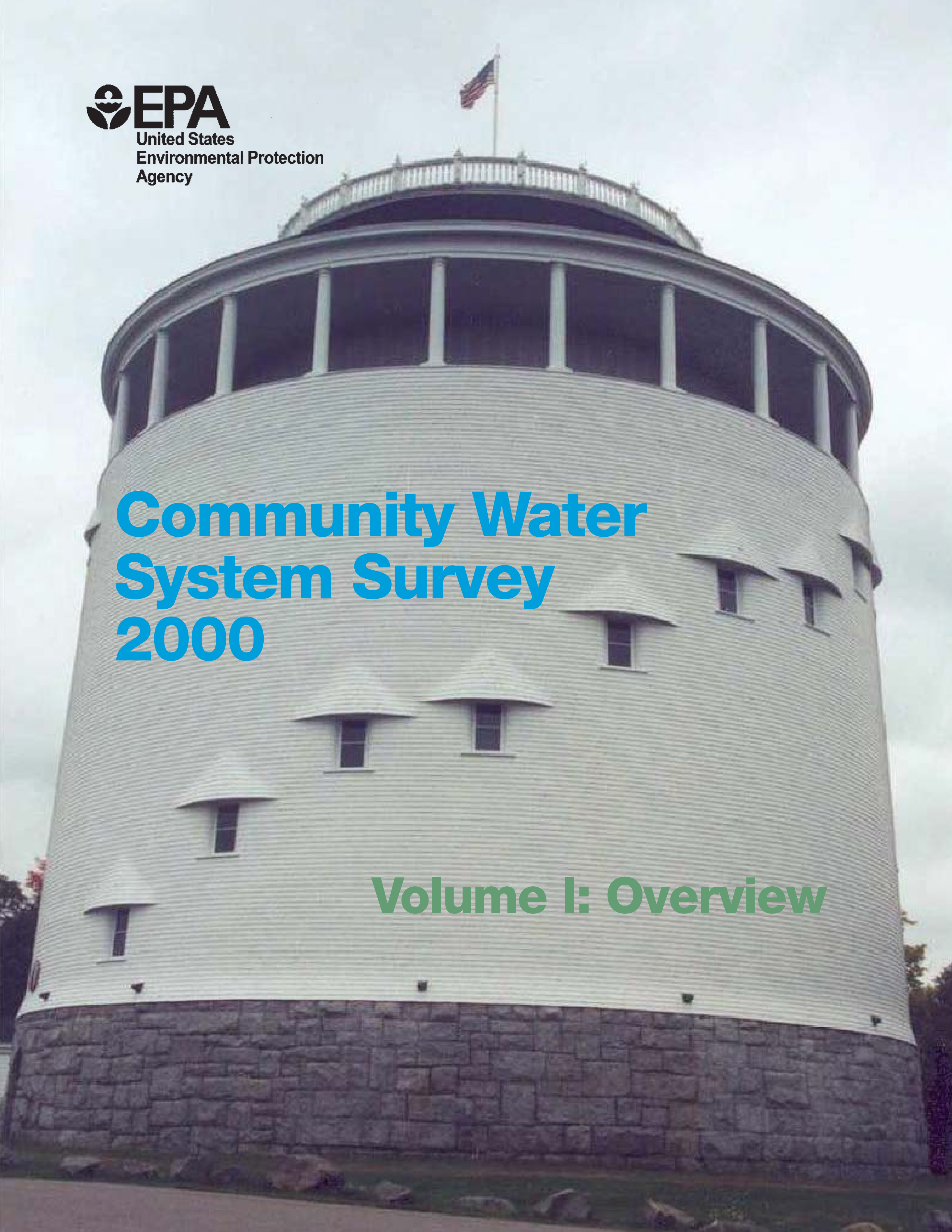
United States
Environmental Protection
Agency

Community Water System Survey 2000

Volume I: Overview



Office of Water (4607M)
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Cover Photo: *Bangor, Maine Water District Thomas Hill Standpipe*. Designed by Ashley B. Tower of Tower and Wallace of New York and Holyoke, MA, the standpipe was built during 1897 by Major James M. Davis on land once owned by the Thomas brothers.

The standpipe is actually two structures: a 1.75 million gallon riveted steel tank enclosed by a 110-foot tall wooden jacket. The tank itself is 75 feet in diameter and 50 feet tall. It is topped by a "carousel," a three-ton steel drum from which 24 iron trusses reach to the sides of the building.

The wooden jacket is 85 feet in diameter. It consists of twenty-four 1-foot x 1-foot x 48-foot hard pine main posts covered by 42,000 board-feet of hard pine and 220,000 cedar shingles. The jacket sits atop a stone foundation 9 feet high and 3 1/2 feet thick. A 100-step winding staircase leads to the 12-foot wide promenade deck overlooking the City of Bangor and surrounding communities.

The standpipe is topped by a 38-foot high flagpole and a railing consisting of 192 banisters that give it the look of a large wedding cake or crown when lit at night. The entire structure was built in just 6 months.

Listed on the National Register of Historic Places and designated as an American Water Works Landmark, the standpipe continues to store water and regulate water pressure for Bangor's downtown.

Photo by Brian Rourke

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Acknowledgements

Many dedicated owners, operators, and managers of community water systems made this survey possible. We would like to thank the more than 1,200 water systems that devoted valuable time to searching through records and completing questionnaires.

The Community Water System Survey was managed by Brian C. Rourke of the EPA Office of Ground Water and Drinking Water (OGWDW). He was assisted with questions related to very large systems by Yvette Selby, also of OGWDW.

The Cadmus Group, Inc. served as prime contractor for this project. Abt Associates, Inc., a subcontractor, was responsible for data processing and contributed to the survey design and sampling plan. Three subcontractors—International Studies and Training Institute, Inc., McNenny Environmental Engineering and Consulting, and Southwest Environmental Engineering—conducted the site visits to collect data from small systems. Norfolk Data, Inc. entered the data into an electronic database.

EXECUTIVE SUMMARY

Study Purpose

The U.S. Environmental Protection Agency (EPA) conducted the 2000 Community Water System (CWS) Survey to obtain data to support its development and evaluation of drinking water regulations. EPA developed the survey database to provide critical data to support regulatory development and implementation. The Agency plans to use the data for regulatory, policy, implementation, and compliance analyses.

Regulatory Development Analyses. EPA must satisfy the requirements of various statutes and regulations for analyses of proposed regulations under the Safe Drinking Water Act (SDWA). The survey provides data on water system operations and finances that are critical to the preparation of these analyses.

Policy Development Analyses. The survey is designed to collect financial and operational data on the full range of water systems to support a variety of policy and guidance initiatives. EPA also uses the data to respond to periodic requests from Congress, federal agencies, and the public for information on the water supply industry.

Regulatory Implementation Analyses. The survey data, along with data from the Drinking Water Infrastructure Needs Survey, can be used to assess the financial capacity of water systems in general, and of small systems in particular.

Compliance Analyses. EPA may use the survey data to develop profiles of operational and financial characteristics for different types of water systems, which can be compared to the Agency's database of compliance records in the Safe Drinking Water Information System (SDWIS). The objective of these analyses would be to identify characteristics of systems that may lead to compliance problems in the future. (The data from the survey will not be used in any enforcement actions.)

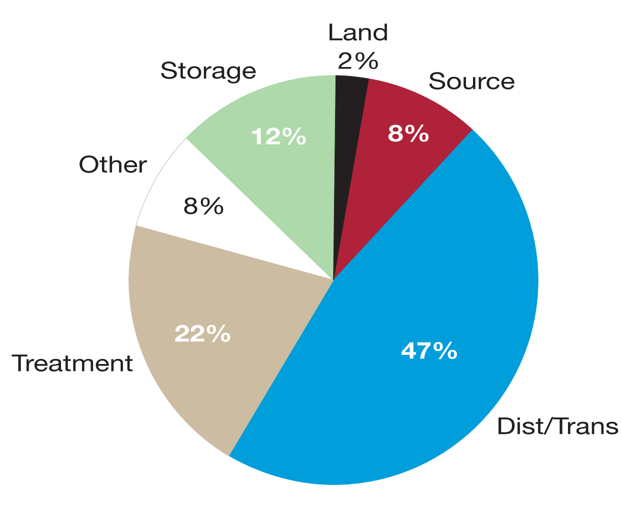
Trends and Key Findings

Most of the operating characteristics of community water systems are unchanged from 1976, when the first CWS Survey was conducted. The vast majority of systems are small and privately owned, but most people still receive their water from large publicly owned systems.

Nevertheless, there have been important changes since the first survey was conducted. They include an increase in the percentage of systems that treat their water and an overall improvement in water system financial performance. Key findings of the 2000 Survey include the following:

- **While systems continue to make substantial capital investments to fund water quality improvements, totaling more than $50 billion over the past 5 years, investment in treatment accounts for only 22 percent of systems' total capital investments**. Among publicly owned systems, 23 percent of investment was for treatment. Sixteen percent of privately owned systems'

Type of Capital Expense



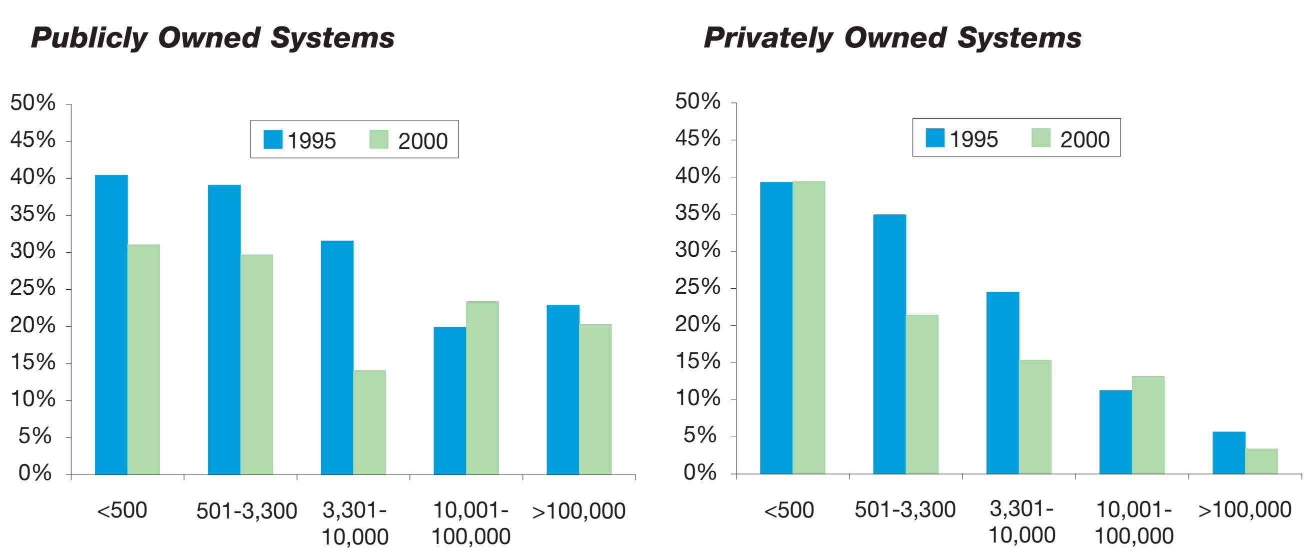
investment was for treatment. The largest share of the investment went toward distribution mains and transmission lines. Storage capacity accounted for an additional 12 percent of the total investment. The data suggest that differences between publicly owned and privately owned systems have more to do with size—publicly owned systems tend to be larger—than with ownership. (See page 18 and Volume II, Tables 69-78.)

- **The percentage of systems operating at a loss declined for most size categories between 1995 and 2000.** Overall, average revenue and expenses increased by slightly more than inflation over the past 5 years, although many systems witnessed real declines in both revenue and expenses per gallon. The percentage of systems operating at a loss or with a deficit across all size categories is 30 percent, down from approximately 40 percent in 1995. (See page 36 and Volume II, Tables 46-66 for details on system revenue and expenses.)
- **The Drinking Water State Revolving Fund is an important source of funds for capital improvements.** Although most of the money for capital spending comes from other sources, the Drinking Water State Revolving Fund (DWSRF) has become an important source of funds for the few years it has existed. In the years of the program included in this report, approximately 17 percent of publicly owned systems relied on the DWSRF to finance at least a portion of their capital improvements. This includes systems that received traditional DWSRF loans and systems that received loans in which all or a portion of the principal repayment is forgiven. Nearly 20 percent of all capital costs for publicly owned systems serving populations of 10,000 or fewer were financed through the DWSRF. (See page 18 and Volume II, tables 79-81.)

Percentage of Capital Expenses Financed by the Drinking Water State Revolving Fund, for Publicly Owned Systems Serving up to 10,000 Persons

Population Served	Percentage
Less than 500	28%
501-3,300	35%
3,301-10,000	5%
All Systems <500 - 10,000	**19%**

Percentage of Systems With Deficits or Losses by Population Service Categories



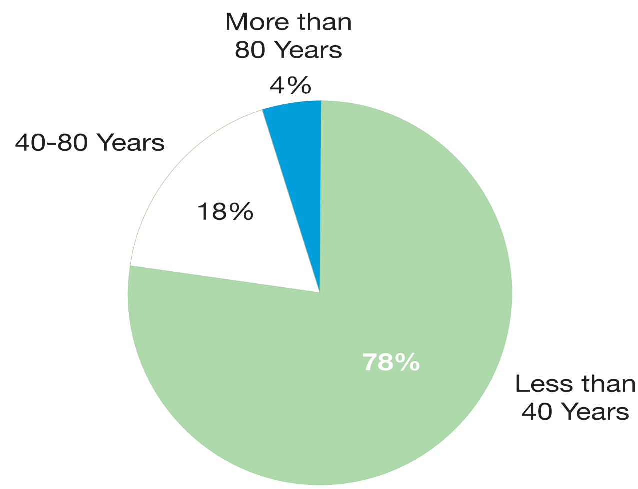
- **The percentage of systems that provide treatment rose between 1976 and 2000.** This trend is consistent with SDWA's emphasis on water quality monitoring and treatment. By the time of the 1996 Amendments to the Act, substantial progress had been made in reducing the number of systems that do not provide treatment. This trend continued through 2000 among small systems, but slowed among larger systems. The end of the decline among larger systems may suggest that they now have treatment in place. (See page 35 and Volume II, Table 9.)

- **Very few small systems use increasing block rate structures.** Only 7 percent of systems serving 500 or fewer persons use an increasing block rate to charge for water. Small systems are much more likely to use uniform rates or to charge a flat fee for water. Larger systems are more likely to use increasing block rates, with over 25 percent of systems serving more than 100,000 persons using these rates. (See page 29 for further detail.)

Percentage of Systems That Use Increasing Block Rates for Residential Customers

Population Served	Percentage
Less than 500	7.0%
501-3,300	15.4%
3,301-10,000	13.4%
10,001-100,000	18.3%
More than 100,000	27.5%

Distribution Mains, by Age



- **While the total number of community water systems increased between 1995 and 2000, the number of small systems declined.** The number of systems serving populations of 100 or fewer declined by 8 percent. The number of systems serving more than 3,300 persons, on the other hand, increased by 20 percent. (See page 35 for further detail.)

- **Systems continue to invest considerable funds in their distribution networks.** Over the past 5 years, systems replaced over 50,000 miles of the more than 1.8 million miles of pipe in their networks, at a cost of more than $4 billion. The pipe in the ground is relatively new; most of it is less than 40 years old, while less than 5 percent is more than 80 years old. (See page 14 and Volume II, Tables 35-38.)

Final Status of Systems Selected in 2000 CWS Survey						
	Population Served					
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000	Total
Sample Selected	394	209	296	510	397	**1,806**
System merged with another system in sample	1	0	0	3	2	**6**
Ineligible system	26	0	1	1	2	**30**
Refusals and invalid responses	28	0	127	222	142	**519**
Received	336	207	168	284	251	**1,246**
Response Rate (percent)	85%	99%	57%	56%	63%	**69%**

Survey Methodology

This is the fifth edition of the CWS Survey. EPA previously collected data in 1976, 1982, 1986, and 1995. As with past surveys, the Agency collected information on the most important operational and financial characteristics of community water systems. EPA took steps to improve response rates, ensure accurate responses, and reduce the burden of the survey on systems, especially small systems serving 3,300 or fewer persons. EPA sent water system experts from the Cadmus Group and 3 other companies to collect data from small systems. It mailed the survey to medium and large systems, and provided extensive assistance through a toll-free telephone hot line.

EPA started the 2000 Survey in the summer of 1999 with the development of preliminary questionnaires and a sampling plan. The survey was designed to collect data for the year 2000. Full-scale data collection occurred from June to October 2001. The overall response rate was 69 percent; 90 percent of small systems selected participated in the survey.

1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) defines a community water system as a public water system that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. Community water systems are a tremendously diverse group that resists being described in terms common to all. They range from very small, privately owned systems whose primary business is something other than water supply (such as mobile home parks) to huge, publicly owned systems serving millions of people.

The unusual architecture of the Thomas Hill Standpipe in Bangor, Maine (cover illustration) illustrates this diversity and the difficulty of characterizing large numbers of systems in more or less uniform groups. The Thomas Hill Standpipe is hardly everyone's idea of what a water storage facility should look like. Yet distinguishing and unusual features are to be found in water systems throughout the country. Because EPA is charged with protecting the water quality of over 50,000 of these systems, the challenge of this report is to describe water systems according to certain basic characteristics while still recognizing their incredible diversity.

EPA periodically collects information on the financial and operating characteristics of the public water supply industry to support the regulatory development process. The Agency conducted the 2000 Community Water System (CWS) Survey as part of this effort. EPA will use the information from this survey to prepare Economic Analyses (EAs) in support of regulatory development and to analyze economic and operating factors that affect national drinking water quality.

This report presents the information collected from the 2000 CWS Survey in two volumes. Volume I, the Overview, provides perspective on the industry by extrapolating the survey data to present a national picture of water systems. It presents the data by system size, ownership, and source of water. It also compares the 2000 data to similar data from the CWS Surveys of 1995, 1986, 1982, and 1976. Volume II, the Detailed Report, summarizes the survey findings in a series of tables that display national estimates of water system characteristics with particular application to regulatory development. Volume II also provides a detailed methodology and copies of the survey instruments.

Background

The CWS Survey was designed to collect operating and financial information from a representative sample of community water systems. To reduce the survey's burden on small systems, the data were collected from systems serving 3,300 or fewer persons through site visits by water system professionals. Systems serving more than 3,300 persons received questionnaires in the mail. Water system professionals were assigned to each system that received a mailed questionnaire to help the system respond to the survey's questions. A toll-free telephone number and an e-mail address also were provided to the systems for technical support.

Planning and design of the survey began in the summer of 1999. Through a series of planning sessions, preliminary versions of the survey instrument were developed. A separate version of the questionnaire was developed for systems serving more than 500,000 persons. These systems were asked additional questions about concentrations of several contaminants in raw and finished water and about average well depth. Questions that would not apply to very large systems were excluded from their version of the questionnaire. A pre-test of the questionnaires was conducted in July 2000 to gauge respondents' reactions to the draft questionnaires. This was followed by a full-scale pilot test in April and May 2001. Two clusters of small systems were selected for site visits and questionnaires were mailed to 40 systems.

The 2000 Survey collected some new data. Detailed data on source capacity were collected for the first time. New

Summary of 2000 CWS Survey Questionnaire	
Question Number	Summary of Question
General Information	
1	Contact information, including name, telephone number, and e-mail address of person completing the questionnaire
2	Year for which operating and financial data are provided
Operating Information	
3	System ownership
4	Form of government for publicly owned systems
5	Annual water deliveries, including unaccounted for water
*6	Names of other water systems that purchased this system's water
7	Annual production, by source
8	Maximum water produced in a 24 hour period
*9	System schematics
*10	Data on water source by type, including daily production by source
11	Indicates whether system treats its water
12	Average daily production, peak production, and design capacity for system's treatment facilities
*13	Treatment objectives
14	Treatment practices
*15	Contaminant concentrations (asked only of systems serving more than 500,000 people)
*16	Water treatment waste residual management
*17	Treatment plant operators and SCADA
18	Water storage, including type of storage and capacity`
19	Distribution mains, including miles of pipe in place by diameter, miles replaced and its cost, and age of pipe
20	Number of connections and customers served, by customer class
*21	Map of service area
*22	Indicate whether system has a cross-connection control program
*23	Indicate type of cross-connection control program
*24	Indicate elements included in cross-connection control program
Financial Information	
26	Water sales and water related revenues, by customer class
27	Non-water related revenue
28	Average annual water bill
29	Billing structure
30	Use lifeline rates
31	Water system expenses
32	Water system capital investment for previous 5 years

*New information

Final Status of Systems Selected in 2000 CWS Survey						
	Population Served					
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data on treatment were collected, including treatment objectives and the management of water treatment residuals. Data on contaminant concentrations were collected for systems serving over 500,000 persons. New information was collected on the type of storage and its capacity, as well as elements of cross-connection control programs.

The survey also collected system schematics and maps. Some information collected in the past was not collected in the 2000 Survey, including data about source water protection, operator certification, and systems' financial assets and liabilities.

