

Prepared in cooperation with the
PUERTO RICO AQUEDUCT AND SEWER AUTHORITY
PUERTO RICO DEPARTMENT OF NATURAL AND ENVIRONMENTAL RESOURCES, and
PUERTO RICO ENVIRONMENTAL QUALITY BOARD

Estimated Water Use in Puerto Rico, 2000

Open-File Report 2005-1201



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By Wanda L. Molina-Rivera

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Conversion Factors, Datums, Water-Quality Unit, and Acronyms

Multiply	By	To obtain
Area		
acre	4,047	square meter (m ²)
Flow rate		
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year (hm ³ /yr)
gallon per day (gal/d)	0.003785	cubic meter per day (m ³ /d)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m ³ /s)
Volume		
acre-foot (acre-ft)	1,233.489	cubic meter (m ³)
gallon (gal)	3.785	liter (L)

Datums:

Horizontal Datum - Puerto Rico Datum, 1940 Adjustment

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929) - a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called "Sea Level Datum of 1929".

Abbreviated water-quality unit used in this report:

gWh Gigawatt-hour

Acronyms used in this report:

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
 USGS United States Geological Survey

Estimated Water Use in Puerto Rico, 2000

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Abstract

Water-use data were compiled for the 78 municipios of the Commonwealth of Puerto Rico for 2000. Five offstream categories were considered: public-supply water withdrawals, domestic self-supplied water use, industrial self-supplied withdrawals, crop irrigation water use, and thermoelectric power fresh water use. Two additional categories also were considered: power generation instream use and public wastewater treatment return-flows. Fresh water withdrawals for offstream use from surface- and ground-water sources in Puerto Rico were estimated at 617 million gallons per day. The largest amount of fresh water withdrawn was by public-supply water facilities and was estimated at 540 million gallons per day. Fresh surface- and ground-water withdrawals by domestic self-supplied users was estimated at 2 million gallons per day and the industrial self-supplied withdrawals were estimated at 9.5 million gallons per day. Withdrawals for crop irrigation purposes were estimated at 64 million gallons per day, or approximately 10 percent of all offstream fresh water withdrawals. Saline instream surface-water withdrawals for cooling purposes by thermoelectric power facilities was estimated at 2,191 million gallons per day, and instream fresh water withdrawals by hydroelectric facilities at 171 million gallons per day. Total discharge from public wastewater treatment facilities was estimated at 211 million gallons per day.

Introduction

The National Water-Use Information Program of the U.S. Geological Survey (USGS) is a 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. It is essential for water-resources planners and managers to have information regarding the amount of water used, and where and how it is used, so they can adequately assess many of the critical water problems facing Puerto Rico.

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 and maintain an adequate database for major use categories of importance to water resources managers and planners in Puerto Rico.

Purpose and Scope

This report presents estimates of the amount of water withdrawn by public-supply water facilities, domestic and industrial self-supplied users, for crop irrigation use, and by thermoelectric power facilities. Two additional water-use categories also were considered: power generation instream use and public wastewater treatment. Water-use estimates are aggregated by municipios, irrigation districts, principal aquifer systems, and for public-supply water withdrawals, by areas where it is estimated that 80 percent or more of the public-supply water withdrawal is used within the indicated geographic area—a municipio, an aggregate of municipios, or some of the "barrios" of an adjacent municipio (as shown in fig. 1). Data are presented in tabular format together with graphics and maps showing the water-use distribution in Puerto Rico during 2000.

Acknowledgments

The author gratefully acknowledges the following Commonwealth agencies for their cooperation in making the data available: the PRASA, PRDNER, Puerto Rico Department of Health (PRDOH), and the Puerto Rico Electric Power Authority (PREPA). The author is also grateful to Fernando Gómez-Gómez, USGS Hydrologist, for his valuable contribution to the report and who provided a thorough technical review of all topics, especially the public-supply water withdrawals and domestic self-supplied water use, and the crop irrigation water-use sections.



Figure 1. Location of public-supply water aggregated areas in Puerto Rico, as used in this report, 2000 (numbers are referenced to table 1).

Data-Compilation Procedures

Water-use data for major offstream categories were compiled on the basis of the use category as follows: for 46 public-supply water aggregated service areas as previously defined (fig. 1), domestic and industrial self-supplied use by municipios (fig. 2), crop irrigation by irrigation districts (fig. 3), and principal aquifer systems (fig. 4). The sources of data and the methods used to compile water use differ for each category and are described in the following sections.

Public-Supply Water Withdrawals and Domestic Self-Supplied Water Use

Public-supply water withdrawal use is water withdrawn by public and private suppliers that furnish water for at least 25 people, or have a minimum of 15 service connections. Fresh water withdrawal data were obtained from electronic files from the PRASA, reporting the production of surface-water facilities and wells by municipio during 2000 (Puerto Rico Aqueduct and Sewer Authority, 1999); and from the PRDOH, for the non-PRASA systems (Puerto Rico Department of Health, 2000). Data are aggregated into 46 public-supply water service areas and categorized as PRASA or non-PRASA (fig. 1).

The number of people served by the PRASA public-supply water systems in each water-use service area was calculated by subtracting the population served by non-PRASA systems (PRDOH) and the domestic self-supplied population from the total population as obtained in the 2000 Census (U.S. Department of Commerce, 2000). The sum of non-PRASA and domestic self-supplied population in Puerto Rico in 2000 should be nearly 4 percent of the total population based on the trend since 1960. The sum of population served by the PRASA, non-PRASA, and domestic self-supplied thus would be equal to the 2000 total population for Puerto Rico.

Domestic self-supplied water use refers to water used by individual households that are not served by public-supply water systems—PRASA and non-PRASA. Data on fresh water withdrawals and population served were not available for the domestic self-supplied water-use estimates. Domestic self-supplied population in the 46 public-supply water service areas used in this report was estimated by assuming that about 4 percent of the population in Puerto Rico is not served by the PRASA systems (F. Gómez-Gómez, U.S. Geological Survey, written commun., 2003). On this basis, approximately 3 percent of the population is served by non-PRASA systems, as estimated by the PRDOH, and thus, about 1 percent is domestic self-supplied. To obtain an estimate of the domestic self-supplied population within each public-supply water service area, the ratio of non-PRASA population in the water-use service area divided by the total Puerto Rico non-PRASA population was multiplied by the total Puerto Rico estimate of domestic self-supplied population (equal to 1 percent of the 2000 total population for Puerto Rico). The 2000 population was estimated by the U.S. Bureau of Census at 3,808,610

people (U.S. Department of Commerce, 2000). Therefore, approximately 30,700 people are assigned to the domestic self-supplied use category.

Self-supplied domestic water withdrawals were estimated by multiplying self-supplied population by a per capita-use coefficient of 68 gallons per day per person (gal/d-p), based on 250 gallons per household with 3.7 persons per household.

Industrial Self-Supplied Withdrawals

Industrial self-supplied withdrawals refers to water used for industrial purposes in such industries as pharmaceutical, chemical and allied products, food processing, and petroleum refining. Water for industrial uses at facilities requiring relatively large amounts of water as part of industrial processes is obtained from self-supplied ground-water withdrawals (100 percent). Industrial facilities requiring lesser amounts of water are typically supplied from public-supply water facilities.

The withdrawal data included in this report are limited to industrial self-supplied ground-water withdrawals and were obtained from individual industries. In Puerto Rico, most of the self-supplied industries are located along the north coast of the island and can be grouped in the Standard Industrial Classification (SIC) Code number 28 (U.S. Department of Labor, 2005). The SIC code 28 refers to chemical and allied products. Also included are aggregated ground-water withdrawals within island municipios with withdrawals greater or equal to 0.10 but less than 0.50 million gallons per day (Mgal/d) from "light industry" (industrial parks with withdrawals greater or equal to 0.10 but less than 0.50 Mgal/d) located within industrial parks (fig. 2).

Crop Irrigation Water Use

Crop irrigation water use is defined as water applied to the land to assist in the growing of crops, nursery plants, and pastures. Water applied to golf courses and parks was not included in this category. The surface-water withdrawals for crop irrigation purposes were estimated for agricultural areas served by irrigation districts of the PREPA. There are four irrigation districts in Puerto Rico: the Guayama and Juana Díaz Irrigation Districts in the south coast, the Valle de Lajas Irrigation District in the southwest, and the Isabela Irrigation District in northwestern Puerto Rico (fig. 3).

