043
CDB	Jan 24	17.501 ± 2.328	0.142 ± 0.012	0.221 ± 0.011
	Apr 25	8.880 ± 2.415	0.042 ± 0.006	0.323 ± 0.019
	Nov 5	2.142 ± 1.825	0.074 ± 0.035	0.089 ± 0.036
GRNE	Jan 24	3.667 ± 1.929	0.226 ± 0.022	0.326 ± 0.014
	Apr 25	2.135 ± 2.135	0.226 ± 0.010	0.844 ± 0.022
	Nov 5	1.809 ± 1.809	8.362 ± 2.294	6.623 ± 1.184
WPDC	Jan 24	12.247 ± 2.180	0.147 ± 0.014	0.256 ± 0.012
	Feb 7	7.733 ± 1.848	0.069 ± 0.031	0.289 ± 0.022
	Apr 25	2.646 ± 2.201	0.159 ± 0.009	0.433 ± 0.022
	Nov 5	4.107 ± 1.897	0.078 ± 0.035	0.142 ± 0.040

Figure 6-8 is the same plot for air particulate gross beta. The ZON7 and PATT locations exhibit the same pattern as the Livermore Valley median—sometimes slightly less than the Livermore Valley median—sometimes slightly greater, with no large deviations. Investigation of these locations indicated that there is no pattern in the 1994 air particulate gross alpha and gross beta sampling that would tie the GRNE result to airborne emissions from LLNL (see Chapter 4, Air Monitoring). Contemporaneous storm water gross alpha and gross beta measurements at WPDC (the LLNL outfall location) were at levels typical for that location and less than one-third of the MCL.

Figures 6-9 and 6-10 show the historical trend in storm water gross alpha and gross beta, respectively. In these figures and other storm water historical trend figures in this chapter, all available data for the influent and effluent locations of the two runoff pathways through the LLNL site have been aggregated. Also, data have been aggregated on a wet season basis—that is, October of one year through May of the next—rather than on a calendar year basis. Thus, data on storm plots labeled 1993 actually represent October 1993 through May 1994, and

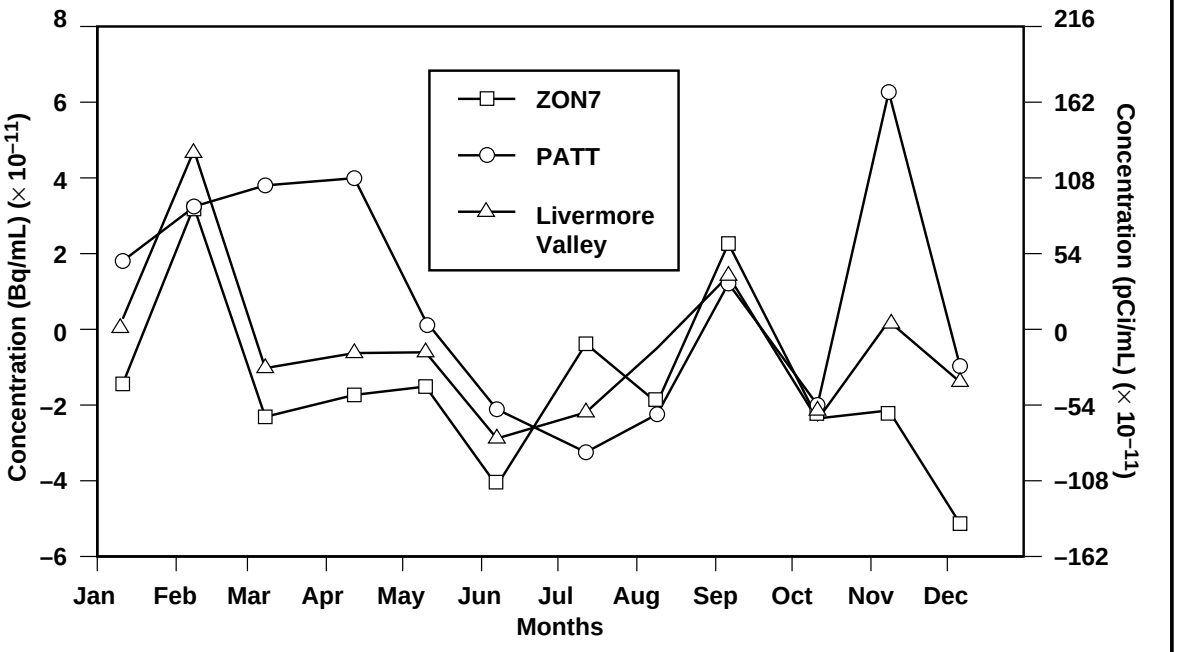

Figure 6-7. Monthly median gross alpha on air filters for 1994, comparing ZON7 and PATT location with Livermore Valley medians.

