Characteristics of effluents from small municipal wastewater treatment facilities in 2000

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ABSTRACT - Nineteen publicly owned treatment plants (POTWs) discharge treated wastewater directly to the coastal ocean within the SCB. Fifteen of these, the small POTWs, are characterized by discharges of less than 25 million gallons per day (mgd). This study characterized the effluents of small POTWs for the year 2000 and evaluated the historical trends in small POTW discharges since 1971, paying particular attention to the changes in effluent quality and volume since 1995. Additionally, the relative significance of small POTWs to pollutant loading in the SCB was determined by comparison to annual discharges from large POTWs.

The total effluent flow from small POTWs in 2000 was 140 mgd (194 x 10^9 L), a 2% decrease from flows recorded in 1995. Mass emissions from small POTWs decreased for the majority of the constituents evaluated, many by more than 50%. Only two pollutants showed an increase in cumulative small POTW mass emissions from 1995 levels including BOD (46%) and oil/grease (22%). In 2000, small POTWs contributed approximately 12% of the combined wastewater discharge generated by the large and small POTWs, and an average of 8% of the pollutant load among the constituents evaluated. Small POTWs represent a minor source of pollutants to the SCB when compared to large POTWs; however, they nevertheless necessitate intermittent assessments of this type so that environmental managers may continue to monitor the status of this point source.

INTRODUCTION

The coastal ocean within the Southern California Bight (SCB) is an important recreational and economic resource. As home to almost 17 million people (U.S. Census Bureau 2002), southern California is one of the most densely populated coastal regions in the U.S. (Culliton *et al*. 1990). More than 175 million beach-goer days occur annually, helping to drive a tourism industry that generates an estimated $9 billion in ocean-related activities each year (Schiff *et al*. 2002). The significance of the coastal ocean as a recreational resource is mitigated by its necessity for other purposes, many of which result in the discharge of pollutants to coastal waters. Among these sources of contaminants are treated municipal wastewater, industrial effluents, stormwater runoff, and discharges from power generating stations, oil platforms, and dredging projects.

Nineteen POTWs discharge treated municipal and industrial wastewater directly to the SCB. Fifteen of these, the small POTWs, are characterized by effluent discharges of less than 25 mgd (Figure 1, Appendix I).

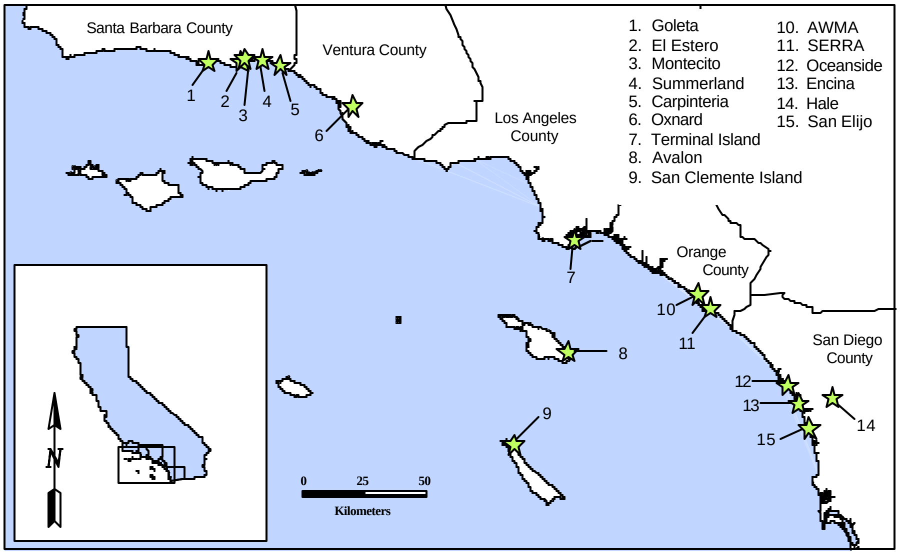

Figure 1. Locations of the small municipal wastewater treatment facilities that discharge to the SCB.

The four remaining POTWs (large POTWs) discharge more than 100 mgd each. Historically, small POTWs have represented only a minor fraction of the total volume and constituent load from large and small POTWs combined (SCCWRP 1973, 1989, Schafer 1990, SCCWRP 1995, Raco-Rands 1996). As large POTW facilities continue to improve source control and pre-treatment capabilities, small POTWs have the potential of becoming a more significant source of contaminants to the SCB. As a result, they remain an important management concern.

Each of the small POTWs self-monitors its discharges under individual National Pollutant Discharge Elimination System (NPDES) permits. In addition, three separate Regional Water Quality Control Boards (Los Angeles RWQCB, Santa Ana RWQCB, and San Diego RWQCB) conduct regulatory assessments on a per-facility basis. As a result, there has been little need for a standard monitoring program. The lack of such a program, however, has resulted in dissimilar monitoring and reporting frequencies, analytical methods, target analytes, and method sensitivities (e.g., detection limits) among small POTWs. Moreover, calculation methods utilized to estimate effluent quality, such as annual average concentrations and mass emissions, also vary by facility. The lack of a standard management system may not impair regulation of the individual facilities; however, dissimilar data pose a considerable technical challenge for the purpose of conducting regional-scale assessments of pollutant loading from small POTWs.

The objective of this study was to compile and calculate effluent characterization data for each of the small POTWs, thus enabling the conduct of regional assessments among facilities. The objective was accomplished in three steps. First, a unified data management system was developed so that annual average flows, concentrations, and mass emissions for all small POTWs could be calculated using a single standardized methodology. Second, concentration and mass emission estimates were computed for all small POTW dischargers in 2000, and were compared to historical mass emission estimates for these facilities. Third, emissions from small POTWs were compared to emissions from large POTWs in an effort to gauge the relative significance of this source.

METHODS

Effluent data were obtained from monthly, quarterly, and annual discharge monitoring reports from the individual small POTWs. The constituents chosen for this assessment did not represent the entirety of wastewater analyses conducted by the individual agencies. Specific parameters were chosen based on the existence of data for consistent historical comparisons, and based on the known influence of these constituents in the marine environment. These parameters included general constituents such as suspended solids, BOD, oil and grease, various metals, nutrients, DDTs, PAHs, PCBs, and toxicity.

Annual average flow-weighted concentrations (FWC) and mass emission estimates (ME) were calculated based on small POTW self-monitoring results for the calendar year 2000. Mass emission estimates were calculated from the product of the mean daily flow, the constituent concentration, the number of days in the given month, and a unit conversion factor. Mass emissions were calculated for each constituent for each month, and were then summed over all months in the year to obtain an annual estimate:

$$ME_{const} = \sum_{i=1}^{12} \mu\,(F_i * C_i * D_i)$$

where

ME_{const} = Mass emissions of a particular constituent
F_i = Mean daily flow in month i
C_i = Constituent concentration for month i
D_i = Number of days of discharge in month i
μ = Unit conversion factor (varies depending on units of concentration measurement)

The FWCs were calculated by dividing the annual mass emission for a given constituent by the total annual volume of effluent. This calculation was then corrected by a unit conversion factor to obtain the proper units for the specific parameter:

$$FWC_{const} = \mu * \frac{ME_{const}}{AEV}$$

where

FWC_{const} = Flow-weighted concentration of a particular constituent
μ = Unit conversion factor (varies depending on

units of concentration measurement)
ME_{const} = Mass emissions of a particular constituent
AEV = Annual effluent volume

This scheme for estimating FWC often resulted in average levels below the RL for a constituent when one or more months had non-detectable quantities (which were assigned a value of zero for calculations). Where this was the case, the FWC was reported as not detected (nd).

Effluent volume was the product of the month-averaged mean daily flow (provided by the agencies) and the number of days of discharge in the given month. Annual effluent volumes were then a sum of these monthly volumes:

$$AEV = \sum_{i=1}^{12} \mu (F_i * D_i)$$

where

AEV = Annual effluent volume
F_i = Mean daily flow in month i
D_i = Number of days of discharge in month i
μ = Unit conversion factor (varies depending on units of concentration measurement)

In order to perform these calculations, the chemistry data were standardized to monthly time steps. For constituents analyzed at a frequency greater than once per month, this entailed calculation of an arithmetic mean of all samples in a given month. Where the frequency of constituent analysis was less than monthly, an arithmetic average of available data within the given year was calculated. This average was then used to populate months for which no data existed. This latter manipulation was based on the assumption that the given constituent concentrations were temporally consistent for any given month in the year. Furthermore, constituent measurements below the RLs were assigned to zero for calculating average effluent concentrations.

Analytical methods (Appendix II), reporting levels (Appendix III), and measurement frequency were obtained either from laboratory reports, discharge monitoring reports, or from personnel at the individual facilities. Reporting levels (RL) varied among facilities for individual constituents. When there was more than one RL used during the year for a given constituent and facility, all were reported. However, the greatest RL was used for reporting non-detected values in annual average concentrations. Method detection limits (MDLs) were used in place of RLs whenever RLs were not available. Significant figures were retained in reporting the detection levels used by the facilities, and/or contract laboratories, for effluent chemical analyses.

Historical data for small POTWs were obtained for 1971, 1987, 1989, 1993, 1994, and 1995 (Raco-Rands 1996). Information for 1971, however, only included data describing the flow from small POTWs and selected general constituents, including suspended solids, BOD, oil/grease, ammonia-nitrogen, and cyanide. Metal and pesticide analyses were added in 1987. Historical trends in small POTW effluent were, therefore, analyzed mostly in terms of changes since 1987 and 1995.

Small POTW mass emissions from 1987 to 2000 were also compared to information from large POTWs over the same time period in order to gauge the relative significance of this point source to contaminant loading in the SCB. These data were compared in terms of percent contributions to the total load from small and large POTWs combined. Data from large POTWs were obtained from reports conducting similar assessments of large POTW discharges to the SCB (Steinberger and Schiff 2003). In order to evaluate the bias of varying RLs using our standard technique of assigning zero for non-detected values, pollutant loads for the small and large POTWs were also calculated using the RL or MDL in place of zeros for the year 2000.

