7. Surface Water Monitoring

Erich R. Brandstetter
Richard A. Brown

Introduction

Lawrence Livermore National Laboratory monitors surface water 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. The water samples are analyzed for radionuclides, high 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. In addition, a fish bioassay is performed annually for storm water entering and leaving the Livermore site via the Arroyo Las Positas pathway.

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. In addition, LLNL's National Pollutant Discharge Elimination System (NPDES) Permit (NPDES No. CA0030023, WDR 95-174) for the Livermore site contains specific monitoring requirements.

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.

7. Surface Water Monitoring

Surface Water

Surface and drinking water near the Livermore site and in the Livermore Valley are sampled at locations shown in **Figure 7-1** according to procedures set out in Appendix A of the *Environmental Monitoring Plan* (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 sources POOL and TAP are also sampled, as described above, for gross alpha, gross beta, and tritium. POOL is sampled monthly, TAP quarterly.

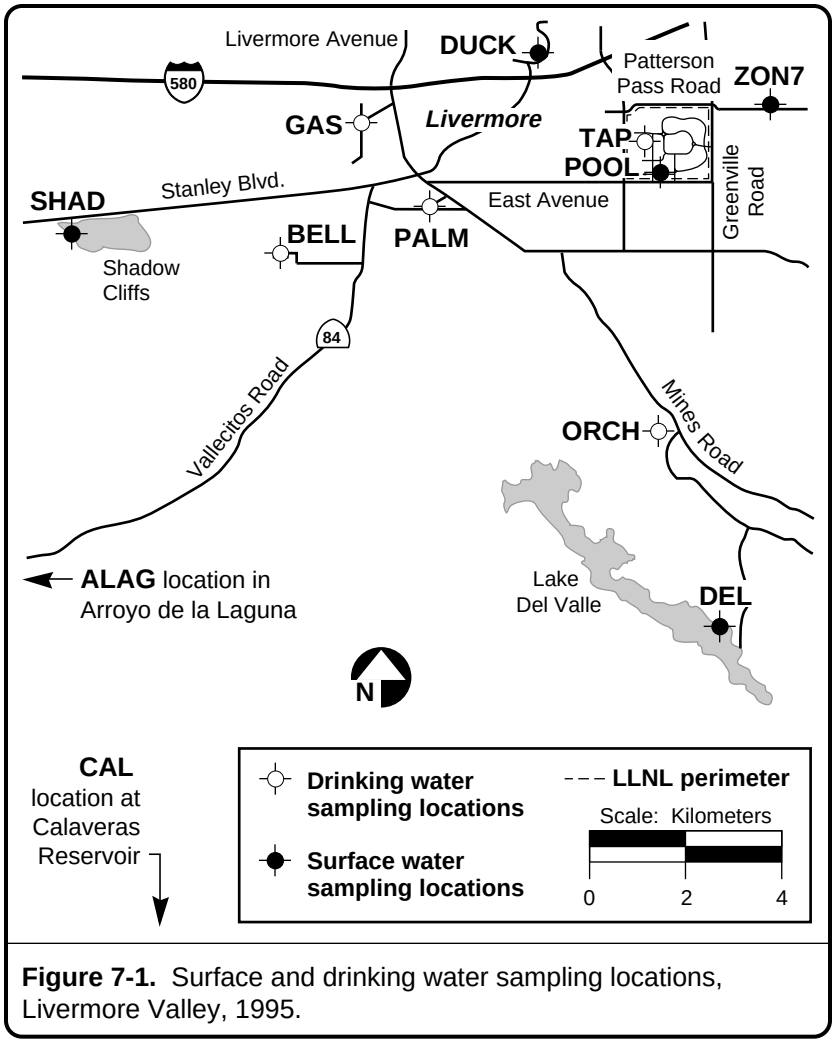

Figure 7-1. Surface and drinking water sampling locations, Livermore Valley, 1995.

Rainfall

Rainfall is sampled for tritium according to written procedures in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995). The tritium activity measured in rainfall in the Livermore Valley results primarily from atmospheric emissions of tritiated water vapor (HTO) from stacks at LLNL's Tritium Facility (Building 331), and SNL/California's former Tritium Research Laboratory. The B343 rain sampling 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. HTO emissions resulted from various continuing cleanup activities at both facilities. The total measured atmospheric emission of HTO from these facilities in 1995 was 5.1 TBq, equal to 140 curies (Ci). Of this amount, LLNL released 2.3 TBq (63 Ci)(see Chapter 5).

The rain sampling station locations are shown on **Figure 7-2.** 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.

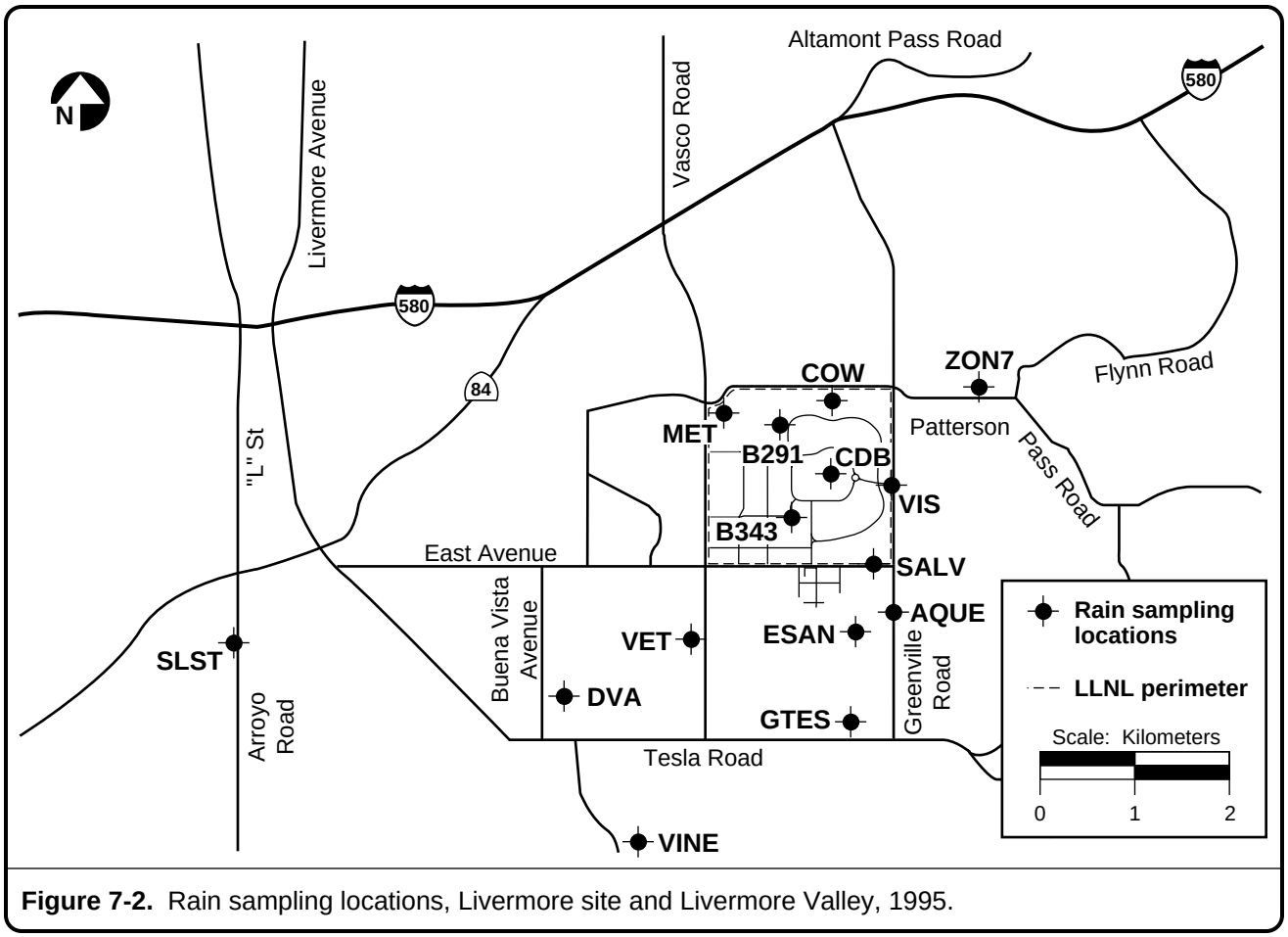

Figure 7-2. Rain sampling locations, Livermore site and Livermore Valley, 1995.

Winds measured at LLNL during rain events are predominantly from the southwest quadrant and totaled 49% of the 1995 wind field. Winds from the northwest, northeast, and southeast quadrants counted for 16, 21, and 14%, respectively, during rain events. One station, SLST, located west-southwest of LLNL, is utilized to determine upwind background levels of tritium activity in rainfall (**Figure 7-2**). Station MET is located on site at the meteorological tower. 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. A new rain sampling station southwest of LLNL (VET) was established in October 1994 to provide an off-site location that would be downwind during the 21% of the rain events in which wind is from the northeast quadrant (**Figure 7-2**). Three additional rain sampling stations in existence prior to 1993—VINE (nearly 3 km south-southwest of the southwest corner of LLNL), BVA (2 km southwest of LLNL), and GTES (about 1.8 km south of the southeast corner of LLNL)—were reinstituted in 1995. These locations were reinstitued to determine the extent of tritium activity in rainfall to the southwest of LLNL and SNL/California.

One central location is used to collect rainfall for tritium activity measurements at LLNL's Experimental Test Site (Site 300) (**Figure 7-3**). Rain samples are collected monthly from Site 300 during the rainy season. Over the past 24 years, 155 measurements of rainfall samples collected at this location give a maximum tritium activity of only 9.1 Bq/L (250 pCi/L), a median of 2.3 Bq/L (62 pCi/L), with a standard deviation of 2.1 Bq/L (57 pCi/L). The tritium activity measured in rainfall at Site 300 has been indistinguishable from atmospheric background over the past 24 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. In 1995, the San Francisco Bay Region Water Quality Control Board issued a Waste Discharge Requirements and National Pollutant Discharge Elimination System (NPDES) Permit (NPDES No. CA0030023, WDR 95-174) for the Livermore site, which replaced coverage

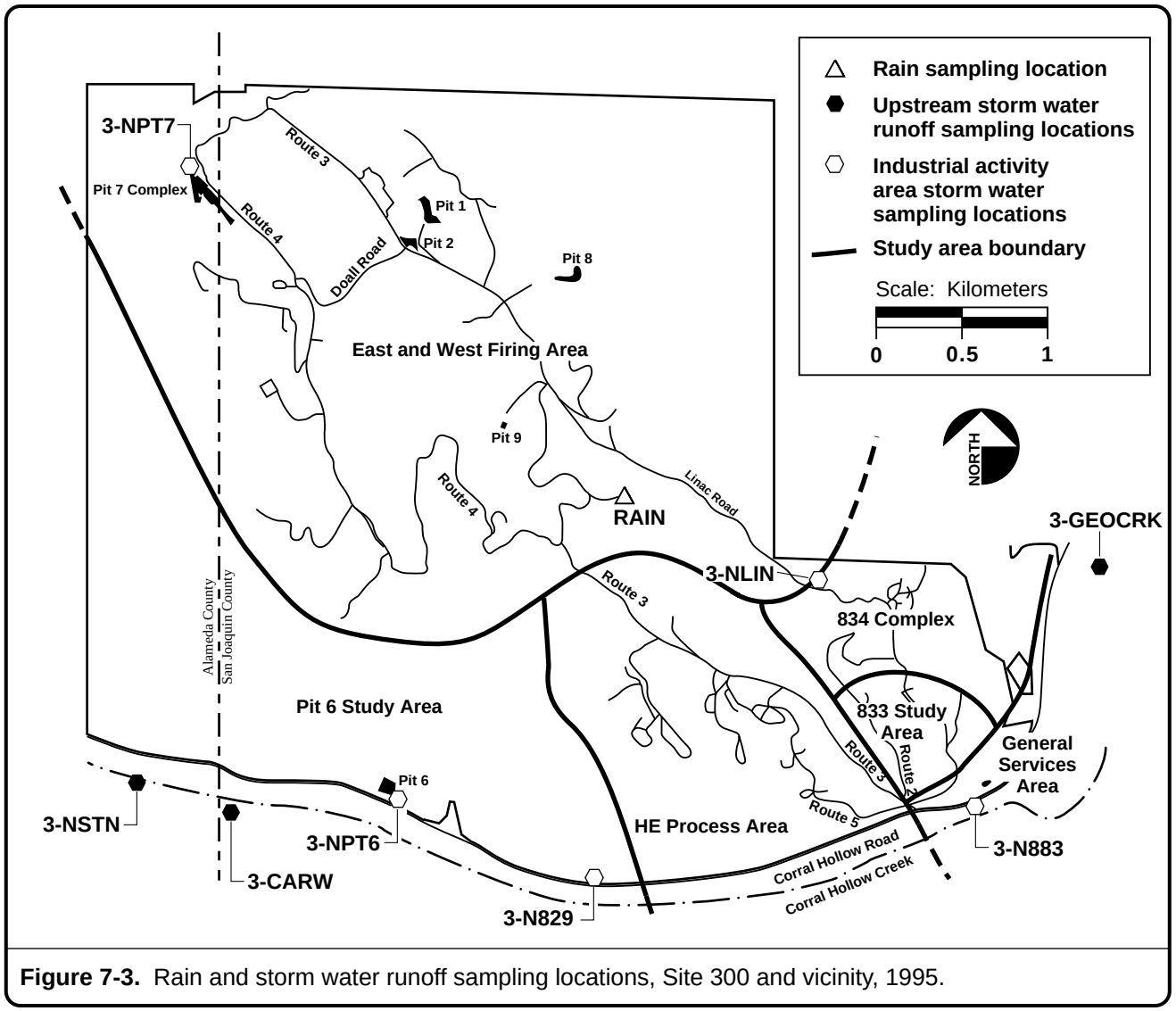

Figure 7-3. Rain and storm water runoff sampling locations, Site 300 and vicinity, 1995.

under the Statewide General NPDES Permit for Storm Water Discharges Associated with Industrial Activities (Order No. 91-13-DWQ). The new permit includes specific monitoring and reporting requirements. The current list of analyses requested for storm water samples is given in **Table 7-1**. Flow patterns at the site are such that storm water at sampling locations includes components from other sources, such as neighboring agricultural land, parking lots, and landscaped areas. Because of this, and because a wide range of activities is conducted at the Livermore site, 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 sufficient.

