

Estimated Water Use in Puerto Rico, 1986-87

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CONVERSION FACTORS, ABBREVIATED ELECTRICAL UNITS, AND ACRONYMS

Multiply	By	To obtain
foot	0.3048	meter
acre-foot	1,233.489	cubic meter
cubic foot per second	0.02832	cubic meter per second
gallon per day	3.785	liter per day
gallon per minute	0.0630	liter per second
million gallons per day	43.81	liter per second
square mile	2.590	square kilometer

Abbreviated electrical units used in this report:

GWh gigawatthour
kWh kilowatthour

Acronyms used in this report:

MSHA U.S. Mine Safety and Health Administration
PRASA Puerto Rico Aqueduct and Sewer Authority
PRDNER Puerto Rico Department of Natural and Environmental Resources
PRDOH Puerto Rico Department of Health
PREPA Puerto Rico Electric Power Authority
PREQB Puerto Rico Environmental Quality Board
SWUDS State Water-Use Data System
USGS U.S. Geological Survey

Estimated Water Use in Puerto Rico, 1986-87

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Abstract

Water use during calendar years 1986 and 1987 was estimated for the 78 municipios of the Commonwealth of Puerto Rico. Eight offstream water-use categories were considered during the study including: public supply, domestic, industrial, mining, thermoelectric power, livestock, irrigation, and sewage-treatment discharges. Three instream water-use categories were considered: hydroelectric power, reservoir evaporation, and saline water used at thermoelectric powerplants. Freshwater withdrawals for offstream use from surface and ground water in Puerto Rico were 630 and 648 million gallons per day in 1986 and 1987, respectively. The largest amount of freshwater (instream use) withdrawn was for hydroelectric power: 564 million gallons per day in 1986 and 511 million gallons per day during 1987. Reservoir evaporation is considered to be a consumptive use associated with the storage of water. Evaporation from 14 reservoirs in Puerto Rico totaled 24,100 acre-feet during 1986 and 23,600 acre-feet in 1987 from a total reservoir surface area of 6,390 acres. The largest amount of saline water (instream use) withdrawn was for thermoelectric power: 2,130 million gallons per day in 1986 and 1,740 million gallons per day during 1987. The second largest freshwater withdrawal was made by public-supply facilities. These facilities withdrew 398 million gallons per day during 1986 and 413 million gallons per day during 1987. Total discharge from public sewage-treatment facilities reported an increase from 154 million gallons per day in 1986 to 163 in 1987. Fresh surface- and ground-water

withdrawals for domestic and industrial self-supplied facilities were estimated at about 34 million gallons per day during 1986 and 1987. Mining activities, which in Puerto Rico are mostly limited to the production of sand and gravel, withdrew about 2.6 million gallons per day of freshwater during 1986 and 1987. Livestock activities required 7.4 million gallons per day from surface- and ground-water sources to meet the water needs of 8.56 million animals reported in Puerto Rico during 1986 and 1987. Freshwater withdrawals for irrigation purposes were estimated at 186 million gallons per day in 1986 and 190 million gallons per day in 1987, or about 30 percent of all offstream freshwater withdrawals in both years.

INTRODUCTION

The National Water-Use Information Program of the U.S. Geological Survey (USGS) is a Federal-State Cooperative Program designed to compile, store, and disseminate water-use information locally and nationwide. The program was implemented in Puerto Rico in 1980 to provide data for the management of the Commonwealth's water resources. Planners and managers need to have accurate information regarding the amount of water used, and where and how it is used, so that they can adequately assess many of the critical water problems facing Puerto Rico.

The major objectives of the National Water-Use Program in Puerto Rico are to:

1. Maintain accountability of water use;
2. Create a computerized data base for data entry and retrieval of water-use information at the local, regional, and national levels;

3. Compile water-use data of uniform quality;
4. Define new methodologies for obtaining high quality water-use data;
5. Present information and reports that will help in projecting the future water needs of Puerto Rico;
6. Identify water-use problems so that appropriate management solutions can be determined; and
7. Improve the collection, analysis, and dissemination of water-use information.

In order to meet the general objectives of the Water-Use Program and to maintain an adequate data base, the USGS maintains cooperative agreements with the Puerto Rico Aqueduct and Sewer Authority (PRASA), the Puerto Rico Department of Natural and Environmental Resources (PRDNER), and the Puerto Rico Environmental Quality Board (PREQB) to compile water-use data for major use categories of importance to water manager and planners in Puerto Rico.

Purpose and Scope

This report presents estimates of the amount of water withdrawn from **surface-** and **ground-water** sources and used for offstream and instream uses in Puerto Rico during 1986 and 1987. The eight categories of offstream water use include public supply, **domestic, industrial, mining, thermoelectric power, livestock, irrigation, and sewage-treatment** discharges. Three categories of **instream water use** include **hydroelectric power** generation, **reservoir evaporation**, and **saline water** use at thermoelectric powerplants. Data were obtained from the PRASA, PRDNER, the Puerto Rico Department of Health (PRDOH), the Puerto Rico Electric and Power Authority (PREPA), the U.S. Bureau of the Census, and the U.S. Mine Safety and Health Administration (MSHA).

Discussion about the sources and methods used to compile the data parallels the presentation and discussion of water-use data by category. Data tables are compiled by **municipio**, which constitute the basic

political subdivision in Puerto Rico. All data are stored in a computerized storage-retrieval system, the State Water-Use Data System (SWUDS), which is administered by the USGS.

A number of terms are used throughout the body of this report that may be unfamiliar to the reader. Selected terms are highlighted in boldface type at their first usage in the text. Concise working definitions of these selected terms are supplied in a glossary at the back of the report.

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SOURCES AND METHODS USED TO COMPILE WATER-USE DATA

Politically, Puerto Rico is divided into 78 municipios (fig. 1). Water-use data for a number of categories were compiled for each municipio. Eight offstream water-use categories were considered during the study including public supply, domestic, industrial, mining, thermoelectric power, livestock, irrigation, and sewage treatment as a water-use related category. Three instream uses, hydroelectric power generation, reservoir evaporation, and saline water **withdrawals** at thermoelectric powerplants. The sources and the methods used to compile water-use data differ for each category and are described in the following sections.

Public-Supply Withdrawals and Deliveries to Domestic, Commercial, and Industrial Users

Public supply includes **freshwater** withdrawals and deliveries to domestic, **commercial**, and industrial water-use customers, and **public uses** such as water for firefighting, street washing, municipal parks, and swimming pools. Data were obtained from bimonthly and annual reports prepared by the PRASA (Puerto Rico Aqueduct and Sewer Authority, 1986a,b and 1987a,b). The public-supply deliveries to commercial facilities also include the water distributed by the PRASA to government installations. These data were supplied by the PRASA (Puerto Rico Aqueduct and Sewer Authority, 1986a and 1987a).

The domestic use category also includes **public-supply facilities** that are not operated by PRASA, but serve more than 25 people or have a minimum of 15 hookups and are known as NON-PRASA systems. These data were supplied by the PRDOH (Puerto Rico Department of Health, 1988).

The surface-water public-supply population was calculated by dividing surface-water withdrawals by total withdrawals, and then multiplying the quotient by the estimated total public-supply population (PRASA plus NON-PRASA population). The ground-water public-supply population was estimated by subtracting the population served by surface-water systems from the total public-supply population. The population using potable water was divided by the annual domestic water use to estimate the water used per day per person (**per capita water use**). This total was divided by the number of days in a year. These calculations yield a water-use estimate of 48 gallons per day per person (gal/d/p) in Puerto Rico.

Sewage Treatment

The sewage-treatment category was included in this report because it contains information on the amount of water returned to the hydrologic system by sewage-treatment facilities and the number of public facilities that treat **wastewater**. Sewage-treatment discharges from domestic, commercial, and industrial users served from public-supply systems were obtained from annual reports prepared by the PRASA (Puerto Rico Aqueduct and Sewer Authority, 1986a and 1987a). These annual reports indicate the number of public sewage-treatment facilities and the volume of **sewage** treated by municipio.

Self-Supplied Domestic

The **self-supplied** domestic water withdrawals were estimated by multiplying the population not served by a public-supply system in each municipio by the per capita water-use estimate of daily water consumption. The self-supplied domestic population was determined by subtracting the public-supplied population, served by PRASA and NON-PRASA systems, from the total population. The total populations by municipio for 1986 and 1987 were estimated using the Census of Population and Housing for 1980 and 1990 (U.S. Department of Commerce, 1982 and 1991).

Self-Supplied Industrial and Mining

The annual self-supplied industrial surface- and ground-water withdrawals were estimated from the PRDNER files. These files contain the self-supplied users and the amount of water used by each industry.

The 1986 and 1987 fresh surface- and ground-water withdrawals used for mining purposes were obtained from the Permits and Franchises Division of the PRDNER and from an inventory of sites conducted by the MSHA. Water withdrawals were determined only for sand and gravel quarries, which are the primary mining activities in Puerto Rico.

Thermoelectric and Hydroelectric

Freshwater use from public supply for the Puerto Nuevo and Palo Seco thermoelectric powerplants; from self-supplied ground-water withdrawals at the Aguirre and Costa Sur powerplants; and, the instream saline water use (seawater withdrawals) was obtained from reports prepared by the PREPA. Most of the freshwater withdrawn by thermoelectric powerplants is used for boiler feed, whereas saline water is used in its entirety for cooling purposes.

Total annual amount of instream water use by hydroelectric powerplants throughout Puerto Rico during 1986 and 1987 were obtained from monthly power-generation reports by the PREPA. The amount of water used for hydroelectric power was obtained from the amount of power generated by each facility on a monthly basis. The following equation was used to obtain monthly instream water use.

$$\text{Water Use} = P * F / N \quad (1)$$

where,

P is the gross power generation, in kWh;

F is a specific factor for each reservoir, given the relation between monthly energy production versus instream water requirement, in acre-ft per kWh; and

N is the number of days in a month.

Livestock

Livestock in Puerto Rico totaled 8,557,316 according to the 1987 Census of Agriculture (U.S. Department of Commerce, 1989). The fresh surface- and ground-water withdrawals used for livestock watering purposes are presented in two subcategories: (1) the water associated with the production of red meat, poultry, eggs, and milk, called "stock" water use; and (2) the "animal specialties" water use, which includes the water associated with the production of fur-bearing animals, horses, rabbits, and aquaculture (fish farms).

Total freshwater withdrawals for livestock were estimated by multiplying the number of animals in each municipio by the estimated daily amount of water required per animal. Total water use for livestock was estimated by multiplying the daily average watering requirements per animal (Kirk, 1982) (table 1) by the total number of animals reported in the agricultural census. In general, the livestock watering requirements given in table 1 represent maximum rates in the life cycle. As an example, water requirements for pigs range from 0.6 gal/d for piglets to about 6.0 gal/d for lactating sows (U.S. Department of Commerce, 1990, p. 394).

Table 1. Daily livestock water requirements

[gal/d, gallon per day]

Livestock	Water required (gal/d)
Dairy cows.....	35
Cattle, horses, mules.....	12
Hogs.....	4
Sheep, goats.....	2
Rabbits.....	1
Chickens.....	.06

Irrigation

Surface-water withdrawals for irrigation purposes were estimated using an inventory of the amount of water withdrawn from reservoirs owned by the PREPA and for the island's only independent irrigation district at Ponce. Ground-water withdrawals for irrigation purposes were estimated by obtaining data from several reports that document the hydrologic conditions in the southeastern coastal plain of Puerto Rico during synoptic hydrologic surveys conducted during April to May 1986 in the south coastal plain in the area east of the Río Jueyes (municipios of Salinas, Guayama, Arroyo, and Patillas) and during April to May 1987 in the area west of the Río Jueyes (municipios of Santa Isabel and Juana Díaz). Data obtained from these reports include daily withdrawal rates from all operating irrigation wells in the area (Rodríguez-del-Río and Quiñones-Aponte, 1987; Torres and Gómez-Gómez, 1987; Quiñones-Aponte and Gómez-Gómez, 1987; Dacosta and Gómez-Gómez, 1987). Ground-water withdrawals for irrigation purposes at municipios of Aguadilla, Cabo Rojo, Coamo, Guánica, and Yabucoa were obtained from a water withdrawal rate of 1,933 gallons per day per acre (F. Gómez-Gómez, U.S. Geological Survey, oral commun., 1991).

Calculations for surface-water withdrawals at Ponce were made by multiplying the number of acres of land irrigated by the total water withdrawal rate (surface plus ground water) per acre calculated for areas mostly dedicated to sugarcane and irrigated by the furrow method. The water withdrawal rate obtained was 3,800 gal/d/acre (F. Gómez-Gómez, U.S. Geological Survey, oral commun., 1991). This water withdrawal rate was then multiplied by the total irrigated acreage in the municipio of Ponce. The difference between the estimated total irrigation withdrawal and the accounted ground-water withdrawal was considered as the total surface-water withdrawal. Surface-water withdrawals for irrigation purposes in the Isabela Irrigation District were estimated from irrigation deliveries reported by the PREPA. This factor represents the ratio of total water released to the irrigation canal at the Lago de Guajataca dam (municipio of Quebradillas) divided by the sum of total water delivered to PRASA public-water supply filtration plants and to irrigators. Data presented on the number of acres irrigated were obtained from the 1987 Census of Agriculture (U.S. Department of Commerce, 1989).

