Plan For Developing a Water-Use Data Program in Rhode Island

U.S. GEOLOGICAL SURVEY

Water Resources Investigations Report 90-4207

Prepared in cooperation with the

RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT and

RHODE ISLAND GOVERNOR'S OFFICE OF HOUSING, ENERGY, AND INTERGOVERNMENTAL RELATIONS

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By M. A. Horn and P. A. Craft

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U.S. DEPARTMENT OF THE INTERIOR

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GLOSSARY

Consumptive use (CU): Water withdrawn that evaporates or transpires from irrigated plants; is transpired by humans or domestic animals; is incorporated into products, domestic animals, or crops; evaporates from open storage, treatment, or conveyance systems; discharges into brackish or saline waters after use if fresh at the point of withdrawal. Can occur anywhere in the water-use processes from point of withdrawal through point of return flow.

Distribution (DTB): The systematic and intentional dispersal of water (usually treated or pumped subsequent to withdrawal) by a public supplier to specific users or other public suppliers. If sold to other public suppliers, it is distributed directly by the receiving public supplier to specific users.

Exfiltration (EX): Water that leaks from a conveyance system or storage area into the surrounding and underlying materials. This process will occur if the ambient ground-water pressure is less than the internal pressure of the conveyance system or storage area at a point of breach (leakage). May be considered a form of return flow.

Infiltration (IN): Water that infiltrates into a low or unpressurized conveyance system, such as a wastewater-collection system. This process will occur if the ambient ground-water pressure exceeds the internal pressure of the conveyance system at a point of breach (leakage). This form of infiltration may be considered a form of ground-water withdrawal. A second type of infiltration is the interconnection of surface runoff collection systems and wastewater-collection systems. This is generally not considered a form of ground-water withdrawal.

Potable-water Treatment (PWT): The processes that withdrawn water undergoes (pumping subsequent to withdrawal, chlorinization, fluoridation, filtration, and others) prior to distribution. PWT is intended to ensure compliance with Safe Drinking Water Standards or otherwise improve water quality.

Return flow (RF): Generally, water that is systematically and intentionally returned to fresh surface or ground water and thus becomes available for reuse. Return flow can be directly to surface or ground water or indirectly to ground water through septic systems. Exfiltration and excess irrigation water can be also considered indirect return flow.

Specific use (SU): The application of water by the user(s). The user(s) can be an individual household or industry, or an aggregate, such as a community or surface-water basin. Specific use will contain the elements total deliveries, specific consumptive use, and total releases.

Total deliveries (part of specific use) **(TDL):** The sum of all water delivered to a user or a group of users either through a distribution system or by self-supply. The distributed water has probably undergone treatment and(or) pumping subsequent to withdrawal.

Specific consumptive use (part of specific use) **(SC):** Water that evaporates, transpires, is incorporated in the product during specific use, or discharges into brackish or saline water after specific use (assuming that it was withdrawn as freshwater). The volume of specific consumptive use can be estimated as the difference between the volume of water delivered to the user and the volume of water released by the user. Also considered part of consumptive use.

Total releases (part of specific use) **(TRL):** The sum of all water that is released from a point of use to an on-site wastewater-treatment facility, to a collection system for off-site wastewater treatment, or as return flow.

Transfers (TRN): The systematic and intentional conveyance of untreated ground or surface water for storage, as in a reservoir, or the dewatering of quarries, mines, or construction sites where the water is returned directly to the hydrologic system without specific use of the water. It is not delivered to a specific user. Transfered water can cross specific geographic or hydrologic boundaries.

Wastewater collection (WWC): The systematic and intentional accumulation of postuser water and possible storm runoff for wastewater treatment prior to release to a surface-water or ground-water system.

Wastewater treatment (WWT): The removal of most solid constituents and possible chemical/biological treatment of postuser water. WWT

is intended to meet regulations designed to minimize the environmental effect at the point of release and on the hydrologic system.

Withdrawals (WD): Generally, the systematic and intentional removal of surface water or ground water from the natural hydrologic system for eventual specific use. This system may have been enhanced by manmade structures such as dams, canals, levees, weirs, aqueducts, and so on. The point of withdrawal occurs at the location where the water being withdrawn is diverted from its contact with the natural hydrologic system. Withdrawal measurement points can be wells or can be located on streams, lakes, reservoirs, or other surface-water bodies from which water is withdrawn.

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
million gallons per day (Mgal/d)	3,758	cubic meter per day

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

Plan for Developing a Water-Use Data Program in Rhode Island

By M. A. Horn and P. A. Craft

ABSTRACT

Management and technical issues are involved in developing a comprehensive and effective water-use data program for the State of Rhode Island. Important management issues are (1) legislative authority, (2) primary agency responsibility, and (3) interagency coordination. Important technical issues are (1) minimum data requirements, (2) computer data-system requirements that include easy data entry, maintenance, updates, retrievals, and cross-references to other computer software and systems, and (3) water-use-data quality-assurance and quality-control requirements. Minimum data requirements outlined for collection, computer processing, analysis, and dissemination of data apply to (1) withdrawals from surface- and ground-water sources, (2) specific use by users, (3) return flow to surface and ground water, (4) consumptive use, (5) treatment, and (6) conveyance of water from suppliers to users and from users to wastewater treatment systems.

INTRODUCTION

In Rhode Island, withdrawals of fresh surface water are approaching the operational capacities of developed water supplies (the Rhode Island Division of Planning, 1988). This problem can be alleviated through development of new sources of water supply, more efficient use of existing supplies, or a combination of both. Evaluation of alternatives requires access to accurate, comprehensive, and comparable water-use data. Collection, computer processing, analysis, and dissemination of water-use data is costly and time-consuming, especially if undertaken at times of crises. By developing and implementing a well-planned and continuous water-use data program, collection of data would not only be more efficient and less costly, but would generate data of known reliability.

Previous approaches to managing water supplies in Rhode Island concentrated on a utility-oriented perspective that mainly focused on the development of new sources of withdrawals. However, the Rhode Island Division of Planning (RIDOP) (1988) recognized that "provision of water supplies should be contained within the broader context of a water resource management plan." Thus, development of new water supplies is being planned to minimize adverse impacts on the environment in general. The RIDOP report also states that "a single central repository should be established for water resources and related data to serve the needs of all agencies involved."

Local, State, and Federal agencies need water-use data from all aspects of water use, from points of withdrawal to points of return flow, to develop a comprehensive water-resource management plan. Withdrawal data alone do not provide sufficient information for management of water resources. Sound decisions about the development of new water supplies and the efficient use of existing supplies require current, accurate, and complete information on what happens to water between points of withdrawal and

return flow. Decisions such as whether to expand withdrawals in one area or limit them in another need to be supported by a geographic inventory of existing withdrawals, interbasin transfers, leakage, consumptive use, and return flow. An effective water-resource management plan is contingent upon the data provided by a comprehensive water-use data program.

The benefits from developing a water-use data program are far-reaching. The most significant benefit would be to enable State agencies to base decisions regarding water-supply development and requirements for conservation measures on information contained in a comprehensive water-use data base. Other benefits would include (1) identifying areas of concentrated withdrawals, (2) minimizing the need for sporadic, but costly inventories of current water-use for water-resource development plans, and (3) providing input for assessing the impact that the development of new withdrawals, specific users, or wastewater treatment facilities could have in a given area. Additionally, by developing a program that is compatible with the U.S. Geological Survey's (USGS) National Water-Use Information Program, particularly with respect to following national recommendations for data collection and quality control, Rhode Island data can be used to respond to interstate, regional, and national water-use data needs.

Purpose and Scope

This report presents a plan for developing a program of periodic and systematic collection, computer processing, analysis, and dissemination of water-use data. It defines water-use data and the current water-use program in Rhode Island and discusses development of a new program. It also evaluates alternatives in view of existing programs in order to help the State develop a water-resource management plan that reflects its needs and philosophy.

Description of Study Area

Rhode Island's 968,000 people (Solley and others, 1985, p. 59) live on 1,214 square miles. This population density of 797 people per square mile is second in the United States only to New Jersey. Fortunately, with an average annual rainfall of almost 45 inches, ample replenishment of both surface and ground water is available except during periods of drought.

Rhode Island's surface water is stored in 357 freshwater lakes and ponds, and in numerous perennial streams located in the 16 major drainage basins entirely or partially within Rhode Island (fig. 1). The largest drainage basins are Narragansett Bay basin, and basins for the Blackstone, Pawtuxet, and Pawcatuck Rivers. The State also has 21 major groundwater reservoirs (fig. 2) consisting of highly permeable sand and gravel deposits that underlie most of the State's major river valleys. Small quantities of water that generally are sufficient for domestic supply are also available from fractured crystalline bedrock and till aquifers. Bedrock aquifers underlie the entire State; till aquifers cover the bedrock in approximately two-thirds of the State's land area.

Of the many lakes, ponds, and perennial streams in Rhode Island, only a small number are committed to water supply. A few public water-supply reservoirs that serve Rhode Island are located in neighboring Massachusetts. In 1985, surface-water supplies accounted for about 80 percent of the 148 million gallons per day (Mgal/d) withdrawn by all users (Solley and other, 1988). Several public-water systems which formerly relied partially or completely on ground water, have switched to surface-water supplies. This changeover has resulted largely because groundwater supplies have been contaminated or were otherwise of poor quality.

Several of the systems that converted to surface-water sources have become dependent upon the Scituate Reservoir complex, operated by the Providence Water Supply Board. The reservoir accounted for about 50 percent of all withdrawals in the State (Division of Planning, 1988). Demands on the Scituate Reservoir are now (1990) approaching its safe yield as calculated by the State Water Resources Board, which has required the State to evaluate alternatives for meeting future demands. While an obvious alternative would be to develop new supplies, a second important alternative would be to manage current supplies more efficiently. Implementation of this alternative would require continuous collection, computer processing, and analysis of water-use data.

Water supply is not the only problem requiring attention. Diversion of water out of the drainage basin upstream from wastewater discharges can create insufficient low-flow stream discharges for required dilution of contaminants. The high cost of treating wastewater is further incentive for developing strategies that will lessen the volume of water requiring treatment and discharge.

