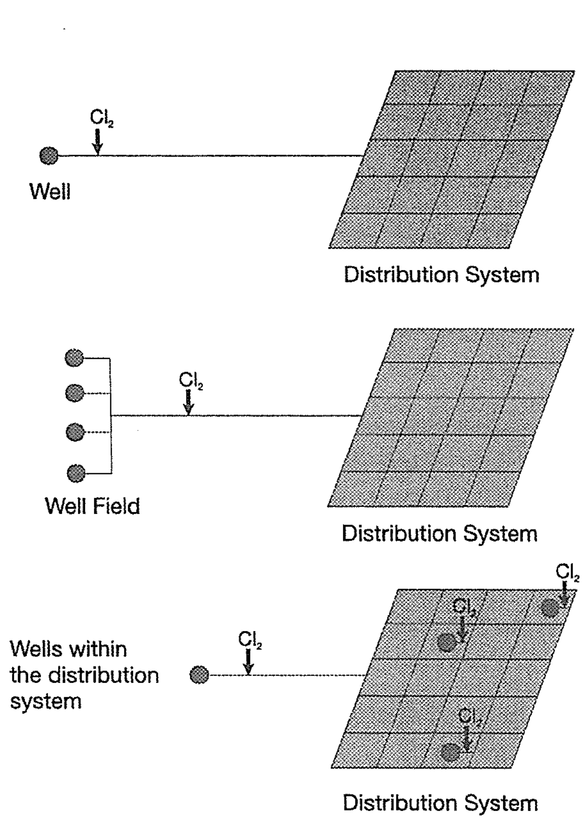
Total production of all community water systems is approximately 51 billion gallons per day, including unaccounted for water. (Unaccounted for water includes system losses, water consumed in the treatment process, fire fighting, and other uncompensated usage.) Systems that rely primarily on surface sources 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.)

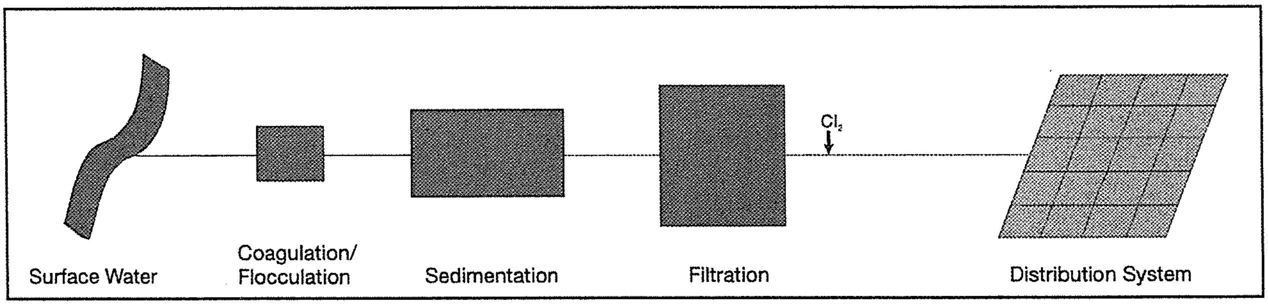
Water systems use many different practices to achieve their treatment objectives. Processes include chemical addition, coagulation/flocculation, settling and sedimentation, filtration, membranes, and softening. To characterize the various treatment practices, each plant in the sample was assigned to 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

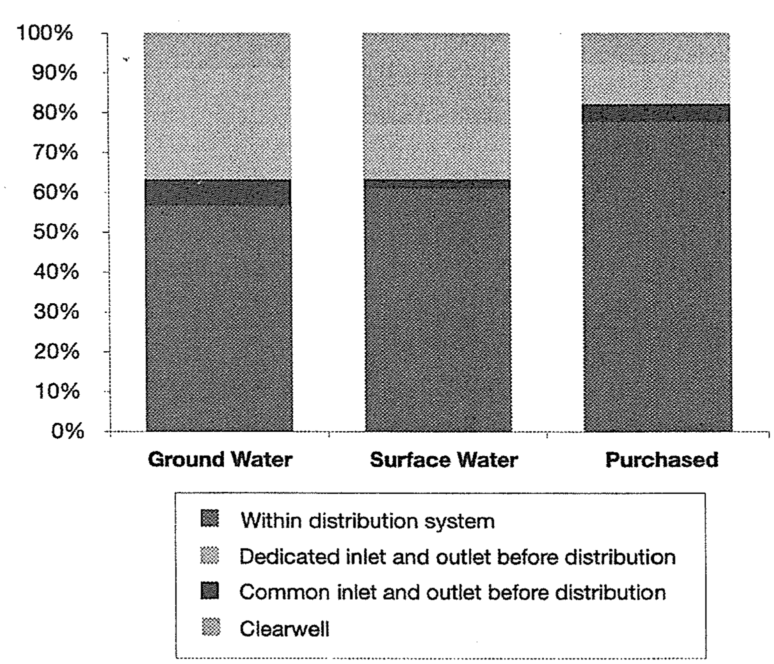
Twenty-two percent of facilities treating only surface water have an operator on site 24 hours a day, 7 days a week (or "24/7"). The larger the system—and the larger the plant itself—the more likely an operator is on duty 24/7; 80 percent of surface water plants in systems serving more than 50,000 persons—and 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.)