Reservoir Evaporation

Evaporation of water from a reservoir is considered to be a **consumptive use** associated with the storage of water. It was calculated for the manmade impoundments in Puerto Rico that have a normal capacity equal to or greater than 5,000 acre-ft. The annual water loss to evaporation for 14 reservoirs throughout Puerto Rico was calculated using the following equation:

$$RE = RA * PE * K, \quad (2)$$

where,

RE is the reservoir evaporation, in thousands of acre-feet per year;

RA is the reservoir area, in thousands of acres;

PE is the class A annual pan evaporation, in feet; and

K is a constant, equal to 0.7.

The surface area for each reservoir was obtained from the PREPA and the PRDNER. Reservoir levels were assumed to be at the spillway elevation. Class A Pan Evaporation was taken from the National Oceanic and Atmospheric Administration data (U.S. Department of Commerce, 1986, 1987).

WATER USE BY CATEGORY

Freshwater withdrawals during 1986 from surface- and ground-water use categories totaled 630 Mgal/d; surface-water withdrawals totaled 463 Mgal/d and ground-water withdrawals totaled 167 Mgal/d. Freshwater withdrawals during 1987 from surface- and ground-water use categories totaled 648 Mgal/d; surface-water withdrawals totaled 481 Mgal/d and ground-water withdrawals totaled 167 Mgal/d (fig. 2). Withdrawals during 1986-87 by municipio are summarized in tables 2 through 18 for the categories of water use presented in this section.

Public-Supply Withdrawals and Deliveries to Domestic, Commercial, and Industrial Users

There were 160 public-supply facilities operating in Puerto Rico supplied from surface-water sources during 1986. In addition, there were 333 public-supply wells. The number of public-supply facilities decreased

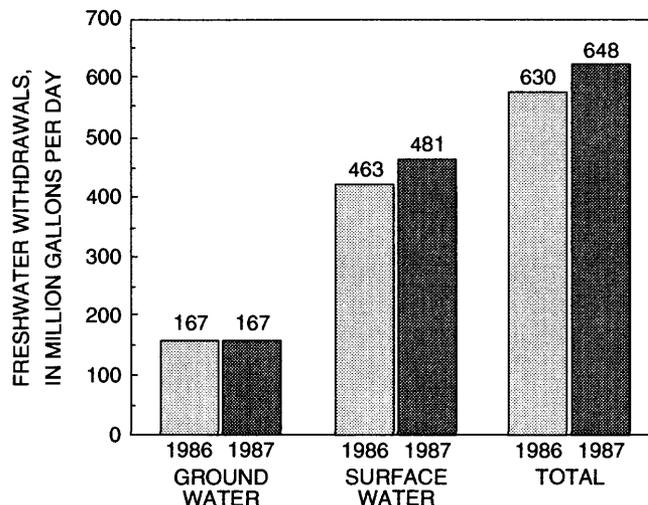


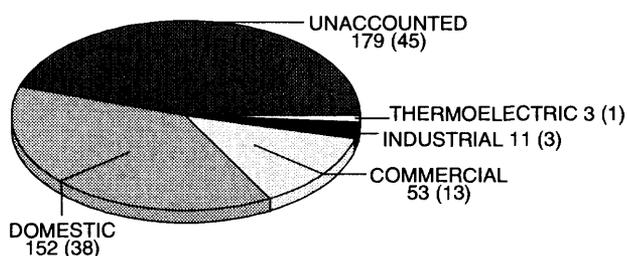
Figure 2. Freshwater withdrawals in Puerto Rico during 1986 and 1987.

to 154 and the number of wells decreased to 326 in 1987. Culebra is the only municipio that obtains its public supply from a seawater desalinization plant.

Freshwater withdrawals by public-supply facilities from surface- and ground-water sources totaled 398 Mgal/d during 1986 and 413 Mgal/d during 1987. The largest public-supply withdrawal during both years was an average of 77 Mgal/d from the Sergio Cuevas facility at Trujillo Alto (tables 2 and 3). This facility withdraws water from the Lago Loíza Reservoir and provides water to the municipios of Trujillo Alto, Caguas, Carolina, San Juan, some sectors of Guaynabo, and Catáño.

Distribution of potable water by PRASA during 1986 was as follows: 152 Mgal/d (38 percent) for domestic use; 53 Mgal/d (13 percent) for commercial use; 11 Mgal/d (3 percent) for industrial use; 3 Mgal/d (1 percent) for thermoelectric use; and, 179 Mgal/d (45 percent) for unaccounted use. Unaccounted use includes public uses, losses due to system distribution leaks, illegal connections, and accounting errors (fig. 3). During 1987, PRASA delivered the following amounts: 154 Mgal/d (37 percent) for domestic use; 52 Mgal/d (13 percent) for commercial use; 12 Mgal/d (3 percent) for industrial use; 3 Mgal/d (1 percent) for thermoelectric use; and 192 Mgal/d (46 percent) for unaccounted use (fig. 4). Deliveries from public-supply systems by type of use for each municipio during 1986 and 1987 are listed in tables 4 and 5.

TOTAL: 398 MILLION GALLONS PER DAY

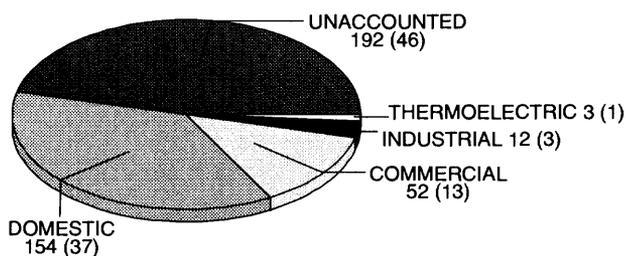


EXPLANATION

179 (45) Numbers to left of parentheses indicate rate of water use for given category in million gallons per day. Value in parentheses indicates percentage of total.

Figure 3. Public-supply deliveries to domestic, commercial, industrial, thermoelectric, and unaccounted uses in Puerto Rico during 1986.

TOTAL: 413 MILLION GALLONS PER DAY



EXPLANATION

192 (46) Numbers to left of parentheses indicate rate of water use for given category in million gallons per day. Value in parentheses indicates percentage of total.

Figure 4. Public-supply deliveries to domestic, commercial, industrial, thermoelectric, and unaccounted uses in Puerto Rico during 1987.

Positive values resulting from the difference between withdrawals and deliveries within a municipio and listed under "unaccounted use" in tables 4 and 5 may represent exports of public-water supply to adjacent municipios in addition to the reasons previously defined under unaccounted use. Negative values indicate importation of public-water supply from adjacent municipios to such an extent that public-supply deliveries to a municipio exceed its public-supply withdrawals.

Sewage Treatment

Most public sewage-treatment plants in Puerto Rico are near the principal urban center in each municipio. Islandwide, there were only nine regional

wastewater-treatment plants (RWWTP) operating during 1986 and 1987. These plants were: (1) the Puerto Nuevo RWWTP in San Juan serving the municipios of San Juan, Cataño, and part of Guaynabo; (2) the Carolina RWWTP in Loíza serving Loíza, Carolina, Canóvanas, and Trujillo Alto; (3) the Bayamón RWWTP in Cataño serving Bayamón, part of Guaynabo, and part of Cataño; (4) the Arecibo RWWTP in Arecibo serves Arecibo, (5) the Barceloneta RWWTP in Barceloneta serves Barceloneta and Manatí; (6) the Mayagüez RWWTP in Mayagüez, serves the municipios of Mayagüez, Hormigueros, and part of Cabo Rojo; (7) the Aguada RWWTP in Aguada serves Aguada, Aguadilla, and Moca; (8) the Camuy RWWTP in Camuy serves the municipios of Camuy and Hatillo; and (9) the Ponce RWWTP in Ponce serves Ponce. Although most public sewage-treatment plants provide secondary treatment, the large regional plants only provide primary treatment and discharge their effluent through ocean outfalls.

Total discharge from public sewage-treatment plants reported an increase from 154 Mgal/d in 1986 to 163 Mgal/d in 1987. However, the number of public sewage-treatment plants decreased from 108 in 1986 to 102 in 1987. This change corresponds to the shut-down of facilities at the municipios of Trujillo Alto and Carolina and completion of trunk lines to the regional wastewater-treatment plants at Arecibo and Mayagüez. A summary of the amount of water released by public sewage-treatment plants and the number of operating plants by municipio during 1986 and 1987 is presented in table 6.

Self-Supplied Domestic

About 25 percent of the total offshore freshwater withdrawn in Puerto Rico was used for domestic purposes during 1986 and 1987. Public-supply systems delivered 152 Mgal/d for domestic use during 1986 and 154 Mgal/d in 1987 to an estimated population of 3 million people (tables 7 and 8). The average per capita domestic water use from public supply was estimated to be 48 gal/d/p during both years. The population served by self-supplied systems was estimated to be about 385,000 in 1986 and 384,000 in 1987, which represents withdrawals of about 19 Mgal/d each year, applying the same per capita use obtained for public supplied users.

Table 2. Total freshwater withdrawals by public-supply facilities and population served by municipio, by source for 1986

[Location of municipios is shown in figure 1. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day]

Municipio	Freshwater withdrawals (Mgal/d)			Population served (thousands)		
	Surface water	Ground water	Total	Surface water	Ground water	Total
Adjuntas.....	1.35	0.33	1.68	9.21	1.86	11.07
Aguada.....	.01	.05	.06	28.03	.00	28.03
Aguadilla	14.19	.00	14.19	47.58	.00	47.58
Aguas Buenas .....	.91	.23	1.14	20.03	1.15	21.18
Aibonito.....	2.09	.59	2.68	14.49	4.15	18.64
Añasco .....	.31	.07	.38	21.52	.00	21.52
Arecibo	2.60	11.57	14.17	15.16	67.41	82.57
Arroyo.....	.01	1.18	1.19	.14	15.92	16.06
Barceloneta .....	.00	2.53	2.53	.00	16.40	16.40
Barranquitas.....	1.11	.27	1.38	15.75	2.20	17.95
Bayamón.....	.32	.00	.32	206.93	.00	206.93
Cabo Rojo.....	.00	3.57	3.57	.00	31.22	31.22
Caguas	5.96	.47	6.43	109.63	3.55	113.18
Camuy.....	.91	.34	1.25	16.71	6.24	22.95
Canóvanas.....	6.08	.00	6.08	22.63	.00	22.63
Carolina .....	.00	.02	.02	177.38	.00	177.38
Cataño.....	.00	.00	.00	21.38	.00	21.38
Cayey	3.43	1.17	4.60	29.75	10.24	39.99
Ceiba.....	.00	.00	.00	13.26	.00	13.26
Ciales	1.35	.51	1.86	9.58	3.67	13.25
Cidra	2.27	.58	2.85	20.35	5.20	25.55
Coamo.....	1.64	.58	2.22	20.99	7.13	28.12
Comerio	1.36	.00	1.36	12.33	.00	12.33
Corozal	1.47	.00	1.47	27.01	.00	27.01
Culebra .....	.06	.01	.07	.91	.15	1.06
Dorado .....	.00	3.99	3.99	.00	25.49	25.49
Fajardo.....	6.51	.00	6.51	31.61	.00	31.61
Florida.....	.00	1.86	1.86	.00	6.41	6.41
Guánica.....	.00	3.64	3.64	.00	16.60	16.60
Guayama.....	3.88	.82	4.70	29.11	6.15	35.26
Guayanilla.....	.26	1.55	1.81	2.62	16.13	18.75
Guaynabo.....	23.46	.00	23.46	74.76	.00	74.76
Gurabo .....	.00	.60	.60	.00	22.33	22.33
Hatillo	1.66	.83	2.49	16.17	8.08	24.25
Hormigueros.....	.00	.88	.88	.00	15.24	15.24
Humacao.....	2.56	.09	2.65	44.91	1.58	46.49
Isabela.....	2.38	.00	2.38	34.19	.00	34.19
Jayuya	1.44	.00	1.44	11.89	.00	11.89
Juana Díaz	1.21	3.91	5.12	7.18	23.14	30.32
Juncos	2.43	.72	3.15	19.50	5.78	25.28

Table 2. Total freshwater withdrawals by public-supply facilities and population served by municipio, by source for 1986—
Continued