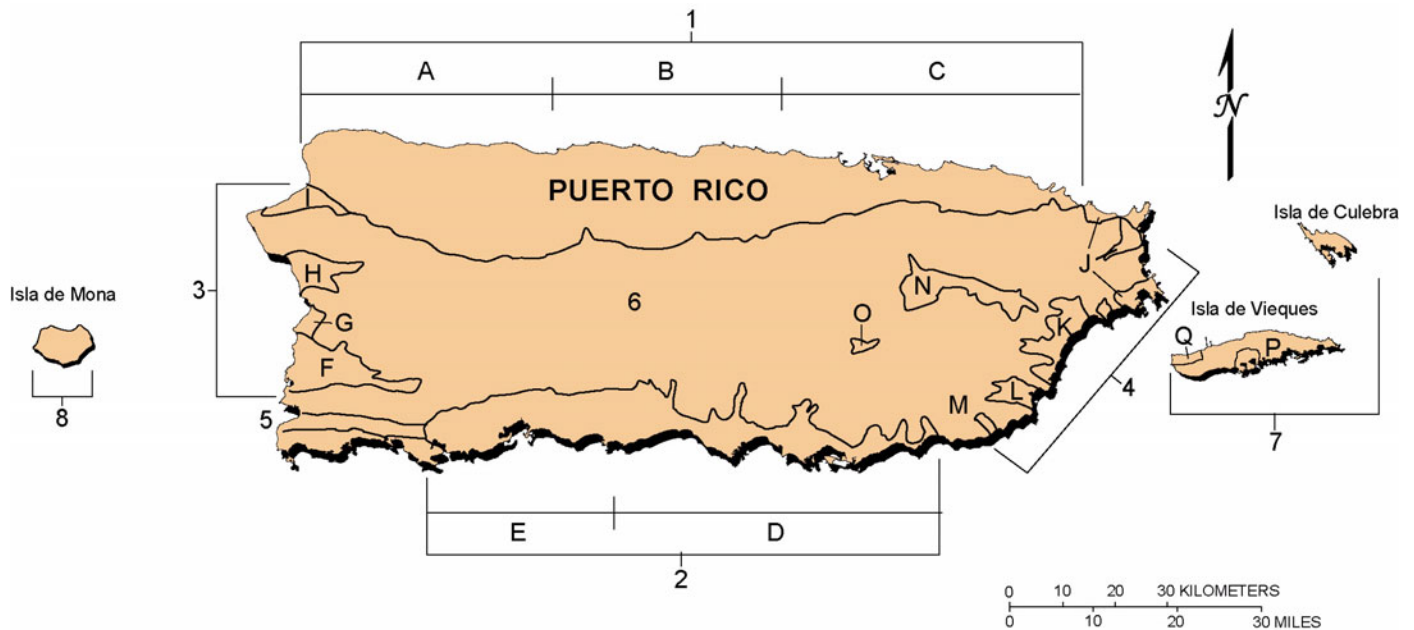
The Guayama Irrigation District withdraws water from the Río Guamaní, the Lago Carite, and the Lago Patillas reservoirs, and delivers the water to agricultural lands in the municipios of Arroyo, Guayama, Patillas, and Salinas. In 2000, water conveyed by the Guayama Irrigation District was also the source of public-supply water to two PRASA filtration plants in the municipio of Guayama: the Guayama and Guamaní Filtration Plants. The Lago Carite in the municipio of Cayey is also the source of public-supply water to the Farallón Filtration Plant at Cayey. Approximately 76 percent of the withdrawals from irrigation canals of the Guayama Irrigation District were for public-supply water use.



Figure 2. Location of municipios in Puerto Rico.



Figure 3. Location of the Puerto Rico Electric Power Authority Irrigation Districts in Puerto Rico, 2000.



EXPLANATION

GROUND-WATER PROVINCES

- 1. North Coast Province
- 2. South Coast Province
- 3. West Coast Province
- 4. East Coast Province
- 5. Lajas Valley
- 6. Interior Province
- 7. Isla de Vieques and Culebra
- 8. Isla de Mona

AQUIFER NAMES

North Coast Limestone aquifer system:

- A. West Coast to Río Grande de Arecibo area
- B. Río Grande de Arecibo to Río de La Plata area
- C. Río de La Plata to Río Espíritu Santo area

- D. South Coastal Plain Aquifer System
- E. Tallaboa-Guayanilla-Yauco-Guánica Valleys
- F. Río Guanajibo Valley
- G. Río Yaguez Valley
- H. Río Grande de Añasco Valley
- I. Río Culebrinas Valley
- J. Fajardo area
- K. Naguabo-Humacao area
- L. Yabucoa Valley
- M. Maunabo Valley
- N. Caguas-Juncos Valleys
- O. Cayey Valley
- P. Esperanza
- Q. Resolución

Figure 4. Ground-water provinces and aquifers of Puerto Rico and outlying islands (modified from Gómez-Gómez, 1987).

The Juana Díaz Irrigation District withdraws water exclusively from the Lago Guayabal reservoir at Villalba and conveys the water to agricultural lands in Juana Díaz, Santa Isabel, and the part of Salinas to the west of the Río Nigua of Salinas.

The Isabela Irrigation District withdraws water from Lago Guajataca reservoir in the municipio of Quebradillas and conveys the water to agricultural lands in the municipios of Aguadilla, Isabela, and Moca. About 93 percent of the water conveyed by the Isabela Irrigation District was the source of water at Isabela and Aguadilla (old) PRASA filtration plants in Isabela and Aguadilla to serve the population of Isabela, Aguadilla, Aguada, Moca, and Rincón.

The Valle de Lajas Irrigation District withdraws water exclusively from the Lago Loco reservoir at Guánica and conveys the water to agricultural lands in Cabo Rojo, Guánica, Lajas, Sabana Grande, and Yauco. Diversion from Lago Loco to the Valle de Lajas Irrigation District provided the surface water withdrawn by the PRASA to filtration plants in Sabana Grande (Maginas Filtration Plant) and in Lajas (Lajas Filtration Plant). Public-supply water withdrawals from the Valle de Lajas Irrigation Canal represents about 27 percent of the total withdrawals from the Lago Loco reservoir to the Valle de Lajas Irrigation District.

Estimates of ground-water withdrawals for crop irrigation within irrigation districts were estimated on the basis of site-specific studies at the municipios of Santa Isabel and Salinas on irrigation water use (Kuniansky and others, 2004; J.M. Rodríguez, U.S. Geological Survey, written commun., 2003), and data on irrigation withdrawals at irrigation districts provided by the PREPA. The 1998 and 2002 Census of Agriculture (U.S. Department of Agriculture, 2003) were used to obtain an estimate of the year 2000 acreage irrigated by municipio within the irrigation districts.

In addition, the crop irrigation water-use estimate also was aggregated for the eight principal aquifer systems of the Island: South Coastal Plain (SCP), North Coast Limestone (NCL), East Coast Province (ECP), West Coast Province (WCP), Tallaboa, Guayanilla, Yauco, and Guánica Valleys, Lajas Valley, Interior, and Vieques and Culebra (Islands aquifers) (fig. 4).

Thermoelectric Power Water Use

The thermoelectric power category includes water used in the generation of electric power using fossil fuel. In Puerto Rico, the saline water withdrawal is entirely seawater used for once-through cooling purposes. The fresh water used is self-supplied or is delivered by a water supplier through a distribution system that is mostly used for boiler feed and domestic use within the facility. In 2000, Puerto Rico had four active thermoelectric power plants located throughout the Island (fig. 5). The estimates of water withdrawals for thermoelectric power were provided by the PREPA.

Hydroelectric Power Instream Water Use

Water used for hydroelectric power generation is classified as an instream use and refers to the water used in the generation of electricity at power plants, where turbine generators are driven by falling water. During 2000, there were nine active hydroelectric power plants throughout Puerto Rico (fig. 5). The total amount of instream water use by hydroelectric power plants was obtained from the PREPA for the year 2002. The total amount, however, is considered representative of instream use during 2000.

Public Wastewater Treatment

The location of the wastewater treatment facilities and the quantities of treated wastewater released from the facilities (return flow) to the environment are important in the management of water resources in Puerto Rico. Most public wastewater treatment facilities in Puerto Rico are located in the vicinity of the principal urban center in each municipio. Fourteen regional wastewater treatment plants (RWWTP) operated islandwide during 2000. These plants were (1) the Puerto Nuevo RWWTP located in San Juan serving principally the municipios of San Juan, Cataño, and parts of Guaynabo; (2) the Carolina RWWTP located in Loíza serving the municipios of Loíza, Carolina, Canóvanas, and Trujillo Alto; (3) the Bayamón RWWTP located in Cataño serving the municipios of Bayamón, and parts of Guaynabo, Cataño, and Toa Baja; (4) the Arecibo RWWTP located in Arecibo serving the municipio of Arecibo; (5) the Barceloneta RWWTP located in Barceloneta serving the municipios of Barceloneta, Manatí, and part of Vega Baja; (6) the Mayagüez RWWTP located in Mayagüez serving the municipios of Mayagüez, Hormigueros, Añasco, and part of Cabo Rojo; (7) the Aguadilla RWWTP located in Aguada serving the municipios of Aguada, Aguadilla, and Moca; (8) the Camuy RWWTP located in Camuy serving the municipios of Camuy and Hatillo; (9) the Ponce RWWTP located in Ponce serving the municipio of Ponce; (10) the Cayey RWWTP located in Cidra serving the municipios of Cidra and Cayey; (11) the Guayama RWWTP located in Guayama and serving the municipios of Guayama, Salinas, and Arroyo; (12) the Humacao RWWTP located in Humacao serving the municipios of Humacao, Naguabo, and Las Piedras; (13) the Caguas RWWTP located in Caguas serving the municipios of Caguas and Gurabo; and (14) the Santa Isabel RWWTP located in Santa Isabel serving the municipios of Coamo and Santa Isabel.