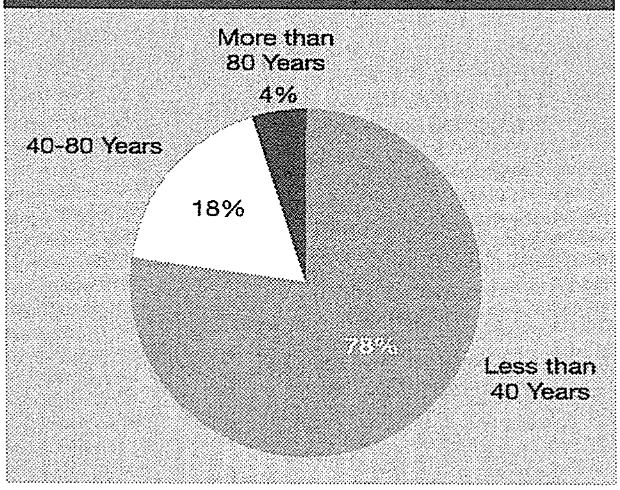
Storage

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

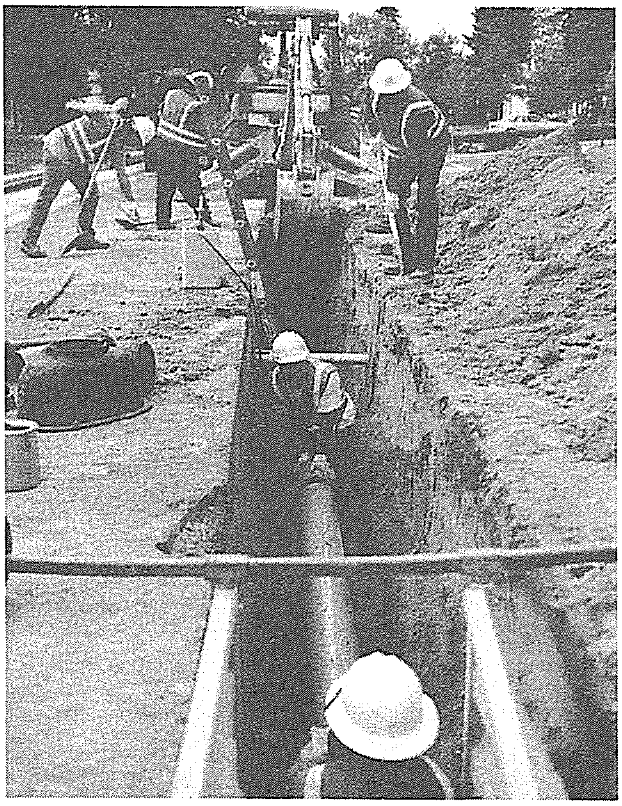


Distribution Mains, by Age



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

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

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 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.

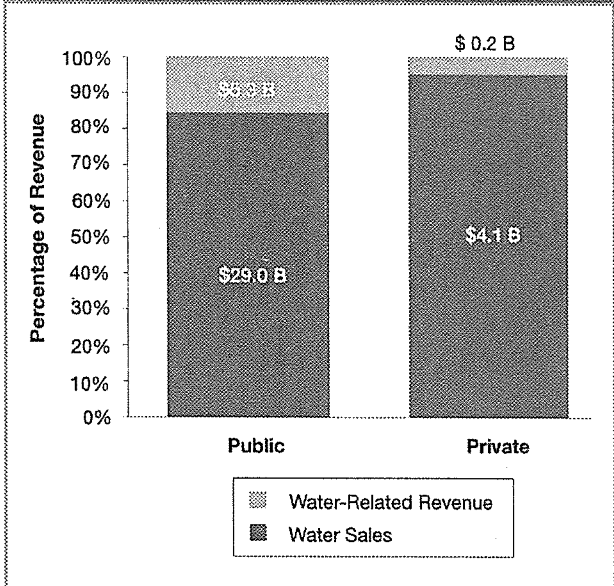
Residential customers provide the majority of water sales revenue for community water systems in all size categories.