Municipio	Freshwater withdrawals (Mgal/d)			Population served (thousands)		
	Surface water	Ground water	Total	Surface water	Ground water	Total
Lajas	1.33	0.00	1.33	18.50	0.00	18.50
Lares	1.02	.02	1.04	24.97	.00	24.97
Las Marías .....	.64	.00	.64	6.14	.00	6.14
Las Piedras.....	.21	.13	.34	10.65	6.59	17.24
Loíza .....	.00	.00	.00	25.93	.00	25.93
Luquillo	2.14	.00	2.14	14.35	.00	14.35
Manatí.....	.00	7.77	7.77	.00	38.42	38.42
Maricao.....	.35	.00	.35	3.40	.00	3.40
Maunabo.....	.10	.92	1.02	.80	9.06	9.86
Mayagüez	16.84	.62	17.46	86.10	3.17	89.27
Moca .....	.41	.00	.41	23.67	.00	23.67
Morovis.....	2.15	.00	2.15	18.27	.00	18.27
Naguabo.....	11.37	.00	11.37	19.55	.00	19.55
Naranjito .....	.48	.10	.58	23.89	.00	23.89
Orocovis	2.57	.06	2.63	18.99	.00	18.99
Patillas .....	.49	.93	1.42	4.11	12.34	16.45
Peñuelas	2.63	.02	2.65	18.49	.00	18.49
Ponce	17.70	7.93	25.63	123.83	55.25	179.08
Quebradillas.....	2.33	.08	2.41	17.55	.60	18.15
Rincón.....	.00	.78	.78	.00	10.28	10.28
Río Grande.....	14.69	.00	14.69	35.39	.00	35.39
Sabana Grande.....	1.54	.31	1.85	17.47	3.52	20.99
Salinas.....	.00	2.87	2.87	.00	22.76	22.76
San Germán	1.52	.00	1.52	29.18	.00	29.18
San Juan.....	.00	.02	.02	422.20	.00	422.20
San Lorenzo.....	2.64	.07	2.71	33.54	.00	33.54
San Sebastián.....	2.35	.01	2.36	28.56	.00	28.56
Santa Isabel.....	.00	1.61	1.61	.00	15.66	15.66
Toa Alta	53.85	.00	53.85	28.16	.00	28.16
Toa Baja.....	.00	2.37	2.37	.00	88.61	88.61
Trujillo Alto.....	76.11	.00	76.11	54.32	.00	54.32
Utuado	2.80	.00	2.80	27.51	.00	27.51
Vega Alta .....	.18	4.34	4.52	.97	23.45	24.42
Vega Baja.....	1.42	5.50	6.92	8.57	33.20	41.77
Vieques .....	.00	.00	.00	8.08	.00	8.08
Villalba	1.53	.03	1.56	17.20	.36	17.56
Yabucoa .....	.71	1.48	2.19	8.28	20.29	28.57
Yauco.....	2.07	.04	2.11	34.24	.69	34.93
Total	317.39	80.97	398.36	2,345.55	667.67	3,013.22

Table 3. Total freshwater withdrawals by public-supply facilities and population served by municipio, by source for 1987

[Location of municipios are shown in figure 1. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day]

Municipio	Freshwater withdrawals (Mgal/d)			Population served (thousands)		
	Surface water	Ground water	Total	Surface water	Ground water	Total
Adjuntas.....	1.39	0.28	1.67	9.81	1.57	11.38
Aguada.....	.01	.05	.06	28.51	.00	28.51
Aguadilla	14.18	.00	14.18	47.96	.00	47.96
Aguas Buenas .....	.84	.26	1.10	19.45	1.94	21.39
Aibonito.....	1.50	.70	2.20	12.99	6.18	19.17
Añasco .....	.36	.08	.44	21.73	.00	21.73
Arecibo	2.93	12.91	15.84	15.55	68.48	84.03
Arroyo.....	.00	1.04	1.04	.00	16.59	16.59
Barceloneta .....	.00	2.14	2.14	.00	17.32	17.32
Barranquitas.....	1.35	.22	1.57	17.20	1.00	18.20
Bayamón.....	.59	.00	.59	206.05	.00	206.05
Cabo Rojo.....	.00	3.23	3.23	.00	31.97	31.97
Caguas	7.07	.35	7.42	112.73	1.29	114.02
Camuy.....	.88	.59	1.47	14.12	9.47	23.59
Canóvanas.....	5.88	.00	5.88	23.08	.00	23.08
Carolina .....	.00	.02	.02	175.84	.00	175.84
Cataño.....	.00	.00	.00	22.51	.00	22.51
Cayey.....	4.11	2.49	6.60	25.49	15.51	41.00
Ceiba.....	.00	.00	.00	13.68	.00	13.68
Ciales	1.52	.81	2.33	8.89	4.80	13.69
Cidra	2.46	1.13	3.59	18.36	7.39	25.75
Coamo.....	1.54	1.10	2.64	16.72	11.77	28.49
Comerio	1.80	.00	1.80	11.37	1.36	12.73
Corozal	2.91	.00	2.91	38.15	.00	38.15
Culebra .....	.05	.01	.06	.90	.18	1.08
Dorado .....	.00	3.10	3.10	.00	25.77	25.77
Fajardo.....	6.51	.00	6.51	31.86	.00	31.86
Florida.....	.00	1.81	1.81	.00	6.56	6.56
Guánica.....	.00	3.71	3.71	.00	17.02	17.02
Guayama.....	4.34	.74	5.08	30.52	5.20	35.72
Guayanilla.....	.27	1.75	2.02	2.57	16.55	19.12
Guaynabo.....	23.93	.00	23.93	76.22	.00	76.22
Gurabo .....	.00	.47	.47	.00	22.71	22.71
Hatillo.....	2.15	.74	2.89	18.30	6.30	24.60
Hormigueros .....	.00	.75	.75	.00	15.33	15.33
Humacao.....	2.28	.09	2.37	45.19	1.78	46.97
Isabela.....	1.65	.00	1.65	35.01	.00	35.01
Jayuya	1.48	.00	1.48	11.83	.00	11.83
Juana Díaz	1.43	3.57	5.00	8.81	21.98	30.79
Juncos	3.09	.90	3.99	20.61	6.00	26.61

Table 3. Total freshwater withdrawals by public-supply facilities and population served by municipio, by source for 1987—
Continued

Municipio	Freshwater withdrawals (Mgal/d)			Population served (thousands)		
	Surface water	Ground water	Total	Surface water	Ground water	Total
Lajas	1.34	0.00	1.34	18.98	0.00	18.98
Lares .....	.97	.02	.99	25.19	.00	25.19
Las Marías .....	.71	.00	.71	6.30	.00	6.30
Las Piedras.....	.21	.13	.34	10.51	6.50	17.01
Loíza .....	.00	.00	.00	26.77	.00	26.77
Luquillo	2.28	.00	2.28	14.42	.00	14.42
Manatí.....	.00	7.52	7.52	.00	38.73	38.73
Maricao.....	.98	.00	.98	3.46	.00	3.46
Maunabo.....	.09	.73	.82	.90	9.14	10.04
Mayagüez	17.21	.57	17.78	87.49	2.90	90.39
Moca .....	.27	.00	.27	24.32	.00	24.32
Morovis.....	2.08	.00	2.08	18.70	.00	18.70
Naguabo.....	12.04	.00	12.04	19.68	.00	19.68
Naranjito .....	.86	.11	.97	24.24	.00	24.24
Orocovis	2.52	.06	2.58	19.22	.00	19.22
Patillas .....	.24	.88	1.12	3.63	13.30	16.93
Peñuelas	2.35	.02	2.37	19.20	.00	19.20
Ponce	17.50	7.52	25.02	127.29	54.45	181.74
Quebradillas.....	2.36	.25	2.61	16.67	1.77	18.44
Rincón.....	.00	.78	.78	.00	10.58	10.58
Río Grande.....	20.82	.00	20.82	35.29	.00	35.29
Sabana Grande.....	1.83	.35	2.18	17.73	3.39	21.12
Salinas.....	.00	3.05	3.05	.00	23.27	23.27
San Germán	1.55	1.15	2.70	16.48	12.89	29.37
San Juan.....	.00	.01	.01	424.56	.00	424.56
San Lorenzo.....	2.75	.06	2.81	23.78	.00	23.78
San Sebastián.....	2.09	.01	2.10	29.14	.00	29.14
Santa Isabel.....	1.30	.95	2.25	9.13	6.67	15.80
Toa Alta	50.38	1.04	51.42	28.75	.59	29.34
Toa Baja.....	.00	1.08	1.08	.00	91.56	91.56
Trujillo Alto.....	78.51	.00	78.51	54.82	.00	54.82
Utua.....	2.86	.00	2.86	27.92	.00	27.92
Vega Alta .....	.09	4.31	4.40	.50	24.17	24.67
Vega Baja.....	1.25	5.32	6.57	8.15	34.70	42.85
Vieques .....	.00	.00	.00	8.13	.00	8.13
Villalba	1.57	.14	1.71	16.58	1.46	18.04
Yabucoa .....	.66	1.86	2.52	6.44	22.33	28.77
Yauco	1.96	.17	2.13	32.66	2.95	35.61
Total	330.13	83.13	413.26	2,349.04	703.37	3,052.41

Table 4. Public-supply deliveries by type of use and municipio for 1986

[Location of municipios are shown in figure 1. Unaccounted use: Positive values are the difference between withdrawals and deliveries in a municipio. Negative values indicate importation of public-water supply from adjacent municipios to such an extent that public-supply deliveries to a municipio exceed its public-supply withdrawals. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day]

Municipio	Water deliveries by type of use (Mgal/d)					
	Domestic	Commercial	Industrial	Thermoelectric power	Unaccounted use	Total deliveries
Adjuntas	0.50	0.12	0.00	0.00	1.06	1.68
Aguada	1.22	.20	.05	.00	-1.41	.06
Aguadilla.....	2.36	1.00	.18	.00	10.65	14.19
Aguas Buenas .....	.98	.13	.02	.00	.01	1.14
Aibonito .....	.98	.22	.21	.00	1.27	2.68
Añasco .....	.97	.12	.05	.00	-.76	.38
Arecibo.....	4.22	1.69	.17	.00	8.09	14.17
Arroyo.....	.79	.17	.02	.00	.21	1.19
Barceloneta .....	.83	.33	.01	.00	1.36	2.53
Barranquitas .....	.96	.14	.00	.00	.28	1.38
Bayamón	11.17	2.08	.33	.00	-13.26	.32
Cabo Rojo	1.79	.43	.02	.00	1.33	3.57
Caguas.....	5.76	1.50	.26	.00	-1.09	6.43
Camuy.....	1.04	.30	.03	.00	-.12	1.25
Canóvanas.....	1.20	.24	.04	.00	4.60	6.08
Carolina.....	8.33	1.98	1.10	.00	-11.39	.02
Cataño	1.44	1.59	1.55	.00	-4.58	.00
Cayey	1.80	.37	.18	.00	2.25	4.60
Ceiba .....	.53	.06	.01	.00	-.60	.00
Ciales .....	.53	.12	.02	.00	1.19	1.86
Cidra.....	1.28	.20	.05	.00	1.32	2.85
Coamo	1.17	.28	.25	.00	.52	2.22
Comerio .....	.57	.11	.02	.00	.66	1.36
Corozal.....	1.22	.20	.02	.00	.03	1.47
Culebra.....	.05	.02	.00	.00	.00	.07
Dorado	1.33	.30	.04	.00	2.32	3.99
Fajardo	1.71	.50	.10	.00	4.20	6.51
Florida.....	.36	.05	.00	.00	1.45	1.86
Guánica .....	.88	.23	.01	.00	2.52	3.64
Guayama	1.61	.65	.08	.00	2.36	4.70
Guayanilla.....	.87	.25	.00	.00	.69	1.81
Guaynabo	4.54	3.25	.26	1.21	14.20	23.46
Gurabo	1.00	.18	.04	.00	-.62	.60
Hatillo	1.27	.35	.07	.00	.80	2.49
Hormigueros .....	.75	.08	.01	.00	.04	.88
Humacao	2.39	1.30	.49	.00	-1.53	2.65
Isabela	1.64	.42	.03	.00	.29	2.38
Jayuya .....	.48	.17	.06	.00	.73	1.44

Table 4. Public-supply deliveries by type of use and municipio for 1986—*Continued*

