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Sewerable Water Monitoring

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Introduction

In 1999, the Livermore site discharged an average of 1.0 million liters (ML) per day of wastewater to the City of Livermore sewer system, an amount that constitutes 4.4% of the total flow to the system. This volume includes wastewater generated by Sandia National Laboratories/California, which is discharged to the LLNL collection system and combines with LLNL sewage before it is released at a single point to the municipal collection system (**Figure 6-1**). In 1999, Sandia/California generated approximately 13% of the total effluent discharged from the Livermore site. LLNL's wastewater contains sanitary sewage and industrial wastewater and is discharged in accordance with permit requirements and the City of Livermore Municipal Code, as discussed below in the Pretreatment Discharges and Categorical Discharges sections.

The effluent is treated at the Livermore Water Reclamation Plant (LWRP). As part of the Livermore-Amador Valley Wastewater Management Program, the treated sanitary wastewater is transported out of the valley through a pipeline and discharged into San Francisco Bay. A small portion of this treated wastewater is used for summer irrigation of the adjacent municipal golf course. Sludge from the treatment process is disposed of in sanitary landfills.

LLNL receives water from two suppliers. LLNL's primary water source is the Hetch-Hetchy Aqueduct. Secondary or emergency water deliveries are taken from the Alameda County Flood Control and Water Conservation District Zone 7. This water is a mixture of ground water and water from the South Bay Aqueduct of the State Water Project. Water quality parameters for the two sources are obtained from the suppliers and are used to evaluate compliance with the discharge permit conditions that limit changes in water quality between receipt and discharge.

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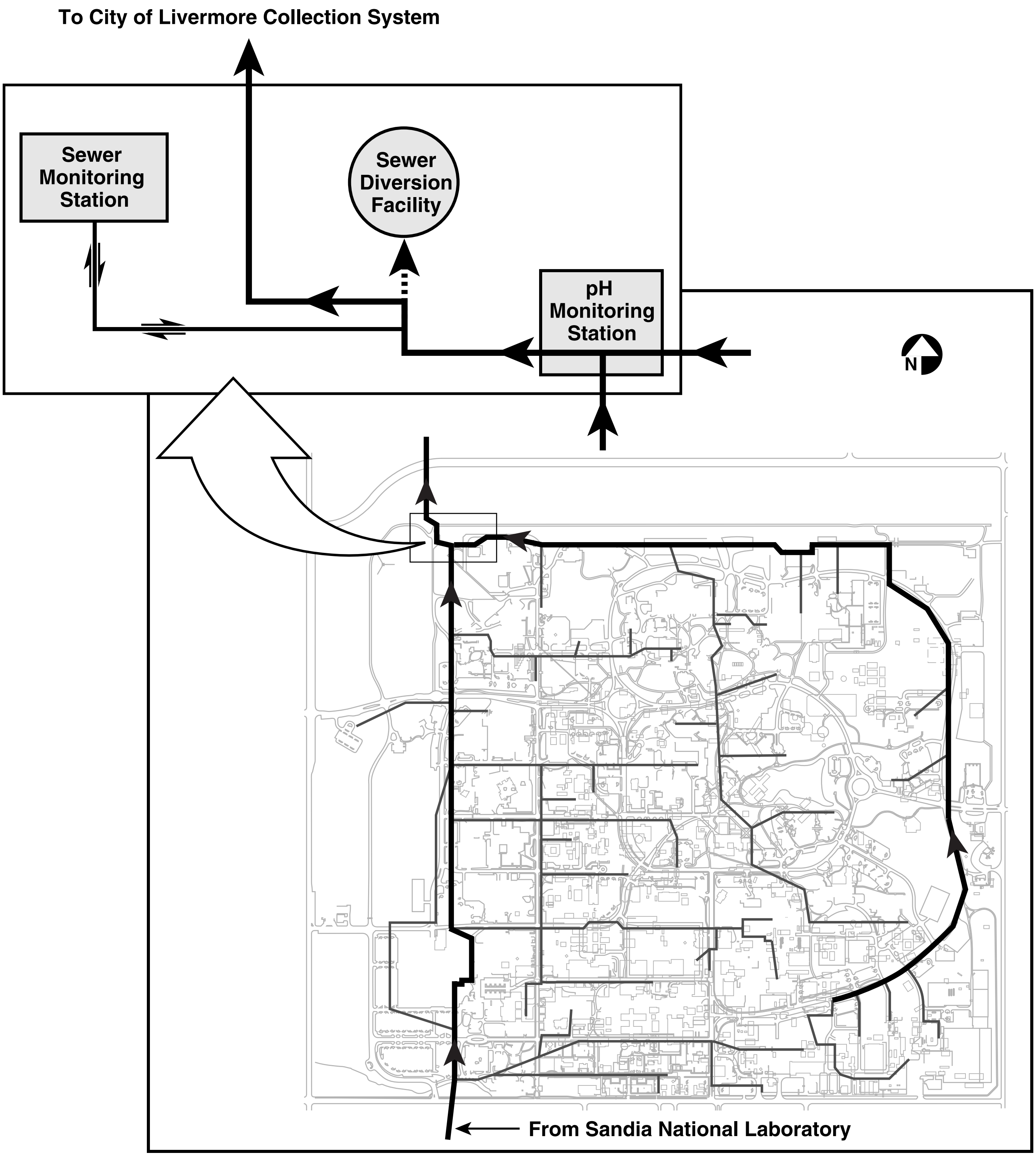

Figure 6-1. LLNL sanitary sewer system, monitoring stations, and diversion facility.

Preventive Measures

Administrative and engineering controls at the Livermore site are designed to prevent potentially contaminated wastewater from being discharged directly to the sanitary sewer. Waste generators receive training on proper waste handling. LLNL personnel review facility procedures and inspect processes to ensure appropriate discharges. Retention tanks collect wastewater from processes that might release contaminants in quantities sufficient to disrupt operations at the LWRP. Wastewater that cannot be discharged into one or more of surface water collection units at LLNL's Experimental Test Site (Site 300) is transported to LLNL's Livermore site and managed under Livermore site retention tank administrative controls. Ground water (generated from startup operations associated with new, portable ground water treatment units, tests of experimental treatment units, and maintenance of existing treatment facilities) is analyzed for pollutants of concern and must meet permitted criteria, or LWRP approval must be obtained before it can be discharged to the sanitary sewer. Finally, to verify the success of training and control equipment, wastewater is sampled and analyzed not only at the significant points of generation, as defined by type and quantity of contaminant generated, but also at the point of discharge to the municipal sewer system.

For facilities with installed retention tank systems, collected wastewater is discharged to the sanitary sewer only if analytical laboratory results show that pollutant levels are within allowable limits (Grandfield 1989). LLNL developed internal discharge guidelines for specific sources and operations to ensure that sewer effluent for the entire site complies with LLNL's wastewater discharge permit.

Table 6-1 shows LLNL's internal discharge guidelines for wastewater discharged to the sewer. Any processes that discharge to the sanitary sewer are subject to the general pretreatment self-monitoring program specified in the Wastewater Discharge Permit issued by the LWRP, and, as such, are managed by LLNL using these internal discharge guidelines as applied at the point of discharge into the LLNL sewer.

