

Water Use and Availability, Block Island, Rhode Island, 2000

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RHODE ISLAND GEOLOGICAL SURVEY
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Abstract

Metered Block Island Water Company account data and coefficient-based water-use estimates were used to estimate island-wide withdrawal, use and disposal of water for Block Island, RI during 2000. Total water use for the island is estimated at 81.33 million gallons per year, or 0.22 million gallons per day (MGD). Self-supply is the dominant type of supply accounting for 79% of total withdrawals. Domestic and commercial use account for 63% and 31% respectively of water use on the island. Hotels comprise the dominant commercial use accounting for 19% of all water use on the island.

Wastewater on Block Island is either processed at the New Shoreham Wastewater Treatment plant and subsequently discharged to Rhode Island Sound, or discharged as ground-water return flow through individual sewage disposal systems. The Block Island wastewater treatment facility reports discharging 38.02 millions gallons during 2000, comprised of an estimated 24.36 million gallons from domestic and commercial connections and an additional 13.66 million gallons of volume attributed to infiltration, harbor use, and septic-system pumping. An estimated 42.66 million gallons per year is returned to the ground through individual sewage treatment systems. Consumptive use is estimated at 10.85 million gallons.

Block Island Water Company withdrawals remained relatively constant from 1990 to 2000 despite an increasing customer base, because per household use rates declined from 266 gallons/household/day in 1990 to 165 gallons/household/day in 2000. Self-supply domestic withdrawals increased by 12 million gallons during this period reflecting an increase in the number of self-supplied residential units on the island.

Ground-water recharge on Block Island is estimated at 2.6 to 3.6 billion gallons per year. Current withdrawals represent only 2 to 3% of this total. Because much of the ground water withdrawn is returned to the flow system through septic systems, the net withdrawal is approximately 1% of the total recharge volume. This suggests that additional ground-water withdrawals are possible. The magnitude of possible withdrawals, however, is dependent on well placement and pumping rate.

Introduction

Although total water use in the United States has remained relatively constant over the past 10 years (Solley and others, 1998), the proportion of water withdrawn in traditionally rural areas is increasing as a result of the outmigration of urban populations. In Rhode Island, total public-supply withdrawals decreased from 116 million gallons per day in 1985 (Mgal/d) to 114 Mgal/d in 1995; ground-water withdrawals by rural self-supplied domestic users, however, have increased by 30% over the same period, from 5.6 Mgal/d to 7.3 Mgal/d (Johnston and Baer, 1987; Solley and others, 1998). Developers, farmers, and conservation groups in these rural areas are often at odds over what constitutes a “safe yield” and what the environmental impacts of a proposed withdrawal or development will be. Because the surface-water and ground-water systems form an integrated hydrologic unit, withdrawals from aquifers affect not only water-

table elevations, but stream flows and wetland habitat as well. In 1999, drought conditions in Rhode Island produced streamflows and ground-water levels below the 30-year record minima, prompting heightened concerns over effective resource management (U.S. Geological Survey, personal communication).

Water-use is a significant concern on Block Island, particularly following a water-supply crisis in June 1997. An algae bloom in the Town's primary water-supply pond, Sands Pond necessitated installation of 4,000 feet of 6-inch plastic pipe from Fresh Pond to the treatment plant at Sands Pond in order to meet the public-supply demands. The Town has since revitalized an existing wellfield in the Sands Pond area, and currently uses it as its withdrawal point for public-water supply.

Environmentally sound water-resource management strategies must be based on accurate information about water use and water availability. In order to address this need, the Rhode Island Water Resources Board is compiling water-use data for the State of Rhode Island.

Purpose and Scope

This report provides detailed information on water use for the Town of New Shoreham, Block Island, RI during 2000. Water-use statistics were compiled for public and self-supply users on the island through a combination of metered records and population-based estimates. A historical comparison is included between the 2000 data and the 1990 data compiled by Veeger and Johnston (1996).

Acknowledgements

The Block Island Water Company and the Town of New Shoreham Planning Department provided most of the data used in the preparation of this report. Special thanks to Janet Ziegler of the Block Island Water Company and Emily Wild of the US Geological Survey.

Description of Study Area

Setting

The Town of New Shoreham, commonly known as Block Island, is approximately 10 miles south of the Rhode Island mainland. The island is made up of glacial deposits, which contain gravel, sand, and interbedded fine-grained units, and comprise an exposed segment of a Wisconsinan glacial moraine (Stone and Sirkin, 1996). Fresh water in these unconsolidated sediments forms a lens-shaped body that "floats" on salt water because of its lower density. The lens is thinnest near the perimeter and thickest near the central parts of the island, where it is estimated to exceed 350 feet (Veeger & Johnston 1996). The ground-water flow system in this aquifer includes local shallow (33 feet) subsystems that are superimposed on a deeper regional flow system. The regional flow system is three dimensional, with ground-water flow in the central portions of the island flowing downward and toward the island perimeter, then upward, eventually discharging into salt water or as seeps along the beaches and sea cliffs. The island depends on ground water to supply its 1,010 year-round residents and up to 10-fold more summer visitors, with approximately 93% of residences depending on private wells or springs for their water supply.

The Rhode Island Department of Environmental Management has given a GAA classification to all of the island, with the exception of a small area that encompasses a closed

landfill. The GAA classification indicates that ground water is suitable for public drinking-water use without treatment. In 1984, the Town successfully petitioned the U.S. Environmental Protection Agency for sole-source aquifer status. This designation recognizes an aquifer as the “sole or principal” source of drinking water for an area (U.S. Environmental Protection Agency, 1984). This designation is made when no significant surface water source is available to supply drinking water.

Table 1. Selected demographic characteristics for New Shoreham, Rhode Island (U.S. Census Bureau, 1992, 2001).

	1990	2000	% Change
Population (as of April 1 of census year)	836	1,010	20.8
Total Housing Units	1,264	1,606	27.1
Occupied Housing Units (as of April 1 of census year)	361	472	30.7
Seasonal Housing Units	810	1,109	36.9

Population

According to Census 2000, the island has 1,010 year-round residents and a total of 1,606 housing units. This represents a 20.8% increase in the year-round population and a 27.1% increase in the number of housing units over the last decade (table 1). The island experiences a dramatic increase in population during the summer months. The island has almost 1000 hotel, bed & breakfast, rooming house rooms (Town of New Shoreham written communication, 2001). This capacity, coupled with occupancy of 1,109 seasonal housing units, swells the summer population of the island to an average of 7,000 to 8,000 residents.