The survey sample was drawn from the approximately 52,000 systems in the 50 states and the District of Columbia in the Safe Drinking Water Information System (SDWIS). The survey used a stratified random sample design to ensure the sample is representative. The sample was stratified to increase the efficiency of estimates based on it. Systems were grouped based on the populations they serve and their sources of water. (Details of the sampling plan are provided in Volume II.) To limit travel costs, systems serving up to 3,300 persons were selected in geographic clusters in a two-stage design. A sample of 1,806 systems was selected, including a census of all systems serving populations of 100,000 or more.

Full-scale data collection was conducted during the summer of 2001. Site visitors were sent to approximately 600 small systems and questionnaires were mailed to approximately 1,200 medium and large systems. Approximately 69 percent of the sampled systems responded to the survey. The above table summarizes the final status of the systems in the sample. Each completed questionnaire was subject to a thorough review by senior water system experts before being processed for data entry.

Data Presentation

Volumes I and II of the CWS Survey Report present tabulations of the data collected by the CWS Survey. In Volume II, the data are generally presented according to eight service categories denoted by size. Systems are assigned to each size category based on the population served, either directly (i.e., retail customers), or through the sale of water to other public water suppliers (i.e., wholesale customers). The detailed size categories are:

- 100 or fewer
- 101-500
- 501-3,300
- 3,301-10,000
- 10,001-50,000
- 50,001-100,000
- 100,001-500,000
- More than 500,000

Systems serving up to 10,000 persons are considered small. The eight size categories are different from the categories used in 1995. The 1995 Survey split the 501-3,300 category into two: 501-1,000 and 1,001-3,300. The 1995 Survey also combined the 100,001-500,000 and greater than 500,000 categories. Volume I presents data by fewer size categories:

- 500 or fewer
- 501-3,300
- 3,301-10,000
- 10,001-100,000
- More than 100,000

These size categories support the Agency's various analytic requirements, as discussed below. Data on treatment plants also are presented by the average daily production, in millions of gallons. These data are shown by seven size categories:

- 0.01 millions of gallons per day (MGD) or fewer
- 0.01-0.10 MGD
- 0.1-1.0 MGD
- 1-10 MGD
- 10-100 MGD
- More than 100 MGD

Data tabulations also are presented according to ownership (public or private) and primary water source. Systems are classified based on their *primary* source: ground water, surface water, or purchased water. For example, a system is classified as a ground water system if it receives more of its water from ground water sources than from surface or purchased sources. Because systems can have three sources of water, some may receive less than one-half of their water from their primary source.

Many of the tables in Volume II present the 95 percent confidence intervals for each cell in the table. As discussed in Volume II, the confidence intervals are relatively large in some cases, due to the diversity of community water systems. Although characterizing the overall level of precision is difficult due to the large number of estimates provided and the diversity of water systems, the sample generally met the precision targets of the sampling plan. For example, the confidence intervals for estimates of average revenue and expenses is approximately ± 10 percent of the average. The estimated confidence interval for the portion of systems providing treatment is approximately ± 5 percentage points. (See Volume II for a detailed description of the sampling plan and precision targets.)[1]

Intended Uses of CWS Survey Data

The 2000 CWS Survey database was developed primarily to provide the Agency with critical data to support its regulatory development and implementation efforts. The Agency last undertook this effort in 1995, and before that in 1986, to coincide with the 1986 SDWA Amendments.

EPA conducted the 2000 CWS Survey to determine the current baseline of operational and financial characteristics of the water supply industry, last established by the 1995 CWS Survey. By comparing the results of this survey with the 1995 survey, changes in water industry operations and expenses since 1995 can be measured.

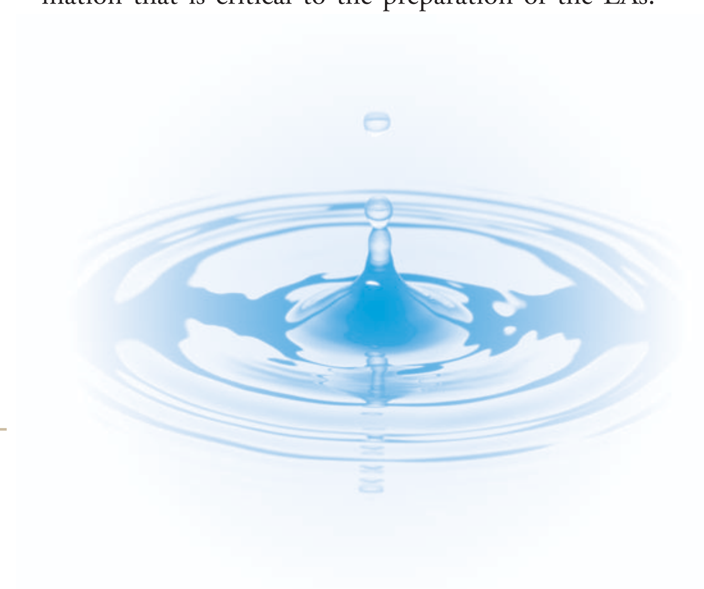
Regulatory Development Analyses

Before establishing new regulations, the Agency must satisfy the analytic requirements of various statutes and regulations including:

- Executive Order 12866.
- Paperwork Reduction Act (PRA).
- Regulatory Flexibility Act (RFA).
- Small Business Regulatory Enforcement Fairness Act (SBREFA).
- Unfunded Mandates Reform Act (UMRA).

EPA is required by SDWA to specify best available technologies (BATs) for the removal of drinking water contaminants and must consider technologies that can be afforded by different classes (i.e., sizes) of water systems. Data from the CWS Survey will be useful when identifying BATs for the removal of contaminants, conducting affordability analysis, and developing affordability criteria. The survey data will be used in a national-level affordability criteria document.

In addition, the Agency must prepare EAs that detail the national costs and benefits of all proposed regulatory actions and alternatives under consideration. In general, the CWS Survey data provide baseline information that is critical to the preparation of the EAs.



[1] The data presented in Volumes I and II are tabulated in Stata. The calculations are carried out in a series of programs referred to as "do files." EPA has these programs on file and will make them available upon request.

Without an accurate baseline, changes imposed by regulations cannot be measured. Analyses such as these support EPA's estimates of the cost of complying with new regulations. Toward this end, data will be used in the development of the next edition of the *Baseline Handbook*.

The CWS Survey also collected data on production capacity, system storage capacity, pipe, population served, connections, and treatment facilities to support the development of SDWA burden estimates in Information Collection Requests (ICRs).

The RFA and SBREFA require the Agency to demonstrate that SDWA regulations do not impose unreasonable economic and financial burdens on small businesses or governments. The analyses required by the RFA and SBREFA can be supported by many of the same CWS Survey data elements as the EA and ICR analyses.

EPA uses data from the CWS Survey to help determine if SDWA regulations are affordable for small systems like the Newport Water District (NWD) in Maine, which serves 1,800 people. Pictured are Thomas Todd, Superintendent, and Gary Silvia, Trustee, of NWD.

Policy Development Analyses

The diverse water systems in the CWS Survey database provide financial and operational data that EPA can use to support various initiatives to develop policies and guidance for states and public water systems concerning the implementation and enforcement of drinking water regulations. These policy initiatives can involve, for example, defining financial affordability (i.e., ability to pay).

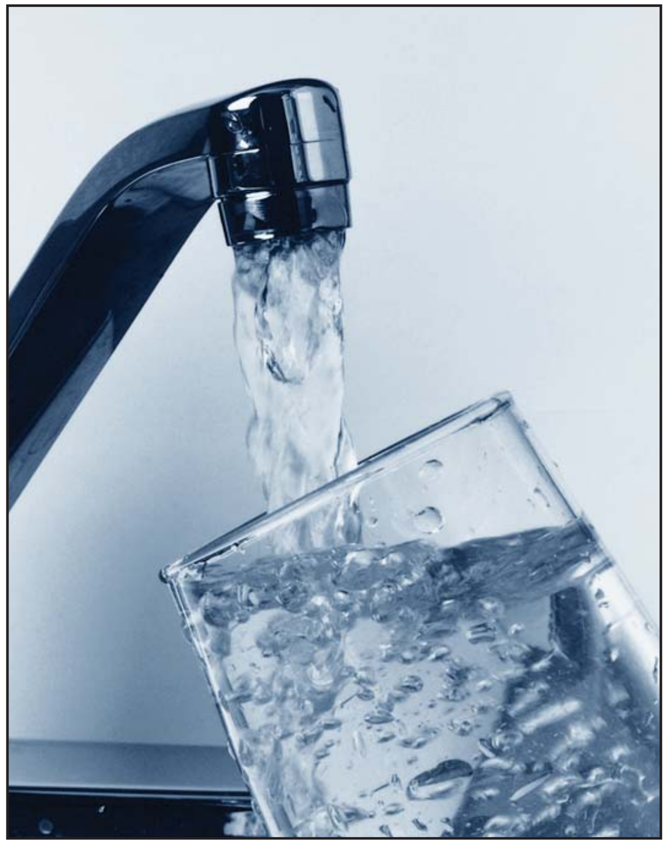
The Agency is continually engaged in efforts to provide summary information and reports on the status of regulatory development, implementation, and enforcement activities. Further, the Agency is periodically required to prepare a program-level ICR to document the burden imposed on states, the water industry, and federal agencies in implementing SDWA regulations. The Agency also receives periodic requests from Congress, federal agencies, and the public for information on the water supply industry. The 2000 CWS Survey provides current information on the water industry to satisfy these efforts.

Regulatory Implementation Analyses

A critical issue for EPA to address under the 1996 SDWA Amendments is whether the drinking water industry, and small systems in particular, have the technical and financial capacity to comply with SDWA regulations over a sustained period. Small water systems face financial problems and larger systems have potentially serious financial concerns as regulatory compliance and infrastructure repair and replacement drive operating costs higher. As a result, the Agency is assisting states and water suppliers in building the necessary technical and financial capacity. Congress has provided money to assist the states and EPA in building additional capacity through the Drinking Water State Revolving Fund for public water systems. CWS Survey data, and data from the Drinking Water Infrastructure Needs Survey, may be used to assess the ability of the water industry to finance infrastructure investments.

Compliance Analyses

The Agency is engaged in several efforts to upgrade and expand its water industry databases. One intended use of the CWS Survey database is to support the development of operational and financial profiles for different types of water systems, which can be statistically correlated with the Agency's compliance records in SDWIS. The objective of this analysis is to identify the operational and financial characteristics that may result in future compliance problems. EPA can then develop guidance to target systems that may exhibit these characteristics. (While the data will support analyses of compliance issues, they will not be used in any enforcement action.)



Organization of the Report

This report has two volumes. Volume I presents an overview of the data and the key findings of the survey. It is composed of an Executive Summary, which summarizes the key findings and highlights of the survey results, and three chapters:

- **Chapter 1. Introduction.** Chapter 1 describes the background, purpose, survey methodology, intended uses, and the organization of the overall report.

- **Chapter 2. National Projection Summary.** Chapter 2 provides an aggregate perspective on basic water industry demographics and operational and financial characteristics of the industry. It presents a national profile of water systems, their customers, and their operating and financial characteristics.

- **Chapter 3. Key Findings and Trends.** This chapter discusses the principal findings of the CWS Survey. It summarizes the operational and financial survey findings and compares them to the 1995, 1986, 1982, and 1976 Surveys.

Volume II presents a detailed summary of data collected in the CWS Survey. No narrative descriptions accompany these tabulations. The results are divided between operating and financial characteristics. The order of presentation generally corresponds to the order and organization of the survey questionnaire. The tables on system operation generally track the movement of water through the system, presenting data on source, then treatment, storage, distribution, and cross-connection control. The financial tables present data on revenue, billing rates and structure, expenses, and capital expenditures.

Volume II also describes in detail the survey methodology. It provides information on sample design and weighting, the small system site visits, the mail survey, and quality assurance. Copies of the survey questionnaires are supplied in an appendix.

2 NATIONAL PROJECTIONS SUMMARY

The 2000 CWS Survey collected operational and financial data for a representative, but diverse group of water systems. The systems rely on various sources of water, use a number of treatment practices, and serve populations of various sizes and customer classes. They face a variety of financial challenges. This chapter presents an overview of the operations and finances of these systems, providing a broad description of the water industry. Using data from the sample, industry totals are presented in order to establish themes and patterns that will be explored in greater detail in Chapter 3.

Number of Public Water Systems and Population Served*

System Type	Systems		Population Served (in millions of persons)
	Number	Percentage of Total	
Community Water Systems	53,410	32.0%	258.5
Nontransient Non-community Water Systems	20,334	12.2%	6.8
Transient Non-community Water Systems	93,041	55.8%	12.9

*Data from *Factoids: Drinking Water and Ground Water Statistics for 2000*, EPA 816-K-01-004, June 2001. Excludes systems in the Commonwealths and Trust Territories.

Water System Profiles

Nearly 170,000 public water systems provide water to over 258 million people throughout the United States, according to the latest inventory of systems. Public water systems include community and non-community water systems.

The survey estimates there are 52,186 community water systems in the 50 states and the District of Columbia, which is consistent with the latest inventory data. (The differences imply some systems in the current inventory may not be active community water systems. See Table 1 in Volume II for additional detail on the estimated number of community water systems. The survey's estimate of the population served by community water systems also is slightly lower than the current inventory data, as will be shown below.) Nearly 70 percent of public water systems are non-community systems, but the vast majority of people are served by community water systems. This is essentially unchanged from 1995.

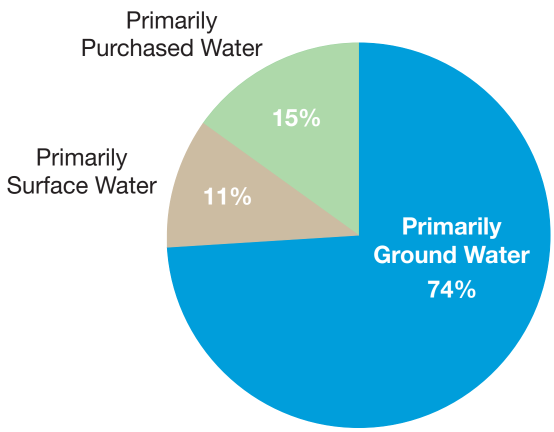
Because community water systems provide the most exposure to risks from contaminants, they are the focus of this survey. The tables that follow, and the data reported in Volume II, deal only with community water systems.

Water Source, System Ownership, and System Size

The water industry in the United States is characterized chiefly by its diversity. It includes publicly owned systems, private for-profit and not-for-profit systems, and systems that provide water only as an ancillary function of their primary business. It includes systems serving as few as 25 persons and relying largely on ground water, to large wholesalers that provide treated surface water to several million customers.

There are many ways to classify water systems. EPA regulatory analyses categorize systems by the source of water, ownership, and size of the population served. Source water characteristics are used in EPA analyses to account for operational configurations, potential sources of contamination, regulatory requirements, and costs associated with different water quality conditions. The Agency takes water system ownership into account when estimating the potential cost impacts of drinking water regulations. Publicly and privately owned systems differ in rate structure, sources of funds for capital improvements, source of water used, and size of service population. The size of the population served by a system affects the quantity of water needed; it also affects production requirements, treatment practices,

Percentage of Community Water Systems, by Primary Source of Water



operations, and financial capacity. Water production tends to involve large fixed-costs, so water systems typically exhibit economies of scale as their service populations increase. Thus, the unit cost of providing water varies according to system size.

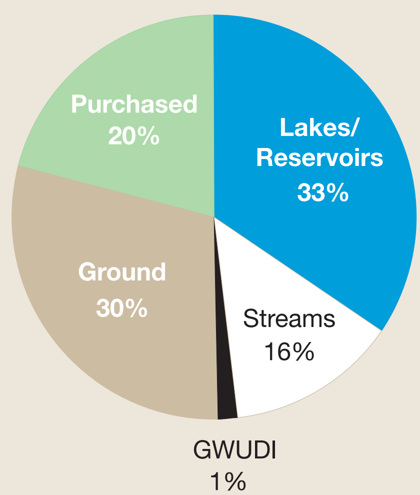
Nearly 75 percent of the nation's community water systems rely primarily on ground water. Almost 11 percent rely primarily on surface water, while the remaining 15 percent purchase either raw or treated water as their primary source.

Fifty percent of all water produced by systems comes from surface sources, including flowing streams, lakes and reservoirs, and ground water under the direct influence of surface water (GWUDI). Approximately two-thirds of surface water comes from lakes or reservoirs. An additional 31 percent comes from flowing streams, and 1 percent is GWUDI.

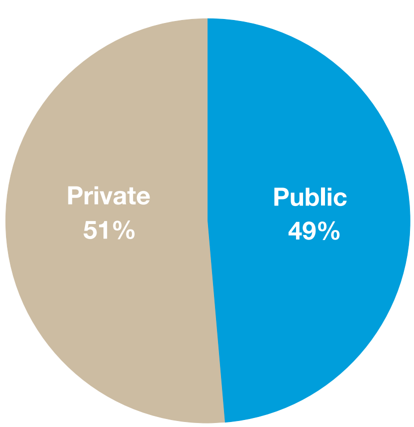
Twenty percent of water is purchased. Over 75 percent of the water purchased is treated. The remaining 30 percent of the water produced by systems comes from ground sources. The ground water is drawn from more than 105,000 wells that feed into approximately 88,000 entry points to the nation's distribution systems. (Table 2 in Volume II provides further detail on the number of systems by water source.)

Community water systems are evenly split between public and private ownership. The overwhelming majority of publicly owned systems are owned by towns, cities, counties, or other forms of local government. Of the 51 percent of systems that are privately owned, 27 percent are run as for-profit businesses and 34 percent are not-for-profit entities. Approximately 39 percent of privately owned systems, or 20 percent

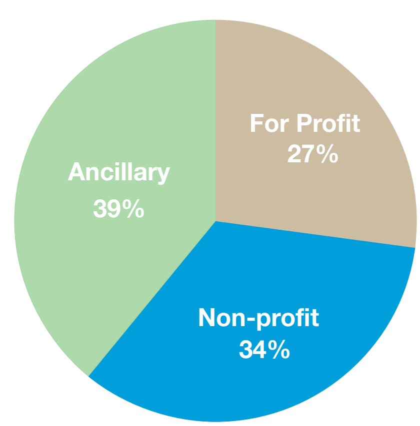
Percentage of Water Produced by Source



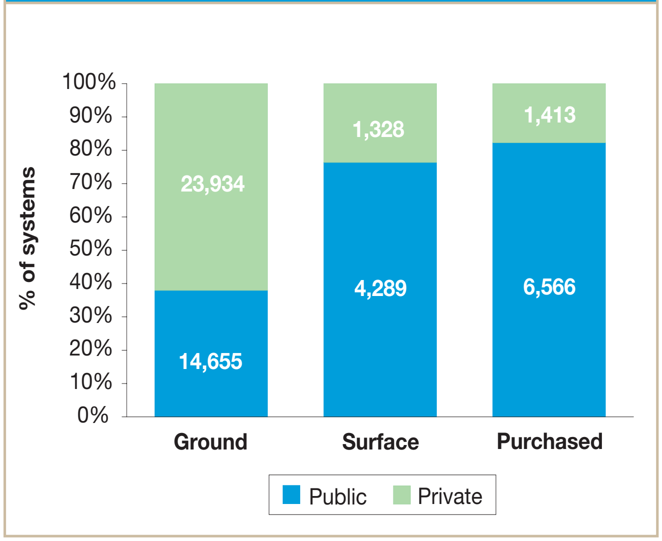
Percentage of Community Water Systems, by Ownership



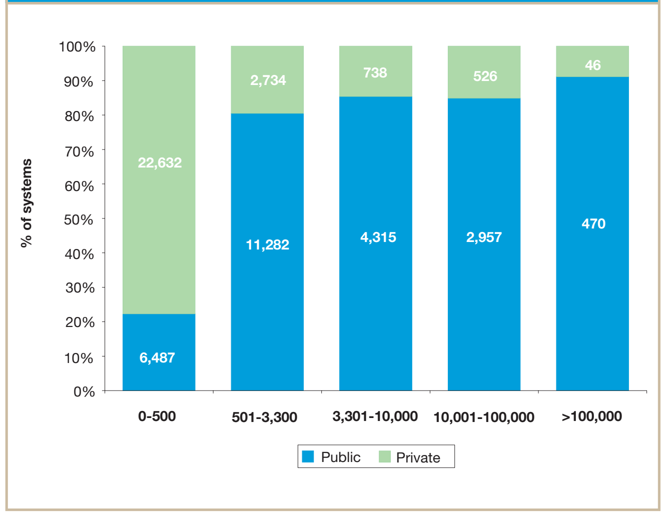
Percentage of Private Community Water Systems, by Type



