Characterization of Stormwater Discharges at the San Isidro Industrial Park, Canóvanas, Puerto Rico

By José M. Rodríguez

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CONVERSION FACTORS, ABBREVIATED WATER-QUALITY UNITS, AND ACRONYMS

Multiply	By	To obtain
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
hectare	2.471	acre
square meter (m^2)	10.76	square foot
cubic meter (m^3)	35.3145	cubic foot
liter per second (L/s)	0.0353	cubic foot per second

Abbreviated water-quality units used in report:

mg/L	milligram per liter
g	gram
mg/m^2	milligram per square meter

Acronyms used in report:

BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
NPDES	National Pollutant Discharge Elimination System
PRIDCO	Puerto Rico Industrial Development Company
SIC	Standard Industrial Classification
SIIP	San Isidro Industrial Park
TOC	Total organic carbon
TSS	Total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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ABSTRACT

Stormwater discharges from the San Isidro Industrial Park, Canóvanas, Puerto Rico, were investigated in 1993 and 1994 by measuring the flow rate and collecting samples at three separate outfalls. The drainage areas for each outfall were delineated and estimated. The flow rate was used to calculate the volume of the discharges. The collected samples were analyzed to determine the quality of the discharges. Constituent mass and mass per area were estimated for each outfall.

The average concentrations of oil and grease, biochemical oxygen demand, and total phosphorous from all the samples collected were below the U.S. Environmental Protection Agency stormwater benchmark concentrations. Average concentrations of chemical oxygen demand, total suspended solids, and nitrate plus nitrite exceeded the benchmark concentrations in some of the sampled drainage areas.

INTRODUCTION

Studies conducted on a nationwide scale (U.S. Environmental Protection Agency, 1983) have demonstrated that the runoff from urban and industrial areas is a significant source of surface-water pollution. It was determined that urban and industrial runoff contains some pollutants in quantities comparable to, and in some cases greater than, effluents from wastewater secondary-treatment plants.

In order to control the quality of the stormwater discharges, the Federal Water Pollution Control Act, as amended in 1987 [section 402(p)], required the U.S. Environmental Protection Agency (USEPA) to establish permit application requirements under the National Pollutant Discharge Elimination System (NPDES) for stormwater discharges associated with industrial activity. In response to this requirement, the USEPA requires the owners or operators of facilities discharging stormwater associated with industrial activity to comply with the permit application requirements.

From June 1993 to January 1994, the U.S. Geological Survey (USGS) in cooperation with the Puerto Rico Industrial Development Company (PRIDCO) conducted a study to characterize the stormwater discharges at the San Isidro Industrial Park (SIIP), which is located in northeastern Puerto Rico (fig. 1). The SIIP is one of a number of industrial parks located throughout Puerto Rico that are owned by the PRIDCO.

The study conducted at the SIIP was the initial part of a data collection effort to investigate the characteristics of the stormwater discharges from various industrial areas in Puerto Rico. The information collected during these studies will improve the understanding of the stormwater discharges and indicate areas that may need improvement relating to stormwater management practices.

This report presents the data collected at three drainage subareas of the SIIP. Stormwater runoff was characterized at each of the drainage subareas during two storm events. Data collected include site drainage, industrial activities in the study area, rainfall, and stormwater discharge flow rates, volumes, and quality. These data were collected following methods similar to those required for a NPDES stormwater permit.

DESCRIPTION OF THE STUDY AREA

The SIIP is located east of the urban center of the town of Canóvanas, northeastern Puerto Rico. The principal hydrologic surface features related to the study area are the Caño San Isidro, an unnamed creek, the Río Grande de Loíza, and a wetland area (fig. 1). The Caño San Isidro and the unnamed creek are the water bodies that receive the stormwater discharges from the SIIP. The Caño San Isidro flows northward and discharges into the Río Grande de Loíza. The unnamed creek flows northward to a wetland area. Several drainage channels, which eventually discharge into the Río Grande de Loíza, cross the wetland area.

Site Drainage

The SIIP occupies an area of about 55 hectares, which is divided into four subareas based on their drainage (fig. 2). Approximately 26 percent of the park is covered by impervious surfaces. Subareas 1, 2, and 3 were investigated during this study. However, subarea 4, which covers approximately 79,000 m^2 was not included in the study because no industry was in operation in that area during the investigation.

Subarea 1 covers about 62,700 m^2 and contains eight industrial lots (fig. 3). Approximately one-third (21,500 m^2) of subarea 1 is covered by pavement and buildings (table 1). The stormwater flow pattern in subarea 1 (fig. 3) is mainly from the individual lots to the street.

Table 1. Estimated area covered by impervious surfaces and total area drained by each outfall in three subareas of the San Isidro Industrial Park, Canóvanas, Puerto Rico
[m^2, square meters]

Outfall number	Outfall location (Latitude-Longitude)	Area of impervious surface (m^2)	Total area drained (m^2)	Sampling area (m^2)	Receiving water body
1	18°23’16” - 65°53’12”	21,500	62,700	62,700	Caño San Isidro
2	18°23’11” - 65°53’09”	85,900	216,000	204,600	Caño San Isidro
3	18°23’28” - 65°52’32”	34,100	192,800	30,500	Unnamed creek