Table 7-1. 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	
Organochlorine pesticides – EPA Method 608	
Chlorinated pesticides – EPA Method 615	
Volatile organics – EPA Method 624	
Semivolatile organics – EPA Method 625	
Fish bioassay (fathead minnow)	

About one-fourth of the storm water runoff generated within the Livermore site drains into the Drainage Retention Basin, or DRB (**Figure 7-4**), a lined depression turned into a man-made lake through the collection of runoff. The DRB discharges to a culvert that leads to Arroyo Las Positas. 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 1995, the Livermore site storm water sampling network consisted of nine locations (**Figure 7-4**). Six locations characterize storm water either entering (influent: ALPE, ALPO, GRNE, and ASS2) or exiting (effluent: WPDC and ASW) the Livermore site. Locations CDB and CDB2 characterize runoff from the southeastern quadrant of the Livermore site entering the DRB, and location CDBX characterizes water leaving the DRB.

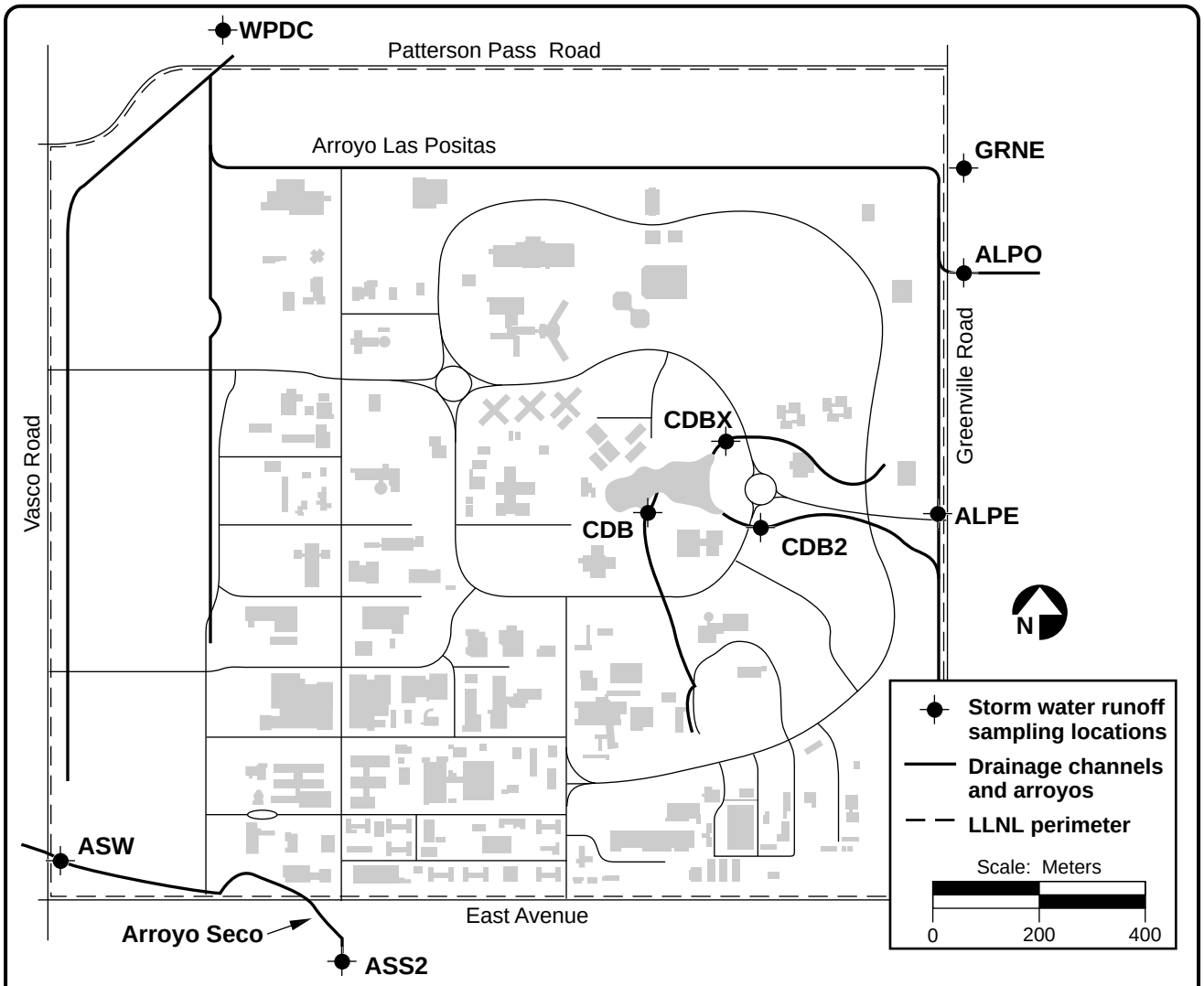

Figure 7-4. Storm water runoff sampling locations, Livermore site and vicinity, 1995.

The Site 300 storm water sampling network began in 1994 with six locations and expanded to nine locations in 1995 (**Figure 7-3**). Location CARW was added to further characterize background conditions in Corral Hollow Creek, along with existing location NSTN. Location GEOCRK was formerly reported in Chapter 8 (Routine Ground Water Monitoring at Site 300) because there is a spring upgradient of the location, which contributes water representative of ground water. GEOCRK was transferred to storm water monitoring in order to utilize the location to characterize runoff in Corral Hollow Creek downgradient of Site 300. The remaining five locations were selected to characterize ways in which storm water runoff could potentially be affected by specific Site 300 activities.

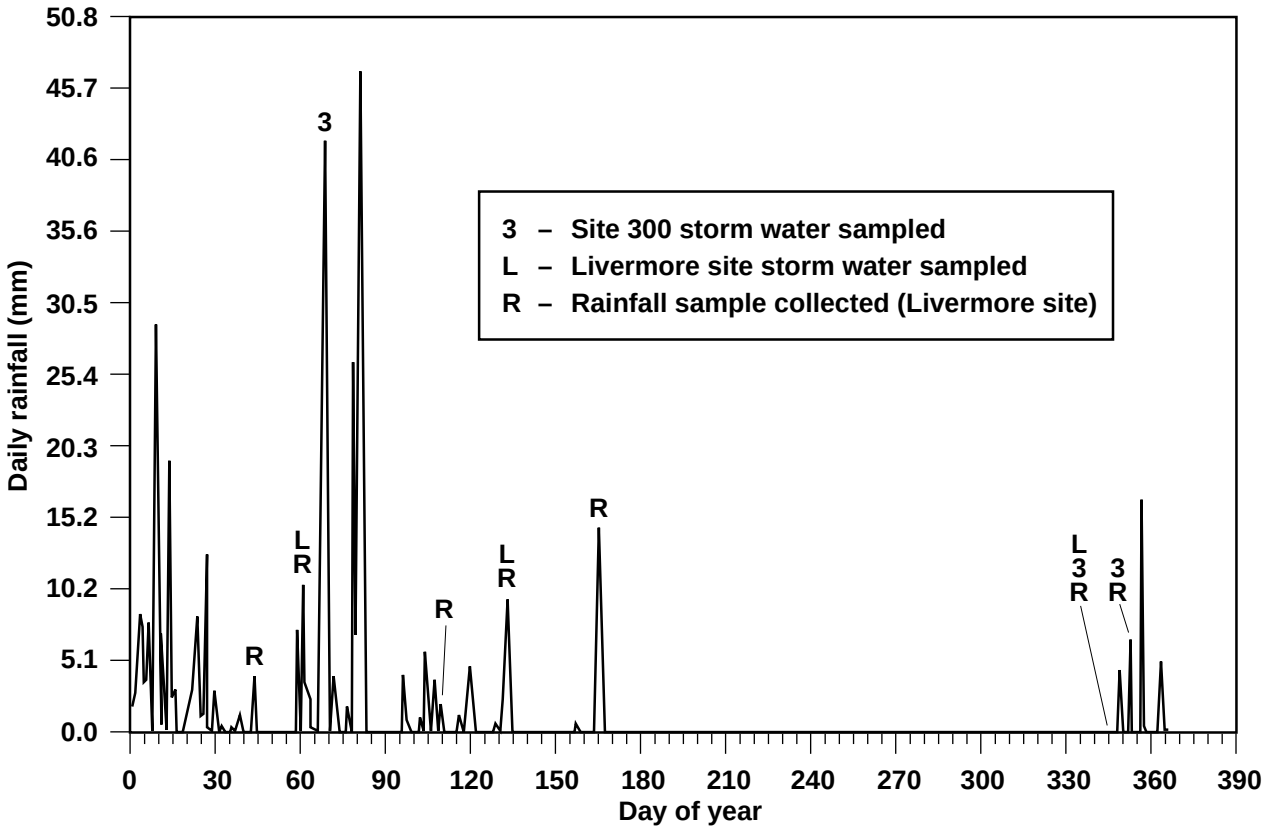

Figure 7-5. 1995 rainfall and sampling events. (Rainfall data were not available for the December 11 storm event.)

Storm water was sampled on five dates during 1995. **Figure 7-5** shows sampling dates overlaid on a plot of daily rainfall. LLNL obtained samples from all six Livermore site locations on March 2, May 13, and December 11. Samples were collected from some Site 300 locations on March 9, December 11, and December 18. 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 surface water, drinking water, and storm water at the Livermore site, Livermore Valley, and Site 300 and vicinity.

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 are generally less than 10% of the drinking water maximum contaminant levels (MCLs): 0.56 Bq/L (15 pCi/L) for gross alpha and 1.85 Bq/L (50 pCi/L) for gross beta. However, the maximum activity detected for gross alpha (0.38 Bq/L; 10.3 pCi/L) at location ORCH was slightly more than 50% of the MCL (see **Table 7-2**). Detailed data are in Volume 2, Table 7-1). Historically, gross alpha and gross beta radiation has fluctuated about the laboratory detection limits with no trends apparent. At these very low levels, the error measurements are nearly equal to the measured values so that no trends are apparent in the data. **Figure 7-6** shows gross beta radiation in surface and drinking water since 1988.

Storm water gross alpha and gross beta samples are listed in **Table 7-3**. Because there were only three storm events sampled at each site in 1995, the entire data set is presented. Storm water gross alpha and gross beta were below MCLs, except for samples collected December 11 at influent locations ALPO and GRNE. Because ALPO and GRNE are influent locations, the gross alpha and gross beta sources for these Livermore site locations were upstream and off the site (see **Figure 7-4**). The origin of this off-site source for alpha and beta radiation is unknown.

In order to investigate possible sources for the December 11 ALPO and GRNE gross alpha and gross beta, 1995 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 7-7** 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 is slightly higher than the Livermore Valley median in November, it is within the variation expected at such low levels. **Figure 7-8** is the same plot for air particulate gross beta. The ZON7 and PATT locations exhibit the same pattern as the Livermore Valley median, with no large deviations, and are slightly less than the Livermore Valley median for September through December. Investigation of these locations indicated that there is no pattern in the 1995 air particulate gross alpha and gross beta sampling that would tie the ALPO and GRNE results 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 (**Table 7-3**) typical for that location and less than one-third of the MCL.

