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CBO

STUDY

Future Investment in Drinking Water and Wastewater Infrastructure

November 2002

The Congress of the United States ■ Congressional Budget Office

Notes

Numbers in the text and tables may not add up to totals because of rounding.

Unless otherwise indicated, all costs referred to are in 2001 dollars.

Cover photo shows chlorine contact tanks at a wastewater treatment plant within the Delta Diablo Sanitation District, Antioch, California.

Preface

According to experts from the Environmental Protection Agency and various nonfederal groups, the nation's drinking water and wastewater systems face increasing challenges over the next several decades in maintaining and replacing their pipes, treatment plants, and other infrastructure. But there is neither consensus on the size and timing of future investment costs nor agreement on the impact of those costs on households and other water ratepayers.

The Congressional Budget Office (CBO) has analyzed those issues at the request of the Chairmen and Ranking Members of the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure and the Subcommittee on Environment and Hazardous Materials of the House Committee on Energy and Commerce. This study provides background information on the nation's water systems, presents CBO's estimates of future costs for water infrastructure under two scenarios—a low-cost case and a high-cost case—and discusses broad policy options for the federal government. In keeping with CBO's mandate to provide objective, impartial analysis, this report makes no recommendations.

The study was written by Perry Beider and Natalie Tawil of CBO's Microeconomic and Financial Studies Division, under the supervision of David Moore and Roger Hitchner. Many people within CBO and outside it provided valuable assistance; they are acknowledged in Appendix D.

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November 2002

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Water industry authorities and analysts believe that maintaining the nation's high-quality drinking water and wastewater services will require a substantial increase in spending over the next two decades. They point to many types of problems with existing water infrastructure, including the collapsed storm sewers in various cities, the 1.2 trillion gallons of water that overflows every year from sewer systems that commingle stormwater and wastewater, and the estimated 20 percent loss from leakage in many drinking water systems.

But the amount of money needed for future investment in water infrastructure is a matter of some debate, and various estimates have been developed. The "needs surveys" of drinking water and wastewater systems conducted periodically by the Environmental Protection Agency (EPA) provide one measure of potential investment costs. Others are offered by groups such as the Water Infrastructure Network (WIN) and the American Water Works Association. The Congressional Budget Office (CBO) has also analyzed future costs for water infrastructure and presents its estimates here as low-cost and high-cost scenarios, illustrating the large amount of uncertainty surrounding those future costs.

In the debate about future investment in water systems, both the amount of money that will be needed and the source of those funds are at issue. Advocates of more federal spending have argued that estimates of the difference between future costs and some measure of recent spending—the "funding gap"—justify increased federal support. However, higher future costs could be funded from many sources and are not necessarily a federal responsibility.

The federal government currently supports investment in water systems through several programs. They include state revolving funds (SRFs) for wastewater and drinking water, which receive capitalization grants through appropriations to EPA; loan and grant programs of the Department of Agriculture's Rural Utilities Service; and the Community Development Block Grants administered by the Department of Housing and Urban Development. Notwithstanding those and various smaller programs, the large majority of the funding for drinking water and wastewater services in the United States today comes from local ratepayers and local taxpayers.

Ultimately, society as a whole pays 100 percent of the costs of water services, whether through ratepayers' bills or through federal, state, or local taxes. Federal subsidies for investment in water infrastructure can redistribute the burden of water costs from some households to others. However, subsidies run the risk of undermining the incentives that managers and consumers have to make cost-effective decisions, thereby retarding beneficial change in the water industry and raising total costs to the nation as a whole.