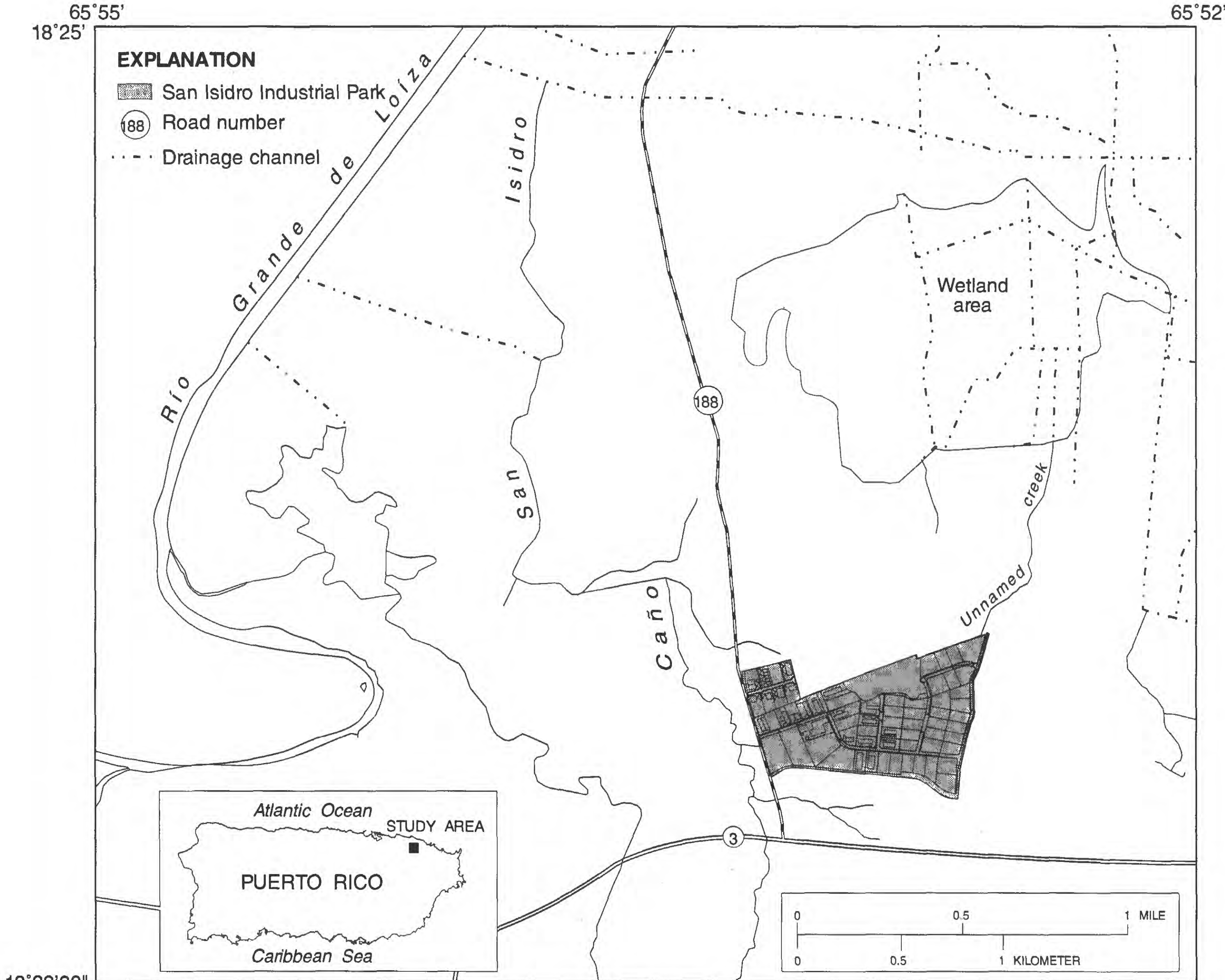

Figure 1. Location of the study area in northeastern Puerto Rico.