RESULTS

Small POTW Discharges in 2000

The combined average flow from all 15 municipal wastewater treatment facilities in 2000 was approximately 140 mgd (Table 1). Average annual flows at the individual facilities ranged from 0.02 mgd (0.02 x 10^9 liters/year) at the Summerland Sanitary District to 22.9 mgd (32 x 10^9 liters/year) at the Encina Wastewater Authority. The total volume of treated effluent discharged by the small POTWs in 2000 was 51,255 million gallons (194 x 10^9 liters). Six facilities accounted for nearly 80% of this total effluent volume: the Aliso Water Management Agency (AWMA), Encina Wastewater Treatment Plant (WTP), Hale Resource Recovery Facility (Hale), Oxnard WTP, Southeast Regional Reclamation Authority (SERRA), and Terminal Island WTP.

Most of the facilities examined in this study provided a minimum of secondary treatment for wastewater discharged to the SCB (Table 1). The

Table 1. Flow rates and pre-treatment levels of the small POTWs in 2000.

Municipal Wastewater Facility	Effluent Flow (mgd)	Level of Treatment
Avalon	0.52	Secondary
AWMA	17.6	Secondary/Tertiary[a]
Carpinteria	1.5	Secondary
El Estero	6.0	Secondary/Tertiary[a]
Encina	22.9	Secondary/Tertiary[a]
Goleta	4.7	Primary/Secondary
Hale	14.3	Secondary/Tertiary[a]
Montecito	1.1	Secondary
Oceanside	12	Secondary/Tertiary[a]
Oxnard	21	Secondary
San Clemente Island	0.02	Secondary
San Elijo	3.0	Secondary
SERRA	18.7	Secondary
Summerland	0.14	Tertiary
Terminal Island	15.9	Secondary
TOTAL	**139.9**	

mgd = Millions of gallons per day.

other purposes; effluent discharged to the SCB only undergoes secondary treatment.

Goleta Sanitary District discharged a mix of primary and secondary treated effluent, and the Summerland Sanitary District discharged only wastewater that had undergone full tertiary treatment.

The 15 small POTWs had differing frequencies of effluent analysis, largely as a reflection of the different monitoring requirements in their NPDES permits (Table 2). The frequency of metal analyses for the small POTWs ranged from weekly to annually. Suspended solids, oil/grease, BOD, settleable solids, turbidity, and nutrient (N and P) measurements varied widely, ranging from daily to quarterly, although monthly analyses were typical for these parameters for the majority of facilities. Analyses of total DDTs, total PCBs, total PAHs, and phenols varied from monthly to once every two years. Chronic and acute toxicity bioassays were conducted monthly to annually.

A few of the small POTWs were not required by their permits to measure many of the constituents included in this study. In particular, Terminal Island was not required to measure phenolic compounds, and the City of Santa Barbara was not required to analyze for metals or selected organics in 2000. For the City of Santa Barbara, these parameters had been tested for in 1999, and were not detected in any measurable quantities. According to the permit for the City of Santa Barbara, the El Estero Wastewater Treatment Plant was thereafter only required to submit a quarterly certification that these compounds are not added to their waste stream.

Of those facilities that did routinely measure constituent concentrations, 56% of the constituents measured for each facility had a coefficient of variation (CV) less than 50% (Table 3). CVs greater than 100% (22% of constituents) were characteristic of constituents that often had measurements below detection limits, therefore increasing the variability. Based on the calculation of the median CV for each constituent, organic constituents, toxicity bioassays, cyanide, and several metals had the highest measurement variabilities for small POTWs in 2000.

Annual average concentrations for general constituents typically varied by less than two orders of magnitude among facilities for a given constituent (Table 4). The greatest variance in effluent concentration among all 15 facilities occurred for oil/grease, for which the annual average concentrations varied by three orders of magnitude, ranging from 0.07 mg/L (Summerland) to 17 mg/L (Oceanside). Suspended solids concentrations ranged from 1.9 mg/L (Summerland) to 40 mg/L (Goleta), and BOD concentrations ranged from 0.51 mg/L (Summerland) to 62 mg/L (Goleta).

Most trace metals were not detected from small POTW effluents in 2000 (Table 4). Zinc was detected by all but three facilities (Avalon, San Clemente, and Summerland), and was not a required analysis by the City of Santa Barbara. The majority of the cadmium, chromium, and mercury measurements (86%) were below detection limits; 79% of the selenium and silver measurements were below detection limits; 71% of the arsenic measurements were below detection limits; and 57-64% of the nickel, lead, and copper measurements were below detection limits. All metals with the exception of selenium were detected in effluent from the Goleta Sanitary District.

The small POTWs rarely detected concentrations of organic compounds in 2000 (Table 4). Phenolic

Table 2. Frequency of constituent analyses for small POTWs in 2000.

Constituent	Avalon	AWMA	Carpinteria	El Estero	Encina	Goleta	Hale	Montecito	Oceanside	Oxnard	San Clemente Island	San Elijo	SERRA	Summerland	Terminal Island
Suspended Solids	Monthly	Monthly	1/ 6 days	Daily	Daily	5/week	Monthly	1/ 6 days	Daily	Daily	Monthly	Daily	Monthly	1/ 6 days	Weekly
Settleable Solids	Monthly	Monthly	Daily	Daily	Daily	5/week	Monthly	Daily	Daily	Daily	Monthly	Daily	Monthly	Daily	Weekly
BOD	Monthly	na	1/ 6 days	na	Daily	5/week	Monthly	1/ 6 days	Monthly	Daily	1-5/month	Monthly	2/month	1/ 6 days	Weekly
CBOD	na	Monthly	na	1/ 6 days	Daily	na	Monthly	na	Daily	na	Monthly	Daily	Monthly	na	na
Oil/Grease	Quarterly	Monthly	1/ 6 days	1/ 6 days	Daily	2/week	Monthly	Monthly	Monthly	Daily	Monthly	Monthly	Monthly	Monthly	Weekly
Ammonia-N	Quarterly	Monthly	Monthly	Monthly	Daily	Monthly	Monthly	Monthly	Monthly	Weekly	2/month	Monthly	Monthly	Monthly	Monthly
Nitrate-N	Quarterly	na	na	na	na	na	na	na	Quarterly	Monthly	Monthly	na	na	na	na
Nitrite-N	na	na	na	na	na	na	na	na	Quarterly	Monthly	Monthly	na	na	na	na
Organic-N	na	na	na	na	na	na	na	na	na	Monthly	na	na	na	na	na
ortho-Phosphate	na	na	na	na	na	na	na	na	Quarterly	na	na	na	na	na	na
Cyanide	Annually	Quarterly	Semiannually	na	Quarterly	Annually	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Monthly
Turbidity	Monthly	Monthly	1/ 6 days	Daily	Daily	5/week	Monthly	1/ 6 days	Daily	Daily	Monthly	Monthly	Monthly	1/ 6 days	Daily
Acute Toxicity	-	-	-	-	-	-	Monthly	na	-	-	-	-	-	na	-
Pimephales promelas (survival)	-	Monthly	Quarterly	Quarterly	Monthly	Monthly	-	-	Monthly	Monthly	3/year	Quarterly	Monthly	-	Monthly
Gasterosteus aculeatus (survival)	Quarterly	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Menidia beryllina (survival)	-	-	-	Quarterly	-	-		-	-	-	-	-	-	-	-
Chronic Toxicity	-	-	-	-	-	-	Monthly	-	-	-	-	-	-	-	-
Atherinops affinis (growth)	-	-	-	-	-	-	-	-	-	-	4/year	-	-	-	-
Atherinops affinis (survival)	-	-	-	-	-	-	-	-	-	-	4/year	-	-	-	-
Dendraster excentricus (fertilization)	-	-	-	-	-	-	-	-	Monthly	-	-	-	-	-	-
Haliotis rufescens (development)	-	-	-	-	-	Quarterly	-	-	-	-	-	-	-	-	Monthly
Macrocystis pyrifera (germination)	-	-	-	-	-	-	-	Annually	-	-	3/year	-	-	-	-
Macrocystis pyrifera (germination/growth)	-	-	-	-	-	-	-	-	-	-	-	-	Monthly	-	-
Macrocystis pyrifera (growth)	-	-	-	-	-	-	-	Annually	-	-	3/year	-	-	-	-
Menidia beryllina (growth)	-	-	-	-	Monthly	-	-	Annually	-	-	-	-	-	Annually	-
Menidia beryllina (survival)	-	-	-	-	Monthly	-	-	Annually	-	-	-	-	-	Annually	-
Mytilus edulis (development)	-	-	-	-	-	-	-	-	-	-	-	Quarterly	-	-	-
Strongylocentrotus purpuratus (fertilization)	Quarterly	-	Semiannually	Quarterly	-	-	-	Annually	Monthly	-	4/year	-	-	Annually	-
Strongylocentrotus purpuratus (growth)	-	Monthly	-	-	-	-	-	-	-	-	-	-	-	-	-
Arsenic	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Monthly
Cadmium	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Quarterly
Chromium	na	Quarterly	na	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	na	Semiannually	Quarterly	Annually	Quarterly
Chromium,III	Annually	Semiannually	Semiannually	nr	na	na	Quarterly	na	na	na	Annually	Annually	Semiannually	na	na
Chromium,VI	Annually	na	Semiannually	nr	na	na	na	Annually	na	na	Annually	na	na	Annually	Quarterly
Copper	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Weekly
Lead	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Quarterly
Mercury	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Weekly
Nickel	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Quarterly
Selenium	Annually	Quarterly	Semiannually	nr	Quarterly	Annually	Quarterly	na	Quarterly	Semiannually	Annually	Semiannually	Quarterly	na	Quarterly
Silver	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Weekly
Zinc	Annually	Quarterly	Semiannually	nr	Quarterly	Monthly	Quarterly	Annually	Quarterly	Weekly	Annually	Semiannually	Quarterly	Annually	Weekly
Phenols	-	-	-	-	-	Annually	-	-	-	-	-	-	-	Annually	-
Nonchlorinated Phenols	Annually	Semiannually	Quarterly	nr	Quarterly	Annually	Quarterly	Annually	Quarterly	Monthly	1/ 2 year	Annually	Semiannually	Annually	na
Chlorinated Phenols	Annually	Semiannually	Quarterly	Quarterly	Quarterly	Annually	Quarterly	Annually	Quarterly	Monthly	1/ 2 year	Semiannually	Semiannually	Annually	Quarterly
Total DDT	Annually	Semiannually	Semiannually	nr	Semiannually	Annually	Quarterly	Annually	Quarterly	Monthly	1/ 2 year	na	Semiannually	Annually	Quarterly
Total PAH	Annually	Semiannually	Semiannually	nr	Semiannually	Annually	Quarterly	na	Quarterly	Semiannually	1/ 2 year	Annually	Semiannually	Annually	Quarterly
Total PCB	Annually	Semiannually	Semiannually	nr	Semiannually	Annually	Quarterly	Annually	Quarterly	Monthly	1/ 2 year	Annually	Semiannually	Annually	Quarterly