Municipio	Water deliveries by type of use (Mgal/d)					
	Domestic	Commercial	Industrial	Thermoelectric power	Unaccounted use	Total deliveries
Juana Díaz	1.38	0.35	0.07	0.00	3.32	5.12
Juncos	1.45	.23	.05	.00	1.42	3.15
Lajas .....	.99	.23	.001	.00	.10	1.33
Lares .....	.99	.19	.00	.00	-.14	1.04
Las Marías .....	.29	.07	.00	.00	.28	.64
Las Piedras.....	.73	.12	.17	.00	-.68	.34
Loíza.....	1.37	.23	.01	.00	-1.61	.00
Luquillo .....	.86	.22	.04	.00	1.02	2.14
Manatí.....	1.67	.50	.05	.00	5.55	7.77
Maricao.....	.12	.03	.02	.00	.18	.35
Maunabo.....	.43	.10	.01	.00	.48	1.02
Mayagüez	4.64	1.83	1.68	.00	9.31	17.46
Moca.....	1.02	.16	.01	.00	-.78	.41
Morovis.....	.75	.14	.01	.00	1.25	2.15
Naguabo.....	.95	.17	.02	.00	10.23	11.37
Naranjito.....	1.14	.14	.00	.00	-.70	.58
Orocovis .....	.75	.11	.01	.00	1.76	2.63
Patillas .....	.78	.11	.04	.00	.49	1.42
Peñuelas.....	.79	.17	.00	.00	1.69	2.65
Ponce	8.85	3.26	.81	.00	12.71	25.63
Quebradillas.....	.89	.26	.14	.00	1.12	2.41
Rincón.....	.52	.11	.01	.00	.14	.78
Río Grande.....	2.04	.39	.04	.00	12.22	14.69
Sabana Grande.....	.99	.19	.04	.00	.63	1.85
Salinas.....	1.14	.24	.02	.00	1.47	2.87
San Germán	1.30	.32	.23	.00	-.33	1.52
San Juan.....	26.24	18.06	.88	.00	-45.16	.02
San Lorenzo.....	1.03	.11	.03	.00	1.54	2.71
San Sebastián.....	1.30	.26	.04	.00	.76	2.36
Santa Isabel.....	.69	.16	.04	.00	.72	1.61
Toa Alta	1.50	.18	.09	.00	52.08	53.85
Toa Baja.....	4.41	.54	.14	1.58	-4.30	2.37
Trujillo Alto.....	1.16	.34	.00	.00	74.61	76.11
Utua.....	1.10	.30	.01	.00	1.39	2.80
Vega Alta	1.22	.31	.51	.00	2.48	4.52
Vega Baja.....	2.20	.51	.08	.00	4.13	6.92
Vieques .....	.41	.16	.01	.00	-.58	.00
Villalba .....	.66	.13	.02	.00	.75	1.56
Yabucoa	1.42	.25	.01	.00	.51	2.19
Yauco	1.68	.46	.03	.00	-.06	2.11
Total	152.37	52.97	11.16	2.79	179.07	398.36

Table 5. Public-supply deliveries by type of use and municipio for 1987

[[Location of municipios are shown in figure 1. Unaccounted use: Positive values are the difference between withdrawals and deliveries in a municipio. Negative values indicate importation of public-water supply from adjacent municipios to such an extent that public-supply deliveries to a municipio exceed its public-supply withdrawals. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day]

Municipio	Water deliveries by type of use (Mgal/d)					
	Domestic	Commercial	Industrial	Thermoelectric power	Unaccounted use	Total deliveries
Adjuntas.....	0.52	0.14	0.00	0.00	1.01	1.67
Aguada.....	1.26	.19	.05	.00	-1.44	.06
Aguadilla	2.48	1.14	.18	.00	10.38	14.18
Aguas Buenas	1.01	.13	.03	.00	-.07	1.10
Aibonito.....	1.01	.23	.27	.00	.69	2.20
Añasco .....	.97	.12	.05	.00	-.70	.44
Arecibo	4.21	1.64	.15	.00	9.84	15.84
Arroyo.....	.82	.18	.03	.00	.01	1.04
Barceloneta.....	.86	.37	.01	.00	.90	2.14
Barranquitas.....	1.05	.13	.00	.00	.39	1.57
Bayamón.....	9.64	2.02	.35	.00	-11.42	.59
Cabo Rojo.....	1.65	.44	.03	.00	1.11	3.23
Caguas	5.78	1.54	.25	.00	-.15	7.42
Camuy.....	1.08	.30	.02	.00	.07	1.47
Canóvanas.....	1.27	.24	.05	.00	4.32	5.88
Carolina	11.12	3.50	1.10	.00	-15.70	.02
Cataño.....	1.40	2.55	2.02	.00	-5.97	.00
Cayey.....	1.93	.37	.21	.00	4.09	6.60
Ceiba.....	.54	.06	.01	.00	-.61	.00
Ciales .....	.59	.13	.02	.00	1.59	2.33
Cidra	1.34	.19	.05	.00	2.01	3.59
Coamo.....	1.14	.29	.34	.00	.87	2.64
Comerío .....	.58	.10	.01	.00	1.32	2.01
Corozal	1.07	.19	.02	.00	1.63	2.91
Culebra .....	.04	.02	.00	.00	.00	.06
Dorado	1.34	.36	.04	.00	1.36	3.10
Fajardo.....	1.77	.56	.12	.00	4.06	6.51
Florida.....	.38	.06	.00	.00	1.37	1.81
Guánica.....	.90	.24	.00	.00	2.57	3.71
Guayama.....	1.64	.64	.09	.00	2.71	5.08
Guayanilla.....	.88	.26	.00	.00	.88	2.02
Guaynabo.....	4.62	2.65	.24	1.21	15.21	23.93
Gurabo .....	.99	.16	.05	.00	-.73	.47
Hatillo	1.54	.39	.06	.00	.90	2.89
Hormigueros.....	.77	.08	.02	.00	-.12	.75
Humacao.....	2.43	1.35	.50	.00	-1.91	2.37
Isabela.....	1.61	.43	.04	.00	-.43	1.65
Jayuya.....	.50	.20	.06	.00	.72	1.48

Table 5. Public-supply deliveries by type of use and municipio for 1987—*Continued*

Municipio	Water deliveries by type of use (Mgal/d)					
	Domestic	Commercial	Industrial	Thermoelectric power	Unaccounted use	Total deliveries
Juana Díaz	1.39	0.31	0.05	0.00	3.25	5.00
Juncos	1.36	.23	.04	.00	2.36	3.99
Lajas	1.02	.22	.01	.00	.09	1.34
Lares	1.02	.18	.00	.00	.21	.99
Las Marías .....	.28	.07	.00	.00	.36	.71
Las Piedras .....	.76	.12	.14	.00	.68	.14
Loíza	1.49	.24	.00	.00	1.73	.34
Luquillo .....	.89	.21	.06	.00	1.12	2.28
Manatí	1.80	.53	.07	.00	5.12	7.52
Maricao .....	.13	.04	.02	.00	.79	.98
Maunabo .....	.44	.10	.01	.00	.27	.82
Mayagüez	4.52	1.68	2.21	.00	9.37	17.78
Moca	1.06	.15	.01	.00	-.95	.27
Morovis .....	.81	.13	.01	.00	1.13	2.08
Naguabo .....	.96	.18	.03	.00	10.87	12.04
Naranjito	1.14	.15	.00	.00	-.32	.97
Orocovis .....	.76	.12	.01	.00	1.69	2.58
Patillas .....	.61	.12	.01	.00	.38	1.12
Peñuelas .....	.83	.16	.00	.00	1.38	2.37
Ponce	8.99	3.23	.75	.00	12.05	25.02
Quebradillas .....	.87	.26	.18	.00	1.30	2.61
Rincón .....	.55	.12	.01	.00	.10	.78
Río Grande	1.94	.37	.04	.00	18.47	20.82
Sabana Grande	1.05	.17	.03	.00	.93	2.18
Salinas	1.17	.25	.02	.00	1.61	3.05
San Germán	1.33	.36	.22	.00	.79	2.70
San Juan	24.47	15.14	.74	.00	-40.34	.01
San Lorenzo	1.22	.11	.07	.00	1.41	2.81
San Sebastián	1.43	.29	.04	.00	.34	2.10
Santa Isabel .....	.68	.16	.04	.00	1.37	2.25
Toa Alta	1.61	.19	.08	.00	49.54	51.42
Toa Baja	4.71	.58	.14	1.58	-5.93	1.08
Trujillo Alto	1.17	.34	.00	.00	77.00	78.51
Utua	1.13	.29	.00	.00	1.44	2.86
Vega Alta	1.20	.28	.65	.00	2.27	4.40
Vega Baja	2.26	.43	.07	.00	3.81	6.57
Vieques .....	.43	.17	.00	.00	.60	.00
Villalba .....	.70	.14	.02	.00	.85	1.71
Yabucoa	1.43	.26	.01	.00	.82	2.52
Yauco	1.68	.48	.02	.00	.05	2.13
Total	154.02	52.15	12.28	2.79	192.23	413.47

Table 6. Sewage-treatment water releases and number of facilities by municipio, for 1986 and 1987

[Location of municipios are shown in figure 1. Mgal/d, million gallons per day]

Municipio	1986		1987		Municipio	1986		1987	
	Total public releases (Mgal/d)	Number of facilities	Total public release (Mgal/d)	Number of facilities		Total public releases (Mgal/d)	Number of facilities	Total public release (Mgal/d)	Number of facilities
Adjuntas	0.32	1	0.32	1	Lajas	0.31	3	0.38	3
Aguada	2.14	1	2.90	1	Lares .....	.30	1	.21	1
Aguadilla.....	.00	0	.00	0	Las Marías .....	.06	1	.06	1
Aguas Buenas..	.30	1	.25	1	Las Piedras.....	.53	2	.53	2
Aibonito .....	.60	1	.58	1	Loíza	11.06	2	15.50	2
Añasco.....	.45	1	.41	1	Luquillo .....	.70	1	.70	1
Arecibo.....	.00	0	6.20	1	Manati.....	.00	0	.00	0
Arroyo .....	.35	1	.36	1	Maricao.....	.05	1	.05	1
Barceloneta	5.58	1	5.86	1	Maunabo .....	.27	1	.20	1
Barranquitas ...	.27	1	.26	1	Mayagüez	1.01	4	7.00	5
Bayamón	3.27	4	2.84	4	Moca.....	.55	1	.00	0
Cabo Rojo .....	.13	1	.12	1	Morovis.....	.26	2	.29	2
Caguas.....	6.50	1	5.60	1	Naguabo.....	.48	3	.49	3
Camuy .....	.00	0	.25	1	Naranjito.....	.28	1	.28	1
Canóvanas .....	.98	4	.74	4	Orocovis .....	.17	2	.15	2
Carolina.....	8.95	5	.60	1	Patillas .....	.47	1	.48	1
Catano	14.33	1	17.50	1	Peñuelas .....	.42	1	.42	1
Cayey	1.45	2	1.50	2	Ponce	12.10	1	12.10	1
Ceiba .....	.46	1	.42	1	Quebradillas....	.18	1	.25	1
Ciales.....	.18	1	.20	1	Rincón.....	.16	1	.15	1
Cidra.....	.65	2	.52	2	Río Grande.....	1.42	5	1.59	5
Coamo .....	.63	1	.50	1	Sabana Grande..	.37	1	.40	1
Comerío.....	.16	1	.16	1	Salinas.....	.62	2	.68	2
Corozal .....	.56	1	.49	1	San Germán	1.00	1	1.03	1
Culebra.....	.00	0	.00	0	San Juan.....	51.10	1	52.22	1
Dorado.....	1.15	1	1.10	1	San Lorenzo....	.61	1	.50	1
Fajardo	1.62	1	1.60	1	San Sebastián...	.70	1	.70	1
Florida .....	.35	1	.35	1	Santa Isabel.....	.60	1	.60	1
Guánica .....	.33	2	.49	2	Toa Alta .....	.71	2	.75	2
Guayama .....	.00	0	.00	0	Toa Baja.....	.46	1	.49	1
Guayanilla.....	.38	1	.32	1	Trujillo Alto	1.17	5	.35	2
Guaynabo	2.04	1	.00	0	Utua do .....	.48	1	.57	1
Gurabo.....	.60	1	.57	1	Vega Alta .....	.64	1	.67	1
Hatillo .....	.72	1	.62	1	Vega Baja.....	1.60	1	1.27	1
Hormigueros ...	.42	1	.47	1	Vieques .....	.15	1	.15	1
Humacao	2.77	3	2.72	3	Villalba .....	.16	1	.28	1
Isabela .....	.90	1	1.12	1	Yabucoa .....	.65	1	.55	1
Jayuya .....	.31	1	.32	1	Yauco	1.01	1	1.00	1
Juana Díaz.....	.50	1	.75	1	Total	153.78	108	162.60	102
Juncos.....	.62	1	.55	1					

Table 7. Domestic self-supplied withdrawals and deliveries from public-supply systems by municipio, for 1986

[Location of municipios are shown in figure 1. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day; gal/d, gallon per day; --, not applicable]