Data Compilation and Analysis

Data Compilation

Data for the Block Island water-use compilation were acquired from the following sources:

- Block Island Water Company
- Town of New Shoreham Planning Department
- Town of New Shoreham Finance Department
- Rhode Island Economic Development Council
- U.S. Geological Survey
- U.S. Bureau of Census
- RI Department of Environmental Management Division of Agriculture 1999 farm survey

These sources were used to identify withdrawals for water supply, withdrawal and use by category (for example, domestic, commercial, or livestock) and return by category (for example, public sewer system or individual sewage disposal system).

Data Analysis

A variety of methods including public-supply meter readings, private well meter readings, population estimates, and water-use coefficients were used to calculate the 2000 water-use statistics for Block Island. The methods used are briefly outlined in the following sections. A detailed explanation can be found in the *Estimation of Withdrawal and Use* chapter.

Public Supply Withdrawals and Use

Withdrawals from the Block Island Water Company (BIWC) wellfield at Sands Pond are reported on a monthly basis (table 2). Withdrawals for March 2000 were estimated by the water company due to inaccurate meter readings. BIWC maintains quarterly metered water-use data for 227 accounts. These data were used to establish the volume of water used by each customer. Accounts were classified as commercial (82), public use (8) or domestic (137 of which were 116 active), and water use for 2000 was totaled for these use categories on the basis of the quarterly meter readings. Metered water use for each category was rounded to the nearest 10,000 gallons after summation.

Self-Supply Withdrawal and Use

Self-supply, water withdrawn directly by the user, is a significant component of water use on Block Island. Estimation of withdrawals and use by self-supplied users on Block Island is complicated by the seasonal nature of the population. Although the year-round population is approximately 1,000 residents, the summer population swells to over 7,000 residents, including approximately 2,000 nightly hotel guests. On peak weekends, the island population may exceed 10,000 residents and overnight guests. The use of standard population-based water-use estimation techniques (Horn, 2000) is therefore, not appropriate. Withdrawals and use were instead estimated for self-supplied domestic and commercial users on a quarterly basis to reflect the changing seasonal population. A combination of metered withdrawals (metered for wastewater purposes) and local coefficients were used to generate the self-supply water-use estimates included in this report.

Self-supply domestic withdrawal and use. Self-supply domestic withdrawal and use were estimated using metered sewer data and per household water-use coefficients. The water-use coefficients were derived from metered BIWC domestic users and housing data from the 2000 U.S. Census. These data were used to calculate self-supplied domestic withdrawals and use for the 3rd quarter of 2000, assuming that all self-supplied households were occupied during the quarter. Withdrawals for the remaining quarters were calculated as a fraction of the 3rd quarter total using ratios derived from quarter-to-quarter comparisons for BIWC-supplied domestic users.

Self-supply commercial withdrawal and use. Self-supply commercial withdrawal and use were estimated using metered sewer account data and hotel water-use coefficients. Because water-use by lodging facilities constitutes a significant percentage of the total commercial water use on Block Island, a separate commercial water-use category was established to permit independent tracking of this category. It should be noted that we did not attempt to estimate non-hotel commercial self-supply withdrawals over and above those users connected to the wastewater collection system. All large commercial users are connected to the wastewater collection system; therefore the error introduced by this approximation is expected to be small.

Table 2. Monthly production data for the Block Island Water Company wellfield, January – December 2000. Data for March 2000 were estimated by the Block Island Water Company due to meter problems.

Month	Monthly Withdrawal (in million gallons)	Average Daily Withdrawal (in gallons per day)	Withdrawals by Quarter (in million gallons)
January	0.78	25,052	
February	0.60	21,336	
March*	0.73	23,529	2.10
April	1.10	36,683	
May	1.29	41,619	
June	1.89	63,133	4.28
July	3.09	99,811	
August	2.95	95,093	
September	1.92	63,892	7.96
October	1.23	39,620	
November	0.93	30,865	
December	0.68	21,987	2.84
Total	17.18	47,076	17.18
* indicates estimated value			

Self-supply livestock withdrawal and use. Block Island has a small population of livestock estimated to include approximately 50 horses, 50 beef cows and 10 dairy cows. Water use for this category was estimated using livestock water-use coefficients.

Consumptive Use

A portion of water withdrawn is consumed during use and removed from the system. This loss can occur through a variety of avenues including evaporation, consumption by humans or animals, or incorporation into products. Consumptive use on Block Island was estimated as a fraction of total withdrawals using coefficients for each category of use (Horn, 2000).

Public Wastewater Return Flow

The New Shoreham Sewer District wastewater collection and treatment system has 273 users (116 commercial, 9 public use and 148 domestic) and waste volume is estimated on the basis of metered water withdrawals and metered treatment plant wastewater discharges to Rhode Island Sound. Because this method does not consider losses to consumptive use, public wastewater return flows reported herein were estimated using metered withdrawals adjusted for consumptive use.

Ground-Water Return Flow

Private wastewater disposal through septic systems is considered ground-water return flow because leachate from the system is returned to the ground-water system. The volume of ground-water return flow was calculated as the residual volume after sewage system discharge and consumptive use were subtracted from total withdrawals.

Estimation of Water Withdrawal

Public Supply

Public supply is available from the BIWC in a small portion of the island covered by the New Shoreham Water District (figure 1). The BIWC withdraws ground water from a wellfield next to the Sands Pond treatment plant. Withdrawals are metered and reported on a monthly basis. Withdrawals for 2000 total 17.18 million gallons (table 2). Withdrawals during the 3rd quarter (July through September) account for 46% of total annual withdrawals.

Self-Supply

Most residences (1,496 of the 1,606 units) and some businesses use private wells for their water supply. Self-supply ground-water withdrawals were estimated using two methods: 1) metered self-supply withdrawals and 2) population-based water-use coefficients.

Metered Self-Supply Withdrawals

For billing purposes, the New Shoreham Sewer District meters self-supply withdrawals by users who are connected to the municipal wastewater collection system. These metered withdrawals were used to estimate self-supply withdrawals for domestic, commercial (hotel), commercial (non-hotel), and public users connected to the sewer system.

Population-Based Local Water-Use Coefficients

Local water-use coefficients were developed for self-supply domestic and hotel water users who dispose of their wastewater in individual sewage disposal systems.