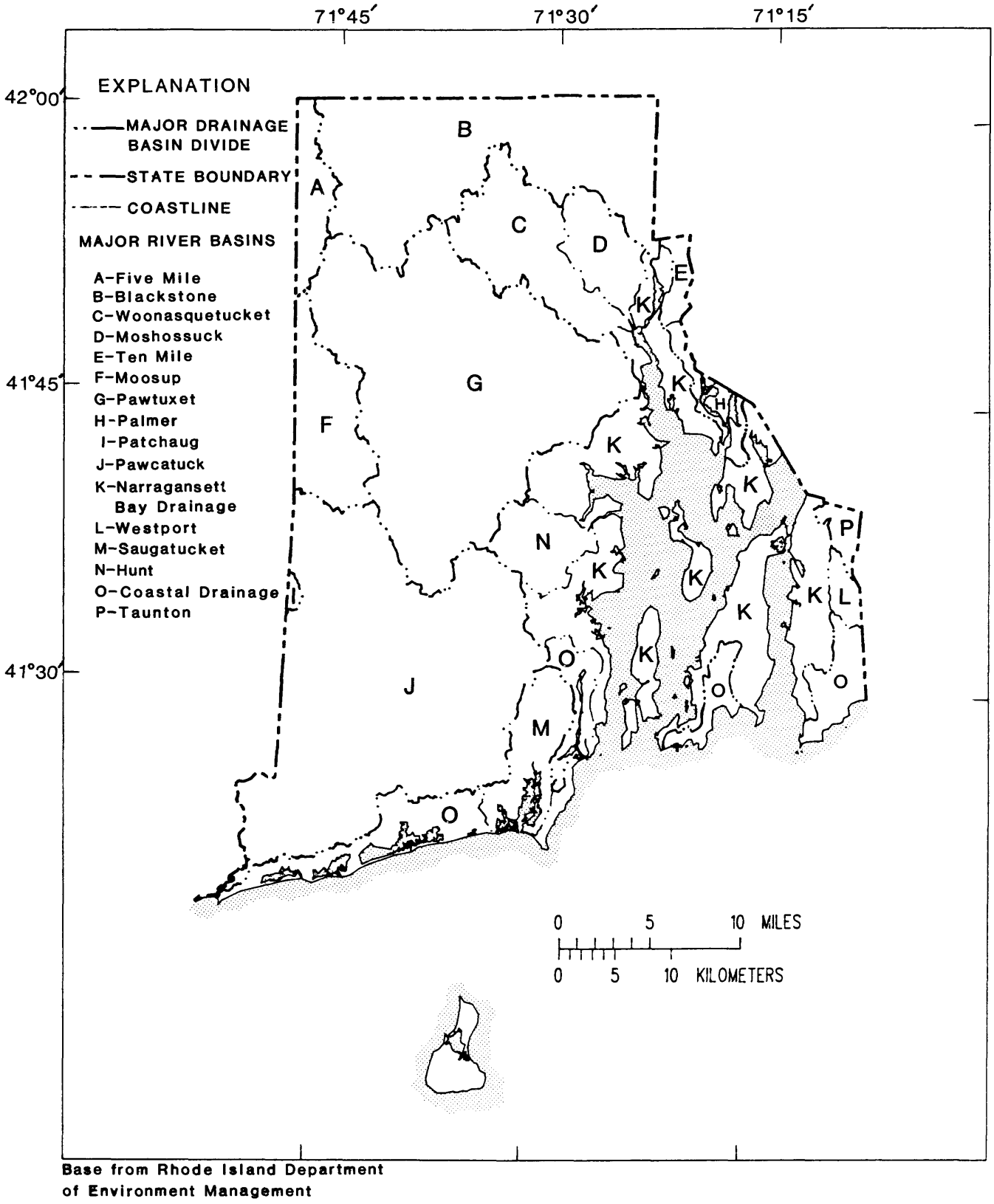

Figure 1.--Major drainage basins in Rhode Island.

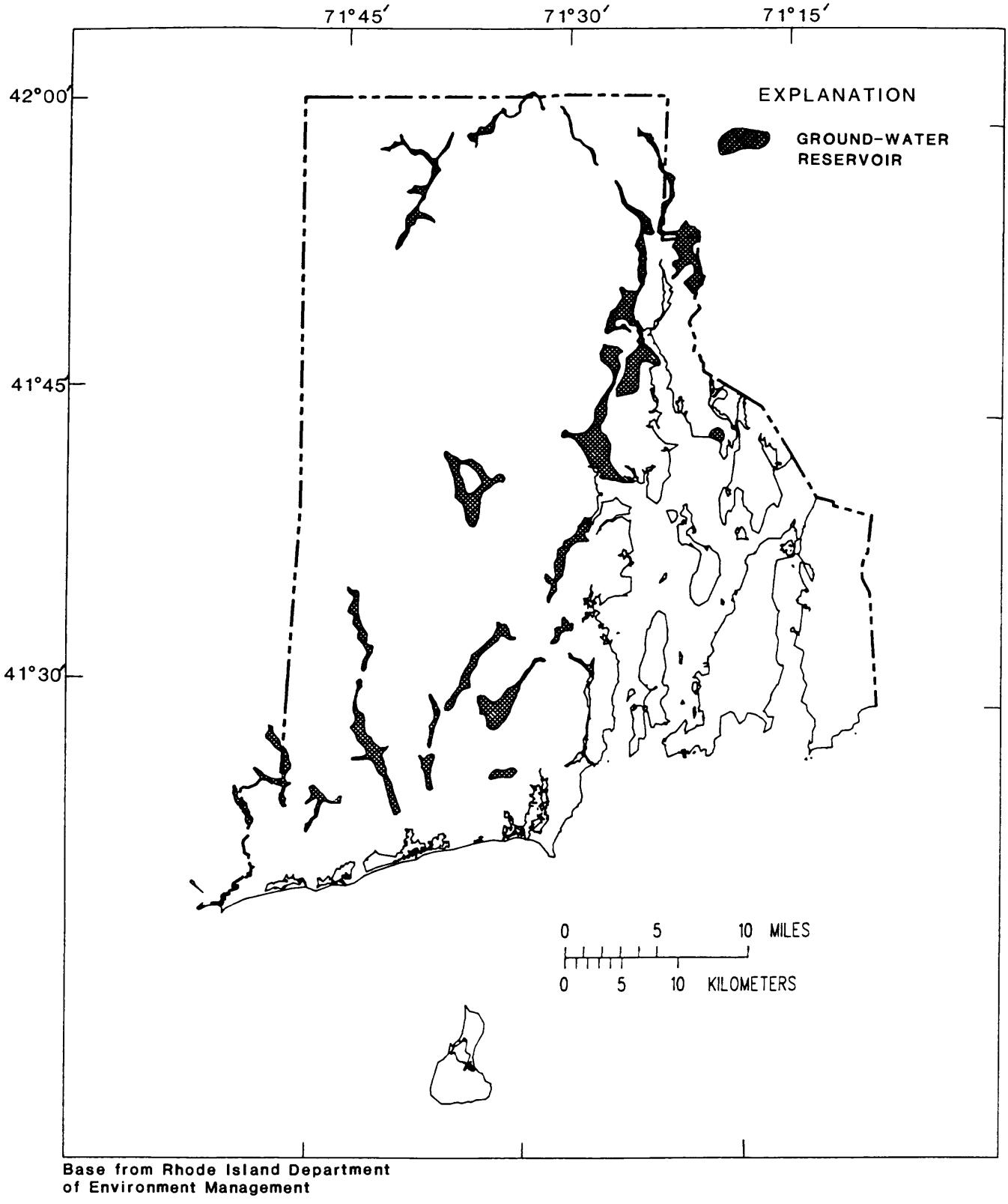

Figure 2.--Ground-water reservoirs in Rhode Island.

PREVIOUS AND RELATED STUDIES

The USGS has been compiling data to provide estimates of water use in the United States every 5 years since 1950. The National Water-Use Information Program was established by the USGS in 1978 to meet the need for a single source of uniform information on water use. The objectives of this Federal/State cooperative program are to (1) collect, store, and disseminate water-use data that complement data on the availability and quality of the Nation's water resources; (2) develop and operate computer data systems that will be responsive to the data needs of users at both national and state levels; and (3) devise new methods and techniques to improve and standardize the collection and analysis of water-use information (Mann and others, 1982). In support of these objectives, the USGS has developed both a Site-Specific Water-Use Data System (SSWUDS) and an Aggregated Water-Use Data System (AWUDS). Use of these data bases has encouraged consistent data collection and computer processing nationally.

The USGS's Rhode Island office's involvement in water-use data collection prior to 1980 was limited to collection of water-use data for the 5-year reports. In 1980, the USGS's Rhode Island office had a cooperative agreement with Rhode Island Statewide Planning whereby funds were given to the State by the USGS to collect water-use data for 1980 and develop a statewide plan for water-use data collection. During the first year of the project, data were to be collected; during the second year, the plan was to be developed. Unfortunately, funding limitations during the second year of the project prevented completion of the water-use-data plan. However, the interest in developing a water-use-data plan continued. In 1985, the Rhode Island Department of Environmental Management (RIDEM) requested that the USGS's water-use program provide assistance in setting up a water-use data program in Rhode Island. This effort was later joined by the Governor's Office of Housing, Energy, and Intergovernmental Relations, based on the assumption that such a program would result in both reducing energy and water consumption in Rhode Island.

DESCRIPTION OF WATER-USE DATA

In this report, water-use activities are separated into six processes: (1) withdrawal, (2) specific use, (3) return flow, (4) consumptive use, (5) treatment, and (6) conveyance. Figure 3 is a generalized diagram showing the interrelationships of these water-use processes. A definition, a discussion of minimum-data requirements, and a table listing suggested minimum-data requirements are provided for each of the six processes. The data requirements are divided into three main types: (1) owner or facility, (2) measurement point, and (3) volume or rate. One owner may be involved in more than one process and have more than one measurement point for each process (for instance, in the withdrawal process, there may be five wells and two reservoirs, and in the return-flow process, two discharge pipes). There may be annual data for several years for each measurement point. The data requirements are set up to (1) describe the owner, (2) identify the process and describe the measurement points, and (3) record the volume or rate (annual or monthly) associated with each measurement point.

Site-specific owner, measurement point, and volume or rate data are not available for all users. In some cases, it is more reasonable to record an aggregate total for users in a specific area. For instance, if 1,000 residents in a township have their own wells, their withdrawals would be recorded as 1,000 residents multiplied by a per capita volume to obtain the domestic self-supplied withdrawals for that town. Table 1 is a list of use categories relevant for Rhode Island. Also in this table is an indication of whether each use category should ideally be collected on a site-specific basis (I) or as an aggregate (A), by geographic area (municipal civil division, county, basin, or subbasin) or both. Site-specific data are particularly important when all individual users use large volumes of water, such as in mining or in powerplant operation. Aggregate data are preferred when all of the individual users use only a small volume of water and the total volume used is based on a group of users and a coefficient of use per user, such as for livestock. Site-specific and aggregate data can be collected for some use categories, such as industrial use, where some users exceed a specified volume and some use less than this specified volume.

Suggested aggregate minimum-data requirements include a unique identification number, use type, and process type. Occasionally, a more detailed definition of use type may be used, such as dairy cattle as a sub-category of agricultural (nonirrigation). A suggested list of data elements for aggregate data is provided in table 2.