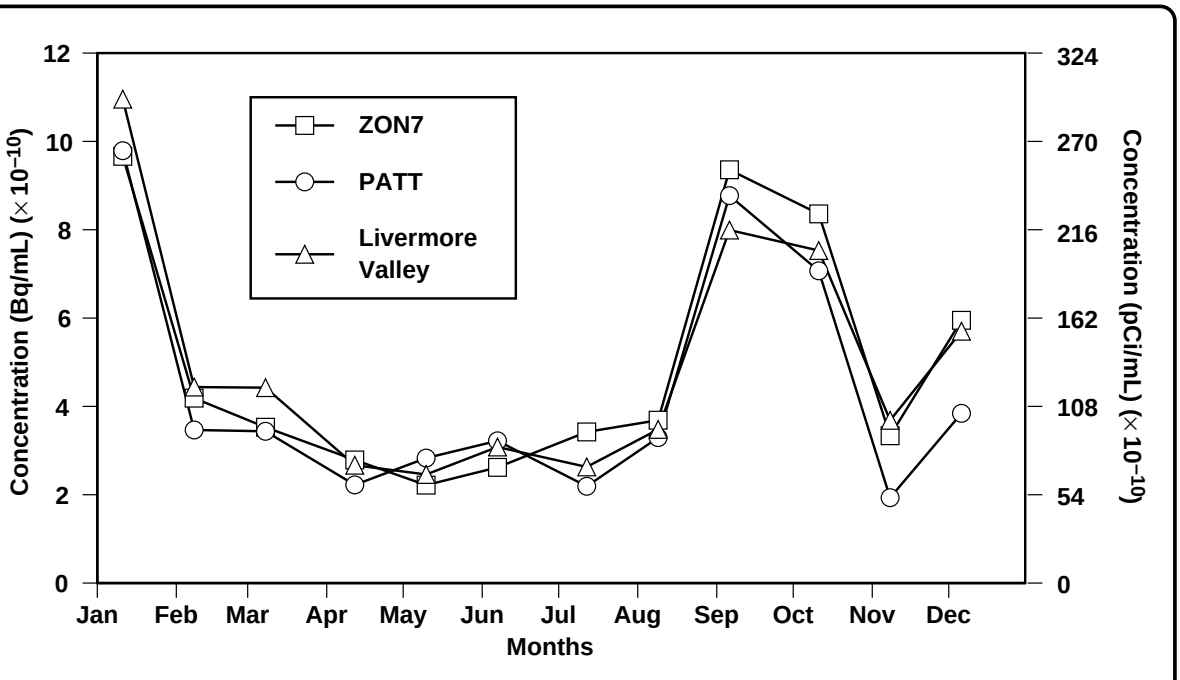

Figure 6-8. Monthly median gross beta on air filters for 1994, comparing ZON7 and PATT location with Livermore Valley medians.

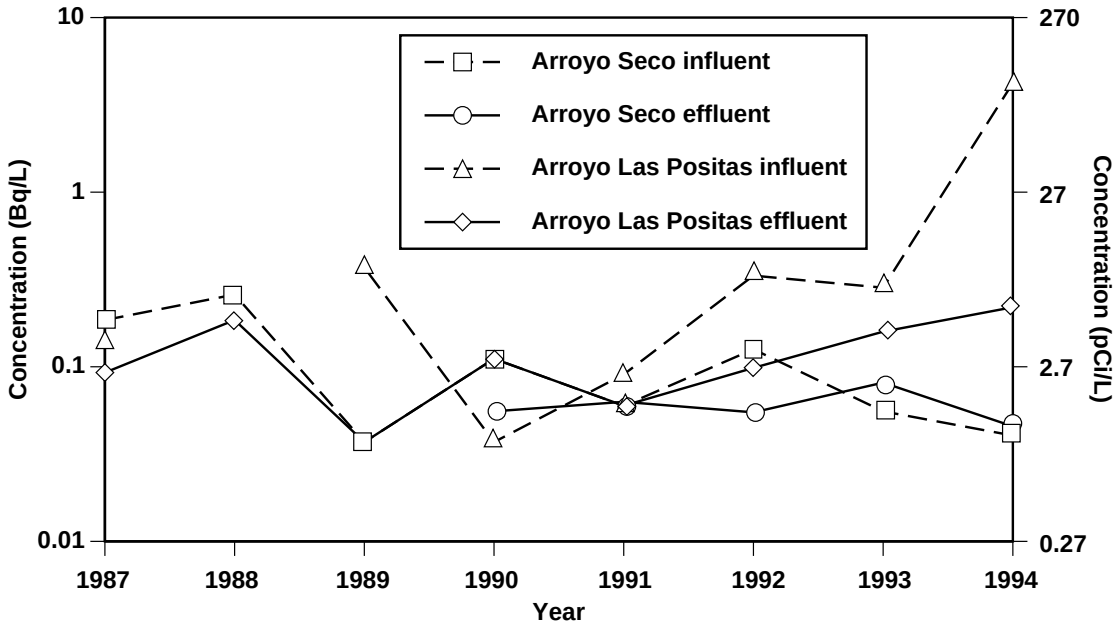

Figure 6-9. Annual median gross alpha in LLNL storm water.