Domestic water-use coefficient. The domestic water-use coefficient was calculated on the basis of metered water use by BIWC residential customers as follows:

$$3^{\text{rd}} \text{ quarter domestic metered use} \div \# \text{ of residential units served} = \text{per household water use}$$

The coefficient was calculated on a per household basis because the number of residents varies considerably over the course of the year making per capita estimates difficult. Per capita and per household water-use coefficients for all four quarters are shown in table 3 and are based on 2.3 people per household during the off-season (U.S. Census Bureau, 2001) and 3 people per household average over the summer. The 3rd quarter household and per capita water-use

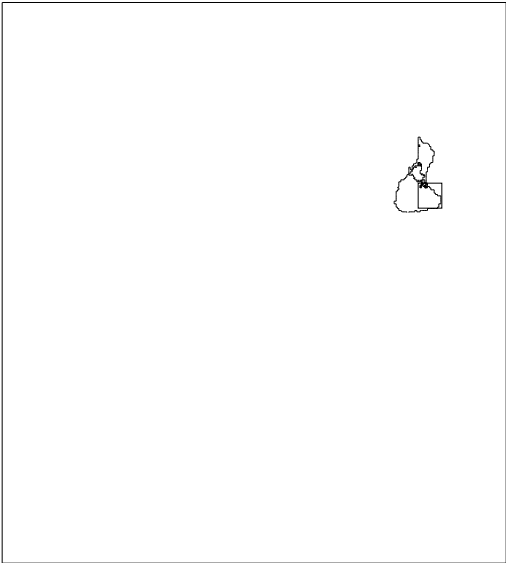


Figure 1. Area served by public supply from the Block Island Water Company, Block Island, RI (Water District from BIGIS, other coverages from RIGIS).

coefficients are considered the most reliable, because water use during this period reflects a more uniform level of occupancy than during the other three quarters.

Table 3. Per capita and per household domestic water-use coefficients for Block Island, RI during 2000.

PUBLIC SUPPLY (2000)	Q1	Q2	Q3	Q4
Public Supply Deliveries (gallons)	400,000	770,000	1,670,000	620,000
# of active BIWC accounts	71	102	110	106
Estimated # of people per household	2.3	2.3	3.0	2.3
Estimated # of people served/day	163	235	330	244
# of days per quarter	90	91	92	92
per capita use per day (gallons)	27	36	55	28
per household use per day (gallons)	63	83	165	63

Self-supply (non-metered) water withdrawals for the 3rd quarter were estimated as follows:

$$\# \text{ of self-supply (non-metered) residences} \times 165 \text{ gallons/day} \times 92 \text{ days/quarter} = \\ 3^{\text{rd}} \text{ quarter self-supply (non-metered) withdrawals}$$

Withdrawals for the other three quarters were estimated as a fraction of 3rd quarter use using ratios derived from metered BIWC residential customers:

For the 1st quarter for example:

$$3^{\text{rd}} \text{ quarter self-supply (non-metered)} \times (1^{\text{st}} \text{ quarter BIWC residential use} / 3^{\text{rd}} \text{ quarter BIWC} \\ \text{residential use}) = 1^{\text{st}} \text{ quarter self-supply (non-metered) use}$$

Hotel water-use coefficient. Because the number of hotel employees varies significantly over the course of the year and the resulting potential for estimation error is large, employee based-coefficients were not used in this study. Instead, local metered water-use data were used to develop a per guest, per day, hotel water-use coefficient. Data were collected from the New Shoreham Chamber of Commerce on the number of guest rooms on the island (appendix I). Occupancy levels were obtained from a survey of hotels (table 4). Double occupancy was assumed for all rooms. All large lodging facilities are either connected to the public water system or the public wastewater system, permitting estimation based on metered deliveries. The remaining lodging establishments had an average of fewer than 10 rooms; a hotel water-use coefficient of 51 gallons per guest per day was therefore used to estimate water use for these small self-supply hotels (table 5).

Monthly self-supply (non-metered) hotel withdrawals were estimated as follows:

$$\# \text{ of guest rooms} \times 2 \text{ guests/room} \times \text{monthly occupancy rate} \times 51 \text{ gallons/guest/day} \times \\ \# \text{ of days/month} = \text{monthly self-supplied (non-metered) hotel use.}$$

Table 4. Reported hotel occupancy on Block Island, RI [Note: occupancy for November through April is assumed to be negligible for the purposes of water use estimation].

MONTH	Hotel Occupancy
May	46%
June	69%
July	92%
August	97%
September	77%
October	35%

Table 5. Hotel water-use coefficient as a function of hotel size, Block Island, RI during 2000.

Average Water Use/Guest/day in gallons (3rd quarter)	
#of rooms	
<10	51
10 -25	62
26-50	61
>51	65
Average	63

Livestock water-use coefficient. Published water-use coefficients were used to estimate withdrawals for livestock use: horses and cows (non-dairy) = 12 gallons/day, dairy cows = 35 gallons/day. The water-use coefficients were multiplied by the animal population to estimate total livestock water use.

Withdrawal Estimates

Total island-wide withdrawals on Block Island for 2000 are estimated at 81.33 million gallons (table 6). Self-supply withdrawals are the dominant source of withdrawals accounting for 79% of total estimated withdrawals during 2000.

Table 6. Summary of estimated public-supply and self-supply withdrawals on Block Island, RI during 2000, in million gallons.

Summary of Estimated Withdrawals (in million gallons)	Q1	Q2	Q3	Q4	2000 Total
Public-Supply (BIWC) withdrawals	2.10	4.28	7.96	2.84	17.18
Estimated self-supply withdrawals	6.44	15.02	32.65	10.04	64.15
Total Withdrawals	8.54	19.30	40.61	12.88	81.33

Estimation of Water Use by Category

Total water use on Block Island during 2000 was estimated by summing water use in each of the following categories: domestic, commercial, public use, livestock, and unaccounted-for use. No significant water use was found for industrial, power, and irrigation use. Water-use characteristics for Block Island are summarized in figures 2 and 3 and table 7.