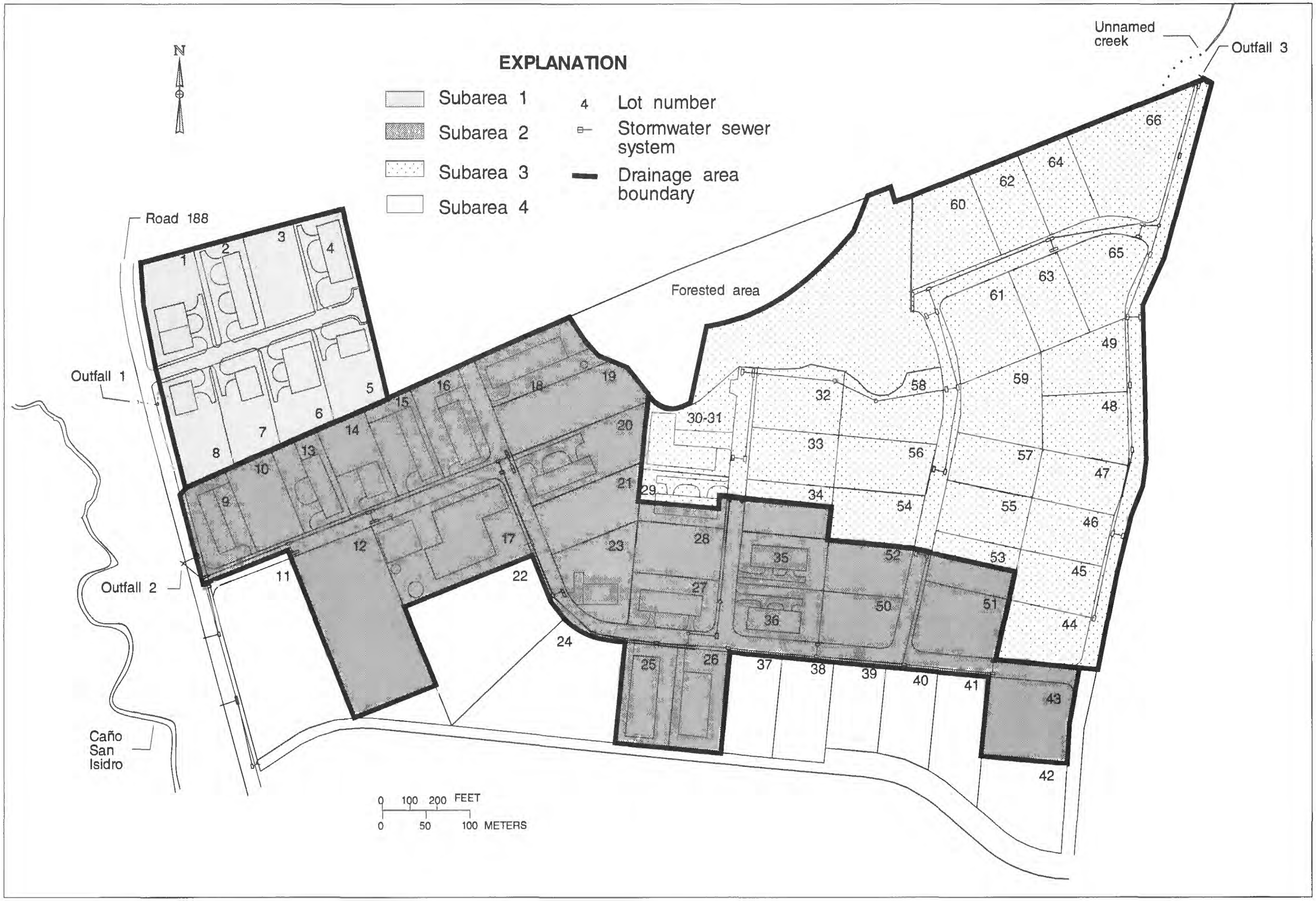

Figure 2. Location of drainage subareas at the San Isidro Industrial Park, Canóvanas, Puerto Rico.

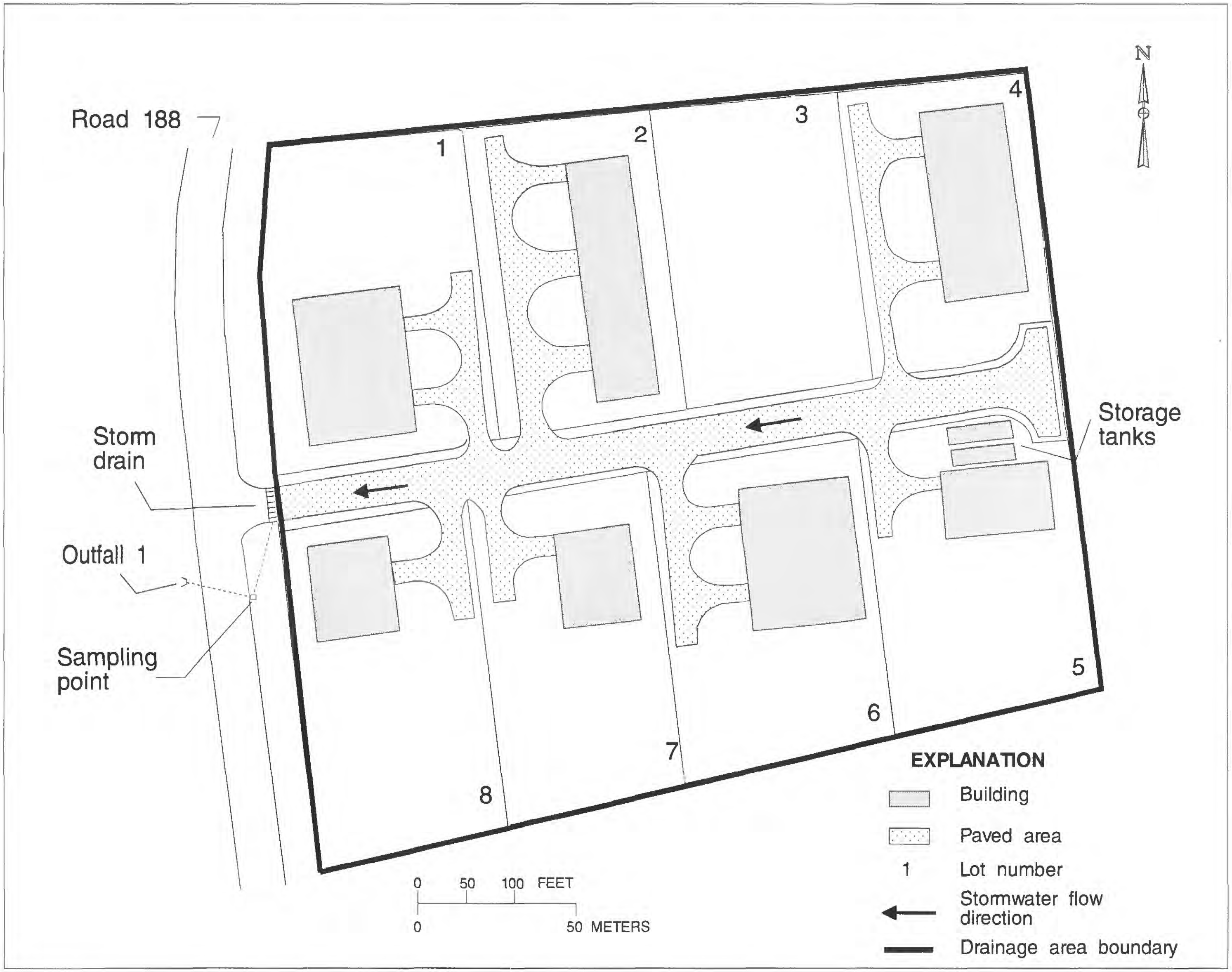

Figure 3. Site drainage of subarea 1 in the San Isidro Industrial Park, Canóvanas, Puerto Rico.

At the street, the stormwater flows toward a storm drain located at the intersection with road 188. The storm drain collects the stormwater and conveys it by underground pipe across road 188 to outfall 1. The stormwater discharge eventually flows into Caño San Isidro.