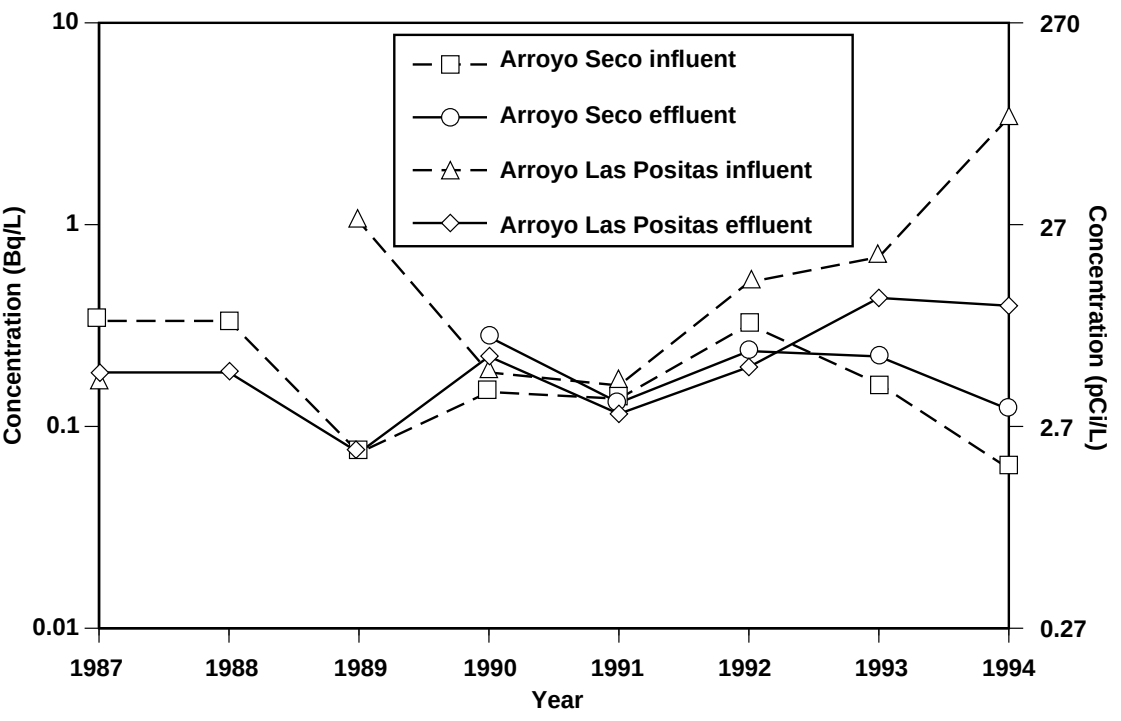

Figure 6-10. Annual median gross beta in LLNL storm water.

data labeled 1994 represent October through December 1994 (a partial wet season, pending collection of 1995 data). Finally, plots include all available storm water influent/effluent data for each constituent. The Arroyo Seco pathway shows no discernible pattern. Gross alpha, and, to a lesser extent, gross beta results seem to be increasing slightly at the influent locations on the Arroyo Las Positas pathway. This is reflected, to a lesser degree, in the results at the Arroyo Las Positas effluent locations. In order to better investigate any future results that may be inconsistent with historical data, LLNL has instituted a procedure of archiving storm water samples from all influent locations. If another high gross alpha or gross beta result is obtained, we will conduct an isotopic analysis using the archived water, an important first step in determining the nature of the source.

Tritium

Median tritium activity (0.8 Bq/L or 21.7 pCi/L) and the maximum tritium activity (2.982 Bq/L or 80.6 pCi/L) at surface and drinking water locations in the Livermore Valley (excluding POOL) were much less than 1% of the drinking water MCL (**Table 6-2**). Water in the LLNL swimming pool had the highest median value and individual measurement. The median activity for tritium at POOL for 1994 was 4.51 Bq/L (122 pCi/L), compared to 7.4 Bq/L (200 pCi/L) in 1993, with both values 1% or less of the drinking water MCL. The highest single observation for POOL was 5.96 Bq/L (161 pCi/L), compared to 10.25 Bq/L (277 pCi/L) in 1993.

Tritium activities in the POOL have decreased from 1988 (the beginning of monitoring for tritium) to 1994 (**Figure 6-11**). The decrease in tritium activities has been most marked since 1991, the last year with significant tritium emissions from Building 331, the Tritium Facility, located very near to the POOL. Median tritium activities in the on-site TAP have also decreased with time since 1988. Tritium activities in the off-site surface waters and drinking waters have decreased very gradually, almost imperceptibly on a logarithmic scale (**Figure 6-11**).

Tritium activities measured in rainfall at the LLNL site and vicinity are shown in **Table 6-4**. The Livermore site rainfall has exhibited elevated tritium activities in the past (Gallegos et al. 1994). During 1994, however, measurements of tritium activity in rainfall were all far below the 740 Bq/L (20,000 pCi/L) MCL established by the EPA for drinking water. Rainfall samples were collected on January 25, March 25, April 11, April 26, May 9, and November 7, 1994. The highest activity measured was 91 Bq/L (2460 pCi/L). This activity was recorded in a sample collected from station ESAN on March 25, 1994. This station is 0.3 kilometers east of the former Tritium Research Laboratory at Sandia, California, and 1.1 kilometers southeast of LLNL's Building 331.