System Ownership by Primary Source of Water



Community Water Systems, by Ownership and Population Service Categories

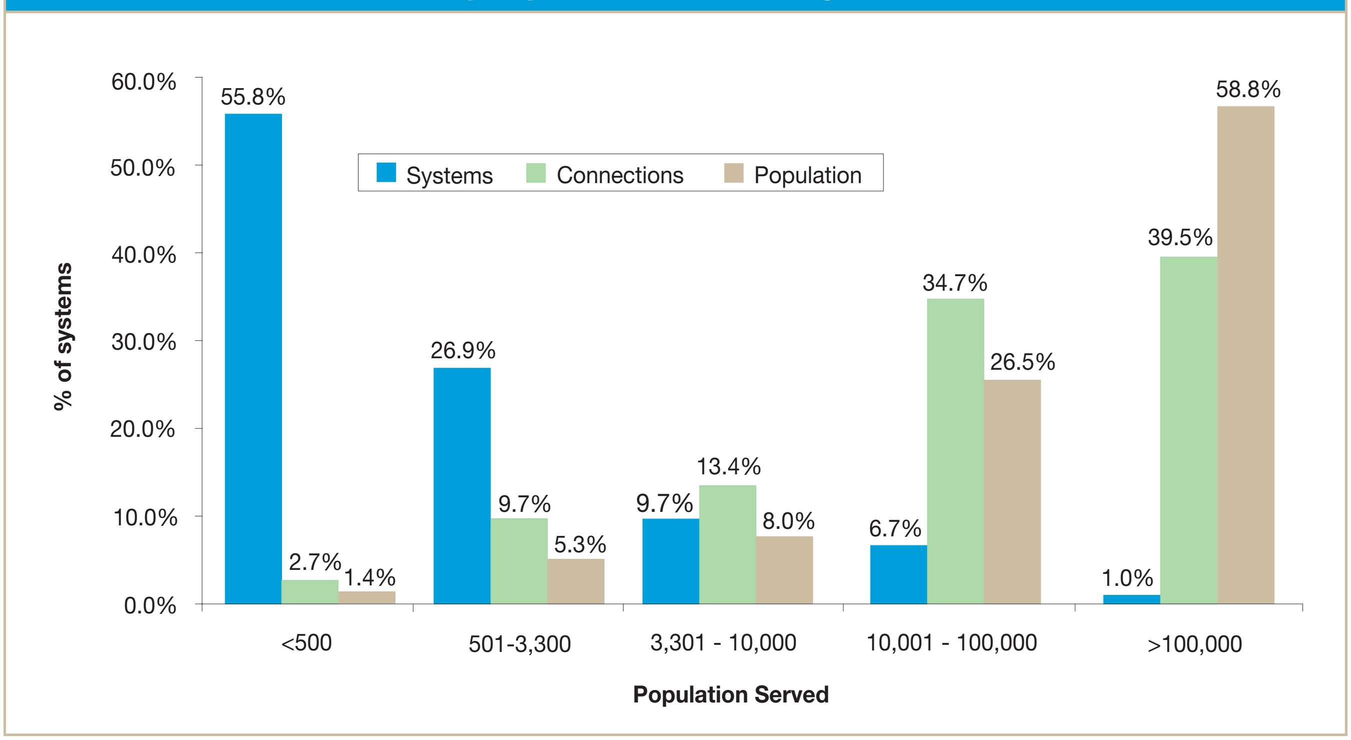


of all systems, are ancillary systems (i.e., systems whose primary business is not water supply but who provide water as an integral part of their principal business). These systems tend to serve small populations, produce smaller quantities of water, and often do not bill customers separately for water. (See Table 3 in Volume II for further detail on system ownership.)

Most systems that rely mainly on surface or purchased water are publicly owned. Publicly owned systems are also more likely to rely primarily on purchased or surface sources.

The vast majority of water systems are relatively small; systems that serve 3,300 or fewer persons account for 83 percent of all water systems. Ten percent of systems serve 3,301 to 10,000 persons. Systems serving more than 100,000 persons account for less than 1 percent of all community water systems. Yet, most people get their water from large systems, as will be shown in the

Community Water Systems Connections vs. Systems by Population Service Categories

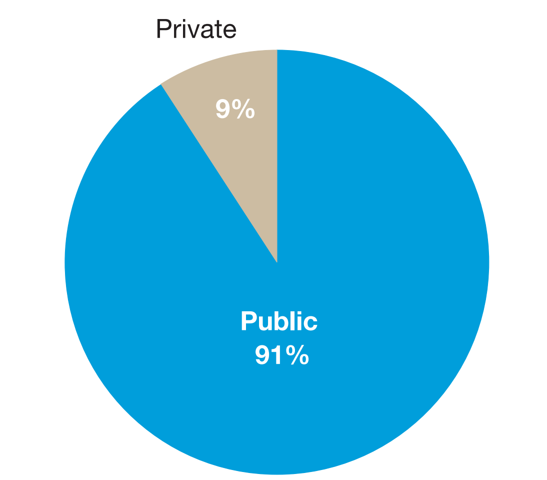


next section. And because publicly owned systems tend to be larger, most people get their water from publicly owned systems. In fact, many of the differences between publicly and privately owned systems may be due to scale, rather than ownership, since most small systems are privately owned.

Water System Production, Customers, and Connections

According to the survey, community water systems directly serve more than 254 million individuals. They serve nearly 75 million customer connections, 91 percent of which are for residential customers. Because most connections are residential, the number of connections and the population served are correlated. The balance are commercial, industrial, or other nonresidential connections. Many systems sell water wholesale to other public water suppliers. Some systems both buy and sell water.

Total Water Production by Ownership

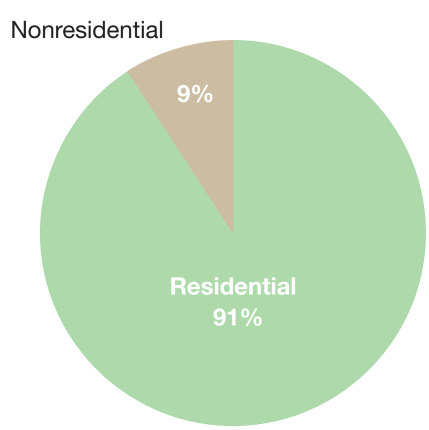


While systems serving more than 100,000 persons comprise less than 1 percent of all systems, they provide water to nearly 40 percent of the customer connections. On the other hand, more than one-half of all community water systems serve fewer than 500 persons, but they provide water to less than 3 percent of all service connections. (Table 4 in Volume II provides detail on water production by system size and primary source of water.)

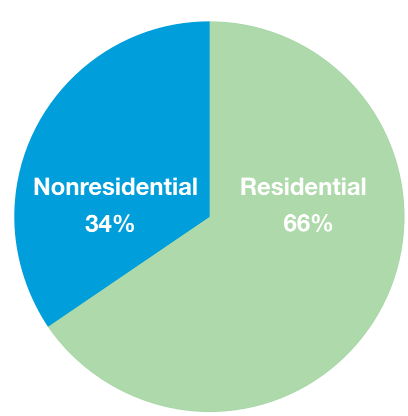
Wholesale deliveries account for more than one-quarter of all water delivered. The remaining deliveries are for residential and nonresidential retail customers. Residential customers account for two-thirds of retail water deliveries, and nonresidential customers account for the balance. Commercial and industrial customers receive 39 percent of the nonresidential retail water deliveries, or 13 percent of all retail deliveries. Agricultural and other customers receive the balance of the nonresidential retail deliveries. (See Table 41 in Volume II for further detail on retail water deliveries.)

Systems deliver 119,000 gallons annually per residential connection, or approximately 325 gallons per day. While residential customers are the majority of all connections, each customer (not surprisingly) receives far less water than each nonresidential customer. Nonresidential customers receive 618,000 gallons annually, or nearly 1,700 gallons per day. Despite the fact that nonresidential customers comprise only 9 percent of all connections, they consume more than one-third of the water delivered.

Retail Connections, by Customer Class



Retail Water Deliveries, by Customer Class (Excludes Wholesale Deliveries)

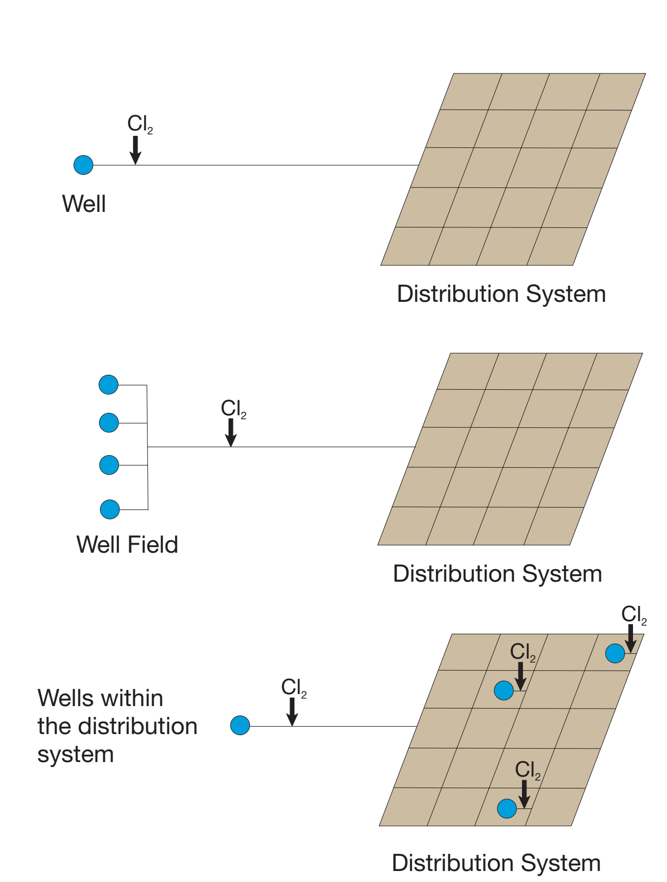


Total production of all community water systems is approximately 51 billion gallons per day, including unaccounted for water. (Unaccounted for water includes system losses, water consumed in the treatment process, fire fighting, and other uncompensated usage.) Systems that rely primarily on surface sources account for just over 50 percent of production. Large systems produce almost two-thirds of the water. Most large surface water systems are publicly owned, so it is not surprising that publicly owned systems produce much of the nation's drinking water; public systems, of all sizes and sources, account for 91 percent of all water production, more than 18 trillion gallons per year.

Operational Summary

The 2000 CWS Survey collected detailed information on system operations. These data will enable the Agency to identify operational differences among systems and to develop an up-to-date characterization of water systems throughout the industry. The survey collected operational data from source-to-tap: data were collected on the quantities of water produced by source for each entry point to the distribution system, including capacity information by well, intake, and points of purchase; treatment objectives and practices; treatment facility capacity; treatment residual management; and storage and distribution capacity. Detailed schematics of treatment plants and the systems were collected as well. Water treatment is often complex, and the schematics provide detailed information about the operation of the facilities in the sample. A sample of schematics, for ground water and surface water plants of several sizes, is provided in Appendix A.

Examples of Chlorination Schematics



Water Treatment

Water is treated in a plant or facility. For this report, a treatment plant or facility is any location where the water system takes steps to change the quality of the water. It includes standard plants that are clearly recognized as treatment facilities, such as conventional filtration plants. It also includes smaller facilities that may not be considered treatment plants in other contexts; for example, a chemical feed on a well that adds chlorine to the water is considered a treatment plant in this report. There is one exception to the general rule that all points where the system makes changes to the water is a treatment facility. Systems may boost disinfection or adjust pH within their distribution system; these sites are not counted as treatment facilities.

Seventy-one percent of all water systems treat all or some of their raw water. This includes systems that purchase all of their water, most of which purchase treated water and do not provide additional treatment. Eighty percent of systems that have their own sources of water provide some treatment, from simple disinfection to complex filtration plants. More than 99 percent of systems that rely on surface sources for at least a portion of their water treat the water. Most ground water systems provide treatment as well, but most of the systems that do not treat water are ground water systems: of the systems that do not provide treatment and do not purchase all of their water, 88 percent rely solely on ground water. (Table 9 in Volume II provides additional detail on the percentage of systems not providing treatment.)

Percentage of Plants with Each Treatment Objective	Ground Water Plants	Surface Water Plants
Algae Control	1%	34%
Corrosion Control	26%	58%
Disinfection	98%	99%
Oxidation	11%	21%
Iron or Manganese Removal/Sequestration	45%	32%
Fluoridation	21%	49%
Taste and Odor	8%	49%
TOC Removal	1%	31%
Particulate/Turbidity Removal	9%	86%
Organic Contaminant Removal	2%	19%
Inorganic Contaminant Removal	4%	17%
Radionuclides Removal	2%	5%
Other	15%	18%

Treatment Objectives and Practices

Treatment plants are designed to meet many objectives. Ninety-eight percent of the nation's treatment plants are designed to disinfect water. Forty-three percent are designed to either remove or sequester iron or manganese, and 31 percent are designed for corrosion control. Twenty-three percent are designed for particulate or turbidity removal. Although the addition of fluoride is not designed to improve the safety of water, 25 percent of the plants add fluoride.

There are important treatment objective differences between plants treating ground water and plants treating surface water. For example, ground water plants are more likely to treat for iron or manganese removal or sequestration than surface water plants. Eighty-six percent of plants treating surface water are designed to remove particulates or turbidity, compared to less than 10 percent of systems treating ground water. Twice as many surface water plants are designed for corrosion control. (See Tables 19 and 20 for additional details on treatment plant objectives.)

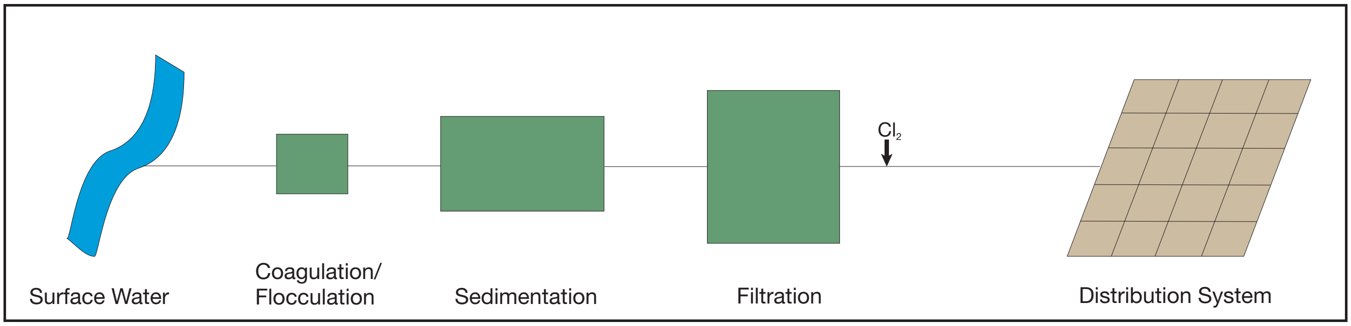
Water systems use many different practices to achieve their treatment objectives. Processes include chemical addition, coagulation/flocculation, settling and sedimentation, filtration, membranes, and softening. To characterize the various treatment practices, each plant in the sample was assigned to one of several treatment trains, from the relatively simple to the very complex. (Appendix A provides detailed definitions of each scheme.) Fifty-five percent of plants that solely treat ground water only disinfect. At the other end of the spectrum, 35 percent of surface water plants use conventional filtration similar to the schematic on the next page. A conventional filtration plant like the one depicted may use as many as 9 steps, including pre-disinfection, flocculation, sedimentation, filtration, post-disinfection, and clearwell to provide contact time for the disinfectant. In the schematic shown, the plant disinfects with chlorine after filtration. Other conventional filtration plants may add chlorine or other disinfectants at this or other points in the process. Schematics of each of the treatment trains are provided in Appendix A. (See Tables 21-26 in Volume II for further information on treatment practices.)

Treatment Residual Management

The cost of disposing of treatment residuals is an important component of treatment costs and must be included in evaluations of treatment requirements. Treatment practices produce a range of residual wastes, including brines, concentrates, and spent media. Systems have several options for disposing of residuals, including land application, direct discharge to surface water, or discharge to sanitary sewers. Just over 30 percent of surface water systems, most of them larger systems, dewater their treatment residuals. Ground water systems, on the other hand, rarely dewater. Surface water systems also are more likely to rely on direct discharge than ground water systems, reflecting their proximity to surface water and the type of treatment they use. Only 16 percent discharge to

Percentage of Plants Using Various Treatment Schemes

Treatment Practice	Ground Water Plants	Surface Water Plants
Disinfection Only	55%	11%
Disinfection and other Chemical Addition Only	16%	1%
IX, AA, Aeration	14%	4%
Filters	8%	12%
Direct Filtration	0%	14%
Conventional Filtration	0%	35%
Membrane Filters	0%	2%
Softening	6%	21%



sanitary sewers. While this is one-half the share of plants that use evaporation ponds, more than three-quarters of plants that have access to sanitary sewers rely on them for disposal of liquid waste. (See Tables 29-32 in Volume II for more detail.)

Operators and SCADA

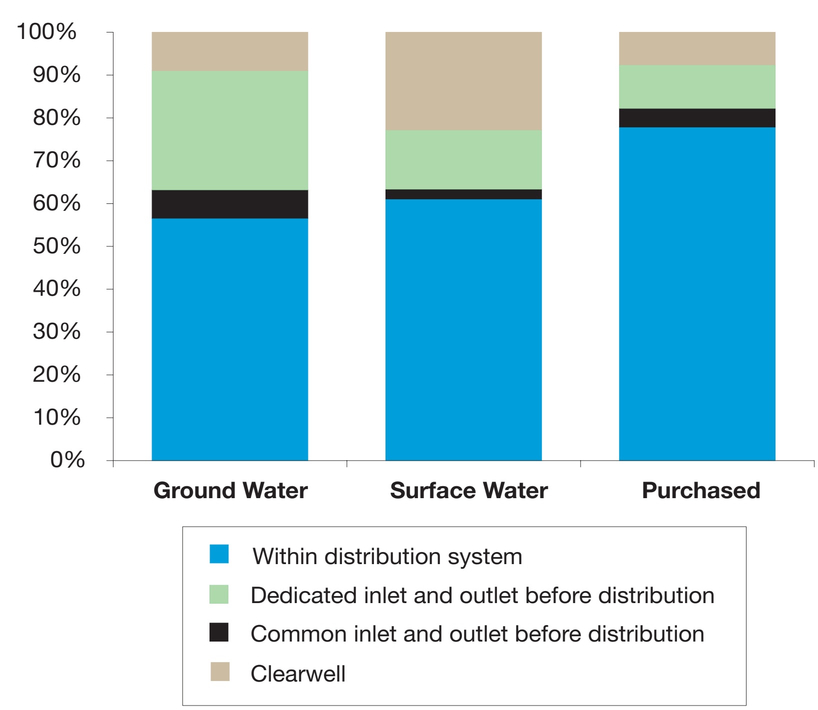
Twenty-two percent of facilities treating only surface water have an operator on site 24 hours a day, 7 days a week (or "24/7"). The larger the system—and the larger the plant itself—the more likely an operator is on duty 24/7; 80 percent of surface water plants in systems serving more than 50,000 persons—and more than 95 percent of the plants in systems serving more than 500,000 persons—have operators on duty around the clock. All surface water plants that produce at least 100 million gallons of water a day have 24/7 operators. Ground water systems are far less likely to have an operator on duty at all hours, in part because they are less likely to be run around the clock. Less than 2 percent of all plants treating only ground water have 24/7 operators; it is more common among larger plants, but no more than one-half of the largest systems and plants have operators on duty 24/7. (Tables 15 and 16 in Volume II provide additional information on system operators.)

Many of the plants have Supervisory Control and Data Acquisition (SCADA) systems for either process monitoring or control. Plants that do not have around-the-clock operators may use SCADA to monitor or control their systems when the operator is not on site. Nineteen percent of the plants that treat ground water and do not have around-the-clock operators use SCADA for process monitoring; 14 percent use it for process control. The percentages are double for surface water plants. For both ground water and surface water plants, large plants and plants in larger systems are more likely to use SCADA than small plants or plants in smaller systems. (See Tables 17 and 18 in Volume II for additional detail.)

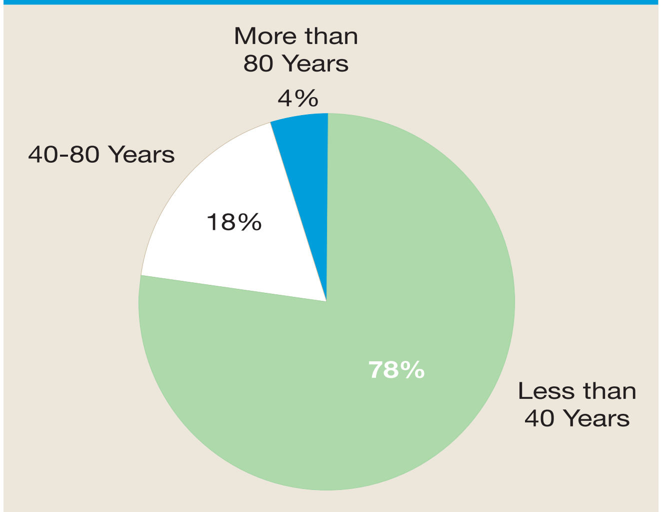
Storage

Water storage is an integral component of a water system. In addition to providing a cushion against fluctuations in demand, storage often is required to provide contact time for disinfectants. In this context, not all storage is equal; clearwell and storage with dedicated inlets and outlets will provide contact time,

Type of Water Storage, by Source of Water



Distribution Mains, by Age



but storage that "rides the line" (i.e., with a common inlet and outlet) may not.