Subarea 2 (fig. 4) covers approximately 216,000 m^2 and contains 23 industrial lots. Approximately 85,900 m^2 of subarea 2 is covered by pavement and buildings (table 1). Two lots (9 and 10) in subarea 2 were excluded from the study because of a lack of a suitable data collection site where water-sampling instruments could be installed. However, of the two excluded lots, industrial activities were only taking place at lot 9, which occupies 5,581 m^2 or 3 percent of subarea 2.

The stormwater flow pattern in subarea 2 is mainly from the individual lots to the streets (fig. 4). Upon reaching the street, the stormwater flows into the park stormwater sewer system. There are two exceptions to the flow pattern described above; lots 17 and 26. Most of the stormwater from lot 17 is discharged directly to the park stormwater sewer system through two outlets located on the northeastern and eastern boundary of the lot (fig. 4). On lot 26, the stormwater flowing along the east side of the lot is conveyed to the stormwater sewer system by a drainage swale (fig. 4). The outfall of the stormwater sewer system that drains subarea 2 discharges across road 188. As in subarea 1, the stormwater from subarea 2 eventually flows into Caño San Isidro.

Subarea 3 (fig. 5) covers approximately 192,800 m^2 and contains 26 industrial lots. Approximately 34,100 m^2 is covered by pavement and buildings. For the purpose of this study, only the stormwater discharges from the section of subarea 3 where industrial activity was taking place at the time of the study was characterized. This section comprises 30,500 m^2, of which 6,900 m^2 or 22 percent is covered by pavement and buildings.

The stormwater flow pattern at subarea 3 is similar to that at subarea 2. Stormwater flows from the individual lots to the street, where it is conveyed off site by the stormwater sewer system (fig. 5). The outfall for the stormwater sewer system that drains subarea 3 discharges to an unnamed creek that flows into a wetland area north of the industrial park.

Industrial Activity

Selected information was collected related to the type of industrial activity conducted by each building tenant at the SIIP. The types of industrial activities at the SIIP were classified using the Standard Industrial Classification (SIC) (U.S. Executive Office of the President, 1987). Depending on the level of detail the SIC can use a 2- to 4-digit classification system, in which the first two digits show the major group, the third shows the industry group, and the fourth shows the industry code. In this report the 2-digit classification is used.

A total of 31 industries were active at the SIIP during the time of the study (table 2). Subarea 1 is utilized by 9 industries located in 5 buildings. Four of the industries located within subarea 1 manufacture products classified under SIC 28. SIC 28 classifies manufacturers of chemical and allied products.

Subarea 2 is occupied by 20 industries (excluding lot 9) distributed in 13 buildings. In this area, the principal types of industrial activities are under SIC 28 and SIC 20 (7 and 4 industries, respectively). SIC 20 classifies manufacturers of food and food-related products.

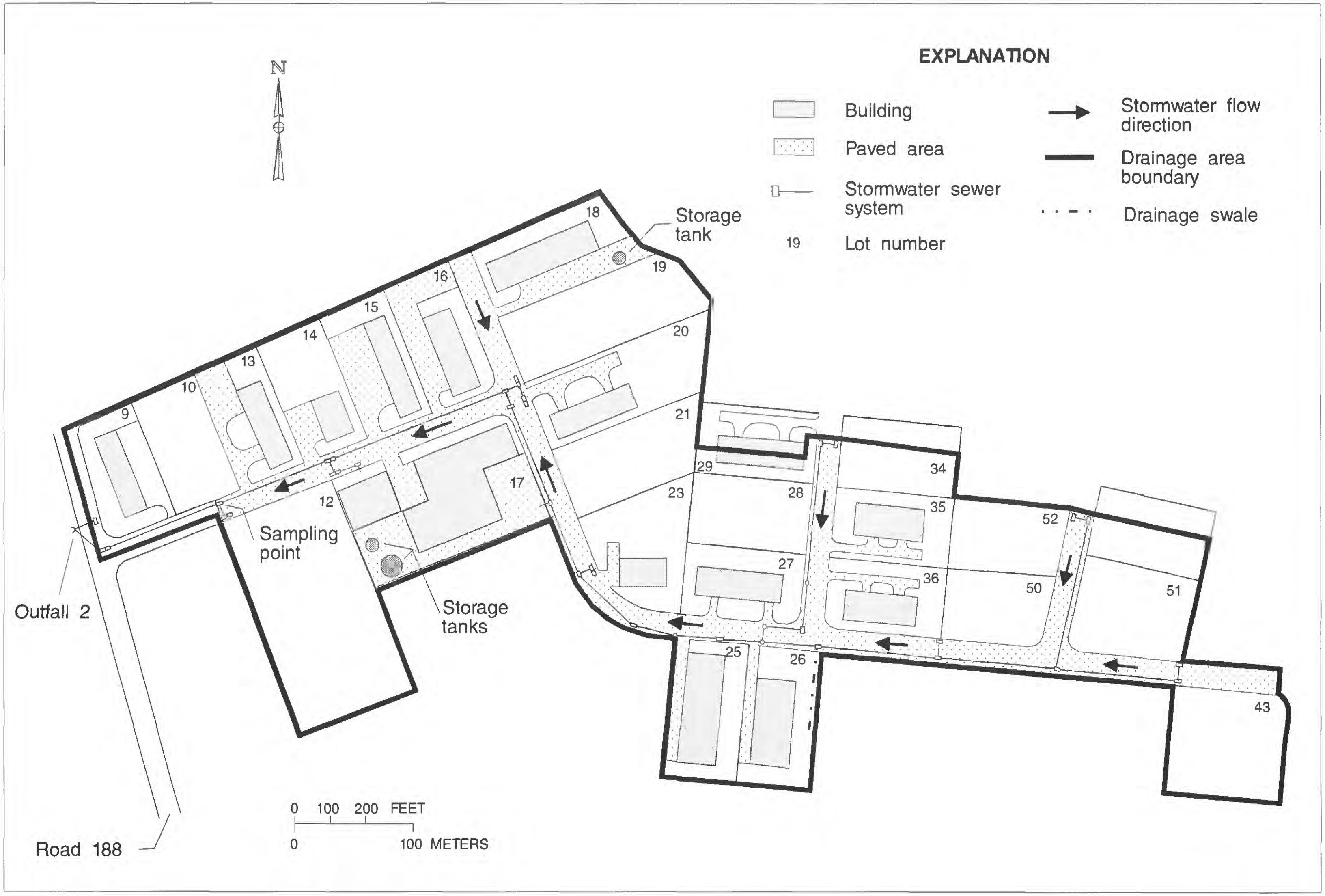

Figure 4. Site drainage of subarea 2 in the San Isidro Industrial Park, Canóvanas, Puerto Rico.

