Characteristics of Effluents from Small Municipal Wastewater Treatment Facilities in 1994

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Since the early 1970s, 90% of the municipal wastewater effluents discharged directly to the Southern California Bight (SCB) have come from the four largest treatment facilities: Hyperion Wastewater Treatment Plant (City of Los Angeles), Joint Water Pollution Control Plant (JWPCP) of the County Sanitation Districts of Los Angeles County, Wastewater Treatment Plants 1 and 2 of County Sanitation Districts of Orange County (CSDOC), and Point Loma Wastewater Treatment Plant (PLWTP) of the City of San Diego. Southern California Coastal Water Research Project (SCCWRP) has published annual effluent constituent concentrations and mass emission estimates for these four facilities for two decades. In addition, there are 15 smaller municipal wastewater facilities that discharge to the SCB (Figure 1, Appendix 1). SCCWRP summarized the mass emissions from these facilities in 1971, 1987, 1989, and 1993 (SCCWRP 1973, 1989, 1990, 1995).

In contrast to the large facilities, the small municipal wastewater facilities discharge effluent through relatively short, shallow-water outfalls and thus provide a higher level of treatment to the sewage prior to discharge (SCCWRP 1990). However, as the mass emissions from the large facilities decline (see *Characteristics of Effluents from Large Municipal Wastewater Treatment Plants in 1994* in this report), the inputs to the SCB from the small facilities may become more significant. Hence, we will summarize the mass emissions from these facilities more frequently.

In this report, we summarize concentrations of effluent constituents and estimate mass emissions for the small municipal wastewater facilities for 1994 and discuss trends in mass emissions from these facilities since 1971.

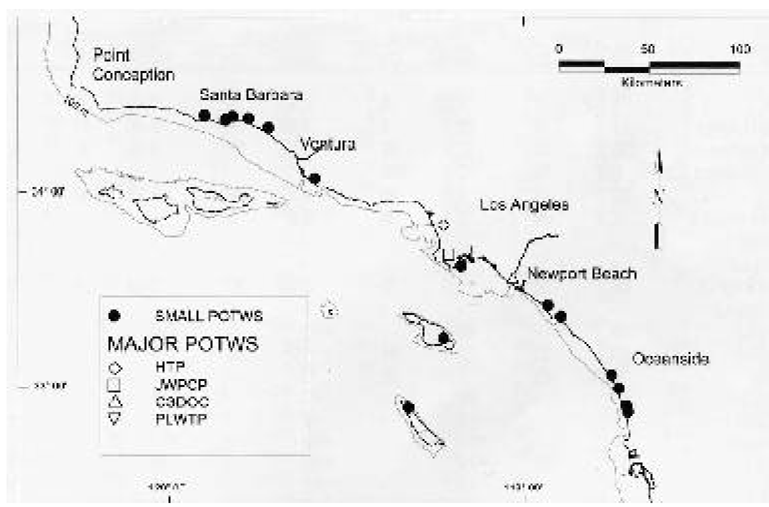

FIGURE 1. Locations of the municipal wastewater facilities that discharge to the Southern California Bight. POTWs = publicly owned treatment works; large POTWs (HTP = Hyperion Treatment Plant; JWPCP = Joint Water Pollution Control Plant; CSDOC = County Sanitation Districts of Orange County; PLWTP = Point Loma Wastewater Treatment Plant).

MATERIALS AND METHODS

We obtained data on effluent characteristics of the smaller facilities from the effluent monitoring data reports that are required by the Regional Water Quality Control Boards (Central Coast, Los Angeles, Santa Ana, and San Diego regions) under the National Pollutant Discharge Elimination System (NPDES) permits.

Monthly constituent concentrations below method detection limits were treated as zeros in calculations of annual mean constituent concentrations. If our calculated annual mean was below the method detection limit reported by the dischargers, we reported the method detection limit as the annual mean.

Monthly contaminant mass emissions were estimated from the product of mean daily flow and constituent concentration in month *i* and the number of days in the month. These were summed over all months to obtain the annual estimate (Appendix 2). Monthly constituent concentrations below the method detection limits were treated as zeros. If a constituent concentration was not analyzed for a certain month, had unacceptable results, or the sampling month was unknown (in the case of some quarterly measurements) the annual mean concentration was used in calculating mass for that month.