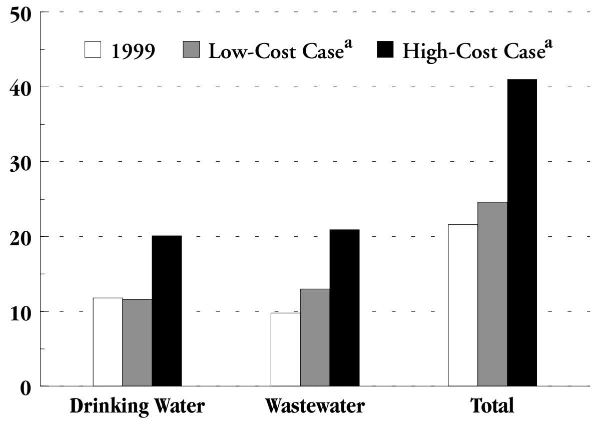
CBO's Estimates of Future Costs for Water Infrastructure

CBO estimates that for the years 2000 to 2019, annual costs for investment will average between $11.6 billion and $20.1 billion for drinking water systems and between $13.0 billion and $20.9 billion for wastewater systems (*see Summary Figure 1*).

Summary Figure 1.

CBO's Estimates of Annual Investment Costs for Water Infrastructure

(Billions of 2001 dollars)



Source: Congressional Budget Office.

a. Average annual costs for the 2000 to 2019 period.

CBO also projects that annual costs over the period for operations and maintenance (O&M), which are not eligible for aid under current federal programs, will average between $25.7 billion and $31.8 billion for drinking water systems and between $20.3 billion and $25.2 billion for wastewater systems. (Unless otherwise noted, all costs in this study are in 2001 dollars.) For its estimates, CBO chose the 2000 to 2019 period to simplify comparisons with earlier estimates developed by the Water Infrastructure Network, a coalition of groups representing service providers, elected officials, engineers, construction companies, and environmentalists. Data on actual spending in 2000 and 2001 are not yet available.

CBO's estimates of future investment and O&M spending under two different scenarios—a low-cost case and a high-cost case—are intended to span the most likely possibilities that could occur. The range of estimates reflects the limited information available at the national level about existing water infrastructure. For example, there is no accessible inventory of the age and condition of pipes, even for the relatively few large systems that serve most of the country's households. That lack of adequate system-specific data compounds the uncertainty inherent in projecting costs two decades into the future. Indeed, given the limitations of the data and the uncertainty about how future technological, regulatory, and economic factors might affect water systems, CBO does not rule out the possibility that the actual level of investment required could lie outside of the range it has estimated.

Under each scenario, the estimates are intended to represent the minimum amount that water systems must spend (given the scenario's specific assumptions) to maintain desired levels of service to customers, meet standards for water quality, and maintain and replace their assets cost-effectively. However, the estimates exclude certain categories of investment. Because water systems are still developing estimates of the costs for increasing security in the wake of the September 11 attacks, the estimates do not include those expenses—but preliminary reports suggest that security costs will be relatively small compared with the other costs for investment in infrastructure. Also excluded from the estimates is investment by drinking water systems to serve new or future customers. Such projects are generally not eligible for assistance from the SRFs and, hence, are not covered in EPA's needs survey.

CBO's estimates measure investment spending in costs as financed rather than in current resource costs, the yardstick that economists typically use. Costs as financed comprise the full capital costs of investments made out of funds on hand—that is, on a pay-as-you-go basis—during the time period being analyzed and the debt service (principal and interest) paid in those years on new and prior investments that were financed through borrowing. In contrast, current resource costs include the investments' capital costs, regardless of how they are paid for, and exclude payments on past investments. Current resource costs are more suitable than other measures of investment for analyzing whether society is allocating resources efficiently—for example, in assessing the costs and benefits of water-quality regulations. But CBO's present analysis takes goals for water quality and services as a given and focuses on the financial impact of meeting those goals. For that purpose, measuring costs as financed is more useful than measuring current resource costs because the former better indicates the burden facing water systems and their ratepayers at a given time.

Summary Table 1.

Assumptions Used in CBO's Low-Cost and High-Cost Cases

	Low-Cost Case	High-Cost Case
Capital Factors		
Savings from Increased Efficiency by Drinking Water and Wastewater Systems (Percent)	15.0	5.0
Drinking Water Systems		
Annual percentage of pipes replaced	0.6	1.0
Average annual cost for regulations not yet proposed (Billions of 2001 dollars)	0	0.53
Wastewater Systems		
Annual percentage depreciation	2.7	3.3
Share of investments in EPA's needs survey for replacing existing capital (Percent)	25.0	15.0
Average annual cost for abating combined sewer overflows (Billions of 2001 dollars)	2.6	5.4
Financing Factors		
Real (Inflation-Adjusted) Interest Rate (Percent)	3.0	4.0
Repayment Period	30 years	25 years
Pay-As-You-Go Share of Total Investment (Percent)	15.0	30.0

Source: Congressional Budget Office.