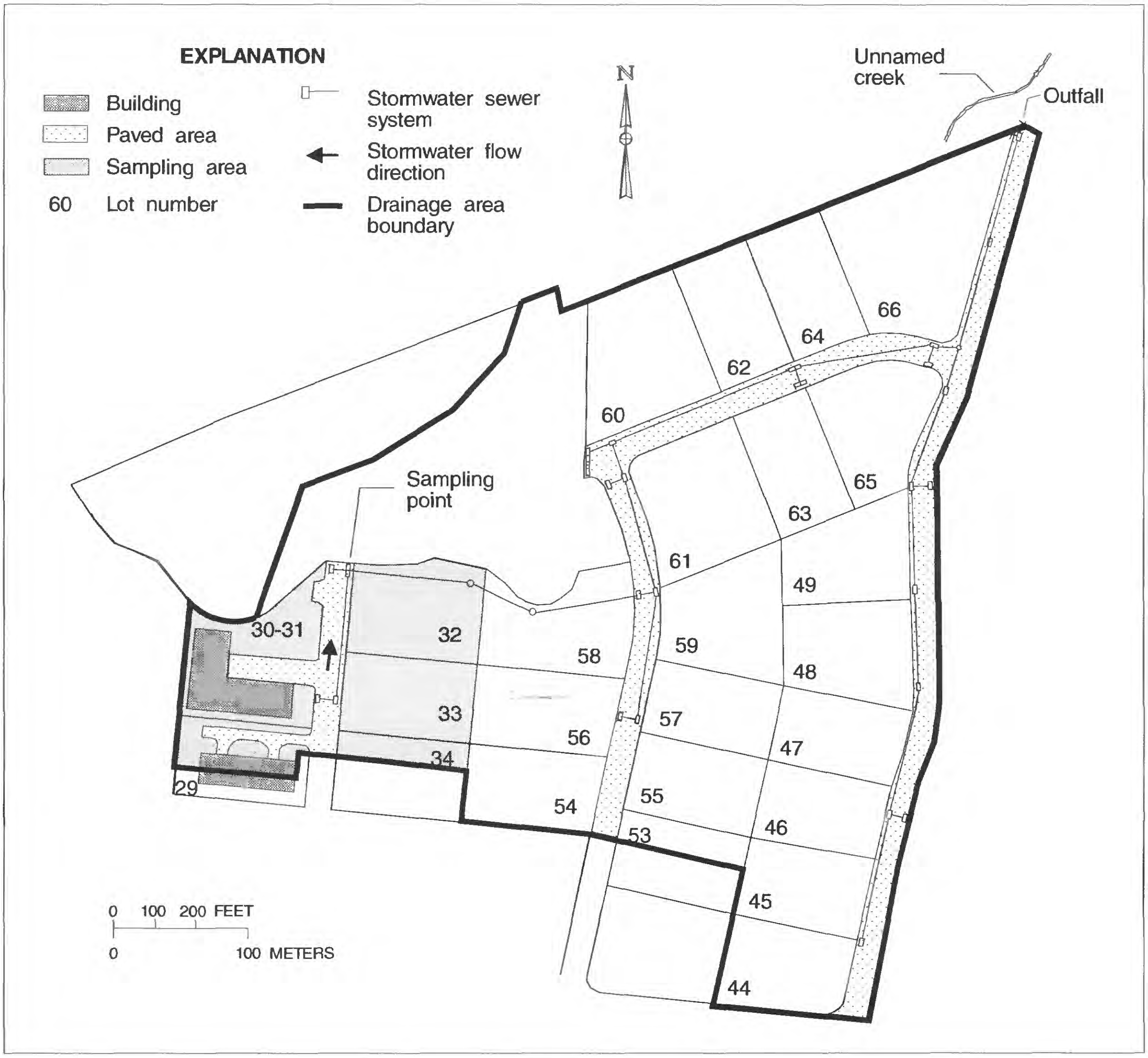

Figure 5. Site drainage of subarea 3 in the San Isidro Industrial Park, Canóvanas, Puerto Rico.

Table 2. Industrial activities at the San Isidro Industrial Park, Canóvanas, Puerto Rico
[SIC, Standard Industrial Classification]