In past reports, effluent mass emissions were estimated from the product of the total annual flow and the mean annual constituent concentrations (SCCWRP 1973, 1989, 1990). If the annual mean constituent concentration was below the detection limit, the mass emissions were not estimated, even though there may have been measurable concentrations during some months. Beginning with SCCWRP (1995), mass emissions were estimated for all months with measurable concentrations even though annual mean constituent concentrations may have been below detection limits.

RESULTS

In 1994, the 15 small municipal wastewater facilities discharged 131 million gallons per day (mgd) (496 x 10^6 L/day) of treated effluent into the SCB (Table 1). Daily flow rates varied over three orders of magnitude among the small facilities. Most of the agencies provided secondary treatment, although the type of treatment ranged from a combination of primary/secondary to tertiary.

Also during 1994, three-quarters of the constituent concentrations varied by an order of magnitude or more (Table 2). At individual treatment plants, 35% of the annual mean constituent concentrations and toxicity values that were above method detection limits had coefficients of variation higher than 50%.

Mass emissions also varied greatly among facilities. Encina had the highest emissions of BOD, ammonia-N, arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc (Table 3). Carpinteria had the highest emissions of nonchlorinated phenols, DDT and PCB, and Terminal

TABLE 2. Means and coefficients of variation (CV) of annual constituent concentrations in effluents from small municipal

	Goleta		Santa Barbara		Montecito		Summerland		Carpinteria		Oxnard		Terminal Island	
Constituent	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
Flow (mgd)	4.62	7	7.05	5	0.87	4	0.12	11	1.31	6	17.4	3	16.1	6
Flow (million L/day)	17.5	7	26.7	5	3.29	4	0.45	11	4.96	6	65.9	3	60.9	6
Suspended solids (mg/L)	36.9	32	12.6	37	7.3	17	3.99	38	27	6	9.4	39	7	40
Settleable solids(mL/L)	0.2	35	0.3	226	-	-	-	-	0.2	39	<0.1	-	0.03	71
BOD (mg/L)	52.1	29	9.6	25	5.7	23	5.75	40	23	11	16.1	31	5	55
Oil & Grease (mg/L)	7.5	34	3.1	28	2.0	0	-	-	2.0	3	2	28	3.4	16
Nitrate-N (mg/L)	-	-	-	-	-	-	-	-	-	-	4.5	75	-	-
Nitrite-N (mg/L)	-	-	-	-	-	-	-	-	-	-	1.07	59	-	-
Ammonia-N (mg/L)	39.7	15	15.6	13	0.60	90	0.68	84	27.7	17	15	27	0.8	142
Organic N (mg/L)	-	-	-	-	-	-	-	-	-	-	3.5	61	-	-
Cyanide (µg/L)	<5	-	40	-	<10	-	10	-	10	141	40	48	<5	-
Turbidity (NTU)	33.1	18	3.2	51	1.0	16	-	-	12.9	34	3.5	39	2.9	34
Toxicity (TU)	0.76	43	0.85	69	0	-	-	-	10	0	0.42	70	0.11	234
Arsenic (µg/L)	<5	-	<5	-	<5	-	<5	-	3.1	141	2.3	22	3	40
Cadmium (µg/L)	<1[d]	-	<5	-	<2	-	<2	-	<1	-	<4	-	<1	-
Chromium (µg/L)	<5	-	<10	-	<10	-	<10	-	5	141	<10	-	<1[e]	-
Copper (µg/L)	33	50	<10	-	<10	-	10	-	<50	-	17.5	18	5	109
Lead (µg/L)	<5	-	<2	-	<2	-	<2	-	<5	-	<10	-	<2	-
Mercury (µg/L)	<0.5	-	<0.2	-	<0.2	-	<0.2	-	<1	-	<0.5	-	<0.3[d]	-
Nickel (µg/L)	<50	-	<10	-	<10	-	-	-	<10	-	22.2	20	<2	-
Selenium (µg/L)	<5	-	<5	-	-	-	-	-	-	-	-	-	25	81
Silver (µg/L)	<5	-	<10	-	<5	-	<5	-	<10	-	<4	-	<0.4	-
Zinc (µg/L)	<40	-	40	-	60	-	30	-	<50	-	17.5	37	44	13
Phenols (µg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorinated[f]	<10	-	<5	-	<50[d]	-	<50[d]	-	<10	-	<10	-	nd[h]	-
Nonchlorinated[f]	<10	-	<10	-	<50[d]	-	<50[d]	-	<10	-	<10	-	-	-
DDT (µg/L)	<0.02	-	<0.02	-	-	-	-	-	0.04	0	<0.2[d]	-	nd	-
PCB (µg/L)	<0.1	-	<0.5	-	-	-	-	-	<0.1	-	<0.8[d]	-	nd	-