Municipio	Self supplied				Public supplied		Total withdrawals and deliveries (Mgal/d)	Per capita use (gal/d)
	Population (thousands)	Withdrawals (Mgal/d)			Population served (thousands)	Deliveries from public supply (Mgal/d)		
		Surface water	Ground water	Total				
Adjuntas	8.11	0.06	0.36	0.42	11.07	0.50	0.92	45.17
Aguada	6.14	.05	.22	.27	28.03	1.22	1.49	43.52
Aguadilla.....	9.86	.49	.00	.49	47.58	2.36	2.85	49.60
Aguas Buenas.....	3.05	.03	.11	.14	21.18	.98	1.12	46.27
Aibonito	5.21	.23	.04	.27	18.64	.98	1.25	52.58
Añasco.....	2.93	.00	.14	.14	21.52	.97	1.11	45.07
Arecibo.....	8.17	.00	.42	.42	82.57	4.22	4.64	51.11
Arroyo	2.09	.00	.10	.10	16.06	.79	.89	49.19
Barceloneta	3.74	.00	.19	.19	16.40	.83	1.02	50.61
Barranquitas	6.07	.15	.17	.32	17.95	.96	1.28	53.48
Bayamón	3.71	.18	.00	.18	206.93	11.17	11.35	53.98
Cabo Rojo	5.51	.00	.34	.34	31.22	1.79	2.13	57.34
Caguas.....	14.07	.18	.56	.74	113.18	5.76	6.50	50.89
Camuy	4.77	.00	.21	.21	22.95	1.04	1.25	45.32
Canóvanas.....	12.21	.64	.00	.64	22.63	1.20	1.84	53.03
Carolina.....	.00	.00	.00	.00	177.38	8.33	8.33	46.96
Cataño	9.87	.52	.00	.52	21.38	1.44	1.96	67.35
Cayey	4.38	.20	.00	.20	39.99	1.80	2.00	45.01
Ceiba	3.00	.12	.00	.12	13.26	.53	.65	39.97
Ciales.....	4.09	.17	.00	.17	13.25	.53	.70	40.00
Cidra.....	7.16	.00	.36	.36	25.55	1.28	1.64	50.10
Coamo	4.51	.07	.11	.18	28.12	1.17	1.35	41.61
Comerío.....	7.11	.33	.00	.33	12.33	.57	.90	46.23
Corozal	4.14	.17	.00	.17	27.01	1.22	1.39	45.17
Culebra.....	.37	.01	.00	.01	1.06	.05	.06	47.17
Dorado.....	3.17	.00	.17	.17	25.49	1.33	1.50	52.18
Fajardo	3.35	.18	.00	.18	31.61	1.71	1.89	54.10
Florida	1.70	.00	.09	.09	6.41	.36	.45	56.16
Guánica	2.91	.00	.22	.22	16.60	.88	1.10	53.01
Guayama	5.77	.22	.04	.26	35.26	1.61	1.87	45.66
Guayanilla.....	2.62	.05	.09	.14	18.75	.87	1.01	46.40
Guaynabo	13.27	.93	.00	.93	74.76	4.54	5.47	60.73
Gurabo.....	4.34	.01	.19	.20	22.33	1.00	1.20	44.78
Hatillo	6.95	.22	.11	.33	24.25	1.27	1.60	52.37
Hormigueros .....	.00	.00	.00	.00	15.24	.75	.75	49.21
Humacao	5.09	.00	.28	.28	46.49	2.39	2.67	51.41
Isabela	4.27	.20	.00	.20	34.19	1.64	1.84	47.97
Jayuya	3.31	.13	.00	.13	11.89	.48	.61	40.37
Juana Díaz.....	14.20	.00	.64	.64	30.32	1.38	2.02	45.51

Table 7. Domestic self-supplied withdrawals and deliveries from public-supply systems, by municipio, for 1986—*Continued*

Municipio	Self supplied				Public supplied		Total withdrawals and deliveries (Mgal/d)	Per capita use (gal/d)
	Population (thousands)	Withdrawals (Mgal/d)			Population served (thousands)	Deliveries from public supply (Mgal/d)		
		Surface water	Ground water	Total				
Juncos	3.25	0.16	0.05	0.21	25.28	1.45	1.66	57.36
Lajas	3.96	.21	.00	.21	18.50	.99	1.20	53.51
Lares	3.14	.04	.09	.13	24.97	.99	1.12	39.65
Las Marías	2.94	.15	.00	.15	6.14	.29	.44	47.23
Las Piedras	8.46	.00	.42	.42	17.24	.73	1.15	42.34
Loíza	0	.00	.00	.00	25.93	1.37	1.37	52.83
Luquillo	2.47	.15	.00	.15	14.35	.86	1.01	59.93
Manatí	0	.00	.00	.00	38.42	1.67	1.67	43.47
Maricao	3.02	.11	.00	.11	3.40	.12	.23	35.29
Maunabo	2.27	.06	.04	.10	9.86	.43	.53	43.61
Mayagüez	9.43	.00	.50	.50	89.27	4.64	5.14	51.98
Moca	7.76	.34	.00	.34	23.67	1.02	1.36	43.09
Morovis	5.36	.23	.00	.23	18.27	.75	.98	41.05
Naguabo	2.27	.11	.00	.11	19.55	.95	1.06	48.59
Naranjito	2.31	.06	.05	.11	23.89	1.14	1.25	47.72
Orocovis	1.44	.04	.02	.06	18.99	.75	.81	39.49
Patillas	2.44	.11	.00	.11	16.45	.78	.89	47.42
Peñuelas	2.67	.09	.02	.11	18.49	.79	.90	42.73
Ponce	9.19	.21	.24	.45	179.08	8.85	9.30	49.42
Quebradillas	2.60	.13	.00	.13	18.15	.89	1.02	49.04
Rincón	1.76	.00	.08	.08	10.28	.52	.60	50.58
Río Grande	5.71	.33	.00	.33	35.39	2.04	2.37	57.64
Sabana Grande .....	.80	.03	.01	.04	20.99	.99	1.03	47.17
Salinas	4.82	.00	.24	.24	22.76	1.14	1.38	50.09
San Germán	4.97	.23	.00	.23	29.18	1.30	1.53	44.55
San Juan	14.39	.00	.71	.71	422.20	26.24	26.95	62.15
San Lorenzo .....	.53	.01	.02	.03	33.54	1.03	1.06	30.71
San Sebastián	9.00	.00	.42	.42	28.56	1.30	1.72	45.52
Santa Isabel	3.87	.00	.17	.17	15.66	.69	.86	44.06
Toa Alta	11.07	.69	.00	.69	28.16	1.50	2.19	53.27
Toa Baja .....	.00	.00	.00	.00	88.61	4.41	4.41	49.77
Trujillo Alto .....	.00	.00	.00	.00	54.32	1.16	1.16	21.35
Utua	7.28	.29	.00	.29	27.51	1.10	1.39	39.99
Vega Alta	7.79	.02	.36	.38	24.42	1.22	1.60	49.96
Vega Baja	10.67	.12	.46	.58	41.77	2.20	2.78	52.67
Vieques .....	.15	.00	.00	.00	8.08	.41	.41	50.74
Villalba	4.87	.17	.01	.18	17.56	.66	.84	37.59
Yabucoa	5.89	.13	.16	.29	28.57	1.42	1.71	49.70
Yauco	5.40	.26	.00	.26	34.93	1.68	1.94	48.10
Total	385.17	10.02	9.23	19.25	3,013.22	152.37	171.62	--

Table 8. Domestic self-supplied withdrawals and deliveries from public-supply systems, by municipio, for 1987

[Location of municipios are shown in figure 1. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day; gal/d, gallon per day; --, not applicable]

Municipio	Self supplied				Public supplied		Total withdrawals and deliveries (Mgal/d)	Per capita use (gal/d)
	Population (thousands)	Withdrawals (Mgal/d)			Population served (thousands)	Deliveries from public supply (Mgal/d)		
		Surface water	Ground water	Total				
Adjuntas	7.87	0.06	0.36	0.42	11.38	0.52	0.94	45.69
Aguada	6.10	.05	.23	.28	28.51	1.26	1.54	44.20
Aguadilla	9.96	.49	.00	.49	47.96	2.48	2.97	51.71
Aguas Buenas.....	3.14	.03	.12	.15	21.39	1.01	1.16	47.22
Aibonito.....	4.96	.28	.00	.28	19.17	1.01	1.29	52.69
Añasco.....	2.92	.00	.15	.15	21.73	.97	1.12	44.64
Arecibo	7.37	.00	.36	.36	84.03	4.21	4.57	50.10
Arroyo	1.75	.00	.10	.10	16.59	.82	.92	49.43
Barceloneta.....	3.03	.00	.15	.15	17.32	.86	1.01	49.65
Barranquitas	6.22	.21	.21	.42	18.20	1.05	1.47	57.69
Bayamón.....	6.99	.34	.00	.34	206.05	9.64	9.98	46.78
Cabo Rojo.....	5.21	.00	.27	.27	31.97	1.65	1.92	51.92
Caguas	14.78	.18	.55	.73	114.02	5.78	6.51	50.69
Camuy	4.43	.00	.21	.21	23.59	1.08	1.29	45.78
Canóvanas	12.26	.64	.00	.64	23.08	1.270	1.91	55.03
Carolina .....	.00	.00	.00	.00	175.84	11.12	11.12	63.24
Cataño.....	9.57	.47	.00	.47	22.51	1.40	1.87	62.19
Cayey.....	3.92	.20	.08	.28	41.00	1.93	2.21	47.07
Ceiba.....	2.80	.16	.00	.16	13.68	.54	.70	39.47
Ciales.....	3.83	.16	.00	.16	13.69	.59	.75	43.10
Cidra	7.68	.00	.41	.41	25.75	1.34	1.75	52.04
Coamo	4.44	.08	.13	.21	28.49	1.14	1.35	40.01
Comerio.....	6.92	.31	.00	.31	12.73	.58	.89	45.56
Corozal .....	.00	.00	.00	.00	38.15	1.07	1.07	28.05
Culebra .....	.38	.02	.00	.02	1.08	.04	.06	37.04
Dorado.....	3.41	.00	.17	.17	25.77	1.34	1.51	52.00
Fajardo.....	3.58	.20	.00	.20	31.86	1.77	1.97	55.56
Florida.....	1.69	.00	.09	.09	6.56	.38	.47	57.93
Guánica.....	2.61	.00	.17	.17	17.02	.90	1.07	52.88
Guayama.....	5.45	.20	.04	.24	35.72	1.64	1.88	45.91
Guayanilla	2.30	.03	.07	.10	19.12	.88	.98	46.03
Guaynabo	13.02	.88	.00	.88	76.22	4.62	5.50	60.61
Gurabo	4.48	.01	.18	.19	22.71	.99	1.18	43.59
Hatillo.....	6.98	.32	.11	.43	24.60	1.54	1.97	62.60
Hormigueros.....	.00	.00	.00	.00	15.33	.77	.77	50.23
Humacao.....	5.51	.00	.28	.28	46.97	2.43	2.71	51.74
Isabela.....	3.62	.17	.00	.17	35.01	1.61	1.78	45.99
Jayuya.....	3.46	.14	.00	.14	11.83	.50	.64	42.27
Juana Díaz	13.90	.00	.62	.62	30.79	1.39	2.01	45.14

Table 8. Domestic self-supplied withdrawals and deliveries from public-supply systems, by municipio, for 1987—*Continued*

Municipio	Self supplied				Public supplied		Total withdrawals and deliveries (Mgal/d)	Per capita use (gal/d)
	Population (thousands)	Withdrawals (Mgal/d)			Population served (thousands)	Deliveries from public supply (Mgal/d)		
		Surface water	Ground water	Total				
Juncos.....	2.44	0.09	0.03	0.12	26.61	1.36	1.48	51.11
Lajas.....	3.68	.19	.00	.19	18.98	1.02	1.21	53.74
Lares.....	3.14	.04	.08	.12	25.19	1.02	1.14	40.49
Loíza.....	.00	.00	.00	.00	26.77	1.49	1.49	55.66
Luquillo.....	2.72	.16	.00	.16	14.42	.89	1.05	61.72
Manatí.....	.00	.00	.00	.00	38.73	1.80	1.80	46.48
Maricao.....	2.90	.10	.00	.10	3.46	.13	.23	37.57
Maunabo.....	2.15	.05	.04	.09	10.04	.44	.53	43.82
Mayagüez.....	8.73	.43	.01	.44	90.39	4.52	4.96	50.01
Moca.....	7.48	.32	.00	.32	24.32	1.06	1.38	43.59
Morovis.....	5.34	.28	.00	.28	18.70	.81	1.09	43.32
Naguabo.....	2.34	.11	.00	.11	19.68	.96	1.07	48.78
Naranjito.....	2.39	.06	.05	.11	24.24	1.14	1.25	47.03
Orocovis.....	1.39	.04	.02	.06	19.22	.76	.82	39.54
Patillas.....	2.15	.10	.00	.10	16.93	.61	.71	36.03
Penuelas.....	2.30	.08	.02	.10	19.20	.83	.93	43.23
Ponce.....	6.40	.15	.16	.31	181.74	8.99	9.30	49.47
Quebradillas.....	2.48	.11	.01	.12	18.44	.87	.99	47.18
Rincón.....	1.51	.00	.08	.08	10.58	.55	.63	51.98
Río Grande.....	6.95	.56	.00	.56	35.29	1.94	2.50	54.97
Sabana Grande.....	.93	.03	.01	.04	21.12	1.05	1.09	49.72
Salinas.....	4.50	.00	.22	.22	23.27	1.17	1.39	50.28
San Germán.....	4.98	.22	.00	.22	29.37	1.33	1.55	45.28
San Juan.....	12.32	.00	.60	.60	424.56	24.47	25.07	57.64
San Lorenzo.....	10.56	.10	.37	.47	23.78	1.22	1.69	51.30
San Sebastián.....	8.73	.00	.41	.41	29.14	1.43	1.84	49.07
Santa Isabel.....	3.68	.09	.07	.16	15.80	.68	.84	43.07
Toa Alta.....	11.10	.56	.01	.57	29.34	1.61	2.18	54.87
Toa Baja.....	.00	.00	.00	.00	91.56	4.71	4.71	51.44
Trujillo Alto.....	.00	.00	.00	.00	54.82	1.17	1.17	21.34
Utuado.....	6.92	.27	.00	.27	27.92	1.13	1.40	40.47
Vega Alta.....	8.13	.01	.34	.35	24.67	1.20	1.50	48.64
Vega Baja.....	10.48	.10	.43	.53	42.85	2.26	2.79	52.74
Vieques.....	.19	.00	.00	.00	8.13	.43	.43	52.89
Villalba.....	4.67	.16	.01	.17	18.04	.70	.87	38.80
Yabucoa.....	6.20	.14	.17	.31	28.77	1.43	1.74	49.70
Yauco.....	5.15	.24	.00	.24	35.61	1.68	1.92	47.18
Total.....	383.65	10.78	8.35	19.13	3,052.41	154.02	173.15	--