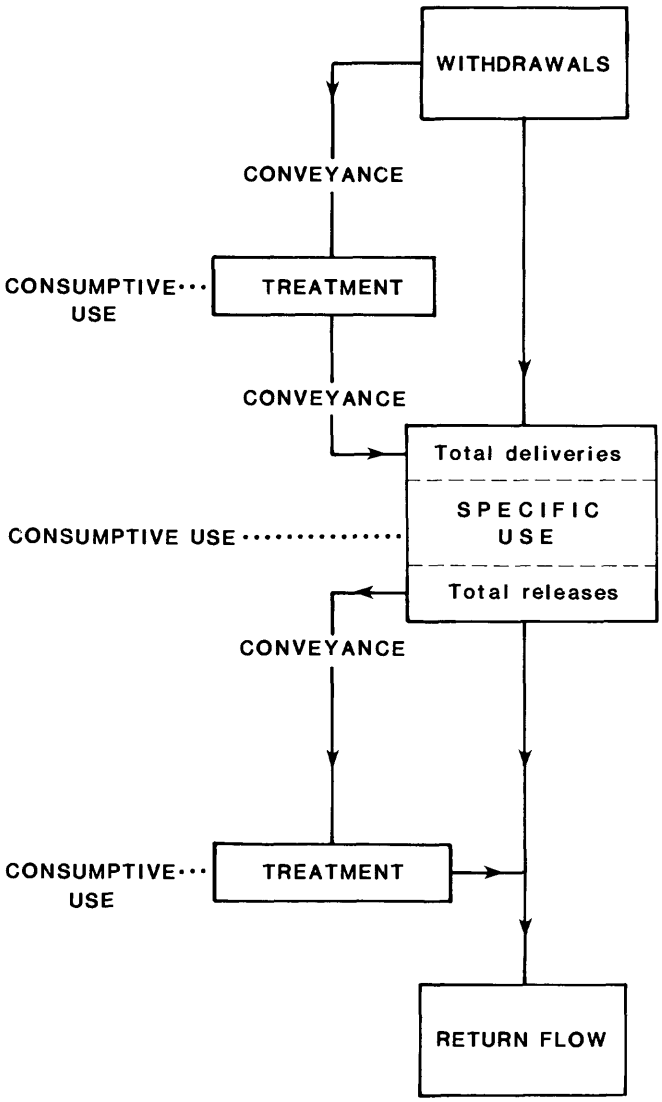

Figure 3.--General water-use flow diagram.

Suggested minimum-data requirements for owner for which site-specific data are collected include a unique identification number, name, address, use type, and water-use process. A more detailed list of data elements is provided in table 3.

Withdrawal (WD) is the systematic and intentional removal of surface water or ground water from a naturally occurring system that may have been enhanced by manmade structures. The point of withdrawal occurs at the location where the water being withdrawn is diverted from its natural course. In Rhode Island, most freshwater is withdrawn by public suppliers, industries, commercial users, institutions, and irrigators. Minor volumes commonly are withdrawn for the remaining types of use categories described in table 1. The exception is unmetered-public use, such as, fire fighting, hydrant flushing, or leaks, which is a specific use of public-supply withdrawals.[1]

Withdrawal measurement points can be wells, or on streams, lakes, or reservoirs from which the water is withdrawn. Minimum-data requirements for withdrawal point(s), include (1) unique identification number(s), (2) location, (3) source of water, (4) ensuing process, and (5) construction of manmade structures (Table 4). Minimum-data requirements for all measurement points for each process will include a previous and an ensuing process. The previous process will indicate the unique identification of the measurement point or owner from which the water was received. The ensuing process will indicate the unique identification of the measurement points or owner to which the water will be sent. Identification of these points will facilitate tracking water from points of withdrawal to points of return flow. Minimum-data requirements for the annual volume include the volume, year, and reliability of each withdrawal value. A more detailed list of data elements is provided in table 4.

Specific use (SU) is the heart of water use and is defined in this report as the application of water by the user(s). The user(s) can be an individual household or industry, or an aggregate, such as a community or surface-water basin. Specific use occurs after distribution of publicly-supplied water or after withdrawal of self-supplied water.

All activity prior to specific use involves supplying the user with water. All activity after specific use involves the disposal of water. These two sets of activities are useful in deriving components in a mass water balance. Specific use is equal to the sum of all water delivered to or withdrawn by a user or group of users (Total deliveries or TDL). Specific use also is equal to the sum of the water consumed (Specific consumption or SC) plus all water released (Total releases or TRL) by that user or group of users, or, SU = TDL = SC + TRL. The values for the processes that can be measured can be put into the above equation so that

[1] Terms in bold print are defined in the glossary in the front of this report.

Table 1.--*Water-use categories.*

Use Type	Compilation[1]	Description
Aquaculture	I	farming of organisms that live in water, such as fish, shellfish, and algae. Includes fish hatcheries, bait and fish harvesting
Agriculture (non-irrigation)	A	livestock
Commercial	I/A	water for commercial activities, such as for office buildings, stores, or restaurants
Domestic	A	residential or household use
Hydro-electric Power Generation	I	considered a withdrawal if water is diverted from the river before driving turbines
Industrial	I/A	used for processing, washing, cooling, and fabrication
Institutional	I/A	schools, nursing homes, hospitals, prisons
Irrigation-Agricultural	I/A	crops, orchards, and nurseries
Irrigation-Commercial	I	golf courses, lawns, and parks
Mining	I	includes both non-dewatering use (extraction of minerals, slurries, high pressure application) and dewatering of quarries and mines
Public Supply	I	withdrawn by public and private water suppliers and delivered to groups of users
Thermo-electric Power Generation	I	water used in generating power in a fossil- or nuclear-fueled plant, usually for cooling
Recreation	I/A	includes parks, camps, arcades, snow-making, resorts, pools
Unmetered-publicly supplied	A	part of publicly-supplied water that is not metered, and includes use that is both accounted (such as fire fighting and street cleaning) and unaccounted (leaks and unauthorized use)
Wastewater treatment	I	processing to remove or reduce undesirable constituents in waste water

[1] I *means individual use,* A *means aggregate use*

estimates can be developed for the remaining components. For example, if 100 Mgal/d were delivered to a factory, 10 Mgal/d were incorporated into the product, and 80 Mgal/d were discharged into the waste-water collection system, 10 Mgal/d could be assumed to have evaporated.

Table 5 was developed to track volumes delivered, consumed, and released during the specific-use process. Each water-use category is associated with certain kinds of deliveries, consumptive use, and releases, which are also shown in table 5.

Total deliveries (TDL) is the sum of all water delivered to a user or a group of users either through a distribution system or by self-supply. The distributed water has probably undergone treatment and(or) pumping subsequent to withdrawal. Facility characteristics, listed in table 6, focus on the relation between how the water is used and the volume used in order to develop an accurate coefficient between production (such as energy, crops, mineral tonnage, livestock, or industrial products) and specific use. Total deliveries to users can be estimated on the basis of related elements, such as number of employees, people served, kilowatt-hours generated, acres ir-

Table 2.--*Suggested minimum-data requirements for aggregate data.*

OWNER DATA
AGGREGATE OF USE TYPE BY GEOGRAPHIC AREA OR POLITICAL SUBDIVISION
UNIQUE IDENTIFICATION NUMBER
USE CATEGORY
sub-category
PROCESS(ES)
MEASUREMENT-POINT DATA
PROCESS
PRECEDING PROCESS
ENSUING PROCESS
AGGREGATE AREA
County
Community
Major drainage basin
Subbasin
ANNUAL-VOLUME DATA
NUMBER OF USERS
WATER-USE COEFFICIENT
MONTHLY AND ANNUAL VOLUMES
Estimation method
Method accuracy and reliability
Source of data
Source of corroborative data

rigated, tons of metal processed, or square feet cooled. Table 7 lists suggested minimum-data requirements for the total-delivery aspect of the specific-use process. Site-specific data probably should be collected for the largest publicly-supplied users.

Specific-consumptive use (SC) is water that evaporates, is incorporated in the the product during specific use, or discharges into brackish or saline water after specific use (assuming that it was withdrawn as freshwater). The volume of specific-consumptive use can be estimated as the difference between the volume of water delivered to the user and the volume of water released by the user. Table 5 lists the type of specific-consumptive use associated with each use category. Specific-consumptive use is a component of consumptive use, and is included here because it is part of the calculation for mass balance, TDL = SC + TRL.

Total releases (TRL) is the sum of all water that is released from a point of use to an on-site wastewater-treatment facility, to a collection system for off-site wastewater treatment, or as return flow. Table 5 lists the type of total releases associated with each use category. By continually refining estimation techniques throughout the specific-use process, accuracy of estimates for return-flow and consumptive-use data can be improved.

Return flow (RF) generally is water that is systematically and intentionally returned to fresh surface water or ground water for reuse. Return flow can be made directly to surface water and ground water, or indirectly to ground water through a septic system.

Table 3.--*Suggested owner minimum-data requirements.*

OWNER DATA	
INDIVIDUAL USER	AGGREGATE OF USE TYPE BY GEOGRAPHIC AREA OR POLITICAL SUBDIVISION
IDENTIFICATION	IDENTIFICATION
Unique identification number	Unique identification number
Name	--
Street address	--
City, State, zip code	--
Mailing city, state, zip code	--
Contact	--
Telephone number	--
USE CATEGORY	USE CATEGORY and sub-category
PROCESS(ES)	PROCESS(ES)

Table 4.--*Suggested minimum-data requirements for the withdrawal process.*

OWNER DATA--unique identification number
WITHDRAWAL POINT DATA
IDENTIFICATION
Unique identification number
Identification used by owner
Type (reservoir, stream, well, or leak into WWT)
Other agency ID numbers
LOCATION
County
Community
Hydrologic unit
Subbasin
Latitude, longitude (well or intake)
USGS quadrangle name
SOURCE
Name of reservoir, stream, aquifer
ENSUING PROCESS
Transfer (water body), treatment (facility), distribution system (purveyor system), specific user (facility), or aggregation reference
CONSTRUCTION DATA FOR RESERVOIR
Construction date
Total and usable storage
Surface area
Average water depth
Status (active, standby)
Drainage area
Source of water, if part of chain
Type fill & outlet
Spillway release volume
Yield & method of calculation
Elevation of spillway (MSL)
CONSTRUCTION DATA FOR STREAM INTAKE
Construction date
Pump capacity
Status (active, standby)
Pipe diameter and material
Elevation
CONSTRUCTION DATA FOR WELL(S)
Construction date
Pump capacity
Construction method
Openings: type, diameter, top & bottom elevation
Driller
Well depth
Casing diameter and material
Elevation of land surface (MSL)
Status (active, standby)
VOLUME WITHDRAWN
MONTHLY AND ANNUAL VOLUMES
Estimation method
Source of data
Meter accuracy and reliability
Estimation method accuracy and reliability
Source of corroborative data

Return flow is most commonly encountered as the volume discharged to surface water by a municipal or industrial wastewater-treatment facility. However, return flow has other sources. Discharges to ground water occur through septic tanks, by leakage from distribution and sewer lines (conveyance loss), and by application of irrigation water in excess of what evapotranspirates. Other discharges to surface water include dewatering of quarries, mines, and construction sites, and the release of water from flooded fields.