If pollutant levels exceed internal permissible concentrations, the wastewater is treated to reduce pollutants to the lowest levels practical and below LLNL guidelines, or it is shipped to an off-site treatment or disposal facility. Liquids containing radioactivity are handled on site and may be treated using processes that reduce the activity to levels well below those required by DOE Order 5400.5 or they are shipped to an off-site treatment or disposal facility. Internal guidelines for retention tank systems and specific sources and operations are discussed later in the Pretreatment Discharges section. Process wastewater generation and discharge frequency from retention tanks vary from monthly to yearly, depending upon the process. During 1999, there were approximately 31 retention tank systems in use at the Livermore site, with an average of 14 wastewater retention tanks discharged each month, averaging a volume of 8000 liters per tank.

Table 6-1. LLNL's internal discharge guidelines for pollutants in wastewaters.

Nonradioactive pollutants in wastewaters	
Constituent	**Discharge guidelines**
Metals (mg/L)	
Arsenic	0.06[(a)]
Cadmium	0.9
Copper	10
Chromium (total)	4.9
Lead	4.9
Mercury	0.05
Nickel	5
Silver	1
Zinc	15
Cyanide (mg/L)[(b)]	5
Oil and grease (mg/L)	500
Total toxic organics (TTO) (mg/L)[(c)]	4.57
pH (pH units)	5–10

Radioisotopes in wastewaters[(d)]		
Parameter	**Individual discharge**	**Total daily limit for site**
Gross alpha	11.1 Bq/L (300 pCi/L)	185 kBq (5.0 µCi)
Gross beta	111 Bq/L (3000 pCi/L)	1.85 MBq (50.0 µCi)
Tritium	185 kBq/L (5.0 µCi/L)	3.7 GBq (100.0 mCi)

a No specific internal discharge limit was developed for this constituent; therefore, the discharge limit in LLNL's wastewater discharge permit is used as a guideline for this parameter.

b Limits apply to cyanide discharges other than cyanide salts. Cyanide salts are classified by the State of California as "extremely hazardous waste" and cannot be discharged to the sewer.

c Total toxic organics is defined by the Livermore Municipal Code as the sum total of all detectable organic compounds that are on the Environmental Protection Agency's current priority pollutant list and that are present in concentrations of 0.01 mg/L or greater. Analysis of samples using EPA Methods 624 and 625 satisfy this requirement. A listing of the specific compounds included may be found in the Data Supplement, Chapter 6.

d There is no gross gamma limit; DOE Order 5400.5 isotope-specific limits apply.

For the year as a whole, the monitoring data reflect the success of LLNL's discharge control program in preventing any adverse impact on the operations of Livermore's treatment plant and are generally consistent with past values.

Monitoring

Monitoring at the Sewer Monitoring Station

LLNL's sanitary sewer discharge permit requires continuous monitoring of the effluent flow rate and pH. Samplers collect flow-proportional composite samples and instantaneous grab samples that are analyzed for metals, radioactivity, toxic chemicals, and water-quality parameters. In addition, as a best management practice, the outflow to the municipal collection system is sampled continuously and analyzed in real time for conditions that might upset the LWRP treatment process or otherwise impact the public welfare. The effluent is continuously analyzed for pH, regulated metals, and radioactivity. If concentrations above warning levels are detected, an alarm is registered at the LLNL Fire Dispatcher's Station, which is attended 24 hours a day, and the site effluent is diverted to the Sewer Diversion Facility (SDF). The monitoring system provides a continuous check on sewage control, and the LWRP is notified of contaminant alarms. Trained staff respond to all alarms to evaluate the cause and take appropriate action.

Monitoring at the Upstream pH Monitoring Station

In addition to the continuous monitoring at the Sewer Monitoring Station (SMS), LLNL monitors pH at the upstream pH Monitoring Station (pHMS) (see **Figure 6-1** for a system diagram). The pHMS continuously monitors pH between 7 a.m. and 7 p.m. during the work week and diverts pH discharges outside the permitted 5 to 10 range to the SDF. The pHMS duplicates the pH monitoring and diversion capabilities of the SMS, but because it is located upstream of the SDF it is able to initiate diversion earlier. Earlier detection allows LLNL to divert all of the unpermitted site effluent.

Diversion System

LLNL operates and maintains a diversion system that activates automatically when either the SMS continuous monitoring system or the pHMS sounds an alarm. For SMS activated alarms, the SDF ensures that all but the first few minutes of the potentially affected wastewater flow is retained at LLNL, thereby protecting the LWRP and minimizing any required cleanup. During pH excursions activated by the pHMS, even the first few minutes of affected wastewater flow is retained. Up to 775,000 L of potentially contaminated sewage can be held pending analysis to determine the appropriate handling method. The diverted effluent may be returned to the sanitary sewer (if it meets LLNL's wastewater discharge permit limits), shipped for off-site disposal, or treated at LLNL's Hazardous Waste Management (HWM) Facility. All diverted sewage in 1999 was returned to the sanitary sewer.

Pretreatment Discharges

The general pretreatment regulations establish both general and specific standards for the discharge of prohibited substances (40 CFR 403.5) that apply to all industrial users. These regulations apply even if LLNL is subject to other federal, state, or local pretreatment standards. The pretreatment standards contain prohibitions intended to protect the LWRP and its operations from interference with its treatment processes or pass-through that would cause the LWRP to violate its own effluent limitations. The LWRP, under the authorization of the San Francisco Bay Regional Water Quality Control Board, requires self-monitored pretreatment programs at both the Livermore site and Site 300. The sampling and monitoring of nondomestic, industrial sources covered by pretreatment standards defined in 40 CFR 403 is required in the 1999-2000 Wastewater Discharge Permit No. 1250 issued for the discharge of wastewater from LLNL into the City of Livermore sewer system. Permit 1250 lists all the self-monitoring parameters that are applied at the SMS before wastewater enters the municipal collection system at LLNL's effluent outfall (see **Figure 6-1**). Parameters with numerical limits are listed in **Table 6-2**. The additional discharge limits shown in **Table 6-2** are discussed below in the Categorical Discharges and Discharges of Treated Ground Water sections. Other required parameters such as flow rate, biological oxygen demand, total dissolved solids, total suspended solids, and tributyltin are also monitored at the SMS but have no specific numerical limits. In 1999, no exceedances of the pollutant limitations in the discharge permit were observed.

Table 6-2. Permit discharge limits for nonradioactive pollutants in LLNL wastewaters.

Parameter	Permit discharge limits			
	Permit 1250			Permit 1510G
	Outfall[(a)]	Metal finishing[(b)]	Electric component[(b)]	Treated ground water
Metals (mg/L)				
Arsenic	0.06	—[(c)]	0.83	0.06
Cadmium	0.14	0.07	—[(c)]	0.14
Chromium (total)	0.62	1.71	—[(c)]	0.62
Copper	1.0	2.07	—[(c)]	1.00
Lead	0.20	0.43	—[(c)]	0.20
Mercury	0.01	—[(c)]	—[(c)]	0.01
Nickel	0.61	2.38	—[(c)]	0.61
Silver	0.20	0.24	—[(c)]	0.20
Zinc	3.0	1.48	—[(c)]	3.00
Organics (mg/L)				
TTO[(d)]	1.00	2.13	1.37	1.00
Other (mg/L)				
Cyanide[(e)]	0.04	0.65	—[(c)]	0.04[(f)]
Oil and grease	100	—[(c)]	—[(c)]	100
pH (pH units)	5–10	—[(c)]	—[(c)]	5–10

a These standards apply at the SMS (the point of discharge to the municipal sewer). All other standards in this table apply at the point of discharge into LLNL's sanitary sewer system.

b These categorical standards were specified by EPA. By regulation, the EPA or City of Livermore limit is used, whichever is lower. The internal limits in **Table 6-1** are applied by LLNL where no other standard is specified.

c There is no specific categorical limit for this parameter; therefore, the **Table 6-1** internal discharge limits apply.

d Total toxic organics is defined by the Livermore Municipal Code as the sum total of all detectable organic compounds that are on the Environmental Protection Agency's current priority pollutant list and that are present in concentrations of 0.01 mg/L or greater. EPA Methods 624 and 625 analysis satisfies this requirement. A listing of the specific compounds included may be found in the Data Supplement, Chapter 6.·

e Limits apply to cyanide discharges other than cyanide salts. Cyanide salts are classified by the State of California as "extremely hazardous waste" and cannot be discharged to the sewer.

f Although Permit 1510G lists a discharge limit for cyanide, sample collection is not required by the self-monitoring program.