Table 7-2. Radioactivity in surface water runoff (Bq/L) at Livermore site, 1995.[a]

	No. of samples	Tritium	Gross alpha	Gross beta
Surface waters only[b]	24			
Median		1.22	0.03	0.15
Minimum		0.13	–0.09	0.04
Maximum		2.19	0.25	0.85
Interquartile range		1.22	0.08	0.16
With POOL[c]	54			
Median		0.77	0.03	0.14
Minimum		0.13	–0.09	0.02
Maximum		8.92	0.38	0.85
Interquartile range		1.36	0.08	0.15
Without POOL[d]	44			
Median		0.61	0.04	0.11
Minimum		0.13	–0.09	0.02
Maximum		2.19	0.38	0.85
Interquartile range		0.82	0.07	0.08
POOL only[e]	10			
Median		5.88	0.01	0.19
Minimum		2.33	–0.06	0.14
Maximum		8.92	0.35	0.31
Interquartile range		2.29	0.07	0.10
Offsite drinking waters only[f]	16			
Median		0.56	0.03	0.11
Minimum		0.34	–0.03	0.04
Maximum		0.88	0.38	0.66
Interquartile range		0.19	0.08	0.16
Onsite TAP only[g]	4			
Median		0.45	0.06	0.031
Minimum		0.38	0.02	0.015
Maximum		0.82	0.08	0.12
Interquartile range		0.16	—[h]	—[h]

a MCL = 740 for tritium, 0.56 for gross alpha, and 1.85 for gross beta.

b Locations: DEL, ZON7, DUCK, ALAG, SHAD, and CAL.

c All locations.

d All locations except POOL.

e Location: POOL only.

f Location: BELL. GAS, PALM, and ORCH.

g Location: TAP only.

h Insufficient data to calculate.

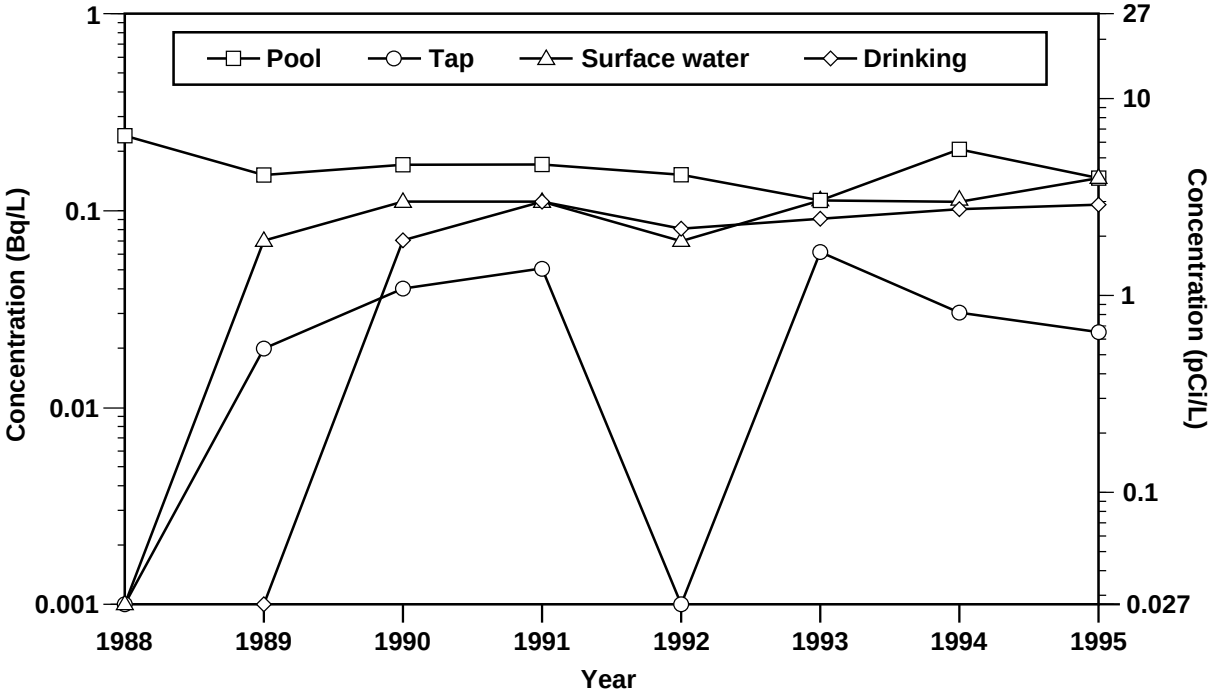

Figure 7-6. Annual median gross beta in surface and drinking water, 1988 to 1995.

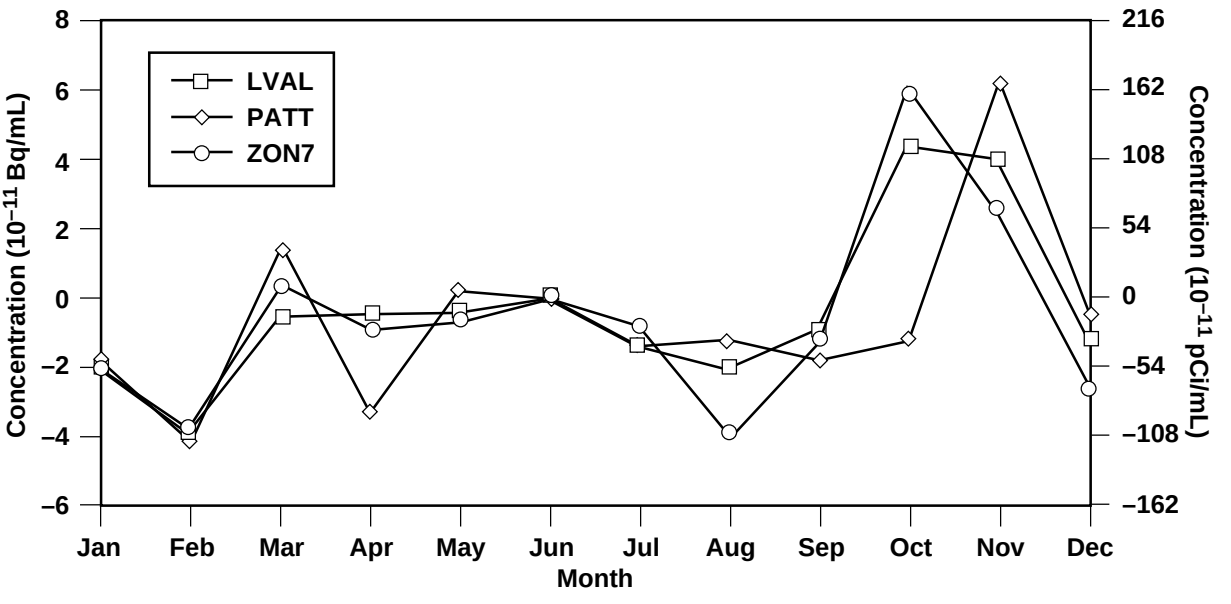

Figure 7-7. Monthly median gross alpha in particulate air samples for 1995, comparing ZON7 and PATT location with Livermore Valley medians (LVAL is the median of all Livermore Valley locations).

Table 7-3. Radioactivity in storm water runoff (Bq/L) at Livermore site, 1995.

Location	Date	Tritium	Gross alpha	Gross beta
ALPE	Mar 2	51.10 ± 3.06	0.10 ± 0.02	0.29 ± 0.01
	May 13	2.42 ± 1.83	0.11 ± 0.07	0.207 ± 0.06
	Dec 11	6.14 ± 2.48	0.11 ± 0.08	0.35 ± 0.07
ALPO	Dec 11	5.77 ± 2.46	0.96 ± 0.47	0.74 ± 0.26
	Dec 11	—[a]	0.65 ± 0.34	1.13 ± 0.30
ASS2	Mar 3	4.74 ± 1.77	0.09 ± 0.01	0.24 ± 0.01
	May 13	<1.77	0.10 ± 0.05	0.23 ± 0.06
	Dec 11	6.59 ± 2.49	0.08 ± 0.06	0.25 ± 0.06
ASW	Mar 2	38.10 ± 2.78	0.14 ± 0.01	0.23 ± 0.01
	May 13	<1.70	0.04 ± 0.03	0.10 ± 0.05
	Dec 11	9.92 ± 2.60	0.11 ± 0.09	0.43 ± 0.08
CDB	Mar 2	18.30 ± 2.27	0.12 ± 0.01	0.23 ± 0.01
	May 13	<1.77	0.03 ± 0.03	0.10 ± 0.05
	Dec 11	3.65 ± 2.39	0.06 ± 0.04	0.11 ± 0.05
CDB2	Mar 3	28.80 ± 2.48	0.08 ± 0.01	0.19 ± 0.01
	May 13	12.50 ± 2.18	0.07 ± 0.05	0.19 ± 0.06
	Dec 11	9.32 ± 2.58	0.09 ± 0.07	0.30 ± 0.07
GRNE	Mar 2	14.20 ± 2.15	0.12 ± 0.01	0.22 ± 0.01
	May 13	<1.82	0.15 ± 0.08	0.27 ± 0.07
	Dec 11	3.06 ± 2.38	2.41 ± 1.07	1.89 ± 0.70
	Dec 11	—[a]	2.44 ± 1.00	2.26 ± 0.74
WPDC	Mar 2	16.90 ± 2.14	0.10 ± 0.01	0.18 ± 0.01
	May 13	3.30 ± 1.86	0.11 ± 0.06	0.26 ± 0.06
	Dec 11	3.61 ± 2.39	0.17 ± 0.11	0.37 ± 0.09

MCL = 740 for tritium, 0.56 for gross alpha, and 1.85 for gross beta.

a Sample reanalyzed for gross alpha and bata only.

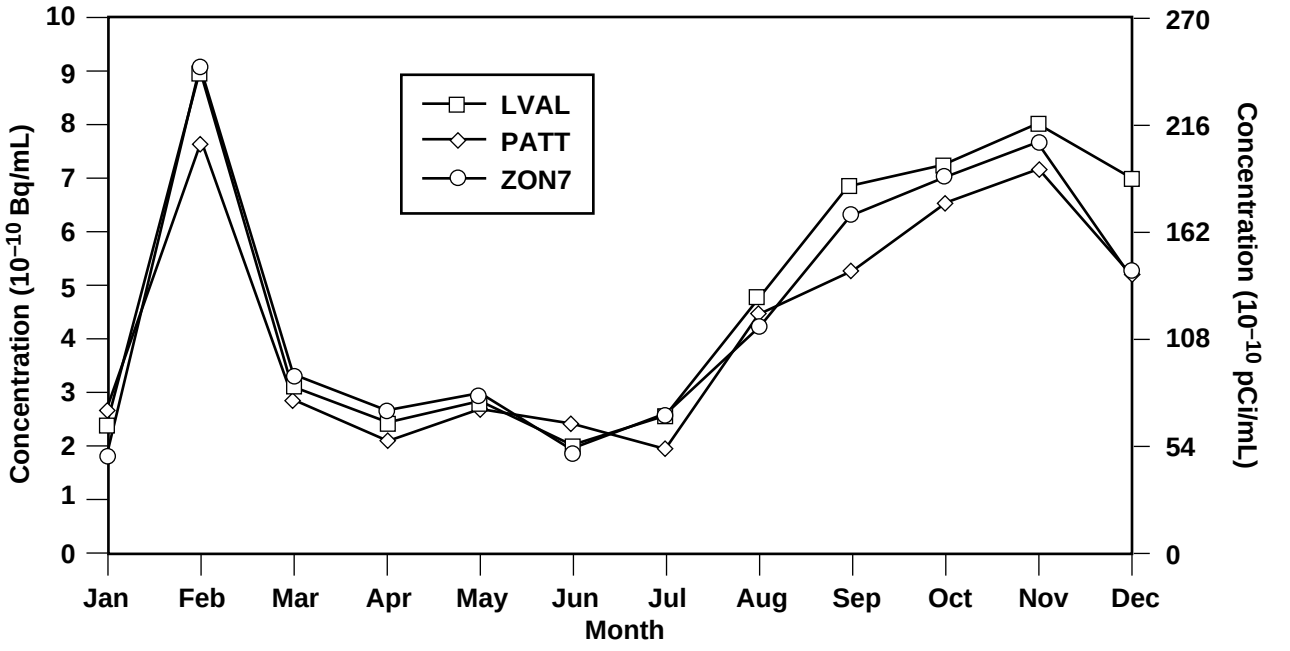

Figure 7-8. Monthly median gross beta in particulate air samples for 1995, comparing ZON7 and PATT locations with Livermore Valley medians (LVAL is the median of all Livermore Valley locations).