How CBO Derived Its Estimates

CBO derived its estimates of investment following the basic approach—including the major sources of data and supplementary models—used by WIN, which projected costs for both physical capital and interest on loans and bonds. Within that approach, CBO's two cases differ in the values for six assumptions about physical capital requirements and for three assumptions about financing costs (*see Summary Table 1*). The assumptions most responsible for the difference in the two scenarios' estimated costs are those about the rate at which drinking water pipes are replaced, the savings associated with improved efficiency, the costs of controlling what are termed combined sewer overflows (CSOs), and the repayment period.[1] (*Summary Box 1* discusses how CBO derived its estimates of O&M costs and compares them with WIN's estimates.)

1. A "combined" sewer system is one that commingles stormwater with household and industrial wastewater. About 5 percent of publicly owned wastewater systems have combined sewers; the rest have separate "sanitary" sewers. Both types of systems can overflow, particularly during a period of heavy rainfall, discharging the excess flow directly into receiving waters.

To estimate physical capital requirements for drinking water and wastewater systems, CBO started with data collected by EPA in its needs surveys and—because the surveys do not adequately cover the full 20-year period—supplemented them with estimates derived from simple models. According to EPA, many drinking water systems have responded to the surveys on the basis of planning documents covering just one to five years, and many wastewater systems plan their investments over a time span of five or 10 years.

The methods CBO used to supplement EPA's survey data differed for drinking water and wastewater systems. For drinking water systems, CBO replaced EPA's data on investments in pipe networks with larger estimates based on a study by Stratus Consulting for the American Water Works Association (AWWA). The Stratus study estimated the need for replacing pipes on the basis of some national-level data and assumptions about the number of drinking water systems nationwide (classified by size and region), the miles of pipe per system, the distribution of pipe mileage by pipe size, the replacement cost of pipes of each size, and the replacement rate.

Summary Box 1.

Estimates of Costs for Water Systems' Future Operations and Maintenance

The Congressional Budget Office (CBO) used relatively simple methods to estimate water systems' future spending on operations and maintenance (O&M). For both drinking water and wastewater systems' O&M in the high-cost case, CBO extrapolated a linear trend from real (inflation-adjusted) spending on O&M over the 1980-1998 period. For the low-cost case, it started with that same linear trend but adjusted it downward to reflect savings from improved efficiency phased in over 10 years, beginning at 2 percent in 1995 and reaching 20 percent by 2004. Thus, only one factor distinguishes the estimates under the two scenarios—which, as a result, probably do not capture as much of the uncertainty surrounding future O&M costs as do CBO's more-detailed models of capital investment.

Estimates of annual O&M costs by the Water Infrastructure Network (WIN)—$29 billion for drinking water and $24 billion for wastewater—are roughly in the middle of the ranges spanned by CBO's two cases. Because CBO and WIN used the same basic approach of extrapolating a future trend from existing data on O&M spending, and both WIN's analysis and CBO's low-cost case assume savings of 20 percent from efficiency gains, one might expect the two sets of estimates to be similar. However, WIN used different spans of data for extrapolation than CBO did (from 1985 to 1994 for drinking water and from 1972 to 1996 for wastewater); used a construction cost index (which might not correspond well to the types of expenditures associated with O&M) to convert the data to real dollars instead of the more general price index for gross domestic product that CBO used; and phased in the efficiency savings two years later. Moreover, for wastewater, WIN extrapolated its trend not from data on O&M spending itself but rather from data on O&M spending per dollar of net capital stock. Although a water system's capital stock is plausibly related to its O&M costs, there is no clear reason for associating each additional dollar of capital stock with an increasing (rather than a steady) amount of additional O&M spending.