Categorical Discharges

The Environmental Protection Agency (EPA) publishes categorical standards as regulations separate from the general pretreatment regulations and developed for broad categories of specific industrial processes determined to be the most significant contributors to point source water pollution. These standards contain specific numerical limits for the discharge of industry-specific pollutants from individual processes. The number of processes at LLNL using these pollutants is subject to rapid and frequent change as programmatic requirements dictate. During 1999, the LWRP identified 17 specific LLNL wastewater generating processes that fall under the definition of two categorical standards: Electrical and Electronic Components (40 CFR 469), and Metal Finishing (40 CFR 433). The discharge limits for these standards are shown in **Table 6-2**. Under the terms in Permit 1250, only those processes that discharge to the sanitary sewer require sampling, inspection, and reporting. Three of the 17 identified processes meet these criteria. In 1999, LLNL analyzed samples for all regulated parameters from these three processes and the results showed that LLNL complied with all federal categorical discharge limits.

The first of the three categorical processes that discharge directly into the sanitary sewer system is an abrasive jet machine (or water-jet) that is regulated under the Metal-Finishing Point Source Category; the filtered water from this process is discharged to the sanitary sewer. The other two discharging categorical processes are both regulated under the Federal Electrical and Electronic Component Point Source Category. One is a series of processes clustered within a single building housing research-scale microfabrication laboratories used for developing prototype semiconductor devices. These laboratories discharge into a building wastewater retention system, and because they are housed within the same building, with no diluting flow, they share a single point of compliance. The second categorical process is a small gallium arsenide cutting operation; this process discharges directly to the sanitary sewer.

The nondischarging processes, all regulated under the Metal-Finishing Point Source Category (40 CFR 433), were printed circuit board manufacturing, electrolysis plating, chemical etching, electroplating, anodizing, coating, painting, cleaning, electrical discharge machining, irridite processing, and abrasive jet machining (water-jet). The wastewater from these processes was contained for removal and appropriate disposal by LLNL's Hazardous Waste Management Division (HWM).

Discharges of Treated Ground Water

LLNL's ground water discharge permit (1510G, 1999) allows treated ground water from site-wide Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 cleanup activities to be discharged in the City of Livermore sanitary sewer in compliance with **Table 6-2** effluent limitations taken from the Livermore Municipal Code.

During 1999, the volume of ground water discharged to the sanitary sewer was approximately 386,000 liters**.** Water discharges during this period were related to start-up operations associated with new portable treatment units being built and installed throughout the site, testing of an experimental nitrate removal treatment system, and maintenance of existing ground water treatment facilities. Twelve separate discharges were sampled and discharged to the sewer during this period, all in compliance with self-monitoring permit provisions of Permit 1510G. Concentrations of regulated compounds were all below discharge limits. Monitoring data are presented in the Data Supplement, Chapter 6.

Radioactive Pollutants in Sewage

Monitoring Results

LLNL determines the total radioactivity released from tritium, alpha emitters, and beta emitters based either on the measured radioactivity in the effluent or on the limit of sensitivity, whichever is higher (see **Table 6-3**). The 1999 combined releases of alpha and beta sources was 0.32 GBq (0.0086 Ci). The combined total is based on the results shown in **Table 6-3**. The tritium total was 7.1 GBq (0.19 Ci), and the annual mean concentration of tritium in LLNL sanitary sewer effluent was 0.019 Bq/mL (0.51 pCi/mL).

Table 6-3. Estimated total radioactivity in LLNL sanitary sewer effluent, 1999.

Radioactive emitter	Estimate based on effluent activity (GBq)[a]	Limit of sensitivity (GBq)
Tritium	7.1	4.2
Alpha sources	0.043	0.034
Beta sources	0.28	0.046

a 37 Gbq = 3.7×10^{10} Bq = 1 Ci.

Summary results for tritium measured in the sanitary sewer effluent from LLNL and LWRP are presented in **Table 6-4**. The monthly tritium numbers are based on the flow-weighted average of the individual daily sample results for a given month. The total annual result is based on the multiplication of each daily sample result or the limit of sensitivity, whichever is greater, by the total flow volume over which the sample was collected, and summing up over all samples. (All other total annual results presented in this chapter for radioactive emitters are also calculated conservatively; the limit of sensitivity or minimum detectable concentration is used to determine the total annual activity when the limit of sensitivity is greater than the sample result.) Also included in the table are fractions of LWRP, Department of Energy (DOE) and 10 CFR 20 limits, discussed in the Environmental Impact section that follows.

Table 6-4. Tritium in sanitary sewer effluents (Bq/mL), LLNL and LWRP, 1999.

Monitoring results			
	LLNL		LWRP
	Daily	Monthly average	Weekly
Maximum	0.929 ± 0.018[a]	0.045[b]	0.017 ± 0.007[c]
Median	0.003	0.006	0.001
IQR[d]	0.008	0.013	0.006
LLNL annual total (GBq)	7.1		

Discharge limits			
	Discharge limit	Fraction of discharge limit	
		LLNL maximum	LLNL median
LWRP permit daily	12	0.075	2.5×10^{-4}
DOE annualized discharge limit for application of BAT[e] (Bq/mL)	370	1.2×10^{-4}[f]	1.7×10^{-5}[f]
10 CFR 20 annual total (GBq)	185	0.038	

a The daily result is for an October sample; the detection limit for the analysis was 0.011 Bq/mL. See the Data Supplement, Chapter 6, for all daily results.

b This is the monthly average for October. All monthly averages are plotted in **Figure 6-2**.

c This is a weekly result for a January sample. This result was the only weekly value above a detection limit; detection limits ranged from 0.005 to 0.013 Bq/mL. See the Data Supplement, Chapter 6, for all weekly results.

d IQR = Interquartile range.

e The DOE annualized discharge limit for application of best available technology (BAT) is five times the Derived Concentration Guide (DCG; ingested water) for each radionuclide released.

f Monitoring results as a fraction of limit are calculated using LLNL monthly average results and the DOE annualized discharge limit.

The historical trend in the monthly average concentration of tritium is shown in **Figure 6-2**. Also included in the figure is the DOE tritium limit (370 Bq/mL), discussed in the Environmental Impact section of this chapter. The trend indicates a well-controlled tritium discharge, orders of magnitude below the DOE tritium limit.