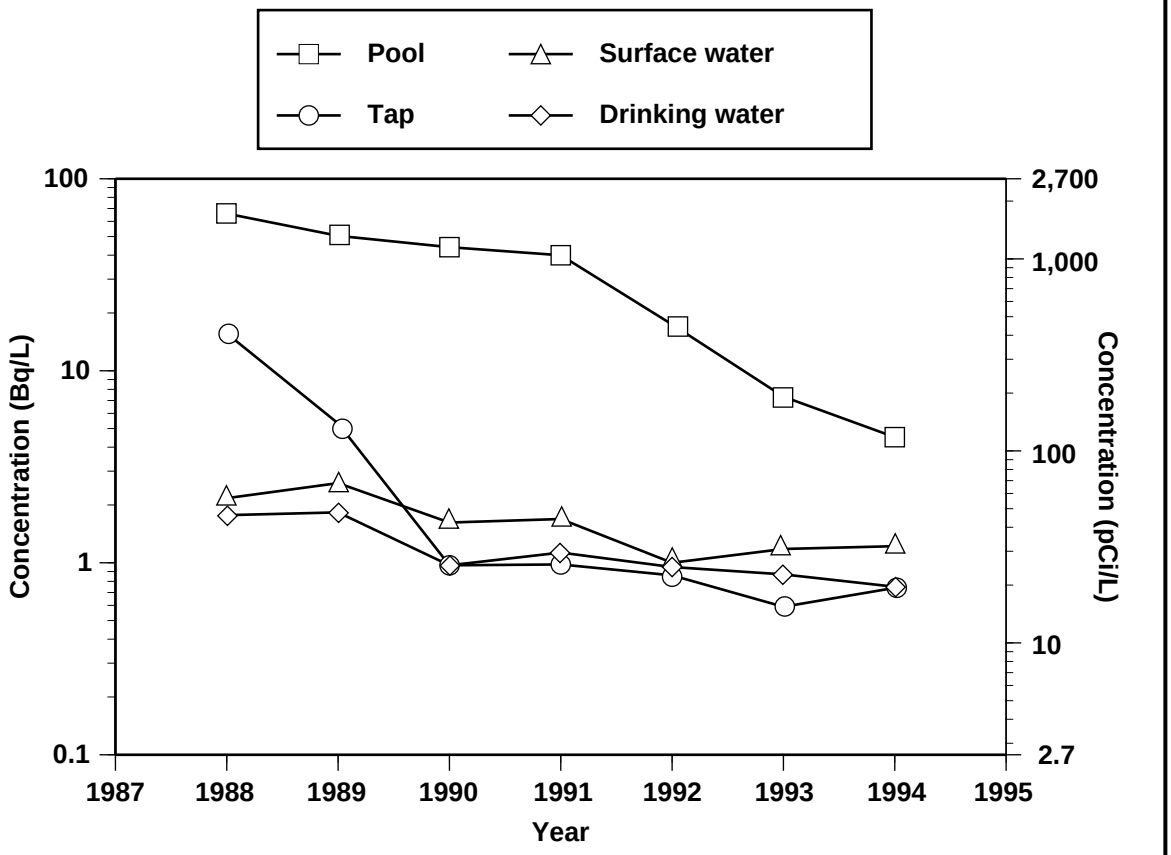

Figure 6-11. Annual median tritium in surface and drinking water, 1988 to 1994.

As expected, the stations in the prevailing downwind directions and closest to the sources showed the highest median tritium activities in rain. For LLNL Building 331 sources and stations, these were stations B343 (28.5 Bq/L; 770 pCi/L), CDB (16.7 Bq/L; 450 pCi/L), and B291 (14.6 Bq/L; 390 pCi/L). The stations most affected by the source at Sandia, California were SALV (12.2 Bq/L; 330 pCi/L), ESAN (11.7 Bq/L; 320 pCi/L), and AQUE (10.4 Bq/L; 280 pCi/L). As expected from the results of past years, the lowest medians were for the prevailing upwind station SLST (1.8 Bq/L; 50 pCi/L), the station MET (1.8 Bq/L; 50 pCi/L), and the most distant downwind station ZON7 (3.4 Bq/L; 90 pCi/L). Station VET, newly established in October 1994, recorded the highest tritium activity (19.4 Bq/L; 520 pCi/L) for the rainfall samples collected on November 7.

This result has prompted the reestablishment in 1995 of three previously discontinued rain sampling stations to the south and southwest of LLNL that historically showed very low tritium activities. The additional stations are needed to determine the extent of tritium activity in rainfall to the southwest of LLNL and Sandia, California.

Table 6-4. Tritium in rain (in Bq/L), Livermore site and Livermore Valley, 1994.

Sampling Location	Jan 25	Mar 25	Apr 11	Apr 26	May 9	Nov 7	Median
On-site							
B343	32.7 ± 2.7	18.1 ± 2.3	38.5 ± 3.2	24.2 ± 2.5	44.0 ± 2.6	3.4 ± 1.8	28.5
CDB	14.0 ± 2.2	8.1 ± 2.0	22.0 ± 2.7	19.4 ± 2.7	22.4 ± 2.2	1.8 ± 1.8	16.7
B291	14.8 ± 2.2	14.5 ± 2.2	18.6 ± 2.6	15.6 ± 2.3	13.7 ± 2.2	1.8 ± 1.8	14.6
VIS	7.4 ± 2.1	7.9 ± 2.0	10.8 ± 2.4	7.2 ± 2.0	6.0 ± 1.7	1.8 ± 1.8	7.3
SALV	12.7 ± 2.2	30.4 ± 2.6	9.6 ± 2.1	53.7 ± 3.2	11.8 ± 1.9	1.8 ± 1.8	12.2
MET	2.4 ± 2.4	1.7 ± 1.7	3.1 ± 2.2	1.8 ± 1.8	1.5 ± 1.5	1.7 ± 1.7	1.8
COW	6.0 ± 2.0	1.8 ± 1.8	9.0 ± 2.4	3.6 ± 1.9	5.4 ± 1.7	1.7 ± 1.7	4.5
Off-site							
ESAN	8.6 ± 2.0	91.0 ± 3.8	20.3 ± 2.7	14.7 ± 2.6	7.8 ± 1.8	1.9 ± 1.9	11.7
AQUE	7.3 ± 2.0	—[a]	13.8 ± 2.5	13.5 ± 2.2	—[a]	1.7 ± 1.7	10.4
ZON7	2.3 ± 1.9	3.4 ± 1.9	3.4 ± 2.2	7.4 ± 2.0	5.1 ± 1.7	1.8 ± 1.8	3.4
SLST	1.8 ± 1.8	1.8 ± 1.8	1.7 ± 1.7	1.7 ± 1.7	1.5 ± 1.5	1.8 ± 1.8	1.8
VET	—[b]	—[b]	—[b]	—[b]	—[b]	19.4 ± 2.4	—[c]

a Rain collected at this location was not sufficient to produce a sample.

b Location VET was added towards the end of the year; therefore, data are only available for November 7.

c Because there is only one data point the median is not listed.

The trend of tritium activity in rainfall at the Livermore site has been downward during the past five years. This decrease mirrors the downward trend in total HTO emissions from LLNL's Tritium Facility and Sandia, California's former Tritium Research Laboratory. These trends are shown in **Figure 6-12**. Values for the median rain tritium activity shown in **Figure 6-12** are derived from the six on-site rain sampling locations that historically have given the highest activities. These locations are B343, B291, CDB, SALV, VIS, and COW (**Figure 6-2**). A nearly six-fold decrease in total HTO emissions has occurred since 1991, from 34.9 TBq (943 Ci) down to 6.2 TBq (168 Ci). This decrease is mirrored by a nearly six-fold decrease in median tritium activity measured in rainfall on site at LLNL (65.9 Bq/L down to 11.3 Bq/L, or 1780 pCi/L down to 300 pCi/L).