In analyzing capital costs for wastewater systems, CBO distinguished between projects to replace existing infrastructure and other investments. It estimated replacement costs for each year of the 2000-2019 period by multiplying the estimated net capital stock in that year by a constant rate of depreciation. CBO assumed that the cost of other investments in each year equals the average annual amount reported in EPA's needs survey, with two adjustments. One adjustment substituted EPA's more recent estimate of the costs of correcting sanitary sewer overflows (SSOs) for the survey's reported needs for repairing and replacing sewers. Because some unidentified portion of the needs reported in the survey and in the later analysis of SSO costs represented amounts to replace existing infrastructure, the second adjustment reduced the sum of those needs to avoid double-counting.

CBO calculated interest costs for investments made during the 2000-2019 period using assumptions about interest rates, borrowing terms, and the share of investments paid for through borrowing rather than on a pay-as-you-go basis. However, much of the principal and interest on investments financed during the period will not be paid until after 2019. To measure investments from 2000 to 2019 in costs as financed, CBO focused only on the debt service paid during the period, whether on newly built projects or on those built before 2000. (As discussed later, that approach differs from WIN's.)

Within the basic approach, CBO selected contrasting assumptions for its low-cost and high-cost cases (shown in *Summary Table 1* on page xi) by examining analyses by other estimators and consulting with industry experts. For example, the assumptions used for the costs of controlling CSOs reflect views from EPA and the CSO Partnership, a coalition of communities that have such overflows and firms that design such controls. In particular, the low-cost case uses EPA's estimate of the cost of controlling 85 percent of rainwater and snowmelt, whereas the high-cost case reflects the CSO Partnership's belief that costs will be roughly twice as high unless states revise standards addressing water quality to allow less expensive controls. Similarly, the values assumed in the two scenarios for the pay-as-you-go share of investment are based on CBO's expectation that systems will increase their use of borrowing as they try to restrain rates in the face of rising investment costs, but they reflect different views among experts about how much and how quickly the use of pay-as-you-go financing will decline.

Comparing Current Spending and Future Costs

As noted earlier, part of the policy debate on investment in water infrastructure has focused on the difference between current spending and future costs and on how that difference could affect household ratepayers. However, the available data on current spending, collected for the Census Bureau's Survey of State and Local Government Finances, shed limited light on the issue because they do not measure spending in costs as financed. The census data identify the current interest payments only of drinking water systems and not of wastewater systems. Further, the data include the capital costs of all investment in a given year—whether the burden of those projects falls on ratepayers in that year or is being deferred through borrowing—and exclude the principal being repaid on previous borrowing.

For 1999, the latest year for which information is available, CBO's best estimates of investment spending are $11.8 billion for drinking water and $9.8 billion for wastewater, measured in costs as financed. To develop those estimates, CBO had to make many assumptions—for example, about the extent to which water systems had borrowed to finance investments over the previous 20 years. Different assumptions could have increased or decreased the results, perhaps by 20 percent.

The difference between those estimates of 1999 investment spending and projected average annual investment from 2000 to 2019 under the low-cost case is close to zero for drinking water systems and is $3.2 billion for wastewater systems. Together, the future costs for both types of systems represent growth of 14 percent from the 1999 levels. That result contradicts the conventional wisdom that the nation's water systems will soon be straining to fund a large increase in investment. Nevertheless, CBO considers that result reasonable, given the uncertainty about the condition of the existing infrastructure, the prospects for cost savings from improved efficiency, and the possibility that water systems will fund more of their investment through borrowing and will borrow for longer terms. Under the high-cost case, the estimated increases average $8.3 billion per year for drinking water and $11.1 billion for wastewater, together representing growth of about 90 percent over the estimated levels for 1999.

Comparing CBO's Estimates with Those of Others

When measured in comparable terms, WIN's estimates are similar to those of CBO's high-cost case. In contrast, estimates obtained from "bottom-up" studies (those that derive national totals from data on individual systems) are even lower than the ones CBO projects in its low-cost case.