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%

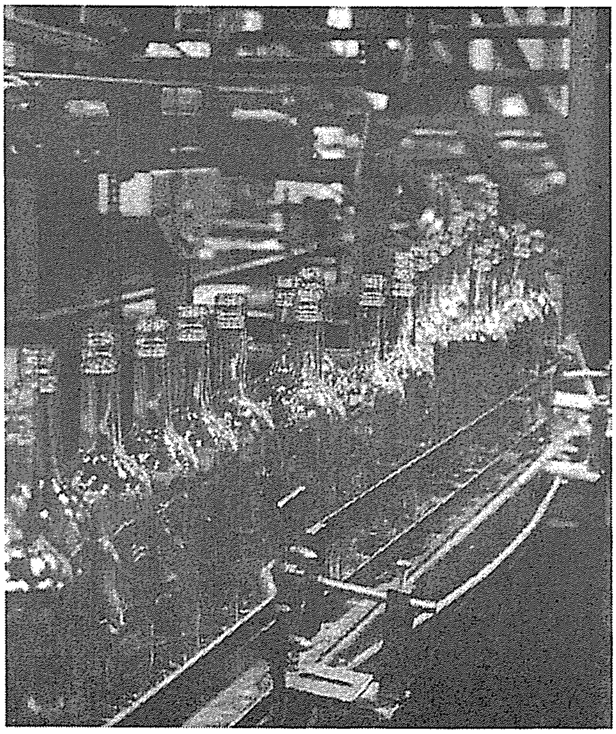
Water-related revenue consists of development fees, connection fees, fines, and other payments unrelated to the quantity of water sold. In 2000, water sales were $33 billion, or 85 percent of total water revenue. Private systems depend slightly more heavily on water sales than public systems—over 95 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.)

Water System Revenue, by System Ownership

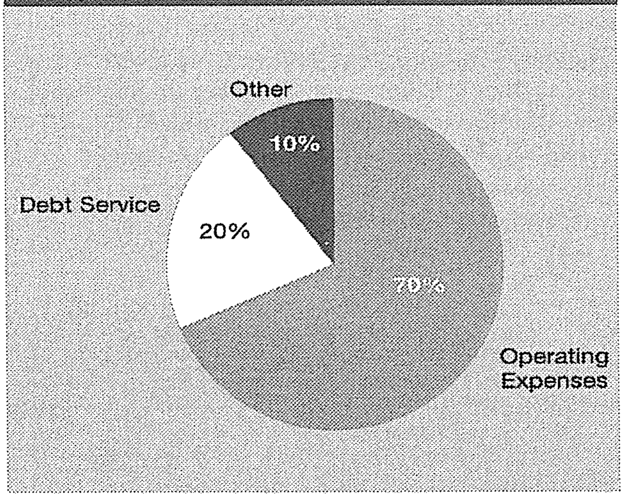


[3] Note: the sum of water sales and water-related revenue in the following table does not match total water revenue in the previous table because some systems could not distinguish between sales and water-related revenue and only reported their total revenue. (Tables 50 and 51 in Volume II provides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

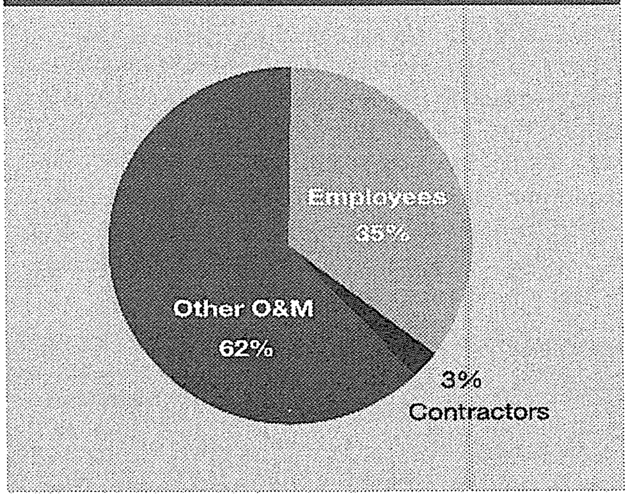


Non-residential customers, such as this bottling plant, provide 20% of all systems' water sales revenue. Systems serving more than 100,000 persons typically have higher commercial and industrial revenues than smaller systems.