The two samples (ALPO and GRNE) for which gross alpha and gross beta were above the MCL were reanalyzed, which confirmed the original results (see **Table 7-3**). In addition, the samples were analyzed for uranium isotopes. Naturally occurring uranium was present in the samples, but not in sufficient quantities to fully account for the gross alpha and gross beta results. These samples were all high in sediments, so it was suspected that the gross alpha and gross beta could be attributed to the sediments, not the liquid portion of the storm water runoff. To investigate this, 1996 samples and selected Site 300 1995 samples were filtered, and the liquid and solid phases analyzed separately. Because of sample volume limitations, this was not done with the 1995 Livermore site samples. Data from 1996 samples confirmed that the greater than typical sediment load caused the high gross alpha and gross beta results. Also, all historical gross alpha and gross beta data were plotted against total suspended solids (TSS) in **Figure 7-9.** This figure shows a clear relationship between gross alpha and gross beta and TSS. Thus, these samples do not indicate that some new source has contributed to increased environmental gross alpha and gross beta radiation, but rather, only that more sediments are being transported in these storm events at these locations. Furthermore, the gross alpha and gross beta in the solid phase is at expected levels. In addition (see **Table 7-4**), the sediment portions of the samples were analyzed for thorium, plutonium, and uranium isotopes (alpha emitters) and potassium isotopes (beta

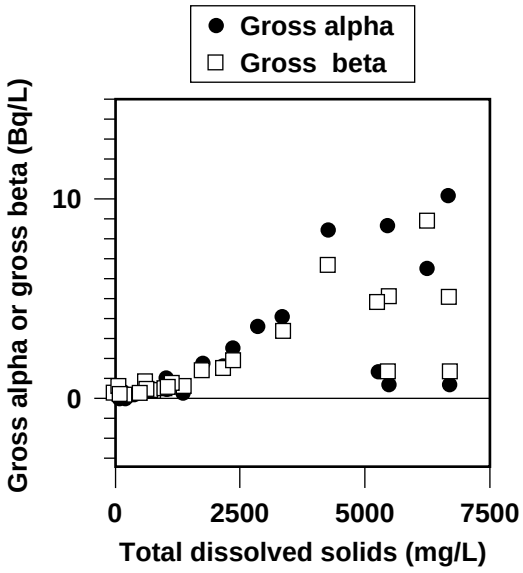

Figure 7-9. Relationship of storm water gross alpha and gross beta to total suspended solids.

Table 7-4. Analysis of sediments from ALPO and GRNE samples for radionuclides (Bq/L).

	Samples	
	ALPO	**GRNE**
Total uranium	0.08 ± 0.01	0.10 ± 0.01
Total plutonium	$5.1 \times 10^{-4} \pm 3.2 \times 10^{-3}$	$4.9 \times 10^{-4} \pm 1.7 \times 10^{-3}$
Total thorium	0.1 ± 0.05	0.744 ± 0.0679
Potassium-40	0.165 ± 0.008	0.90 ± 0.045

emitters). Since other analyses have indicated that the majority of the gross alpha and gross beta activity is contributed by the solid phase of the samples, only the solid phase was analyzed. Plutonium levels were extremely low, less than 5×10^{-4} Bq/L (0.014 pCi/L). Thorium and uranium were present at higher levels, yet not high enough to account for all of the gross alpha and gross beta. However, uranium or thorium decay produces a chain of daughter products that also produce alpha and beta radiation. These daughter products are not observed in the isotopic analyses, but can be calculated from the known uranium and thorium concentrations. When this calculation is performed, approximately 70% of the gross alpha and gross beta radiation is accounted for. Thus, within

the accuracy of the analytical methods, the apparent high levels of gross alpha and gross beta radiation observed in these storm water samples can be attributed to high sediment loads (due to erosion typical to the region) and naturally occurring levels of potassium, thorium, and uranium, along with their daughter products, carried in that sediment. There is no indication of an anthropogenic source of the gross alpha and gross beta levels.

Figures 7-10 and **7-11** 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 1994/1995 represent October 1994 through May 1995, and data labeled 1995 represent October through December 1995. The 1995 points represent a partial wet season, pending collection of 1996 data, and are based on only one sampling event for each location. Finally, plots include all available storm water influent and effluent data for each constituent. The gross alpha and gross beta data show no discernible pattern; the high gross alpha influent value for 1995 is due to the December ALPO and GRNE results discussed above.

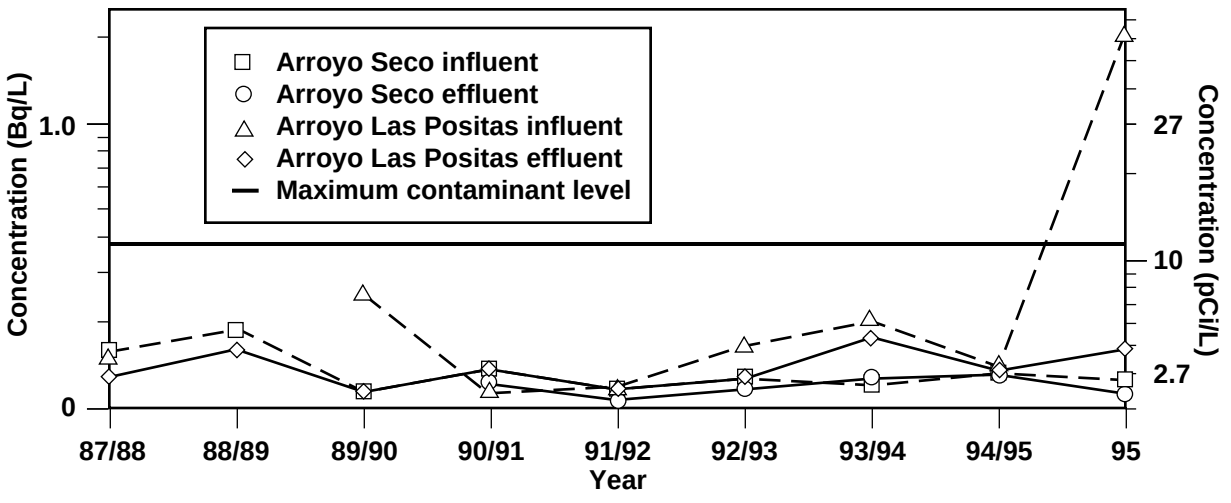

Figure 7-10. Annual median gross alpha in LLNL storm water.

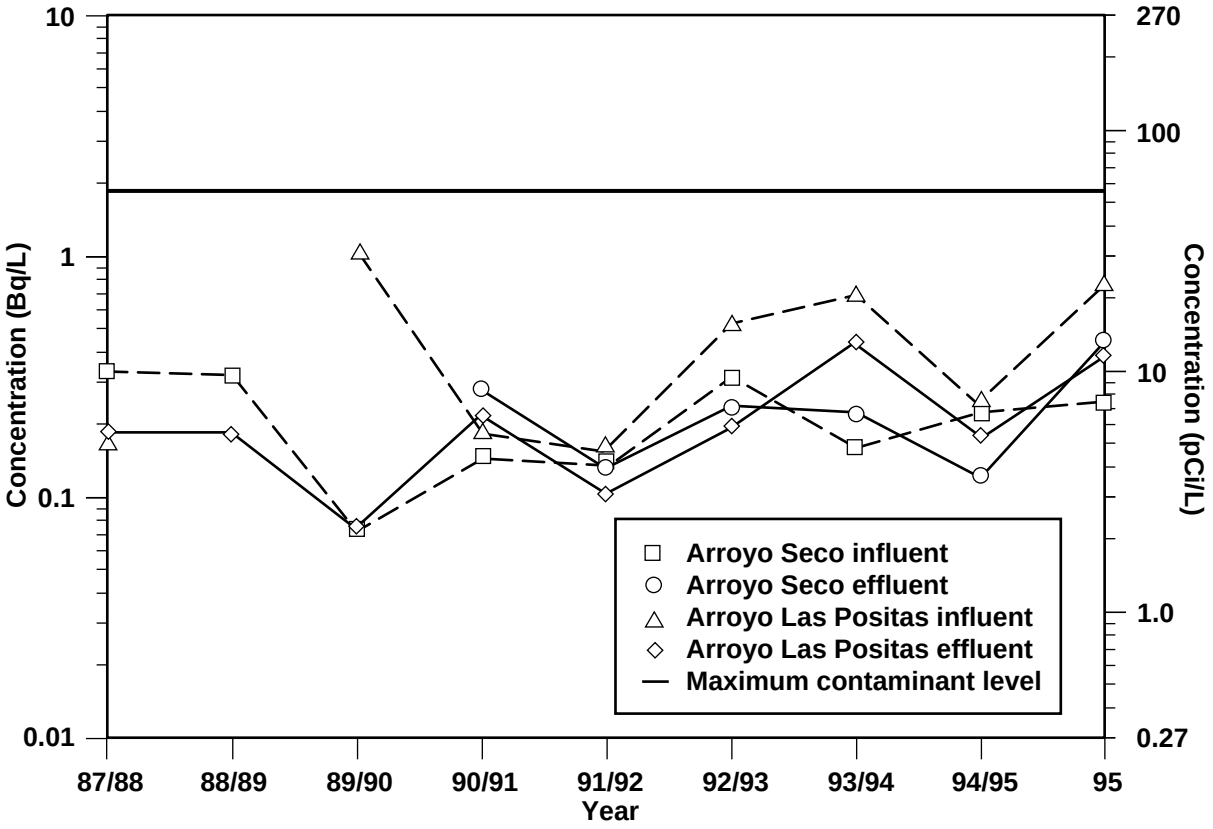

Figure 7-11. Annual median gross beta in LLNL storm water.

Tritium

Median tritium activity was 0.61 Bq/L (16.6 pCi/L) and the maximum tritium activity was 2.19 Bq/L (59.2 pCi/L) at surface and drinking water locations in the Livermore Valley, less than 0.3% of the drinking water MCL (**Table 7-2**). Water in the LLNL swimming pool had the highest median value (**Figure 7-12**) and individual measurement. The median activity for tritium at POOL for 1995 was 5.88 Bq/L (159 pCi/L), compared to 4.51 Bq/L (122 pCi/L) in 1994, with both values less than 1% of the drinking water MCL. The highest single observation for POOL was 8.92 Bq/L (241 pCi/L), which is slightly higher than 5.96 Bq/L (161 pCi/L) maximum detected in 1994.

Tritium activities in the POOL have decreased from 1988 (the beginning of tritium monitoring) to 1994, with a very slight increase in 1995 (**Figure 7-12**). The overall decrease in tritium activities has been most marked since 1991, the last year in which there were significant tritium emissions from Building 331, the

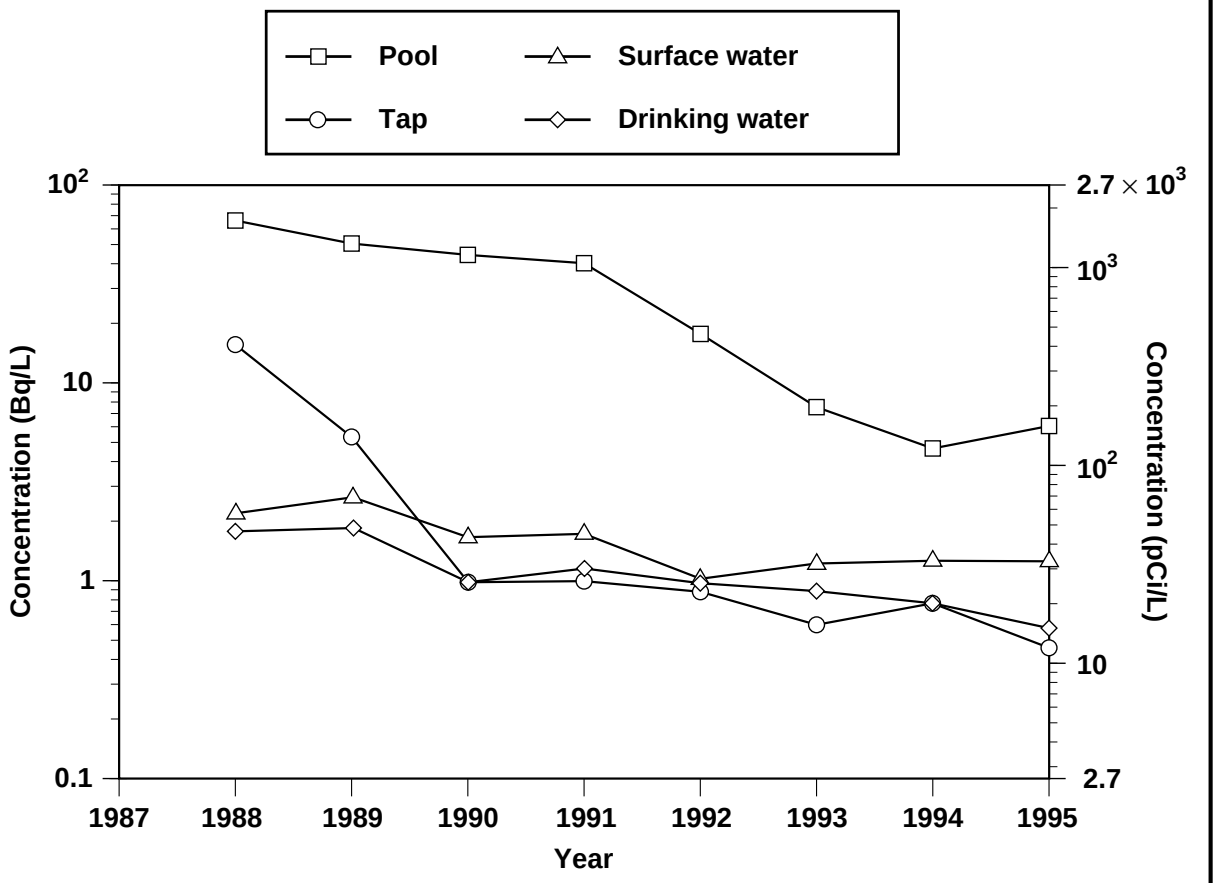

Figure 7-12. Annual median tritium in surface and drinking water, 1988 to 1995.