Comparing CBO's and WIN's Estimates

CBO's estimates of future investment in water infrastructure are not directly comparable with those of the coalition because the latter are not measured in costs as financed. WIN's published estimates comprise total capital costs associated with all investments—whether funded on a pay-as-you-go basis or through debt—during the 2000-2019 period and all interest paid over time on those investments. Thus, they differ from costs-as-financed estimates because they include debt service (principal and interest) paid after 2019 on investments during the two decades instead of debt service paid during that time on pre-2000 investments. That difference is important because the amounts of investment that were financed yearly from 1980 through 1999, and that continue to be paid off from 2000 to 2019, are smaller than the new amounts that the analyses project will be financed during the latter period.

An additional factor complicates comparing CBO's and WIN's estimates. WIN's measure of current spending differs from its measure of future costs, so its estimates of the increased costs are inconsistent. In particular,

Summary Table 2.

Estimates of Average Annual Costs for Investment in Water Systems, Including Financing, 2000 to 2019

(In billions of 2001 dollars)

	Drinking Water	Wastewater	Total
CBO[a]	11.6 to 20.1	13.0 to 20.9	24.6 to 41.0
Water Infrastructure Network			
As published	26.3	24.2	50.5
In costs as financed	21.4	18.9	40.3
Increase in Investment Above Recent Level			
CBO (Using a 1999 baseline)[a]	-0.2 to 8.3	3.2 to 11.1	3.0 to 19.4
Water Infrastructure Network			
As published[b]	12.2	13.5	25.7
In costs as financed[c]	9.4	9.2	18.6

Sources: Congressional Budget Office; Water Infrastructure Network, *Clean and Safe Water for the 21st Century: A Renewed National Commitment to Water and Wastewater Infrastructure* (Washington, D.C.: WIN, April 2000).

a. Ranges are defined by CBO's low-cost and high-cost scenarios.
b. Relative to a 1996 baseline.
c. CBO's approximation of WIN's results using a 1999 baseline.

WIN's measure of current spending includes the interest paid in the current year on past investments in drinking water infrastructure and does not include interest on investments in wastewater infrastructure. Again, however, its measure of costs for future years includes all subsequent interest payments on investments made in each such year.

Using more-detailed results provided by WIN's analysts, CBO found that measuring future investment in costs as financed reduces WIN's estimates of average annual needs from $26.3 billion to $21.4 billion for drinking water and from $24.2 billion to $18.9 billion for wastewater—an overall reduction of 20 percent (*see Summary Table 2*).[2] CBO also recalculated the coalition's estimates of the difference between current spending and average annual future needs—the so-called funding gap—in costs as financed. (To do so, however, CBO had to approximate WIN's estimate of current debt service, a key component of current spending in costs as financed, because not enough information was available to calculate it directly.) Again, the revised estimates are lower—$9.4 billion instead of $12.2 billion for drinking water and $9.2 billion instead of $13.5 billion for wastewater, for a combined reduction of 25 percent.

The reductions that result from measuring investment volume in costs as financed bring WIN's estimates close to those of CBO's high-cost case: the coalition's figures are somewhat higher for drinking water and a little lower for wastewater. The similarity in the two sets of estimates is not surprising, given that CBO and WIN used the same basic modeling approach and that the specific assumptions used in CBO's high-cost scenario either duplicate those in WIN's analysis—both assume that 1 percent of drinking water pipes and 3.3 percent of wastewater capital will be replaced annually—or differ in ways that tend to offset each other. Thus, CBO's high-cost case does not provide independent support for WIN's esti-

2. Those comparisons express all costs in 2001 dollars. As originally published, WIN's annual estimates of future spending were in 1997 dollars and totaled $24 billion for drinking water systems and $22 billion for wastewater systems. See Water Infrastructure Network, *Clean and Safe Water for the 21st Century: A Renewed National Commitment to Water and Wastewater Infrastructure* (Washington, D.C.: WIN, April 2000).

Summary Table 3.