The public wastewater treatment category includes information on facilities of the PRASA engaged primarily in the collection, treatment, and disposal of wastewater conveyed through a sewer system. Return of treated water generally is to surface waters, with the exception of the municipio of Florida where it is discharged to the subsurface. The wastewater treatment category is included in this report because it contains information on the amount of water returned to the hydrologic system by public wastewater treatment facilities and the number of public facilities that treat wastewater.

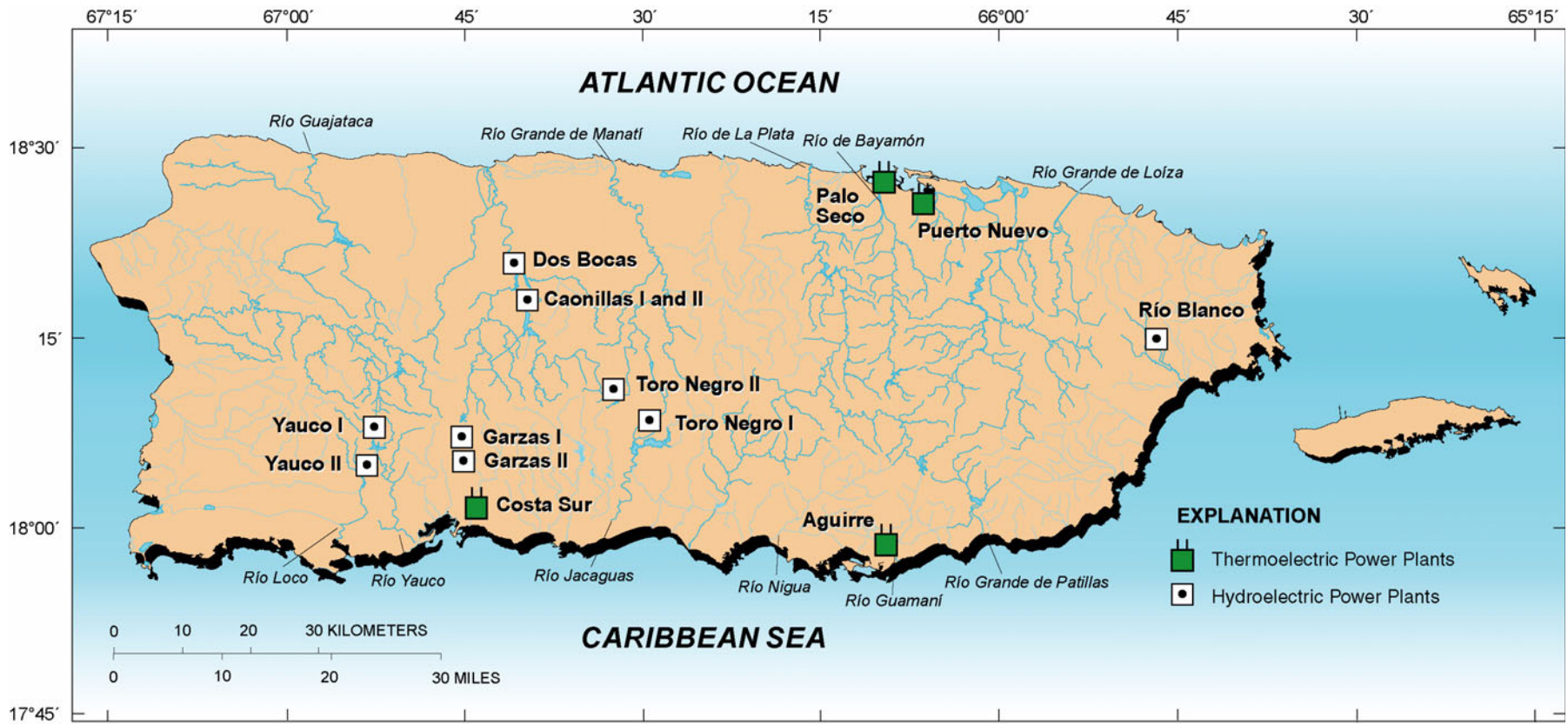


Figure 5. Location of the thermoelectric and hydroelectric power plants in Puerto Rico during 2000.

The wastewater treatment discharges presented in this report are from calendar year 2001, because the wastewater treatment category was not included in the 2000 Water Use National Effort (Hutson and others, 2004). Since the wastewater treatment discharges are fundamental to understand the water balance of the public-supply water systems, the numbers were acquired and compiled a year after the national compilation was concluded. The wastewater treatment discharges from domestic, commercial, and industrial users, however, are considered representative of flows for calendar year 2000. The 2001 wastewater treatment discharges from domestic, commercial, and industrial users connected to the sewer systems were obtained from annual reports prepared by the PRASA for calendar year 2001.

Water Use by Category and Source of Water

Water-use data are divided into offstream and instream uses. Offstream use is defined as water withdrawn or diverted from ground- or surface-water sources and conveyed to the place of use. Offstream water-use categories considered in this report are: public-supply water withdrawals, domestic self-supplied water use, industrial self-supplied withdrawals, crop irrigation water use, and thermoelectric power fresh water use. An estimated 617 Mgal/d was withdrawn for offstream uses throughout Puerto Rico during 2000. The largest offstream use was for public-supply water purposes and accounted for 540 Mgal/d or 88 percent of the total withdrawals. The metropolitan San Juan service area accounted for 42 percent of the total public-supply water withdrawals in Puerto Rico. About 64 Mgal/d (10 percent) of all offstream fresh water withdrawals was used for crop irrigation purposes. Fresh surface- and ground-water withdrawals for domestic self-supplied water use were estimated to be 2 Mgal/d, and industrial self-supplied water use was estimated to be 9.5 Mgal/d in 2000. Instream use is defined as water that is used, but not withdrawn, from a surface-water source for such purposes as hydroelectric power generation, navigation, water-quality improvement, fish propagation, and recreation. An estimated 2,362 Mgal/d was withdrawn for instream uses throughout Puerto Rico during 2000.

Public-Supply Water Withdrawals and Domestic Self-Supplied Water Use

During 2000, public-supply water distributed by the PRASA was provided by 170 surface-water facilities and 460 wells. Fresh water withdrawals from surface- and ground-water sources were estimated at 540 Mgal/d in 2000. Of the total population in 2000 (3,808,610 inhabitants), approximately 96 percent or about 3,661,000 people were estimated to be served by a public-supply water system belonging to the

PRASA and 3 percent or about 116,000 by non-PRASA systems (table 1). The metropolitan service area, as aggregated in this report, comprises the municipios of Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, and part of Caguas. Within this area, it is estimated that about 1,348,400 people are served by a highly interconnected water distribution system supplied from sources within the geographic area. The largest public-supply water withdrawal was 99 Mgal/d from the Sergio Cuevas facility at Trujillo Alto. This facility withdraws water from the Lago Loíza reservoir at Trujillo Alto and provides water principally to the municipios on the eastern half of the metropolitan area.

In addition to providing water for domestic use, public suppliers also deliver water to commercial, industrial, thermoelectric power, and other public facilities (the use of water by government facilities such as schools, hospitals, public offices, and for fire hydrants). Public-supply water by the non-PRASA systems is used for domestic purposes. Non-PRASA systems are considered public-water suppliers because they provide piped water for human consumption and have at least 15 connections or regularly serve at least 25 people (U.S. Environmental Protection Agency, 1974).

In 2000, domestic self-supplied water use was estimated at 2 Mgal/d. It is estimated that nearly 31,000 people or about 1 percent of the population in Puerto Rico rely on private wells or springs for their household water needs. Self-supplied domestic water use was derived by multiplying an assumed per capita use rate of 68 gal/d-p, based on 250 gallons per households with 3.7 persons per family (table 2).

The Island's aquifers, as sources of water for public-supply water needs and as the source for self-supplied domestic users, is indicated by the distribution of withdrawals given in table 3. The ground-water geographic province areas for Puerto Rico are shown in figure 4.