As with tritium levels in rainfall, tritium levels in storm water runoff were low; the overall median was 3.5 Bq/L (95.1 pCi/L), or less than 0.5% of the drinking water MCL (**Table 6-3**). The highest tritium activity measured in storm water runoff during 1994 was 25.5 Bq/L (689 pCi/L) at location ASW, about 3.5% of the drinking water MCL. The historical trend (**Figure 6-13**) indicates generally decreasing tritium levels in storm water.

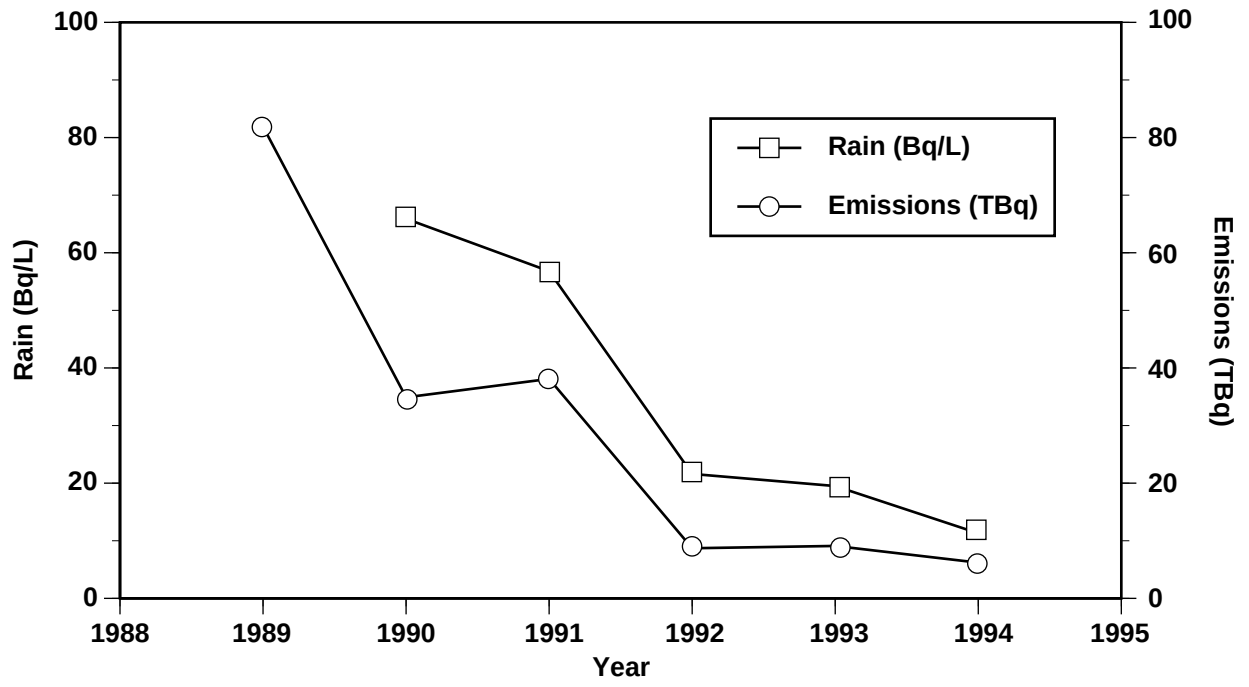

Figure 6-12. Trends of median tritium activity in rain and total stack emissions of HTO by LLNL and Sandia, California, 1989 to 1994.

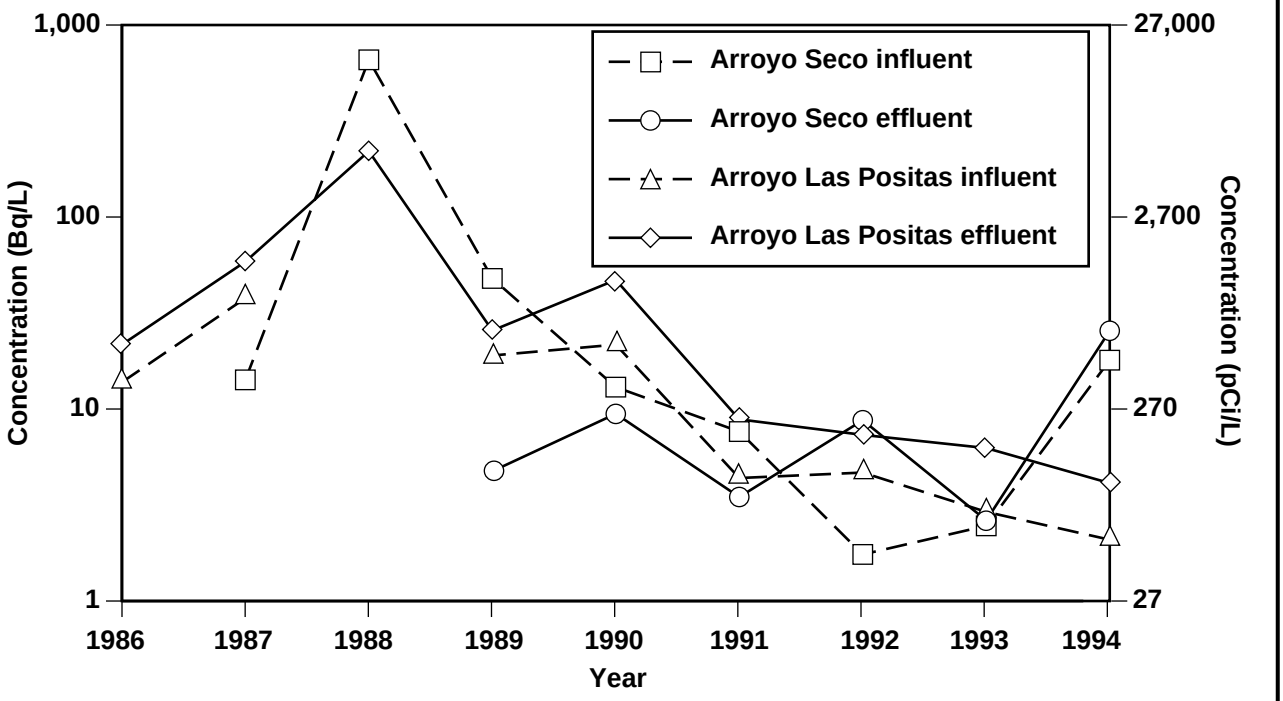

Figure 6-13. Annual median tritium concentrations in LLNL storm water.