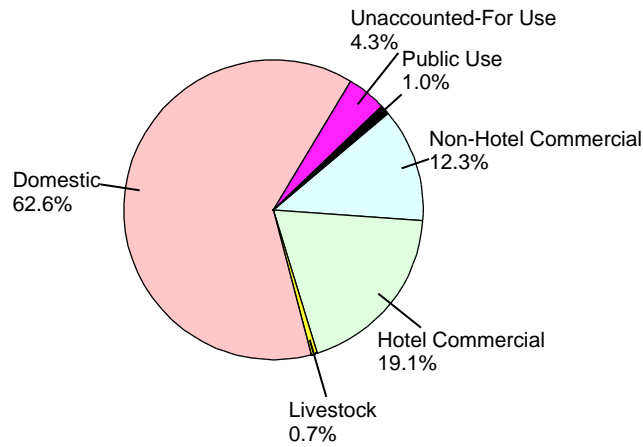


Figure 2. Water use by category on Block Island, RI during 2000.

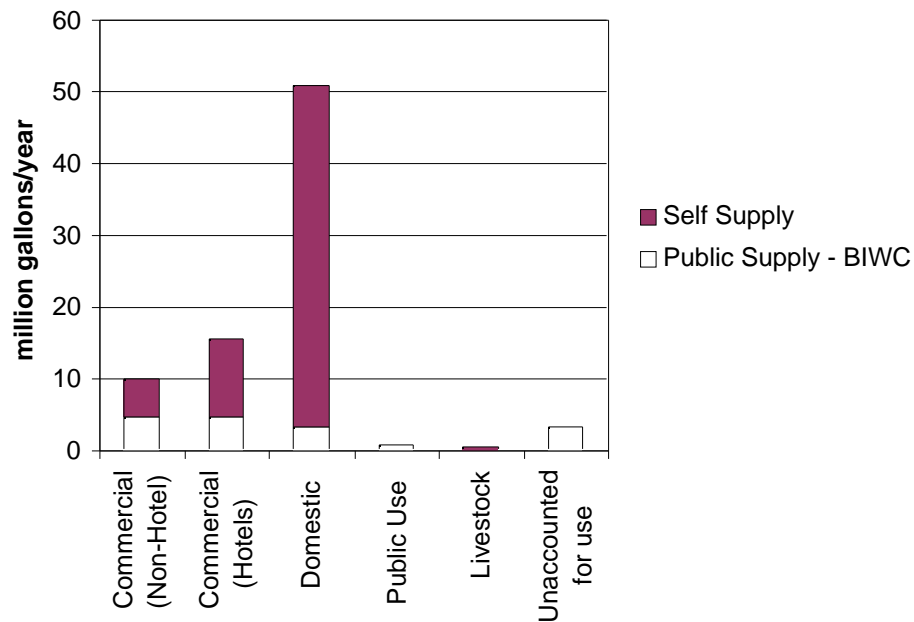


Figure 3. Water supply by category on Block Island, RI during 2000.

Table 7. Summary of estimated water use by category on Block Island, RI during 2000, in million gallons.

Summary of Water Use by Category (in millions gallons)	Q1	Q2	Q3	Q4	2000 Total
Domestic	5.97	11.40	24.48	9.09	50.94
Commercial	1.62	6.66	14.53	2.72	25.53
Public Use	0.06	0.22	0.45	0.11	0.84
Livestock	0.14	0.14	0.14	0.14	0.56
Unaccounted-For Use	0.75	0.88	1.01	0.82	3.46
Total	8.54	19.30	40.61	12.88	81.33

Domestic

Domestic water use is estimated as the sum of metered BIWC domestic deliveries and estimated domestic self-supply withdrawals (table 8). Domestic use during 2000 is 50.94 million gallons or 63% of total withdrawals on the island. Withdrawals from private wells account for 93% of domestic water use (47.48 million gallons).

Table 8. Estimate of domestic water use by supply source, Block Island, RI during 2000, in million gallons.

Domestic Use (in million gallons)	Q1	Q2	Q3	Q4	2000 Total
BIWC Public Supply	0.40	0.77	1.67	0.62	3.46
Self-supply (ground water)	5.57	10.63	22.81	8.47	47.48
Total Domestic Use	5.97	11.40	24.48	9.09	50.94

Commercial

In this study, commercial water use is subdivided into hotel (broadly defined as any commercial lodging establishment) use and non-hotel (restaurants, retail establishments, businesses) use.

Hotel Commercial Water Use

Hotel water use is estimated as the sum of metered BIWC hotel deliveries and estimated hotel self-supply withdrawals (table 9). Hotel use during 2000 is 15.54 million gallons or 19% of total withdrawals on the island. Withdrawals from private wells account for 69% of hotel water use (10.73 million gallons/year).

Table 9. Estimate of hotel commercial water use by supply source, Block Island, RI during 2000, in million gallons.

Hotel Commercial Use (in million gallons)	Q1	Q2	Q3	Q4	Annual
BIWC Public Supply	0.43	1.19	2.52	0.67	4.81
Self-supply (ground water)	0.23	2.84	6.88	0.78	10.73
Total Hotel Commercial Use	0.66	4.03	9.40	1.45	15.54

Non-Hotel Commercial Water Use

Non-hotel commercial water use is estimated as the sum of metered BIWC non-hotel commercial deliveries and non-hotel commercial metered self-supply withdrawals (table 10). Non-hotel commercial use during 2000 is 9.99 million gallons or 12% of total withdrawals on the island. Withdrawals from private wells account for 53% of non-hotel commercial water use (5.26 million gallons/year).

Table 10. Estimate of non-hotel commercial water use by supply source, Block Island, RI during 2000, in million gallons.

Non-Hotel Commercial Use (in million gallons)	Q1	Q2	Q3	Q4	Annual
BIWC Public Supply	0.46	1.26	2.38	0.63	4.73
Self-supply (ground water)	0.50	1.37	2.75	0.64	5.26
Total non-Hotel Commercial Use	0.96	2.63	5.13	1.27	9.99

Other Water-Use Categories

Domestic and commercial use account for approximately 94% of total water use on Block Island during 2000. The remaining 6% or 4.86 million gallons is comprised of public use (municipal facilities), livestock use, and unaccounted-for use (table 11).

Table 11. Estimate of public, livestock, and unaccounted-for water use by supply source, Block Island, RI during 2000, in million gallons.

Other Water Use (in million gallons)	Q1	Q2	Q3	Q4	Annual
Public Use - BIWC Public Supply	0.06	0.18	0.38	0.10	0.72
Public Use - Self-supplied	0.00	0.04	0.07	0.01	0.12
Livestock – 100% Self-supplied	0.14	0.14	0.14	0.14	0.56
Unaccounted-for Use - BIWC	0.75	0.88	1.01	0.82	3.46

Public Use

Public water use is estimated on the basis of metered BIWC deliveries and metered self-supply withdrawals (table 11). Public use during 2000 is 0.84 million gallons or 1% of total withdrawals on the island. Withdrawals from private wells account for 14% of public water use (0.12 million gallons/year).