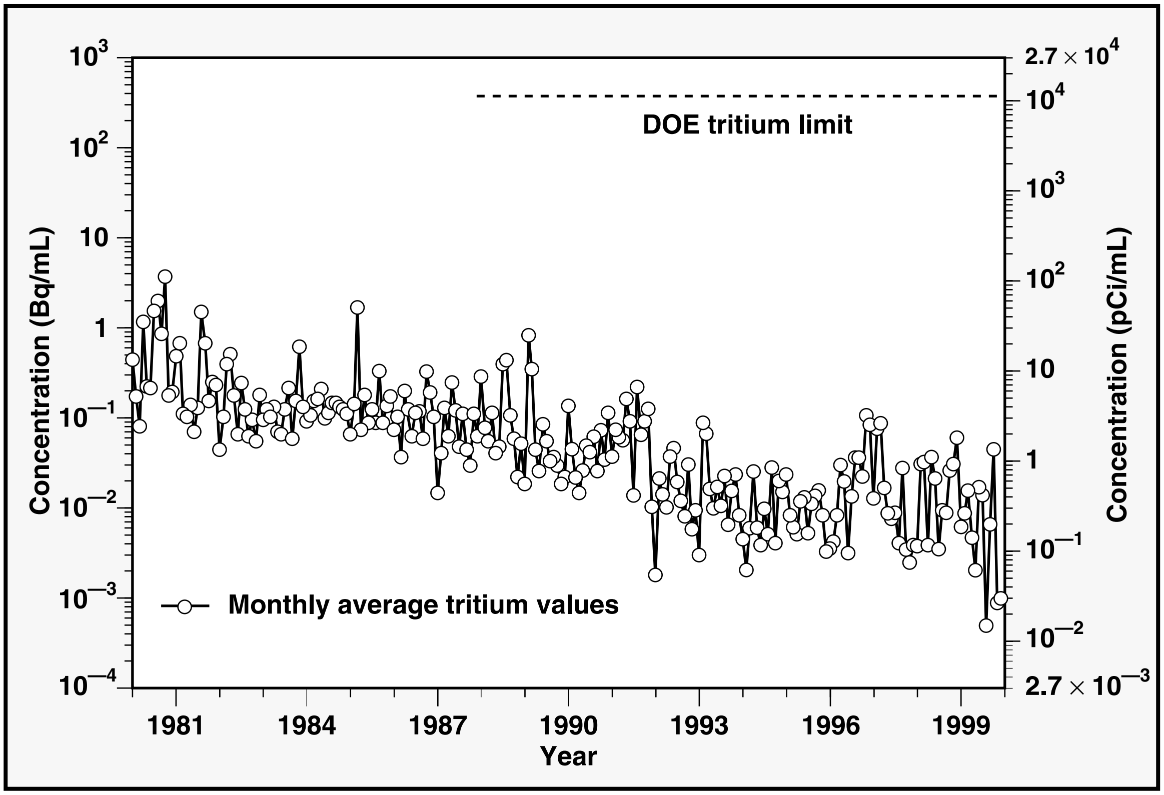

Figure 6-2. Historical trend in tritium concentration in LLNL sewage.

The concentrations of ^{239}Pu and ^{137}Cs measured in the sanitary sewer effluent from LLNL and LWRP are presented in **Table 6-5**. The plutonium and cesium numbers are the direct results for analyses of monthly composite samples of LLNL and LWRP effluent, and quarterly composites of LWRP sludge. At the bottom of the table, the total annual activity released is given by radioisotope. Also included in the table are fractions of DOE limits, discussed in the Environmental Impact section.

Figure 6-3 shows the average monthly plutonium and cesium concentrations in sewage since 1990. For 1999, the annual mean concentration of ^{137}Cs was 3.2×10^{-6} Bq/mL (8.6×10^{-5} pCi/mL); the annual mean concentration of ^{239}Pu was 1.8×10^{-7} Bq/mL (4.9×10^{-6} pCi/mL).

Table 6-5. Cesium and plutonium in sanitary sewer effluents, LLNL and LWRP, 1999.

Month	^{137}Cs (µBq/mL)				^{239}Pu (nBq/mL)				^{239}Pu (mBq/dry g)	
	LLNL		LWRP		LLNL		LWRP		LWRP sludge[(a)]	
	Radioactivity	MDC[(b)]	Radioactivity[(c)]	MDC[(b)]	Radioactivity	MDC	Radioactivity	MDC	Radioactivity	MDC
Jan	1.2 ± 0.6	0.4	<0.42	0.42	54.8 ± 19.4	10.1	6.5 ± 10.9	17.1		
Feb	0.73 ± 1.00	0.58	<0.40	0.40	155 ± 39	13	–4.9 ± 14.4	25.8		
Mar	0.81 ± 0.74	0.48	<0.36	0.36	76.6 ± 34.0	25.2	5.1 ± 19.1	44.4	0.12 ± 0.02	0.00
Apr	1.0 ± 0.9	0.5	<0.37	0.37	160 ± 83	64	17.9 ± 20.5	25.2		
May	0.42 ± 5.96	5.33	–1.7 ± 8.3	7.2	67.3 ± 28.9	10.1	9.0 ± 38.1	75.9		
Jun	1.2 ± 6.6	6.0	—[(d)]	—[(d)]	108 ± 38	16	—[(d)]	—[(d)]	0.094 ± 0.031	0.014
Jul	3.4 ± 3.2	3.1	2.6 ± 2.7	2.5	124 ± 41	24	–1.8 ± 12.6	27.4		
Aug	1.1 ± 7.0	6.2	–2.6 ± 3.7	2.9	71.0 ± 25.3	13.3	–0.71 ± 1.41	8.55		
Sep	2.5 ± 3.3	2.1	0.68 ± 3.89	3.46	844 ± 76	9	10.3 ± 19.2	31.4	0.18 ± 0.05	0.01
Oct	–0.92 ± 5.03	4.29	–0.78 ± 3.12	2.64	264 ± 36	7	1.35 ± 2.20	6.66		
Nov	2.0 ± 3.0	2.8	–0.07 ± 3.44	2.99	128 ± 28	7	0.10 ± 3.40	7.33		
Dec	3.2 ± 3.6	3.4	–1.2 ± 4.0	3.4	58.5 ± 19.9	9.3	6.1 ± 15.1	22.6	0.38 ± 0.04	0.01
Median	1.1		0.4		116		5.1		0.15	
IQR[(e)]	1.4		1.4		86		8.0		0.12	
	pCi/mL[(f)]								pCi/dry g[(f)]	
Median	3.0×10^{-5}		9.7×10^{-6}		3.1×10^{-6}		1.4×10^{-7}		0.0040	
IQR[(e)]	3.7×10^{-5}		3.8×10^{-5}		2.3×10^{-6}		2.2×10^{-7}		0.0033	

	Annual total discharges by radioisotope		
	^{137}Cs	^{239}Pu	Total[(g)]
Bq/y	1.2×10^{6}	6.8×10^{4}	1.3×10^{6}
Ci/y	3.3×10^{-5}	1.8×10^{-6}	3.5×10^{-5}
	Fraction of limit[(h)]		
DOE annualized discharge limit for application of BAT[(i)]	5.7×10^{-6}	4.8×10^{-7}	3.6×10^{-6}

Note: Radioactivities are reported as the measured concentration and either an uncertainty (±2σ counting error) or as being less than or equal to the detection limit or minimum detectable concentration (MDC). If the concentration is less than or equal to the uncertainty or the detection limit, the result is considered to be a nondetection. See Main Volume, Chapter 14, Quality Assurance.