[a]The number of significant figures are those reported by the agencies. See Appendix 1 for complete facility names.
[b]Carbonaceous BOD only.
[c]Ammonium.
[d]Maximum of the range of detection limits reported.
[e]Only includes chromium VI.
[f]EPA method 420.2 (Colorimetric method).

Municipal Wastewater Facility	Flow (mgd[a])	Level of Treatment
Goleta	4.6	Primary/Secondary
Santa Barbara	7.0	Secondary
Montecito	0.87	Secondary
Summerland	0.12	Tertiary
Carpinteria	1.3	Secondary
Oxnard	17.4	Secondary
Terminal Island	16.1	Secondary
Avalon	0.54	Secondary
San Clemente Island	0.018	Secondary
AWMA[b]	17.7	Secondary
SERRA[c]	16.2	Secondary
Oceanside	12.1	Secondary
Encina	20.3	Secondary
San Elijo + Escondido	17.2	Secondary
Total	131.4	

[a]See Appendix 1 for complete facility names.
[b]Aliso Water Management Agency.
[c]South East Regional Reclamation Authority.
mgd=million gallons per day (1 mgd = 3,785,000 L/day).

TABLE 1. Volume and level of effluent treatment for the small municipal wastewater treatment facilities that discharged to the Southern California Bight in 1994.

wastewater treatment plants that discharged to the Southern California Bight in 1994.

Avalon		San Clemente Island		AWMA		SERRA		Oceanside		Encina		San Elijo		Escondido	
Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
0.54	19	0.018	7	17.7	10	16.2	4	12.1	5	20.3	3	2.89	3	14.4	2
2.04	19	0.068	7	67.0	10	61.3	4	45.8	5	76.8	3	10.9	3	54.5	2
25	79	8.8	35	7.13	12	11.1	8	6.3	25	6.2	25	10.7	26	8.6	42
<0.1	-	nd	-	-	-	0.2	43	<0.1	-	0.06	7	0.3	94	<0.1	-
3	44	24	83	5.28[b]	9	5.3[a]	17	4.3[b]	24	24	22	25.0	29	6.2[b]	30
<5	-	3.2	227	2.0	141	<5	-	<2.5	-	0.8	58	1.1	51	0.5	95
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.26	79	0.19	-	15.9	63	17	15	18.7	20	21.0[c]	18	23	21	26	30
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
38	27	nd	-	<20	-	<20[d]	-	<20	-	22	169	nd	-	10	141
2.2	51	1.2	42	-	-	4.0	7	3.0	27	4.3	31	6	20	2.9	41
0.07	283	-	-	0	-	-	-	1.16	12	0.69	40	0.74	47	0.8	49
<100	-	nd	-	1.7	8	4	118	<10	-	5.9	72	1	200	<1.2	-
<5	-	nd	-	<1	-	<10	-	<3	-	30	41	5	200	<0.25	-
<10	-	nd	-	<1	-	<50[e]	-	<11	-	55	97	10	200	1	82
39	33	nd	-	6	141	13	151	<10	-	59	102	18	55	12	37
<100	-	nd	-	<1	-	<70	-	<70	-	97	41	nd	-	1.7	48
<0.2	-	nd	-	<0.5	-	<0.6	-	<1	-	<0.1	-	nd	-	<0.5	-
<20-	nd	-	48	141	<40	-	<25	-	91	65	83	30	16	37	
<20	-	-	-	2.65	19	-	-	-	-	-	-	-	-	<4	-
<10	-	nd	-	<1	-	<20	-	<10	-	47	98	15	86	<1	-
71	27	50	-	35	77	75	34	14	123	141	58	60	36	97	30
10[f]	173	nd[f]	-	-	-	-	-	-	-	-	-	20[g]	200	-	-
-	-	-	-	<10	-	<110	-	<10	-	<4	-	-	-	<50	-
-	-	-	-	<10	-	<240	-	<84	-	<42	-	-	-	<40	-
<0.02	-	nd	-	-	-	nd	-	<0.04	-	nd	-	nd	-	<0.1	-
<1	-	nd	-	-	-	nd	-	<0.1	-	nd	-	nd	-	<1	-