Systems of all sizes that rely primarily on surface water are more likely to have clearwell storage than are ground water systems. Surface water and ground water systems are more likely to use storage that has dedicated inlets and outlets than storage that rides the line. Surface water systems tend to have greater storage capacity, because ground water systems often do not need storage. All systems tend to have the majority of their storage within their distribution systems, but purchased systems have a larger share than surface and ground water systems. (See Tables 33-34 in Volume II for further detail on water storage.)

Systems replaced over 50,000 miles of pipe in the past 5 years, at a cost of over $4 billion.

Distribution and Cross-Connection Control

Buried infrastructure often is the largest component of a community water system's asset inventory. Water systems maintain more than 1.8 million miles of distribution mains, of which more than 60 percent is less than 6 inches in diameter. Nearly 80 percent of distribution mains are less than 40 years old; 4 percent are more than 80 years old. The older pipe tends to be in larger systems. Systems replaced over 50,000 miles of pipe in the past 5 years, at a cost of over $4 billion. The cost per mile of pipe replaced increases with system size; larger systems tend to be urban and in northern areas, where population density and frost tend to increase the cost of maintaining and replacing water mains.[2] (See Tables 35-38 in Volume II for detailed information on distribution systems.)

To protect their distribution systems against backflow, approximately 43 percent of all water systems have cross-connection control programs. Larger systems are more likely to have a program: more than 90 percent of systems serving more than 100,000 persons have programs, compared to only 26 percent of systems serving up to 500 persons. Public systems are more likely to have programs, largely due to their size; the percentage of public and private systems with cross-connection control programs is similar for systems serving populations of similar size.

More than 75 percent of the systems that have cross-connection programs provide protection up to the tap.

[2] The 1999 Drinking Water Infrastructure Needs Survey collected data on the length of pipe systems expect to replace in the next 20 years and the estimated cost of that pipe. Data from both the Needs Survey and the CWS Survey can be used to estimate the cost per mile of pipe. The cost per mile of pipe replaced is a good deal higher in the Needs Survey than in the CWS Survey. There are important differences in the information collected by the two surveys that account for some of the difference. The main difference is the time period covered by the surveyes. The CWS Survey asks about pipe replaced in the past five years, and the Needs Survey asks about plans to replace pipe in the next 20 years. Sampling error also explains some of the difference; systems that responded to both surveys report similar cost per foot, while systems that did not provide data for both surveys report very different costs per foot.

These programs are called isolation programs. They are designed to prevent backflow from reaching the distribution system and provide protection within the consumer's premises. This is in contrast to programs that provide protection up to the meter; these containment programs prevent backflow from reaching the distribution system, but do not provide protection within the customer's premises. (See Tables 43-45 in Volume II for more details about the cross-connection control programs.)

Financial Summary

EPA needs an accurate assessment of community water systems' finances to gauge the ability of these systems to make the technical and capital investments required for sustainable water operations. The survey asked systems to provide basic information on their annual revenue and expenses. It also requested data on the type of capital investments made over the previous 5 years and the source of funds for the investments.

Revenue and spending data cover a single year, which limits the Agency's ability to draw general conclusions about the financial well-being of the industry. As with the 1995 Survey, the data are intended to provide a snapshot of the water industry. Also, the diverse nature of water systems is reflected in their accounting systems and financial reports. Two systems with similar finances may report them differently, depending on their type of ownership and accounting practices. To facilitate comparisons across systems (as well as to limit the burden of the survey on respondents), the financial data were collected at a relatively high level of aggregation and were subjected to thorough review.

Summary of Revenue and Expenses

Most water system revenue comes from the sale of water. Systems also generate revenue through non-consumption-based charges, such as connection and inspection fees, fines and penalties, and other fixed charges. Some publicly owned systems also may receive payments from a municipal general fund. (On the other hand, some municipalities may use water system revenue to fund other activities.)

Water system revenue in 2000 was $39 billion, 89 percent of which was earned by publicly owned systems. Water system expenditures totaled $32 billion, with publicly owned systems accounting for 90 percent of water systems' expenditures. These aggregate figures mask important differences among systems; while revenue exceeds expenditures for the industry as a whole—and, as will be shown, for most systems—revenue for some systems lags expenditures. (See Tables 46-49 and 59-61 in Volume II for further data on total revenue and expenses.)

Water System Annual Revenues and Expenses (Billions of Dollars)

Water System Ownership	Annual Revenue	Annual Expenses
Publicly Owned	34.5	29.1
Privately Owned	4.3	3.1
All Systems	**38.8**	**32.2**

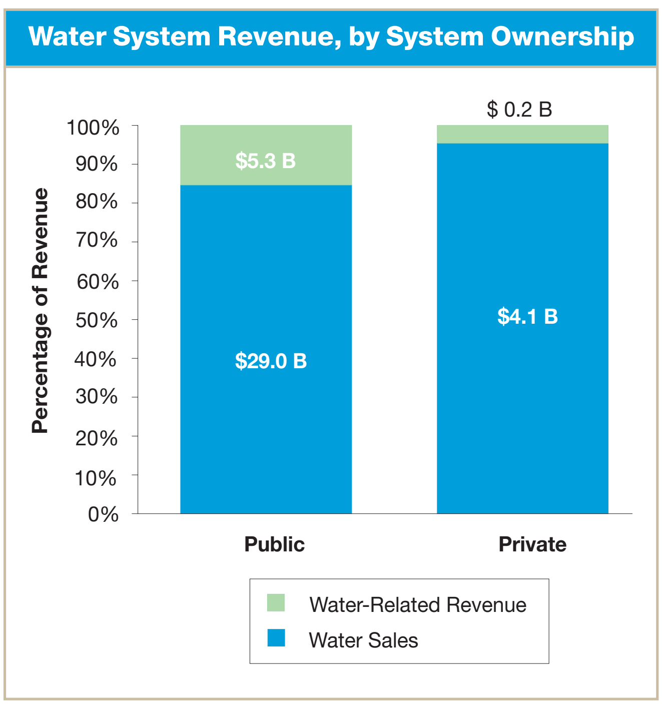
Water systems earn revenue from water sales, fees, fixed charges, and other water-related revenue. Water sales revenue is based on a charge per unit of water sold.

Residential customers provide the majority of water sales revenue for community water systems in all size categories.

Percentage Distribution of System Water Sales Revenue by Customer Class (Excludes Ancillary Systems)					
	Population Served				
Customer Type	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000
Residential	89.3%	83.5%	73.6%	67.1%	49.8%
Commercial/Industrial	6.8%	11.3%	18.6%	21.1%	20.7%
Wholesale	1.1%	2.0%	4.3%	7.4%	24.6%
Other	2.8%	3.3%	3.5%	4.4%	4.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Water-related revenue consists of development fees, connection fees, fines, and other payments unrelated to the quantity of water sold. In 2000, water sales were $33 billion, or 85 percent of total water revenue. Private systems depend slightly more heavily on water sales than public systems—over 95 percent of private system revenue comes from water sales, compared to 85 percent for publicly owned systems.[3]

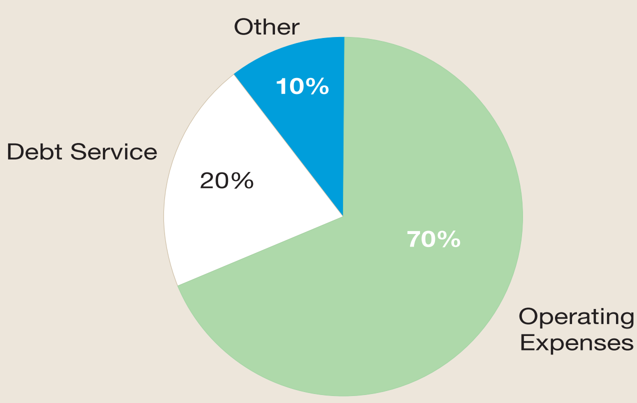
Residential customers provide 60 percent of water sales revenue across systems of all sizes. Commercial and industrial customers account for an additional 20 percent of water sales revenue, and wholesale revenue comprises 17 percent of the total. Smaller systems depend more on residential customers for revenue than do larger systems. Close to 90 percent of water sales revenue for the smallest systems come from residential sales. On the other hand, residential sales account for less than 50 percent of water sales revenue in systems serving more than 100,000 persons. Systems serving more than 100,000 persons typically derive a higher proportion of total revenue from commercial and industrial customers than do smaller systems. (Because ancillary systems often do not charge directly for water, they are excluded from this analysis. See Table 52 in Volume II for more detail.)



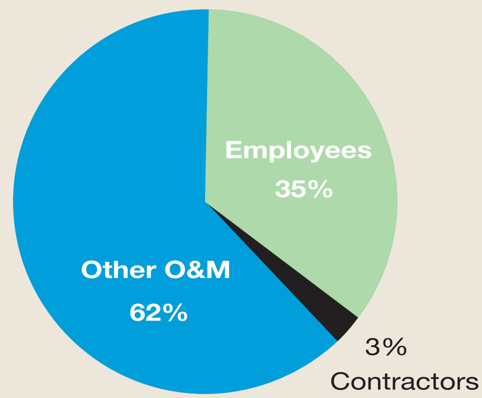
[3] Note: the sum of water sales and water-related revenue in the following table does not match total water revenue in the previous table because some systems could not distinguish between sales and water-related revenue and only reported their total revenue. (Tables 50 and 51 in Volume II provides additional detail on sources of revenue.)

Non-residential customers, such as this bottling plant, provide 20% of all systems' water sales revenue. Systems serving more than 100,000 persons typically have higher commercial and industrial revenues than smaller systems.

Total Expenses, by Type of Expense



Operating Expenses by Component

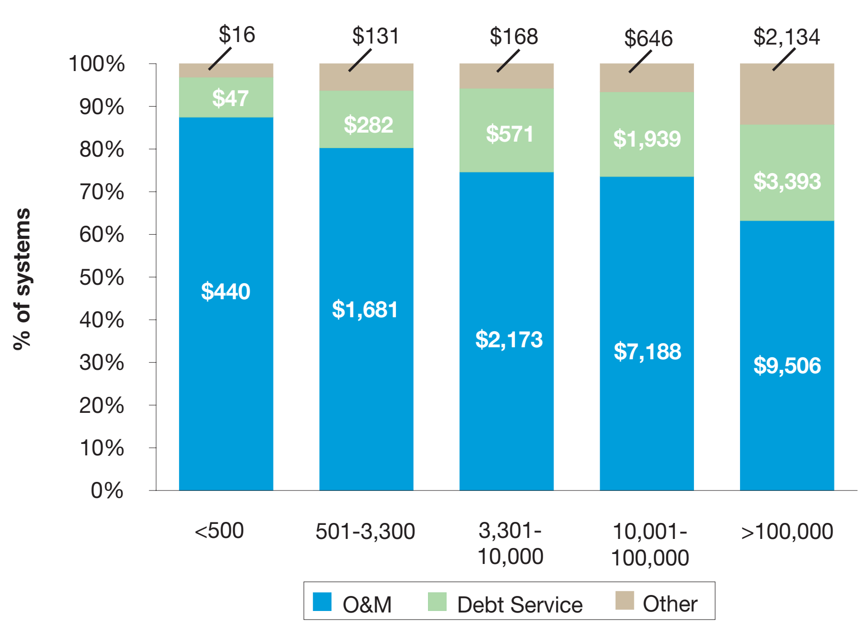


Although residential customers are the source of most water system revenue, non-residential connections generate considerably more income per connection. On average, nonresidential customers pay $1,686 per year, compared to $302 for residential customers. The difference is driven largely by the larger volume of water consumed by nonresidential customers. Additional detail on the average charge per connection and per thousand gallons of water delivered by system is provided in Chapter 3. (See Tables 53-57 in Volume II for additional detail.)

Water systems spent $32.2 billion in 2000 on the production and delivery of water. Routine operations and maintenance accounted for 70 percent of all expenses, or $21 billion. Debt service—interest and principal on past loans—totalled $6 billion, or 20 percent of total expenses. Other expenses, including non-routine expenses and capital investments, make up the balance of spending. (Table 62 in Volume II provides additional detail on expenses by category.)

Thirty-eight percent of routine operating expenses is for employee compensation, including salaries and benefits, and payments to contractors. The balance is for other routine operations and maintenance (O&M). Systems employ 213,000 staff members, including part-timers. They also employ 13,000 employees through contractors hired to operate the systems. (This does not include contractors hired for specific tasks, e.g., electricians hired to fix electrical problems. See Tables 67-68 in Volume II.)

Water System Expenses by Population Service Categories (Dollars in Millions)



Larger systems account for the bulk of water system expenses. O&M accounts for a smaller share of expenses as the population served increases; bigger systems devote more of their expenditures to debt service and other expenses (which includes capital expenditures). As a share of total expenses, debt service for systems serving more than 100,000 persons is twice that of the smallest systems. The share of total expenditures devoted to "other expenses" is three times larger in systems serving more than 100,000 persons than it is in systems serving fewer than 500.

Capital Spending

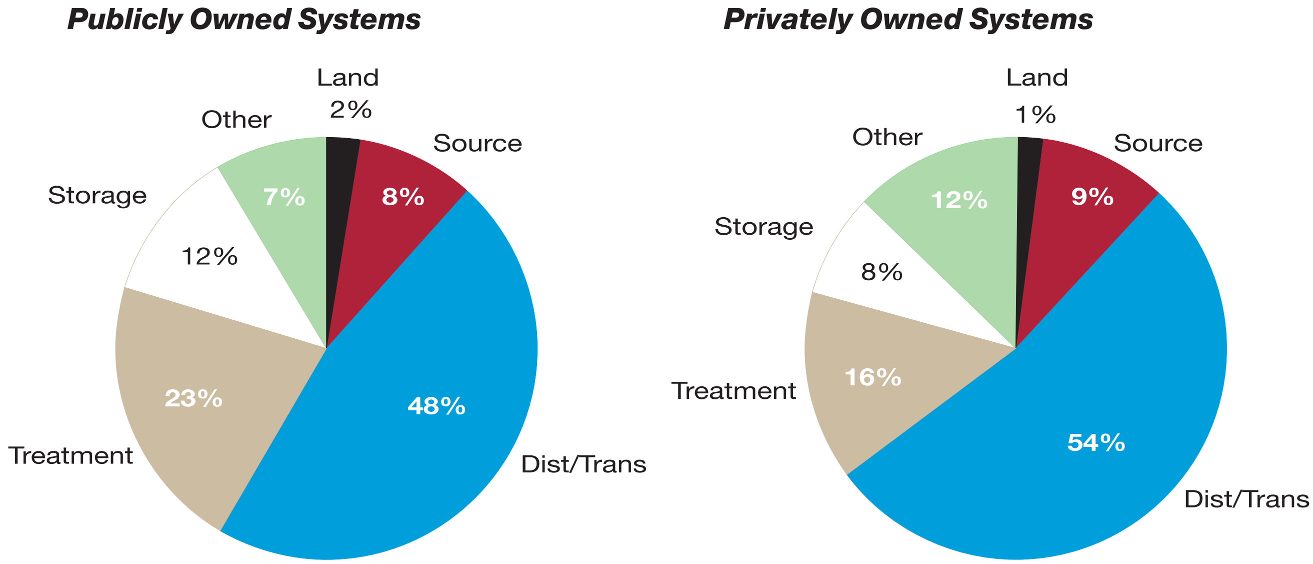
Water systems made nearly $53 billion in capital investments in the 5 years leading up to the survey, or more than $10 billion annually. Spending on distribution mains and transmission lines accounted for 48 percent of all capital investments over this period. Treatment accounted for an additional 20 percent, and storage another 11 percent.[4] Spending for land, source development, and other investments accounted for the rest of the investments.

Sources of Funds for Investment in Drinking Water Infrastructure for the Nation by Ownership and System Size

	Population Served					
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000	All Systems
Publicly Owned Systems						
Current Revenues	13%	27%	34%	47%	37%	39%
DWSRF Loans	15%	23%	4%	4%	2%	4%
DWSRF Principle Repayment Forgiveness	13%	11%	1%	1%	0%	1%
Other Government Loans	12%	15%	17%	17%	1%	8%
Other Government Grants	40%	11%	14%	5%	1%	5%
Borrowing from Private Sector	5%	11%	26%	25%	58%	42%
Other	2%	2%	4%	1%	1%	1%
Privately Owned Systems						
Current Revenues	56%	63%	36%	28%	50%	42%
DWSRF Loans	0%	0%	0%	3%	4%	2%
DWSRF Principle Repayment Forgiveness	0%	0%	0%	0%	0%	0%
Other Government Loans	1%	8%	2%	7%	3%	5%
Other Government Grants	8%	15%	12%	8%	0%	6%
Borrowing from Private Sector	12%	12%	46%	52%	43%	41%
Other	23%	2%	4%	1%	0%	3%
Total						
Current Revenues	23.2%	33.5%	34.2%	45.1%	37.7%	39.1%
DWSRF Loans	11.3%	19.3%	3.8%	3.7%	2.1%	3.9%
DWSRF Principle Repayment Forgiveness	9.9%	9.1%	0.5%	0.8%	0.1%	1.1%
Other Government Loans	9.7%	13.5%	15.4%	15.7%	1.0%	7.7%
Other Government Grants	32.3%	11.4%	13.5%	5.6%	1.2%	5.0%
Borrowing from Private Sector	6.6%	11.1%	28.8%	27.9%	57.1%	41.9%
Other	7.1%	2.1%	3.9%	1.2%	0.7%	1.3%

[4] Systems were asked to report the amount of funds invested in treatment, as well as land, water source, distribution networks, etc. They also were asked to report the percentage of their total capital investment that went towards water quality improvements, system expansion, and replacement or repairs. Spending on treatment and water quality improvements is not identical. Some investment in treatment may be considered spending on water system expansion, system replacement, or repair. Also, spending on items other than treatment, such as the distribution network, may be counted by systems as water quality improvements.

Type of Capital Expense by Ownership



Borrowing from the private sector funded 42 percent of the investments, while current revenue funded 39 percent. The Drinking Water State Revolving Fund (DWSRF) program is an important sources of funds for small systems; half of DWSRF assistance went to systems serving populations of 10,000 or fewer, financing 20 percent of their capital investments. This includes loans in which all or a portion of the principal repayment is forgiven. (These data are for the first three years of the DWSRF program, 1997 through 2000. See table 81 in Volume II for details on capital expenditures.)

The table on page 18 estimates the percentage of total capital investment in the nation that is financed by each source of funds. In contrast, Chapter 3 presents estimates of the percentage of capital investment financed by each funding source for the average system. Because systems invest different amounts, the distribution of the source of funds for the nation in the aggregate will be different from the average system. By way of example, consider two systems. The first invests $10,000 in its infrastructure. It finances 50 percent of the investment from current revenue, and the other 50 percent through borrowing from the private sector. The second system invests $100,000 in its infrastructure and relies on private-sector borrowing for 100 percent of the funds. Ninety-five percent of the capital investment of these two systems is financed by private-sector borrowing ([0.5*$10,000 + 1.0*$100,000]/[$10,000 + $100,000]). This is equivalent to the results reported in this chapter. On the other hand, the two systems on average rely on private-sector borrowing for 75 percent of the funds for their capital investments ([50% + 100%]/2). This is equivalent to the results reported in Chapter 3.

Conclusions

The drinking water industry is large and capital intensive. Water systems spend over $30 billion annually to provide water to more than 250 million persons, and invest more than $10 billion annually in infrastructure. They rely on a range of water sources and treatment practices. The summary measures presented in this chapter provide an overview of the industry as a whole; the tables in Volume II provide detailed information at a system and treatment facility level. The tables provide a sense of the diverse nature of the industry by highlighting differences by system size, ownership, and water source. The tables in Volume II also show a 95 percent confidence interval for most estimates; these intervals often are relatively large, which also reflects the diverse nature of the systems.

Profile of Community Water Systems

There are 52,186 community water systems in the 50 states and the District of Columbia that supply water to nearly 260 million persons. They consist of publicly owned systems, privately owned systems, and systems that provide water only as an ancillary function of their principle business. Most systems rely primarily on ground water sources. The great majority of systems also serve 3,300 or fewer persons. However, most people get their water from large, publicly owned systems that rely primarily on surface water.

Community Water Systems:

By Ownership	
Public	25,510
Private	16,302
Ancillary	10,374
By Water Source	
100 Percent Ground Water	35,308
Mostly Ground Water	3,280
100 Percent Surface Water	4,595
Mostly Surface Water	1,024
100 Percent Purchased Water	6,933
Mostly Purchased Water	1,046
By System Size	
25-500	29,119
501-3,300	14,017
3,301-10,000	5,052
10,001-100,000	3,484
100,000+	514

3 KEY FINDINGS AND TRENDS

This chapter provides a more detailed discussion of the system-level results of the 2000 CWS Survey. The first part of the chapter describes key findings of the survey. The second part compares the results of the 2000 Survey with previous surveys. In both parts, system operations are described first, followed by system finances.