na = Not analyzed.

nr = Not a required analysis.

Dash = Not applicable.

Table 3. Coefficient of variance (CV; in percent units), and median CV, for constituent analyses conducted by the small POTWs in 2000.

Constituent	Avalon	AWMA	Carpinteria	El Estero	Encina	Goleta	Hale	Montecito	Oceanside	Oxnard	San Clemente Island	San Elijo	SERRA	Summerland	Terminal Island	**Median**
Flow	23	15	10	15	6	20	3	14	6	4	10	2	4	14	9	10
Suspended Solids	24	12	31	28	26	11	26	28	28	29	29	21	21	99	0	26
Settleable Solids	84	310	54	52	31	32	-	0	77	346	103	63	37	-	88	63
BOD	19	-	23	-	46	10	33	40	42	15	81	-	23	237	90	36
CBOD	-	48	-	15	26	-	18	-	29	-	31	23	19	-	-	25
Oil/Grease	79	346	0	19	101	26	75	346	82	124	75	86	37	346	41	79
Ammonia-N	122	31	45	23	26	10	15	240	8	12	173	25	17	148	148	26
Nitrate-N	53	-	-	-	-	-	-	-	77	103	116	-	-	-	-	90
Nitrite-N	-	-	-	-	-	-	-	-	92	64	154	-	-	-	-	92
Organic-N	-	-	-	-	-	-	-	-	-	31	-	-	-	-	-	31
ortho-Phosphate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanide	-	-	-	-	104	-	-	-	117	-	-	-	-	-	242	117
Turbidity	30	15	46	40	28	9	26	26	21	25	61	32	29	22	30	28
Acute Toxicity							34									
Pimephales promelas (survival)	-	88	200	88	79	24	-	-	19	-	0	68	79	-	131	79
Gasterosteus aculeatus (survival)	200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	200
Menidia beryllina (survival)	-	-	-	67	-	-	-	-	-	-	-	-	-	-	-	67
Chronic Toxicity																
Atherinops affinis (growth)	-	-	-	-	-	-	-	-	-	-	200	-	-	-	-	200
Atherinops affinis (survival)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dendraster excentricus (fertilization)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Haliotis rufescens (development)	-	-	-	-	-	32	-	-	-	-	-	-	-	-	52	42
Macrocystis pyrifera (germination)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrocystis pyrifera (germination/growth)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrocystis pyrifera (growth)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Menidia beryllina (growth)	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	0
Menidia beryllina (survival)	-	-	-	-	0	-	-	-	-	-	-	-	-	-	-	0
Mytilus edulis (development)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pimephales promelas (survival)	-	-	-	-	-	-	-	-	-	40	-	-	-	-	-	40
Strongylocentrotus purpuratus (fertilization)	67	-	-	0	-	-	-	-	-	-	56	-	-	-	-	56
Strongylocentrotus purpuratus (growth)	-	332	-	-	-	-	-	-	-	-	-	-	-	-	-	332
Arsenic	-	-	-	-	-	160	9	-	-	67	-	-	-		72	70
Cadmium	-	-	-	-	7	259	-	-	-	-	-	-	-	-	-	133
Chromium	-	-	-	-	-	46	-	-	-	-	-	-	-	-	200	123
Copper	-	-	-	-	-	45	20	-	-	49	-	-	-	-	219	47
Lead	-	-	-	-	-	63	30	-	115	346	-	-	-	-	-	89
Mercury	-	-	-	-	-	49	-	-	200	-	-	-	-	-	-	125
Nickel	-	-	-	-	-	47	43	-	69	346	-	-	-	-	-	58
Selenium	-	-	-	-	-	-	7	-	-	0	-	-	-	-	45	7
Silver	-	-	-	-	-	92	-	-	-	89	-	-	-	-	176	92
Zinc	-	72	141	-	5	41	18	-	68	34	-	141	16	-	33	37
Phenols	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nonchlorinated Phenols	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	20
Chlorinated Phenols	-	-	0	-	-	-	-	-	-	-	-	-	-	-	-	0
Total DDT	-	-	-	-	-	-	-	-	-	-	245	-	-	-	-	245
Total PAH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total PCB	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Dash = Not applicable.

Table 4. Annual average flow-weighted constituent concentrations in effluent from small POTWs in 2000.

Constituent	Avalon	AWMA	Carpinteria	El Estero	Encina	Goleta	Hale	Montecito	Oceanside	Oxnard	San Clemente Island	San Elijo	SERRA	Summerland	Terminal Island
Flow (mgd)	0.52	18	1.5	6.0	23	4.7	14	1.1	12	21	0.02	3.0	19	0.14	16
Flow (L x 10^6/day)	2.0	66	5.8	23	87	18	54	4.1	47	81	0.07	11	71	0.51	60
Suspended Solids (mg/L)	15	8	15	11	9.0	40	14	9.2	4.7	7.6	6.0	11	11	1.9	1
Settleable Solids (mg/L)	0.24	0.07	0.18	0.23	0.07	0.24	0	0.1	0.13	0.02	0.28	0.26	0.42	0	0.006
BOD (mg/L)	7.8	na	9.0	na	31	62	17	3.6	9.4	11	25	na	23	0.51	2.2
CBOD (mg/L)	na	5.3	na	7.2	9.6	na	11	na	3.1	na	12	8.0	7.1	na	na
Oil/grease (mg/L)	11	0.49	3	2.8	0.95	14	1.1	0.17	17	2.2	2.1	1.2	2.8	0.07	1.9
Ammonia-N (mg/L)	0.23	12	0.26	12	23	36	23	0.54	18	19	3.5	21	23	0.42	1.6
Nitrate-N (mg/L)	48	na	na	na	na	na	na	na	4.1	1.6	4.8	na	na	na	na
Nitrite-N (mg/L)	na	na	na	na	na	na	na	na	0.98	0.94	0.18	na	na	na	na
Organic-N (mg/L)	na	na	na	na	na	na	na	na	na	3.2	na	na	na	na	na
ortho-Phosphate (mg/L)	na	na	na	na	na	na	na	na	< 5	na	na	na	na	na	na
Cyanide (ug/L)	< 10	< 200	< 10[c]	na	0.48	0	< 50	< 10	18	< 5	< 50	nd	< 20	< 100	1.3
Turbidity (NTU)	4.1	4.4	2.3	4.2	6.2	47	6.8	1.2	4.0	3.8	1.8	4.5	5.6	1.1	0.91
Acute Toxicity (TUa)	-	-	-	-	-	-	0.99	na	-	na	-	-	-	na	-
Pimephales promelas (survival)	na	0.44	0.10	0.33	0.56	1.19	na	-	1.12	-	0.41	0.59	0.51	-	0.11
Gasterosteus aculeatus (survival)	0.17	na	na	na	na	na	na	-	na	-	na	na	na	-	na
Menidia beryllina (survival)	na	na	na	2.38	na	na	na	-	na	-	na	na	na	-	na
Chronic Toxicity (TUc)	-	-	-	-	-	-	< 58	-	-	-	-	-	-	-	-
Atherinops affinis (growth)	na	na	na	na	na	na	na	na	na	na	0.52	na	na	na	na
Atherinops affinis (survival)	na	na	na	na	na	na	na	na	na	na	< 1	na	na	na	na
Dendraster excentricus (fertilization)	na	na	na	na	na	na	na	na	< 33.3	na	na	na	na	na	na
Haliotis rufescens (development)	na	na	na	na	na	21	na	na	na	na	na	na	na	na	2.2
Macrocystis pyrifera (germination)	na	na	na	na	na	na	na	31.25	na	na	< 2	na	na	na	na
Macrocystis pyrifera (germination/growth)	na	na	na	na	na	na	na	na	na	na	na	na	< 50	na	na
Macrocystis pyrifera (growth)	na	na	na	na	na	na	na	31.25	na	na	< 2	na	na	na	na
Menidia beryllina (growth)	na	na	na	na	17.9	na	na	< 31.25	na	na	na	na	na	17.86	na
Menidia beryllina (survival)	na	na	na	na	17.9	na	na	< 31.25	na	na	na	na	na	17.86	na
Mytilus edulis (development)	na	na	na	na	na	na	na	na	na	na	na	< 31.3	na	na	na
Pimephales promelas (survival)	na	na	na	na	na	na	na	na	na	0.85	na	na	na	na	na
Strongylocentrotus purpuratus (fertilization)	14	na	< 17.86[c]	17.86	na	na	na	31.25	< 33.3	na	9.1	na	na	17.86	na
Strongylocentrotus purpuratus (growth)	na	9.8	na	na	na	na	na	na	na	na	na	na	na	na	na
Arsenic (ug/L)	< 4	< 20	< 10[c]	na	< 15	1.1	1.9	<2	< 9	1.7	< 10	<4[c]	< 20	<2	3.3
Cadmium (ug/L)	< 3	< 20	nd	na	13	0.19	< 2	<1	< 0.6	< 4	< 10	nd	< 20	<1	< 2[c]
Chromium (ug/L)	< 4[b]	< 10	< 5[c]	na	< 100	2.6	< 1.8	<1	< 3	< 10	< 10	<3[c]	< 10	<5	3.3
Copper (ug/L)	< 4	< 30	< 10[c]	na	< 50	33	9.3	8	< 2	11	20	nd	< 30	< 50	3.7
Lead (ug/L)	< 2	< 20	< 10[c]	na	< 50	1.2	1.2	0.8	0.98	1.3	< 5	nd	< 20	<5	< 5
Mercury (ug/L)	< 0.2	< 1	< 0.1[c]	na	< 0.1	0.03	< 0.5	0[d]	0.08	< 0.5	< 4	< 0.4[c]	<5	<1	< 0.3[c]
Nickel (ug/L)	< 7	< 20	< 20[c]	na	< 50	8.7	18	2	5.0	0.90	< 10	nd	< 20	< 10	< 20[c]
Selenium (ug/L)	< 3	< 30	< 10[c]	na	< 15	<2	1.3	na	< 10	0.16	< 10	< 4	< 30	na	10
Silver (ug/L)	< 4	< 20	< 20[c]	na	< 25	1.1	< 1	<1	< 5	2.7	< 10	nd	< 20	< 10	0.10
Zinc (ug/L)	< 1	30	154	na	79	56	69	58	17	27	< 20	25	41	< 0.2	27
Phenols[a] (ug/L)	-	-	-	-	-	< 100	-	-	-	-	-	-	-	< 10	-
Nonchlorinated Phenols	< 8.9	< 20	27	< 20	< 100	< 50	< 50	< 50	< 50[c]	< 50	< 100	< 50[c]	< 20	< 25	na
Chlorinated Phenols	< 8.1	< 10	10	< 30	< 20	< 20	< 10	< 10	< 20[c]	< 50	< 100	nd	< 10	< 20	< 3[c]
Total DDT (ug/L)	< 0.006	< 0.03	< 0.05	na	< 0.1	< 0.05	< 0.1	< 0.05	< 0.06[c]	< 0.001	0.019	na	< 0.03	< 0.1	< 0.01[c]
Total PAH (ug/L)	< 2.3	< 10	< 10	na	< 10	< 10	< 10	na	< 23[c]	<1	< 100	< 23[c]	< 10	< 0.2	< 1.5[c]
Total PCB (ug/L)	< 0.121	< 0.5	< 0.5	na	< 1	< 0.5	< 5	< 0.5	< 1.2[c]	< 0.01	< 2	< 1.2[c]	< 0.5	< 0.5	< 0.065