[g]EPA method 604 or 625 (GC/MS method).
[h]Only includes 2,4,6-trichlorophenol and pentachlorophenol.
BOD=biochemical oxygen demand.
mgd=million gallons per day.
nd=not detectable.
NTU=nephelometric turbidity units.
TUa=toxicity units.

TABLE 3. Estimates of constituent mass emissions from small municipal wastewater treatment facilities that discharged

Constituent	Goleta	Santa Barbara	Montecito	Summerland	Carpinteria	Oxnard	Terminal Island	Avalon	San Clemente Island
Flow[a] (L x 10^9/yr)	6.4	9.7	1.2	0.17	1.8	24	22	0.75	0.02
Suspended solids (mt)	238	123	8.8	0.69	50	223	158	21	0.22
BOD (mt)	336	94	6.9	1.0	41	384	118	2.0	0.59
Oil & Grease (mt)	49	30	2.4	-	3.7	58	76	0.48	0.08
Nitrate-N (mt)	-	-	-	-	-	107	-	-	-
Nitrite-N (mt)	-	-	-	-	-	26	-	-	-
Ammonia-N (mt)	255	151	0.72	0.11	50	359	17	0.20	0.005
Organic N (mt)	-	-	-	-	-	84	-	-	-
Cyanide (kg)	25	389	-	1.7	18	954	13	29	-
Arsenic (kg)	-	-	-	-	5.7	55	69	-	-
Cadmium (kg)	-	-	-	-	-	-	-	-	-
Chromium (kg)	-	-	-	-	9.2	-	-	-	-
Copper (kg)	214	-	-	1.7	-	418	104	30	-
Lead (kg)	2.6	-	-	-	-	27	-	-	-
Mercury (kg)	0.11	-	-	-	-	1.2	-	-	-
Nickel (kg)	-	-	-	-	9.2	534	28	-	-
Selenum	-	-	-	-	-	-	552	-	-
Silver (kg)	25	-	-	-	9.2	-	-	-	-
Zinc (kg)	189	389	72	5.2	46	420	980	54	1.2
Phenols (kg)	-	-	-	-	-	-	-	7[e]	-
Chlorinated[f]	-	-	-	-	-	-	-	-	-
Non-chlorinated[f]	-	-	-	-	8.9	-	-	-	-
DDT (kg)	-	-	-	-	0.07	-	-	-	-
PCB (kg)	-	-	-	-	0.09	-	-	-	-

[a]See Appendix 1 for complete facility names.
[b]Annual flow volumes are the sum of the mean daily flow per month times the number of days in each month.
[c]Only includes carbonaceous BOD.
[d]Ammonium.

Island had the highest emissions of oil and grease and selenium. Emissions of suspended solids were highest at SERRA, cyanide at Oxnard, mercury at Escondido, and total phenols at San Elijo.

The combined emission of all trace metals for all of the small facilities was 27 metric tons (mt). The combined mass emission of individual trace metals was below 5 mt for all metals except for zinc, which was 11 mt (Table 3). The combined emission of DDT and PCBs were less than 0.1 kg each.

The small facilities accounted for 11% of the total volume of municipal wastewater discharged to the SCB in 1994, but only 2% of the suspended solids, oil and grease, and BOD (Table 4). Relative to flow, the small facilities contributed a disproportionately low share of ammonia, arsenic, copper, and DDT. They contributed the majority of the mass emissions of lead and cadmium, and a disproportionately high share of cyanide, chromium, mercury, nickel, silver, and zinc.