Key Findings

Operating Characteristics

The essential functions of a water system are the production and delivery of drinking water. Some community water systems have very sophisticated treatment facilities designed to treat several million gallons of surface water daily. Others have only one or two wells, provide little or no treatment, and serve small populations. Still other systems purchase all of their water from large wholesalers, who sell no water directly to consumers.

The following table summarizes the treatment production and storage capacities of primarily ground water and primarily surface water systems. Surface water systems tend to have larger average daily flows and peak demands, as measured by average daily production and peak daily production. As discussed in Chapter 2, surface systems tend to be larger; but even among systems of equivalent size, surface systems tend to treat more water, which reflects the treatment needs of surface water. (See Tables 5, 13, 14, and 34 in Volume II for additional details.)

One important difference among water systems is the extent to which they have excess capacity. One measure of excess capacity is the ratio of the total amount of water a system can treat daily, known as system design capacity, to the maximum amount of water it needs to produce in a day, i.e., the peak daily capacity. The ratio of design-to-peak capacity is inversely related to system size. The assumption is that larger systems tend to be more efficient. Demand is also assumed to be more stable in larger systems; in a small system, a relatively small change in demand can require a significant change in production.

The results of the 1995 Survey indicated that the design-to-peak ratio also is a function of the source of water: the treatment and storage requirements associated with ground water and surface water affect the ratio of design-to-peak treatment capacity. This result is confirmed in the 2000 data. Ground water systems tend to have larger design capacities, despite their lower treatment flows. Ground water systems generally rely on additional pumping and treatment capacity to meet peak demands. Surface water systems, on the other hand, generally use more capital-intensive treatment techniques and tend to rely on storage to meet peak demands. Therefore, the ratios for ground water systems tend to be higher than the ratios for surface water systems of similar sizes. The ratio for large ground water systems, which tend to have more sophisticated and capital-intensive treatment processes, is similar to large surface water systems.

The decline in the ratio of design-to-peak treatment capacity as the service population increases is reflected in the storage capacity of systems. On average, small systems have just under 214,000 gallons of storage; in contrast, large systems serving more than 100,000 persons have more than 72 million gallons of storage.

Another measure of a system's efficiency is the percentage of water produced that actually gets delivered to customers. Approximately 5 percent of ground water and 10 percent of surface water is uncompensated or unaccounted for water. Some of this water is uncompensated usage—for example, systems may be required to provide water to the municipality for fire protection, without direct compensation. (While they are not paid directly for this water, overall rates may be designed to pay for the cost of providing this water.) Other unaccounted for water is consumed during the treatment process; for example, depending on their type, membranes reject up to 50 percent of the feed water. Water

Summary of Production and Storage	Population Served				
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000
Primarily Ground Water					
Average Daily Production (Gallons)	27,964	153,055	1,031,379	5,272,962	20,144,458
Peak Daily Production (Gallons)	72,592	345,525	1,845,842	9,593,771	28,056,757
Design Capacity (Gallons)	201,969	671,988	2,795,402	7,825,284	36,949,449
Ratio: Design to Peak Capacities	5.21	2.31	2.06	1.42	1.07
Storage Capacity (Gallons)	218,505	270,844	1,092,285	5,789,073	30,059,140
Average Daily Deliveries (Gallons)	23,601	156,116	1,021,541	3,825,897	2,829,421
Ratio: Average Daily Deliveries to Average Daily Production	0.98	0.91	0.90	0.90	0.96
Primarily Surface Water					
Average Daily Production (Gallons)	43,743	278,432	931,677	5,453,497	78,714,010
Peak Daily Production (Gallons)	81,263	511,658	1,575,798	9,082,162	127,779,390
Design Capacity (Gallons)	155,262	964,780	2,315,524	12,453,728	148,531,670
Ratio: Design to Peak Capacities	2.54	2.00	1.47	1.50	1.35
Storage Capacity (Gallons)	167,881	682,418	2,033,940	8,549,816	102,707,800
Average Daily Deliveries (Gallons)	38,655	279,459	908,024	5,787,735	87,122,300
Ratio: Average Daily Deliveries to Average Daily Production	0.98	0.87	0.86	0.90	0.91

also is used to backwash filters. In some sense, these types of unaccounted for water are not inefficiencies; they are inherent in running a water system. System leaks and other losses, in contrast, are a source of inefficiencies because they do not provide added value. (Table 5 in Volume II provides additional detail on unaccounted for water.)

Ratio of Peak Daily Production to Average Daily Production, by Ownership

	Publicly Owned Systems		Privately Owned Systems	
Population Served	Mean	Median	Mean	Median
Less than 100	2.50	2.00	2.63	1.67
101-500	2.56	1.85	2.14	1.98
501-3,300	2.77	1.73	2.36	2.20
3,301-10,000	1.84	1.76	1.78	1.56
10,001-50,000	1.75	1.64	1.58	1.55
50,001-100,000	1.63	1.50	1.43	1.24
100,001-500,000	2.08	1.69	1.44	1.35
More than 500,000	1.66	1.67	1.36	1.36

The table to the left provides another measure of system efficiency, comparing the average ratio of peak daily production to average daily production. Smaller systems tend to have larger ratios than larger systems, which indicates that smaller systems are subject to larger fluctuations in demand than larger systems, relative to the amount of water they produce. Changes in consumption by a few households can have a relatively large impact on a small system; a big system with larger and more predictable commercial and industrial demand may see less variation. (See Tables 12-14 in Volume II for additional details on plant capacity at the plant level.)

In fact, smaller systems are more likely to serve primarily residential customers, as shown in the table at the top of this page. Ninety-five percent of water deliveries in systems serving 100 or fewer persons are to residential customers; publicly owned very small systems almost exclusively serve residential customers. More than one-half of all public and private systems serving up to 500 persons provide water only to residential customers. Commercial, industrial, and other customers become more significant components of water system business as system size increases. Publicly owned systems serving more than 500,000 persons actually sell most of their water to non-residential customers. (See Table 39 in Volume II for additional details.)

The same general pattern holds for water sales revenue. Residential customers provide a smaller portion of total water sales revenue as system size increases. While the general pattern is the same as for deliveries, there are important differences. For very small systems, the percentage of revenue that comes from residential customers is slightly lower than the percentage of water delivered to them. This pattern is reversed in larger systems. This situation implies that residential customers pay lower rates than nonresidential customers in the smallest systems, but pay higher rates in medium and larger systems. (Table 52 in Volume II provides further detail.)

Residential Deliveries as a Percentage of Total Deliveries, by Ownership

	Publicly Owned Systems		Privately Owned Systems	
Population Served	Mean	Median	Mean	Median
Less than 100	99%	100%	95%	100%
101-500	85%	100%	94%	100%
501-3,300	79%	88%	86%	87%
3,301-10,000	63%	59%	70%	79%
10,001-50,000	56%	58%	64%	65%
50,001-100,000	49%	53%	54%	48%
100,001-500,000	46%	50%	47%	41%
More than 500,000	36%	36%	62%	62%

Residential Sales as a Percentage of Total Sales, by Ownership

	Publicly Owned Systems		Privately Owned Systems	
Population Served	Mean	Median	Mean	Median
Less than 100	91%	100%	99%	100%
101-500	86%	98%	98%	100%
501-3,300	86%	92%	91%	100%
3,301-10,000	72%	70%	86%	92%
10,001-50,000	64%	68%	80%	89%
50,001-100,000	57%	64%	74%	79%
100,001-500,000	52%	59%	60%	60%
More than 500,000	39%	45%	72%	69%

Median Annual Water Delivered per Connection (Gallons)

	Customer Category			
Population Served	Residential	Commercial/ Industrial	Agricultural	Other
Less than 100	71,429	0	--	83,333
101-500	72,165	0	0	0
501-3,300	76,271	89,286	111,111	16,667
3,301-10,000	83,775	306,733	1,000,000	363,636
10,001-50,000	87,844	433,657	1,687,500	454,546
50,001-100,000	106,452	610,417	1,934,211	442,049
100,001-500,000	117,219	646,806	882,979	1,832,773
More than 500,000	120,798	806,272	0	381,818

Median annual deliveries per residential connection for systems of all sizes is approximately 77,000 gallons. Annual deliveries per residential connection increase with system size. There is considerable variation in the quantity of water delivered per residential connection, even among systems of similar sizes. Because the deliveries per connection for a small number of systems is very large, the median is a better measure of central tendency than is the mean. As expected, commercial, industrial, and agricultural consumers use considerably more water per connection.[5]

Eighty percent of systems that do not purchase water provide treatment. The following table provides some detail on the type of treatment provided. Virtually all systems that rely solely on surface water sources

Percentage of Systems Applying Various Treatments at One or More Treatment Facility

	Population Served				
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000
100 Percent Ground Water					
Mean Number of Treatment Facilities	1.3	1.5	2.3	2.7	5.7
Percentage of Systems Not Providing Treatment	28%	14%	17%	0%	0%
Treatment Practices					
Disinfection with no additional treatment	60%	36%	33%	23%	17%
Other chemical addition	15%	14%	23%	14%	3%
Ion exchange, Activated Alumina, Aeration	8%	33%	23%	36%	55%
Other Filtration (not direct or conventional)	10%	7%	2%	10%	16%
Direct Filtration	0%	0%	0%	1%	0%
Conventional Filtration	0%	0%	8%	0%	0%
Membranes	1%	0%	0%	1%	0%
Softening	6%	10%	11%	15%	10%
100 Percent Surface Water					
Mean Number of Treatment Facilities	1.0	1.0	1.2	1.1	1.7
Percentage of Systems Not Providing Treatment	0%	0%	0%	0%	0%
Treatment Practices					
Disinfection with no additional treatment	34%	3%	0%	0%	0%
Other chemical addition	0%	3%	5%	0%	2%
Ion exchange, Activated Alumina, Aeration	2%	3%	9%	6%	9%
Other Filtration (not direct or conventional)	25%	12%	8%	0%	2%
Direct Filtration	15%	9%	9%	14%	12%
Conventional Filtration	7%	37%	35%	65%	61%
Membranes	7%	2%	1%	0%	0%
Softening	8%	32%	33%	15%	13%

[5] The estimate in this chapter differs from the one presented in Chapter 2. The estimate of 119,000 gallons reported in Chapter 2 is the estimate of the water received by households and is weighted by the amount of water delivered. The estimate in Chapter 3 is the residential delivery by the median system. Because residential deliveries per system vary by system size, the two estimates are not the same. See Table 41 in Volume II for further detail on average and median deliveries per connection across systems.

provide some treatment as do more than three-quarters of systems that rely solely on ground water. (See Table 9 in Volume II.)

On average, small systems that rely solely on ground water sources average 1.3 treatment facilities. This increases to 2.3 facilities for systems serving 3,301 to 10,000 persons, and to over 5 facilities for systems serving more than 100,000 persons. (The estimate for systems serving populations of more than 100,000 excludes 2 systems that have more than 100 treatment plants. If these outliers are included, the average number of treatment plants per system in this size category increases to 11.) Systems relying solely on surface water, by contrast, tend to have fewer plants on average. Small surface systems average one plant per system, since they tend to have one surface water intake. Surface water systems serving more than 100,000 persons have 1.7 plants on average. There is obviously considerable variation around these averages. Some surface water systems have as many as 8 surface water plants; some ground water systems have more than 200 plants. (See Table 11 in Volume II.)

As systems become larger, the treatment they use tends to become more complex. Approximately 60 percent of small ground water systems simply disinfect. Larger ground water systems are more likely to use other chemicals, disinfectants, and some forms of filtration. They also are much more likely to use softening techniques, including cation exchange. (This analysis is different from the figures presented in Chapter 2, which focused on the percentage of treatment *plants* that used each treatment train. This analysis focuses on the percentage of *systems* that employ each train in at least one plant.) Approximately one-third of surface water systems that serve up to 500 persons use disinfection and no additional treatment. Most surface systems serving more than 500 persons use more sophisticated treatment. Thirty-five percent of systems serving 3,301-10,000 persons use conventional filtration; this increases to more than 60 percent for systems serving more than 10,000 persons. Softening also is relatively common for systems serving populations of more than 500. Less than 1 percent of ground water systems and only 3 percent of surface water systems use membranes. (Tables 21 and 22 provide additional detail on the level of the plant, rather than the system.)

Average Number of Entry Points per System by Primary Water Source

Population Served	Ground Water Systems	Surface Water Systems
Less than 500	1.4	1.4
501-3,300	1.8	1.3
3,301-10,000	2.9	1.6
10,001-100,000	4.6	2.2
More than 100,000	7.6	3.3

A key factor in potential cost of proposed drinking water rules is the number of entry points to the distribution system. If new treatment is required, it would take place at the entry point. As seen in the above table, the number of entry points increases with system size, because larger systems tend to have more sources than smaller systems. Ground water systems tend to have more entry points than surface water systems, since each well may feed directly into the distribution system. In fact, some large ground water systems in the sample had several hundred entry points. (These systems are excluded from the table above. See Table 7 in Volume II for additional detail on the number of entry points per system.)

Miles of Pipe Replaced During Previous Five Years as a Percentage of Total Miles of Existing Pipe, by Ownership

	Publicly Owned Systems		Privately Owned Systems	
Population Served	Mean	Median	Mean	Median
Less than 100	26%	0%	6%	0%
101-500	14%	0%	4%	0%
501-3,300	5%	0%	0%	0%
3,301-10,000	3%	1%	9%	3%
10,001-50,000	4%	1%	2%	0%
50,001-100,000	3%	1%	1%	0%
100,001-500,000	2%	1%	2%	1%
More than 500,000	3%	2%	4%	2%

Population Served per Mile of Existing Pipe, by Ownership (Excludes Wholesalers With No Retail Customers)				
	Publicly Owned Systems		Privately Owned Systems	
Population Served	Mean	Median	Mean	Median
Less than 100	62	65	130	99
101-500	88	75	187	148
501-3,300	134	115	201	90
3,301-10,000	220	168	140	87
10,001-50,000	231	196	346	105
50,001-100,000	279	221	236	223
100,001-500,000	445	275	246	214
More than 500,000	465	315	340	380

While production and treatment often are the focus of economic analyses, the largest component of a water system's asset inventory is pipe. The considerable variation in system spending to maintain distribution networks reflects the diverse age and condition of pipe in the ground, and the financial condition of the systems. Publicly owned systems replaced 7 percent of their pipe, on average, over the past 5 years. Systems serving up to 100 persons replaced 25 percent of their pipe, on average, over this period. (Most replaced none, but several replaced more than 50 percent of their pipe. These systems had less than one-half mile of distribution mains.) The median indicates that at least one-half of the small systems replaced no pipe between 1996 and 2000. The median is somewhat more stable than the mean; the median small system replaced no pipe, and the median medium and large systems replaced approximately 1 percent of their pipe in the past 5 years. (Tables 35-38 in Volume II provide more detailed information about systems' distribution networks.)

Not surprisingly, larger systems tend to have larger populations per mile of pipe than smaller systems, as shown in the above table. This is because large systems, especially publicly owned large systems, tend to be located in densely populated urban areas.

Financial Characteristics

The typical water system has a substantial investment in fixed assets, including pipe, storage, and treatment facilities; the average cost per gallon of water delivered drops as deliveries increase and systems spread the fixed cost of their investment over the larger quantities of water. Larger systems, therefore, face lower average costs than smaller systems and have lower costs per connection and per gallon of water produced. (These economies of scale often mean water systems are natural monopolies and are one reason that water systems are regulated when not owned outright by the public sector.) Because of economies of scale, system size is a key factor in explaining financial performance. In addition to their greater production, larger systems also have larger rate bases and more accountants and support staff. Therefore, larger systems generally perform better financially than small systems. This has implications for the system's financial well being and for its managerial and technical capacity.

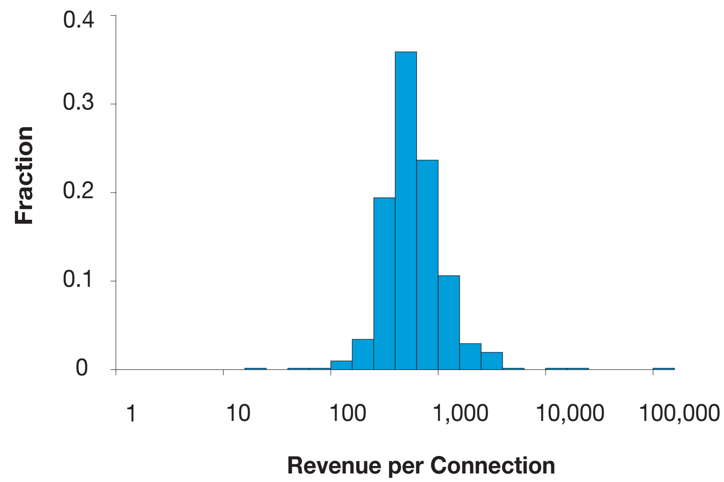
Revenue and Expenses

As discussed in Chapter 2, water systems generate close to $39 billion dollars annually in water sales and water related revenue. On average, water systems earned $815 million in 2000, with considerable variation around this average. Much of the variation is explained by the size of the population served by the system. Systems serving up to 500 persons earn an average of $22,000 per year, while systems serving more than 100,000 persons earn over $41 million. Public systems tend to earn more revenue because they tend to be larger; the average revenue of public and private systems of similar size are roughly equivalent. (See Tables 46-48 in Volume II for more details.)

Average Annual Water Systems Revenue in Dollars		
Population Served	Publicly Owned Systems	Privately Owned Systems
Less than 500	53,176	12,795
501-3,300	185,867	178,375
3,301-10,000	756,035	792,240
10,001-100,000	3,654,402	3,601,541
More than 100,000	40,797,408	45,853,541

One way to compare revenue of different sized systems is to consider revenue per customer connection. The average charge per connection is $416, with considerable variation around the average. (This estimate excludes ancillary systems, which often do not charge directly for water. It also excludes wholesale revenue because systems did not report the number of retail customer connections associated with their wholesale deliveries.) The graph to the right shows the distribution of earnings per connection. Most systems have revenue between $200 and $500 per connection. The distribution has a long, right tail, because some systems earn in excess of $10,000 per connection each year (mostly from large nonresidential customers).