Self-Supplied Industrial and Mining

Ground-water self-supplied withdrawals by industrial users were estimated only for municipios at which withdrawals were equal to or greater than 1.0 Mgal/d. Islandwide, there are only seven municipios at which ground-water self-supplied use is greater than 1.0 Mgal/d (table 9). Based on these data and ground-water use surveys made at other municipios with significant industrial activity (Guayama, Ponce, and Yabucoa), the total industrial self-supplied ground-water withdrawals in Puerto Rico are estimated to be less than 20 Mgal/d for 1986 and 1987. Most of the industrial self-supplied ground-water withdrawals were from aquifers along the north coast of Puerto Rico.

The primary mining activity in Puerto Rico is the production of sand and gravel. This mining activity required an estimated of 2.6 Mgal/d of water during both years. Most of the production was concentrated in the northeastern part of Puerto Rico, with the largest fresh ground-water withdrawal occurring in Toa Baja. Mining water-use activities during 1986 and 1987 are summarized by municipio in table 10.

Table 9. Self-supplied ground-water withdrawal estimates for industrial facilities, by municipio, for 1986 and 1987

[Location of municipios are shown in figure 1. Municipios at which total withdrawals are equal to or greater than 1.0 Mgal/d. All withdrawals in million gallons per day]

Municipio	Self-supplied ground-water withdrawals	
	1986	1987
Arecibo.....	1.48	1.20
Barceloneta.....	3.81	3.64
Guayama.....	1.16	1.16
Manatí.....	2.44	2.04
Ponce.....	3.60	3.60
Vega Alta.....	1.00	1.00
Yabucoa.....	2.62	2.62
Total.....	16.11	15.26

Table 10. Mining withdrawals, by municipio, for 1986 and 1987

[Location of municipios are shown in figure 1. All withdrawals in million gallons per day]

Municipio	Freshwater withdrawals each year		
	Surface water	Ground water	Total
Aguada.....	0.00	0.01	0.01
Caguas.....	.01	.01	.02
Carolina.....	.06	.00	.06
Dorado.....	.00	.29	.29
Guaynabo.....	.12	.00	.12
Naranjito.....	.01	.00	.01
San Germán.....	.17	.00	.17
San Lorenzo.....	.14	.00	.14
Toa Alta.....	.19	.00	.19
Toa Baja.....	.00	1.00	1.00
Vega Alta.....	.00	.04	.04
Vega Baja.....	.00	.51	.51
Total.....	.70	1.86	2.56

Thermoelectric and Hydroelectric

Puerto Rico has four thermoelectric powerplants: Costa Sur in Guayanilla, Aguirre in Salinas, Puerto Nuevo in Guaynabo, and Palo Seco in Toa Baja (fig. 5). These four powerplants generated 12,010 gigawatthours (GWh) of electricity in 1986 and 12,060 GWh in 1987. The instream water use of surface water (seawater) for cooling was 2,130 Mgal/d in 1986 and 1,740 Mgal/d in 1987. In 1986 and 1987, the PRASA delivered a total of 2.79 Mgal/d of freshwater to the Puerto Nuevo and Palo Seco powerplants. Self-supplied ground-water withdrawals were 2.1 Mgal/d in 1986 and 2.4 Mgal/d in 1987 at the Aguirre and Costa Sur powerplants (tables 11 and 12).

During 1986 and 1987, Puerto Rico had 11 active hydroelectric powerplants in Arecibo (Dos Bocas), Naguabo (Río Blanco), Orocovis (Toro Negro II), Patillas (Patillas), Peñuelas (Garzas I and II), Utuado (Caonillas I and II), Villalba (Toro Negro I), and Yauco (Yauco I and II) (fig. 5). These powerplants generated 173 GWh of electricity in 1986 with an average instream water use of 564 Mgal/d. Total hydroelectric power generated in 1987 was 166 GWh with an average instream water use of 511 Mgal/d (table 13).

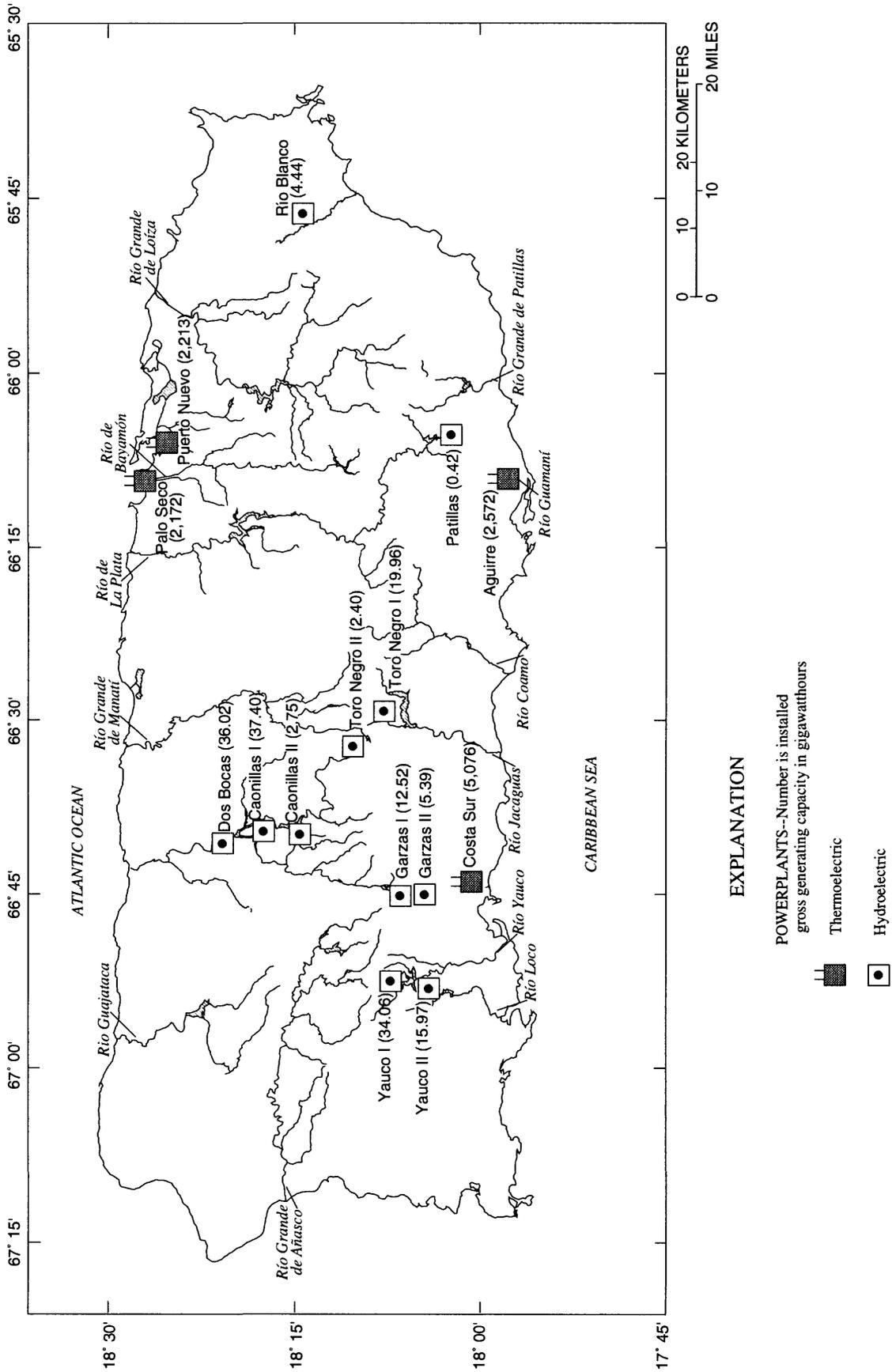


Figure 5. Location of active thermoelectric and hydroelectric powerplants in Puerto Rico during 1986 and 1987.

Table 11. Self-supplied withdrawals, deliveries from public supply, and power generated by thermoelectric powerplants, by municipio, for 1986

[Location of municipios are shown in figure 1. Mgal/d, million gallons per day. GWh, gigawatthour]

Municipio	Self-supplied withdrawals (Mgal/d)			Deliveries from public supply (Mgal/d)	Total withdrawals and deliveries (Mgal/d)	Power generated (GWh)
	Saline surface water	Fresh ground water	Total			
Guayanilla	754.00	1.13	755.13	0.00	755.13	4,935.00
Guaynabo.....	503.00	.00	503.00	1.21	504.21	2,097.00
Salinas	387.00	1.02	388.02	.00	388.02	2,473.00
Toa Baja.....	487.00	.00	487.00	1.58	488.58	2,506.00
Total	2,131.00	2.15	2,133.15	2.79	2,135.94	12,011.00

Table 12. Self-supplied withdrawals, deliveries from public supply, and power generated by thermoelectric powerplants, by municipio, for 1987

[Location of municipios are shown in figure 1. Mgal/d, million gallons per day. GWh, gigawatthour]

Municipio	Self-supplied withdrawals (Mgal/d)			Deliveries from public supply (Mgal/d)	Total withdrawals and deliveries (Mgal/d)	Power generated (GWh)
	Saline surface water	Fresh ground water	Total			
Guayanilla	694.00	1.22	695.22	0.00	695.22	5,217.00
Guaynabo	413.00	.00	413.00	1.21	414.21	2,330.00
Salinas	349.00	1.23	350.23	.00	350.23	2,671.00
Toa Baja	285.00	.00	285.00	1.58	286.58	1,839.00
Total.....	1,741.00	2.45	1,743.45	2.79	1,746.24	12,057.00

Table 13. Water use and power generated by hydroelectric powerplants, by municipio, for 1986 and 1987

[Location of municipios are shown in figure 1. Mgal/d, million gallons per day; GWh, gigawatthour]

Municipio	1986		1987	
	Water use (Mgal/d)	Power generated (GWh)	Water use (Mgal/d)	Power generated (GWh)
Arecibo	354.67	38.61	308.04	33.44
Naguabo.....	17.17	6.33	16.70	2.56
Orocovis	1.10	2.08	1.32	2.62
Patillas .....	.00	.00	.00	.00
Peñuelas.....	10.35	16.57	8.62	15.06
Utuaado	83.13	49.13	52.52	31.16
Villalba	11.67	17.27	15.31	22.66
Yauco.....	85.87	42.93	108.68	58.13
Total	563.96	172.92	511.19	165.63

Livestock

Livestock enterprises reported 8,557,316 animals in Puerto Rico during the agricultural census of 1987 (U.S. Department of Commerce, 1989). The "stock" water use subcategory, which includes dairy cows, cattle, poultry, hogs and pigs, sheep and goats, totaled 8,525,121 animals. Withdrawals were estimated to be about 7.3 Mgal/d from surface- and ground-water sources for this stock subcategory during 1987. The largest withdrawal rate was in the municipio of Hatillo, where about 0.93 Mgal/d was used mostly for dairy cows (table 14).

In the "animal specialties" water-use subcategory in Puerto Rico, there were a total of 9,606 horses and 22,589 rabbits reported during 1987 (U.S. Department of Commerce, 1989). The estimated withdrawals during 1987 for this animal specialties subcategory were 0.12 Mgal/d from surface- and ground-water sources (table 15). Consumptive use for the livestock category was estimated to be 100 percent.