Table 8 lists data that are needed to describe return flow. Important data to collect primarily describe the point through which water is discharged, including (1) identification, (2) location information, (3) preceding processes, (4) ensuing processes, (5) construction data, and (6) volume returned.

Consumptive use (CU) is that part of water withdrawn that (1) is incorporated into manufactured products, livestock, or crops; (2) evaporates from open storage, treatment, or conveyance systems; (3) evapotranspirates from irrigated crops; (4) is transpired by human or domestic animals, and(or) (5) discharges into brackish or saline waters (if withdrawn as freshwater).

Table 9 lists data that are needed to describe the consumptive-use process. Important data to collect primarily describe the point at which water undergoes consumptive use, including (1) identification, (2) location information, (3) preceding processes, (4) destination, and (5) volume of consumptive use.

Treatment is the process whereby water is collected in a facility, undergoes physical and(or) chemical changes, and is then released from the facility. **Potable-water treatment** (PWT) includes the processes that withdrawn water undergoes (pumping subsequent to withdrawal, chlorinization, fluoridation, filtration, and others) prior to distribution. PWT is intended to ensure compliance with Safe Drinking Water Standards or otherwise improve water quality. The second type of treatment, **wastewater treatment** (WWT), includes the removal of most of the solid constituents and chemical/biological treatment of postuser water. WWT is intended to meet regulations designed to minimize the environmental effect at the point of release and on the hydrologic system.

Suggested minimum-data requirements for describing the potable-water treatment process are listed in table 10. Important data to collect primarily describe the facility at which potable-water treatment occurs, including (1) identification, (2) location information,

Table 5.--*Work sheet for the specific-use process.*

AQ = Aquaculture, AL = Agriculture-livestock, CO = Commercial, DO = Domestic, HP = Hydro-electric power, IN = Industrial, IS = Institutional, IR = Irrigation-agricultural, IC = Irrigation- commercial, MI = Mining, PS = Public supply, TP = Thermo-electric power, RC = Recreational, UM = Unmetered, WW = Waste water, __ = data may be available, 0 = no data required.]

TOTAL DELIVERIES	AQ	AL	CO	DO	HP	IN	IS	IR	IC	MI	PS	TP	RC	UM	WW
Withdrawn water	__	__	__	__	__	__	__	__	__	__	__	__	__	0	__
Transferred water	__	__	__	__	__	__	__	__	__	__	__	__	__	__	__
Pre-use Treated water	0	__	__	__	0	__	__	__	__	0	__	__	__	__	__
Distributed water	0	__	__	__	0	__	__	__	__	__	__	__	__	__	
TOTAL SPECIFIC CONSUMPTION															
Evaporation	__	__	__	__	__	__	__	__	__	__	__	__	__	__	__
Product incorporation	__	__	0	0	0	__	0	__	__	__	0	0	0	0	0
Discharged into saline or brackish water	__	0	__	0	__	__	__	__	__	__	__	__	__	__	__
TOTAL RELEASES															
WW collection system	0	0	__	__	0	__	__	0	0	__	__	0	__	__	0
SW return flow	__	0	__	0	__	__	__	__	__	__	__	__	__	__	__
Direct gw return flow	__	__	__	__	0	__	__	__	__	__	__	0	__	__	__
Septic-system gw return flow	0	0	__	__	0	__	__	0	0	__	0	0	__	__	0
In-situ WW treatment	0	0	0	__	0	__	__	0	0	__	0	0	__	0	0

(3) preceding processes, (4) ensuing processes, and (5) volume treated.

Suggested minimum-data requirements for describing the wastewater-treatment process are listed in table 11. Important data to collect primarily describe the facility at which wastewater treatment occurs, including (1) identification, (2) location information, (3) preceding processes, (4) ensuing processes, and (5) volume treated.

Conveyance is the process whereby water is moved from one point to another. Generally, there are three conveyance types: **Transfer** is the movement of water from one water body to another without any specific use occuring or potable-water treatment. **Distribution** is the movement of water after potable-water treatment to a point(s) of specific use. **Wastewater collection** is the movement of water after specific use to the final wastewater-treatment facility before return flow. All three conveyance types are not always present. Transfers occur in complex public-supply systems and during dewatering, distribution occurs primarily through public suppliers, and wastewater collection occurs through sewer systems. Self-supplied users do not have distribution systems, and users who discharge to septic systems or directly to ground or surface waters do not have wastewater-collection systems.

Transfer (TRN) is the systematic and intentional conveyance of untreated ground or surface water for storage, as in a reservoir, or from quarries, mines, or construction sites during dewatering. It is not delivered to a specific user. It is important to collect data on transfers primarily to avoid double-accounting of withdrawals. For instance, a public supplier may withdraw 60 Mgal/d from Reservoir 1 and discharge it in Reservoir 2, then withdraw 80 Mgal/d from Reservoir 2 and pump it into the treatment plant.

Table 6.--*Facility characteristics by water-use category.*

USE TYPE	Facility Characteristics that do not change yearly	Facility Characteristics that do change yearly
Aquaculture	acres, depth of water	number and type of fish
Agriculture (non-irrigation)	aggregate only	
Commercial	building type, size	number of employees, number of customers
Domestic	aggregate only	
Hydro-electric Power Generation	turbine size, plant type	power generated, hours operated
Industrial	sic code, process type, amount of water reuse	estimated production, number of employees
Institutional	how water is used: pools, kitchens	population served
Irrigation--Agricultural	power source, equipment type, conveyance	acres, crop type
Irrigation--Commercial	power source, equipment type, conveyance	acres, type
Mining	sic code, process type amount of water reuse	estimated production, number of employees
Thermo-electric Power Generation	fuel type, plant type, turbine size	power generated, hours operated
Recreation	type	number of customers
Unmetered publicly supplied	aggregate only	

Without coding the first activity as a transfer, withdrawals would equal 140 Mgal/d instead of the 80 Mgal/d. It also is important to keep track of transfer between reservoirs because they may be in different basins, have different surface areas (which will affect total evaporation), or be vulnerable to different kinds of contamination.

Suggested minimum-data requirements for describing the transfer process are listed in table 12. Important data to collect primarily describe the system through which transfer occurs, including (1) identification, (2) location information, (3) preceding processes, (4) ensuing processes, and (5) volume transferred.

Distribution (DTB) is the systematic and intentional dispersal of treated or untreated water by a public supplier to specific users and (or) other public suppliers. It occurs after potable-water treatment and before specific use. Distribution can occur both within the individually billed customer-service area of a public-supply system, or outside this area through interconnections with other public-supply systems. Virtually all distribution in Rhode Island is handled by public suppliers.

Table 13 lists suggested minimum-data requirements for the distribution process. Important data to collect primarily describe the system through which distribution occurs, including (1) identification, (2) location information, (3) preceding processes, (4) ensuing processes, and (5) volume distributed. Relevant data for external distribution (outside the customer service area) include the location and size of interconnections, identification of sender and receiver, and the volume distributed. Data on distribution inside the customer service area include (1) number of service connections for residential, commercial, industrial, and other uses, (2) population served, (3) percent of customers metered, (4) meter descriptions, (5) volume of water distributed to each customer type, and (6) rate type. The volumes distributed to major users may be collected individually.

Wastewater collection (WWC) is the systematic and intentional accumulation of postuser water and possible storm runoff for wastewater treatment prior to

Table 7.--*Suggested minimum-data requirements for specific-use process.*

OWNER DATA--unique identification number
SPECIFIC-USE POINT DATA
IDENTIFICATION
Unique identification number Identification used by owner Type Other agency ID numbers
LOCATION OF WHERE WATER IS USED
County Major drainage basin Latitude, longitude Community Subbasin USGS quadrangle name
PRECEDING PROCESS
Withdrawal, transfer (water body), distribution (name of system)
SPECIFIC CONSUMPTION
Evaporation, product incorporation, discharge to saline or brackish water
ENSUING PROCESS
Wastewater collection (name of system), wastewater treatment (facility name), return flow (septic system, direct ground water (aquifer), or surface water (name) direct
FACILITY CHARACTERISTICS
Description of physical plant and other properties that are unlikely to change every year
VOLUME OF SPECIFIC USE
FACILITY CHARACTERISTICS
Description of physical plant and other properties that change every year
MONTHLY AND ANNUAL VOLUMES
Estimation method Source of data Meter accuracy and reliability Estimation method accuracy and reliability Source of corroborative data

Table 8.--*Suggested minimum-data requirements for the return-flow process.*

OWNER DATA--unique identification number
RETURN-FLOW POINT DATA
IDENTIFICATION
Unique identification number Identification used by owner Type (into fresh-surface water, ground water, or septic system) Other agency ID numbers
LOCATION
County Community Major drainage basin Subbasin Latitude, longitude (discharge pipe) USGS quadrangle name
PRECEDING PROCESS
Specific user (name), WW or PW treatment plant, or distribution or wastewater collection system
DESTINATION OF WATER
Name of receiving surface-water body or aquifer
CONSTRUCTION DATA
Pipe diameter Elevation
VOLUME RETURNED
MONTHLY AND ANNUAL VOLUMES
Estimation method Source of data Meter accuracy and reliability Estimation method accuracy and reliability Source of corroborative data

release to a surface-water or ground-water system. As with distribution, wastewater collection can occur within a specific customer-service area, such as a town, whereby the wastewater-treatment facility bills customers individually. Some regional wastewater-treatment facilities service and bill entire communities, relinquishing individual billing to the communities served. Wastewater released into a collection system may be augmented by infiltration (water leakage into the system) and(or) depleted by exfiltration (water leakage out of the system). Special care must be taken if storm runoff also is collected in the same system.

Table 14 lists data used to describe wastewater collection. Important data to collect primarily describe the system through which wastewater collection occurs, including (1) identification, (2) location information, (3) preceding processes, (4) ensuing processes, and (5)

Table 9.--*Suggested minimum-data requirements for the consumptive-use process.*

OWNER DATA--unique identification number
CONSUMPTIVE-USE POINT DATA
IDENTIFICATION
Unique identification number Type (evaporation, product incorporation, discharge to saline wtr) Other agency ID numbers
LOCATION
County Community Major drainage basin Subbasin Latitude, longitude (discharge pipe) USGS quadrangle name
PRECEDING PROCESS
Withdrawal (open-water body), transfer, PW treatment plant name, distribution system, specific user, wastewater collection system, WW treatment plant
DESTINATION
Atmosphere, product type, or name of receiving saline- or brackish-water body
VOLUME OF CONSUMPTIVE USE
MONTHLY AND ANNUAL VOLUMES
Estimation method Source of data Meter accuracy and reliability Estimation method accuracy and reliability Source of corroborative data

volume collected. Relevant data for wastewater collection from outside the customer service area include the location of transfer points and the volume collected. Data on wastewater collected inside the customer service area include number of service connections for residential, commercial, industrial, and other metered uses, percent of customers metered, population served, rate structure, meter descriptions, and volume of water distributed to each type of customer. The volumes released into the wastewater-collection system by major users can be collected individually.