Agriculture - Livestock

Livestock water use is estimated on the basis of livestock water-use coefficients as outlined above. An average annual livestock population of 50 horses, 50 beef cattle and 10 dairy cows was used in the estimate. Livestock use during 2000 is estimated at 0.56 million gallons or less than 1% of total withdrawals on the island (table 11). Withdrawals from private wells account for 100% of livestock water use.

Unaccounted-For Use

Unaccounted-for use is defined as the difference between metered public water-supply withdrawals and metered public water-supply deliveries. This category reflects the unmetered use of water for: the water treatment plant, fire hydrants, and losses in the water distribution system. During 2000 the BIWC reported withdrawals totaling 17.18 million gallons and metered deliveries of 13.72 million gallons. Unaccounted-for use during 2000 is therefore 3.46 million gallons or 20% of BIWC withdrawals and 4% of island-wide withdrawals (table 11).

Estimation of Wastewater Collection and Return Flow

After use, water is discharged to either the public wastewater collection system or individual sewage disposal systems. A portion of the water however, is lost to consumptive use prior to discharge.

Consumptive Use

Consumptive use on Block Island was estimated using the following consumptive use coefficients: domestic, 15%; commercial and public use, 10%; and livestock 100% (Horn, 2000). These coefficients were applied to the total water use in each category to estimate the consumptive use shown in table 12. These volumes do not contribute to ground-water return flow or public sewer-system flow.

Table 12. Estimate of consumptive use by water-use category, Block Island, RI during 2000, in million gallons.

Consumptive Use, (in million gallons)	Q1	Q2	Q3	Q4	Annual
Domestic	0.90	1.71	3.67	1.36	7.64
Hotel - Commercial	0.07	0.40	0.94	0.15	1.56
Non-Hotel Commercial	0.10	0.26	0.51	0.13	1.00
Public Use	0.01	0.02	0.05	0.01	0.09
Livestock	0.14	0.14	0.14	0.14	0.56
Total Consumptive Use	1.22	2.53	5.31	1.79	10.85

Public Wastewater Collection

The New Shoreham Sewer District defines the portion of Block Island served by the wastewater collection system and wastewater treatment facility (figure 4). Metered deliveries from the BIWC or metered self-supply withdrawals were used to estimate the volume of water discharged to the wastewater system by a given user. Total metered returns to the sewer system for 2000 reported by the New Shoreham Sewer District are 27.34 millions gallons (sum of metered account volumes). This volume, however, does not take into account losses to consumptive use. For the purposes of this analysis, actual discharges to the sewer system were estimated as metered withdrawals minus consumptive use, as outlined above. The resulting estimated discharge to the wastewater collection system from metered users during 2000 is 24.36 million gallons (table 13).

Public Wastewater Discharge

Treated effluent from the New Shoreham wastewater treatment facility is discharged by pipeline to Rhode Island Sound in accordance with a Rhode Island Department of Environmental Management (RIDEM) discharge permit. Sewer discharge flows are metered and reported monthly. Total wastewater discharge reported to RIDEM during 2000 is 38.02 million gallons. This discharge is 10.68 million gallons greater than the sum of metered account flows and 13.66 million gallons greater than the estimated return flows adjusted for consumptive use (table 13). This discrepancy is attributed to unmetered contributions from septic system pump-outs, harbor use, basement sump pumps and infiltration (inflows from manhole covers, storm drains and ground water) (J. Ziegler BIWC, personal communication, 2001).

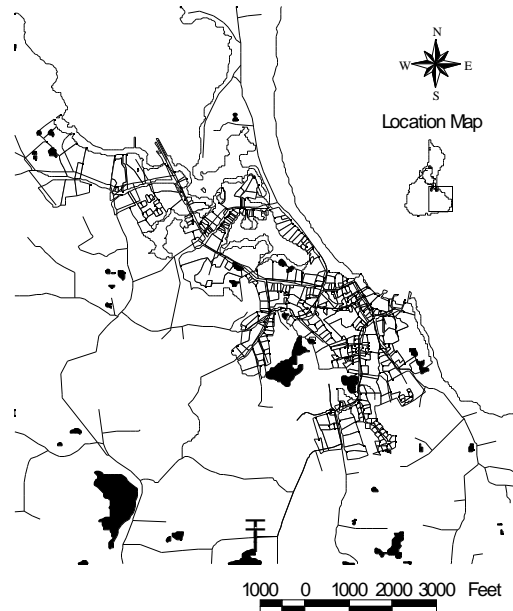


Figure 4. Area served by the New Shoreham Sewer District, Block Island, RI (Sewer District from BIGIS, other coverages from RIGIS).

Ground-Water Return Flow - Individual Sewage Disposal Systems

Most residences and some businesses on Block Island dispose of wastewater through individual sewage disposal systems. The Town of New Shoreham has cataloged 1088 septic systems on the island (Block Island Geographic Information System, written communication, 2000). Returns from these systems to the ground-water system were estimated as:

total withdrawals – (BIWC unaccounted-for use + estimated public wastewater return flow + consumptive use) = ground-water return flow.

Table 13. Estimated returns to the public wastewater collection system from metered users on Block Island, RI during 2000. Flows are estimated from metered withdrawals minus consumptive use.

Wastewater Collection System, (in million gallons)	Q1	Q2	Q3	Q4	Annual
Domestic	0.52	0.97	1.84	0.73	4.06
Hotel/Motel	0.45	2.78	6.63	0.86	10.72
Commercial (non-hotel)	0.86	2.37	4.62	1.14	8.99
Public Use	0.05	0.16	0.29	0.09	0.59
Livestock	0.00	0.00	0.00	0.00	0.00
Total Sewer Returns	1.88	6.28	13.38	2.82	24.36

The total estimated ground-water return flow from septic systems on Block Island during 2000 is 42.66 million gallons (table 14). Domestic-use returns account for 92% or 39.24 million gallons of the annual ground-water return flow on the island.

Table 14. Estimated ground-water return flows on Block Island, RI during 2000.