Subarea	Lot number	SIC	Major group	Main product
1	1	30	Rubber and miscellaneous plastic products	Tire recapping
1	1	34	Fabricated metal products	Rivets
1	2	39	Miscellaneous manufacturing	Candles
1	2	36	Electronic and other electric equipment	Fluorescent lamps
1	2	30	Rubber and miscellaneous plastic products	Plastic suitcases
1	2	28	Chemicals and allied products	Lacquer plastic
1	4	28	Chemicals and allied products	Medical products
1	5	28	Chemicals and allied products	Paints
1	8	28	Chemicals and allied products	Detergents and waxes
2	13	20	Food and related products	Syrup beverages
2	14	36	Electronic and other electric equipment	Cable harnesses
2	15	28	Chemicals and allied products	Industrial paints
2	15	23	Apparel and other textile products	Underwear
2	15	25	Furniture and fixtures	Laminated furniture
2	15	20	Food and related products	Wine and juices
2	16	20	Food and related products	Wine and juices
2	16	27	Printing and publishing	Commercial printing
2	17	28	Chemical and allied products	Biotechnology
2	18	20	Food and related products	Wine and juices
2	20	28	Chemicals and allied products	Pharmaceutical products
2	23	42	Trucking and warehousing	Construction materials
2	25	28	Chemicals and allied products	Pharmaceutical products
2	26	25	Furniture and fixtures	Laminated furniture
2	26	36	Industrial machinery and equipment	Power generators
2	26	39	Miscellaneous manufacturing	Zippers
2	27	28	Chemicals and allied products	Pharmaceutical products
2	36	28	Chemicals and allied products	Cosmetics
2	36	34	Fabricated metal products	Metal fixtures
2	36	28	Chemicals and allied products	Shoe wax
3	29	23	Apparel and other textile products	Underwear
3	30 and 31	24	Lumber and wood products	Kitchen cabinets

Subarea 3 is used by two industries located in separate buildings. The activities taking place within this subarea are classified under SIC 23 and SIC 24: manufacturers of apparel and textile products, and lumber and wood products, respectively.

METHODS OF DATA COLLECTION AND ANALYSIS

Stormwater discharge characteristics were studied at three outfalls that drain different subareas of the SIIP. Data collected at each outfall consisted of rainfall volume and flow rate and quality of stormwater discharge. The data were collected during two storm events at each subarea with an automatic water sampler with an integrated flow meter and a continuous recording raingage. The data-collection instruments were installed at, or as near as possible to, the outfalls.

All flow-rate data and the water samples were collected from inside the stormwater sewer system of the SIIP. The probe of the flow meter and the intake of the sampler were placed at the bottom of the pipe of the sewer system. The automatic sampler and the raingage were installed above street level.

In subarea 1, the sampling point was located about 20 m upgradient from the outfall (fig. 3). All runoff from the lots within this subarea flows through the sampling point.

The sampling point for the discharges from subarea 2 was located about 125 m upgradient from the outfall (fig. 4). As mentioned in the Site Drainage section, the discharges from lots 9 and 10 in subarea 2 were not characterized because they are downgradient from the selected sampling point. Sampling points for subarea 1 and subarea 2 were located upgradient from the outfalls due to the ponding of the discharged stormwater caused by the flatness of the land surface at both outfall areas.

The sampling point at subarea 3 was located about 600 m from the outfall (fig. 5). The sampling point in subarea 3 was located closer to the lots with industrial activities in order to characterize only the stormwater discharges from these lots.

At each of the sampling points, the flow meter was calibrated according to manufacturer instructions and programmed to record flow-rate measurements every five minutes. The flow-rate data were used to determine the stormwater discharge volumes during individual storm events and to determine the required sample volumes during the preparation of the flow-weighted composite samples.

Continuous rainfall data were collected with a tipping bucket type raingage. The raingage was connected to an automatic sampler. The automatic sampler was programmed to begin the collection of stormwater samples when the required amount of rainfall, 2.54 mm, had accumulated. Each representative storm event was preceded by at least 72 hours in which no storm event of a magnitude greater than 2.54 mm of rainfall had occurred.

Two types of stormwater samples were collected during each of the studied storm events --grab and discrete-grab samples. Each grab sample was collected during the first 30 minutes of the storm runoff. Each discrete-grab sample was collected every 20 minutes throughout the storm runoff for a maximum period of 3 hours. The discrete-grab samples were used to prepare a flow-weighted composite sample.

The flow-weighted composite sample was prepared using aliquots of the discrete-grab samples combined in proportion to flow. First, the flow rate at the time of the collection of the discrete-grab samples was determined using the data collected by the flow meter. The required volume from each discrete grab sample to prepare the composite was calculated using the following formula (USEPA, 1991):

$$V_n = \frac{V_{max} \cdot Q_n}{Q_{max}} ,$$

where

- V_n is the volume required from discrete grab sample n to prepare the composite,
- V_{max} is the volume of sample collected at the highest flow rate,
- Q_n is the flow rate associated with sample n, and
- Q_{max} is the highest flow rate at which a sample was collected.

Processed samples were sent for analysis to the USGS National Water Quality Laboratory at Arvada, Colorado. Biochemical oxygen demand (BOD) analyses were performed at a local laboratory to meet the maximum holding time requirement of 24 hours for this analysis.

FLOW RATES AND VOLUMES OF STORMWATER DISCHARGE

Selected characteristics of the storm events studied during this investigation are presented in table 3. The information presented includes the duration of each storm, the duration of each sampling period, the total rainfall, the duration of the dry period preceding each event, the maximum flow rates, and the total flow volumes.

The duration of the sampling period extends from the collection of the grab sample to the collection of the last discrete grab sample. The requirement for the minimum sampling period is 60 minutes and the maximum is 180 minutes.

The dry period preceding the event is the time from the end of the last storm event with more than 2.54 mm of rainfall to the beginning of the studied storm event. Two of the studied storm events (November 11, 1993 and January 10, 1994) did not meet the requirement of the minimum dry period (72 hours) that should precede the event. However, the stormwater discharges from these events were sampled to assure the collection of the samples before February and March, which are the months with the lowest average rainfall (Calvesbert, 1970).

The total flow volumes presented in table 3 were estimated by multiplying each of the flow-rates measurements by the time interval (5 minutes) that represents the portion of the total storm-runoff duration associated with the measurement, and then adding all such partial volumes (USEPA, 1991).

The data collected at the SIIP during six storm events indicated that stormwater maximum flow rates ranged from about 4.53 to 21.9 L/s in subarea 1 and subarea 3, and from about 292 to 595 L/s in subarea 2. Stormwater discharge volumes ranged from about 8.97 to 2,100 m^3 for all three subareas.