DISCUSSION

The annual mean constituent concentrations varied considerably among the wastewater treatment facilities due to the type of wastes treated (domestic and industrial), source control, the volume of water removed for reclamation and inland discharge, and the efficiency and degree of treatment (primary, secondary, or tertiary). The monthly concentrations of some constituents also varied substantially at individual treatment plants. Coefficients of variation higher than 100% generally were due to a high proportion of monthly concentrations below detection limits.

The combined volume of effluent discharged from the small facilities decreased (3%) from 1993 (SCCWRP 1995) to 1994 (Table 5). The combined mass emissions of 63% of the constituents decreased during this period. Silver and arsenic increased the most and DDT, cyanide, and lead decreased the most.

The majority of contributions of the small facilities to the combined municipal wastewater flow and mass emissions of the large and small facilities has decreased or remained the same from 1993 to 1994 (Table 6). Effluent discharge from the small facilities remained at 11% from 1993 (SCCWRP 1995) to 1994. The contribution by the small facilities of suspended solids decreased from 3 to 2%, whereas BOD, and oil and grease remained at 2% during this period. Mercury decreased the most in percent contribution (from 33 to 21%) and silver increased the most (from 10 to 20%).

to the Southern California Bight in 1994[a].

AWMA	SERRA	Oceanside	Encina	San Elijo	Escondido	Total
24	22	17	28	4.0	20	181
175	248	104	174	43	170	1,737
129[c]	118[c]	72[c]	683	100	122[c]	2,207
48	41	31	23	4.5	9.7	377
-	-	-	-	-	-	107
-	-	-	-	-	-	26
389[c]	392	312	589[d]	93	510	3,118
-	-	-	-	-	-	84
-	-	-	611	-	196	2,237
42	76	-	164	5.0	23	440
-	-	-	843	20	4.2	867
-	-	-	1,550	40	20	1,619
147	251	42	1,675	70	228	3,181
-	-	-	2,734	-	33	2,797
-	-	-	0.98	-	5.5	7.8
1158	-	-	2,545	329	306	4,909
65	-	-	-	-	23	640
-	-	-	1,312	60	-	1,406
855	1,622	227	3,971	240	1,915	10,986
-	-	-	-	80[c]	-	87
-	-	-	-	-	-	-
-	-	-	-	-	-	8.9
-	-	-	-	-	-	0.07
-	-	-	-	-	-	0.09

[e]EPA method 420.2 (Colorimetric method).
[f]EPA method 604 or 625 (GC/MS method).
BOD=biochemical oxygen demand.
mt=metric tons.

The annual combined volume of effluent discharged from the small municipal wastewater treatment facilities increased 90% from 1971 to 1994 (Figure 2) and the mass emission of ammonia nearly doubled (Table 5) (SCCWRP 1973). However, mass emissions of oil and grease decreased 91%, BOD decreased 80%, suspended solids decreased 79%, and cyanide decreased 73%. After 1987, trace metal emissions decreased with the exception of arsenic and silver; mercury decreased the most.

Since 1971, the contribution of flow from the small wastewater treatment plants to the combined municipal wastewater discharge of the large and small facilities increased from 7 to 11% (Table 6). Oil and grease, BOD, and suspended solids contributions have all decreased to 2% from 6, 4, and 3% respectively (Figure 3-5). Although emissions of cyanide since 1971 and most trace metals since 1987 have decreased, their contributions have increased. This is due to the higher rate of decrease in mass emissions of trace metals and cyanide at the large facilities than at the smaller facilities from 1971 to 1993. The greatest increases were in lead (from 10 to 68%), followed by cadmium (16 to 56%), silver (5 to 20%), and chromium (4 to 19%). The exception is mercury which decreased from 31 to 21%.

In recent years, the number of effluent monitoring analyses reporting concentrations below detection limits (BDL) has increased. Effluent constituent concentrations have decreased due to source control and increased and improved treatment. If detection limits of the recommended or required techniques are below discharge permit requirements, then BDL results are in compliance with permit requirements. However, BDL results complicate the assessment of total and long-term trends of mass emission into the SCB.