Tritium Facility, located near the POOL. Median tritium activities in the on-site drinking water have also decreased with time since 1988. Tritium in the off-site surface waters and drinking waters has decreased very gradually (**Figure 7-12**).

Tritium activities measured in rainfall at the LLNL site and vicinity are shown in **Table 7-5** The Livermore site rainfall has exhibited elevated tritium activities in the past (Gallegos et al., 1994). During 1995, however, measurements of tritium activity in rainfall were all far below the 740 Bq/L (20,000 pCi/L) Maximum Contaminant Level (MCL) established by the federal EPA for drinking water. Rainfall samples were collected on February 15, March 2, April 19, May 13, June 16, December 11, and December 12, 1995 (see **Figure 7-5**). The highest overall activity was 72.89 Bq/L (1970 pCi/L) measured on April 19 near Building 343, just to the north of the on-site Tritium facility. This value is approximately 10% of the MCL for tritium. The highest off-site activity measured was 55.87 Bq/L

Table 7-5. Tritium activities in rainfall (in Bq/L) for the Livermore site and Livermore Valley.[a]

Location	Median	Minimum	Maximum	Interquartile range	Number
On-site					
B343	22.42	4.92	72.89	26.29	7
B291	10.54	2.19	19.35	10.91	7
CDB	9.84	2.17	24.46	10.34	7
VIS	5.22	2.29	12.91	6.50	7
COW	4.85	1.82	9.36	5.75	7
SALV	3.70	1.75	31.45	9.82	7
MET	2.29	1.97	7.96	0.87	6
On-site summary:	6.84	1.75	72.89	10.78	48
Off-site					
ESAN	4.81	1.79	55.87	29.00	7
ZON7	2.20	1.75	8.44	3.08	7
AQUE	2.10	1.72	28.34	11.41	7
SLST	2.08	1.68	2.80	0.27	7
GTES	1.77	1.64	2.78	0.26	5
VINE	1.92	1.67	9.55	3.24	7
BVA	1.89	1.64	17.06	0.32	7
VET	1.83	1.61	20.68	4.07	6
Off-site summary:	2.05	1.61	55.87	3.03	53
Overall summary	2.78	1.61	72.89	7.07	101

[a] MCL = 740 Bq/L.

(1510 pCi/L). This activity was recorded in a sample collected from station ESAN on March 2, 1995. This station is 0.3 km east of the former Tritium Research Laboratory at SNL/California and 1.1 km southeast of LLNL's Building 331.

As expected, the stations in the prevailing downwind directions and closest to the sources showed the highest median tritium activities in rain. These were stations B343 (**Table 7-5**) and CDB for the LLNL Building 331 sources and stations ESAN, and AQUE for the source at SNL/California. The most distant downwind station, ZON7, had a higher median tritium activity than the median for AQUE, which is within 1 km of the SNL/California tritium source. The lowest median tritium activities for 1995 were located at off-site stations: VET established in October 1994 and new station BVA generally upwind of both tritium facilities. Another new station, VINE, also showed low tritium activities.

Tritium activity in rainfall at the Livermore site has trended downward during the past 6 years. This decrease mirrors the downward trend in total HTO emissions from LLNL's Tritium Facility and SNL/California's former Tritium Research Laboratory. These trends are shown in **Figure 7-13**. Values for the median rain tritium activity shown in **Figure 7-13** are derived from the six on-site rain sampling locations (B343, B291, CDB, SALV, VIS, and COW) that historically have given the highest activities. A nearly seven-fold decrease in total HTO emissions has occurred since 1991, from 34.9 TBq (943 Ci) down to 5.1 TBq (137 Ci; 1 TBq = 10 Bq). This decrease is mirrored by a nearly tenfold decrease in median tritium activity measured in rainfall on site at LLNL (65.9 Bq/L down to 8.5 Bq/L, or 1780 pCi/L down to 230 pCi/L).

As with tritium levels in rainfall, tritium levels in storm water runoff were low; the overall median was 6.0 Bq/L (172 pCi/L), or less than 1% of the drinking water MCL (**Table 7-3**). The highest tritium activity measured in storm water runoff during 1995 was 51.1 Bq/L (1380 pCi/L) at location ALPE, less than 7% of the drinking water MCL. The historical trend (**Figure 7-14**) indicates generally decreasing tritium levels in storm water from the 1988/89 to 1991/92 season, after which the curve is relatively flat.

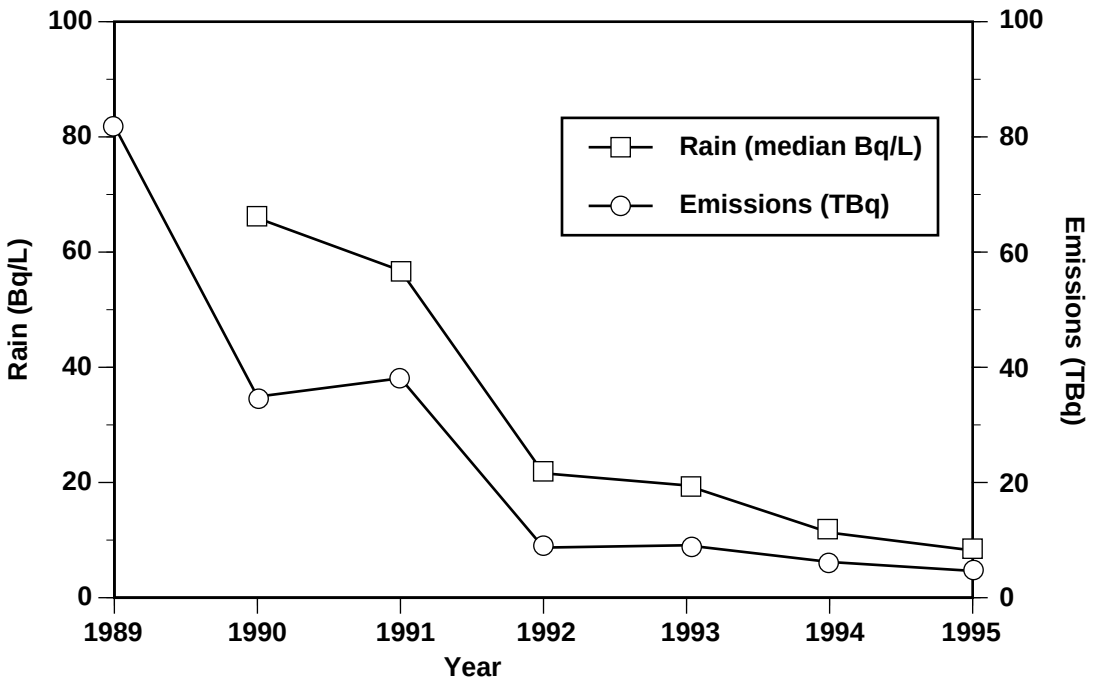

Figure 7-13. Trends of median tritium activity in rain and total stack emissions of HTO by LLNL and SNL/California, 1989 to 1995.

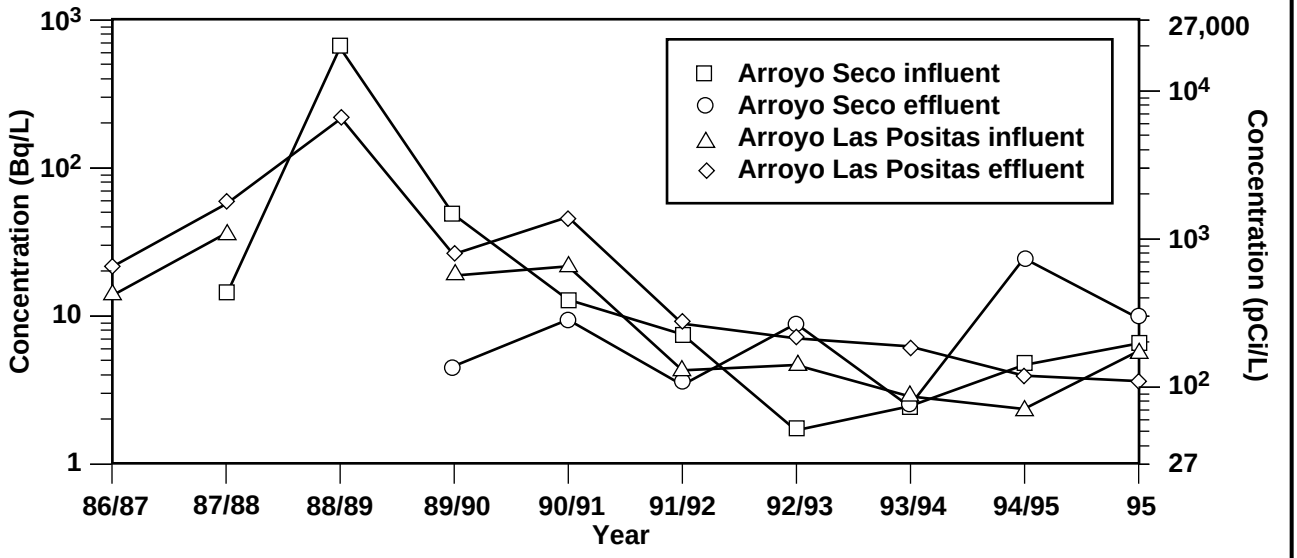

Figure 7-14. Annual median tritium concentrations in LLNL storm water.

Livermore Site and Livermore Valley, Nonradioactive Pollutants in Storm Water

There are currently no numeric criteria that place limits on storm water effluent. The EPA established in the multisector permit benchmark values for 41 parameters, but stressed that these concentrations are not intended to be interpreted as effluent limitations. Rather, they are levels that the EPA has used to determine if storm water discharge from any given facility merits further monitoring. Other water quality criteria were also compared to LLNL storm water analysis results. However, these criteria were defined for other purposes, and therefore not directly applicable to storm water effluent. Nevertheless, use of a broad range of criteria can help ensure high quality in LLNL storm water effluent. Storm water sample results for the Livermore site were compared with criteria listed in *The Water Quality Control Plan, San Francisco Bay Basin Region* (San Francisco Bay RWQCB 1995) and results for Site 300 were compared to criteria listed in *The Water Quality Control Plan* (*Basin Plan)* for the California Regional Water Quality Control Board Central Valley Region (Longley et al. 1994), both newly approved in 1995. Criteria in the Basin Plans include surface water quality objectives for the protection of aquatic life and water quality objectives for waters designated for use as domestic or municipal supply or agricultural supply. These criteria include, by reference, California Maximum Contaminant Levels (MCLs) for drinking water. In addition, results were compared to EPA MCLs and Ambient Water Quality Criteria (AWQC), as well as California AWQC. Finally, comparison was made with criteria listed in the State-level California Inland Surface Waters Plan and California Enclosed Bays

and Estuaries Plan, althoughthese plans were invalidated by a court decision. Criteria not specifically listed in the Basin Plans were obtained from *A Compilation of Water Quality Goals* (Marshack 1995).

This year, as required by LLNL's new NPDES permit (WDR 95-174, NPDES No. CA0030023), an annual fish bioassay was initiated. There are two tests involved in the fish bioassay. In the acute test, 96-hour survival of Fathead Minnow (*Pimephales promelas*) in undiluted storm water collected from location WPDC is observed. The Regional Board has set a criteria of 20% survival compared to the control as an acceptable level. The testing laboratory provides water to use in the control sample. In addition, in agreement with Regional Board guidance, upgradient water from influent locations ALPO, ALPE, and GRNE is used as controls. If fewer than 20% of the fish survive in the WPDC effluent storm water than survive in the control in two consecutive tests, LLNL is required to perform a toxicity reduction evaluation in order to identify the source of the toxicity. In the chronic test, storm water dilutions of 0 (no effluent storm water), 1, 3, 10, 30, and 100% (undiluted storm water) are used to determine a dose-response relationship, if any. No criteria have been set for this test; this test is being performed for information purposes only. In this year's acute toxicity test, 90% survival was observed. In the chronic test, survival rates were 90, 98, 100, 55, 93, and 85% for the dilutions of 0, 1, 3, 10, 30, and 100%, respectively. Because the low survival at the 10% dilution did not continue at the higher concentrations, no dose-response could be developed. The testing laboratory did not provide an explanation for the anomalous result at the 10% level.

Table 7-6 lists nonradioactive constituents found above comparison criteria in Livermore site storm water. In this summary, generally only the most stringent criteria are presented. Complete storm water results are presented in Table 7-4, Volume 2, including all information in **Table 7-6** except criteria.