The water-resource management plan referred to in the Division of Planning document would require development of a comprehensive water-use data program that can track water from points of withdrawal to points of return flow. Figure 4 is a more detailed diagram of water use. Tables 2-14 provide a detailed description for each process in the diagram. Each of the processes from withdrawals to return flow need to be evaluated to determine how the use of water has changed the availability and distribution of water resources. For example, water budgets for a basin require incorporation of data on water moved into or out of the basin through transfers, distribution, wastewater collection, and specific use. When there are minimal interbasin transfers, withdrawal volumes can be compared with return-flow volumes to estimate

Table 10.--*Suggested minimum-data requirements for the potable-water-treatment process.*

OWNER DATA--unique identification number
POTABLE-WATER TREATMENT POINT DATA
IDENTIFICATION
Unique identification number Identification used by owner Other agency ID numbers
LOCATION
County Community Major drainage basin Subbasin Latitude, longitude (discharge pipe) USGS quadrangle name
PRECEDING PROCESS
Withdrawal or transfer point
ENSUING PROCESS
Distribution system, surface-water body, or specific user
FACILITY CHARACTERISTICS
Description of physical plant and other properties that are unlikely to change every year
VOLUME TREATED
FACILITY CHARACTERISTICS
Description of physical plant and other properties that change every year
MONTHLY AND ANNUAL VOLUMES
Estimation method Source of data Meter accuracy and reliability Estimation method accuracy and reliability Source of corroborative data

Table 11.--*Suggested minimum-data requirements for the wastewater-treatment process.*

OWNER DATA--unique identification number
WASTEWATER TREATMENT POINT DATA
IDENTIFICATION
Unique identification number Identification used by owner Type (intermediate, final) Other agency ID numbers
LOCATION
County Community Major drainage basin Subbasin Latitude, longitude (discharge pipe) USGS quadrangle name
PRECEDING PROCESS
Specific user, wastewater-collection system
ENSUING PROCESS
Wastewater-collection system, return-flow point
FACILITY CHARACTERISTICS
Description of physical plant and other properties that are unlikely to change every year
VOLUME TREATED
FACILITY CHARACTERISTICS
Description of physical plant and other properties that change every year
MONTHLY AND ANNUAL VOLUMES
Estimation method Source of data Meter accuracy and reliability Estimation method accuracy and reliability Source of corroborative data

Table 12.--*Suggested minimum-data requirements for the transfer-conveyance process.*

OWNER DATA--Unique identification number
TRANSFER POINT DATA
IDENTIFICATION--ORIGIN
Unique identification number Identification used by owner Type (reservoir, stream, well, dewatering) Other agency ID numbers
LOCATION--ORIGIN
County Community Hydrologic unit Subbasin Latitude, longitude (well or intake) USGS quadrangle name
SOURCE OF WATER
Name of reservoir, stream, aquifer
IDENTIFICATION--DESTINATION
Unique identification number Identification used by owner Type (reservoir, stream, well, dewatering) Other agency ID numbers
LOCATION--DESTINATION
County Community Hydrologic unit Major drainage basin Subbasin Latitude, longitude (discharge pipe) USGS quadrangle name
DESTINATION OF WATER
Reservoir, surface water body, aquifer
VOLUME TRANSFERED
MONTHLY AND ANNUAL VOLUMES
Estimation method Source of data Meter accuracy and reliability Estimation method accuracy and reliability Source of corroborative data

Table 13.--*Suggested minimum-data requirements for the distribution-conveyance process.*

OWNER DATA--unique identification number
INDIVIDUAL DISTRIBUTION POINT--INTERCONNECTIONS TO OTHER SUPPLIERS
IDENTIFICATION
Unique identification number
Type (routine, emergency)
LOCATION
County
Community
Hydrologic unit
Subbasin
Latitude, longitude
USGS quadrangle name
PRECEDING PROCESS
Withdrawal, Potable-water treatment plant name
ENSUING PROCESS
Potable-water treatment plant, distribution system, specific user
CONSTRUCTION DATA
Construction data
Elevation
Size and material of pipe
Status
VOLUME DISTRIBUTED THROUGH INTERCONNECTIONS
MONTHLY AND ANNUAL VOLUMES
Estimation method
Source of data
Meter accuracy and reliability
Estimation method accuracy and reliability
Source of corroborative data
INDIVIDUAL DISTRIBUTION POINT--MAJOR CUSTOMER INSIDE SERVICE AREA
IDENTIFICATION
Unique owner identifier
PRECEDING PROCESS
Withdrawal, Potable-water treatment plant name
ENSUING PROCESS
Specific user
VOLUME DISTRIBUTED
MONTHLY AND ANNUAL VOLUMES
Estimation method
Source of data
Meter accuracy and reliability
Estimation method accuracy and reliability
Source of corroborative data
AGGREGATED DISTRIBUTION CHARACTERISTICS--WITHIN CUSTOMER SERVICE AREA
TYPE OF CUSTOMER
Residential, commercial, industrial, other metered uses, unmetered uses
PRECEDING PROCESS
Withdrawal, PW treatment plant name
SERVICE CHARACTERISTICS
Definition of breakdown
Rate structure
Date and method for pop srvd
Percent of customers metered
Number of service connections
Population served
Frequency of meter readings
General type, service, and age of meters
VOLUME DISTRIBUTED TO CUSTOMERS, AGGREGATED BY USE TYPE
MONTHLY AND ANNUAL VOLUMES
Estimation method
Source of data
Meter accuracy and reliability
Estimation method accuracy and reliability
Source of corroborative data

consumptive use and conveyance loss or gain. But when interbasin transfers are significant, careful analysis of conveyance volumes is essential in order to determine the water budget of a basin. In order to track the flow of water through this complex array of facilities and pipes, careful planning of water-use data collection, coordination between State agencies, analysis of whether collected data meets water-resource management needs, and a good computerized data-management system are required.

STATUS OF RHODE ISLAND WATER-USE DATA COLLECTION

Current Rhode Island legislative authority for water-resource management is distributed among several agencies. Until 1990, these agencies "have not had an explicit set of policies to guide their actions, but have had to rely on a piecemeal approach utilizing relevant elements of the State Guide Plan, the Water Quality Management Plan for Rhode Island ("208" Plan), and various plans done for river basin planning purposes." (Rhode Island Division of Planning, 1988, p 2.1). Three of these agencies--the Rhode Island Water Resources Board (RIWRB), the Rhode Island Department of Health (RIDOH), and the RIDEM--collect data for some water-use processes. The RIWRB is responsible for planning, financing, and developing water-supply projects. RIWRB also has the authority to acquire, lease, and (or) operate municipal water-supply systems. The RIDOH is responsible for monitoring public-drinking-water systems to ensure compliance with Federal and State water-quality

Table 14.--*Suggested minimum-data requirements for the wastewater-collection-conveyance process.*

OWNER DATA--unique identification number
INDIVIDUAL WASTEWATER COLLECTION POINT--(OUTSIDE SERVICE AREA)
IDENTIFICATION
Unique identification number
LOCATION
County
Community
Hydrologic unit
Subbasin
Latitude, longitude
USGS quadrangle name
PRECEDING PROCESS
Specific user, waster-collection system,
Wastewater treament plant name
ENSUING PROCESS
Wastewater treatment plant name
CONSTRUCTION DATA
Construction data
Elevation
Size and material of pipe
Status
VOLUME CONVEYED TO OTHER SYSTEMS
MONTHLY AND ANNUAL VOLUMES
Estimation method
Source of data
Estimation meter accuracy and reliability
Method accuracy and reliability
Source of coroborative data
INDIVIDUAL WASTEWATER COLLECTN POINT--MAJOR CUSTOMER INSIDE SERVICE AREA
IDENTIFICATION
Unique identification number
PRECEDING PROCESS
Specific user, wastewater collection system, WW treatment plant name
ENSUING PROCESS
Wastewater treatment plant name
VOLUME RELEASED INTO WASTEWATER-COLLECTION SYSTEM
MONTHLY AND ANNUAL VOLUMES
Estimation method
Source of data
Meter accuracy and reliability
Estimation method accuracy and reliability
Source of corroborative data
AGGREGATED WASTEWATER-COLLECTION CHARACTERISTICS--WITHIN CUSTOMER SERVICE AREA
TYPE OF CUSTOMER
Residential, commercial, industrial, other metered and unmetered uses
PRECEDING PROCESS
Specific user, wastewater collection system, WW treatment plant name
SERVICE CHARACTERISTICS
Definition of breakdown
Rate structure
Date and method for pop srvd
Percent of customers metered
Number of service connections
Population served
Frequency of meter readings
General type, srvc, & age of meters
VOLUME RELEASED INTO WASTEWATER-COLLECTION SYSTEM, AGGREGATED BY USE TYPE
MONTHLY AND ANNUAL VOLUMES
Estimation method
Source of data
Meter accuracy and reliability
Estimation method accuracy and reliability
Source of corroborative data

standards. The RIDEM is responsible for monitoring compliance with regulations concerning discharge of wastewater. Legislation enacted in 1985 gave a fourth agency, the Division of Planning, the responsibility "for studying and evaluating the needs of the state for current and future water supply" and giving them the power "to formulate and maintain a long range guide-plan and implementing program for development of major water resources and transmission systems needed to furnish water to regional or local public water systems" (Division of Planning, 1988, p 1.4).