CONCLUSIONS

The volume of discharge and the majority of constituent mass emissions from the small municipal wastewater facilities to the SCB decreased from 1993 to 1994. The contribution of the small facilities to the combined discharge of municipal wastewater flow of the small and large municipal wastewater facilities remained at 11% from 1993 to 1994.

As mass emissions from the large facilities decline, a number of constituent inputs to the SCB from the small facilities have become more significant. The small facilities now contribute the majority of cadmium and lead to the

TABLE 4. Estimates of constituent mass emissions from large (>150 mgd, n=4) and small (<25 mgd, n=15) municipal wastewater treatment facilities that discharged to the Southern California Bight in 1994.

	Mass Emissions			Percent of Total	
Constituent	Large[a]	Small[b]	Total	Large	Small
Flow (mgd)	1,069	131	1,200	89	11
Suspended solids (mt)	68,126	1,737	69,863	98	2
BOD (mt)	132,257	2,207	134,464	98	2
Oil and Grease (mt)	18,534	377	18,911	98	2
Ammonia-N (mt)	41,106	3,118	44,224	93	7
Cyanide (mt)	12	2.2	14	85	15
Arsenic (mt)	4.0	0.4	4.4	91	9
Cadmium (mt)	0.7	0.9	1.6	44	56
Chromium (mt)	6.7	1.6	8.3	81	19
Copper (mt)	49	3.2	52	94	6
Lead (mt)	1.3	2.8	4.1	32	68
Mercury (mt)	0.03	0.008	0.04	79	21
Nickel (mt)	28	4.9	33	85	15
Silver (mt)	5.7	1.4	7.1	80	20
Zinc (mt)	72	11	83	87	13
DDT (kg)	7.9	0.07	8	99	1
PCB (kg)	nd	0.09	0.09	-	-

[a]Hyperion Wastewater Treatment Plant (City of Los Angeles), Joint Water Pollution Control Plant of the County Sanitation Districts of Los Angeles County, Wastewater Treatment Plants 1 and 2 of County Sanitation Districts of Orange County, and Point Loma Wastewater Treatment Plant (City of San Diego).
[b]Facililites covered in this report.
BOD = biochemical oxygen demand.
mgd=millions of gallons per day (1 mgd=3,785,000 L/day).
mt=metric tons.
nd = non detectable.

combined emissions of the large and small municipal wastewater facilities. Thus, it is important to monitor mass emissions from the small facilities as well as the large facilities.

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TABLE 5. Combined estimate of mass emissions of constituents from the 15 small (<25 mgd) municipal wastewater treatment facilities that discharged to the Southern California Bight from 1971 to 1994.

	Mass Emissions					Percent Change		
Constituent	1971[a]	1987[b]	1989[c]	1993[d]	1994	1971-1994	1987-1994	1993-1994
Flow (mgd)	69	132	137	135	131	90	-1	-3
Suspended solids (mt)	8,200	4,193	2,984	2,297	1,737	-79	-59	-24
BOD (mt)	11,000	5,178	4,751	2,285	2,207	-80	-57	-3
Oil and Grease (mt)	4,200	708	460	425	377	-91	-47	-11
Ammonia-N (mt)	1,600	1,757	2,716	3,668	3,118	95	77	-15
Cyanide (mt)	8	1.7	0.67	3.6	2.2	-73	29	-39
Arsenic (mt)	-	0.43	0.84	0.32	0.44	-	2	38
Cadmium (mt)	-	1.7	0.53	1.2	0.87	-	-49	-28
Chromium (mt)	-	2.3	0.84	1.5	1.6	-	-30	7
Copper (mt)	-	6.9	3.4	4.5	3.2	-	-54	-29
Lead (mt)	-	6.5	2.9	4.6	2.8	-	-57	-39
Mercury (mt)	-	0.18	0.23	0.01	0.008	-	-96	-20
Nickel (mt)	-	5.5	2.8	4.2	4.9	-	-11	17
Silver (mt)	-	0.87	0.58	0.71	1.4	-	61	97
Zinc (mt)	-	16	12	11	11	-	-31	0
DDT (kg)	-	nd	nd	0.91	0.07	-	-	-92
PCB (kg)	-	nd	nd	0.09	0.09	-	-	0

[a]SCCWRP (1973).
[b]SCCWRP (1989).
[c]SCCWRP (1990).
[d]SCCWRP (1995).