Revenue per Connection



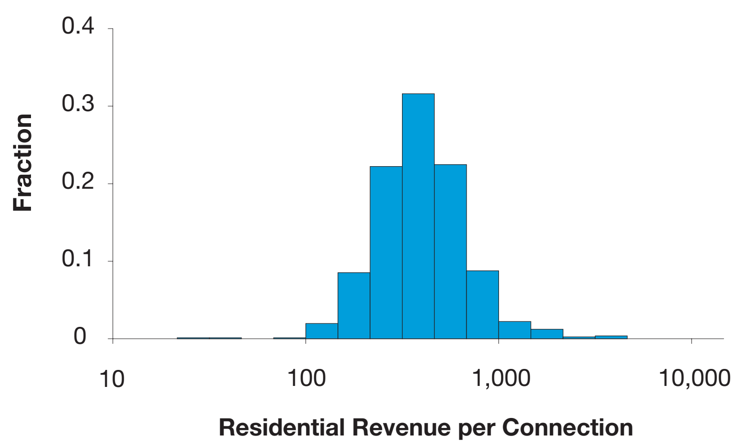
As discussed in Chapter 2, spending on water by residential and nonresidential customers is quite different. Average revenue per connection from nonresidential customers is significantly larger than earnings from residential customers.[6]

Median Revenue per Connection (Excludes Ancillary Systems) in Dollars

	Residential Connections		Nonresidential Connections	
Population Served	Publicly Owned Systems	Privately Owned Systems	Publicly Owned Systems	Privately Owned Systems
Less than 500	222	290	324	69
501-3,300	237	336	392	519
3,301-10,000	217	318	870	551
10,001-100,000	237	287	1,072	1,584
More than 100,000	251	314	1,498	1,293

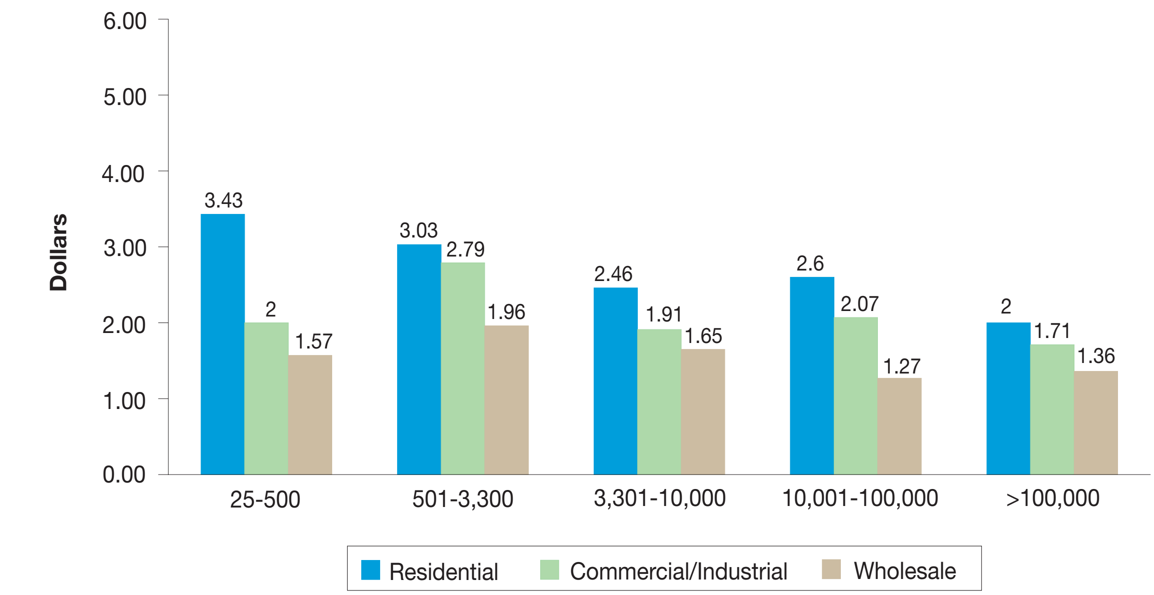
The median system earns $260 per residential connection. Publicly owned systems tend to earn less than privately owned systems per residential connection; this is true overall and within each system size category. Because a small number of systems have very large revenue per connection, median revenue is a better measure of central tendency than the average. (See Tables 56-57 in Volume II for more detail on residential revenue per connection.) Publicly owned systems serving more than 100,000 persons tend to earn more per connection than smaller systems; residential revenue per connection does not vary consistently with system size among privately owned systems. Overall, systems earn $519 per

Residential Revenue per Connection

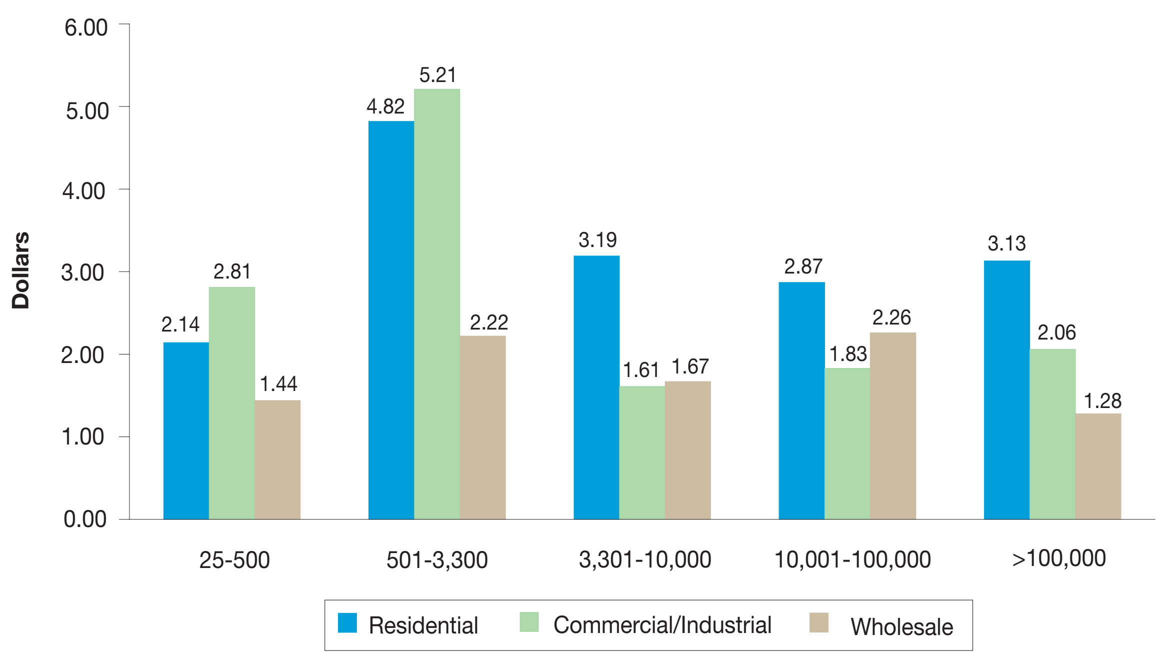


[6] Note that the analysis here is different than the analysis in Chapter 2. Chapter 2 reported the amount paid by typical residential and nonresidential customers. The analysis here in Chapter 3 changes the focus from the customer to the system: it reports the average revenue per connection received by systems, by customer class. Because the number of residential and nonresidential customers differs across systems, and because systems charge different rates for water, the two measures will not be the same.

Revenue per Thousand Gallons: Publicly Owned Systems by Population Service Categories



Revenue per Thousand Gallons: Privately Owned Systems by Population Service Categories



nonresidential connection. Public systems tend to earn more per nonresidential connection than private systems.

Residential customers present special concerns. On average, water systems receive the large majority of their revenue from residential customers, and they would bear much of the cost of efforts to improve water quality and to maintain or expand the system. Median revenue per residential connection is less than 1 percent of median household income.[7] There is a great deal of variation around the median, as well as

[7] This is based on an estimate of national median household income of $42,151 (U.S. Bureau of the Census Current Population Survey, *Money Income in the United States*: 2000.)

considerable variation in household income, so not every household pays this share of their income for drinking water. But on a national basis, most systems charge a relatively small portion of household income for water. (EPA will conduct detailed analysis of the relationship between revenue per connection and household income.)

Percentage Use of Residential Rate Structures

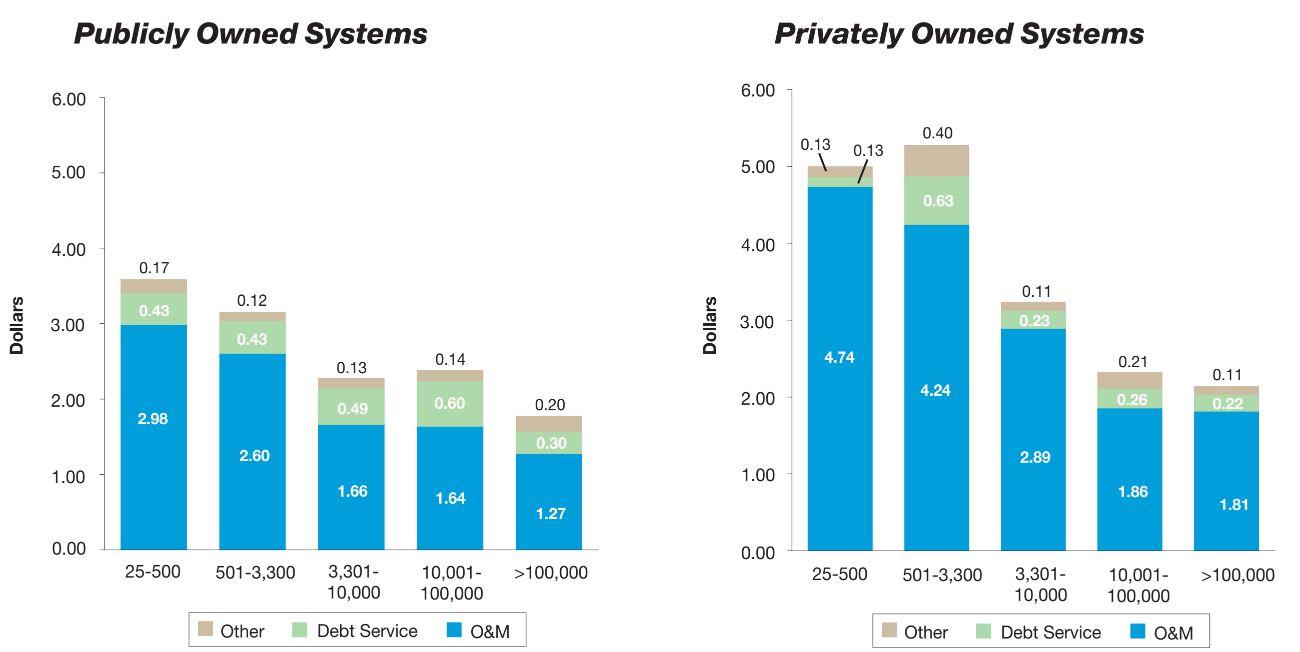
Rate Structure	Population Served: Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000	All Systems
Uniform rates	46.0%	54.0%	55.7%	56.7%	55.6%	**50.6%**
Declining block rate	6.7%	28.3%	34.9%	34.5%	24.5%	**19.1%**
Increasing block rate	7.0%	15.4%	13.4%	18.3%	27.5%	**11.5%**
Peak period or seasonal rate	0.0%	0.3%	2.0%	1.3%	9.6%	**0.6%**
Separate flat fee	26.9%	8.4%	19.9%	26.8%	25.3%	**20.2%**
Combined flat fee	17.2%	0.1%	3.2%	5.2%	2.0%	**9.1%**
Other	1.4%	1.2%	4.1%	1.9%	3.7%	**1.7%**

Note: columns will not sum to 100 because some systems use more than one rate structure.

The final factor that affects system revenue, in addition to the number and type of customer, is the rate the system charges for water. The median rate per thousand gallons for residential customers is $2.72. Nonresidential customers tend to pay less per thousand gallons (except privately owned systems in the smallest size category), and larger systems tend to charge less per thousand gallons. Wholesale customers tend to pay the lowest rates, although their rates are similar to nonresidential customers of privately owned systems serving between 3,301 and 100,000 persons. Their lower rates reflect their relatively high volume of purchases. (See Tables 53-55 in Volume II for further detail.) Balancing costs to nonresidential customers (especially large-volume users) and residential customers is important since demand stability is a key objective of systems. Without large-volume customers, residential customers would not have lower rates and would need to pay a larger share of fixed costs.

Water systems rely on a variety of approaches to charge for water. The most common means of charging residential customers is to use a single rate per gallon of water sold; one-half of all systems rely on uniform rates. Separate flat fees (20 percent of systems) and declining rates (19 percent) are the next most common rate

Spending per Thousand Gallons by Population Service Categories



Distribution of Operating Ratio (Percentage of Systems)					
	Population Served				
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000
Operating Ratio of Publicly Owned Systems					
<1	36.2%	26.5%	14.4%	18.3%	23.6%
1 to 1.2	27.3%	19.5%	28.2%	23.4%	9.6%
>1.2	36.5%	54.0%	57.4%	58.3%	66.8%
Operating Ratio of Privately Owned Systems					
<1	33.7%	9.3%	27.0%	17.3%	6.6%
1 to 1.2	15.8%	34.1%	11.2%	16.5%	36.6%
>1.2	50.5%	56.7%	61.8%	66.2%	56.8%
Operating Ratio of Ancillary Systems					
<1	87.9%	--	--	--	--
1 to 1.2	7.1%	--	--	--	--
>1.2	5.1%	--	--	--	--

structures. Only 12 percent of systems use increasing block rates, and most of them are large systems. Large systems also are more likely to use a seasonal rate structure. Nine percent use a flat fee combined with other non-water related charges. (Table 58 in Volume II provides additional detail on residential rate structures.) Some systems use more than one rate structure.

Chapter 2 reported that systems spent $32 billion in 2000. On average, water systems spent $863 million, with a large degree of variation around the average. As with revenue, expenses depend largely on system size. Systems serving up to 500 persons spent just under $20,000 on average, compared to $683,000 for systems serving more than 100,000 persons. Expenses tend to be higher for publicly owned systems, even among systems of similar size. (These figures exclude ancillary systems to allow comparisons with the revenue estimates.)

A more meaningful comparison is expense per thousand gallons produced. Expenses tend to decline with system size, reflecting the economies of scale inherent in the production and delivery of drinking water. Spending on O&M as a share of total spending also tends to decline with system size. (Tables 63-64 in Volume II provide additional detail on expenses per thousand gallons.)

Privately owned systems tend to spend more per thousand gallons than publicly owned systems, especially if the systems are small. Privately owned systems also tend to spend more per thousand gallons for O&M than publicly owned systems. Spending per thousand gallons for large publicly and privately owned systems is similar.

One measure of the financial health of a system is its operating ratio. The operating ratio is calculated by dividing total operating revenue by O&M expenses. (Note: this measure should not be confused with the operating ratio used by public utility commissions to calculate a rate base.) Operating revenue includes water sales revenue, connection fees, and development fees.[8] O&M expenses include employee and contractor expenses and other routine operating expenses. Debt service expense, capital expenditures, and other non-operating expenses are excluded. (Tables 65-66 in Volume II provide an alternative ratio: total revenue to total operating expenses, including debt service but excluding capital and other non-operating expenses.)

If the operating ratio is less than 1.0, the system is running an operating deficit or loss that year, or it is relying on non-operating revenue to finance operations. As the ratio increases, more funds are available from operations for non-operating expenses like debt service. Ratios of 1.0 to 1.2 are considered acceptable; above 1.2 is considered strong.

The table on this page summarizes operating ratios by system size and ownership. Roughly one-third of publicly and privately owned small systems have

[8] While it would be reasonable to exclude connection and development fees, the expenses they fund would need to be dropped from operations and maintenance expenses. Because these details on expenses are unavailable, they could not be excluded; therefore, the connection and development fees are included in operating revenue. If connection fees and development fees are excluded from the calculation of the operating ratio, the percentage of systems with an operating ratio above 1.2 declines 2-3 percentage points in each size category for both publicly and privately owned systems.

operating ratios of less than 1.0. Most ancillary systems have ratios below 1.0, which reflects the fact that they generally do not charge directly for water; while they may lose money supplying water to their customers, the business as a whole may be profitable. Systems that have ratios less than 1.0 may have positive cash flows due to depreciation. This may have a larger impact on privately owned systems than publicly owned systems, because privately owned systems are more likely to include depreciation in their annual operating expenses. The share of systems with ratios greater than 1.2 increases with system size, to more than two-thirds for the largest systems, whether publicly or privately owned.

A couple of notes of caution regarding the interpretation of these measures are warranted. Systems are grouped into the three categories based on commonly applied thresholds. The ratio thresholds are intended to characterize the industry in general, but they may not be appropriate measures of the well-being of specific water systems. Some well-run water systems may have operating ratios of less than 1.0 for reasons that are consistent with good planning and management, and it would be inappropriate to characterize them as weak. But if the operating ratio of a significant portion of systems in a sector is less than 1.0, the financial well-being of systems in that sector may be in question.

Second, financial data are recorded and reported in different ways by different systems. The questionnaire was designed to collect general information on revenue and expenses in a consistent manner across systems. Data on total debt service payments were collected, but principal and interest payments were not disaggregated. Also, the survey did not collect data on depreciation. The ratio is intended to provide a general measure of financial well-being; more detailed financial data than were available in this survey are required for more specific analyses.

Capital Expenditures

Community water systems invested, on average, $1.2 million in infrastructure over the 1996-2000 period. Publicly owned systems tended to invest more than privately owned ones. Most of the investment is carried out by large systems. (See Tables 69-72 in Volume II for more detail.)

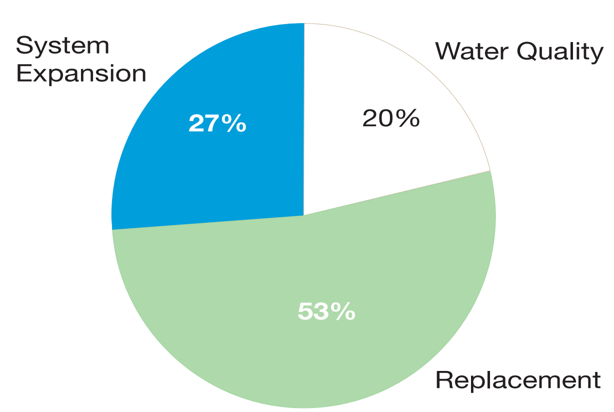
Average Annual Capital Improvement Expenditures (Millions of Dollars)

Population Served	Publicly Owned Systems	Privately Owned Systems
Less than 500	0.034	0.004
501-3,300	0.048	0.060
3,301-10,000	0.199	0.177
10,001-100,000	1.114	0.808
More than 100,000	12.606	10.013

Systems need to invest in infrastructure for a variety of reasons. They may need to upgrade their treatment to improve water quality, either to comply with federal drinking water standards or for other reasons. They also need to maintain their capital stock, making major repairs to worn assets, or replacing assets that have reached the end of their useful lives. Finally, they may need to expand their system capacity to provide water to a growing population.

The survey asked systems to divide their recent capital investments into these three categories. The responses provide a general sense of the underlying reasons for the investment. There is some overlap, because the reasons for investment are not mutually exclusive. For example, a system may need to replace a worn-out asset. In doing so, it may install a larger capacity asset to meet the needs of a growing population; it also may change the technology to comply with federal rules.

Water Industry Capital Expenditures by Purpose



Whether this investment is for water quality improvements, repair and replacement, or system expansion depends largely on the priorities of the system; therefore, it was left up to the system to allocate the funds. Also, systems may report an expenditure as affecting quality only if it is related directly to treatment. Water systems spend much of their funds on their distribution networks; much of this expense may be to improve the quality of their water, but may be reported as repair and replacement.

Purpose of Capital Expenditures by Ownership

	Population Served					
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000	All Systems
Publicly Owned Systems						
Water Quality Improvements	25%	10%	13%	18%	21%	16%
Repair/Replace	58%	54%	55%	43%	39%	53%
Expansion	17%	35%	31%	39%	39%	31%
Privately Owned Systems						
Water Quality Improvements	25%	28%	27%	14%	14%	25%
Repair/Replace	60%	23%	29%	37%	53%	54%
Expansion	15%	49%	45%	49%	32%	21%

Based on the systems' responses, 53 percent of the investment over the past 5 years was to replace or repair assets. Twenty-seven percent of investment was for system expansion. The remaining 20 percent of the total capital investment was for water quality improvements. This 20 percent matches the 1995 Community Water System Survey findings. Privately owned systems tended to use more of their investments for water quality improvements than publicly owned systems. This difference is due, in part, to the larger size of public systems: for both publicly and privately owned systems, the share of investment attributed to water quality improvements tends to decline with system size, and publicly owned systems tend to be larger. (See Tables 76-78 in Volume II for further detail.)

Distribution of Capital Expenditures by Ownership

	Population Served				
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000
Publicly Owned Systems					
Land	0%	1%	3%	2%	3%
Water source	12%	10%	9%	8%	9%
Distribution and transmission system	49%	50%	51%	52%	45%
Treatment	20%	20%	19%	20%	24%
Storage	11%	14%	11%	12%	10%
Other	9%	4%	6%	7%	9%
Privately Owned Systems					
Land	1%	0%	3%	1%	0%
Water source	14%	10%	11%	6%	13%
Distribution and transmission system	32%	46%	46%	60%	52%
Treatment	22%	8%	21%	15%	11%
Storage	22%	27%	9%	6%	4%
Other	9%	8%	4%	12%	20%

An alternative view of the purpose of the investment is to look at what was purchased. On average, 49 percent of the investment by publicly owned systems was for their distribution and transmission systems; privately owned systems spent 40 percent of their investments on these systems. Public systems put an additional 12 percent into storage, while private systems used 18 percent in this way. Treatment accounts for an additional

Percentage of Systems that Use Each Source of Funds by Ownership						
	Population Served					
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000	All Systems
Publicly Owned Systems						
Current Revenue	57%	70%	74%	80%	91%	70%
DWSRF Loans	11%	13%	3%	8%	12%	10%
DWSRF Principle Repayment Forgiveness	14%	7%	2%	4%	3%	7%
Other Government Loans	11%	13%	14%	15%	6%	13%
Other Government Grants	26%	18%	28%	20%	6%	22%
Borrowing from the Private Sector	9%	13%	27%	38%	47%	20%
Other	6%	3%	4%	1%	3%	4%
Privately Owned Systems						
Current Revenue	83%	72%	67%	85%	88%	81%
DWSRF Loans	0%	0%	0%	3%	18%	0%
DWSRF Principle Repayment Forgiveness	0%	0%	12%	0%	0%	0%
Other Government Loans	2%	9%	2%	22%	13%	3%
Other Government Grants	3%	15%	12%	17%	0%	5%
Borrowing from the Private Sector	9%	24%	51%	38%	70%	13%
Other	6%	7%	9%	10%	0%	6%

20 percent of the investment for both public and private systems. Small systems tend to spend a smaller percentage of funds than larger systems on distribution and transmission systems and a greater share on storage, source development, and, at least for private systems, treatment.[9] (See Tables 73-75 in Volume II for additional details.)

Systems have several means of financing their capital investments, including cash, government grants and loans, and private sector borrowing. Most large systems rely on current revenue for at least a portion of their capital investment. A substantial portion of publicly owned systems serving 25-500 persons also relies on other sources of funds, including government grants and loans.

More than 80 percent of all privately owned systems financed their investment with current revenue, while only 13 percent borrowed from private sources. Borrowing by privately owned systems from private-sector sources tends to increase with system size: over 70 percent of systems serving more than 100,000 persons borrow from private sources, while only 9 percent of systems serving up to 500 persons borrow from the private sector. Publicly owned systems are somewhat more likely overall to borrow from private-sector sources; nearly 20 percent did so. While private-sector borrowing increases with system size among publicly owned systems, the largest public systems are less likely than their private-sector counterparts to borrow.

The table above shows that most systems, whether publicly or privately owned, rely on current revenue to

[9] Investment in treatment does not need to equal investment in water quality improvements. See footnote 4 on page 18.