Livermore Site and Livermore Valley, Nonradioactive Pollutants in Storm Water

Storm water sample results were compared to EPA MCLs and Ambient Water Quality Criteria (AWQC), as summarized in *A Comparison of Water Quality Goals* (Marshack 1991). In addition, Livermore site results were compared to criteria listed in the *Water Quality Control Plan, San Francisco Bay Basin Region,* January 17, 1995 revision; and Site 300 results were compared to criteria listed in *The Water Quality Control Plan for the California Regional Water Quality Control Board Central Valley Region*, Second Edition, 1992 (Basin Plans). If a result exceeded a Basin Plan criterion, that criterion was compared to the Marshack criteria. If, then, a Marshack criterion was equal to or more stringent than the Basin Plan criterion, only the Marshack criterion was used for comparison. Although three sets of criteria apply, the Marshack criteria are the most stringent for LLNL results, and only Marshack criteria are discussed below. (Complete storm water results are presented in Table 3, Volume 2.)

Sample results for zinc in storm water exceeded the AWQC (0.054 mg/L) in 11 samples, but were well below the MCL (50 mg/L). In general, zinc levels at influent locations were equal to or greater than corresponding effluent locations, indicating a probable off-site source. The only exception to this was the April 24 storm, in which zinc at WPDC (0.081 mg/L) was just above the AWQC and was below the analytical laboratory reporting limit (0.05 mg/L) at the corresponding influent locations. In addition, zinc at the on-site location (CDB) was above the AWQC for all three storms monitored, with a maximum level of 0.14 mg/L. The available historical data (**Figure 6-14**) indicate a slight increase in zinc levels over the past three years.

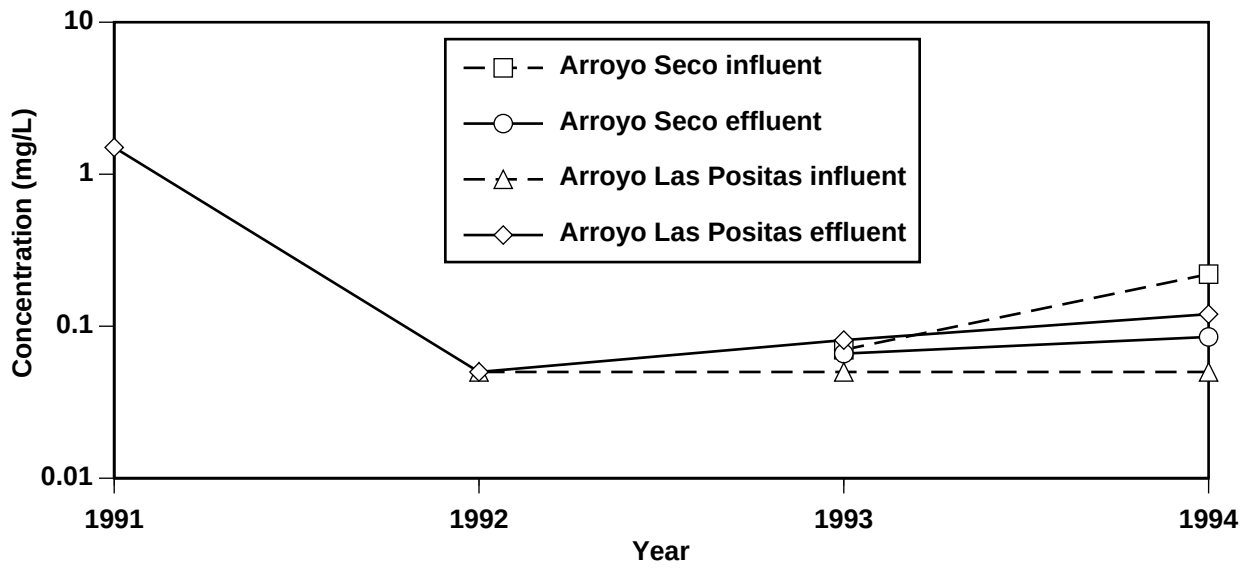

Figure 6-14. Annual median zinc concentrations in LLNL storm water, 1991 to 1994.

Bis(2-ethylhexyl)phthalate was detected once (17 parts per billion) at location WPDC, and in excess of the MCL (4 parts per billion). This plasticizer is ubiquitous in the environment and is known to be used on site (LLNL Wastewater Discharge permit application, 1993–1994). Historically, it is detected at most once or at twice per year at any given location. Therefore, the historical trend plot (open symbols in **Figure 6-15**) is actually more reflective of changes in the reporting levels than of changes in the actual bis(2-ethylhexyl)phthalate level. A plot of maximum detected bis(2-ethylhexyl)phthalate (solid symbols in **Figure 6-15**) shows that maximum levels have remained relatively unchanged. If the data used to generate a particular median were all below reporting levels, the maximum is not shown.