Table 3. Characteristics of the studied storm events at the San Isidro Industrial Park, Canóvanas, Puerto Rico

Subarea	Date of storm event	Duration of storm, in minutes	Duration of sampling period, in minutes	Total rainfall, in millimeters	Duration of the dry period preceding the event, in hours	Maximum flow rate, in liters per second	Total flow volume, in cubic meters
1	09-26-93	10	80	4.3	216	4.53	13.3
1	10-19-93	35	125	5.1	288	12.7	30.8
2	11-13-93	5	165	4.6	65	595	2,100
2	12-27-93	10	165	3.0	78	292	845
3	01-10-94	5	125	3.0	50	12	8.97
3	01-20-94	30	75	5.1	85	21.9	26

QUALITY OF STORMWATER DISCHARGES

A total of 12 stormwater samples were collected at the three selected sampling points near the outfalls that drain the subareas. As mentioned previously, grab and flow-weighted composite samples were analyzed for each storm event.

Each sample was analyzed for BOD, chemical oxygen demand (COD), total organic carbon (TOC), total suspended solids (TSS), ammonia plus organic nitrogen, nitrate plus nitrite nitrogen, total phosphorous and pH. In addition to these constituents the grab samples were analyzed for oil and grease. The results of the laboratory analyses are presented in table 4.

The average concentration for each analyzed constituent or property (except ammonia plus organic nitrogen and total organic carbon) from samples collected at each subarea were compared to benchmark concentrations established by USEPA (table 5). The benchmark concentrations are values above which USEPA determined a stormwater discharge could potentially impair or contribute to impairing water quality or affect human health from ingestion of water or fish (USEPA, 1995). For industries under a stormwater permit these values are a target to achieve by the implementation of pollution prevention measures. The comparison of the average concentrations with the benchmark values is an indicator of meeting stormwater quality targets if the industries were under permit.

The highest oil and grease concentration, 14 mg/L, at the SIIP was detected in the samples from subarea 1. This concentration does not exceed the benchmark concentration for oil and grease (15 mg/L). The average BOD concentration in all the subareas samples, which ranged from 3.8 to 27 mg/L, was below the benchmark concentration (30 mg/L). The average COD concentration for the grab samples collected at subarea 2 (170 mg/L) exceeded the benchmark concentration (120 mg/L). The average TSS concentration (408 and 199 mg/L) of the grab and composite samples collected in subarea 2 exceeded the benchmark concentration (100 mg/L). The higher TSS concentration detected in

Table 4. Physical and chemical characteristics of stormwater discharges from the San Isidro Industrial Park, Canóvanas, Puerto Rico

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; n/a, not applicable; m-d-y, month-day-year]

Subarea	Date (m-d-y)	Sample type	Specific con-ductance (µS/cm)	pH (standard units)	Oil and grease (mg/L)	Bio-chemical oxygen demand (mg/L)	Chemical oxygen demand (mg/L)	Total organic carbon (mg/L)	Total suspended solids (mg/L)	Ammonia plus organic nitrogen (mg/L as N)	Nitrate plus nitrite (mg/L as N)	Total phos-phorous (mg/L)
1	09-26-93	Grab	180	6.8	1	36	120	27	34	1.0	0.92	0.57
1	09-26-93	Composite	170	6.8	n/a	43	130	31	19	1.0	0.68	0.73
1	10-19-93	Grab	232	6.3	14	7.5	110	34	78	1.4	0.62	0.38
1	10-19-93	Composite	176	7.2	n/a	11	80	26	40	1.1	0.37	0.45
2	11-13-93	Grab	152	6.2	1	14	160	33	432	1.0	0.05	0.16
2	11-13-93	Composite	185	6.7	n/a	43	100	22	150	2.0	0.07	0.60
2	12-27-93	Grab	259	10.1	6	15	180	32	384	1.5	0.09	0.21
2	12-27-93	Composite	242	9.9	n/a	11	130	26	248	0.70	0.08	0.10
3	01-10-94	Grab	92	6.8	< 1	2.4	29	8.2	39	0.50	0.08	0.09
3	01-10-94	Composite	124	7.4	n/a	3.3	29	8.3	26	0.40	0.10	0.08
3	01-20-94	Grab	90	8.4	3	5.3	78	15	156	0.80	0.05	0.14
3	01-20-94	Composite	78	8.5	n/a	4.2	68	13	166	0.50	0.05	0.08

Table 5. Stormwater benchmark concentrations determined by the USEPA (1995)

[mg/L, milligrams per liter]

Constituent or property	Benchmark concentration (mg/L)
Oil and grease	15
Biochemical oxygen demand (BOD)	30
Chemical oxygen demand (COD)	120
Suspended solids, total (TSS)	100
Nitrate plus nitrite, as nitrogen	0.68
Phosphorous, total	2.0

samples from subarea 2, compared to samples from subareas 1 and subarea 3, may be the result of ongoing construction projects in subarea 2. Concentrations of TOC in samples collected from the three studied subareas ranged from 8.2 to 34 mg/L.

The ammonia plus organic nitrogen concentration ranged from 0.4 to 2.0 mg/L. The nitrate plus nitrite average concentration for the grab sample collected at Subarea 1 (0.77 mg/L as N), exceeded the benchmark concentration (0.68 mg/L). Average concentrations of total phosphorous in samples from the three subareas were below the benchmark concentration (2.0 mg/L). The pH value for one of the sampled events at subarea 2 was 10.1, which is unusually high for a stormwater discharge.

Values of mass and mass per area calculated for each constituent are presented in tables 6 and 7. To calculate the mass of each constituent present in a grab sample, each concentration was multiplied by the flow volume at the time of the sample collection. The mass of the selected constituents detected in the composite sample was calculated by multiplying each constituent concentration by the total volume of discharge during the sampling period. Concentrations of values below the detection level (less than values) were assumed to be zero; therefore, mass and mass per area values were not calculated for those concentrations.