a Sludge from LWRP digesters is dried before analysis. The resulting data indicate the plutonium concentration of the sludge prepared by LWRP workers for disposal at the Vasco Road Landfill in Alameda County.

b For May through December data, decreased sample count times, lower efficiency detectors and new computer software contributed to greater MDCs than those shown for January through April. Other factors also contributed to the high MDCs shown for LLNL May and June and LWRP May analyses (smaller sample volumes), LLNL August analysis (low chemical recovery), and LLNL October analysis (shorter sample count time than the norm of May through December data).

c The analytical laboratory provided measured concentrations and uncertainties for only the last eight months of 1999.

d No data available because of analytical laboratory error in the analysis of the sample.

e IQR = Interquartile range.

f 1 Ci = 3.7×10^{10} Bq.

g Does not include gross alpha and beta results shown in **Table 6-3** or the tritium results shown in **Tables 6-4** and **6-6**.

h Fraction of limit calculations are based on the annual total discharge for a given isotope and the corresponding concentration-based limit (0.56 and 0.37 Bq/mL for ^{137}Cs and ^{239}Pu, respectively) multiplied by the annual volume of Livermore site effluent.

I The DOE annualized discharge limit for application of best available technology (BAT) is five times the Derived Concentration Guide (DCG; ingested water) for each radionuclide released.

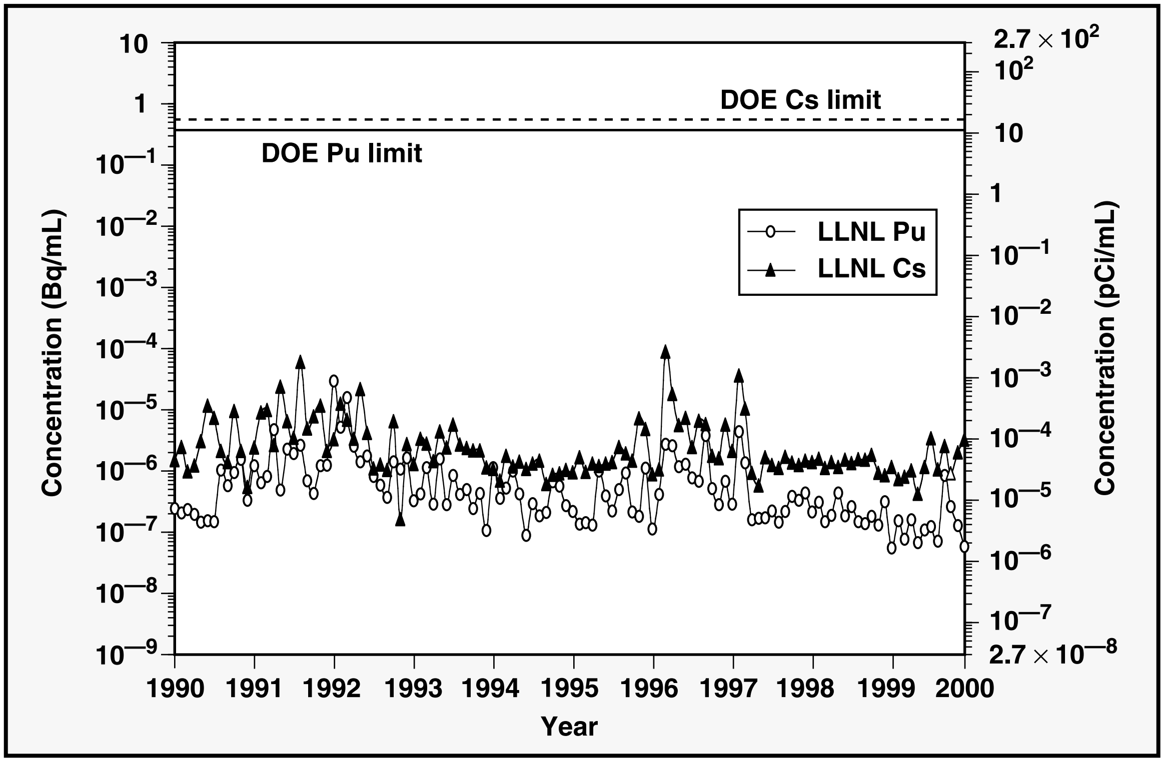

Figure 6-3. Historical trends in average monthly plutonium and cesium concentrations in LLNL sewage.

Environmental Impact

During 1999, no inadvertent discharges exceeded any discharge limits for release of radioactive materials to the sanitary sewer system.

In August 1999, the Work Smart Standards (WSSs) developed for LLNL became effective, as discussed in Chapter 3. As part of the WSS process, standards were selected for sanitary sewer discharges. For radioactive material releases, complementary (rather than redundant) sections from DOE Order 5400.5, Radiation Protection of the Public and Environment, and Title 10 of the Code of Federal Regulations, Part 20, were chosen as standards.

Prior to August 1999, DOE Order 5400.5 established DOE policy requiring that radiological releases to the sanitary sewer comply with legally applicable local and state regulations and that LLNL implement standards generally consistent with those of the Nuclear Regulatory Commission. The most stringent of these limits was adopted in Title 17 of the California Code of Regulations. As a federal facility, LLNL is formally exempt from the requirements of state regulations but followed those requirements under the guidance of DOE. In 1994, the discharge requirements previously found in Title 17 were removed, and the requirements in Title 10 of the Code of Federal Regulations, Part 20, were incorporated by reference.

As selected from DOE Order 5400.5, the WSS for sanitary sewer discharges includes the criteria DOE established for the application of best available technology to protect public health and minimize degradation of the environment. These criteria (the Derived Concentration Guides, or DCGs) limit the concentration of each radionuclide discharged to publicly owned treatment works. If a measurement of the monthly average concentration of a radioisotope exceeded its specific concentration limit, LLNL would be required to improve discharge control measures until concentrations were again below the DOE limits. **Tables 6-4** and **6-5** include the DCGs for the specific radioisotopes of most interest at LLNL.

The median monthly average concentration of tritium in LLNL sanitary sewer effluent was 1.7×10^{-5}, that is, 0.0017% of the DOE DCG, and the maximum monthly average concentration of tritium was 1.2×10^{-4}, 0.012% of the DCG (see **Table 6-4**). The annual average concentration of ^{137}Cs was 5.7×10^{-6} (0.00057%) of the DOE DCG; and the annual average ^{239}Pu concentration was 4.8×10^{-7} (0.000048%) of the ^{239}Pu DOE DCG. These results are shown at the end of **Table 6-5**.

From 10 CFR 20, the numerical discharge limits for sanitary sewer discharges in the WSSs include the annual discharge limits for radioactivity: 185 GBq (5 Ci) of tritium, 37 GBq (1 Ci) of ^{14}C , and 37 GBq (1 Ci) of all other radionuclides combined.

The 10 CFR 20 limit on total tritium activity (185 GBq) dischargeable during a single year overrides the DOE Order 5400.5 concentration-based limit for tritium for facilities such as LLNL that generate wastewater in large volumes. In 1999, the total LLNL tritium release was 3.8% of this Title 10 limit. Total LLNL releases (see **Table 6-3**), in the form of alpha and beta emitters (excluding tritium), were 0.86% of the corresponding Title 10 limit.