Table 6-5 lists nonradioactive contituents found above comparison criteria in Livermore site storm water. Table 6-3, Volume 2, contains all information in **Table 6-5** except criteria. Zinc and bis(2-ethylhexyl)phthalate were, at times, above their respective water quality criteria at effluent locations, and pH results for one storm event were slightly below the minimum of the MCL range. In addition, criteria were exceeded at influent or on-site locations but not at

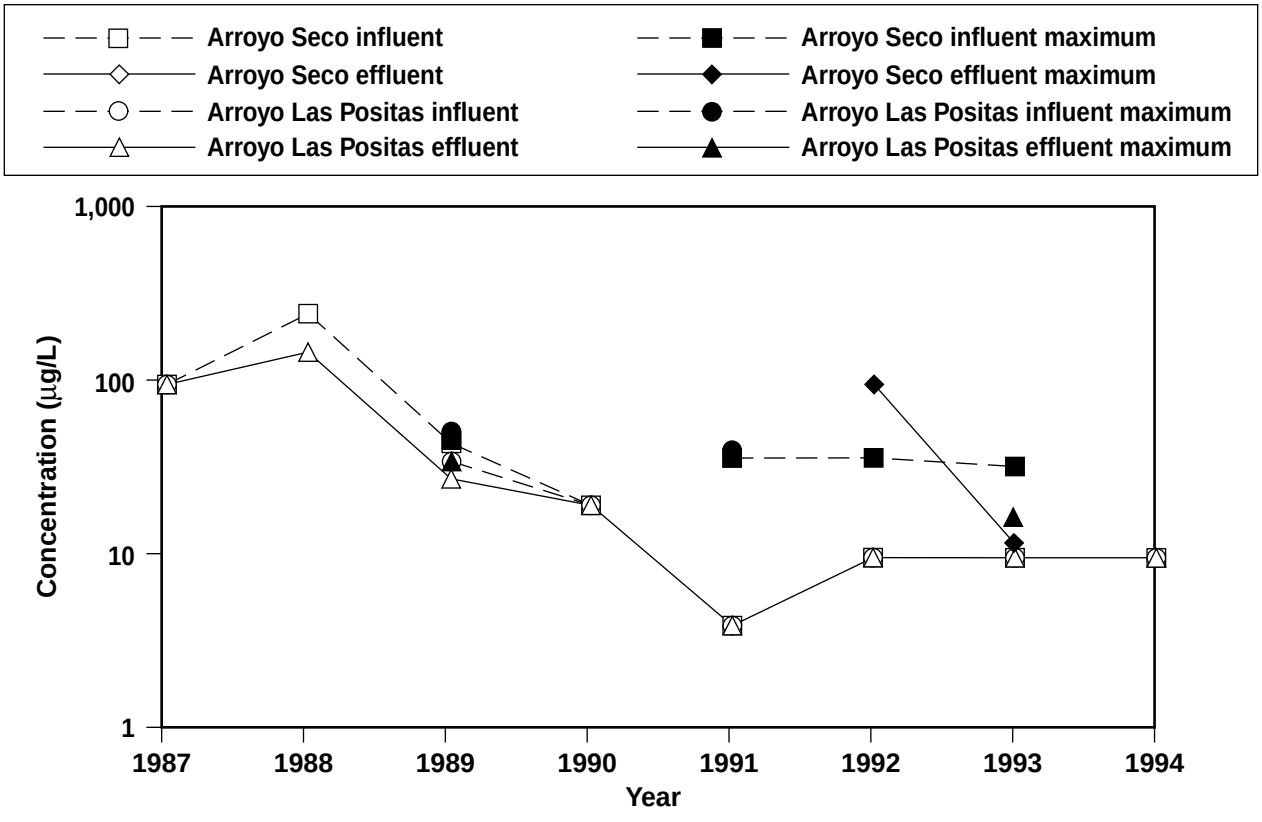

Figure 6-15. Bis(2-ethylhexyl)phthalate in LLNL storm water, 1987 to 1994.

corresponding effluent locations for total alkalinity, total dissolved solids, arsenic, beryllium, chloride, chromium, selenium, sulfate, and 2,4-D.

Table 6-5. Storm water nonradioactive parameters exceeding relevant comparison criteria.

Constituent	Criteria	Date	Location	Concentration (mg/L)
pH	6.5–8.5 (MCL)	11/5/94	ASS2	6.2
			ASW*	6.1
			ALPE	6.4
			WPDC*	6.4
			CDB	6.0
Total alkalinity (as $CaCO_3$)	200 (AWQC)	1/24/94	ALPE	290
Total dissolved solids	500 (MCL)	1/24/94	ALPE	1,500
Arsenic	0.05 (MCL)	4/25/94	CDB	0.074
Beryllium	0.004 (MCL)	4/25/94	GRNE	0.0031
			CDB	0.0012
Chloride	250 (MCL)	1/24/94	ALPE	380
Chromium	0.05 (MCL)	4/25/94	GRNE	0.079
Selenium	0.01 (MCL)	4/25/94	CDB	0.015
Sulfate	250 (MCL)	1/24/94	ALPE	320
Zinc	0.054 (AWQC)	1/24/94	ASS2	0.056
			CDB	0.084
		4/25/94	ASW*	0.066
			ASS2	0.07
			CDB	0.096
			WPDC*	0.081
		11/5–6/94	ASW*	0.085
			ASS2	0.22
			ALPE	0.12
			CDB	0.14
			WPDC*	0.12
Bis(2-ethylhexyl)phthalate	0.004 (MCL)	4/25/94	WPDC*	0.017
2,4-D	0.07 (MCL)	4/25/94	ALPE	0.072

*Effluent locations

MCL = Maximum contaminant level

AWQC = Ambient water quality criteria

Organic constituents detected in 1994 but below comparison criteria were acetone (three observations), 2-butanone (one observation), chloromethane (one observation), 1,3-dichlorobenzene (two observations), 1,2-dichoroethane (three observations), 2,4,5-TP (Silvex, one observation), and trichloroethene (one observation).

Site 300 Radioactivity in Surface Water

Rainfall at the semiarid Site 300 was only sufficient to provide a total of three samples. The samples were collected during the first, second, and fourth quarters of 1994. The measured tritium activities were 0.50 Bq/L, 0.66 Bq/L, and 0.66 Bq/L (13.5, 17.8, and 17.8 pCi/L), respectively. These activities are indistinguishable from atmospheric background activity.