The RIWRB intermittently collects, but does not computer process, information on the withdrawal and distribution of water by 33 of the 89 community public water-supply systems. Collected withdrawal information includes descriptions of sources, such as wells or reservoirs; treatment information includes treatment types; and distribution information includes maximum, minimum, and average daily demand; area and population served; per-capita use for each municipality served; number of active services; capacity of water-storage facilities; distribution-pipe size and materials; source of purchased water; pumping-station data; water-rate schedule (retail and wholesale); emergency connection(s), size, locations, date of last use, volume transferred, date opened and closed; and estimated future use, expansions, and improvements. Occasionally, the RIWRB publishes the results of more extensive field inventories. The RIWRB (1971) published an inventory of data for the public-supply systems that included (1) area served, including a map; (2) total community population; (3) population served; (4) sources of supply; (5) water use,

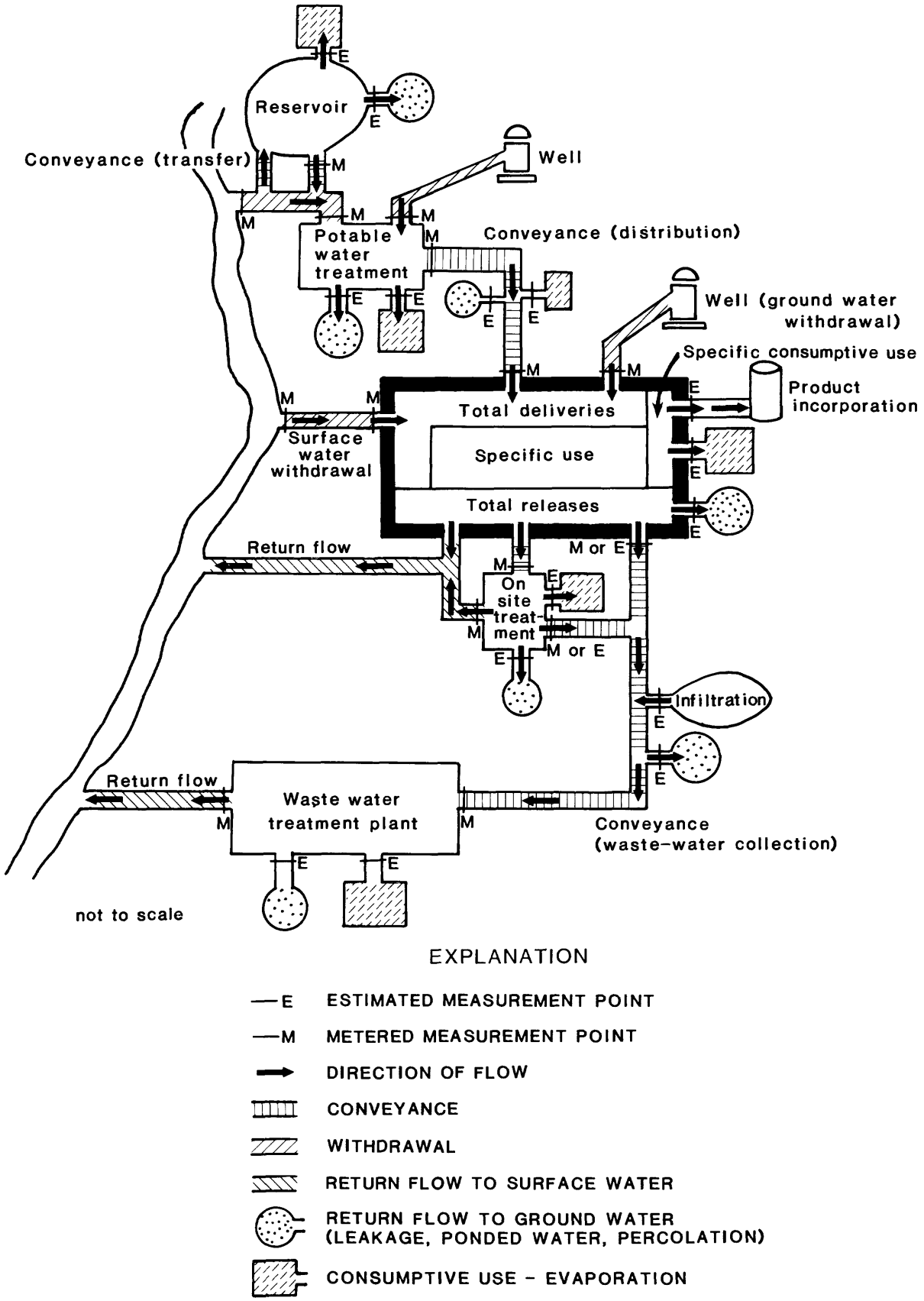

Figure 4.--Detailed water-use flow diagram.

expressed as average daily demand or volume withdrawn; (6) projected 1980 use and availability; and (7) comments about the system, which generally included size and location of storage tanks. This publication is being updated and will include data on the location and size of interconnections. The RIWRB (1974) also published data on the volume of water delivered by public supply systems to industrial and commercial customers. In 1986, the U.S. Army Corps of Engineers published a report on the same topic. However, slightly different techniques for collecting and analyzing the data were used by the two agencies and not all the major public water suppliers were included in the later report.

The RIDOH collects data for monitoring public drinking-water systems to ensure compliance with the water-quality standards that have been set both nationally by the U.S. Environmental Protection Agency (USEPA) and by the State of Rhode Island. The RIDOH collects and computer processes distribution data on the 89 community public water-supply systems, as well as several hundred noncommunity systems. Data on the community systems include: name and location of facility, population served, facility-design capacity, maximum and average daily demand, capacity of water-storage facilities, and water sources. These data are occasionally collected from construction plans for new systems that have been submitted for approval, but are primarily collected through sanitary surveys done at least every 3 years. The data are entered into the RIDOH data base as well as into the USEPA's computer data base, FRDS (Federal Reporting Data System).

The RIDEM periodically collects and computer processes treatment and return-flow data as part of the Rhode Island Pollutant Discharge Elimination System (RIPDES). The purpose of this program is to set limits for, and monitor the concentration of, pollutants discharged to surface waters through a permitting process. Data on the volume of water discharged are collected primarily to calculate the total loadings of specific chemicals to surface waters, and secondarily to monitor the volume of water discharged from wastewater-treatment facilities. The frequency of data collection depends primarily on facility size. The major dischargers are required to report monthly and the minor dischargers are required to report either annually, semi-annually, or quarterly. Collected information on treatment includes name, location, treatment types, and design capacity of the facility; and information on return flow includes monthly average and daily maximum discharge, quantity and concentration of monitored parameters of receiving waterbodies, and location of discharge pipe(s).

Currently, these agencies collect and process data to fulfill their own information requirements. Accordingly, accuracy of the data differ among the agencies, are collected at different intervals, and cover different years. In 1988, the Division of Planning recommended development of a broad water-resource-management plan. This comprehensive approach to water-resource planning goes beyond the combined objectives of the individual State agencies' (RIWRD, RIDOH, and RIDEM) current data-collection efforts. Data needed to meet the Division of Planning's water-resource management objectives that are not currently collected include (1) monthly withdrawals from each source by public suppliers, industries, commercial users, power generating plants, and irrigators; (2) monthly volumes of water sold to other public suppliers; (3) monthly volumes of water distributed by public suppliers to industrial, commercial, and domestic customers; (4) conveyance of potable water or wastewater across drainage-basin boundaries (interbasin transfers).

The Rhode Island Division of Planning (1988, p 2.5-6) has identified policies which it feels are important in setting up state-wide policy for water supply. These recommendations are that--

(1) Demand for water now and in the future must be more clearly defined and should reflect the client composition of the water systems using standard procedures that will facilitate both projections and comparisons to other systems;

(2) Withdrawals from both surface and ground water resources should be regulated based on an improved monitoring system. Withdrawal limitations should be based on the safe yield of surface water reservoirs and the recharge rate of ground water reservoirs;

(3) The state should prepare and maintain long-range plans and implementation programs for regions within the state, and improve coordination among different agencies and government levels involved in water resource issues; and

(4) A single central repository should be established for water resources and related data to see the needs of all agencies involved.

These recommendations are addressed in this proposed plan for the development of a water-use data program in Rhode Island and are considered along with existing State agency responsibilities for water-use data collection.

PLAN FOR DEVELOPING A WATER-USE DATA PROGRAM

Several key issues are involved in developing a comprehensive and efficient water-use data program. These can be divided into management and technical issues. Although resolution of management issues is beyond the scope of this report, they are discussed because of their importance in developing an effective program. Important management issues include establishment of water-use data-collection legislation; assignment of responsibility for program management; and development of an interagency coordinating committee. Important technical issues include establishment of minimum-data requirements; computer data-system requirements that include easy data entry, maintenance, updates, retrieval, and cross-referencing to other computer software and systems; and adoption of a water-use-data quality-control and quality-assurance program.

Legislative Authority

The first management issue concerns the establishment of water-use data-collection legislation. In order for a water-use data program to be effective and efficient, collection of data needs to be routine, periodic, comprehensive, and consistent. Without clear authority to collect water-use data, cost-effective data collection is impaired. Agencies may send out questionnaires to users, but whether or not the forms are returned at all, much less within a specified time to a specified degree of accuracy, is up to the user. Cooperation will be forthcoming from a number of users, but most users will prioritize their responsibilities with a voluntary form unlikely to be a high priority. Collection of data by site visits is time consuming and expensive.

A number of States have enacted legislation requiring collection of withdrawal data or specific-use data or both. These States have concluded that legislation was required to ensure timely and accurate data collection to support water-resource management. Table 15 presents the status of water-use legislation in the other five New England States and a few other States. In general, in those States where legislation has been enacted to manage withdrawals or use, current users who withdraw or use water in excess of a specified rate are required to register with a State agency. New users who withdraw in excess of a specified rate, or registered users who increase their rates of withdrawal, are required to obtain a permit. After the program has been in existence for a number of years, permits are usually required of everyone making withdrawals in excess of the specified rate. Reports of monthly withdrawals are required and are usually sent annually to the designated State agency. Permits are required for water withdrawals in Maryland and Minnesota (greater than 10,000 gal/d), Connecticut (new users only) and Delaware (greater than 50,000 gal/d), Massachusetts and New Jersey (greater than 100,000 gal/d), and in the Delaware River basin (by the Delaware River Basin Commission) (greater than 100,000 gal/d). Registration alone is required of users in New Hampshire (greater than 20,000 gal/d), and is required in the Delaware River basin for water users who withdraw between 10,000 and 100,000 gal/d. There is no legislative authority to collect water-use data in Vermont or Maine. There is, however, a State-funded two-year program to study water-use management in Maine.

If the State of Rhode Island legislates registration or permitting of withdrawals or use, it would be desirable to establish minimum rates of withdrawals to provide data that are significant with respect to Rhode Island hydrology. To obtain optimum information on water use, it may be desirable to require registration or permitting of those public supplies and self-supplied users who withdraw 10,000 gal/d or more and to require those on the public-supply system who use 50,000 gal/d or more to submit periodic reports on their water use. An adequate but less detailed data base will result from the registration or permitting of those who withdraw 50,000 gal/d or more and required reporting for usage in excess of 100,000 gal/d from public-supply systems.

Primary Agency Responsibility

The second management issue concerns assigning responsibility for administering the water-use data program. The objective of assigning responsibility to a single agency or an administrative committee is to develop and maintain a program that can provide for

Table 15.-Legislation for water-use data collection programs in effect as of 1990 in New England and other northeastern States.