[a] Phenols represents the measurement for total phenols, for facilities which did not measure individual phenols.

[b] Avalon measured Chromium III and Chromium VI separately, the reporting limit used here was that for Chromium VI, which was the higher RL of the two.

[c] Value provided is the MDL for the measurement, RL not provided in reports.

[d] RL reported as zero.

na = Not analyzed.

nd = Measurement was below detection level, however RL/MDL not provided or not found.

Dash = Not applicable.

< = Less than the reporting level; where more than one RL was used during the year, the higher of the two was reported here; see Appendix II for all RLs used during 2000.

compounds were only detected by the Carpinteria Sanitary District (0.04 ug/L). All other measurements of phenols were below detection limits. Total DDTs were only detected by San Clemente (0.019 ug/L, CV= 786%). All other measurements of total DDTs were below detection limits. Total PCBs and total PAHs were not detected by any of the fifteen small POTWs.

Twelve of the fifteen small POTWs conducted acute toxicity bioassays. Among these facilities, three different species were used. Acute toxicity levels varied among facilities by one order of magnitude, ranging from 0.10 TUa (Carpinteria) to 2.38 TUa (El Estero) (Table 4). All fifteen small POTWs conducted chronic toxicity bioassays. Eight different species were used for these tests. Chronic toxicity levels ranged from non-detectable levels to 31.25 TUc (Table 4). The CV for chronic toxicity measurements ranged from 0% to 332% among facilities (Table 3). Estimates of chronic toxicity levels varied by two orders of magnitude among facilities.

Total combined emissions of suspended solids, BOD, and oil/grease in the year 2000 were 1,819, 2,882, and 676 metric tons, respectively (Table 5). Individual facility emissions of suspended solids ranged from 0.15 mt (San Clemente) to 285 mt (SERRA); BOD emissions ranged from 0.10 mt (Summerland) to 978 mt (Encina); oil/grease emissions ranged from 0.01 mt (Summerland) to 295 mt (Oceanside). Six of the fifteen facilities each discharged greater than 200 mt of suspended solids in 2000. The remaining nine facilities each discharged less than 90 mt of suspended solids, with Summerland and San Clemente discharging less than 1 mt of suspended solids each. Five facilities discharged upwards of 300 mt of BOD in 2000; the remaining facilities discharged less than 20 mt of BOD. AWMA, El Estero, and San Elijo analyzed CBOD instead of total BOD, and discharged 129 mt, 61 mt, and 33 mt of CBOD, respectively.

The most significant mass emissions of metals from small POTWs occurred for cadmium, copper, nickel, and zinc (> 400 kg each) (Table 5). Of all of the metals evaluated, zinc was emitted in the largest quantity (8,202 kg) during the year 2000, one order of magnitude greater than any other metal.

Individual facility emissions of organic compounds were low because of the low concentrations observed in small POTW effluents (Table 5). Total mass emissions of DDT were 0.47 grams, and total mass emissions of phenols were 77 kg. Total PAHs and total PCBs were not detected by any of the facilities, so no emissions of these compounds could be estimated in 2000 based on the methods used in this study.

Historical Trends

The combined average flow from the small municipal wastewater treatment facilities decreased by 2% from 1995 levels, but increased by 6% from 1987 levels (Table 6). Since 1971, combined flow from the small POTWs has increased 119% (Figure 2).

With the exception of ammonia-N, general constituent mass emissions have decreased since 1971 (Table 6, Figure 3). Commensurate with increases in flows, combined small POTW mass emissions of ammonia-N have increased by more than 110% between 1971 and 2000. Despite increases in flow, combined small POTW mass emissions of suspended solids, BOD, and oil/grease have decreased by 78%, 74%, and 84%, respectively, since 1971.

Most constituents showed relative increases in mass emissions between 1987 and 1995 (Figures 3, 4, 5). These trends, however, appear to have changed abruptly around 1995, having decreased steadily for all constituents since then, with the exceptions of BOD and oil/grease. Historically, mass emissions of DDT and PCB from small POTWs have been relatively low (Figure 5). After increasing to 0.9 kg/yr in 1993, levels dropped to very near analytical detection limits in 2000.

Since 1995, trends in general constituents have varied by analyte (Table 6). Small POTW mass emissions of suspended solids and ammonia-N decreased slightly from 1995 levels by 5% and 4%, respectively. However, combined small POTW mass emissions of oil/grease and BOD emissions increased from 1995 levels by 46% and 22%, respectively.

Combined small POTW mass emissions of all metals have decreased since 1995. Reductions ranged from 6% for cadmium to 96% for lead. Mass emissions of chromium, copper, lead, mercury, nickel, and silver decreased by more than 80%. Mass emissions of cyanide, arsenic, and zinc decreased by 77%, 56%, and 49%, respectively.

Small POTWs Versus Large POTWs

Combined emissions from small POTWs accounted for only a fraction of the total POTW load in 2000, discharging approximately 12% of the total

Table 5. Estimated constituent mass emissions from the small POTWs in 2000.