In addition to the DOE concentration discharge limit for tritium and the 10 CFR 20 annual total discharge limit for tritium, the LWRP established in the 1999-2000 Wastewater Discharge Permit an effluent concentration discharge limit for LLNL daily releases of tritium**.** This new limit is more stringent than the DOE discharge limit: it is a factor of 30 smaller and it applies to daily rather than an annualized concentration. The maximum daily concentration for tritium in 1999 was 7.5% of the permit discharge limit. **Table 6-4** shows this result and the daily effluent discharge limit for tritium. The LWRP established the limit to preserve opportunities for an expanded recycling program for the plant's treated wastewater.

LLNL also compares annual discharges with historical values to evaluate the effectiveness of ongoing discharge control programs. **Table 6-6** summarizes the radioactivity in liquid effluent released over the past 10 years. During 1999, a total of 7.1 GBq (0.19 Ci), of tritium was discharged to the sanitary sewer, an amount that is well within environmental protection standards and is comparable to the amounts reported for the previous seven years. Moreover, the total tritium released by LLNL in 1999 continues the 1992 to 1998 trend of significantly smaller releases than those in the years prior to 1992.

Table 6-6. Radioactive liquid effluent releases from the Livermore site, 1990–1999.

	Liquid effluent (GBq)	
Year	^{3}H	^{239}Pu
1990	25	2.3×10^{-4}
1991	32	6.1×10^{-4}
1992	8	1.9×10^{-3}
1993	13	2.6×10^{-4}
1994	6.9	1.9×10^{-4}
1995	6.0	1.2×10^{-4}
1996	12[a]	4.2×10^{-4}
1997	9.1	2.1×10^{-4}
1998	10	7.7×10^{-5}
1999	7.1	6.8×10^{-5}

a In 1995, Sandia National Laboratories/California ceased all tritium facility operations. Therefore, the annual tritium totals beginning with the 1996 value do not include contributions from Sandia/California.

Figure 6-3 summarizes the ^{239}Pu monitoring data over the past 10 years. The historical levels observed since 1990 average 1 µBq/mL (3×10^{-5} pCi/mL). These historical levels generally are three-millionths (0.000003) of the DOE DCG for the ^{239}Pu. The greatest part of the plutonium discharged in LLNL effluent is ultimately concentrated in LWRP sludge, which is dried and disposed of at a landfill. The median plutonium concentration observed in 1999 sludge (**Table 6-5**), 0.15 mBq/dry g is 620 times lower than the EPA preliminary remediation goal for residential soil (93 mBq/dry g) and is nearly 2500-times lower than the remediation goal for industrial or commercial soil (370 mBq/dry g).

As first discussed in the *Environmental Report 1991* (Gallegos et al. 1992), plutonium and cesium concentrations were slightly elevated during 1991 and 1992 over the lowest values seen historically. As was established in 1991, the overall upward trend was related to sewer cleaning with new, more-effective equipment. The concentrations in 1996 and the first quarter of 1997 were also slightly higher than the lowest values seen historically, although slightly lower than those of 1990 through 1992. In fact, the cyclic nature of the data points in **Figure 6-3** suggests that built-up radionuclides in sewer lines are liberated by line cleaning. The higher plutonium and cesium concentrations are all well below applicable DOE DCGs. In general, the plutonium and cesium concentrations for 1999 are comparable to the lowest values seen historically, and are well below the applicable DOE DCGs. (Note that the open triangle in the figure indicates that the data point was negative; because negative data points cannot be plotted directly against a log scale, its absolute value has been plotted. Also, MDC values for cesium increased in May 1999, so most of the results plotted for the last two-thirds of the year are below their respective MDCs.)

Nonradioactive Pollutants in Sewage

Monitoring Results

Table 6-7 presents monthly average concentrations for all regulated metals in LLNL's sanitary sewer effluent for 1999. The averages were obtained by a flow-proportional weighting of the analytical results for the weekly composite samples collected each month. Each result was weighted by the total flow volume for the period during which the sample was collected. The results are generally typical of the values seen during previous years, 1994–1998. **Figure 6-4** presents historical trends for the average monthly results from 1994 through 1999 for eight of the nine regulated metals; cadmium is not presented because this metal is typically not detected. Trends for chromium, mercury, nickel, and zinc show that average monthly concentrations are slightly elevated overall for mid-1996 through 1999, as compared with the previous two and a half years. The other four metals have no discernible trends in their concentrations, although copper concentrations are noticeably elevated in the latter part of 1999. During the period of January through early September, weekly composite sample were also analyzed for three non/regulated metals (aluminum, beryllium, and iron). Refer to the Data Supplement, Chapter 6, for the analytical results, which were typical of values in previous years.

Table 6-7. Average monthly results for regulated metals in LLNL sanitary sewer effluent (mg/L), 1999.

Month	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Jan	<0.010	0.0036	<0.0050	0.013	0.095	0.00053	0.012	0.011	0.19
Feb	<0.010	<0.0020	<0.0050	<0.010	0.062	0.00035	0.0091	0.010	0.20
Mar	0.012	0.0037	<0.0050	0.024	0.16	0.0017	0.014	0.025	0.35
Apr	0.012	0.0026	<0.0050	0.037	0.18	0.00078	0.011	0.021	0.45
May	<0.010	0.0023	<0.0050	0.012	0.085	0.00039	0.0062	0.0074	0.17
Jun	0.011	0.0031	<0.0050	0.022	0.16	0.00053	0.0082	0.019	0.32
Jul	<0.010	0.0028	0.0051	0.014	0.11	0.00019	0.0057	0.011	0.21
Aug	<0.010	0.0027	<0.0050	0.020	0.19	0.00026	0.0061	0.022	0.19
Sep	0.011	0.0036	<0.0050	0.053	0.28	0.00081	0.010	0.033	0.42
Oct	<0.010	0.0042	<0.0050	0.045	0.25	0.00061	0.011	0.028	0.55
Nov	0.013	0.0034	<0.0050	0.036	0.26	0.00094	0.0082	0.022	0.46
Dec	<0.010	0.0038	<0.0050	0.037	0.16	0.00034	0.0066	0.025	0.48
Median	**<0.010**	**0.0033**	**<0.0050**	**0.023**	**0.16**	**0.00053**	**0.0087**	**0.022**	**0.34**
IQR[a]	**0.001**	**0.0009**	**—[b]**	**0.023**	**0.099**	**0.00044**	**0.0045**	**0.014**	**0.26**
EPL[c]	**0.2**	**0.06**	**0.14**	**0.62**	**1**	**0.01**	**0.61**	**0.2**	**3.0**
Median fraction of EPL	**<0.05**	**0.054**	**<0.036**	**0.037**	**0.16**	**0.053**	**0.014**	**0.11**	**0.11**

Note: Monthly values are presented with less-than signs when all weekly composite sample results for the month are below the detectable concentration

a IQR = Interquartile range.

b Because of the large number of nondetects, the interquartile range cannot be calculated for these metals. See Chapter 14, Quality Assurance.

c EPL = Effluent pollutant limit (LLNL Wastewater Discharge Permit 1997–1998 and 1998–1999).

Weekly and 24-hour composite sample concentrations for eight of nine regulated metals in LLNL sewage are each presented as a percentage of the corresponding effluent pollutant limit (EPL) in **Figure 6-5**; cadmium is not present because it was detected in less than five percent of the samples, with a maximum detected value of no more than 7.1% of the discharge limit. The EPL is equal to the maximum pollutant concentration allowed per 24-hour composite sample, as specified by the LLNL wastewater discharge permit. When a weekly sample concentration is at or above 50% of its EPL, the corresponding daily (24-hour composite) samples collected in the SMS must be analyzed to determine if any of their concentrations are above the EPL. As discussed in the following Environmental Impact section, in 1999, only one weekly composite sample concentration met this 50% action level, and no 24-hour composite sample concentrations were greater than the EPL.