Average Percentage of Funds from Each Source by Ownership

	Population Served					
	Below 500	501-3,300	3,301-10,000	10,001-100,000	Over 100,000	All Systems
Publicly Owned Systems						
Current Revenue	45%	53%	50%	56%	65%	51%
DWSRF Loans	7%	11%	3%	3%	4%	7%
DWSRF Principle Repayment Forgiveness	10%	4%	0%	1%	1%	4%
Other Government Loans	4%	8%	11%	9%	2%	8%
Other Government Grants	20%	11%	16%	5%	1%	13%
Borrowing from the Private Sector	9%	11%	17%	25%	27%	14%
Other	6%	3%	2%	0%	1%	3%
Privately Owned Systems						
Current Revenue	82%	65%	52%	56%	66%	78%
DWSRF Loans	0%	0%	0%	3%	1%	0%
DWSRF Principle Repayment Forgiveness	0%	0%	5%	0%	0%	0%
Other Government Loans	2%	5%	2%	5%	5%	2%
Other Government Grants	2%	10%	4%	10%	0%	4%
Borrowing from the Private Sector	8%	13%	28%	26%	28%	10%
Other	5%	7%	9%	3%	0%	5%

finance their investments; in fact, systems finance the majority of their investments out of current revenue.

Less than 10 percent of publicly owned systems received loans from the DWSRF. An additional 7 percent had principal repayments forgiven by the program. Smaller systems were somewhat more likely to use DWSRF loans and were much more likely than larger systems to receive SRF grants.

The table above shows the average percentage of funds systems obtained from each source. On average, systems receive an additional 12 percent of their investment funds through private-sector borrowing. Publicly owned systems finance somewhat more of their investments through borrowing, due in large part to their size: as system size increases, reliance on borrowing as a source of funds almost quadruples. Publicly owned systems also are more likely to use DWSRF loans. (Some states do not make DWSRF funds available to private systems.) While small privately owned systems borrow more from the private sector than small publicly owned systems, small publicly owned systems more than make up for the difference with DWSRF and other public-sector loans. The table on this page presents estimates of the percentage of capital investment financed by each funding source for the average system. The table on page 18, in contrast, reports the amount that came from each funding source for all capital expenditures nationally, in the aggregate. (Table 80 in Volume II provides further detail on sources of funds.)

Trends

The 2000 Survey is the fifth CWS Survey. Previous surveys were conducted in 1976, 1982, 1986, and 1995, providing data on nearly 25 years of water system operational and financial experience. The analysis will focus on changes since 1995 because those data are used as a baseline for EPA cost models.

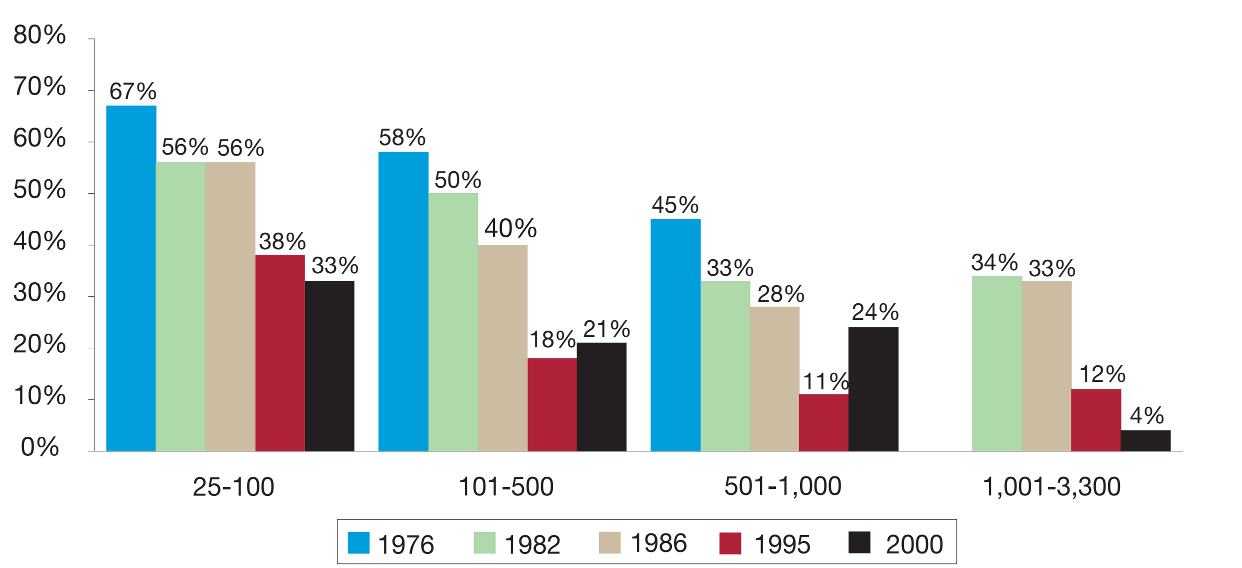
Trends in Operating Characteristics

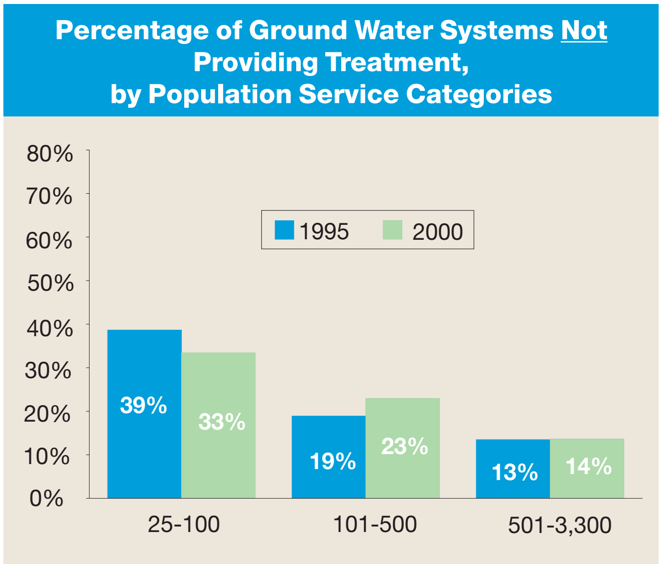
The fundamental characteristics of the water industry have not changed since the 1995 Survey. As described in Chapter 2, most systems are small, privately owned, and rely on ground water sources. Most people, however, receive their water from large, publicly owned systems that rely primarily on surface water sources. More systems relied primarily on purchased water in 2000 than in 1995, increasing from 10.6 percent to 15.3 percent. Fewer systems relied primarily on ground water: 79.8 percent were primarily ground water systems in 1995, compared to 73.9 percent in 2000. Of course, small changes in the quantities of water purchased can produce relatively large changes in the number of systems that are classified as primarily ground water, surface water, or purchased water systems. Therefore, this change does not necessarily represent a dramatic shift in water source.

The total number of systems increased by just under 4 percent between the two surveys. But the number of smallest systems—those serving up to 100 persons—declined by more than 8 percent. This decline was offset by increases in the number of systems serving 101-3,300 persons, so that the total number of systems serving fewer than 3,300 grew by 1 percent. Systems serving more than 3,300 persons grew by nearly 20 percent.

One of the metrics that EPA has followed over the previous CWS Surveys is the percentage of systems that provide no treatment. Since the first survey, this number has steadily declined, as seen in the chart on this page. (Since most large systems provide treatment, the graph focuses on smaller systems.) While the overall number of systems that do not provide treatment continued to decline, the trend appears to have stopped, at least for now, for several size categories in the 2000 Survey. This can be interpreted in one of two ways. It may indicate that progress in ensuring that water purveyors treat their water has slowed. On the other hand, it may indicate that substantial progress has been made since 1974: virtually all water from surface sources receives some form of treatment, and ground water is treated when existing standards require it. Recent changes in federal rules and proposed rules in the pipeline likely will lead to further reductions in the percentage of ground water systems that do not treat. Furthermore, the percentage of the population consuming water from untreated sources is very small because only small ground water systems that serve less than 2 percent of the total population served by

Percentage of Systems Not Providing Treatment by Population Service Categories





community water systems do not treat their water. (Table 9 in Volume II provides further detail on systems not providing treatment in 2000.)

The chart on this page shows that the percentage of ground water systems not providing treatment has remained virtually unchanged since 1995. It focuses solely on ground water systems. It also combines two size categories to increase the precision of the estimate. The percentage of ground water systems not treating declines slightly for the smallest size category, and increases slightly for the others. The differences are not statistically significant.[10]

The overall number of systems that do not provide any treatment continued to decline, according to the 2000 Survey.

Trends in Financial Characteristics

Overall, average water sales and water-related revenue increased between 1995 and 2000. Revenue per thousand gallons increased by 12 percent in real terms between 1995 and 2000, which is an average annual increase of 2.3 percent. Systems serving up to 3,300 persons tended to increase the revenue they collected per thousand gallons, while revenue per thousand gallons declined in real terms for larger systems. (The small system increase may reflect the quality of the data collected in the two surveys; both the overall response rate and the item response rates on the revenue questions for small systems increased dramatically in 2000 because site visitors collected the data. See Table 54 in Volume II for further detail on revenue per thousand gallons.)

Operating expenses per thousand gallons of water delivered increased slightly since 1995. (Operating expenses are equal to employee and other O&M costs and debt service. It excludes capital and other non-operations-related expenses.) As with revenue, the overall increase masks differences among systems of different sizes. Systems in some size categories witnessed modest declines in cost per thousand gallons, while others saw costs per thousand gallons increase over the 5 year period. (Table 63 in Volume II provides details on total expenses per thousand gallons produced.)

While average revenue and expenses per thousand gallons often moved in the same direction for most system size categories, the magnitude of the change was often quite different. For example, revenue per thousand gallons for systems serving more than 100,000 persons declined 14 percent, while their expenses remained relatively constant. While not

[10] Note that the percentage of systems not treating water in 1995 is slightly different than previously reported. The 1995 data include systems that did not respond fully to the treatment questions. Previously, it was assumed that these systems in fact provided treatment. This likely understated the percentage of systems not providing treatment in 1995. These systems were dropped from the current analysis.

Trends in Water Sales Revenues and Operating Expenses (Dollars per Thousand Gallons Delivered)

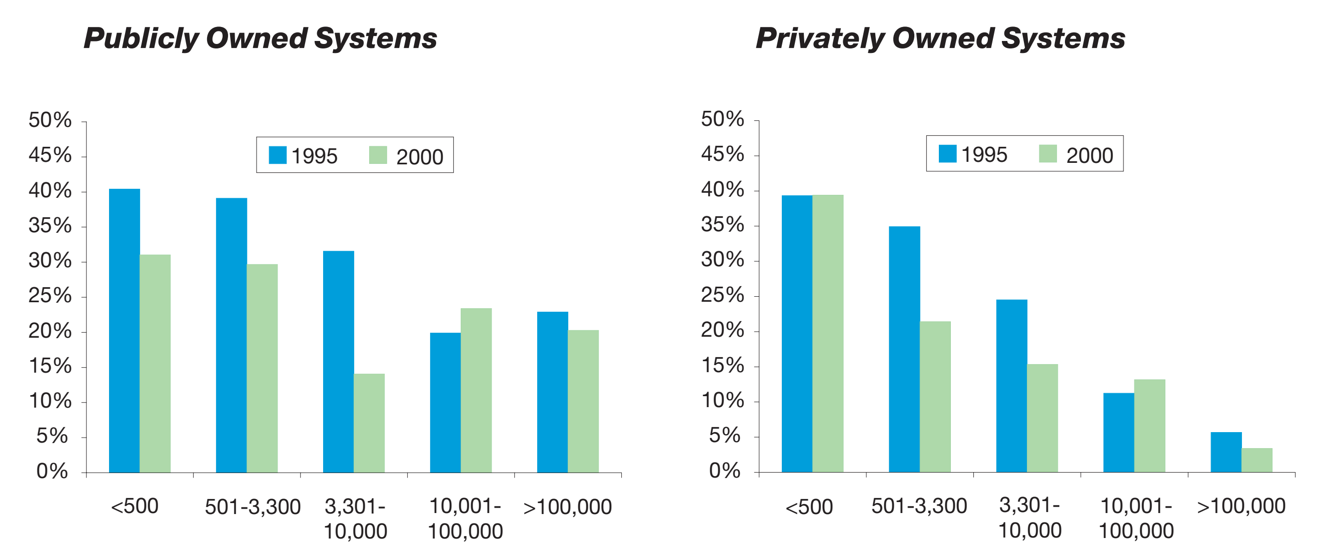
Population Served	Water Sales Revenue 2000	Water Sales Revenue Percentage Change since 1995 (in 2000 Dollars)	Operating Expenses 2000	Operating Expenses Percentage Change since 1995 (in 2000 Dollars)
25-500	4.57	22.7%	3.59	-4.7%
501-3,300	3.97	11.2%	3.40	13.1%
3,301-10,000	2.62	-19.6%	2.26	-11.2%
10,001-100,000	2.56	-3.9%	2.20	1.8%
More than 100,000	1.82	-14.2%	1.60	-0.5%

encouraging, the changes in the relative cost and revenue per thousand gallons does not necessarily translate into a deterioration in a system's financial position, since total expenses and revenue depend on the quantities produced and sold. In fact, changes in the quantities produced and sold can affect costs and revenue per gallon. Overall, a substantial portion of systems continues to have costs that exceed revenue, but the percentage of publicly owned systems reporting an operating deficit and privately owned systems reporting an operating loss declined for all but one size category.

As noted above, operating expenses include employee and other routine operating expenses and debt service; it excludes capital purchases and other expenses not related to system operations. Revenue includes water sales and water-related revenue, and excludes non-water-related revenue.

While more than 40 percent of public systems serving fewer than 500 persons operated with losses in 1995, only 31 percent did so in 2000. The percentage of privately owned systems in the smallest size category operating at a loss was constant at 39 percent. The percentage of publicly and privately owned systems with operating losses or deficits tends to decline with system size. Expenses exceeded revenue in 20 percent of public systems serving more than 100,000 persons in 2000, which is down from 23 percent in 1995. Among privately owned systems of this size, 3.4 percent operated at a loss, compared to 5.7 percent in

Percentage of Systems With Deficits or Losses by Population Service Categories



1995. The percentage of publicly owned systems serving more than 10,000 persons and operating at a loss increased slightly. The percentage of publicly and privately owned systems operating with a deficit or a loss increased slightly between 1995 and 2000 among systems serving 10,001-100,000 persons.

Some caveats are needed before drawing conclusions about the financial well-being of the industry:

- The survey's estimates of surpluses or deficits are from a single year's financial data. As noted earlier, water systems often face temporary deficits while waiting to implement higher rates. There also may be a strong cyclical component to system finances; the recent down turn in the overall performance of the economy may affect system finances, reversing some of the improvements shown in the previous graphs (at least for systems with substantial nonresidential sales).
- Combined systems (e.g., water and sewer, water and power) often had difficulty disaggregating their operating expenses. Many combined utilities track sales revenue for each operation separately, but combine operating expenses. Systems (and site visitors to small systems) often used simple rules of thumb to approximate water-related expenses, e.g., assuming expenses are proportional to revenue. In some cases, non-water-related expenses may remain in reported expenses, which may lead to an overestimate of the percentage of systems that have operating losses or deficits.
- The relatively small percentage of large, privately owned systems that have losses may reflect their reliance on equity capital. Profits are needed to pay dividends to shareholders or to maintain share value.
- Some systems may be technically insolvent. This may be true especially among small systems. For very small systems, there is a thin line between solvency and insolvency; a temporary insolvency may be resolved relatively quickly. For example, a small homeowners association may be able to levy a small assessment on all customers to become solvent.
- Expenses include some items that are important accounting expenses, but do not require cash outlays. Depreciation, for example, often is a large item, but requires no cash payments. Systems, therefore, may be operating at a loss but still have positive cash flow. (See Jordan, J.L., "Do You Use Your Depreciation Funds Wisely," *Opflow*, Vol. 21, No. 12, December 1995, p.1.)

APPENDIX A TREATMENT SCHEME DEFINITIONS AND SCHEMATICS

Treatment plants in the sample are assigned to one of eight treatment schemes, based on the system's response to the treatment questions. The treatment schemes move from relatively simple to relatively complex practices. The more complex practices may include the steps taken in the less complex trains. For example, conventional filtration plants likely disinfect. These treatment schemes are defined as follows.

1. Facilities that provide disinfection and no other treatment. These include:
   - **Chlorination**
   - **Ozone**
   - **UV**
   - **Other (chloramines, chlorine dioxide, etc.)**
   - **Blending**

2. Facilities that provide treatment in the form of chemical addition beyond just disinfection, but less than "mechanical" processes. These practices include:
   - **Corrosion control**
   - **Sequestration**
   - **Fluoridation**
   - **pH control**
   - **Blending**

3. Facilities that use ion exchange, activated alumina, or aeration.

4. Facilities that provide treatment and filter their water, but do not use direct or conventional filtration or membranes. These include:
   - **Microstrainer**
   - **Bag and cartridge**
   - **Green sand filtration**
   - **Diatomaceous earth**
   - **Pressure filtration**
   - **GAC**

5. Systems that provide direct filtration, but do not use conventional filtration, membrane technology, or softening processes.

6. Systems that provide conventional filtration, but do not use direct filtration, membrane technology, or softening processes.

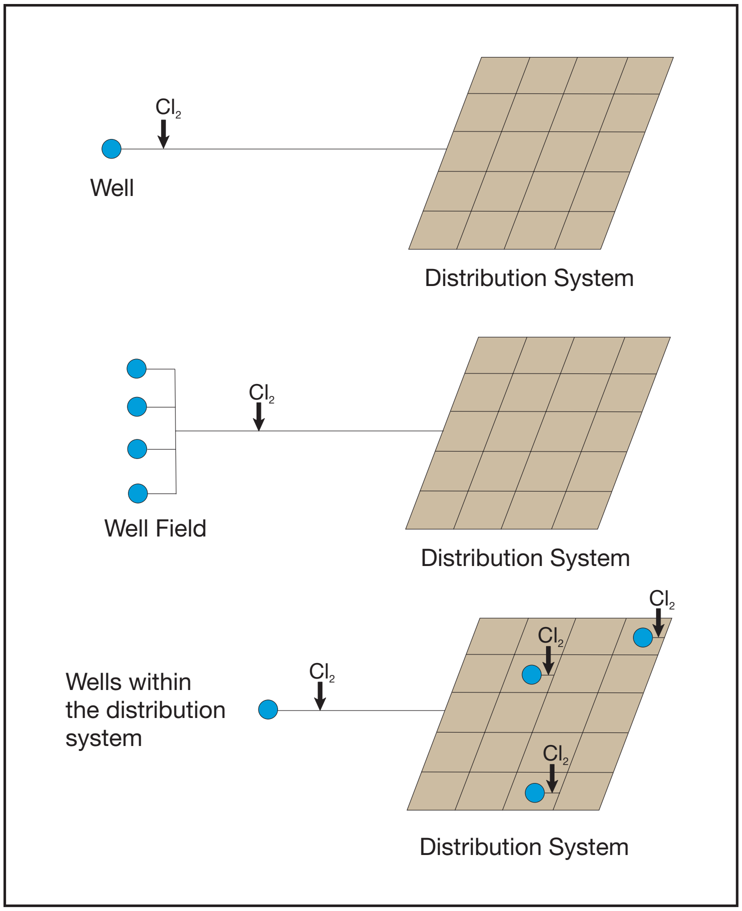
7. Systems that use membrane technology, regardless of what may come before the membrane treatment.