Constituent	Avalon	AWMA	Carpinteria	El Estero	Encina	Goleta	Hale	Montecito	Oceanside	Oxnard	San Clemente Island	San Elijo	SERRA	Summerland	Terminal Island	**TOTAL**
Volume (L x 10^9)	0.72	24	2.1	8.4	32	6.5	20	1.5	17	30	0.02	4.1	26	0.19	22	194
Suspended Solids (mt)	11	200	32	88	284	256	280	14	80	224	0.15	45	285	0.35	22	1,819
Settleable Solids (L x 10^3)	175	1,582	376	1,886	2,304	1,581	nd	148	2,150	523	6.8	1065	10,811	nd	133	22,740
BOD (mt)	5.7	na	19	na	978	401	336	5.4	160	326	0.61	na	601	0.10	49	2,882
CBOD (mt)	na	129	na	61	304	na	212	na	53	na	0.29	33	185	na	na	977
Oil/grease (mt)	8.1	12	6.3	24	30	92	22	0.25	295	64	0.05	5.0	74	0.01	43	676
Ammonia-N (mt)	0.17	300	0.56	104	726	230	458	0.80	315	556	0.09	86	589	0.08	35	3,401
Nitrate-N (mt)	34	-	-	-	-	-	-	-	69	47	0.11	-	-	-	-	150
Nitrite-N (mt)	-	-	-	-	-	-	-	-	17	28	0.004	-	-	-	-	44
Organic-N (mt)	-	-	-	-	-	-	-	-	-	95	-	-	-	-	-	95
ortho-Phosphate (mt)	-	-	-	-	-	-	-	-	nd	-	-	-	-	-	-	nd
Cyanide (kg)	nd	nd	nd	na	15	nd	nd	nd	303	nd	nd	nd	nd	nd	29	347
Arsenic (kg)	nd	nd	nd	na	nd	6.9	38	nd	nd	50	nd	nd	nd	nd	72	166
Cadmium (kg)	nd	nd	nd	na	420	1.3	nd	nd	nd	nd	nd	nd	nd	nd	nd	421
Chromium (kg)	nd	nd	nd	na	nd	17	nd	3.0	nd	nd	nd	nd	nd	nd	72	92
Copper (kg)	nd	nd	nd	na	nd	213	184	12	nd	330	0.48	nd	nd	nd	82	822
Lead (kg)	nd	nd	nd	na	nd	8.0	25	1.2	17	38	nd	nd	nd	nd	nd	88
Mercury (kg)	nd	nd	nd	na	nd	0.20	nd	nd	1.3	nd	nd	nd	nd	nd	nd	1.5
Nickel (kg)	nd	nd	nd	na	nd	56	350	3.0	85	27	nd	nd	nd	nd	nd	520
Selenium (kg)	nd	nd	nd	na	nd	nd	26	na	nd	4.9	nd	nd	nd	na	230	261
Silver (kg)	nd	nd	nd	na	nd	6.9	nd	nd	nd	79	nd	nd	nd	nd	2.3	88
Zinc (kg)	nd	727	325	na	2,507	364	1,356	86	283	797	nd	101	1,052	nd	605	8,202
Phenols (kg)	-	-	-	-	-	nd	-	-	-	-	-	-	-	nd	-	nd
Nonchlorinated Phenols (kg)	nd	nd	56	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	na	56
Chlorinated Phenols (kg)	nd	nd	21	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	21
Total DDT (kg)	nd	nd	nd	na	nd	nd	nd	nd	nd	nd	0.0005	-	nd	nd	nd	0.0005
Total PAH (kg)	nd	nd	nd	na	nd	nd	nd	na	nd	nd	nd	nd	nd	nd	nd	nd
Total PCB (kg)	nd	nd	nd	na	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Dash = Constituent was not analyzed or data were not available.

na = Not analyzed.

nd = Not detected.

Table 6. Historical estimated mass emissions for selected constituents, and the percent changes[a] for selected years, for small POTWs combined.

	Mass Emissions							Percent Change	Percent Change
Constituent	1971	1987	1989	1993	1994	1995	2000	1995-2000	1987-2000
Flow (mgd)	69	132	137	135	131	143	140	(2)	6
Suspended Solids (mt)	8,200	4,193	2,984	2,297	1,737	1,924	1,819	(5)	(57)
BOD (mt)	11,000	5,178	4,751	2,285	2,207	2,364	2,882	22	(44)
Oil/Grease (mt)	4,200	708	460	425	377	463	676	46	(5)
Ammonia-N (mt)	1,600	1,757	2,716	3,668	3,118	3,559	3,401	(4)	94
Cyanide (mt)	8	1.7	0.67	3.6	2.2	1.5	0.35	(77)	(80)
Arsenic (mt)	-	0.43	0.84	0.32	0.44	0.38	0.17	(56)	(61)
Cadmium (mt)	-	1.7	0.53	1.2	0.87	0.45	0.42	(6)	(75)
Chromium (mt)	-	2.3	0.84	1.5	1.6	1.4	0.09	(93)	(96)
Copper (mt)	-	6.9	3.4	4.5	3.2	6.8	0.82	(88)	(88)
Lead (mt)	-	6.5	2.9	4.6	2.8	2.4	0.09	(96)	(99)
Mercury (mt)	-	0.18	0.23	0.01	0.008	0.010	0.002	(85)	(99)
Nickel (mt)	-	5.5	2.8	4.2	4.9	2.7	0.52	(81)	(91)
Silver (mt)	-	0.87	0.58	0.71	1.4	0.63	0.09	(86)	(90)
Zinc (mt)	-	16	12	11	11	16	8.2	(49)	(49)
Total DDT (kg)	-	nd	nd	0.91	0.7	0.3	0.0005	(100)	na
Total PCB (kg)	-	nd	nd	0.09	0.09	nd	nd	nc	nc

[a] Values in parentheses represent a decrease in emissions between the two years.

Dash = Constituents not included in assessment in SCCWRP (1973).

nc = No change.

nd = Not detected.

na = Not applicable, total DDT emissions in 1987 were below detection levels.

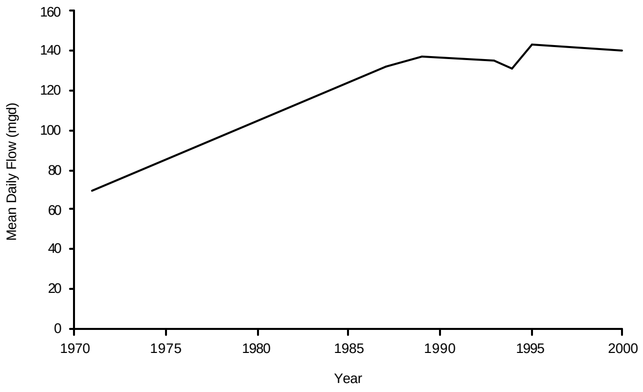

Figure 2. Combined effluent from small POTWs between 1971 and 2000.

effluent volume, which contained an average of 8% of the pollutant load (Table 7). In only one case did the emissions from small POTWs exceed those from large POTWs. Cadmium emissions from small POTWs were 84% of the combined POTW load in 2000. In the case of all but two constituents, emissions from small POTWs were less than 12% of the total load for any given constituent.

reported as not detected (Table 7). Based on these pollutant load estimates, the significance of small POTWs increased from being an average of 8% of the cumlative POTW load to an average of 15% of the cumulative load for constituents detailed in this assessment for 2000. Only 8% of the constituents showed decreases in small POTW significance, and the remainder of constituents remained approximately the same. This information highlights the differences in RLs used by the small and large POTWs. On average, large POTWs have more sensitive analytical detection levels.

Since 1987, the small POTWs have contributed between 10% and 11% of the total effluent volume discharged by all municipal treatment plants, and between 4% and 7% of the pollutant load for general constituents (Figure 6). Contributions of metal constituents have been more significant during this time period, however. Small POTWs contributed between 10% and 28% of the pollutant load for metals between 1987 and 2000, with the highest contributions occurring in 1993 and steadily decreasing thereafter. Small POTWs have consistently represented a relatively small proportion of the total POTW load over the last 30 years, despite the slight increases in contributions of flow and pollutants in the

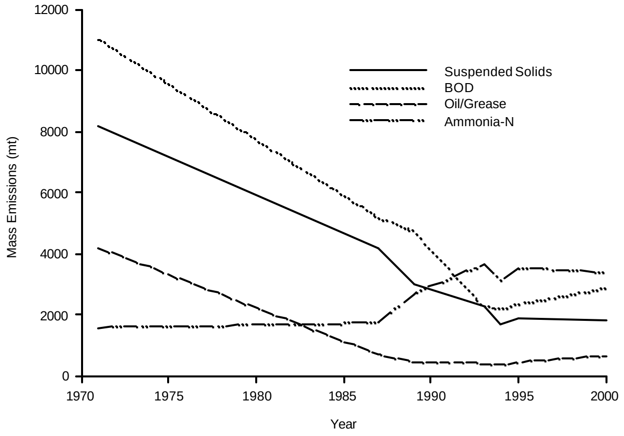

Figure 3. Combined estimated mass emissions of ammonia-N, suspended solids, BOD, and oil/grease from the small POTWs between 1971 and 2000.

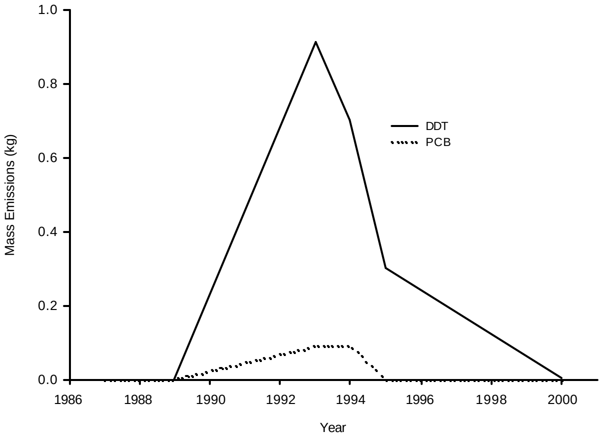

Figure 5. Combined estimated mass emissions of total DDT and total PCB from the small POTWs between 1987 and 2000. Emissions of both DDT and PCB were non-detectable in 1987 and 1989; PCBs have not been detected since 1995 and DDT was not detected in 2000.

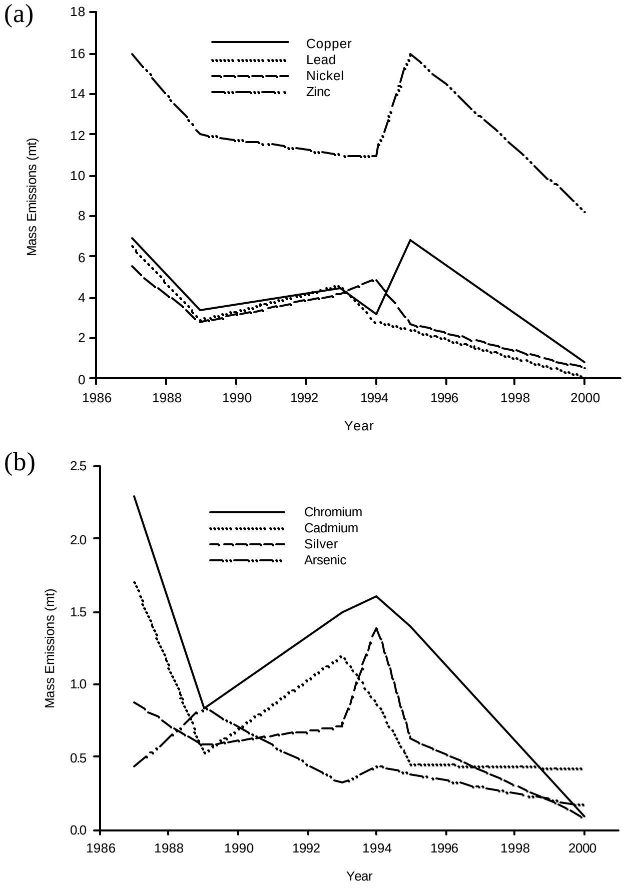

Figure 4. Combined estimated mass emissions of the trace metals (a) copper, lead, nickel, zinc; and (b) chromium, cadmium, silver, and arsenic, between 1987 and 2000 from small POTWs. Data for trace metals do not exist prior to 1987.

mid-1990s. Small POTWs continue to account for an average of 10% of the effluent volume and cumulative pollutant load to the SCB.