Table 14. Total freshwater withdrawals and number of animals served for the stock subcategory, by municipio, for 1986 and 1987

[Location of municipios are shown in figure 1. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day]

Municipio	Freshwater withdrawals (Mgal/d)			Stock population					
	Surface water	Ground water	Total	Dairy cows	Cattle	Poultry	Hogs and pigs	Sheep and goats	Total
Adjuntas	0.02	0.00	0.02	114	496	60,798	855	63	62,326
Aguada .....	.00	.02	.02	78	750	5,523	778	195	7,324
Aguadilla.....	.00	.04	.04	454	1,613	9,385	700	98	12,250
Aguas Buenas.....	.03	.00	.03	118	1,402	23,923	1,313	276	27,032
Aibonito .....	.00	.11	.11	206	3,165	906,399	1,990	662	912,422
Añasco.....	.00	.01	.01	33	630	4,321	610	84	5,678
Arecibo.....	.00	.61	.61	13,563	8,638	127,970	6,462	671	157,304
Arroyo .....	.00	.01	.01	18	520	33,782	192	250	34,762
Barceloneta.....	.00	.05	.05	1,160	707	509	447	279	3,102
Barranquitas .....	.10	.00	.10	199	1,746	982,059	1,973	594	986,571
Bayamón .....	.29	.00	.29	45	597	7,098	4,751	300	12,791
Cabo Rojo .....	.00	.12	.12	629	7,412	20,494	813	995	30,343
Caguas .....	.01	.17	.18	3,150	2,874	281,438	2,674	182	290,318
Camuy .....	.00	.31	.31	7,001	4,564	14,811	2,655	309	29,340
Canóvanas .....	.00	.08	.08	515	3,059	24,558	4,133	1,177	33,442
Carolina.....	.11	.00	.11	1,725	2,721	63,353	1,943	230	69,972
Cataño	0	0	0	0	0	0	0	0	0
Cayey .....	.00	.11	.11	904	2,777	499,526	3,667	661	507,535
Ceiba .....	.03	.00	.03	224	1,363	25,070	953	60	27,670
Ciales.....	.00	.03	.03	386	1,182	10,424	428	210	12,630
Cidra.....	.11	.00	.11	1,134	2,771	302,814	3,538	992	311,249
Coamo .....	.00	.23	.23	483	9,242	1,505,883	2,375	2,984	1,520,967
Comerio.....	.07	.00	.07	125	1,391	546,882	4,635	417	553,450
Corozal .....	.08	.00	.08	741	2,206	196,218	3,922	416	203,503
Culebra .....	.01	.00	.01	0	896	500	10	937	2,343
Dorado.....	.00	.09	.09	1,977	1,602	8,977	400	20	12,976
Fajardo .....	.06	.00	.06	670	2,782	10,716	352	276	14,796
Florida .....	.00	.02	.02	341	307	1,100	47	39	1,834
Guánica .....	.00	.03	.03	29	1,935	931	1,038	1,001	4,934
Guayama .....	.00	.04	.04	115	2,014	115,141	838	1,091	119,199
Guayanilla .....	.00	.03	.03	36	2,146	2,528	867	192	5,769
Guaynabo .....	.02	.00	.02	38	595	49,599	2,045	74	52,351
Gurabo.....	.00	.11	.11	2,218	1,994	20,012	1,328	181	25,733
Hatillo.....	.00	.93	.93	23,775	7,358	21,687	1,077	454	54,351
Hormigueros.....	.00	.02	.02	305	547	900	236	90	2,078
Humacao .....	.00	.07	.07	811	3,052	2,297	1,136	233	7,529
Isabela .....	.00	.12	.12	2,164	2,543	6,583	2,538	328	14,156
Jayuya.....	.02	.00	.02	55	730	13,726	1,919	165	16,595
Juana Díaz.....	.00	.08	.08	535	2,883	42,613	4,692	666	51,389
Juncos.....	.00	.15	.15	2,972	3,331	2,428	1,318	250	10,299

Table 14. Total freshwater withdrawals and number of animals served for the stock subcategory, by municipio, for 1986 and 1987—*Continued*

Municipio	Freshwater withdrawals (Mgal/d)			Stock population					
	Surface water	Ground water	Total	Dairy cows	Cattle	Poultry	Hogs and pigs	Sheep and goats	Total
Lajas.....	0.00	0.15	0.15	614	10,010	52,311	1,589	1,516	66,040
Lares.....	.02	.00	.02	163	711	44,903	508	147	46,432
Las Marías.....	.01	.00	.01	135	225	9,125	699	115	10,299
Las Piedras.....	.22	.00	.22	4,086	5,477	60,269	1,517	138	71,487
Loíza.....	.04	.00	.04	172	1,528	7,132	2,628	349	11,809
Luquillo.....	.04	.00	.04	556	1,099	60,638	1,505	34	63,832
Manatí.....	.01	.16	.17	2,861	2,873	12,410	6,273	459	24,876
Maricao.....	.01	.00	.01	50	288	2,321	153	95	2,907
Maunabo.....	.02	.00	.02	83	1,255	1,790	407	203	3,738
Mayagüez.....	.00	.04	.04	330	1,318	15,406	1,476	317	18,847
Moca.....	.04	.00	.04	302	1,935	3,956	1,226	155	7,574
Morovis.....	.16	.00	.16	2,947	3,874	5,983	2,636	508	15,948
Naguabo.....	.27	.00	.27	4,948	4,460	1,752	11,085	236	22,481
Naranjito.....	.06	.00	.06	223	1,286	365,706	2,814	635	370,664
Orocovis.....	.05	.00	.05	757	1,435	9,784	759	245	12,980
Patillas.....	.00	.05	.05	84	3,487	51,015	1,424	473	56,483
Peñuelas.....	.00	.03	.03	7	1,934	23,117	614	242	25,914
Ponce.....	.00	.05	.05	43	2,577	11,774	4,023	1,143	19,560
Quebradillas.....	.00	.10	.10	1,997	1,978	5,838	1,645	189	11,647
Rincón.....	.00	.02	.02	15	1,275	4,526	215	65	6,096
Río Grande.....	.06	.00	.06	109	3,048	143,323	1,715	553	148,748
Sabana Grande.....	.00	.02	.02	26	1,406	1,014	596	174	3,216
Salinas.....	.00	.09	.09	145	2,689	760,024	1,262	1,664	765,784
San Germán.....	.00	.05	.05	92	3,153	60,812	2,131	391	66,579
San Juan.....	.01	.00	.01	40	102	97,969	981	57	99,149
San Lorenzo.....	.13	.00	.13	1,592	5,581	12,366	2,115	381	22,035
San Sebastián.....	.19	.00	.19	3,966	3,927	7,276	1,673	235	17,077
Santa Isabel.....	.00	.01	.01	6	676	325	150	52	1,209
Toa Alta.....	.11	.00	.11	2,172	1,581	41,400	1,812	143	47,108
Toa Baja.....	.00	.04	.04	556	1,536	220	254	18	2,584
Trujillo Alto.....	.03	.00	.03	270	1,036	27,302	2,190	254	31,052
Utado.....	.07	.00	.07	751	2,463	86,042	2,708	688	92,652
Vega Alta.....	.00	.05	.05	717	1,539	2,164	1,459	160	6,039
Vega Baja.....	.00	.08	.08	1,441	1,244	63,315	1,211	340	67,551
Vieques.....	.00	.10	.10	350	6,917	111	96	130	7,604
Villalba.....	.04	.00	.04	98	1,951	41,128	1,496	367	45,040
Yabucoa.....	.00	.08	.08	939	2,923	4,915	3,432	162	12,371
Yauco.....	.00	.05	.05	120	3,097	6,505	906	768	11,396
Total.....	2.55	4.76	.00	102,809	190,435	8,058,943	141,031	81,903	8,525,121

Table 15. Total freshwater withdrawals and number of animals served for the animal specialties subcategory, by municipio, for 1986 and 1987

[Location of municipios are shown in figure 1. Numbers may not add to totals listed because of independent rounding. Mgal/d, million gallons per day]

Municipio	Freshwater withdrawals (Mgal/d)			Animal specialties population (excluding fish farms)			Municipio	Freshwater withdrawals (Mgal/d)			Animal specialties population (excluding fish farms)		
	Surface water	Ground water	Total	Horses	Rabbits	Total		Surface water	Ground water	Total	Horses	Rabbits	Total
Adjuntas	0.00	0.00	0.00	115	93	208	Lajas	0.00	0.01	0.01	271	162	433
Aguada .....	.00	.00	.00	45	113	158	Lares .....	.00	.00	.00	87	210	297
Aguadilla .....	.00	.00	.00	4	0	4	Las Marías ...	.00	.00	.00	34	210	244
Aguas Buenas	.00	.00	.00	90	105	195	Las Piedras...	.01	.00	.01	200	396	596
Aibonito .....	.00	.00	.00	274	775	1,049	Loíza .....	.00	.00	.00	82	0	82
Añasco .....	.00	.00	.00	23	110	133	Luquillo .....	.01	.00	.01	277	0	277
Arecibo .....	.00	.00	.00	176	290	466	Manatí .....	.00	.00	.00	60	928	988
Arroyo .....	.00	.00	.00	31	0	31	Maricao .....	.00	.00	.00	3	161	164
Barceloneta...	.00	.00	.00	18	210	228	Maunabo .....	.00	.00	.00	44	105	149
Barranquitas .	.00	.00	.00	97	97	194	Mayagüez ....	.00	.00	.00	75	1,542	1,617
Bayamón .....	.00	.00	.00	78	58	136	Moca .....	.00	.00	.00	58	0	58
Cabo Rojo ....	.00	.01	.01	248	275	523	Morovis .....	.01	.00	.01	288	240	528
Caguas .....	.00	.01	.01	157	284	441	Naguabo .....	.00	.00	.00	103	210	313
Camuy .....	.00	.00	.00	102	1,791	1,893	Naranjito .....	.00	.00	.00	43	1,187	1,230
Canóvanas ....	.00	.00	.00	222	1,239	1,461	Orocovis .....	.00	.00	.00	78	305	383
Carolina .....	.00	.00	.00	104	210	314	Patillas .....	.00	.00	.00	201	237	438
Cataño	0	0	0	0	0	0	Peñuelas .....	.00	.00	.00	69	105	174
Cayey .....	.00	.00	.00	131	192	323	Ponce .....	.00	.00	.00	203	244	447
Ceiba .....	.00	.00	.00	109	0	109	Quebradillas.	.00	.00	.00	34	210	244
Ciales .....	.00	.00	.00	45	0	45	Rincón .....	.00	.00	.00	39	110	149
Cidra .....	.00	.00	.00	92	1,313	1,405	Río Grande...	.00	.00	.00	177	186	363
Coamo .....	.00	.02	.02	1,025	220	1,245	Sabana Grande....	.00	.00	.00	51	320	371
Comerio .....	.00	.00	.00	161	1,037	1,198	Salinas .....	.00	.01	.01	236	105	341
Corozal .....	.00	.00	.00	86	284	370	San Germán .	.00	.00	.00	109	218	327
Culebra .....	.00	.00	.00	68	105	173	San Juan .....	.00	.00	.00	37	121	158
Dorado .....	.00	.00	.00	61	105	166	San Lorenzo .	.01	.00	.01	183	240	423
Fajardo .....	.00	.00	.00	88	105	193	San Sebastián	.00	.00	.00	68	444	512
Florida .....	.00	.00	.00	8	0	8	Santa Isabel..	.00	.00	.00	45	0	45
Guánica .....	.00	.00	.00	62	0	62	Toa Alta .....	.00	.00	.00	133	70	203
Guayama .....	.00	.00	.00	247	194	441	Toa Baja .....	.00	.01	.01	259	105	364
Guayanilla ....	.00	.00	.00	131	0	131	Trujillo Alto .	.00	.00	.00	74	439	513
Guaynabo .....	.00	.00	.00	37	105	142	Utuaado .....	.00	.00	.00	132	271	403
Gurabo .....	.00	.00	.00	154	206	360	Vega Alta .....	.00	.00	.00	46	210	256
Hatillo .....	.00	.00	.00	206	818	1,024	Vega Baja .....	.00	.00	.00	75	675	750
Hormigueros.	.00	.00	.00	19	311	330	Vieques .....	.00	.00	.00	143	105	248
Humacao .....	.00	.00	.00	170	531	701	Villalba .....	.00	.00	.00	97	0	97
Isabela .....	.00	.01	.01	218	220	438	Yabucoa .....	.00	.00	.00	102	203	305
Jayuya .....	.00	.00	.00	155	572	727	Yauco .....	.00	.00	.00	93	312	405
Juana Díaz ....	.00	.00	.00	164	0	164	Total .....	.04	.08	.12	9,606	22,589	32,195
Juncos .....	.00	.00	.00	76	35	111							

Irrigation

Withdrawals for irrigation purposes within agricultural lands served by the PREPA irrigation districts in Puerto Rico were about 187 Mgal/d in 1986 and about 192 Mgal/d in 1987. The public irrigation network operated by the PREPA consists of four major irrigation systems: the Guayama and Juana Díaz Irrigation Districts on the south coast, the Valle de Lajas Irrigation District in the southwest, and the Isabela Irrigation District in northwestern Puerto Rico (fig. 6). The Guayama Irrigation District withdraws water from the Río Guamaní and Lago Patillas reservoir, and delivers it to agricultural lands in Patillas, Arroyo, Guayama, and Salinas. The Juana Díaz Irrigation District withdraws water from the Lago Guayabal reservoir, and delivers it to agricultural lands in Juana Díaz and Santa Isabel. The Valle de Lajas Irrigation District withdraws water from Lago Loco Reservoir and delivers it to Cabo Rojo, Lajas, Guánica,

and some sections of Yauco and Sabana Grande. The Isabela Irrigation District withdraws water from Lago Guajataca reservoir, and delivers it to the municipios of Aguadilla, Isabela, and Moca. In addition to the public irrigation network operated by PREPA, there is an independent irrigation district at Ponce. Irrigation withdrawals in the Ponce irrigation district area were estimated at about 29 Mgal/d for 1986 and 1987.