Chromium was detected above the California Inland Surface Waters Plan AWQC (0.016 mg/L) in a number of samples. In one case (ASW on 12/11/95), the effluent value (0.034 mg/L) was slightly higher than the influent value (ASS2, 0.028 mg/L). A plot of historical annual median chromium concentrations (**Figure 7-15**) indicates that chromium concentrations have been gradually increasing since 1992/1993 at both influent and effluent locations, but there is no indication that LLNL is contributing to this increase.

Table 7-6. Storm water nonradioactive parameters exceeding selected comparison criteria.

Constituent	Criteria value (mg/L)	Criteria source	Date	Location	Concentration (mg/L)
Barium	1.0	CA PMCL	12/11/95	GRNE	1.5
				CDB2	1.0
Cadmium	0.005	EPA PMCL	12/11/95	CDB2	0.95
	0.0159[a]	Benchmark			
Chromium	0.016[b]	Inland Plan AWQC	3/2/95-3/3/95	ALPE	0.017
	0.05	EPA PMCL		GRNE	0.016
				CDB2	0.021
				WPDC*	0.017
			5/13/95	ASS2	0.018
				GRNE	0.026
				CDB2	0.017
				WPDC*	0.025
			12/11/95	ASS2	0.028
				ASW*	0.034
				ALPE	0.044
				ALPO	0.05
				GRNE	0.2
				CDB2	1.0
				WPDC*	0.047
Copper	0.027	EPA AWQC[c]	3/2/95	CDB	0.028
	0.0636	Benchmark[a]		WPDC*	0.031
			12/11/95	ALPO	0.06
				GRNE	0.09
				CDB2	1.0
				WPDC*	0.029
Iron	0.3	EPA PMCL	3/2/95	ASS2	4.0
	1.0	Benchmark		ASW*	2.0
				ALPE	6.4
				GRNE	7.4
				CDB	6.2
				CDB2	8.3
				WPDC*	7.9
			5/13/95	ASS2	8.4
				ASW*	2.5
				ALPE	5.0
				GRNE	14.0
				CDB	2.8

...continued on next page

Table 7-6. Storm water nonradioactive parameters exceeding selected comparison criteria (continued).

Constituent	Criteria value (mg/L)	Criteria source	Date	Location	Concentration (mg/L)
Iron (continued)				CDB2	6.7
				WPDC*	12.0
			12/11/95	ASS2	8.4
				ASW*	11.0
				ALPE	14.0
				ALPO	22.0
				GRNE	120.0
				CDB	1.6
				CDB2	2.2
				WPDC*	18.0
Lead	0.015	EPA PMCL 10%[d]	12/11/95	CDB2	1.1
	0.05	Inland Plan Drinking Water			
	0.0816[a]	Benchmark			
	0.11[c]	EPA AWQC			
Manganese	0.5	EPA SMCL	12/11/95	CDB2	1.1
	1.0	Benchmark		GRNE	1.9
Nickel	0.1	EPA PMCL	12/11/95	ALPE	0.18
	1.417[a]	Benchmark		ALPO	0.35
				GRNE	0.28
				CDB2	1.0
Nitrate (as N)	10	EPA PMCL	3/2/95	ASS2	4.1
	0.68[e]	Benchmark		ASW*	2.5
				ALPE	6.7
				GRNE	31.0
				CDB	6.4
				CDB2	2.9
				WPDC*	4.0
Nitrate (as NO_3)	45	EPA PMCL	5/13/95	ASS2	3.6
	3.01[f]	Benchmark		ALPE	17.0
				GRNE	11.0
			12/11//95	ASS2	<5.0
				ASW*	<5.0
				ALPE	4.3
				ALPO	4.8
				GRNE	9.2
				CDB	4.4
				CDB2	<5.0
				WPDC*	<5.0

...continued on next page

Table 7-6. Storm water nonradioactive parameters exceeding selected comparison criteria (continued).

Constituent	Criteria value (mg/L)	Criteria source	Date	Location	Concentration (mg/L)
pH	6.5-8.5	EPA SMCL	3/2/95	CDB	6.4
	6.0-9.0	Benchmark	3/9/95	N883*	6.2
			5/13/95	CDB	6.5
			12/18/95	N829*	8.7
				NLIN	8.8
Silver	0.0082[(c)]	EPA AWQC	12/11/95	ALPO	0.011
	0.0318[(a)]	Benchmark		CDB2	0.81
Specific conductance (μmhos/cm)	900	CA SMCL	3/2/95	ALPE	910
Total alkalinity	>20	EPA AWQC	3/2/95	ASW*	10
				CDB	9.5
				CDB2	17
				WPDC*	10
			5/13/95	ASS2	19
				ASW*	12
				CDB	7.6
				CDB2	19
				WPDC*	18
			12/11/95	ASS2	11
				ASW	11
				CDB	11
				CDB2	17
Total suspended solids	100	Benchmark	3/9/95	NLIN*	6600
				NPT7*	160
				NSTN	1300
				CARW	20,000
			5/13/95	ALPE	120
				GRNE	150
				WPDC*	210
			12/11/95	ASS2	210
				ASW*	310
				ALPE	200
				ALPO	1000
				GRNE	2300
				CDB2	210
				WPDC*	400
				NPT7*	100

...concluded on next page

Table 7-6. Storm water nonradioactive parameters exceeding selected comparison criteria (concluded).

Constituent	Criteria value (mg/L)	Criteria source	Date	Location	Concentration (mg/L)
Total suspended solids (continued)			12/18/95	N829*	5200
				NLIN*	6200
				NPT6*	2800
Zinc	0.174	EPA AWQC[(c)]	3/2/95	GRNE	0.26
	0.117	Benchmark		CDB	0.16
					0.26
				CDB2	0.14
				WPDC*	0.19
			5/13/95	CDB	0.14
				WPDC*	0.14
			12/11/95	ASS2	0.13
					0.37
				ASW	0.13
				ALPO	0.12
				GRNE	0.4
				CDB	0.14
					0.18
				CDB2	1.0
				WPDC	0.21
2,4-D	0.070	EPA PMCL	3/2/95	ALPE	0.12
			5/13/95	GRNE	17,000
				ALPE	1000

[a] Hardness-dependent benchmark values are calculated using an assumed hardness of 100 mg/L.

[b] This value assumes all chromium is Cr (VI).

[c] Value is hardness-dependent; calculated based upon receiving water hardness of 164 mg/L.

[d] The MCL for lead includes this "Action Level," to be exceeded in no more than 10% of samples.

[e] Benchmark is for nitrate plus nitrite as N.

[f] In order to compare benchmark to data, benchmark for nitrate plus nitrite as N was converted to equivalent value for nitrate as NO_3.

*Effluent locations.

Abbreviations:

AWQC — Ambient Water Quality Criteria for the protection of freshwater aquatic life.

Bay Plan — California Enclosed Bays and Estuaries Plan (this Plan was invalidated by a court decision).

Benchmark — EPA storm water benchmark value.

Drinking Water — Criteria for water with designated use as drinking water.

Inland Plan — California Inland Surface Waters Plan (this Plan was invalidated by a court decision).

San Francisco Plan — Water Quality Control Plan, San Francisco Bay Basin Region.

PMCL —- Primary Maximum Contaminant Level.

SMCL — Secondary Maximum Contaminant Level.

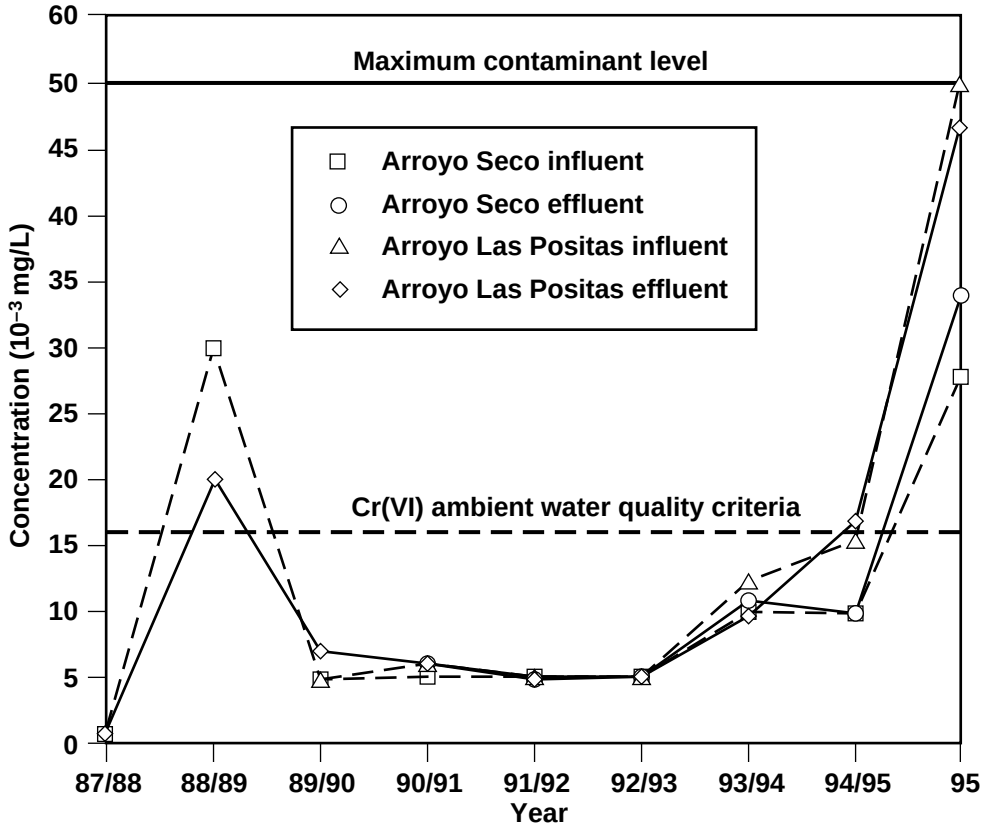

Figure 7-15. Annual median total chromium concentrations in LLNL storm water.

Copper was detected above the EPA AWQC (0.27 mg/L) in four samples, including one instance at effluent location WPDC (0.034 mg/L) in which influent locations were below the criteria. However, only two samples, influent location GRNE (0.09 mg/L) and onsite location CDB (1.0 mg/L), were above the benchmark value (0.0636). Historically, annual median copper concentrations (Figure 7-16) were reduced dramatically in the 1992/1993 season from early measurements (0.85 and 0.97 mg/L). Since then, annual median concentrations have shown little change, although there are indications that copper concentrations are increasing slightly.

Iron was detected above the MCL and benchmark values in every sample. Because past, annual median iron concentrations have virtually all been at the detection limit of 0.1 mg/L, a historical plot is not shown. All the values were obtained through a test method that was applied to iron in storm water for the first time beginning in 1995. The new test method produces higher iron concentrations for two reasons. First, with the previous test method, samples

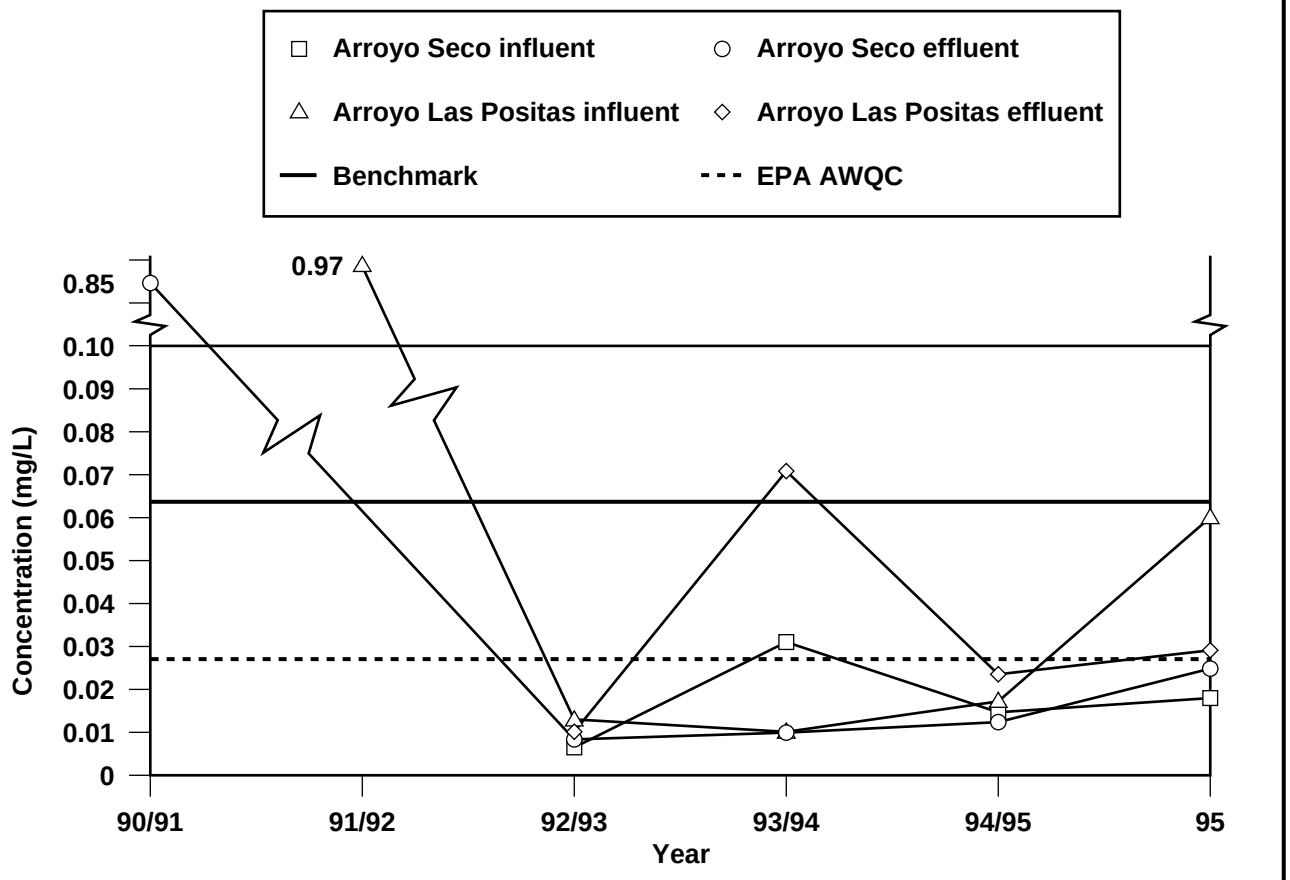

Figure 7-16. Annual median copper concentrations in LLNL storm water.

with high sediment loads were filtered. Second, the new test method incorporates a "digestion" procedure that extracts the metals from the suspended solids.