Ground-Water Return Flow, (in million gallons)	Q1	Q2	Q3	Q4	Annual
Total withdrawals	8.54	19.30	40.61	12.88	81.33
BIWC Unaccounted for Use	0.75	0.88	1.01	0.82	3.46
Billed flows to WWT facility (from water meter readings)	2.13	7.04	14.98	3.19	27.34
Estimated returns to WWT (85% of metered residential use & 90% of other use)	1.88	6.28	13.38	2.82	24.36
Consumptive use est. of 15 % of residential use & 10% of other use	1.22	2.53	5.31	1.79	10.85
Total Return flow	4.69	9.61	20.91	7.45	42.66

Estimation of Water Availability

On Block Island, recharging precipitation naturally forms a lens of freshwater that floats on brackish or saltwater present at depth in the glacial sediments of the island. The thickness of the freshwater lens represents a balance between recharge (from precipitation) and discharge of ground water along the coastline. The volume of freshwater potentially available for withdrawal on Block Island is therefore a function not only of the volume of precipitation that recharges the aquifer each year, but also the volume of discharging ground water required to prevent significant encroachment of surrounding saltwater on the freshwater lens.

Two methods are used herein to estimate the recharge volume: 1) a water-budget method, and 2) a water-table fluctuation method. Both methods calculate the average annual volume of freshwater that recharges the island aquifer, and are not intended as a quantitative measure of the production capacity of the island aquifer. Withdrawals at this rate would compromise the sustainability of the freshwater lens on the island and would produce water-table declines that exceed the recovery capacity of the system.

The maximum potential volume available for withdrawal is significantly less than the recharge volume and is a function of the number of production wells, pumping rate, well spacing and depth, type of wastewater disposal (septic system or sewer) and potential impact on the saltwater/freshwater interface.

Water-Budget Method

Ground-water recharge can be estimated as the fraction of precipitation that percolates through the ground to the water table after losses to surface runoff and evapotranspiration (the combined process of evaporation and plant transpiration):

$$\text{recharge} = \text{precipitation} - (\text{surface runoff} + \text{evapotranspiration})$$

Ground-water recharge on Block Island using this method is estimated at 18.6 inches/year, assuming a median annual precipitation of 38.9 inches, surface runoff of 0.8 inches and evapotranspiration of 19.5 inches (Veeger and Johnston, 1996). Applied over the 11 square mile area of the island, this is the equivalent of 3,600 million gallons per year. Potential sources of error in this method include uncertainties in the magnitude of surface runoff and evapotranspiration. An error of approximately +/- 25% may exist in the estimate of evapotranspiration. The potential error in the estimation of surface runoff is difficult to quantify but because surface runoff is small relative to the other components of the water budget this potential source of error is not considered to be significant. The resulting range of ground-water recharge is therefore 18.6 inches per year +/- 5 inches, or 3,600 million gallons per year +/- ~1,000 million gallons per year.

Water-Table Fluctuation Method

Water availability was also evaluated by estimating the annual flux of ground water through the aquifer system on Block Island using water-table recession curves during periods of little to no recharge and water-table recovery during periods of recharge (table 15). The recoverable fluctuation of the water table provides an estimate of the volume of ground water that discharges from the island and is subsequently replaced by infiltrating precipitation. Water-table fluctuations were estimated using data from wells and ponds on the island (Burns, 1993). The water-table fluctuation is multiplied by the area of the aquifer to obtain the volume of aquifer drained. This volume is then multiplied by the specific yield of the aquifer to obtain the volume of water drained and subsequently recharged upon recovery of the water table:

$\text{recharge} = \text{maximum annual water-table fluctuation} \times \text{area} \times \text{specific yield}$

Specific yield, the fraction of water drained from a given volume of sediment, is a characteristic of the aquifer material. Because the glacial deposits that comprise the island are not uniform, two distinct zones were considered: the sandy-diamict zone and the sand and gravel zone as

Table 15. Estimate of long-term average annual ground-water recharge on Block Island, RI using water-table fluctuations [Note: reported areas do not include the recharge buffer strip shown on figure 5].

Aquifer Unit	Area (square feet)	Specific Yield	# Wells	Maximum Water-Table Decline (feet)	Maximum Annual Recharge (in million gallons)
Sandy Diamict	98,900,000	0.15	20	6.3	700
Sand & Gravel	114,700,000	0.25	18	9.0	1,900
Total	213,600,000				2,600

identified by Stone and Sirkin (1996). Specific yields of 15% and 25% respectively, were used for these units. Areas for each unit were calculated from figure 5.

Ground-water recharge on Block Island using the water-table fluctuation method is estimated at 2,600 million gallons per year. This method is a more conservative method than the water-budget method, but nevertheless should not be interpreted as an estimate of the production capacity of the island. This estimate is consistent with the low end of the water-budget method

recharge range. It cannot be emphasized enough however, that this is not the volume of water available for withdrawal. Rather this represents the volume of water that sustains the freshwater lens on the island.

Withdrawal vs. Availability

Total current withdrawals on Block Island (81.33 million gallons) represent only 2 to 3% of the total recharge volume, and net withdrawals (withdrawals minus ground-water return flow = 38.67 million gallons) represent approximately 1% of total recharge. Withdrawals at this level have produced few problems of saltwater intrusion. Intrusion has been reported in selected wells in the low-lying Old Harbor area and in 1982 the BIWC production well (#5) experienced an increase in chloride concentrations from a background level of approximately 30 mg/L to almost 200 mg/L in late summer as a result of drawdown-induced saltwater encroachment (Veeger and Johnston, 1996). This well is completed 109 feet below sea level and clearly demonstrates the susceptibility of deep wells to saltwater contamination. Additional ground-water

withdrawals are possible, however, consideration must be given to well depth, spacing, and proximity to the coast, and impact of ground-water return flow on water quality.

Temporal Trends in Water Use 1990-2000

A 1990 water-use assessment for Block Island considered domestic, commercial and municipal water use by BIWC customers and domestic self-supply users (Veeger and Johnston, 1996). Because commercial self-supply use was not estimated in the 1990 evaluation, the 2000 figures used in this section of the report have been adjusted to permit comparison of comparable water-use statistics.

Total water use, as defined above, increased from an estimated 53 million gallons, or 0.145 MGD in 1990, to 61 million gallons, or 0.167 MGD in 2000 (table 16). Although BIWC deliveries did not increase during the 1990 to 2000 period, self-supply withdrawals account for a 8 million gallon/year water-use increase (figure 6). Public-supply commercial use remained relatively constant over the period of record. Because commercial self-supply withdrawals were not estimated in the 1990 study, it is not possible to evaluate temporal trends in this category.