Industrial Self-Supplied Withdrawals

Ground-water withdrawals by industrial users were estimated only for municipios in which aggregated withdrawals were equal to or greater than 0.50 Mgal/d for chemical and allied products (SIC 28 Code) (U.S. Department of Labor, 2005). The municipios of Arecibo, Barceloneta, and Guayama, where a number of pharmaceutical companies have large facilities, had the largest ground-water withdrawals during 2000. Yabucoa had substantial industrial activity related to the refining of petroleum products (SIC 29). Ground-water withdrawals were estimated to be 9 Mgal/d for 2000 (table 4a). In addition to this amount, ground-water withdrawal from industries located within the Island's 250 "light industry" industrial parks was estimated at less than 1.0 Mgal/d (J.M. Rodríguez, U.S. Geological Survey, written commun., 2003) (table 4b).

Table 1. Estimated public-supply water withdrawals and population served in million gallons per day, 2000.

[Aggregate of municipios in which it is estimated that 80 percent or more of public-supply water withdrawals within given municipios. Location of areas shown in figure 1.]

Number	Areas	2000 Census of population ¹	Population served by PRASA systems	Population served by non-PRASA systems	Total population served	PRASA withdrawal	Non-PRASA withdrawal	Total withdrawals
	Puerto Rico	3,808,610	3,661,656	116,232	3,777,888	532.11	7.90	540.01
1	Metropolitan area: Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, Caguas areas (Barrio San Antonio and Barrio Río Cañas)	1,349,884	1,342,835	5,605	1,348,440	227.72	0.38	228.10
2	Caguas, Gurabo area (Barrio Navarro)	132,415	123,139	7,376	130,515	12.50	0.50	13.00
3	Juncos, Gurabo area (Barrios Hato Nuevo and Mamey)	48,132	48,046	0	48,046	8.00	0.00	8.00
4	Gurabo	19,860	19,526	334	19,860	2.31	0.02	2.33
5	Dorado, Vega Alta	71,927	71,927	0	71,927	11.99	0.00	11.99
6	Manatí, Vega Baja	107,338	107,338	0	107,338	15.33	0.00	15.33
7	Barceloneta	22,322	22,322	0	22,322	3.65	0.00	3.65
8	Florida	12,367	12,367	0	12,367	1.14	0.00	1.14
9	Arecibo	100,131	99,037	870	99,907	16.28	0.06	16.34
10	Camuy, Hatillo	74,169	74,169	0	74,169	7.46	0.00	7.46
11	Isabela	44,444	44,444	0	44,444	5.65	0.00	5.65
12	Quebradillas	25,450	25,450	0	25,450	3.18	0.00	3.18
13	Aguadilla, Moca, Aguada, Rincón	161,191	157,235	3,146	160,381	20.80	0.21	21.01
14	Mayagüez, Añasco, Cabo Rojo area (Barrio Guanajibo), Hormigueros area (Barrio Guanajibo)	136,709	134,918	1,424	136,342	21.72	0.10	21.82
15	Cabo Rojo, Hormigueros area (Barrio Benavente)	43,727	43,601	100	43,701	4.50	0.01	4.51
16	Hormigueros	9,871	9,871	0	9,871	0.69	0.00	0.69
17	Lajas, San Germán	63,366	61,203	1,720	62,923	7.53	0.12	7.65
18	Guánica, Yauco	68,272	62,218	4,814	67,032	8.90	0.33	9.23
19	Guayanilla	23,072	22,167	720	22,887	2.05	0.05	2.10
20	Maricao, Sabana Grande	32,384	32,158	180	32,338	4.39	0.01	4.40
21	Las Marías	11,061	10,935	100	11,035	1.42	0.01	1.43
22	San Sebastián	44,204	43,394	644	44,038	3.64	0.04	3.68
23	Lares	34,415	33,248	928	34,176	2.57	0.06	2.63
24	Utuado	35,336	31,962	2,683	34,645	3.77	0.18	3.95
25	Adjuntas	19,143	16,350	2,221	18,571	1.62	0.15	1.77

Table 1. Estimated public-supply water withdrawals and population served in million gallons per day, 2000.—Continued

[Aggregate of municipios in which it is estimated that 80 percent or more of public-supply water withdrawals within given municipios]

Number	Areas	2000 Census of population ¹	Population served by PRASA systems	Population served by non-PRASA systems	Total population served	PRASA withdrawal	Non-PRASA withdrawal	Total withdrawals
26	Peñuelas	26,719	22,582	3,290	25,872	1.76	0.22	1.98
27	Ponce	186,475	182,637	3,052	185,689	31.77	0.21	31.98
28	Juana Díaz	50,531	46,821	2,950	49,771	3.70	0.20	3.90
29	Villalba	27,913	24,916	2,383	27,299	2.47	0.16	2.63
30	Jayuya	17,318	12,905	3,509	16,414	1.59	0.24	1.83
31	Ciales	19,811	19,323	388	19,711	2.60	0.03	2.63
32	Morovis	29,965	28,760	0	28,760	3.57	0.00	3.57
33	Orocovis	23,844	18,380	4,678	23,058	2.30	0.32	2.62
34	Coamo, Santa Isabel	59,262	57,728	1,220	58,948	9.28	0.08	9.36
35	Barranquitas, Naranjito, Corozal	95,485	76,941	14,746	91,687	9.27	1.00	10.27
36	Comerío	20,002	17,381	2,084	19,465	1.34	0.14	1.48
37	Aibonito	26,493	25,049	1,148	26,197	3.97	0.08	4.05
38	Salinas	31,113	27,494	2,878	30,372	4.42	0.20	4.62
39	Aguas Buenas, Cidra	71,785	63,349	6,708	70,057	6.91	0.46	7.37
40	Cayey	47,370	45,318	1,632	46,950	8.27	0.11	8.38
41	Guayama, Arroyo, Patillas	83,570	78,251	4,230	82,481	11.72	0.29	12.01
42	Humacao, Las Piedras, Naguabo, Vieques, Culebra	128,247	120,209	6,392	126,601	12.75	0.43	13.18
43	Maunabo	12,741	12,332	325	12,657	1.52	0.02	1.54
44	Yabucoa	39,246	26,809	9,890	36,699	2.66	0.67	3.33
45	San Lorenzo	40,997	36,968	3,204	40,172	3.21	0.22	3.43
46	Luquillo, Fajardo, Ceiba	78,533	67,643	8,660	76,303	8.22	0.59	8.81

¹ U.S. Department of Commerce, 2000

12 Estimated Water Use in Puerto Rico, 2000

Table 2. Estimated domestic self-supplied water use and population served in million gallons per day, 2000.

[Location of areas shown in figure 1]

Number	Areas	Estimated self-supplied population	Total self-supplied withdrawals
	Puerto Rico	30,722	2.09
1	Metropolitan area: Toa Alta, Toa Baja, San Juan, Trujillo Alto, Río Grande, Bayamón, Cataño, Guaynabo, Carolina, Loíza, Canóvanas, Caguas areas (Barrio San Antonio and Barrio Río Cañas)	1,444	0.10
2	Caguas, Gurabo area (Barrio Navarro)	1,900	0.13
3	Juncos, Gurabo area (Barrios Hato Nuevo and Mamey)	86	0.01
4	Gurabo	0	0.00
5	Dorado, Vega Alta	0	0.00
6	Manatí, Vega Baja	0	0.00
7	Barceloneta	0	0.00
8	Florida	0	0.00
9	Arecibo	224	0.00
10	Camuy, Hatillo	0	0.00
11	Isabela	0	0.00
12	Quebradillas	0	0.00
13	Aguadilla, Moca, Aguada, Rincón	810	0.06
14	Mayagüez, Añasco, Cabo Rojo area (Barrio Guanajibo), Hormigueros area (Barrio Guanajibo)	367	0.02
15	Cabo Rojo, Hormigueros area (Barrio Benavente)	26	0.00
16	Hormigueros	0	0.00
17	Lajas, San Germán	443	0.03
18	Guánica, Yauco	1,240	0.08
19	Guayanilla	185	0.01
20	Maricao, Sabana Grande	46	0.00
21	Las Marías	26	0.00
22	San Sebastián	166	0.01
23	Lares	239	0.02
24	Utua	691	0.05
25	Adjuntas	572	0.04
26	Peñuelas	847	0.06
27	Ponce	786	0.05
28	Juana Díaz	760	0.05
29	Villalba	614	0.04
30	Jayuya	904	0.06
31	Ciales	100	0.01
32	Morovis	1,205	0.08
33	Orocovis	786	0.05
34	Coamo, Santa Isabel	314	0.02
35	Barranquitas, Naranjito, Corozal	3,798	0.26
36	Comerío	537	0.04
37	Aibonito	296	0.02

Table 2. Estimated domestic self-supplied water use and population served in million gallons per day, 2000.—Continued

[Location of areas shown in figure 1]

Number	Areas	Estimated self-supplied population	Total self-supplied withdrawals
38	Salinas	741	0.05
39	Aguas Buenas, Cidra	1,728	0.12
40	Cayey	420	0.03
41	Guayama, Arroyo, Patillas	1,089	0.07
42	Humacao, Las Piedras, Naguabo, Vieques, Culebra	1,646	0.11
43	Maunabo	84	0.01
44	Yabucoa	2,547	0.17
45	San Lorenzo	825	0.06
46	Luquillo, Fajardo, Ceiba	2,230	0.15

Table 3. Public-supply water withdrawal and domestic self-supplied use in million gallons per day by ground-water provinces, 2000.