DISCUSSION

Small POTWs appear to be a minor source of contaminants to the SCB relative to large POTWs. Similarly, the relatively small contributions from small POTWs do not appear to result in large-scale receiving water impacts. Regional monitoring of the SCB in 1998 demonstrated that the aerial extent of sediment contamination near small POTW outfalls was less extensive than areas near outfalls from large POTWs, and was more similar to reference regions of the SCB (Noblet *et al.* 2002). In addition, fish assemblages near small POTWs were similar to assemblages observed in reference regions of the SCB, and the occurrence of external pathologies in fish were rare (Allen *et al.* 2002).

Although general conclusions regarding the relatively minor role of small POTWs appear warranted, mass emission estimates for specific constituents from small POTWs is hindered by discrepancies in monitoring requirements among facilities. For example, only six of twenty-six constituents examined in this study were analyzed by all fifteen facilities. The lack of data for some facilities potentially causes

Table 7. Combined estimated mass emissions from large and small POTWs in 2000 calculated using (1) the standard methodology in which non-detected results were treated as zeros (DL=0), and (2) the RL or MDL in place of zeros for non-detected results (DL=RL/MDL). Also reported are the percent contributions from small and large POTWs to the total mass emissions, for both cases.

	DL = 0			*DL = RL/MDL*		
Constituent	Total Mass Emissions	Small POTWs (%)	Large POTWs (%)	Total Mass Emissions	Small POTWs (%)	Large POTWs (%)
Volume (L x 10^9)	1683	12	88	1683	12	88
Suspended Solids (mt)	66,450	3	97	66,450	3	97
Settleable Solids (L x 10^3)	330,289	7	93	365,555	6	94
BOD (mt)	100,626	3	97	100,630	3	97
Oil/Grease (mt)	15,516	4	96	15,747	6	94
Ammonia-N (mt)	45,968	7	93	45,969	7	93
Nitrate-N (mt)	430	35	65	432	35	65
Nitrite-N (mt)	479	9	91	480	9	91
Organic-N (mt)	4,620	2	98	4,620	2	98
Total Phosphorus[b] (mt)	1,899	0	100	1,902	0	100
Cyanide (mt)	10	4	96	13	19	81
Arsenic (mt)	4	5	95	5	27	73
Cadmium (mt)	1	84	16	2	39	61
Chromium (mt)	5	2	98	39	56	44
Copper (mt)	52	2	98	57	7	93
Lead (mt)	1	12	88	13	20	80
Mercury (mt)	0	6	94	1	16	84
Nickel (mt)	32	2	98	43	7	93
Selenium (mt)	9	3	97	10	15	85
Silver (mt)	4	2	98	8	20	80
Zinc (mt)	74	11	89	74	11	89
Phenols (mt)	113	0	100	113	0	100
Nonchlorinated phenols	4	0	100	27	18	82
Chlorinated phenols	58	0	100	97	8	92
Total DDT (kg)	2	0	100	93	16	84
Total PAH (kg)	739	0	100	31,393	5	95
Total PCB (kg)	0	-	-	2,279	13	87

[a] CBOD only measured by select small POTW facilities.

[b] Total phosphorus calculated from phosphate and phosphorus results.

Dash = Not applicable.

nd = Not detected.

underestimation of the actual pollutant load. This bias, however, is likely to be small since missing information was observed only for the smallest facilities, those that discharged less than 10 mgd, representing only 12% of total small POTW volume.

An additional factor that results in a potentially underestimated pollutant load is the use of zeros for results reported as not detected. This calculation technique represents a minimum load estimate, but potentially confounds comparisons when the RL differs dramatically among facilities. To overcome this bias, we calculated load estimates using detection levels instead of zeros for non-detected measurements. While this resulted in increases in mass emission estimates ranging from one to five orders of magnitude for small POTWs, similar increases were observed for large POTWs, and our general conclusion regarding relative loading remains largely un-

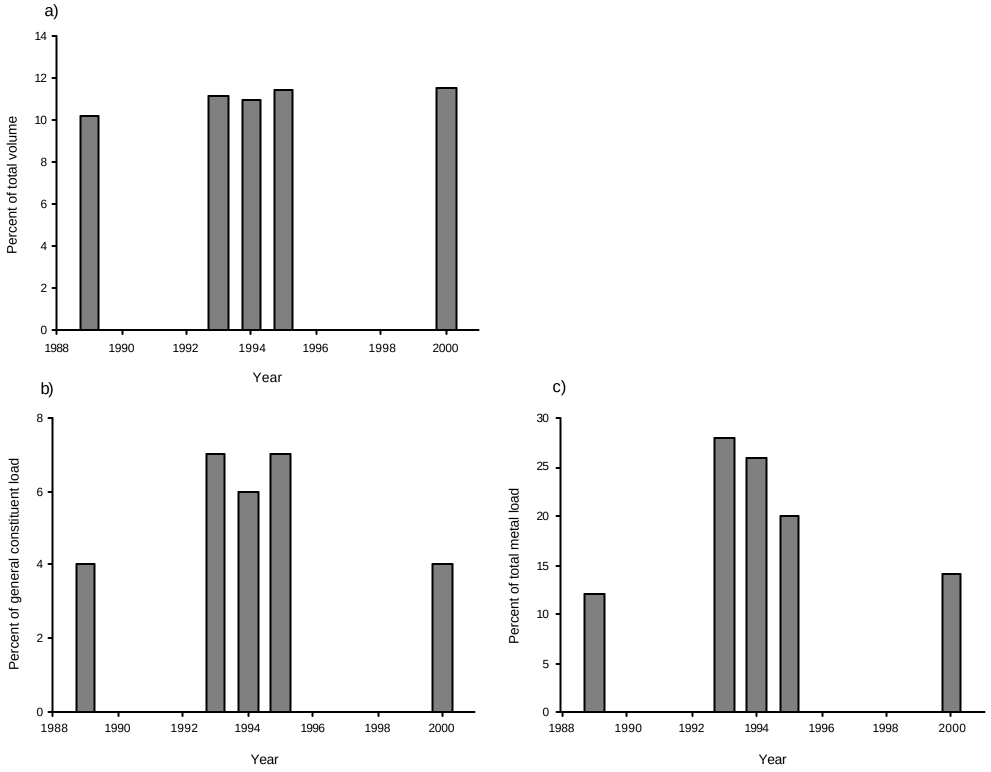

Figure 6. Average percent contribution from small POTWs to the (a) total combined volume from large and small POTWs combined, (b) the total constituent load for general constituents (suspended solids, oil/grease, BOD, ammonia nitrogen, and cyanide) from small and large POTWs combined, and (c) the total trace metal load (arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc) from small and large POTWs combined. Contributions from large POTWs (not shown) represent the remainder of the total percentage.

changed. However, for those managers most interested in quantifying the magnitude of discharges from individual facilities, the issue of RLs remains an issue of concern. This is particularly true for organic compounds, such as total DDTs and total PAHs, because these compounds are most frequently below limits of detection in effluent measurements.

Since 1971, small POTWs appear to have improved the quality of effluent they discharge to the coastal ocean. This appears to have resulted from increased management efforts, rather than as a consequence of increased detection levels from previous years. The RLs used by the small POTWs for constituent analyses were first included in this assessment in 1995. Comparison of 1995 and 2000 RLs revealed that six facilities actually had lower RLs in 2000, four facilities had approximately the same RLs, three facilities had slightly higher RLs, and two facilities could not be compared for a lack of data in 1995. Furthermore, monitoring data existed for more constituents and facilities in 2000 than in 1995, which should theoretically increase estimated constituent loads if effluent quality remained the same. While the lack of information encountered in this study likely caused an underestimation of the constituent load discharged to the SCB, the load estimates derived for 1995 were likely an even greater underestimation. This indicates that small POTWs have indeed improved effluent quality since 1995, and that these trends are not simply a manifestation of changing reporting and monitoring procedures.

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Appendix I. Small POTWs that discharged to the SCB in 2000.