The highest observed tritium in Site 300 storm water runoff (**Table 6-6**) was 1.4 Bq/L (37.8 pCi/L), less than 0.2% of the drinking water MCL of 740 Bq/L (20,000 pCi/L). The maximum gross beta level observed in Site 300 storm water runoff (1.5 Bq/L, or 41 pCi/L) was also below the applicable MCL (1.85 Bq/L, or 50 pCi/L). Gross alpha radiation measured at location NPT7 on May 6 (0.69 Bq/L, or 18.6 pCi/L) was just above the drinking water MCL (0.56 Bq/L, or 15 pCi/L). The gross alpha level in the next storm water sample from that location (0.073 Bq/L, or 2.0 pCi/L, on December 15), however, was approximately one-tenth that of the previous sample, and well below the MCL. One sample at the off-site location (NSTN) was also above the gross alpha MCL, at 1.59 Bq/L (43 pCi/L).

Table 6-6. Radioactivity in storm water runoff at Site 300 (in Bq/L), 1994.

Location	N883		NPT7		NSTN
Date	May 6	Dec 14	May 6	Dec 15	May 6
Tritium	0.296 ± 0.992	1.339 ± 1.339	1.014 ± 1.014	1.399 ± 1.399	0.648 ± 0.984
Gross alpha	0.196 ± 0.017	0.046 ± 0.006	0.69 ± 0.038	0.073 ± 0.010	1.595 ± 0.067
Gross beta	0.429 ± 0.030	0.119 ± 0.010	0.747 ± 0.044	0.239 ± 0.011	1.532 ± 0.056
Uranium-234	0.003 ± 0.001	0.011 ± 0.009	0.063 ± 0.003	0.021 ± 0.007	0.115 ± 0.003
Uranium-235	–0.002 ± 0.001	0.003 ± 0.005	0.002 ± 0.001	0.001 ± 0.002	0.005 ± 0.001
Uranium-238	0.0004 ± 0.001	0.009 ± 0.007	0.069 ± 0.003	0.019 ± 0.007	0.123 ± 0.004

Site 300 Nonradioactive Pollutants in Storm Water

There were two pH readings in Site 300 storm water runoff (**Table 6-7**) outside of the MCL range (6.5 to 8.5); a pH of 6.1 was measured at location N883 on May 6, and a pH of 9.4 was measured at NPT7 on December 14. All other nonradioactive constituents and parameters were comparable to or below those measured at the background location (NSTN) in Corral Hollow Creek. The only Site 300 values higher than the background location were within the uncertainty of the test, with two total organic carbon readings of 14 mg/L at location N883, compared to 13 mg/L at NSTN.

Table 6-7. Site 300 storm water runoff, nonradioactive parameters, 1994.

Parameters	Storm Date	N883	NPT7	STN
Total organic halides (mg/L)	Feb 7	<0.01	<0.01	—[a]
	May 6	0.016	0.024	0.1
	Dec 14	0.038	0.059	—[a]
Total organic carbon (mg/L)	Feb 7	5	4	—[a]
	May 6	14	10	13
	Dec 14	14	10	—[a]
Total suspended solids (mg/L)	Feb 7	9	880	—[a]
	May 6	19	550	2,100
	Dec 14	62	40	—[a]
pH (units)	Feb 7	6.6	8.1	—[a]
	May 6	6.1	7.7	7.6
	Dec 14	6.5	9.4	—[a]
Specific conductance (μmhos/cm)	Feb 7	15	110	—[a]
	May 6	30	130	830
	Dec 14	24	280	—[a]

[a] There was not sufficient rainfall to produce runoff at location STN on February 7 and December 14 so no data are available for STN on these dates.

Environmental Impact

Tritium activities in off-site drinking waters (as well as the on-site TAP location) were all well below the drinking water MCL; they are in the approximate range of the estimated background levels (the background ranges from 3–4 Bq/L or 80–110 pCi/L). The potential impact of such tritium in drinking water supplies was estimated by using the effective dose equivalent (EDE). Appendix B presents the method used to calculate dose. Of all off-site drinking waters measured, the maximum tritium activity, 1.4 Bq/L (38 pCi/L), occurred at location

GAS (at a service station) sampled on July 13, 1994. The EDE to an adult who ingested two liters of this tap water per day for one year would be 0.017 μSv (1.7 μrem), which is approximately 0.002% of the DOE standard allowable dose of 1.0 mSv/yr (100 mrem/yr). All other off-site waters, if ingested at the 2-liter-per-day rate, would result in even lower EDEs. The data from waters sampled during 1994 and the estimated potential maximal dose demonstrates a negligible impact of LLNL operations on valley waters resulting from releases of tritium to the atmosphere.

The environmental impact of tritium measured in rainfall samples from LLNL, Sandia, California, the Livermore Valley, and Site 300 was negligible. The highest tritium activity measured in a 1994 rainfall sample was 91 Bq/L (2460 pCi/L). This activity is only 12% of the 740 Bq/L limit established for drinking water by the EPA. The EDE to an adult who ingested two liters of this rain per day for one year would be 0.001 mSv (0.1 mrem), which is 0.1% of the DOE standard allowable annual dose of 1.0 mSv (100 mrem).

Storm water runoff contained levels of zinc and bis(2-ethylhexyl)phthalate that were, at times, above their respective water quality criteria at effluent locations. No other constituent at Livermore-site storm water effluent locations were observed above a regulatory limit. In addition, pH results for one storm event were slightly below the minimum of the MCL range. At Site 300, measurements at effluent locations indicated one gross alpha reading and two pH readings outside of MCLs. Although some 1994 storm water results were above criteria, there is no evidence that indicates any impact to off-site biota.