Irrigation withdrawals from the most intensively irrigated areas in Puerto Rico averaged about 186 and 190 Mgal/d during 1986 and 1987, respectively, to irrigate about 48,070 acres of land (27,300 acres by spray irrigation methods and 20,670 acres by flood irrigation methods) (tables 16 and 17). Surface-water sources accounted for 133 Mgal/d of the total withdrawals in 1986 and 137 Mgal/d in 1987. Ground-water withdrawals were estimated at about 53 Mgal/d during both years.

Table 16. Freshwater withdrawals and irrigated land by type for irrigation use, by municipio, for 1986

[Location of municipios are shown in figure 1. Mgal/d, million gallons per day]

Municipio	Freshwater withdrawals (Mgal/d)			Irrigated land by type (thousand acres)		
	Surface water	Ground water	Total	Spray	Flood	Total
Aguadilla.....	0.33	0.04	0.37	0.02	0.17	0.19
Arroyo.....	1.85	.91	2.76	.66	.92	1.58
Cabo Rojo.....	.39	.58	.97	.30	.20	.50
Coamo.....	.12	.73	.85	.38	.06	.44
Guanica.....	1.70	1.14	2.84	.59	.88	1.47
Guayama.....	6.93	.48	7.41	1.73	3.57	5.30
Isabela.....	.75	.01	.76	.08	.39	.47
Juana Díaz.....	.00	15.12	15.12	3.09	.77	3.86
Lajas.....	.00	.02	.02	1.05	3.44	4.49
Patillas.....	25.98	.00	25.98	.00	.76	.76
Ponce.....	24.65	4.04	28.69	5.88	1.67	7.55
Quebradillas..	19.20	.00	19.20	.19	.58	.77
Salinas.....	.00	12.23	12.23	4.65	.62	5.27
Santa Isabel...	.00	18.02	18.02	6.39	2.03	8.42
Villalba.....	21.67	.00	21.67	.00	.05	.05
Yabucoa.....	.00	.06	.06	.03	.00	.03
Yauco.....	29.17	.00	29.17	2.26	4.56	6.82
Total.....	132.74	53.38	186.12	27.30	20.67	47.97

Table 17. Freshwater withdrawals and irrigated land by type for irrigation use, by municipio, for 1987

[Location of municipios are shown in figure 1. Mgal/d, million gallons per day]

Municipio	Freshwater withdrawals (Mgal/d)			Irrigated land by type (thousand acres)		
	Surface water	Ground water	Total	Spray	Flood	Total
Aguadilla.....	0.33	0.04	0.37	0.02	0.17	0.19
Arroyo.....	1.85	.91	2.76	.66	.92	1.58
Cabo Rojo.....	.39	.58	.97	.30	.20	.50
Coamo.....	.12	.73	.85	.38	.06	.44
Guanica.....	1.70	1.14	2.84	.59	.88	1.47
Guayama.....	8.25	.48	8.73	1.73	3.57	5.30
Isabela.....	.75	.01	.76	.08	.39	.47
Juana Díaz.....	.00	15.12	15.12	3.09	.77	3.86
Lajas.....	.00	.02	.02	1.05	3.44	4.49
Patillas.....	34.44	.00	34.44	.00	.76	.76
Ponce.....	24.65	4.04	28.69	5.88	1.67	7.55
Quebradillas..	19.59	.00	19.59	.19	.58	.77
Salinas.....	.00	12.23	12.23	4.65	.62	5.27
Santa Isabel...	.00	18.02	18.02	6.39	2.03	8.42
Villalba.....	21.67	.00	21.67	.00	.05	.05
Yabucoa.....	.00	.06	.06	.03	.00	.03
Yauco.....	23.41	.00	23.41	2.26	4.56	6.82
Total.....	137.15	53.38	190.53	27.30	20.67	47.97

Reservoir Evaporation

The amount of water that evaporated from 14 reservoirs throughout Puerto Rico was estimated to be about 24,100 acre-ft in 1986 and 23,600 acre-ft in 1987 from a total reservoir area of 6,390 acres. Lago Toa Vaca and Lago Guayabal in Villalba had the largest amount of evaporation, totaling 5,720 acre-ft in 1986 and 5,630 acre-ft in 1987 from a total reservoir area of 1,170 acres (table 18, fig. 6).

Table 18. Water evaporation from reservoirs and their surface area, by municipio, for 1986 and 1987

[Location of municipios are shown in figure 1]

Municipio	Reservoir	Reservoir area (thousand acres)	Evaporation (thousand acre-feet)	
			1986	1987
Adjuntas.....	Lago Garzas	0.10	0.34	0.34
	Lago Guayo	.28	.88	.90
Arecibo	Lago Dos Bocas	.63	2.13	2.03
Cidra	Lago Cidra	.27	.97	.97
Comerio	Lago Comerio II	.06	.20	.19
Guayama.....	Lago Carite	.33	1.04	1.05
Patillas	Lago Patillas	.31	.73	1.25
Quebradillas....	Lago Guajataca	1.00	3.80	3.22
Toa Alta	Lago La Plata	.56	1.88	1.79
Trujillo Alto....	Lago Loíza	.71	2.94	2.92
Utuado	Lago Caonillas	.70	2.35	2.24
Villalba	Lago Toa Vaca	.84	4.11	4.04
	Lago Guayabal	.33	1.61	1.59
Yauco	Lago Luchetti	.27	1.16	1.09
Total		6.39	24.14	23.62

SUMMARY

Puerto Rico is divided, politically, into 78 municipios. Water-use data were compiled for each municipio. Data were compiled for eight offstream water-use categories; public-supply, domestic, industrial, mining, thermoelectric power, livestock, irrigation, and sewage-treatment discharges as a water-use related category. Three instream water-use categories hydroelectric power, reservoir evaporation, and thermoelectric saline cooling water.

During 1986, freshwater withdrawals from surface- and ground-water sources (excluding sewage treatment) averaged 630 Mgal/d in 1986 and 648 Mgal/d during

1987. Freshwater withdrawals to public-supply facilities from surface- and ground-water supplies totaled 398 Mgal/d during 1986 and 413 Mgal/d during 1987.

The largest amount of water delivered by PRASA was for unaccounted uses, 179 Mgal/d (45 percent) in 1986 and 192 Mgal/d (46 percent) during 1987. The second largest delivery by the PRASA was for domestic uses, 152 Mgal/d in 1986 and 154 Mgal/d during 1987. Public sewage-treatment plants treated 154 and 163 Mgal/d in 108 and 102 facilities during 1986 and 1987, respectively.

In Puerto Rico, about 25 percent of the total freshwater withdrawn was used for domestic purposes during 1986 and 1987. Ground-water self-supplied withdrawals by industrial users were estimated only for municipios at which withdrawals were equal to or greater than 1.0 Mgal/d. Islandwide, it was averaged at 16 Mgal/d in 1986 and 1987. The production of sand and gravel is the primary mining activity in Puerto Rico. In 1986 and 1987, mining operations used 2.6 Mgal/d of ground water both years.

Puerto Rico has four thermoelectric powerplants that consume large amounts of saline water for cooling. These withdrawals totaled 2,130 Mgal/d during 1986 and 1,740 Mgal/d in 1987. PRASA also delivered 2.8 Mgal/d of fresh ground water to the Puerto Nuevo and Palo Seco powerplants. The Aguirre and Costa Sur powerplants withdrew 2.1 Mgal/d of freshwater in 1986 and 2.4 Mgal/d in 1987 from their ground-water wells.

During 1986 and 1987, there were 11 active hydroelectric powerplants located throughout Puerto Rico. These powerplants used the largest amount of instream freshwater 564 Mgal/d in 1986 and 511 Mgal/d in 1987.

Livestock enterprises reported 8,557,316 animals in Puerto Rico during 1986 and 1987. The stock subcategory totaled 8,525,121 animals, and used 7.3 Mgal/d from surface- and ground-water sources during 1986 and 1987. The animal specialties subcategory totaled 9,606 horses and 22,589 rabbits, and used 0.12 Mgal/d from both sources in 1986 and 1987.

The public irrigation district operated by the PREPA consists of four major systems. During 1986 and 1987, 186 and 190 Mgal/d of water were withdrawn, respectively, to irrigate 47,970 acres of land.

Reservoir evaporation is considered to be a consumptive use associated with the storage of water. The evaporation of water from 14 reservoirs in Puerto Rico totaled 24,100 acre-feet during 1986 and 23,600 acre-feet in 1987 from a total reservoir surface area of 6,390 acres.

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GLOSSARY

- Commercial water use:** water for motels, hotels, restaurants, office buildings, other commercial facilities, and civilian and military institutions. The water is obtained from a public supply or is self supplied.
- Consumptive use:** that part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.
- Domestic water use:** water for household purposes, such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, and watering lawns and gardens. The water is obtained from a public supply or is self supplied.
- Freshwater:** water that contains less than 1,000 milligrams per liter (mg/L) of dissolved solids; generally, more than 500 mg/L of dissolved solids is undesirable for drinking and many industrial uses.
- Ground water:** generally all subsurface water as distinct from surface water; specifically, that part of the subsurface water in the saturated zone, where the water is under pressure greater than atmospheric.
- Hydroelectric power water use:** use of water in generating electricity at powerplants where the turbine generators are driven by falling water; and instream use.
- Industrial water use:** water used to manufacture products such as steel, chemical, and paper products. It includes water used in petroleum refining such as processing, washing, and cooling operations. This category includes self-supplied water and water purchased from a water supplier.
- Instream water use:** water use taking place within the stream channel for such purposes as hydroelectric power generation, navigation, water-quality improvement, fish propagation, and recreation. In Puerto Rico, instream water primarily is used in the generation of hydroelectric power.
- Irrigation water use:** application of water on lands to assist in the growing of crops and pastures or to maintain vegetative growth in recreational lands, such as parks and golf courses.

Livestock water use: water for stock watering, feed lots, dairy operations, fish farming, and other farm needs. Livestock as used here includes cattle, sheep, goats, hogs, and poultry. Also included are such animal specialities as horses, rabbits, bees, pets, fur-bearing animals in captivity, and fish in captivity.

Mining water use: water use for extraction of minerals occurring naturally including solids, such as coal and ores; liquids, such as crude petroleum; and gases, such as natural gas. Also includes uses associated with quarrying, well operations (dewatering), milling (crushing, screening, washing, floatation, and so forth), and other preparations customarily completed at the mine site or as part of a mining activity. The primary mining activity in Puerto Rico is the production of sand and gravel.

Municipio: minimum legal or jurisdictional unit in Puerto Rico as used by the U.S. Bureau of Census. It is more or less equivalent to a county in the United States.

Offstream use: water withdrawn or diverted from a ground- or surface-water source for use in public supply, industry, irrigation, livestock, thermoelectric power generation, and other activities.

Per capita water use: the average amount of water used per person during a standard time period, generally per day.

Public-supply facilities: water withdrawn by public and private water suppliers and delivered to groups of users. Public suppliers provide water for various uses, such as domestic, commercial, thermoelectric power, industrial, and public water use.

Public water use: water supplied from a public supply and used for such purposes as firefighting, street washing, and municipal parks and swimming pools.

Reservoir Evaporation: water loss by evaporation from manmade impoundments, which have a normal capacity equal to or greater than 5,000 acre-feet. Normal capacity is defined as the total volume in a reservoir below the normal retention level, including dead storage but excluding flood-control and surcharge storage.

Saline water: water that contains more than 1,000 milligrams per liter of dissolved solids.

Self-supplied water: water withdrawn from a surface- or ground water source by a user rather than being obtained from a public supply.

Sewage: wastewater carried off by sewer and drains.

Sewage treatment: processing of wastewater for the removal or reduction of contained solids or other undesirable constituents.

Surface water: an open body of water, such as a stream or a lake.

Thermoelectric power water use: amount of water used in the production of electric power generated with fossil fuel. Fossil fuels include coal, oil, and natural gas. The water used is self supplied or is delivered by a water supplier through a distribution system.

Wastewater: water that carries wastes from homes, businesses, and industries.

Withdrawal: water removed from the ground or diverted from a surface-water source for use.