[Location of geographic areas shown in figure 4]

Ground-water province	Geographic areas ¹	Withdrawal and use		Total
		Public-supply water systems withdrawal	Domestic self-supplied use	
Puerto Rico		94.75	2.09	96.84
North Coast	1A, B, and C	47.84	0.11	47.95
South Coast	2D	23.30	0.25	23.55
South Coast	2E	5.42	0.15	5.57
West Coast	3F, G, H, and I	5.79	0.08	5.87
East Coast	4J, K, L, and M	3.00	0.58	3.58
Lajas Valley	5	0.34	0.03	0.37
Interior	6	6.92	0.83	7.75
Interior	N and O	2.14	0.05	2.19
Islas de Vieques and Culebra	7P and Q	0.00	0.00	0.00

¹ Numbers and letters correspond to those shown in figure 4.

Table 4a. Industrial self-supplied withdrawals in million gallons per day by municipio, 2000.

[Location of municipios shown in figure 2. Only those municipios at which the aggregated industrial self-supplied withdrawals were estimated at 0.50 million gallons per day or greater are listed. SIC, Standard Industrial Classification]

Municipio	SIC	Ground-water withdrawals
Puerto Rico		9.00
Arecibo	28	1.75
Barceloneta	28	3.34
Guayama	28	1.40
Manatí	28	0.89
Ponce	22	0.75
Yabucoa	29	0.87

Table 4b. Industrial self-supplied withdrawals in million gallons per day from industries located at municipal industrial parks, 2000.

[Location of municipios shown in figure 2. Includes only municipal industrial parks with withdrawals greater or equal to 0.10 but less than 0.50 million gallons per day; data provided by J.M. Rodríguez, U.S. Geological Survey, written commun., 2003. SIC, Standard Industrial Classification]

Municipio	SIC	Ground-water withdrawals
Puerto Rico		0.54
Bayamón	20	0.26
Caguas	28	0.18
Cidra	20, 28	0.10

Crop Irrigation Water Use

During 2000, the estimated irrigation withdrawals in Puerto Rico averaged about 64 Mgal/d or 71,409 acre-feet per year (acre-ft/yr) for 37,861 acres of land. Surface and ground water accounted for about 32 Mgal/d of the total withdrawals for each source (table 5).

Surface-water withdrawals for irrigation use during calendar year 2000 was primarily from the four major irrigation systems operated by the PREPA: the Guayama and Juana Díaz Irrigation Districts on the south coast; the Isabela Irrigation District in the northwest, and the Valle de Lajas Irrigation District in the southwestern Puerto Rico (fig. 3). In 2000, these surface-water systems provided 29 Mgal/d (table 6, fig. 6).

Irrigation water use was also aggregated by aquifer areas. The South Coastal Plain (SCP) aquifer system provided an estimated 15 Mgal/d, the largest amount of water used for crop irrigation, followed by the North Coast Limestone (NCL) aquifer system, which provided an estimated 6.8 Mgal/d. The remaining 10 Mgal/d were provided by the aquifer or the East Coast Province (ECP) and the West Coast Province (WCP) (0.5 Mgal/d); the Tallaboa, Guayanilla, Yauco, and Guánica Valleys (5.8 Mgal/d); the Lajas Valley (0.0 Mgal/d) and the Interior (3.9 Mgal/d) (fig. 7).

In addition to the public irrigation network operated by the PREPA, there is an independent irrigation district at Ponce. Irrigation withdrawals in the Ponce Irrigation District area were estimated at about 1 Mgal/d during 2000.

Thermoelectric Power Water Use

In 2000, Puerto Rico had four thermoelectric power plants: Palo Seco in Cataño, Costa Sur in Guayanilla, Puerto Nuevo in Guaynabo, and Aguirre in Salinas (fig. 5). Seawater used for cooling was 2,191 Mgal/d; the PRASA delivered an estimated total of 2.3 Mgal/d of fresh water to the Puerto Nuevo and Palo Seco power plants. The total ground-water withdrawal by the Aguirre and Costa Sur power plants was 1.8 Mgal/d in 2000 (table 7).

Hydroelectric Power Instream Water Use

In 2002, Puerto Rico had nine active hydroelectric power plants located in Arecibo (Dos Bocas), Naguabo (Río Blanco), Orocovis (Toro Negro II), Peñuelas (Garzas I and II), Utuado (Caonillas I and II), Villalba (Toro Negro I), and Yauco (Yauco I and II) (fig. 5). These power plants generated nearly 115 gigawatt-hour (gWh) of electricity in 2002 with an average instream fresh water use of about 171 Mgal/d (table 8).

Public Wastewater Treatment

Total discharge from 71 active public wastewater treatment facilities was reported as about 211 Mgal/d in 2001 (table 9). Return flow of treated wastewater to ocean outfalls (Atlantic Ocean or Caribbean Sea) was estimated at 172 Mgal/d (82 percent) from 16 wastewater treatment facilities and was estimated to streams at 32 Mgal/d (15 percent) from 44 facilities. Four facilities returned about 4 Mgal/d of treated wastewater to estuaries and seven facilities discharged an estimated about 4 Mgal/d to wetlands (fig. 8). A summary of the amount of water released by public wastewater treatment plants and the number of operating facilities by municipio during 2001 is presented in table 9.

Total Water Use

Total water use in Puerto Rico in 2000 was estimated for seven categories: public-supply water withdrawals, domestic self-supplied water use, industrial self-supplied withdrawal, crop irrigation water use, thermoelectric power fresh water use, hydroelectric power, and public wastewater treatment. The total offshore fresh water withdrawals in 2000 were estimated to be about 617 Mgal/d and the instream water withdrawals were estimated to be 2,191 Mgal/d of saline (sewage) used for cooling at thermoelectric plants; about 171 Mgal/d of fresh water from island streams were for hydroelectric power (table 10).

Total withdrawals by category are listed in table 11. In 2000, the largest total water withdrawal was for thermoelectric power, of which 99 percent (2,191 Mgal/d) was saline. Public-supply water use accounted for the largest fresh water withdrawal (540 Mgal/d), followed by the crop irrigation at 64 Mgal/d.

Table 5. Estimated acres irrigated and irrigation water use by aquifer areas, 2000.

[Location of principal aquifer areas shown in figure 4]

Aquifer system	Municipio	Estimated acres irrigated	Application rates, in feet per year	Irrigation water use by source					
				in acre-feet per year			in million gallons per day		
				SW	GW	Total	SW	GW	Total
Puerto Rico		37861		35455	35954	71409	31.66	32.10	63.76
South Coastal Plain	Arroyo	251	2.3	577	0	577	0.52	0.00	0.52
	Guayama	306	2.3	704	0	704	0.63	0.00	0.63
	Juana Díaz	1285	3.2	2210	1901	4111	1.97	1.70	3.67
	Patillas	116	2.3	267	0	267	0.24	0.00	0.24
	Ponce	1214	1.0	311	902	1213	0.28	0.81	1.08
	Salinas	3780	2.3	2229	6465	8694	1.99	5.77	7.76
	Santa Isabel	5103	3.2	8780	7551	16331	7.84	6.74	14.58
Total		12055		15078	16819	31897	13.46	15.01	28.48
North Coastal Plain	Aguadilla	1301	2.0	2603	0	2603	2.32	0.00	2.32
	Arecibo	1649	1.0	0	1649	1649	0.00	1.47	1.47
	Barceloneta	241	1.0	0	241	241	0.00	0.22	0.22
	Bayamón	57	1.0	0	57	57	0.00	0.05	0.05
	Camuy	803	1.0	0	803	803	0.00	0.72	0.72
	Canóvanas	5	1.0	0	5	5	0.00	0.00	0.00
	Carolina	40	1.0	0	40	40	0.00	0.04	0.04
	Cataño	0	1.0	0	0	0	0.00	0.00	0.00
	Dorado	773	1.0	0	773	773	0.00	0.69	0.69
	Florida	241	1.0	0	241	241	0.00	0.22	0.22
	Hatillo	1694	1.0	0	1694	1694	0.00	1.51	1.51
	Isabela	509	2.0	1018	0	1018	0.91	0.00	0.91
	Manatí	643	1.0	0	643	643	0.00	0.57	0.57
	Moca	64	2.0	128	0	128	0.11	0.00	0.11
	Morovis	220	1.0	220	0	220	0.20	0.00	0.20
	Toa Baja	987	1.0	0	987	987	0.00	0.88	0.88
	Vega Alta	182	1.0	0	182	182	0.00	0.16	0.16
Vega Baja	226	1.0	0	226	226	0.00	0.20	0.20	
Quebradillas	100	1.0	0	100	100	0.00	0.09	0.09	
Total		9735		3969	7641	11610	3.54	6.82	10.37