NPDES Permit Number	Name of Facility	City	County	Agency
Central Coast Regional Water Quality Control Board				
CA0048160	Goleta Wastewater Treatment Plant	Goleta	Santa Barbara	Goleta Sanitary District
CA0048143	El Estero Wastewater Treatment Plant	Santa Barbara	Santa Barbara	City of Santa Barbara
CA0047899	Montecito Wastewater Treatment Plant	Montecito	Santa Barbara	Montecito Sanitation District
CA0048054	Summerland Wastewater Treatment Facility	Summerland	Santa Barbara	Summerland Sanitation District
CA0047364	Carpinteria Wastewater Treatment Plant	Carpinteria	Ventura	Carpinetria Sanitation District
Los Angeles Regional Water Quality Control Board				
CA0054097	Perkins Wastewater Treatment Plant	City of Oxnard	Ventura	City of Oxnard
CA0053856	Terminal Island Wastewater Treatment Plant	City of Los Angeles	Los Angeles	City of Los Angeles
CA0054372	Santa Catalina Island Sewage Treatment Plant	City of Avalon	Los Angeles	City of Avalon
CA0110175	San Clemente Island Sewage Treatment Plant	San Clemente Island	Los Angeles	U.S. Navy--Navy Auxiliary Landing Field
San Diego Regional Water Quality Control Board				
CA0107611	AWMA	Laguna Niguel	Orange	Aliso Water Management Agency
	El Toro Water District	Lake Forest		
	Moulton Niguel Water District	Laguna Niguel		
	South Coast Water District	Laguna Beach		
	City of Laguna Beach	Laguna Beach		
	Emerald Bay Service District	Laguna Beach		
	Irvine Ranch Water District	Irvine		
CA0107417	SERRA	Dana Point	Orange	South East Regional Reclamation Authority
	Capistrano Beach Sanitary District	Capistrano Beach		
	Dana Point Sanitary District	Dana Point		
	Moulton-Niguel Water District	San Clemente		
	Santa Margarita Water District	Santa Margarita		
	City of San Clemente	San Clemente		
	City of San Juan Capistrano	San Juan Capistrano		
CA0107433	Oceanside Ocean Outfall	Oceanside	San Diego	City of Oceanside Water Utilities Department
	La Salina Wastewater Treatment Plant	Oceanside		
	San Luis Rey Wastewater Treatment Plant	Oceanside/Vista		
	Fallbrook Sanitary District, Plant 1 and Plant 2	Fallbrook		
CA0107395	Encina Ocean Outfall	Carlsbad	San Diego	Encina Wastewater Authority
	Vallecitos Water District	San Marcos		
	Buena Santitation District	Vista		
	Luecadia County Water District	Leucadia		
	City of Carlsbad	Carlsbad		
CA0107981	Hale Avenue Resource Recovery Facility	Escondido	San Diego	City of Escondido
CA0107999	San Elijo Water Pollution Control Facility	Cardiff by the Sea	San Diego	San Elijo Joint Powers Authority

Appendix II. Analytical methods used for constituent analyses by small POTWs and/or contract laboratories in 2000.

Constituent	Avalon	AWMA	Carpinteria	El Estero	Encina	Goleta	Hale	Montecito	Oceanside	Oxnard	San Clemente Island
Suspended Solids	nf	EPA 160.2	nf	nf	nf	nf	nf	nf	SM 2540 D	nf	SM 2540 D
Settleable Solids	nf	EPA 160.5	nf	nf	nf	nf	nf	nf	SM 2540 F	nf	SM 2540 F
BOD	nf	na	nf	na	nf	nf	nf	nf	SM 5210 B	nf	SM 5210 B
CBOD	na	SM 5210 B	na	nf	nf	na	nf	na	SM 5210 B	na	SM 5210 B
Oil/Grease	EPA 413.1	EPA 413.1	SM 5520 B	na	na	na	na	EPA 413.1	EPA 1664	na	EPA 413.2
Ammonia-N	EPA 350.2	EPA 350.3	SM 4500 NH3 H	na	na	na	na	EPA 350.1	SM 4500 NH3 B,C	na	EPA 350.2
Nitrate-N	EPA 300.0	na	na	na	na	na	na	na	EPA 300	na	EPA 352.1
Nitrite-N	na	na	na	na	na	na	na	na	EPA 300	na	EPA 354.1
Organic-N	na	na	na	na	na	na	na	na	na	na	na
ortho-Phosphate	na	na	na	na	na	na	na	na	EPA 300	na	na
Cyanide	EPA 335.2	EPA 335.2	SM 4500 CN C,E	na	SM 4500 CN E	SM 4500 CN C,E	na	SM 4500 CN C,E	SM 4500 CN C,E	na	EPA 335.2
Turbidity	na	EPA 180.1	na	na	na	na	na	na	SM 2130 B	na	SM 2130 B
Acute Toxicity	-	-	-	-	-	-	(nf)	-	-	-	-
Pimephales promelas (survival)	-	(nf)	(c)	(e)	(nf)	(e)	-	-	(nf)	(j)	(j)
Gasterosteus aculeatus (survival)	(a)	-	-	-	-	-	-	-	-	-	-
Menidia beryllina (survival)	-	-	-	(e)	-	-	-	-	-	-	-
Chronic Toxicity	-	-	-	-	-	-	(nf)	-	-	-	-
Atherinops affinis (growth)	-	-	-	-	-	-	-	-	-	-	(b)
Atherinops affinis (survival)	-	-	-	-	-	-	-	-	-	-	(b)
Dendraster excentricus (fertilization)	-	-	-	-	-	-	-	-	(d)	-	-
Haliotis rufescens (development)	-	-	-	-	-	(h) & (i)	-	-	-	-	-
Macrocystis pyrifera (germination)	-	-	-	-	-	-	-	(i)	-	-	(b)
Macrocystis pyrifera (germination/growth)	-	-	-	-	-	-	-	-	-	-	-
Macrocystis pyrifera (growth)	-	-	-	-	-	-	-	(i)	-	-	(b)
Menidia beryllina (growth)	-	-	-	-	(nf)	-	-	(h)	-	-	-
Menidia beryllina (survival)	-	-	-	-	(nf)	-	-	(h)	-	-	-
Mytilus edulis (development)	-	-	-	-	-	-	-	-	-	-	-
Strongylocentrotus purpuratus (fertilization)	(b)	-	(d)	(f) & (g)	-	-	-	(d)	(d)	-	(b)
Strongylocentrotus purpuratus (growth)	-	(nf)	-	-	-	-	-	-	-	-	-
Arsenic	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3113 B	EPA 200.8	na	EPA 206.2	EPA 200.7	na	EPA 200.7
Cadmium	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3111 B	EPA 200.8	na	EPA 200.8	EPA 200.7	na	EPA 200.7
Chromium	-	EPA 200.7	-	na	SM 3111 B	EPA 200.8	na	EPA 200.8	EPA 200.7	na	-
Chromium,III	EPA 200.7	EPA 6010	EPA 200.7	na	-	-	na	-	-	-	EPA 200.7
Chromium,VI	SM 3500 G,D	-	SM 3500 Cr D	na	-	-		SM 7196	-	-	EPA 7196 A
Copper	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3111 B	EPA 200.8	na	EPA 200.8	EPA 200.7	na	EPA 200.7
Lead	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3112 B	EPA 200.8	na	EPA 200.8	EPA 200.7	na	EPA 200.7
Mercury	EPA 245.1	EPA 245.1	EPA 245.2	na	SM 3112 B	EPA 245.2	na	EPA 245.2	EPA 245.1	na	EPA 245.1
Nickel	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3111 B	EPA 200.8	na	EPA 200.8	EPA 200.7	na	EPA 200.7
Selenium	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3113 B	EPA 200.8	na		EPA 200.7	na	EPA 200.7
Silver	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3111 B	EPA 200.8	na	EPA 272.1	EPA 200.7	na	EPA 200.7
Zinc	EPA 200.7	EPA 200.7	EPA 200.7	na	SM 3111 B	EPA 200.8	na	EPA 200.8	EPA 200.7	na	EPA 200.7
Phenols	-	-	-	-	-	EPA 420.1	-	-	-	-	-
Nonchlorinated Phenols	na	EPA 625	na	na	EPA 625	EPA 625	na	EPA 625	EPA 625	na	EPA 8270 C
Chlorinated Phenols	na	EPA 625	na	EPA 8270	EPA 625	EPA 625	na	EPA 625	EPA 625	na	EPA 8270 C
Total DDT	EPA 608	EPA 608	na	na	EPA 608	EPA 608	na	EPA 608	EPA 608	na	EPA 608
Total PAH	EPA 625	EPA 625	EPA 625	na	SM 3510	EPA 625	na	na	EPA 625	na	EPA 8270 C
Total PCB	EPA 608	EPA 608	EPA 608	na	EPA 608	EPA 608	na	EPA 608	EPA 608	na	EPA 608

(a) - (U.S. EPA 1991).
(b) - (SWRCB 1990).
(c) - (SWRCB 1995).
(d) - (Dinnel *et al*. 1987).
(e) - (U.S. EPA 1993).
(f) - (Chapman *et al.* 1995).
(g) - (SWRCB 1996).
(h) - (Weber *et al.* 1988).
(i) - (Hunt *et al.* 1989).
(j) - (U.S. EPA 1985).
(k) - (SWRCB 1991).
nf = Not found.
dash = Not applicable.
na = Not analyzed.
"SM" refers to protocols found in the Standard Methods for the Examination of Water and Wastewater (Clesceri 1992).
"EPA" refers to protocols established in the California Ocean Plan: Water Quality Control Plan, Ocean Water of California (SWRCB-Cal EPA 1990, 1997).

Appendix III. Reporting limits used for constituent analyses by small POTWs and/or contract laboratories in 2000.