Total Expenses, by Type of Expense



Operating Expenses by Component

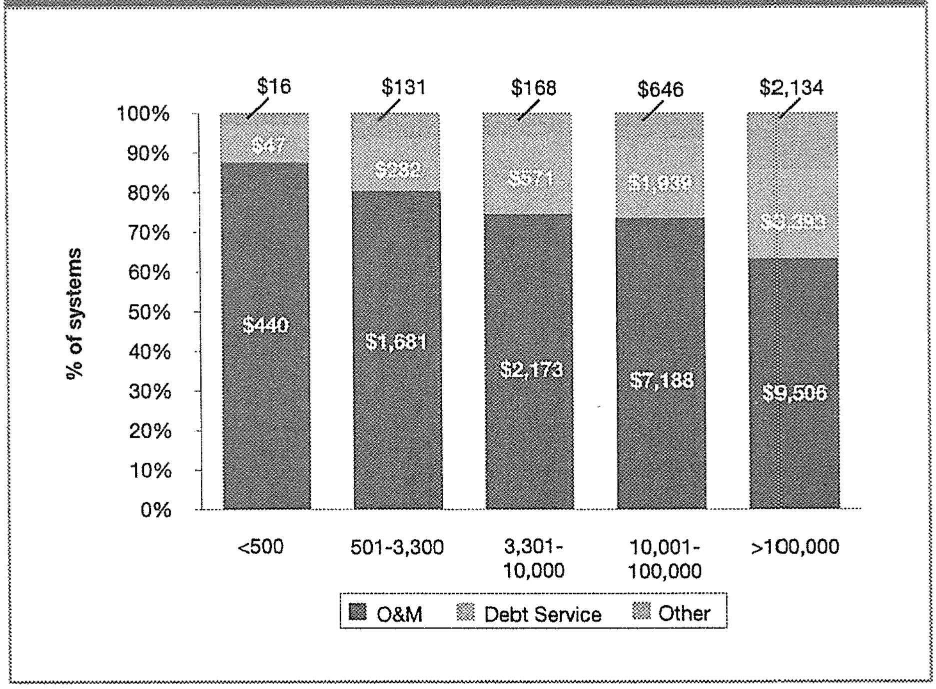


Although residential customers are the source of most water system revenue, non-residential connections generate considerably more income per connection. On average, nonresidential customers pay $1,686 per year, compared to $302 for residential customers. The difference is driven largely by the larger 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.

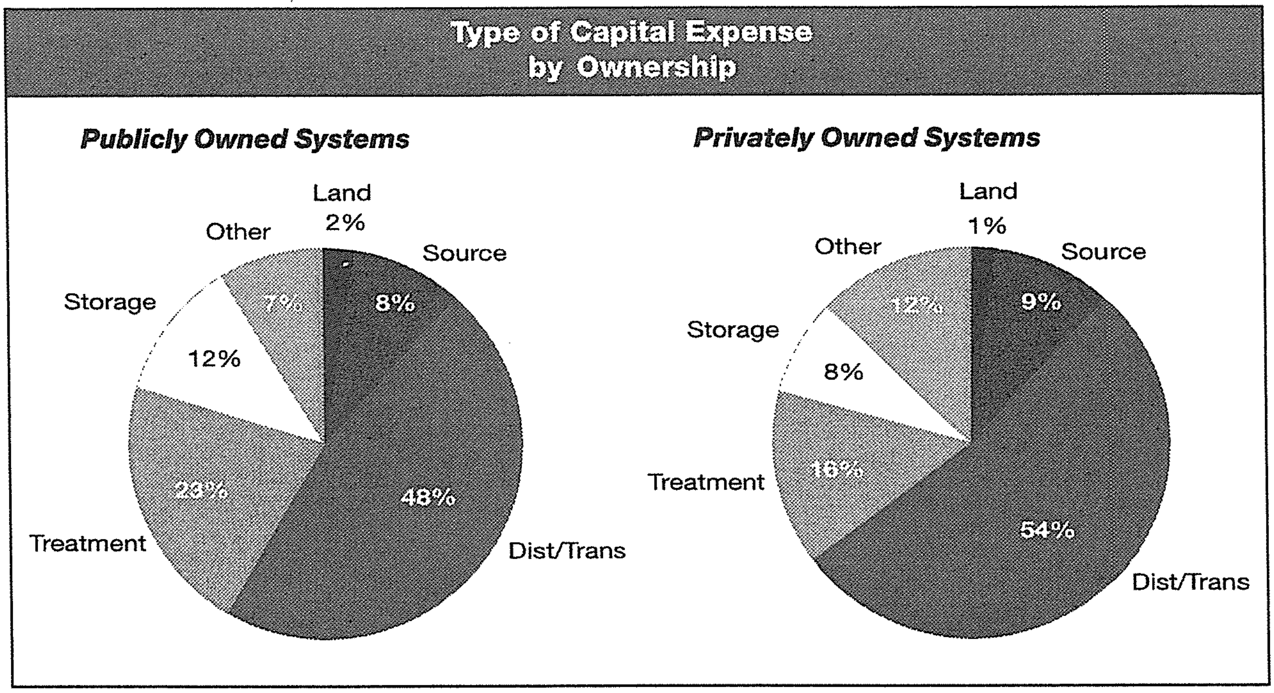
Capital Spending

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.



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