Table 5. Estimated acres irrigated and irrigation water use by aquifer areas, 2000.—Continued

[Location of principal aquifer areas shown in figure 4]

Aquifer system	Municipio	Estimated acres irrigated	Application rates, in feet per year	Irrigation water use by source					
				in acre-feet per year			in million gallons per day		
				SW	GW	Total	SW	GW	Total
East Coast Valleys	Ceiba	24	1.0	24	0	24	0.02	0.00	0.02
	Fajardo	179	1.0	179	0	179	0.16	0.00	0.16
	Humacao	159	1.0	0	159	159	0.00	0.14	0.14
	Maunabo	66	1.0	0	66	66	0.00	0.06	0.06
	Naguabo	149	1.0	149	0	149	0.13	0.00	0.13
	Yabucoa	25	1.0	25	0	25	0.02	0.00	0.02
Total		602		377	225	602	0.34	0.20	0.54
West Coast Valleys	Aguada	132	1.0	132	0	132	0.12	0.00	0.12
	Añasco	67	1.0	67	0	67	0.06	0.00	0.06
	Cabo Rojo	780	2.0	1560	0	1560	1.39	0.00	1.39
	Hormigueros	174	1.0	0	174	174	0.00	0.16	0.16
	Mayagüez	145	1.0	0	145	145	0.00	0.13	0.13
	Rincón	62	1.0	0	62	62	0.00	0.06	0.06
	San Germán	299	1.0	299	0	299	0.27	0.00	0.27
Total		1659		2058	381	2439	1.84	0.34	2.18
Tallaboa, Guayanilla, Yauco, and Guánica Valleys	Guánica	1816	3.2	1490	4322	5812	1.33	3.86	5.19
	Guayanilla	802	1.0	431	371	802	0.38	0.33	0.72
	Peñuelas	44	1.0	24	20	44	0.02	0.02	0.04
	Yauco	748	3.2	613	1779	2392	0.55	1.59	2.14
	Total		3410		2558	6492	9050	2.28	5.80
Lajas Valley	Lajas	4815	2.0	9629	0	9629	8.60	0.00	8.60
	Sabana Grande	598	2.0	1195	0	1195	1.07	0.00	1.07
Total		5413		10824	0	10824	9.66	0.00	9.66
Interior	Adjuntas	250	1.0	250	0	250	0.22	0.00	0.22
	Aguas Buenas	90	1.0	90	0	90	0.08	0.00	0.08
	Aibonito	56	1.0	0	56	56	0.00	0.05	0.05
	Barranquitas	73	1.0	0	73	73	0.00	0.07	0.07
	Caguas	60	1.0	0	60	60	0.00	0.05	0.05
	Cayey	48	1.0	0	48	48	0.00	0.04	0.04

Table 5. Estimated acres irrigated and irrigation water use by aquifer areas, 2000.—Continued

[Location of principal aquifer areas shown in figure 4]

Aquifer system	Municipio	Estimated acres irrigated	Application rates, in feet per year	Irrigation water use by source					
				in acre-feet per year			in million gallons per day		
				SW	GW	Total	SW	GW	Total
Interior	Ciales	47	1.0	0	47	47	0.00	0.04	0.04
	Cidra	48	1.0	0	48	48	0.00	0.04	0.04
	Coamo	455	1.0	0	455	455	0.00	0.41	0.41
	Comerío	21	1.0	0	21	21	0.00	0.02	0.02
	Corozal	158	1.0	0	158	158	0.00	0.14	0.14
	Guaynabo	308	1.0	0	308	308	0.00	0.28	0.28
	Gurabo	838	1.0	0	838	838	0.00	0.75	0.75
	Jayuya	228	1.0	0	228	228	0.00	0.20	0.20
	Juncos	295	1.0	0	295	295	0.00	0.26	0.26
	Lares	85	1.0	0	85	85	0.00	0.08	0.08
	Las Marías	48	1.0	0	48	48	0.00	0.04	0.04
	Las Piedras	96	1.0	0	96	96	0.00	0.09	0.09
	Loíza	96	1.0	96	0	96	0.09	0.00	0.09
	Luquillo	0	1.0	0	0	0	0.00	0.00	0.00
	Maricao	48	1.0	0	48	48	0.00	0.04	0.04
	Naranjito	64	1.0	0	64	64	0.00	0.06	0.06
	Orocovis	146	1.0	146	0	146	0.13	0.00	0.13
	San Juan	9	1.0	9	0	9	0.01	0.00	0.01
	San Lorenzo	307	1.0	0	307	307	0.00	0.27	0.27
	San Sebastián	575	1.0	0	575	575	0.00	0.51	0.51
Toa Alta	290	1.0	0	290	290	0.00	0.26	0.26	
Trujillo Alto	24	1.0	0	24	24	0.00	0.02	0.02	
Utua	51	1.0	0	51	51	0.00	0.05	0.05	
Villalba	162	1.0	0	162	162	0.00	0.14	0.14	
Río Grande	11	1.0	0	11	11	0.00	0.01	0.01	
Total		4987		591	4396	4987	0.53	3.93	4.45
Vieques and Culebra	Culebra	0	1.0	0	0	0	0.00	0.00	0.00
	Vieques	0	1.0	0	0	0	0.00	0.00	0.00
Total		0		0	0	0	0.00	0.00	0.00

Table 6. Estimated acres irrigated and irrigation water use by irrigation district, 2000.

[Location of irrigation districts shown in figure 3]

Irrigation district	Municipio	Estimated acres irrigated	Application rates, in feet per year	Irrigation water use by source					
				in acre-feet per year			in million gallons per day		
				SW	GW	Total	SW	GW	Total
Puerto Rico		21472		33003	22018	55021	29.47	19.66	49.12
Guayama	Arroyo	251	2.3	577	0	577	0.52	0.00	0.52
	Guayama	306	2.3	704	0	704	0.63	0.00	0.63
	Patillas	116	2.3	267	0	267	0.24	0.00	0.24
	Salinas	3780	2.3	2229	6465	8694	1.99	5.77	7.76
	Total	4453		3777	6465	10242	3.37	5.77	9.14
Juana Díaz	Juana Díaz	1285	3.2	2210	1901	4111	1.97	1.70	3.67
	Santa Isabel	5103	3.2	8780	7551	16331	7.84	6.74	14.58
	Total	6388		10990	9452	20442	9.81	8.44	18.25
Isabela	Aguadilla	1301	2.0	2603	0	2603	2.32	0.00	2.32
	Isabela	509	2.0	1018	0	1018	0.91	0.00	0.91
	Moca	64	2.0	128	0	128	0.11	0.00	0.11
	Total	1874		3749	0	3749	3.35	0.00	3.35
Valle de Lajas	Cabo Rojo	780	2.0	1560	0	1560	1.39	0.00	1.39
	Guánica	1816	3.2	1490	4322	5812	1.33	3.86	5.19
	Lajas	4815	2.0	9629	0	9629	8.60	0.00	8.60
	Sabana Grande	598	2.0	1195	0	1195	1.07	0.00	1.07
	Yauco	748	3.2	613	1779	2392	0.55	1.59	2.14
	Total	8757		14487	6101	20588	12.94	5.45	18.38

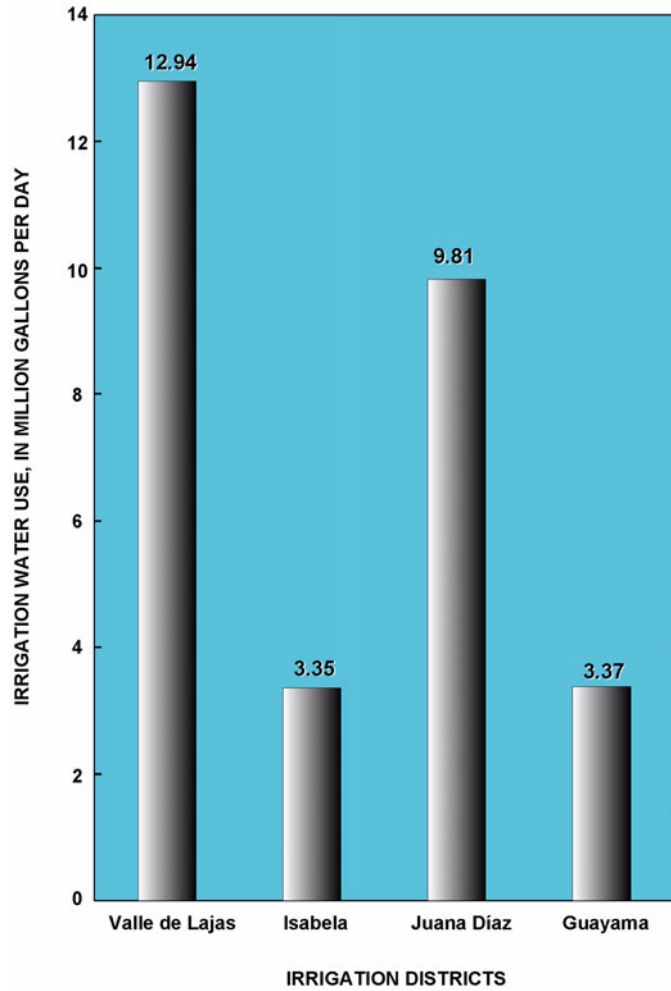


Figure 6. Estimated irrigation water use in million gallons per day by irrigation district, 2000.