8. Systems that provide softening processes, regardless of what may come before or after the softening.

Treatment Scheme 1: Chlorination/Other Disinfection Only
Application: All Sizes Categories - Surface Water and Ground Water

Well

Chlorinator

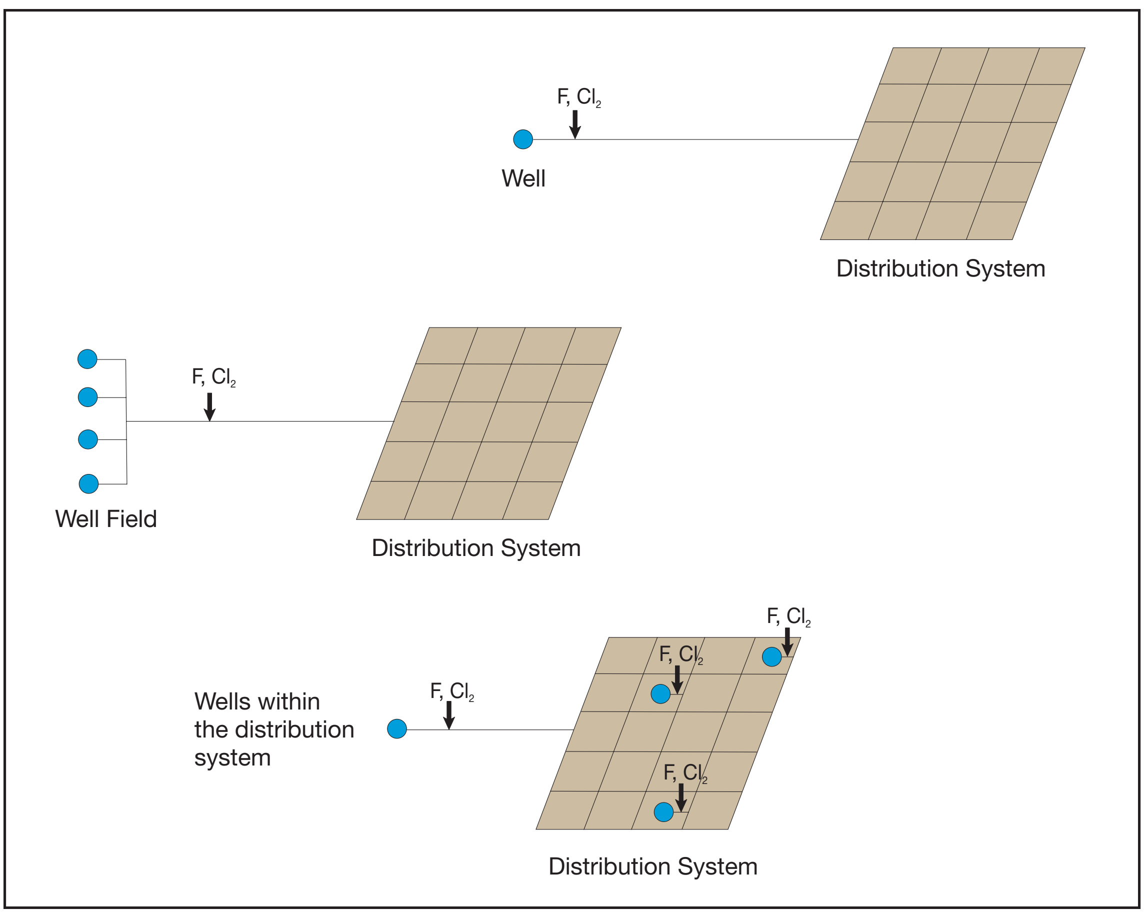


Treatment Scheme 2: Other Chemical Addition
Application: All Size Categories - Surface Water and Ground Water

Source: Well Field

Chlorination

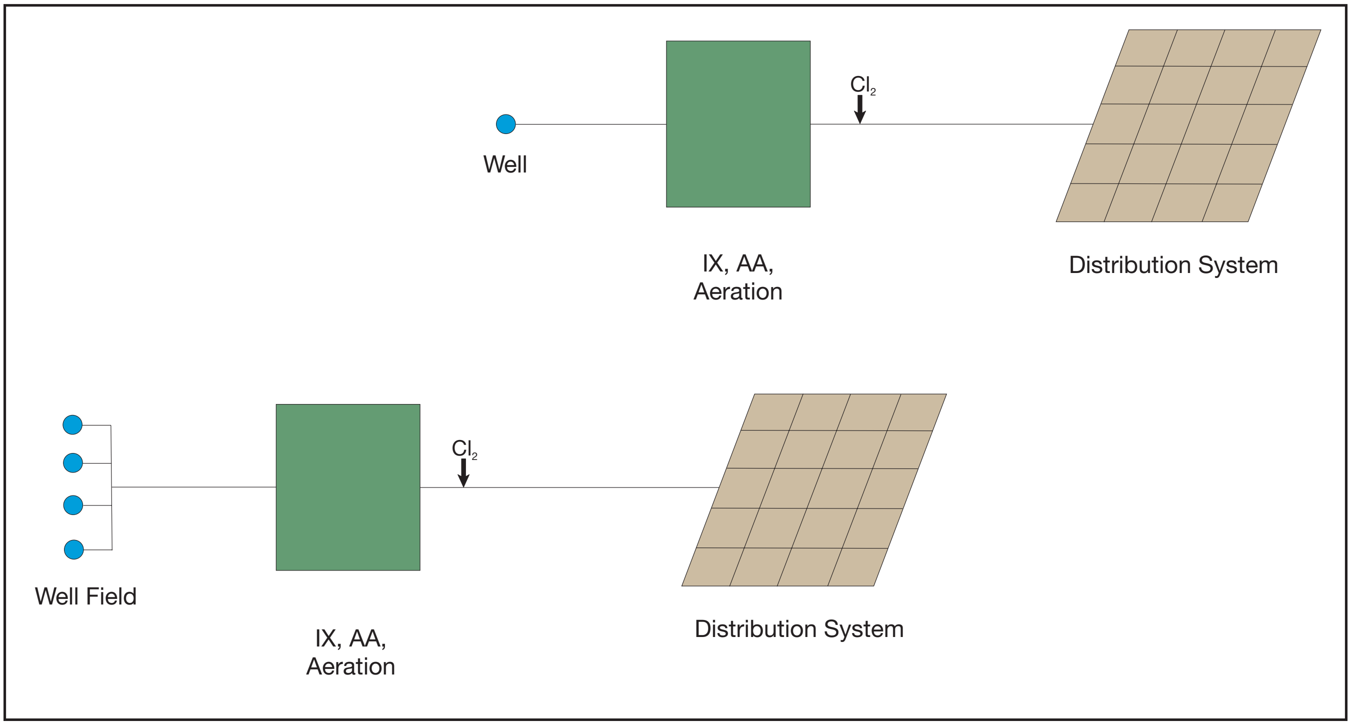
Fluoride Addition



Treatment Scheme 3: Ion Exchange, Activated Alumina, Aeration
Application: All Size Categories - Ground Water

Source

Cation Exchange



Anion Exchange

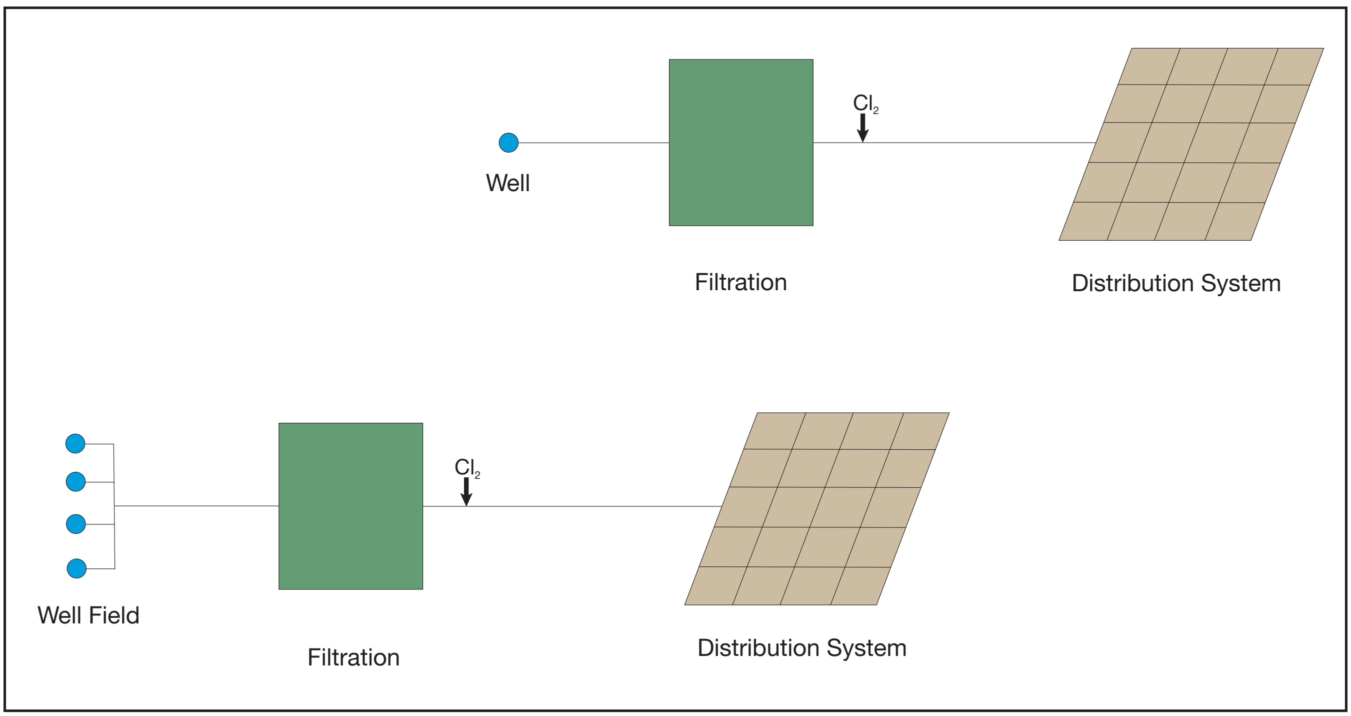
Chlorination

Treatment Scheme 4: Filters
Application: All Size Categories - Ground Water and Surface Water

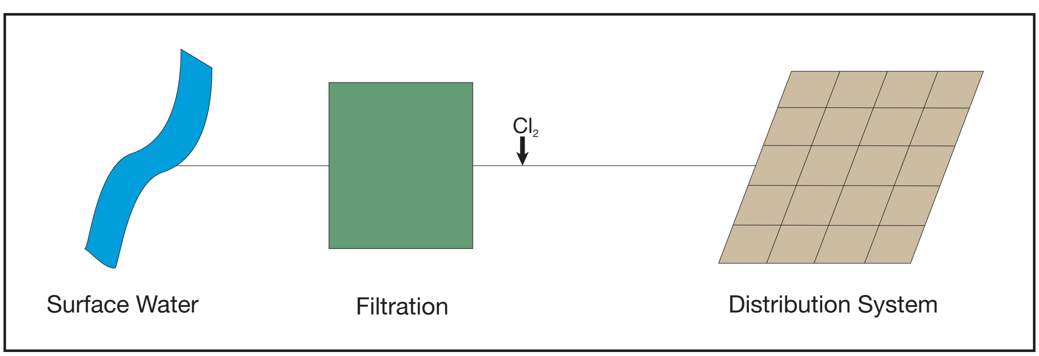

Source


Bag Filter and Chlorination


Cartridge Filtration



Ground Sources

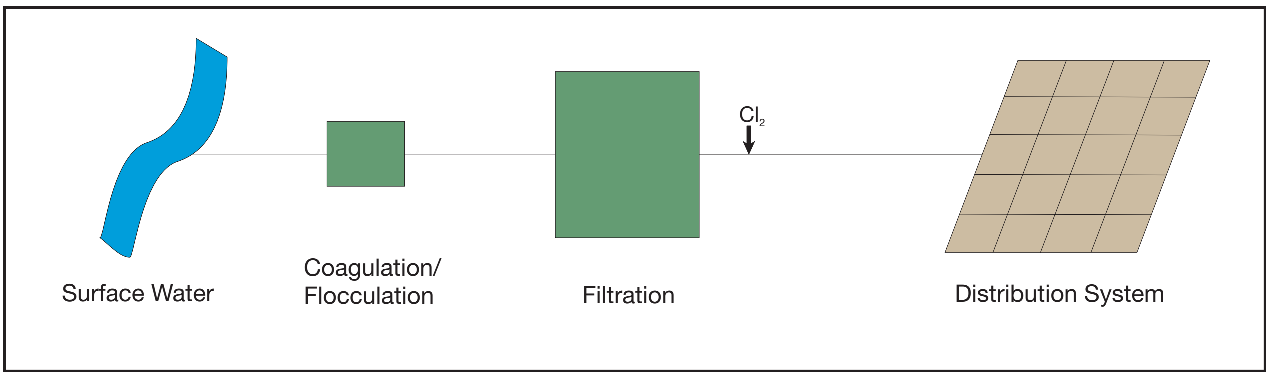


Surface Sources

Treatment Scheme 5: Direct Filtration
Application: All Size Categories - Surface Water

Source

Coagulation/Flocculation
Chemical Addition

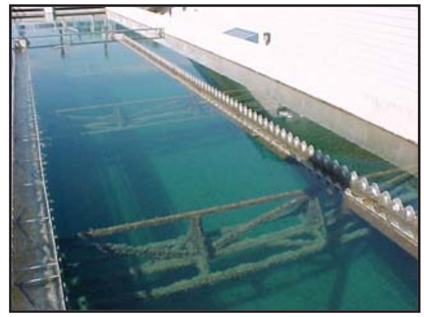


Filtration

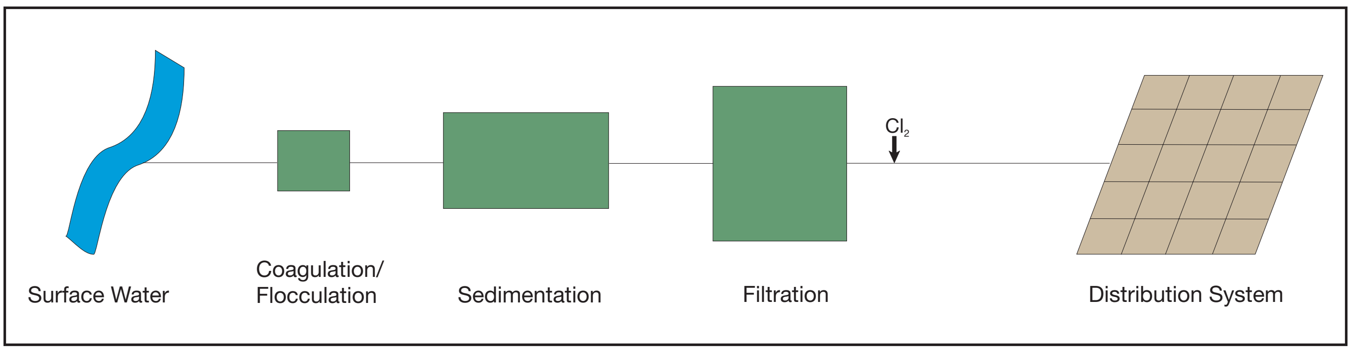
Chlorination

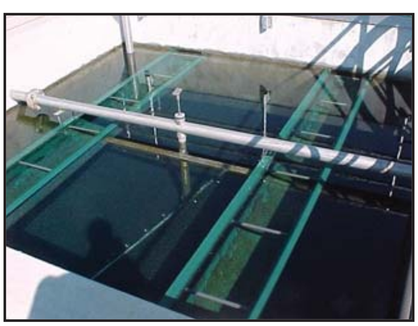
Treatment Scheme 6: Conventional Filtration
Application: All Sizes - Surface Water

Source



Coagulation/Flocculation/ Sedimentation





Filtration

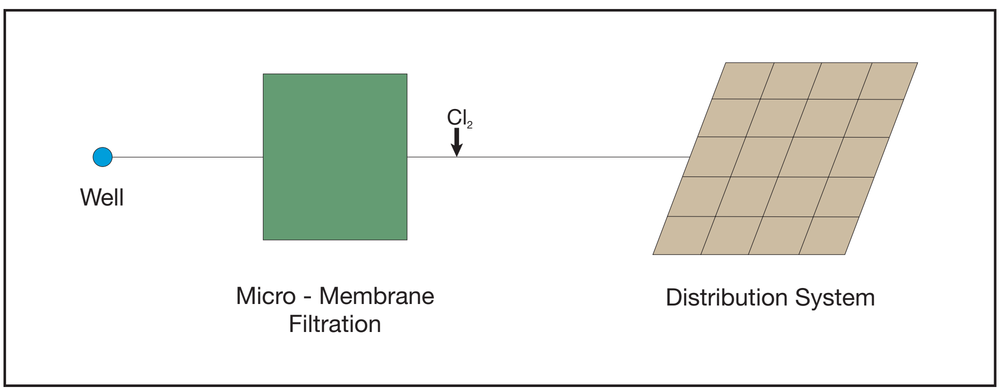
Chlorination

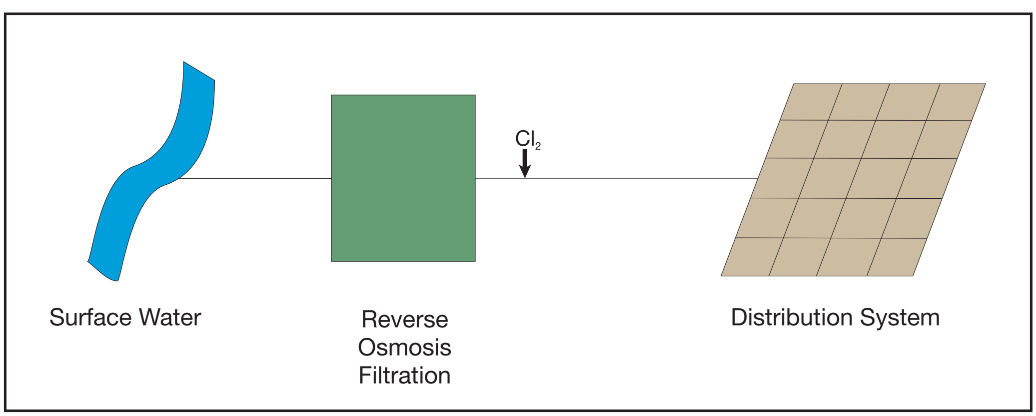
Treatment Scheme 7: Membrane Filtration
Application: All Sizes - Ground Water and Surface Water

Source

Chlorination

Reverse Osmosis Unit

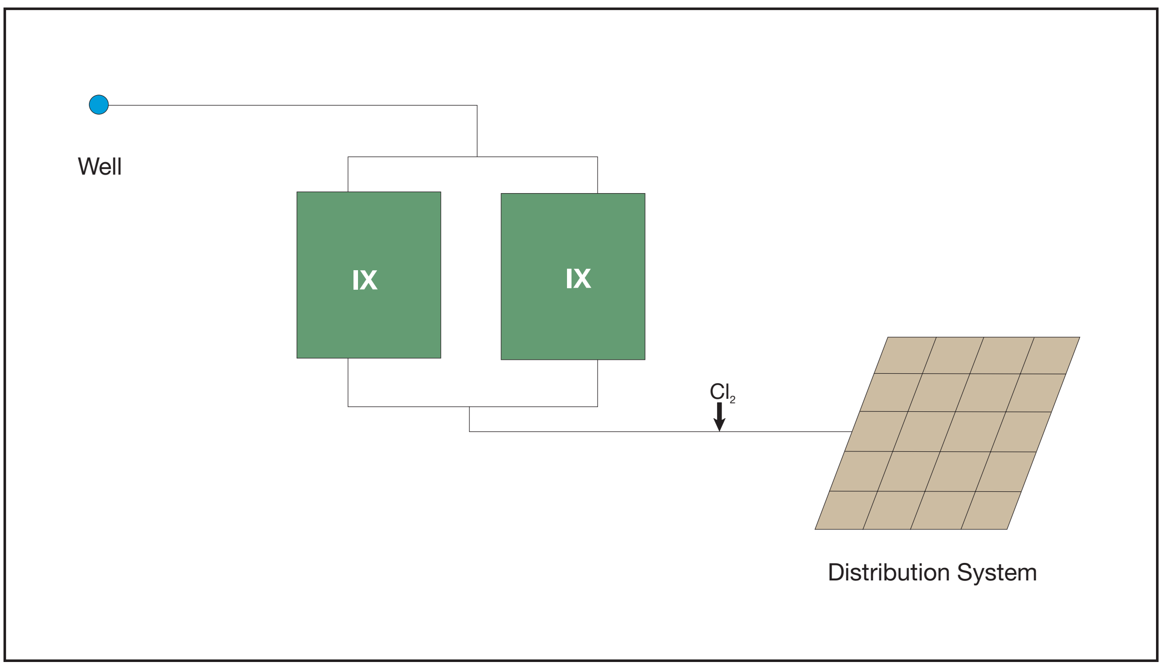




Treatment Scheme 8a: Softening
Application: All Sizes - Ground Water


Source


Cation Exchange

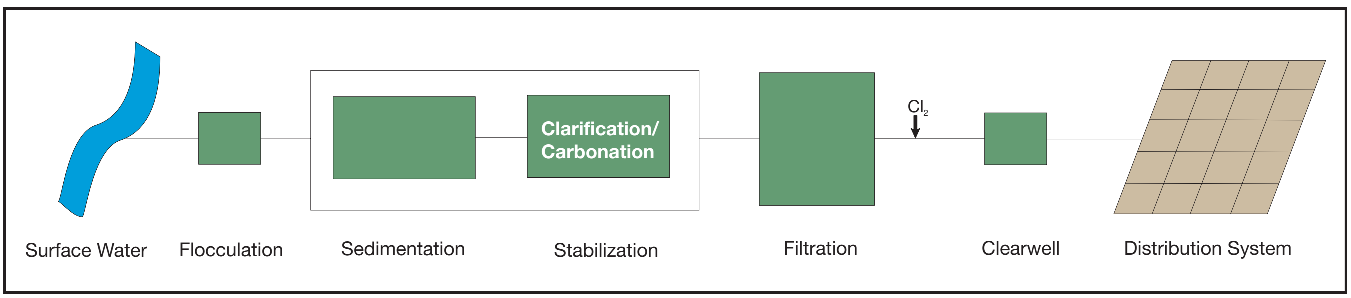


Treatment Scheme 8b - Softening
Application: All Sizes - Surface Water

Source

Coagulation

Lime Addition



Flocculation

Sedimentation/Filtration

Lime Addition

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