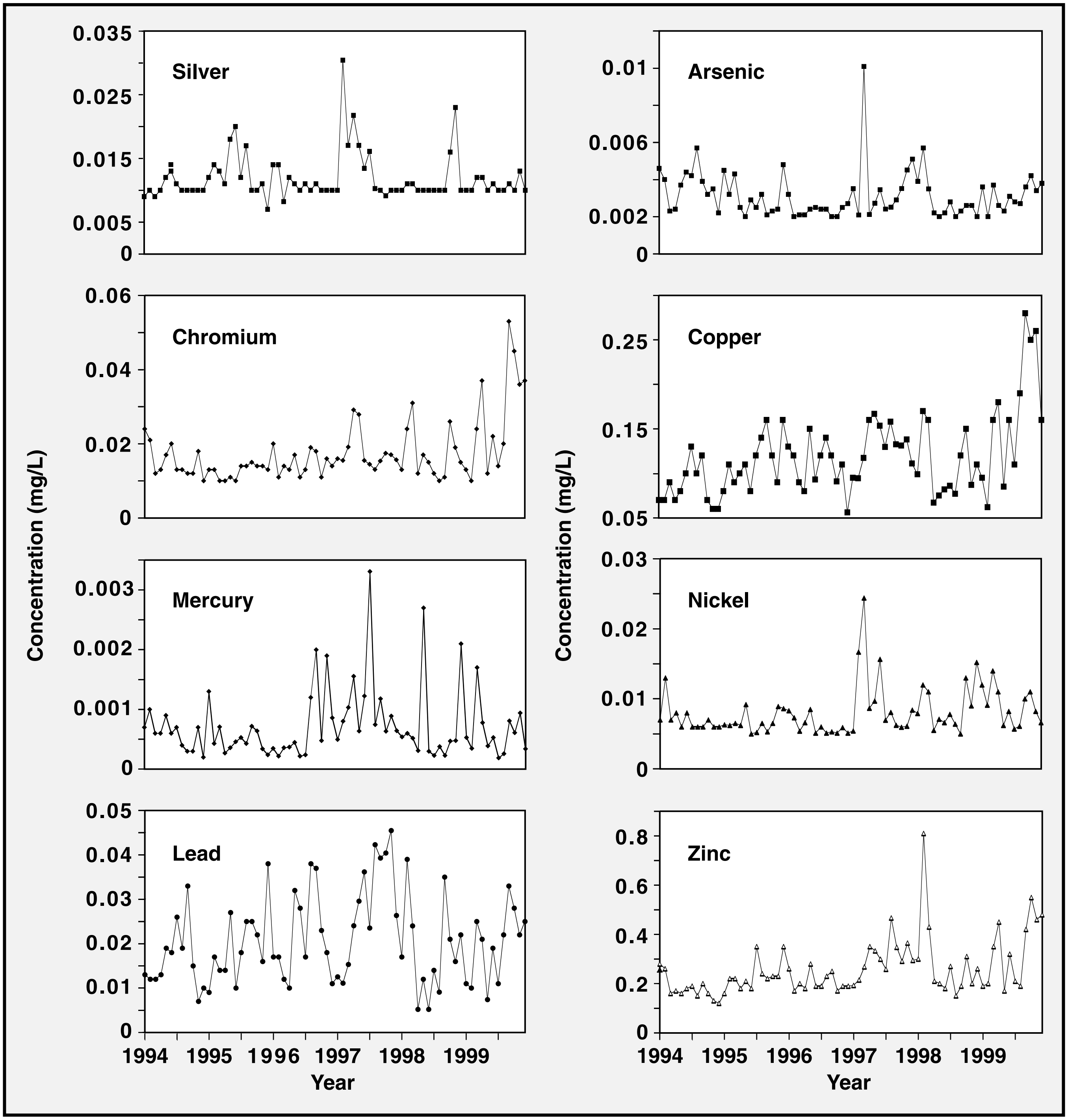

Figure 6-4. Average monthly concentrations for eight of the nine regulated metals in LLNL sanitary sewer effluent showing trends from 1994 to 1999.

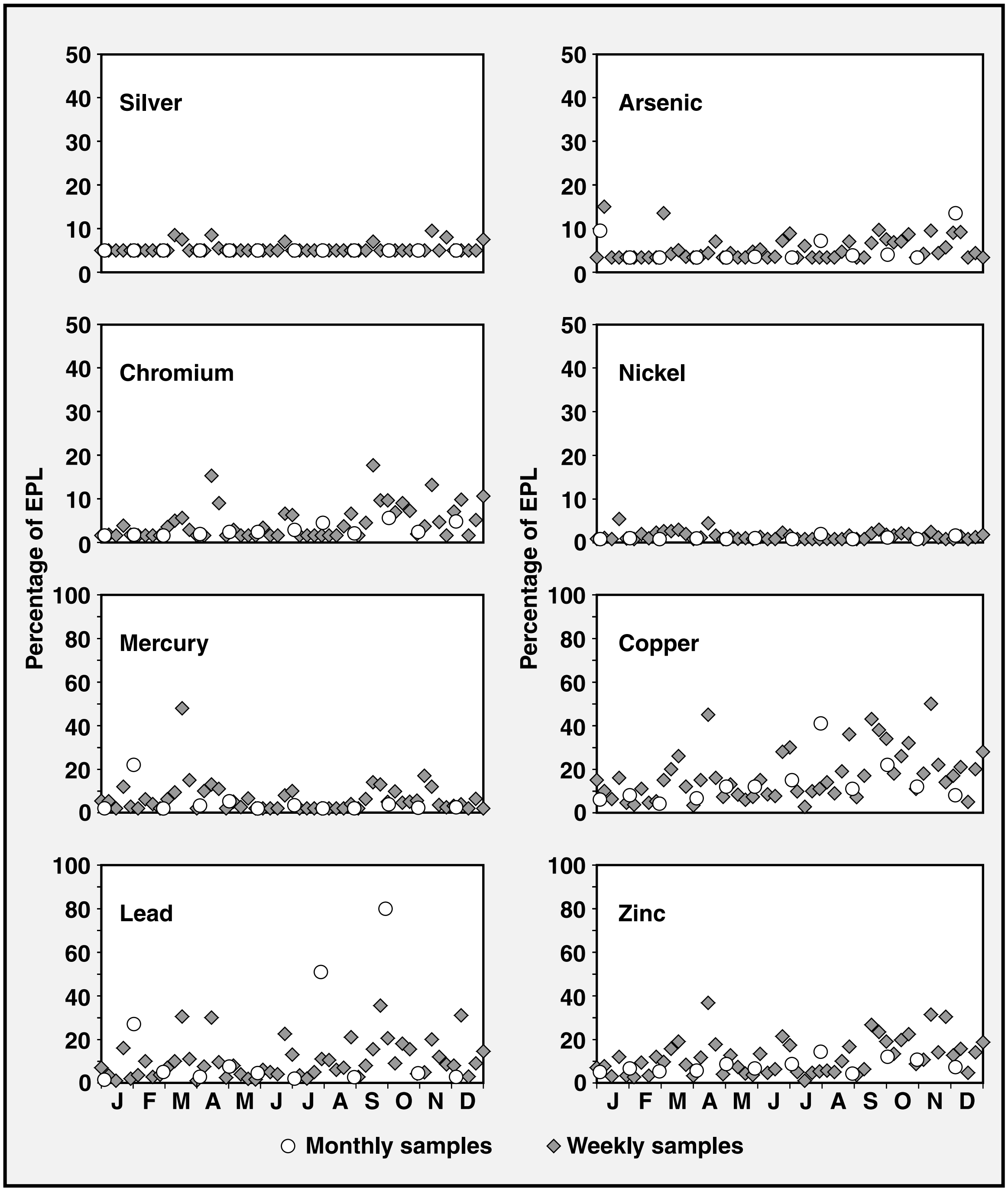

Figure 6-5. Results as percentages of effluent pollutant limits (EPLs) for eight of the nine regulated metals in LLNL sewage, 1999.