[gal/d = gallons per day; MGL = Massachusetts General Law; NJSA = New Jersey Statutory Authority; PL = Public Law]

STATE	Permit or registration program[1]	Year program began	Minimum volume needing action gal/d	Frequency of pumpage records	Legislative reference
Connecticut	Registration permit-1982	1982	50,000	monthly	Connecticut General Statute 22A.354-378
Delaware	Permit	1973	50,000 in 1986; in 1973 all withdrawal	monthly	Title 7 Delaware Code Chapter 60
Maine	none	---	---	---	---
Maryland	Permit	1934	10,000	monthly	Title 08.05.02
Massachusetts	Registration Permit-1985	1985	100,000	monthly	MGL Chapter 21G 310 CMF 36.00
Minnesota	Permit	1937	10,000	monthly	State laws from 1937 to 1977
New Hampshire	Registration	1987	20,000	monthly	Chapter 402, Laws of 1983
New Jersey	Permit	1907	100,000	monthly	NJSA 58:IA-1 et seq, PL1981,CH 262
Vermont	none	---	---	---	---
Delaware River Basin Commission	Permit	1961	100,000	monthly	Delaware Rvr B Compact 1961
	Registration	1985	10,000	monthly	Amendmnt 85-19

[1]Registration required for existing users. Permits required for new users after indicated date.

the collection and computer processing of comprehensive and consistent data with a known reliability. Among the options available for collecting, computer processing, analyzing, and disseminating water-use data, one might consider (1) a single agency could be assigned to perform all of the work; (2) a single agency could be assigned to coordinate the work done by several agencies; or (3) an administrative committee, composed of representatives from the agencies, could be assigned to coordinate the work done by the agencies. As discussed previously, current Rhode Island legislation gives general responsibility for water-data management to several agencies but leadership responsibility to none.

In order to address the previously outlined issues in water-resource management, data for water-use activities from the point of withdrawal through the point of return flow need to be collected. This can be done by sending data-collection forms to users who (1) withdraw, (2) transfer, (3) treat to obtain potability, (4) distribute, (5) use, or (6) consume water, as well as those who (7) collect or (8) treat wastewater, or those who (9) return water to ground or surface water.

Data collection for these nine activities will be more effective if it is standardized and coordinated. Comparability will be more likely if the data are collected for the same time period, the water-use terms are defined, and the accuracy for meter readings or estimation methods is requested. Comprehensibility will be more likely if data is requested for all activities for all users. Cross-referencing data so that it can be linked with other computer systems also will be easier. These advantages can be realized by choosing any of the three administrative options listed above.

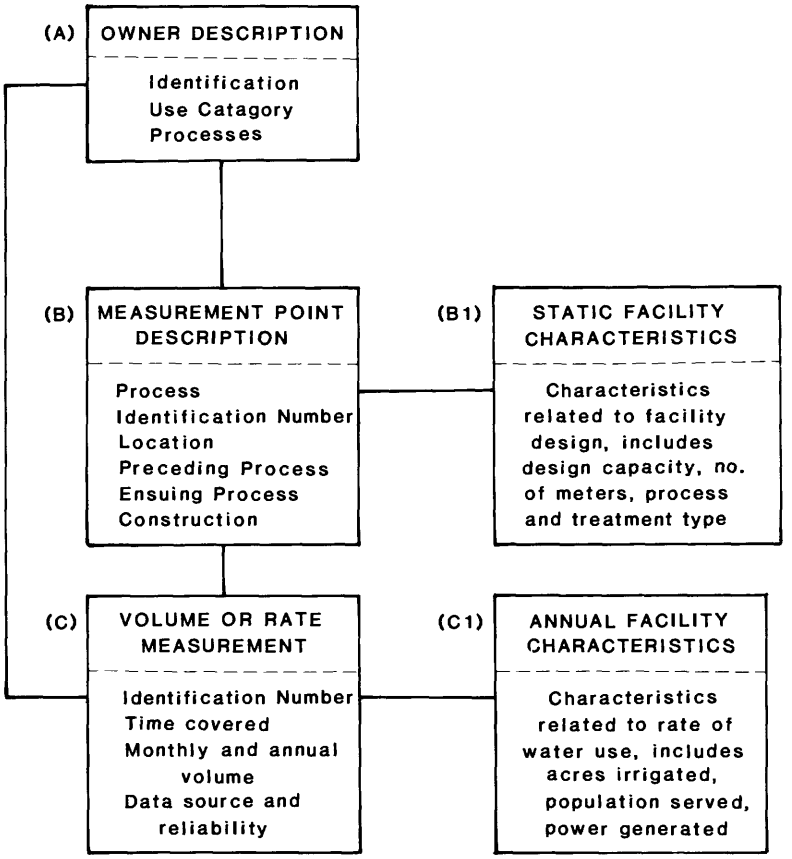

Figure 5.--General computer-file structure.

Data collection begins by sending data-collection forms to users. Ideally, these forms will have been developed in coordination with all agencies who have an interest in water-resource management. Data-request forms issued by other states commonly include a statement of authority for collecting the data; a deadline; a clear, concise, and succinct description of the required data and its qualifiers; and a name and phone number for users to call with questions. Some States (Minnesota and New Hampshire, for example) use one or two follow-up mailings shortly after the response deadlines have passed to insure optimum data returns.

Staff will be needed to answer questions from users about completing the form and for reviewing completed forms. The reviewed forms can then be computer processed. Efficient collection and proccessing of water-use data will be achieved if the forms are easy for the user to complete and for the water-use staff to process. The number of staff needed will depend on the specified rate of withdrawal or use, which determines the population of users receiving the forms.

Interagency Coordination

The third management issue concerns whether to develop an interagency-water-use-advisory committee. One of the recommendations of the RIDOP was "improvement of coordination among different agencies and government levels involved in water resource issues "(Division of Planning, 1988, p 2.6). One way to improve coordination is by creating a committee that would not only focus on data collection, but would address technical issues in comprehensive water-resource management.

Minnesota established such a coordinating committee in 1977, the System for Water Information Management Committee, which still meets. The Minnesota committee, which consists of representatives of several State and Federal agencies, (1) discusses

methods for improving data exchange through adopting data-collection and computer-processing standards; (2) informs each other of computer hardware and software acquisitions; (3) works together on areal data-collection efforts; and (4) develops ideas for projects that would benefit water-resource management as a whole, such as the development of index data bases for lakes, wells, and rivers.

Members of the interagency-water-use-advisory committee and their respective agencies, should benefit from the combined experience regarding data collection, computer processing, analysis, and dissemination. Additionally, this committee could promote the exchange of ideas and explore plans for studies of mutual interest, thus avoiding possible duplication of effort and expenditure. Committee members could include representatives from State agencies, such as RIDEM, RIDOH, RIDOP, RIWRB, GOHEIR, Public Utilities Commission (PUC), the Water Resources Coordinating Council (WRCC), Rhode Island Geographic Information System Coordinating Committee, University of Rhode Island Water Resources Center; Federal agencies, such as the Soil Conservation Service, Department of Agriculture, USEPA, U.S. Army Corps of Engineers, and the USGS; and nongovernmental organizations, such as conservation or environmental groups. In an advisory committee, the role of facilitator, or chair, is especially critical and can be a formal appointment or informally rotate among the agencies.

Determination of Minimum-Data Requirements

The types of data collected as part of an ideal comprehensive water-use data program were discussed in the water-use data section and are summarized in tables 2-14. The six processes described include: withdrawal, specific use, return-flow, consumptive use, treatment, and conveyance (transfers, distribution, and wastewater collection). Clearly, it is not feasible to collect data from all users, but, as discussed previously, it is desirable to collect data from those who withdraw water or use water or both at rates greater than some minimum rate considered significant in terms of Rhode Island's hydrology.

Frequency of recording intervals, monthly or annual, is an important factor because it affects the usefulness of the data. Annual summaries of water use may be adequate for determining statewide use and overall water-use trends. However, monthly summaries would allow evaluation of seasonal use and assessment of the effectiveness of conservation measures.

The frequency with which the State collects recorded water-use data also must be considered because it affects the cost of data collection. Recorded water-use data may be collected every year, every other year, or less frequently. During years of normal precipitation, water use is unlikely to differ significantly from previous years unless a large industry or power-plant is placed in operation, for example. However, during years of extreme weather, water use can differ considerably from previous years, particularly if drought restrictions are in effect. Initially, it may be prudent to collect data annually in order to evaluate the effects of seasonal and climatic variations or population growth on water use. An advantage to annual data collection is that users become more familiar with completing the forms, plan for it by enhancing compatibility of their records with the forms, and usually designate the same person to handle it--all of which improves the data. Almost all States in the Northeast that have a permit or registration program collect monthly data annually.

Computer Processing

The advantage of computer processing is the ease with which a complex and comprehensive data set can be sorted or resorted by owner, by use type, by county and city, or by resource to obtain different subsets. A well designed data system can be updated at any time and can produce summaries of the data in a variety of useful formats, including tables, maps, and graphs. Water-use summaries, data subsets, or even the entire data file can be made available to other users, both within or outside an agency, in a form of the agency's choosing--hard copy, tape, or disk.

However, the real power of a computer becomes obvious as one progresses from the simple tasks outlined above to more complicated and sophisticated analyses. A variety of computer statistical packages can be used to evaluate the data for accuracy; indicate anomalies; detect trends over time and relation among specific characteristics, such as rainfall and total use, lot size and residential use, and wastewater charges and industrial use. The computer also can generate the data-collection forms, complete with mailing address and the previous year's data to be updated by the user. Computer-processed water-use data can be linked to a geographic information system

(GIS), which is an automated mapping system, to generate maps showing the geographic distribution of water resources, water withdrawals, and water return-flow. The utility of a computer data system is limited only by the imagination and skill of its designer(s).

A suggested general computer-file structure is illustrated in figure 5. The system includes (A) files to describe facilities or owners; (B) files to describe measurement points, such as wells, reservoir intakes, or discharge pipes; and (C) files for recording volume or rate of withdrawal, specific use, and return flow. This file structure is similar to the USGS's Site-Specific Water-Use Data System (SSWUDS), and to the state water-use data bases in New Hampshire and Connecticut.

The facility or owner description files (A), which generally require infrequent updating, store associated unique identification numbers and descriptive data on the location, use-type, and reference to all processes associated with the owner. The measurement-point description files (B) store associated unique identification numbers, and describe the location and construction for all points at which measurements or estimates of volume or rate can be made. Related to the measure-point description files, are static facility characteristics files (B1) that contain descriptive information on treatment plants and conveyance systems which do not change yearly, such as design capacity, or treatment types.

The third set of files, the volume or rate measurement files (C), contain the monthly and annual volumes for each process and documentation as to their accuracy and reliability. Related to the volume or rate measurement files are annual facility characteristics files (C1) that contain descriptive information which changes yearly, such as population served, acres irrigated, or power generated. In some cases, data are available only as a total for a facility rather than from specific wells or intake pipes. Therefore, the volume or rate measurement file should be related to both the owner description file and the measurement-point description file.

Additional refinements on this general structure can be developed in accordance with the resources available to the agency charged with water-use data management. The State may wish to initially use SSWUDS for its water-use data program to experiment with this type of file structure. If the data base that the State subsequently develops is compatible with SSWUDS, then the State's data base could be used more easily as a source for the USGS's 5-year estimated-water-use reports. User manuals, which include a data dictionary, need to be available to all users.