TABLE 6. Contributions of constituent mass emissions from small municipal wastewater treatment facilities to the combined municipal wastewater discharged to the Southern California Bight for 1971, 1987, 1993, and 1994.

	Contribution of Small Facilities as % of Total[a]				Difference in Percent Contribution		
Constituent	1971	1987	1993	1994	1971-1994	1987-1994	1993-1994
Flow	7	10	11	11	4	1	0
Suspended solids	3	3	3	2	-1	-1	-1
BOD	4	3	2	2	-2	-1	0
Oil & grease	6	3	2	2	-4	-1	0
Ammonia-N	3	4	8	7	4	3	-1
Cyanide	4	6	20	15	11	9	-5
Arsenic	-	3	5	9		6	4
Cadmium	-	16	67	56		40	-11
Chromium	-	4	18	19		15	1
Copper	-	5	9	6		1	-3
Lead	-	10	72	68		58	-4
Mercury	-	31	33	21		-10	-12
Nickel	-	7	12	15		8	3
Silver	-	5	10	20		15	10
Zinc	-	6	12	13		7	1
DDT	-	-	9	1			-8
PCB	-	-	-	-			

[a]Total = Combined municipal wastewater from the small and large municipal wastewater treatment facilities.
BOD = biochemical oxygen demand.

APPENDIX 1.

Names of the governing agencies and the small municipal wastewater treatment facilities that discharged to the Southern California Bight in 1994.

CENTRAL REGIONAL WATER QUALITY CONTROL BOARD

Goleta Sanitary District - Goleta Wastewater Treatment Plant
City of Santa Barbara - El Estero Wastewater Treatment Plant
Montecito Sanitary District - Montecito Wastewater Treatment Plant
Summerland Sanitary District - Summerland Wastewater Treatment Plant
Carpinteria Sanitary District - Carpinteria Wastewater Treatment Plant

LOS ANGELES REGIONAL WATER QUALITY CONTROL BOARD

City of Oxnard - Perkins Wastewater Treatment Plant
City of Los Angeles - Terminal Island Wastewater Treatment Plant
City of Avalon - Santa Catalina Island Sewage Treatment Plant
US Navy - Navy Auxiliary Landing Field - San Clemente Island Sewage Treatment Plant

SAN DIEGO REGIONAL WATER QUALITY CONTROL BOARD

AWMA (Aliso Water Management Agency) - Aliso Ocean Outfall
- El Toro Wastewater Reclamation Plant
- Los Alisos Wastewater Treatment Plant
- AWMA Joint Regional Treatment Plant
- AWMA Coastal Water Treatment Plant

SERRA (South East Regional Reclamation Authority) - SERRA Ocean Outfall
- Capistrano Beach Wastewater Treatment Plant
- Moulton Niguel Water District 3A Treatment Plant
- City of San Clemente Wastewater Treatment Plant
- Santa Margarita Water District
  - Oso Creek Water Reclamation Plant
  - Chiquita Water Reclamation Plant
- Jay B. Latham Regional Wastewater Treatment Plant

City of Oceanside Water Utilities Department - Oceanside Ocean Outfall
- La Salina Wastewater Treatment Plant
- San Luis Rey Wastewater Treatment Plant
- Fallbrook Sanitary District, Plant 1 and Plant 2

Encina Wastewater Authority - Encina Ocean Outfall
- Meadow Lark Water Reclamation Plant
- Shadow Ridge Water Reclamation Plant
- Gafner Water Reclamation Plant

San Elijo Joint Powers Authority - San Elijo Water Pollution Control Facility
- City of Escondido, Hale Avenue Resource Recovery Facility (treated separately from San Elijo).

APPENDIX 2.

Mass Emission Equation

Annual mass emissions (ME) of constituents were estimated from:

$$ME = \sum_{i=1}^{12} (F_i C_i D_i)$$

where

F_i = mean daily flow in month *i*:
C_i = constituent concentration in month *i*, or annual mean concentration (for months not measured); and
D_i = number of days in month *i*.