Constituent	Avalon	AWMA	Carpinteria	El Estero	Encina	Goleta	Hale	Montecito	Oceanside	Oxnard	San Clemente Island	San Elijo	SERRA	Summerland
Suspended Solids (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Settleable Solids (mL/L)	-	0.1	-	-	-	-	0.1, 0.12	-	0.1	0.1	-	-		-
BOD (mg/L)	-	-	-	-	-	-	-	-	2.4	-	-	-	-	5
CBOD (mg/L)	-	4.2, 5.5	-	-	-	-	-	-	-	-	5	-	-	-
Oil/Grease (mg/L)	1.6	5, 6, 10	-	-	-	-	1	2	5	5[a]	-	0.1	-	2
Ammonia-N (mg/L)	0.1[a]	-		-	-	-	-	0.6	6	-	-	-	-	0.5
Nitrate-N (mg/L)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrite-N (mg/L)	-	-	-	-	-	-	-	-	1	-	0.06	-	-	-
ortho-Phosphate (mg/L)	-	-		-	-	-	-	-	2, 5	-	-	-	-	-
Cyanide (ug/L)	10	20, 200	10[a]	-	2	10	50	10	10	5	50	-	20	100
Acute Toxicity (TUa)														
Pimephales promelas (survival)	-	0.41	-	-	-	-	-	-	-	-	-	0.41	0.41	-
Chronic Toxicity (TUc)	-	-	-	-	-	-	50, 58	-	-	-	-	-	-	-
Atherinops affinis (growth)	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Atherinops affinis (survival)	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Dendraster excentricus (fertilization)	-	-	-	-	-	-	-	-	33.3	-	-	-	-	-
Macrocystis pyrifera (germination)	-	-	-	-	-	-	-	-	-	-	1.9, 2	-	-	-
Macrocystis pyrifera (germination/growth)	-	-	-	-	-	-	-	-	-	-	-	-	50	-
Macrocystis pyrifera (growth)	-	-	-	-	-	-	-	-	-	-	1.9, 2	-	-	-
Menidia beryllina (growth)	-	-	-	-	-	-	-	31.25	-	-	-	-	-	-
Menidia beryllina (survival)	-	-	-	-	-	-	-	31.25	-	-	-	-	-	-
Mytilus edulis (development)	-	-	-	-	-	-	-	-	-	-	-	31.3	-	-
Strongylocentrotus purpuratus (fertilization)	17.56	-	17.86[a]	-	-		-	-	33.3	-	-	-	-	-
Strongylocentrotus purpuratus (growth)	-	50	-	-	-		-	-	-	-	-	-	-	-
Arsenic (ug/L)	4	5,20	10[a]	-	15	2	-	2	9	0.5	10	4[a]	5, 20	2
Cadmium (ug/L)	3	5, 20	-	-	10	0.2	1.1, 2	1	0.6	4	10	-	5, 20	1
Chromium (ug/L)	-	10	-	-	100	1	1.025-1.8	1	3	10	-	3[a]	10, 18	10
Chromium,III	2	10	5[a]	-	-	-	0.45, 1.6, 1.7	-	-	-	10	-	10	-
Chromium,VI	4	-	10[a]	-	-	-	-	5	-	-	10	-	-	5
Copper (ug/L)	4	30	10[a]	-	50	1	-	1	6	10	-	-	30	50
Lead (ug/L)	2	20	10[a]	-	50	0.2	-	0	2	10	5	-	20	5
Mercury (ug/L)	0.2	0.005, 1	0.1[a]	-	0.1	0.01	0.5	0	1	0.5	4	0.4[a]	1, 5	1
Nickel (ug/L)	7	10, 20	20[a]	-	50	1	-	1	7[a]	10	10	-	10, 20	10
Selenium (ug/L)	3	20, 21, 30	10[a]	-	15	2	-	-	7, 10	-	10	4	20, 21, 30	-
Silver (ug/L)	4	5, 20	10[a]	-	25	1	1	1	5	4	10	-	5, 20	10
Zinc (ug/L)	1	20	50[a]	-	50	4	-	4	4[a]	-	20	-	-	50
Phenols (ug/L)	-	-	-	-	-	100	-	-	-	-	-	-	-	5
Nonchlorinated Phenols (ug/L)	-	-	100	10, 20	-	-	0.05, 0.075, 0.1	-	-	-	-	-	-	-
2,4-Dimethylphenol	6.2	-	10	10	9.5, 10, 20	10	-	10	10[a]	10	2, 10, 100	-	-	10
2,4-Dinitrophenol	7.1	20	50	10	100	50	50	50	50[a]	50	1, 10, 100	50[a]	5, 20	25
2-Methyl-4,6-Dinitrophenol	8.9	10	50	10	19, 40	50	50		50[a]	50	1, 10, 100	-	2, 10	25
2-Nitrophenol	7.9	-	10	10	4.8, 5, 10	10	-	10		10	2, 10, 100	-	-	10
4-Nitrophenol	4.5	-	50	30	100	50	-	50	50[a]	50	1, 10, 100	-	-	25
Phenol	8.3	-	10	10	4.8, 5, 10	10	-	10	10[a]	10	1, 10, 100	-	-	10
Chlorinated Phenols (ug/L)	-	-	-	10, 20	-	-	0.085, 0.093, 0.1	-	-	50	-	-	-	-
2,4,6-Trichlorophenol	6.9	10	10	10	9.5, 10, 20	10	10	10	50[a]	10	1, 10, 100	-	10	10
2,4-Dichlorophenol	6.8	-	10	10	4.8, 5, 10	10	-	10	10[a]	10	1, 10, 100	-	-	10
2-Chlorophenol	8.1	-	10	10	4.8, 5, 10	10	-	10	10[a]	10	1, 10, 100	-	-	10
4-Chloro-3-methylphenol	6	-	20	10	9.5, 10, 20	20	-		20[a]	20	1, 10, 100	-	-	20
Pentachlorophenol	5.1	-	50	10	-	50	-	50	50[a]	50	1, 10, 100	-	-	25
Total PAH (ug/L)	-	10	10	-	-	-	10	-	-	-	-	-	0.5, 10	-
Acenaphthene	-	-	10	-	-	10	-		18[a]	0.5, 0.8	2, 10, 100	18[a]	-	0.2
Acenaphthylene	1.7	-	10	-	1	10	-		23[a]	1	2, 10, 100	23[a]	-	0.2
Anthracene	1.6	-	10	-	0.05	10	-		10[a]	0.1	1, 10, 100	6.6[a]	-	0.2
Benzo(a)anthracene	1.2	-	10	-	0.05	10	-	-	10[a]	0.1	1, 10, 100	0.13[a]	-	0.2
Benzo(a)pyrene	1.6	-	10	-	0.05	10	-	-	10[a]	0.2	1, 10, 100	0.23[a]	-	0.2
Benzo(b)fluoranthene	1.5	-	10	-	0.1	10	-	-	10[a]	0.2	1, 10, 100	0.18[a]	-	0.2
Benzo(g,h,i)perylene	1.7	-	10	-	0.1	10	-	-	0.76[a]	0.1	1, 10, 100	0.76[a]	-	0.2
Benzo(k)fluoranthene	2.3	-	10	-	0.1	10	-	-	0.17[a]	0.1	1, 10, 100	0.17[a]	-	0.2
Dibenzo(a,h)anthracene	-	-	10	-	0.1	10	-	-	10[a]	0.3	1, 10, 100	0.3[a]	-	0.2
Fluoranthene	1.3	10	10	-	4.8, 10	10	10	-	10[a]	0.8	1, 10, 100	10[a]	0.5, 10	0.2
Fluorene	1.6	-	10	-	-	10	-	-	10[a]	0.8	2, 10, 100	2.1[a]	-	0.2
Indeno[1,2,3-cd]pyrene	1.7	-	10	-	0.1	10	-	-	10[a]	0.1	1, 10, 100	0.43[a]	-	0.2
Naphthalene	1.5	-	10	-	-	10	-	-	18[a]	0.8	2, 10, 100	18[a]		0.2
Phenanthrene	1.5	-	10	-	0.1	10	-	-	10[a]	0.8	1, 10, 100	6.4[a]	-	0.2
Pyrene	1.1	-	10	-	0.1	10	-	-	10[a]	0.1	1, 10, 100	2.7[a]	-	0.2
Chrysene	1.5	-	10	-	0.1	10	-	-	10	0.05, 0.1	1, 10, 100	1.5	-	0.2
Total DDT (ug/L)	-	-	0.05	-	-	-	0.1	-	-	0.001	-	-	-	-
DDD	0.006	-	-	-	-	-	-	-	-	-	-	-	-	-
DDE	0.004	-	-	-	-	-	-	-	-	-	-	-	-	-
DDT	0.005	0.03	-	-	-	-	-	-	-	-	-	-	0.03	-
o,p'-DDD	-	-	-	-	0.1	-	-	-	-	-	0.1	-	-	-
o,p'-DDE	-	-	-	-	0.1	-	-	-	-	-	0.1	-	-	-
o,p'-DDT	-	-	-	-	0.1	-	-	-	-	-	0.1	-	-	-
p,p'-DDD	-	-	0.05	-	-	0.05	-	0.05	0.06[a]	-	0.06, 0.1	-	-	0.1
p,p'-DDE	-	-	0.05	-	-	0.05	-	0.05	0.04[a]	-	0.04, 0.1	-	-	0.1
p,p'-DDT	-	-	0.05	-	0.1	0.05	-	0.05	0.05[a]	-	0.05, 0.1	-	-	0.1
Total PCB (ug/L)	-	0.5	-	-	-	-	5	-	-	0.01	-	-	0.5	-
arochlor-1016	0.049	-	0.5	-	1	0.5	-	0.5	0.5[a]	-	1	0.5[a]	-	0.5
arochlor-1221	0.1	-	0.5	-	1	0.5	-	0.5	0.5[a]	-	0.5, 2	0.5[a]	-	0.5
arochlor-1232	0.06	-	0.5	-	1	0.5	-	0.5	0.6[a]	-	0.6, 1	0.6[a]	-	0.5
arochlor-1242	0.031	-	0.5	-	1	0.5	-	0.5	0.3[a]	-	0.3, 1	0.3[a]	-	0.5
arochlor-1248	0.121	-	0.5	-	1	0.5	-	0.5	1.2[a]	-	1, 1.2	1.2[a]	-	0.5
arochlor-1254	0.017	-	0.5	-	1	0.5	-	0.5	0.2[a]	-	0.2, 1	0.2[a]	-	0.5
arochlor-1260	0.031	-	0.5	-	1	0.5	-	0.5	0.3[a]	-	0.3, 1	0.3[a]	-	0.5

[a] Value provided is the MDL for the analysis.

Dash = Not applicable.