Ideally, the computer-processing software (computer programs) for the water-use data system should be easy to use. This can be accomplished through the development of menus and help files that assist the user through the steps needed to accomplish the user's objective. Ease and flexibility of report generation should be considered in developing or purchasing software. Computer generation of standard data-collection forms can streamline data collection. Additional refinements might include generation of forms that require entry of data in machine-readable format.

Data-processing-software development includes planning for entry of data for new measurement points, maintenance of the data base, and update of data for previously processed measurement points. Data maintenance includes continual refinement of the data-system structure and processing software. Data-processing software need to be flexible to changes in minimum-data requirements and upgrades in computer software and hardware (machines). Periodic update of the annual or monthly volume or rate measurement files (C) and their associated facility characteristics files (C1) will need to be performed. In addition, a separate strategy for infrequent update of owner (A), measurement-point description (B), and static facility characteristics (B1) files will be needed.

The water-use data base as outlined in this report requires that data be obtained from a number of different agencies, such as RIDOH, RIDEM, and RIWRB. Because of this, it is important that a standard system of unique identification numbers for each facility and measurement point be used by all participating agencies. Standardization of measurement-point identifiers will allow the data collected and processed by one agency to be cross-referenced with the data of another agency. This will permit automated data transfer from other agencies to a common water-use data base on a regular basis, such as return-flow data from the RIPDES program. Additionally, statistical comparisons between different sets of the same type data, such as RIDOH average annual demand and the reported calculated average annual demand will be possible. Associated with this number would be a brief description of the facility or measuring point, and reference numbers used by the major agencies throughout the state.

A data-base manager is essential in establishing uniform data-entry, update and retrieval procedures. The data processing software needs to be easy to use and efficient. The structure of the data base needs to be designed to meet the needs of the regulatory agency(ies) collecting the data and formatted to be compatible with other State and Federal data bases.

Quality Assurance/Quality Control

Data collection needs to be well managed to form the basis upon which to make sound water-resource management decisions. There are three major objectives in a quality-assurance and quality-control program: (1) to determine the reliability and consistency of currently collected data, (2) to develop methods to eliminate processing errors and catch basic inaccuracies within the data, and (3) to refine the consistency of water-use data through development and implementation of data-reporting and analysis standards.

An initial approach to ascertain the reliability of water-use data is to ask water managers and users how they obtain and report their water-use data. The results of such interviews provide valuable insight as to the variety and reliability of methods used to meter and estimate water use. This information would allow reliability codes to be assigned to the reported water-use data. The development of standard reliability codes that are printed on coding forms will encourage consistency in data collection both over time and among different users.

Development of a protocol for comparing raw data with computer-processed data will minimize data-entry errors. Computer software could be developed to--

(1) Determine geographical accuracy of data sites by ensuring that sites with a specified latitude and longitude are associated with the correct drainage basin, ground-water reservoir, city, and county.

(2) Check that the sum of the monthly reports equals the annual total for a given site or user.

(3) Check for consistency with historical data, for instance a change greater than 5 or 10 percent from the previous reporting period would require investigation as to whether the change was real or due to errors.

(4) Compare reported water-use data with current independent variables such as temperature, rainfall, population changes, industrial production, withdrawal restrictions, and development, with those generated in previous year.

(5) Compare monthly reported water-use data with historical monthly and seasonal water-use data for similar patterns.

The final phase of the quality control/quality assurance program would be to recommend methods to users that would improve consistency, accuracy, and documentation of water-use data. Experience in this program would promote development of methods for use by the agencies to perform field work and analytical projects that would further refine the water-use data. The USGS is encouraging the development of quality-assurance and quality-control standards for water-use data collection and computer processing compatible with the USGS's Water-Use Information Program. Development of a water-use data program that make use of common standards for data collection and processing would make available Rhode Island's data in response to water-use data needs at not only the local and State levels, but at the interstate, regional, and national levels as well.

SUMMARY

Current legislative authority for water-resource management in Rhode Island is distributed among several agencies. Three of these--the Water Resources Board (RIWRB), the Department of Health (RIDOH), and the Department of Environmental Management (RIDEM)--collect data for some water-use processes.

The RIWRB intermittently collects, but does not computer process, information on the withdrawal and distribution of water by 33 of the 89 community public water-supply systems. Collected withdrawal information includes descriptions of sources; treatment information includes treatment types; and distribution information includes maximum, minimum, and average daily demand, area and population served, per-capita use for each municipality served, number of active services, capacity of water-storage facilities, distribution-pipe size and materials, source of purchased water, and water-rate schedules (retail or wholesale).

The RIDOH collects and computer processes distribution data on the 89 community public water-supply

systems, as well as several hundred noncommunity systems. Data on the community systems include name and location of facility, population served, facility-design capacity, maximum and average daily demand, capacity of water-storage facilities, and water sources. These data are occasionally collected from construction plans for new systems that have been submitted for approval but are primarily collected through sanitary surveys done at least every 3 years.

The RIDEM periodically collects and computer processes treatment and return-flow data as part of the Rhode Island Pollutant Discharge Elimination System program. The frequency of data collection primarily depends on facility size. The major dischargers are required to report monthly, and the minor dischargers are required to report either annually, semiannually, or quarterly. Collected information on treatment includes name, location, treatment types, and design capacity of the facility; and information on return flow includes monthly average and daily maximum discharge, quantity and concentration data with respect to receiving water bodies, and location of discharge pipe(s).

Currently, these agencies collect data to fulfill their own information requirements. Accordingly, accuracy of the data differ among the agencies, are collected at different intervals, and cover different years. In 1988, the Division of Planning recommended development of a broad water-resource-management plan. This comprehensive approach to water-resource planning goes beyond the combined objectives of the individual State agencies' (RIWRD, RIDOH, and RIDEM) current data-collection efforts. Data needed to meet the Division of Planning's water-resource management objectives that are not currently collected include (1) monthly withdrawals from each source by public suppliers, industries, commercial users, power generation plants, and irrigators; (2) monthly volumes of water sold to other public suppliers; (3) monthly volumes of water distributed by public suppliers to industrial, commercial, and domestic customers; and (4) conveyance of potable water or wastewater across drainage basin boundaries (interbasin transfers).

Several key issues are involved in developing a comprehensive and efficient water-use data program. These can be divided into management and technical issues. Although resolution of management issues is beyond the scope of this report; they are discussed because of their importance in developing an effective program. Important management issues include establishment of water-use data collection legislation, assignment of responsibility for program management, and development of an interagency water-use advisory committee.

The first management issue concerns whether to establish legislation that would require registration or permitting of users whose withdrawals or use exceed a specified volume or rate. For example, New Hampshire requires registration for water use that equals or exceeds 20,000 gal/d per facility; New Jersey requires permits for withdrawals that equal or exceed 100,000 gal/d per facility. States that have enacted water-use data collection legislation have concluded that such legislation is required to ensure timely and accurate data collection to support water-resource management.

The second management issue concerns assigning responsibility for administering the data-collection program. Several options are available for collecting, computer processing, analyzing, and disseminating water-use data: (1) A single agency could be assigned to perform all of the work; (2) a single agency could be assigned to coordinate work done by several agencies; and (3) an administrative committee, composed of representatives from the agencies, could be assigned to coordinate the work done by the agencies. The objective of assigning responsibility to a single agency or an administrative committee is to develop and maintain a program that can provide for the collection and computer processing of comprehensive and consistent data with a known reliability.

The third management issue concerns whether to develop an interagency water-use-advisory committee. This committee, unlike the one mentioned in (3) above, would focus on the data collection and also would address technical issues in overall water-resource management. Members of this committee and their respective agencies could benefit from their combined experience in data collection, computer processing, analysis, and dissemination. Additionally, this committee could promote the exchange of ideas and explore plans for studies of mutual interest, thus avoiding a possible duplication of effort and expenditure. Committee members could include representatives from State agencies, such as the RIDEM, RIWRB, RIDOH, RIDOP and the Public Utilities Commission; Federal agencies, such as the Soil Conservation Service, Department of Agriculture, USEPA, U.S. Army Corps of Engineers, and the USGS; and nongovernmental organizations, such as conservation or environmental groups.

Three additional issues involve technical aspects of the water-use data program. These issues include establishment of minimum-data requirements, establishment of data-processing standards, and adoption of a quality-control and quality-assurance program.

The first technical issue involves determining the minimum data needed to adequately document the withdrawal, specific-use, return-flow, consumptive-use, treatment, and conveyance processes. Included in this issue are (1) establishment of the minimum specified volume required for permitting or registration, if this option is chosen; (2) determination of whether monthly or annual water-use data are required; and (3) determination of whether the data need to be collected, every year, every 2 years, or less frequently.

The second technical issue concerns computer processing of the data. A data-base manager is essential for establishing uniformity of data-entry, updating, and retrieval procedures. The data base needs to be easy to use and efficient. The structure of the data base must be designed to meet the needs of the regulatory agency(ies) collecting the data and must be compatible with the appropriate State and Federal data bases. The data-base structure might consist of a series of files that describe the user, measurement points, and volume.

The third technical issue concerns adoption of quality-assurance and quality-control programs that would determine the reliability and improve the accuracy of collected data.

The development of a uniform statewide water-use data program in Rhode Island depends on the resolution of several issues. The key to resolving these issues is the formation of a coordinated approach among local, State, and Federal agencies. Data collected and analyzed by several agencies need to be coalesced to address water-resource-management issues. Equally important is the development of a computerized system that will enhance the entry, analysis, and dissemination of data. The USGS's National Water-Use Information Program has developed a site-specific water-use data base that may be useful to the State while the State develops a data-base system that meets their specific needs.

REFERENCES CITED

Mann, W.B. IV, Moore, J.E., and Chase, E.B., 1982, A national water-use information program: U.S. Geological Survey Open-File Report 82-862, 12 p.

Rhode Island Division of Planning, 1988, Water Supply Policies for Rhode Island, State Guide Plan Element 721, Report Number 61, Providence, Rhode Island, 97 p.

Rhode Island Water Resources Board, 1971, Public Water Systems - Inventory and Characteristics of Public Water Supplies, Water and Related Land Resources Planning Task No. 2, Providence, Rhode Island, (March, 1971), 98 p.

Rhode Island Water Resources Board, 1974, Rhode Island Industrial Water, Providence, Rhode Island, (October, 1974), 66 p.

Solley, W.B., Merk, C.F., and Pierce, R.R., 1988, Estimated use of water in the United States in 1985: U.S. Geological Survey Circular 1004, 82 p.

U.S. Army, Corps of Engineers (New England Division), 1986, Industrial/Commercial Water Consumption from Public Water Supply Systems, Section 22, Rhode Island, Boston Massachusetts (July, 1986), 80 p.

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