Thus, the difference between these two methods is that the previous method measured primarily dissolved metal, whereas the new method additionally measures the contribution of the sediments carried in the storm water.

At one location and on two dates pH was 6.4 and 6.5, at or below the EPA secondary MCL. Overall, annual medians at both influent and effluent locations have been within the MCL bounds (**Figure 7-17**). In the Arroyo Seco pathway, the pH has been very slightly lower at the effluent point than at the influent point, though for the 1995 data point, influent and effluent pH were the same. In the Arroyo Las Positas pathway, median pH has been from 0.7 to 1.05 lower at the effluent point than it is at the influent point. However, the difference between influent and effluent has decreased every year, indicating an improvement in LLNL storm water quality.

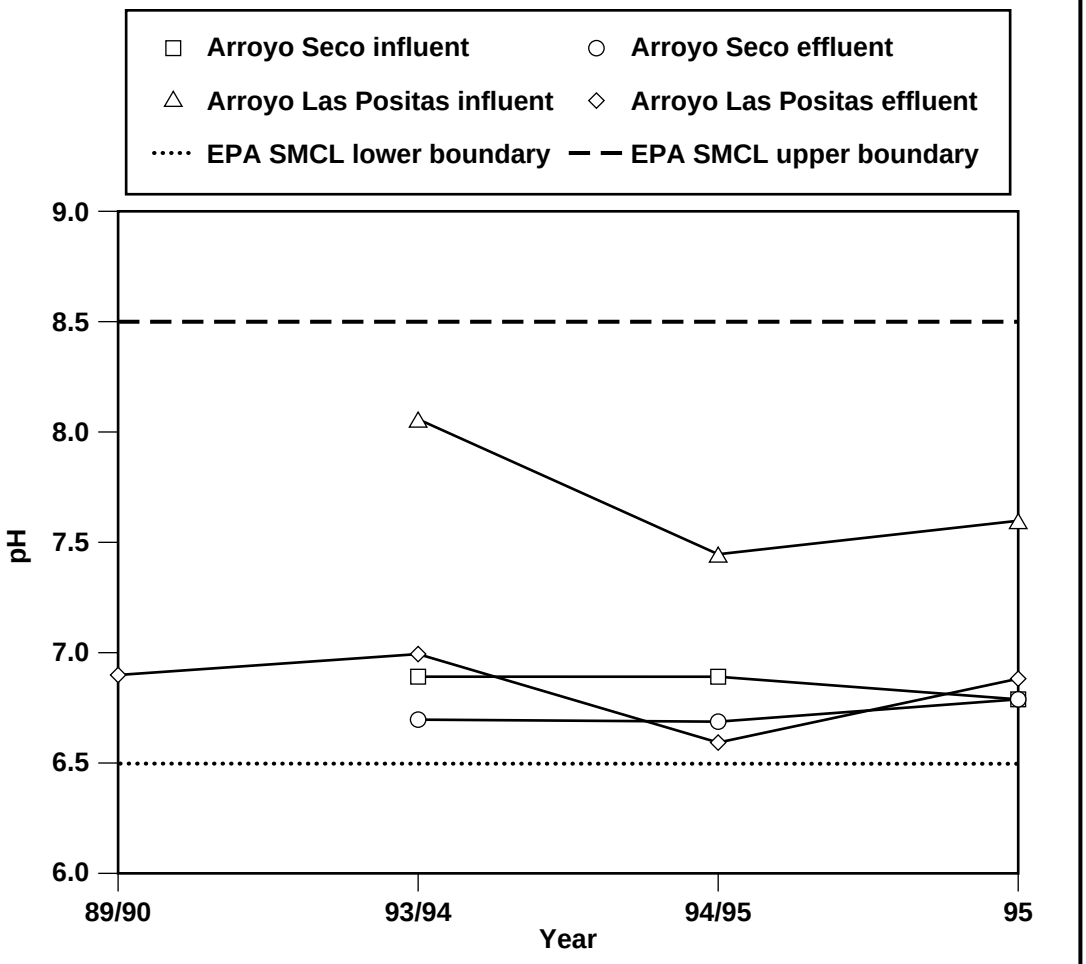

Figure 7-17. Annual median pH of LLNL storm water.

Total suspended solids (TSS) were frequently above the benchmark value (100 mg/L). No other criteria were found for TSS. However, TSS levels were primarily due to the natural, upgradient TSS. In general, annual median effluent TSS closely tracks influent TSS (**Figure 7-18**). With the exception of the 1995 Arroyo Las Positas pathway, annual median effluent TSS never differed from influent TSS by more than 100 mg/L. The high influent Arroyo Las Positas TSS can most likely be attributed to a road construction project (not conducted by LLNL) in the vicinity of the influent points.

Zinc was frequently above the AWQC (0.174 mg/L) and/or the benchmark (0.117 mg/L) values, although there was only one case (5/13/95 WPDC, at 0.14 mg/L) in which an effluent value above criteria could not be attributed to a corresponding influent value. Thus, the source of zinc seems to be primarily off site and/or naturally occurring There seems to be a gradual increase in zinc

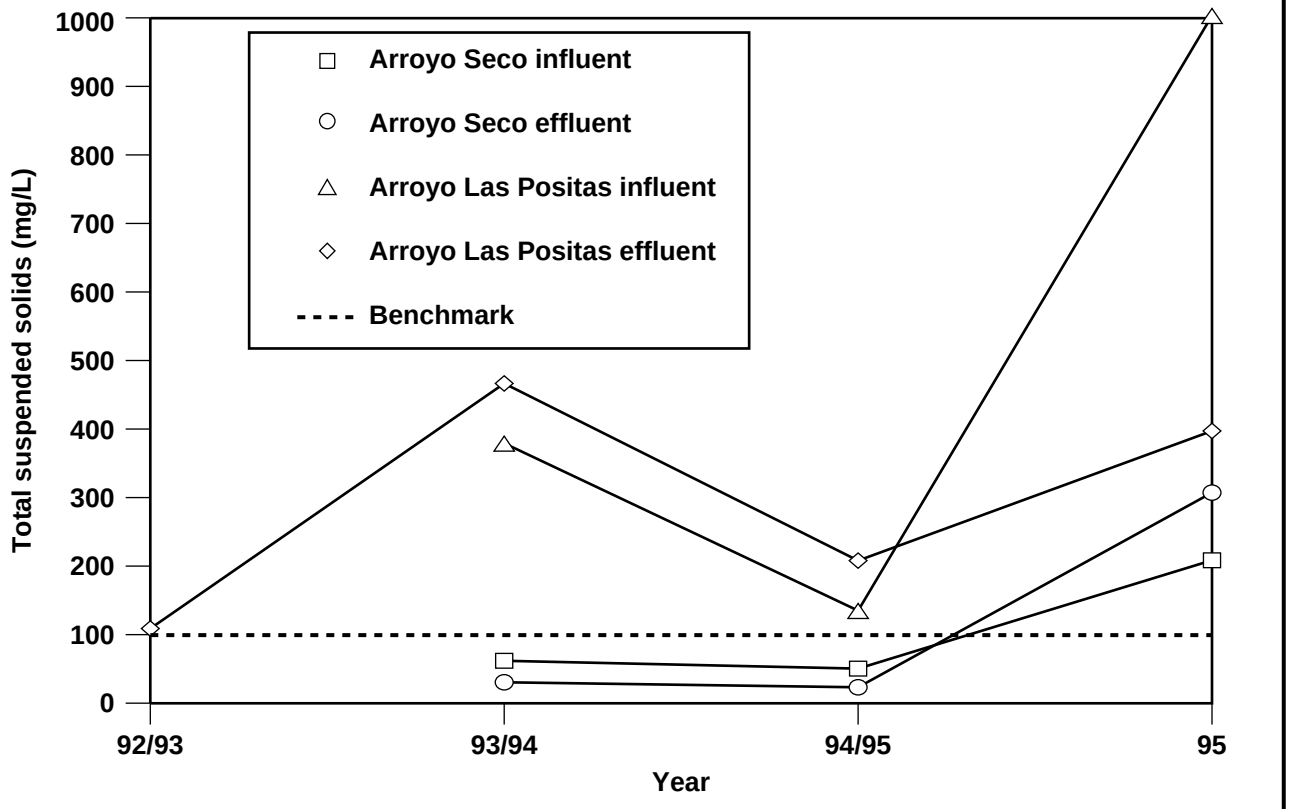

Figure 7-18. Annual median total suspended solids in LLNL storm water.

concentrations since the 1992/1993 season (**Figure 7-19)**, with Arroyo Seco effluent somewhat less than influent, and Arroyo Las Positas effluent slightly greater than influent.

Chromium, copper, and zinc are common constituents in urban runoff (**Table 7-7**); in one study (Salomons et al. 1995), zinc and copper were the most frequently detected constituents in urban runoff. All three elements have been linked with automobile metal corrosion and emissions; copper and zinc concentrations have been correlated with traffic volume, and one study showed a zinc concentration of 0.37 mg/L in highway runoff. In addition, zinc is released from automobile tires (Salomons et al. 1995.). Thus, it is likely that these types of nonindustrial sources are contributing metals to storm water runoff.

Whereas most criteria are a maximum level, the AWQC for total alkalinity as $CaCO_3$ (20 mg/L) is a minimum. Storm water samples frequently had alkalinities below this level. In addition, for two of the three sampling events, alkalinity was lower at the Arroyo Las Positas effluent point than at any of the

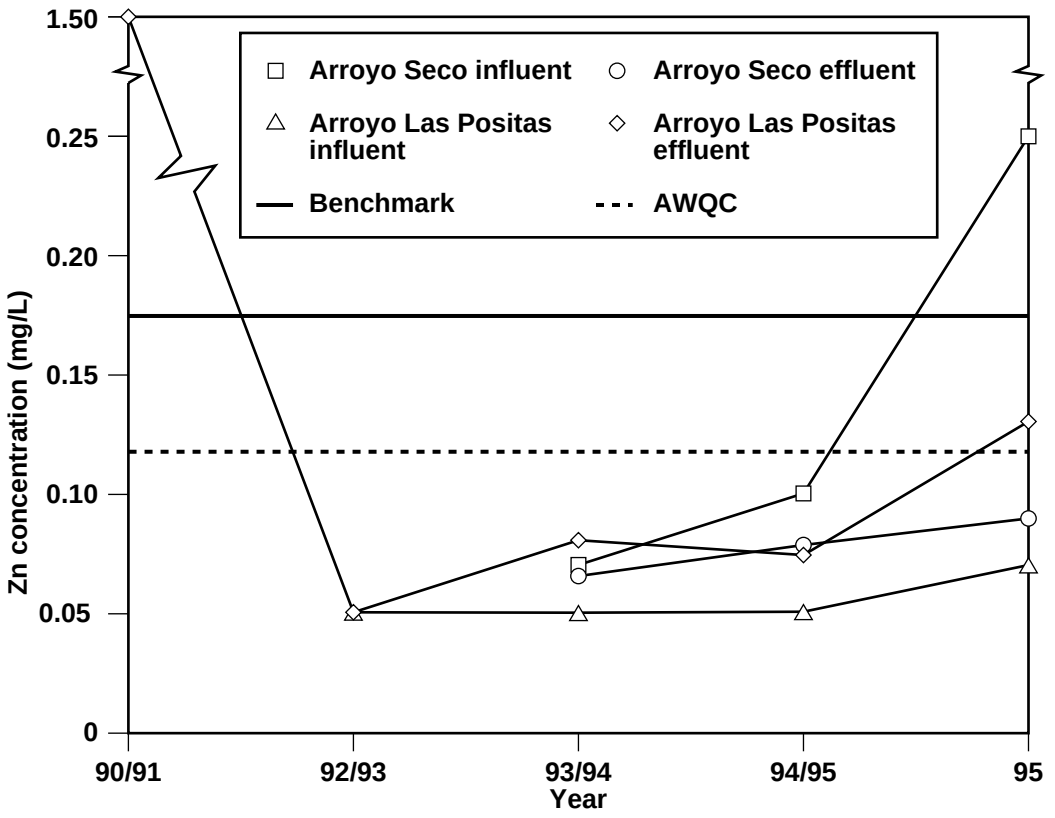

Figure 7-19. Annual median zinc concentrations in LLNL storm water.