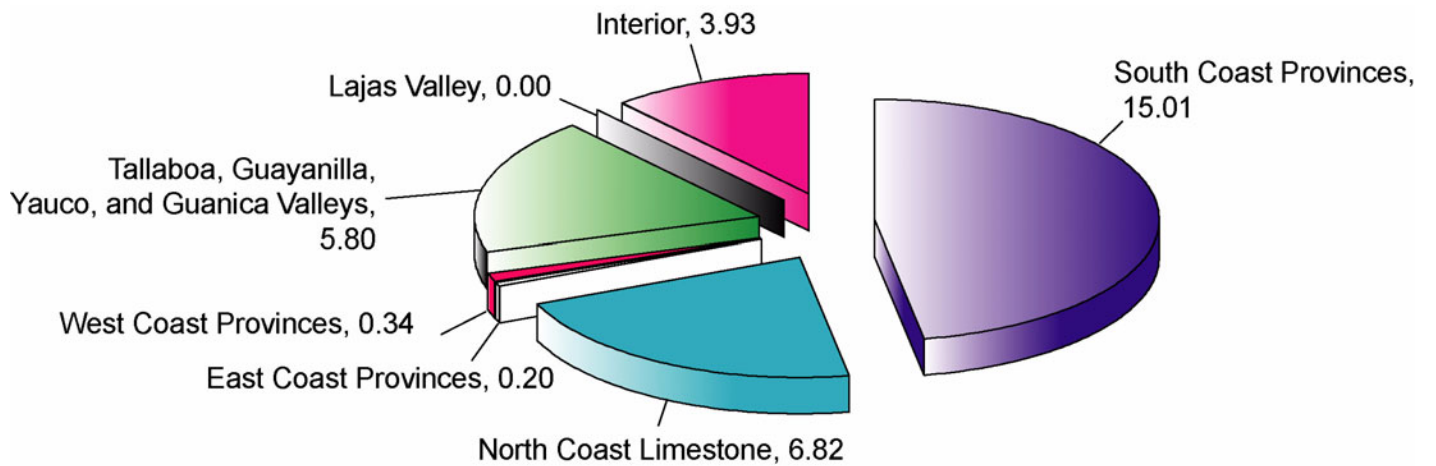


Figure 7. Estimated irrigation water use in million gallons per day by aquifer area, 2000.

Table 7. Self-supplied withdrawals and deliveries from public-water supply by thermoelectric power plants by municipio, 2000.

[Location of municipios shown in figure 2. Mgal/d, million gallons per day]

Municipio	Self-supplied withdrawals (Mgal/d) by source and type			Deliveries from public supply (Mgal/d)	Total withdrawals and deliveries (Mgal/d)
	GW	SW	Total		
	Fresh	Saline			
Puerto Rico	1.78	2190.75	2192.53	2.33	2194.86
Cataño	0.00	442.42	442.42	1.10	443.52
Guayanilla	1.16	681.54	682.69	0.00	682.69
Guaynabo	0.00	472.47	472.47	1.23	473.70
Salinas	0.63	594.32	594.95	0.00	594.95

Table 8. Water use and power generated by hydroelectric power plants by municipio, 2002.

[Location of municipios shown in figure 2]

Municipio	Instream water use		Power generation, gigawatt-hours
	in million gallons per day	in acre-feet per year	
Puerto Rico	170.72	191,202	114.50
Arecibo	94.06	105,345	35.00
Naguabo	2.37	2,654	2.67
Orocovis	0.69	773	1.42
Peñuelas	1.44	1,613	2.60
Utua	28.16	31,539	20.04
Villalba	3.16	3,539	11.20
Yauco	40.84	45,740	41.57

Table 9. Wastewater treatment facilities, maximum design capacity, average return flow, and receiving water body by municipio, 2001.

[Location of municipios shown in figure 2. Mgal/d, million gallons per day]

Municipio	Facility name	Maximum design capacity, Mgal/d	Average return flow, Mgal/d	Receiving water body
Puerto Rico			210.85	
Adjuntas	Adjuntas	0.60	0.49	Río Cidra
Aguada	Aguadilla Regional	8.00	4.27	Atlantic Ocean
Aguas Buenas	Aguas Buenas	0.60	0.37	Río Bairoa
Aibonito	Aibonito	1.80	0.42	Río Aibonito
Arecibo	Arecibo Regional	10.00	6.21	Atlantic Ocean
Barceloneta	Barceloneta Regional	8.33	6.09	Atlantic Ocean
Barranquitas	Barranquitas (Nueva)	0.60	0.26	Río Barranquitas
Cabo Rojo	Boquerón / Villa Taína	0.70	0.14	Canal de Boquerón
Caguas	Caguas Regional	12.00	9.21	Río Bairoa
	Las Carolinas	0.08	0.23	Río Cagüitas
	Borinquen	0.30	0.18	Río Turabo
Camuy	Camuy Regional	3.02	0.92	Atlantic Ocean
Canóvanas	Villas de Loíza	0.75	0.00	Quebrada Cambalache
Cataño	Bayamón Regional	40.00	39.92	Atlantic Ocean
Cayey	El Torito	0.25	0.17	Río de la Plata
Ceiba	Ceiba	1.40	0.47	Quebrada Santa
Ciales	Ciales	0.60	0.31	Río Grande de Manatí
Cidra	Cayey Regional	4.28	3.84	Río de la Plata
	Vista Monte	0.08	0.00	Río Sabana
Comerío	Comerío	1.00	0.31	Río de la Plata
Corozal	Corozal	1.25	0.70	Río Cibuco
Dorado	Dorado	2.02	1.13	Río de la Plata
Fajardo	Fajardo	2.20	2.56	Río Fajardo
Guánica	Playa Santa	0.50	0.04	Land infiltration
	Guánica	0.80	0.58	Caribbean Sea
Guayama	Guayama Regional	10.00	4.91	Caribbean Sea
Guayanilla	Guayanilla	0.73	0.44	Río Guayanilla
Gurabo	Gurabo	1.60	0.00	Río Gurabo
Humacao	Humacao Regional	8.30	5.29	Caribbean Sea
Isabela	Isabela	1.00	0.61	Atlantic Ocean
Jayuya	Jayuya	0.50	0.47	Río Grande de Jayuya
Juncos	Juncos	1.00	0.91	Río Valenciano
Lajas	La Parguera	0.10	0.08	Land infiltration
	El Valle de Lajas	0.10	0.03	Quebrada Las Cañitas
	Lajas	0.60	0.34	Quebrada Mondongo
Lares	Lares Nueva	1.21	1.24	Río Guajataca
Las Marías	Las Marías	0.25	0.08	Quebrada Arena
Las Piedras	Pueblito del Río	0.10	0.00	Río Gurabo
Loíza	Carolina Regional	45.00	25.58	Atlantic Ocean
Luquillo	Luquillo	1.30	1.06	Río Sabana
Maricao	Maricao	0.18	0.09	Río Maricao

Table 9. Wastewater treatment facilities, maximum design capacity, average return flow, and receiving water body by municipio, 2001.—Continued

[Location of municipios shown in figure 2. Mgal/d, million gallons per day]