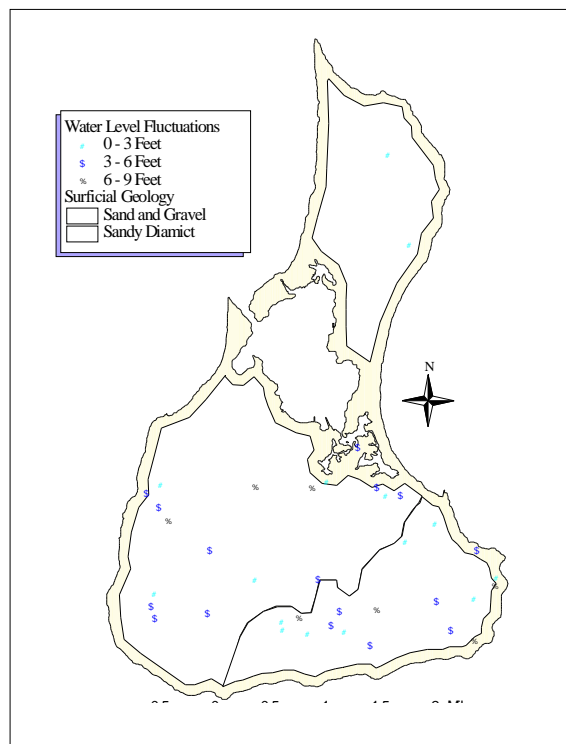


Figure 5. Distribution of aquifer materials and maximum water-table fluctuations in wells on Block Island, RI.

Use rates based on metered BIWC deliveries show a significant decline from 266 gallons/household/day in 1990 to 165 gallons/household/day in 2000. This decline is attributed to water conservation measures tied to fee re-structuring by the BIWC during the late 1990s (table 16). Per capita use rates are difficult to estimate for Block Island because of uncertainty in the population served. The 55 gallon/capita/day use for 2000 reported in table 16 was estimated from 3rd quarter water-use data and reflects an average occupancy rate of 3 people per household per day during the quarter.

Table 16. Temporal trends in water use on Block Island, RI, 1990 – 2000.

	1990	2000
Household Use (gal/day)	266	165
Per Capita Use (gal/day)	68	55
BIWC Rates	\$40 per 3000 gal \$4.70/1000 gal over 3000	\$25 per 1000 gal for all use \$55 per 1000 gal penalty over cap
BIWC Annual Withdrawals (gal/year)	17,400,000	17,180,000
Total Water Use* (gal/year)	53,000,000	61,000,000*

*Total water use is defined as the sum of BIWC deliveries and self-supplied domestic withdrawals for purposes of the 1990-2000 comparison. See tables 6 and 7 for comprehensive 2000 data.

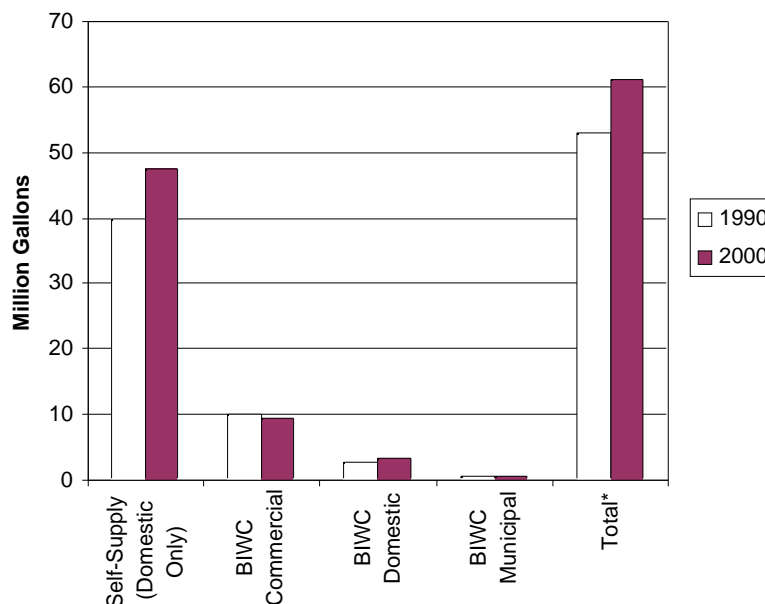


Figure 6. Temporal trends in water use on Block Island, RI, 1990 - 2000. [*Total water use is defined as the sum of BIWC deliveries and self-supplied domestic withdrawals for purposes of the 1990-2000 comparison].

Summary and Conclusions

Metered BIWC account data and coefficient-based water-use estimates were used to estimate island-wide withdrawal, use and disposal of water for Block Island during 2000 (figure 7). Total water use for the island is estimated at 81.33 million gallons per year. Self-supply is the dominant type of supply accounting for 79% of total withdrawals. Water use was also estimated for the following use categories: domestic, commercial (hotel and non-hotel), public, livestock and unaccounted-for use. Domestic and commercial use account for 63% and 31% respectively of water use on the island. Hotels comprise the dominant commercial use accounting for 19% of all water use on the island.

Wastewater on Block Island is either processed at the New Shoreham Wastewater Treatment plant and subsequently discharged to Rhode Island Sound, or discharged as ground-water return flow through individual sewage disposal systems. The wastewater treatment facility reports discharging 38.02 millions gallons during 2000 comprised of an estimated 24.36 million gallons from domestic and commercial connections and an additional 13.66 million gallons of volume attributed to infiltration, harbor use, and septic-system pumping. An estimated 42.66 million gallons per year is returned to the ground through individual sewage treatment systems. Consumptive use, water removed from the system during use, is estimated at 10.85 million gallons.

A comparison of BIWC withdrawals and self-supply domestic withdrawals during 1990 and 2000 show that although BIWC withdrawals have remained relatively constant, self-supply domestic withdrawals increased by approximately 8 million gallons. BIWC withdrawals remained constant despite a larger customer base in 2000 because per household use rates declined from 266 gallons/household/day in 1990 to 165 gallons/household/day in 2000. The increase in self-supply domestic withdrawals reflects an increase in the number of self-supplied residential units on the island.

Ground-water recharge on Block Island is estimated at 2.6 to 3.6 billion gallons per year. Current withdrawals represent only 2 to 3% of this total. Because much of the groundwater withdrawn is returned to the flow system through septic systems, the net withdrawal is approximately 1% of the total recharge volume. This suggests that additional withdrawals are possible, however, the magnitude of possible withdrawals is dependent on well placement and pumping rate.