Detections of anions, metals, and organic compounds and summary data concerning other physical and chemical characteristics of the sanitary sewer effluent are provided in **Table 6-8**. (All of the corresponding analytical results are provided in the Data Supplement Table 6-7.) Although samples were analyzed for bromide, nitrite (as N), carbonate alkalinity (as $CaCO_3$), hydroxide alkalinity (as $CaCO_3$), selenium, and cyanide, those analytes were not detected in any sample acquired during 1999, and so are not presented in the table. The results are quite typical of those seen in previous years except the sampling frequency for two regulated parameters was decreased. LLNL decreased the sampling frequency for oil and grease, and cyanide in response to changes in sampling requirements made by the LWRP, as discussed in detail in the Data Supplement Chapter 6.

Environmental Impact

Table 6-7 presents monthly average and summary statistics for all regulated metals concentrations in LLNL's sanitary sewer effluent. At the bottom of the table, the annual median concentration for each metal is compared with the discharge limit. In 1999, the metals that approached closest to the discharge limits were copper, lead, and zinc at 16%, 11%, and 11%, respectively.

Although average monthly concentrations for chromium, mercury, nickel, and zinc have generally been slightly elevated for the last several years (see **Figure 6-4**), all of the individual weekly and 24-hour composite results for 1999 were less than 50% of the corresponding discharge limits. In fact, only one metal result met the 50% action level in LLNL's Wastewater Discharge Permit. In November 1999, a weekly composite sample had a copper concentration of 0.50 mg/L, or 50% of the discharge limit of 1.0 mg/L (see **Figure 6-5**). The daily samples that correspond to the appropriate weekly composite sampling period of November 11–17 were submitted for copper analysis. All of the analytical results for the daily samples were less than the effluent pollutant limit; no sample had a measured copper concentration greater than 0.09 mg/L.

In 1999, the SMS continuous monitoring system detected four discharges outside of the permitted pH range of 5 to 10. Two of the discharges were below pH 5 and two were above pH 10: all four discharges were captured in the SDF. For comparison, 2, 13, and 1 such diversions occurred in 1998, 1997, and 1996, respectively.

Table 6-8. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 1999.[a]

24-hour composite sample parameter (mg/L)	Detection frequency[b]	Minimum	Maximum	Median	IQR[c]
Alkalinity					
Bicarbonate alkalinity (as $CaCO_3$)	11/11	130	221	185	24
Total alkalinity (as $CaCO_3$)	11/11	130	221	185	23
Anions					
Bromide	2/12	<0.10	0.62	<0.11	—[d]
Chloride	10/12	22	63	44	12
Fluoride	10/12	<0.050	0.68	0.088	0.065
Nitrate (as NO_3)	2/12	<0.40	1.6	<0.40	—[d]
Orthophosphate	12/12	12	198	18	5.3
Sulfate	12/12	4.0	44	9.7	8.7
Nutrients					
Ammonia nitrogen (as N)	12/12	28	53	40	9.3
Total Kjeldahl nitrogen	12/12	0.61	60	46	15
Oxygen demand					
Biochemical oxygen demand	11/12	<75	305	140	112
Chemical oxygen demand	12/12	130	664	302	293
Solids					
Solid settling rate (mL/L/h)	12/12	19	62	27	14
Total dissolved solids	12/12	120	510	233	92
Total suspended solids	12/12	84	398	123	235
Volatile solids	12/12	55	380	255	150
Total metals					
Aluminum[e]	11/12	<0.20	1.2	0.49	0.29
Beryllium[e]	0/12	<0.00020	<0.0010	<0.00050	—[d]
Calcium	12/12	11	19	14	2.8
Iron[e]	12/12	0.55	3.2	1.7	0.94
Magnesium	12/12	1.9	4.6	2.8	0.68
Potassium	12/12	13	99	18	4.3
Sodium	12/12	21	64	36	11
Total organic carbon	12/12	31	94	47	18
Tributyltin (ng/L)	2/2	7.0	33	20	13

Table 6-8. Monthly monitoring results for physical and chemical characteristics of the LLNL sanitary sewer effluent, 1999 (concluded).[a]

Grab sample parameter	Detection frequency[b]	Minimum	Maximum	Median	IQR[c]
Semivolatile organic compounds (µg/L)					
Benzoic acid	3/12	<10	<300	<44	—[d]
Benzyl alcohol	5/12	<2.0	<100	<10	—[d]
Bis(2-ethylhexyl)phthalate[f]	6/12	<5.0	<200	<17	—[d]
Butyl benzyl phthalate[f]	1/12	<2.0	55	<5.0	—[d]
Diethylphthalate	6/12	4.9	<50	<10	—[d]
m- and p- Cresol	1/3	<5.0	<50	<19	—[d]
p- Cresol	3/9	<2.0	<50	<16	—[d]
Total cyanide (mg/L)	0/7	<0.02	<0.02	<0.02	—[d]
Oil and grease (mg/L)	4/4	14	23	20	3
Total recoverable phenolics (mg/L)	3/3	0.024	0.069	0.038	—[d]
Volatile organic compounds (µg/L)					
1,4-Dichlorobenzene	10/12	<0.50	3.6	1.5	0.73
Acetone	12/12	54	360	120	70
Benzene[f]	1/12	<0.50	<2.0	<0.50	—[d]
Chloroform[f]	12/12	8.5	23	14	5.8
Dichlorodifluoromethane	1/12	<0.50	<4.0	<0.50	—[d]
Methylene chloride[f]	2/12	<1.0	<2.0	<1.0	—[d]
Toluene[f]	7/12	<0.50	<2.0	0.71	0.67

a The 24-hour composite sample results plotted in **Figure 6-5** and nondetected values reported in the Data Supplement, Chapter 6, are not reported in this table.

b The number of times an analyte was positively identified, followed by the number of samples that were analyzed (generally 12, one sample for each month of the year).

c IQR = Interquartile range.

d When the detection frequency is less than or equal to 50%, there is no range, or there are less than four results for a sample parameter, the interquartile range is omitted.

e Weekly sampling results for these parameters are included Data Supplement Table 6-5.

f Indicates priority toxic pollutant parameter used in assessing compliance with the total toxic organic permit limit of 1 mg/L (1000 µg/L) issued by the Livermore Water Reclamation Plant.

Monitoring results for 1999 reflect an outstanding year for LLNL's sewerable water discharge control program and Livermore site personnel. LLNL achieved 100% compliance with the provisions of its wastewater discharge permit.