Municipio	Facility name	Maximum design capacity, Mgal/d	Average return flow, Mgal/d	Receiving water body
Maunabo	Maunabo	0.50	0.27	Río Maunabo
Mayagüez	Mayagüez Regional	22.50	9.80	Atlantic Ocean
Morovis	Morovis	0.50	0.44	Río Indio
	Unibón	0.09	0.07	Río Unibón
Naguabo	Río Blanco Heights	0.05	0.02	Río Blanco
Naranjito	Naranjito	0.50	0.41	Río Guadiana
Orocovis	Alturas de Orocovis	0.05	0.04	Río Orocovis
	Orocovis	0.50	0.14	Río Orocovis
Patillas	Patillas	1.00	0.36	Caribbean Sea
Peñuelas	Peñuelas	0.75	0.58	Río Guayanés
Ponce	Ponce Regional	18.00	14.02	Caribbean Sea
Río Grande	Río Grande Estates	0.50	0.46	Quebrada Suspiro
	Coco Beach	0.12	0.11	Río Espíritu Santo
	Palmer	0.25	0.00	Río Mameyes
Sabana Grande	Sabana Grande	1.00	0.95	Río Guanajibo
San Germán	San Germán	1.75	1.17	Quebrada Rodeo
San Juan	Puerto Nuevo Regional	72.00	51.11	Atlantic Ocean
San Lorenzo	San Lorenzo	1.23	0.90	Río Grande de Loíza
San Sebastián	San Sebastián (Compacta)	0.44	0.36	Río Culebrinas
	San Sebastián (Nueva)	1.00	0.46	Río Culebrinas
Santa Isabel	Santa Isabel Regional	2.00	1.92	Caribbean Sea
Toa Alta	Toa Alta	0.75	1.03	Río de la Plata
	Toa Alta Heights	1.00	0.65	Río Mucarabones
Trujillo Alto	Villas del Sol	0.10	0.00	Río Grande de Loíza
Utua	Utua	0.71	0.45	Río Grande de Arecibo
Vega Alta	Vega Alta	1.00	1.11	Río Cibuco
Vega Baja	Vega Baja	2.20	1.45	Caño Cabo Caribe
Vieques	Vieques	0.50	0.29	Atlantic Ocean
Yabucoa	Yabucoa	1.50	0.93	Canal de Santiago
Yauco	Yauco	1.68	1.42	Río Yauco

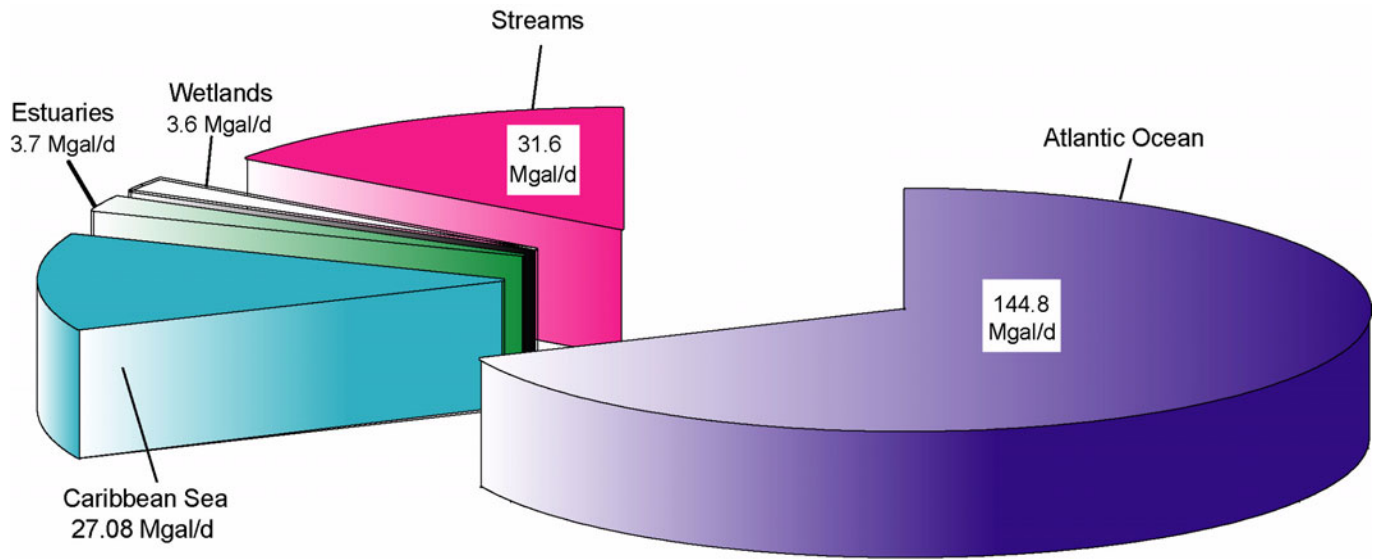


Figure 8. Estimated return flow of treated wastewater from public wastewater treatment facilities by receiving water body, 2001.

Table 10. Total water use estimates for offstream and instream categories in million gallons per day, 2000.

Water use category	Total withdrawals
Puerto Rico	2807.93
Offstream use	
Public-supply water use	
PRASA withdrawal	532.11
Non-PRASA withdrawal	7.90
Domestic self-supplied water use	2.09
Industrial self-supplied water use	9.54
Crop irrigation	63.76
Thermoelectric power	
Fresh water withdrawals	1.78
Total offstream fresh water withdrawal	617.18
Instream use	
Hydroelectric power	170.72
Saline withdrawals thermoelectric power	2190.75

Table 11. Total water withdrawals by water-use categories in million gallons per day, 2000.

Water use category	Fresh water withdrawal	Saline water withdrawal
Public supply	540.01	
Domestic	2.09	
Industrial	9.54	
Crop Irrigation	63.8	
Thermoelectric power	1.78	2190.75

Summary

Puerto Rico is divided into 78 municipios. Water-use data for 2000 were aggregated by municipio in Puerto Rico. The data were compiled for five major offstream categories: public-supply water withdrawals; domestic and industrial self-supplied water use; crop irrigation water use; and thermoelectric power fresh water use. Two water-use categories also were considered: power generation instream water use and public wastewater treatment.

During 2000, fresh water withdrawals from surface- and ground-water sources were estimated at 617 Mgal/d. Public-supply water withdrawals from surface- and ground-water sources constitute the major fresh water use category and were estimated at 540 Mgal/d. The population served by public-supply facilities operated by the Puerto Rico Aqueduct and Sewer Authority was estimated to be 96 percent of the total population for Puerto Rico in 2000 (about 3,656,000 persons). Non-PRASA public-supply water withdrawals were estimated at 7.9 Mgal/d to serve a population of about 116,000. The water withdrawn by domestic self-supplied users was estimated at 2 Mgal/d by a population of about 31,000. Ground-water withdrawal by industrial users (estimated only for municipios in which withdrawals were 0.50 Mgal/d or greater) was estimated at 9 Mgal/d. Withdrawal by self-supplied industries located within the Island's 250 "light industry" industrial parks was estimated at 0.54 Mgal/d.

Crop irrigation withdrawals from surface- and ground-water sources were estimated at 64 Mgal/d, of which 49 Mgal/d were in areas supplied by the public irrigation network operated by the PREPA. Ground-water withdrawals from the Island's two major aquifers were about 15 Mgal/d for the South Coastal Plain aquifer system and 6.8 Mgal/d for the North Coast Limestone aquifer system.

In 2000, Puerto Rico had four thermoelectric power plants that used large amounts of seawater for cooling. These instream saline withdrawals totaled 2,191 Mgal/d. Fresh water use at thermoelectric power plants consisted of 2.3 Mgal/d from the PRASA to the Puerto Nuevo and Palo Seco plants and 1.8 Mgal/d from local aquifers at the Aguirre and Costa Sur power plants on the south coast. There were nine active hydroelectric power plants located throughout Puerto Rico. These power plants had an instream water use of 171 Mgal/d of instream fresh water in 2002. Wastewater return flows from 71 publicly owned facilities were reported as 211 Mgal/d during 2001.

Cited References

- Gómez-Gómez, Fernando, 1987, Planning report for the Caribbean Islands Regional Aquifer-System Analysis project: U.S. Geological Survey Water-Resources Investigations Report 86-4074, 50 p., 3 pls.
- Hutson, S.S., Barber, N.L., Kenny, J.F., Linsey, D.S., Lumia, D.S., and Maupin, M.A., 2004, Estimated use of water in the United States in 2000: U.S. Geological Survey Circular 1268, 44 p.
- Kuniansky, E.L., Gómez-Gómez, Fernando, and Torres-González, Sigfredo, 2004, Effects of aquifer development and changes in irrigation practices on ground-water availability in the Santa Isabel area, Puerto Rico: U.S. Geological Survey Water-Resources Investigations Report 03-4303, 56 p.
- Puerto Rico Aqueduct and Sewer Authority, 1999-2000, Annual Water Production Report: (electronic files).
- Puerto Rico Department of Health, 2000, Non-PRASA System Inventory: 36 p.
- U.S. Department of Agriculture, 2003, 2002 Census of Agriculture, Puerto Rico municipio profiles: accessed August 2004 at www.nass.usda.gov/census/census02/puertorico/profiles/index.htm.
- U.S. Department of Commerce, 2000, U.S. Census Bureau, Census 2000 Data for Puerto Rico: accessed August 2002 at www.census.gov/census2000/states/pr.html.
- U.S. Department of Labor, Occupational Safety and Health Administration, 2005, SIC Major Group 28: Chemicals and allied products: accessed May 2005 at www.osha.gov/pls/imis/sic_manual.display?id=21&tab=group.
- U.S. Environmental Protection Agency, 1974, Safe Drinking Water Act: accessed August 2004 at www.epa.gov/region5/defs/html/sdwa.htm.