The mass values calculated for oil and grease ranged from 1.09 to 540 g; BOD, 2.51 to 90,500 g; COD, 30.3 to 211,000 g; TOC, 8.56 to 46,300 g; and TSS, 30.3 to 211,000 g. Mass values calculated for ammonia plus organic nitrogen as N ranged from 0.522 to 4,210 g; nitrate plus nitrite as N, 0.064 to 147g; and total phosphorous, 0.094 to 1,260 g.

The mass per area values calculated for oil and grease ranged from 0.017 to 2.64 mg/m^2; BOD, 0.082 to 442 mg/m^2; COD, 0.993 to 1,030 mg/m^2; TOC, 0.281 to 226 mg/m^2; and TSS, 0.59 to 1,540 mg/m^2 (table 7). Mass per area computed for ammonia plus organic nitrogen as N ranged from 0.17 to 20.6 mg/m^2; nitrate plus nitrite as N, 0.016 to 0.720 mg/m^2; and total phosphorous, 0.003 to 6.17 mg/m^2. The highest mass per area values for all the analyzed constituents were for subarea 2.

Table 6. Mass, in grams, of selected water-quality constituents and properties of stormwater discharges from the San Isidro Industrial Park, Canóvanas, Puerto Rico

[n/a, not applicable; n/c, not calculated; m-d-y, month-day-year; comp, composite]

Subarea	Date (m-d-y)	Sample type	Oil and grease	Bio-chemical oxygen demand	Chemical oxygen demand	Total organic carbon	Total suspended solids	Ammonia plus organic nitrogen, as N	Nitrate plus nitrite, as N	Total phos-phorous
1	09-26-93	Grab	1.09	39.1	130	29.3	37.0	1.09	1.00	0.620
		Comp	n/a	572	1,730	413	253	13.3	9.05	9.72
1	10-19-93	Grab	22.7	12.2	178	55.2	127	2.27	1.01	0.617
		Comp	n/a	330	2,470	802	1,230	34.0	11.4	13.9
2	11-13-93	Grab	170	2,380	27,200	5,600	73,400	170	8.50	27.2
		Comp	n/a	90,500	211,000	46,300	316,000	4,210	147	1,260
2	12-27-93	Grab	540	1,270	15,200	2,720	32,600	127	7.64	17.8
		Comp	n/a	9,300	109,000	22,000	210,000	592	67.6	84.6
3	01-10-94	Grab	n/c	2.51	30.3	8.56	40.7	0.522	0.084	0.094
		Comp	n/a	29.6	260	74.5	233	3.59	0.898	0.718
3	01-20-94	Grab	3.82	6.75	99.4	19.1	199	1.02	0.064	0.178
		Comp	n/a	109	1,770	338	4,320	13.0	1.30	2.08

Table 7. Mass per area, in milligrams per square meter, of selected water-quality constituents of stormwater discharges from the San Isidro Industrial Park, Canóvanas, Puerto Rico

[n/a, not applicable; n/c, not calculated; m-d-y, month-day-year; comp, composite]

Subarea	Date (m-d-y)	Sample type	Oil and grease	Biochemical oxygen demand	Chemical oxygen demand	Total organic carbon	Total suspended solid	Ammonia plus organic nitrogen, as N	Nitrate plus nitrite, as N	Total phos-phorous
1	09-26-93	Grab	0.017	0.620	2.08	0.47	0.59	0.017	0.016	0.010
		Comp	n/a	9.13	27.6	6.58	4.03	0.212	0.144	0.155
1	10-19-93	Grab	0.362	0.194	2.84	0.880	2.02	0.036	0.016	0.010
		Comp	n/a	5.27	39.4	12.8	19.7	0.541	0.182	0.222
2	11-13-93	Grab	0.830	2.17	133	27.4	359	0.830	0.042	0.133
		Comp	n/a	442	1,030	226	1,540	20.6	0.720	6.17
2	12-27-93	Grab	2.64	6.23	74.7	13.3	159	0.623	0.037	0.087
		Comp	n/a	45.5	537	107	1,020	2.89	0.331	0.413
3	01-10-94	Grab	n/c	0.082	0.993	0.281	1.33	0.017	0.002	0.003
		Comp	n/a	0.971	8.53	2.44	7.65	0.118	0.029	0.024
3	01-20-94	Grab	0.125	0.221	3.26	0.626	6.52	0.033	0.002	0.006
		Comp	n/a	3.59	58.0	11.1	142	0.427	0.043	0.068

SUMMARY

The San Isidro Industrial Park is located in the municipality of Canóvanas in northeastern Puerto Rico. The SIIP covers about 55 hectares and is divided into four drainage subareas. Approximately 26 percent of the park is covered by impervious surfaces.

A total of 31 industries were operating at the SIIP during the study period. These industries were distributed throughout 19 buildings. The main type of activity at the park is classified under SIC 28, which groups manufacturers of chemical and allied products.

During six storm events measured in this study, stormwater discharge maximum flow rates ranged from about 4.5 to 22 L/s in subareas 1 and 3, and from about 292 to 595 L/s in subarea 2. Stormwater discharge volumes for all three subareas ranged from about 9.0 to 2,100 m^3.

The analyses of the stormwater samples collected from the three studied subareas of the SIIP, indicated that concentrations for oil and grease ranged from less than 1 to 14 mg/L. BOD concentrations ranged from 2.4 to 43 mg/L and concentrations of COD ranged from 29 to 180 mg/L. Concentrations of TSS ranged from 19 to 432 mg/L. Values for pH ranged from 6.2 to 10.1 units. The maximum concentrations of ammonia plus organic nitrogen as N, nitrate plus nitrite as N, and total phosphorous were 2.0, 0.92, and 0.73 mg/L, respectively.

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