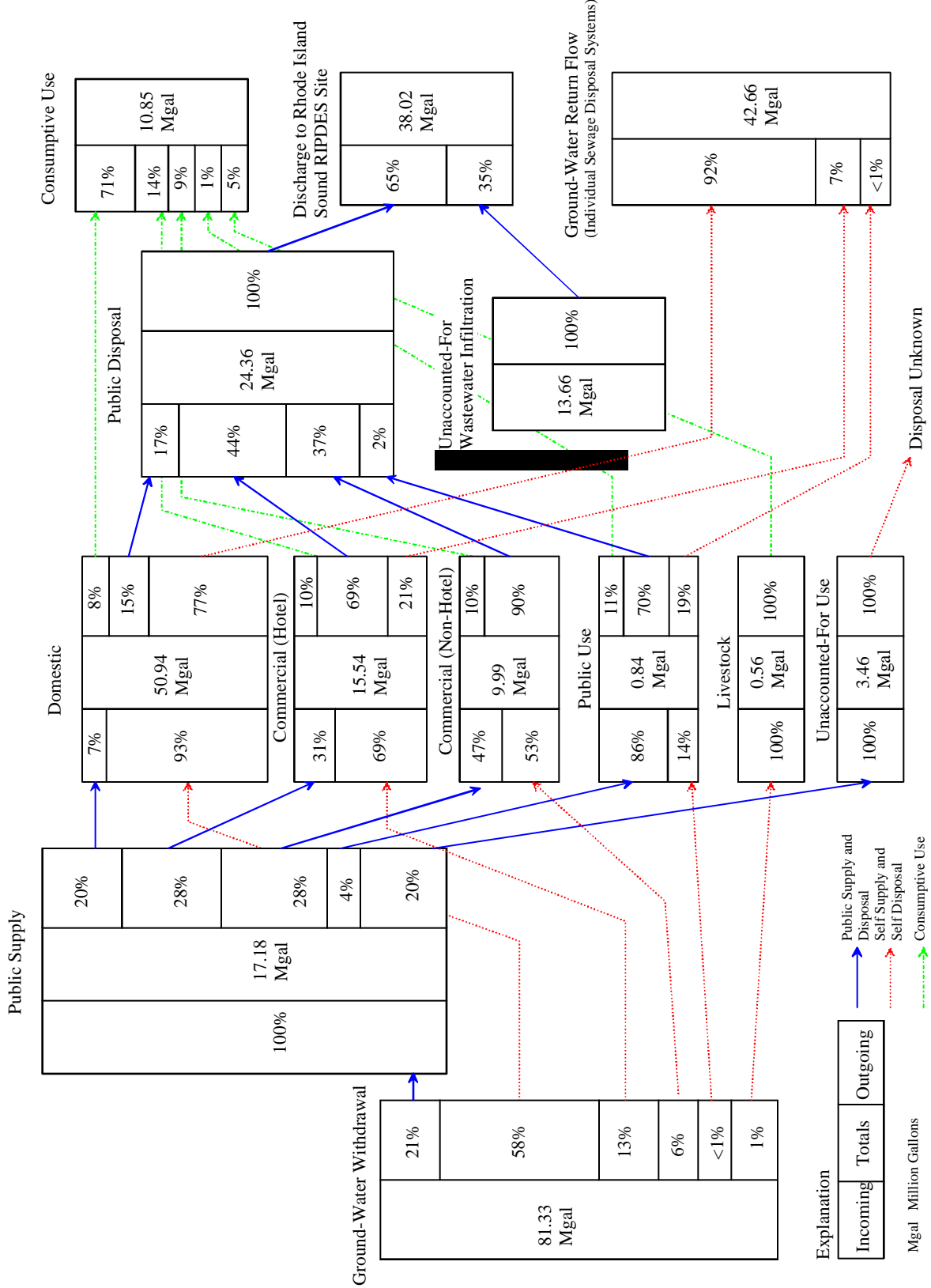


Figure 7. Water-use summary for Block Island, RI, during 2000.

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Appendix I.

Public supply and public wastewater status of commercial lodging establishments on Block Island, RI (Data from New Shoreham Chamber of Commerce, Block Island Water Company).

Hotel	Public Supply	Public Wastewater	Number of Rooms
Captain Willis House	N	N	10
Hygia House	N	N	11
Old Town Inn	N	N	10
Rose Farm Inn-Farm House & Capt. Rose House	N	N	19
Adrianna	N	Y	10
Atlantic Inn	N	Y	21
Bellevue House	N	Y	16
Champlin's Marina Motel Units	N	Y	20
Champlin's Marina Theatre	N	Y	15
Highview Inn & Eatery	N	Y	30
Narragansett Inn	N	Y	51
National Employee Housing	N	Y	11
Overlook	N	Y	36
Pier 76 Building	N	Y	12
Sam Peckhams	N	Y	40
Seacrest Inn	N	Y	17
Twin Maples, Inc.	N	Y	18
Rosalie Ccopacatty	Y	N	4
1661 Inn & Guest House	Y	Y	18
Anchor House Inn	Y	Y	4
Blue Dory Inn	Y	Y	12
Capt Nicks	Y	Y	7
Dodge Cottage	Y	Y	11
Eureka Hotel	Y	Y	29
Gables II	Y	Y	11
Gables Inn	Y	Y	14
Gothic Inn	Y	Y	10
Harborside Inn	Y	Y	36
Hotel Manisses	Y	Y	17
Inn at Old Harbor	Y	Y	10
Island Home	Y	Y	10
Millpond Cottages	Y	Y	15
National Hotel	Y	Y	45
New Shoreham House	Y	Y	15
Perry Cottage	Y	Y	5
Sea Breeze Inn	Y	Y	16
Seaside Market	Y	Y	18
Sheffield House	Y	Y	7
Spring House Hotel	Y	Y	78
Star Cottage	Y	Y	3
Surf Hotel & Surfside	Y	Y	47
Water Street Inn	Y	Y	10
B&B's, Guest Houses (not on public water)	N	N	142
Other Rental Rooms	N	N	38
Totals			979

Appendix II

BINEWUDS Database – NEWUDS Access relational database populated with Block Island, RI water use data for 2000 on CD ROM. Users must have Access to view the database

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