Table 7-7. Concentrations (mg/L) of priority pollutants in runoff from urban source areas (from Salomons et al.1995).

	Source area					
Constituent	**Roofs**	**Parking**	**Storage**	**Streets**	**Vehicle service**	**Landscaped area**
Chromium	0.007–0.51	0.018–0.31	0.06–0.34	0.0033–0.03	0.019–0.32	0.1–0.25
Copper	0.017–0.9	0.02–0.77	0.03–0.3	0.015–1.25	0.0083–0.58	0.08–0.3
Zinc	0.1–1.58	0.03–0.15	0.066–0.29	0.058–0.13	0.067–0.13	0.032–1.16

influent points. The historical plot (**Figure 7-20**) indicates no obvious trends in alkalinity. However, it does show that, for the Arroyo Las Positas pathway, effluent alkalinity is generally 10-30 mg/L lower than influent alkalinity.

A number of measurements, barium, cadmium, lead, manganese, nickel, nitrate, silver, specific conductance, and 2,4-D (2,4-dichlorophenoxy acetic acid), were above comparison criteria. However, no exceedences at effluent points were higher than at influent points, indicating an off site or possibly naturally occurring source. Furthermore, with the exception of nitrate, each of these constituents exceeded criteria in at most four samples. Other organic constituents detected in 1995 were chloroform and 2,4,5-T (one detection each). Chloroform was below criteria, and no criteria were found for 2,4,5-T (2,4,5-trichlorophenoxy acetic acid).

Site 300 Radioactivity in Surface Water

Rainfall at the semiarid Site 300 was only sufficient to provide a total of four samples. The samples were collected during the first, second, and fourth quarters of 1995. The measured tritium activities were 0.37 Bq/L, 2.21 Bq/L, 2.16 Bq/L, and 2.17 Bq/L (9.9, 59.8, 58.5, and 58.6 pCi/L), respectively. These activities are indistinguishable from atmospheric background activity.

Tritium was only detected in one 1995 Site 300 storm water runoff sample location, NLIN, on December 18, at 2.98 Bq/L, about 0.4% of the MCL (**Table 7-8**). On March 9, gross alpha was above its MCL (0.56 Bq/L or 15 pCi/L) at locations CARW, NLIN, and NSTN. Gross beta on the date was above its MCL (1.86 Bq/L or 50 pCi/L at locations CARW and NLIN. The remaining sample from these locations was filtered, and the solid and liquid phases reanalyzed separately. The recount was somewhat lower than the original result and showed that nearly all of the gross alpha and gross beta was due to the greater-than-typical sediment loads and not to increased environmental gross alpha and gross beta radiation (**Table 7-9**). On December 18, gross alpha and/or gross beta were above MCLs at locations N829, NPT6, and NPT7. In this case, recounts confirmed the initial results. Uranium isotopic analysis showed the presence of naturally occurring uranium in all the March 9 and December 18 samples, but not enough to account for the gross alpha and gross beta. Because of budget limitations, one sample (December 18, NLIN) was selected for isotopic analysis. As in the case of the Livermore site samples, the plutonium level was extremely low (1.16×10^{-4} Bq/L or 31.4×10^{-4} pCi/L); uranium, thorium, and potassium levels (0.39, 1.70, and 35.9 Bq/L, respectively) were higher, but not enough higher to account for all the observed gross alpha and gross beta; and calculated daughter product emissions accounted for the majority of the gross alpha and gross beta.

Table 7-8. Radioactivity in storm water runoff at Site 300 (in Bq/L), 1995.

Location	Date	Tritium	Gross alpha	Gross beta
CARW	Mar 9	<1.62	33.82 ± 1.30	21.50 ± 0.67
	Mar 9[a]		6.857 ± 2.916	9.916 ± 5.720
N829	Mar 9	<1.56	0.13 ± 0.01	0.17 ± 0.01
	Dec 18	<2.31	1.26 ± 1.18	4.85 ± 1.07
	Dec 18[a]		3.885 ± 1.517	5.439 ± 1.110
N883	Mar 9	<1.61	0.12 ± 0.01	0.15 ± 0.01
	Dec 11	<1.99	0.07 ± 0.06	0.15 ± 0.06
NLIN	Mar 9	<1.55	10.10 ± 0.44	5.07 ± 0.22
	Mar 9[a]		2.658 ± 0.987	3.737± 2.049
	Dec 18	2.98 ± 2.38	6.59 ± 3.29	8.99 ± 2.52
	Dec 18[a]		7.955 ± 2.923	7.955 ± 1.998
NPT6	Dec 18	<2.33	3.66 ± 2.29	8.47 ± 2.41
	Dec 18[a]		3.589 ± 2.22	9.065 ± 1.85
NPT7	Mar 9	<1.57	0.13 ± 0.01	0.18 ± 0.01
	Dec 11	<2.02	0.07 ± 0.05	0.15 ± 0.06
NSTN	Mar 9	<1.64	1.50 ± 0.07	1.27 ± 0.04
	Mar 9[a]		0.15 ± 0.21	0.59 ± 0.19

Location	Date	Uranium-234	Uranium-235	Uranium-238
CARW	Mar 9	0.0078 ± 0.0041	0.0041 ± 0.0033	0.0044 ± 0.0030
	Mar 9			
N829	Mar 9	0.0118 ± 0.0063	0.0048 ± 0.0044	0.0118 ± 0.0067
	Dec 18	0.19 ± 0.02	0.0148 ± 0.0048	0.19 ± 0.02
N883	Mar 9	0.0070 ± 0.0037	0.003 ± 0.0025	0.0059 ± 0.0033
	Dec 11	0.0073 ± 0.0037	0.0014 ± 0.0016	0.0042 ± 0.0024
NLIN	Mar 9	0.56 ± 0.10	0.06 ± 0.0148	0.52 ± 0.09
	Dec 18	0.378 ± 0.0322	0.0189 ± 0.0063	0.45 ± 0.04
NPT6	Dec 18	0.163 ± 0.0189	0.0115 ± 0.0048	0.21 ± 0.02
NPT7	Mar 9	0.0130 ± 0.0052	0.0004 ± 0.0011	0.0096 ± 0.0044
	Dec 11	0.0141 ± 0.0052	0.0031 ± 0.0030	0.0085 ± 0.0041
NSTN	Mar 9	0.11 ± 0.02	0.0048 ± 0.0033	0.11 ± 0.02

[a] Recount performed for gross alpha and gross beta only.

Table 7-9. Activities of liquid and solid components of Site 300 storm water runoff samples (Bq/L).

	CARW	NLIN		NSTN
	(Mar 9)	Mar 9	Dec 12	(Mar 9)
Gross alpha	6.86 ± 2.92	2.66 ± 0.987	3.59 ± 2.22	0.738 ± 0.536
Gross alpha (solid phase)	6.85 ± 2.92	2.43 ± 0.981		0.6549 ± 0.529
Gross alpha (liquid phase)	0.0119 ± 0.016	0.228 ± 0.110		0.0829 ± 0.083
Gross beta	9.92 ± 5.72	3.74 ± 2.05	9.07± 1.85	1.032 ± 0.182
Gross beta (solid phase)	8.954 ± 5.661	2.4568 ± 1.987		0.492 ± 0.039
Gross beta (liquid phase)	0.962 ± 0.821	1.28 ± 0.500		0.540 ± 0.178
Uranium (solid phase)			0.39 ± 0.0295	
Plutonium (solid phase)			$1.16 \times 10^{-4} \pm 2.30 \times 10^{-3}$	
Thorium (solid phase)			1.70 ± 0.123	
Potassium-40 (solid phase)			0.132 ± 0.00666	

Site 300 Nonradioactive Pollutants in Storm Water

Three pH readings in Site 300 storm water runoff (**Table 7-10**) were outside of the MCL range (6.5 to 8.5); a pH of 6.2 was measured on March 2 at location N883, and pH of 8.7 and 8.8 were measured on December 18 at locations N829 and NLIN, respectively. In addition, TSS was often above the benchmark value (100 mg/L). This can readily be attributed to naturally occurring sediment loads in storm water runoff. Total suspended solids at background locations ranged as high as 20,000 mg/L, with a 94/95 median of over 10,000 mg/L, compared to a maximum effluent TSS of 6600 mg/L. All other nonradioactive constituents and parameters were below comparison criteria.

Environmental Impact

Tritium activities in all off-site drinking waters (as well as the on-site TAP location) were well below the drinking water MCL; they were within the range of the estimated background levels (background ranges from 3–4 Bq/L). The potential impact of such levels of tritium in drinking water supplies was estimated by determining the effective dose equivalent (EDE). Appendix B presents the method to calculate dose. Of all off-site drinking waters measured, the maximum tritium activity, 0.88 Bq/L (23.8 pCi/L), occurred at location ORCH (a drinking water source on private property near LLNL) sampled on January 13, 1995. The EDE to an adult who ingested 2 L of water at this concentration per day for 1 year would be 0.011 μSv (1.1 μrem), which is approximately 0.001% of the DOE standard allowable dose of 1.0 mSv/y (100 mrem). All other off-site waters, if ingested at the 2 L/day rate, would result in even lower EDEs.

Table 7-10. Site 300 storm water runoff, nonradioactive parameters, 1995.

Location	Storm date	Total organic halides (mg/L)	Total organic carbon (mg/L)	Total suspended solids (mg/L)	pH	Specific conductance (μmhos/cm)	HMX[a] (μg/L)	RDX [a] (μg/L)	TATB[a] (μg/L)	TNT[a] (μg/L)
CARW	Mar 9	0.13	13	20,000	7.5	700				
N829	Mar 9	<0.02	1.5	99	6.6	17	—[b]	—[b]	—[b]	—[b]
	Dec 18	0.04	5.3	5200	8.7	85	<20	<30	<70	<30
N883	Mar 9	—[b]	2	33	6.2	14				
	Dec 11	0.014	20	9	6.5	62				
NLIN	Mar 9	<0.02	8.9	6600	8.3	190				
	Dec 18	0.041	8.2	6200	8.8	120				
NPT6	Dec 18	0.028	4.4	2800	7.3	27				
NPT7	Mar 9	0.022	2.4	160	8.1	69				
	Dec 11	<0.01	5	100	8.1	72				
NSTN	Mar 9	0.16	6.5	1300	7.8	870				

[a] Analysis performed for location N829 only.

[b] Sample not collected due to field technical error.

The environmental impact of tritium measured in rainfall samples from LLNL, SNL/California, the Livermore Valley, and Site 300 was negligible. The highest tritium activity measured in a 1995 rainfall sample was 72.9 Bq/L (1970 pCi/L). This activity is less than 10% of the 740 Bq/L limit established for drinking water by the federal EPA. The EDE if an adult were to ingest 2 L of this rain per day for 1 year would be approximately 0.001 mSv (0.1 mrem), which is 0.1% of the DOE standard allowable annual dose of 1.0 mSv (100 mrem).

The environmental impact of tritium measured in storm water effluent from LLNL and Site 300, was also negligible. The highest tritium activity measured in a 1995 runoff effluent sample was 16.9 Bq/L (456 pCi/L). This activity is less than 2.5% of the 740 Bq/L limit established for drinking water by the federal EPA. The EDE if an adult were to ingest 2 L of this water per day for 1 year would be approximately 0.2 μSv (0.02 mrem), which is 0.02% of the DOE standard allowable annual dose of 1.0 mSv (100 mrem). The data from waters sampled during 1995 and the estimated potential maximal dose demonstrate a minimal impact of LLNL operations on valley waters resulting from releases of tritium to the atmosphere.

Three Site 300 effluent samples contained gross alpha and/or gross beta above MCL criteria, but this was attributed to high TSS. Storm water effluent also contained levels of chromium, copper, iron, nitrate, TSS, and zinc that were, at times, above their respective water quality criteria. In addition, pH was at times outside of the MCL range, and alkalinity was at times below the minimum AWQC. Although some 1995 storm water results were above criteria, there is no evidence that indicates any impact to off-site biota.