Estimates of Average Annual Costs for Investment in Water Systems, Measured as Capital Resource Costs, 2000 to 2019

(In billions of 2001 dollars)

	Drinking Water	Wastewater	Total
CBO[a]	12.0 to 20.5	14.9 to 22.3	26.9 to 42.7
Water Infrastructure Network	20.9	19.2	40.1
Environmental Protection Agency			
Clean Water Needs Survey[b]			
As published	n.a.	7.3	n.a.
Adjusted for more recent estimate of costs to control sanitary sewer overflows	n.a.	11.4	n.a.
Drinking Water Infrastructure Needs Survey[c]			
As published	8.0	n.a.	n.a.
Adjusted for underreporting	11.1	n.a.	n.a.
American Water Works Association[d]	8.5	n.a.	n.a.

Sources: Congressional Budget Office; Environmental Protection Agency, Office of Water, *1996 Clean Water Needs Survey: Report to Congress*, EPA 832-R-97-003 (September 1997); Environmental Protection Agency, Office of Water, *Drinking Water Infrastructure Needs Survey: Second Report to Congress*, EPA 816-R-01-004 (February 2001); American Water Works Association, *Reinvesting in Drinking Water Infrastructure: Dawn of the Replacement Era* (Denver, Colo.: AWWA, May 2001); Water Infrastructure Network, *Clean and Safe Water for the 21st Century: A Renewed National Commitment to Water and Wastewater Infrastructure* (Washington, D.C.: WIN, April 2000).

Note: n.a. = not applicable.

a. Ranges reflect CBO's low-cost and high-cost cases.
b. Estimate for 1996 through 2015.
c. Estimate for 1999 through 2018.
d. Estimate for 2000 through 2029.

mates but instead suggests that to obtain estimates of that magnitude requires making relatively pessimistic assumptions.

Comparing CBO's Estimates and Estimates from Bottom-Up Studies

Support for lower estimates of investment costs comes from bottom-up studies by EPA and the AWWA. Those studies measure investment in current resource costs—again, total capital costs regardless of financing but without including interest costs. So comparing their estimates with CBO's and WIN's projections requires that those projections also be expressed in terms of resource costs.

When the results are measured comparably, the estimates from CBO's low-cost case are above those from EPA's and AWWA's studies, even after some (perhaps incomplete) adjustments to EPA's estimates to try to correct for the surveys' limitations in capturing investments over the full 20-year horizon (*see Summary Table 3*).

- EPA's latest available wastewater survey, conducted in 1996 and published in 1997, estimated that average annual needs were $7.3 billion per year.[3] Substituting EPA's later projection of costs for controlling sanitary sewer overflows raises the estimate to $11.4 billion.

- For drinking water, EPA's 1999 needs survey (published in 2001) estimated average annual needs of $8.0

3. Environmental Protection Agency, Office of Water, *1996 Clean Water Needs Survey: Report to Congress*, EPA 832-R-97-003 (September 1997).

billion; if the amount of underreporting in that survey equals the amount that EPA found in follow-up visits to 200 medium-sized and large systems after the initial 1995 needs survey, then the estimate of $8.0 billion can be scaled up to $11.1 billion.[4]

- The AWWA conducted a detailed engineering analysis of the needs of 20 medium-sized and large drinking water systems; extrapolating from that admittedly small base to national totals, the association estimated that average annual needs cost $8.5 billion.[5]

Water Costs in Household Budgets

How might future costs of investment in water infrastructure and of operations and maintenance affect household budgets? CBO estimates that in the late 1990s, total household bills for drinking water and wastewater services combined represented 0.5 percent of household income nationwide. By 2019, CBO projects, household water bills will account for 0.6 percent of national household income under the low-cost scenario and 0.9 percent under the high-cost scenario. According to the best available international data, such shares would not be high compared with the income shares devoted to household water bills in many other industrialized countries.[6]

CBO's estimates assume steady levels of support financed by taxpayers and constant shares of water costs paid by household and nonhousehold ratepayers. Any changes in those levels or shares would shift the form of the impact on household budgets but would not change the average impact nationwide, since households ultimately pay 100 percent of water costs, whether through water bills, taxes, or the costs of other goods and services produced using water.

National shares, however, can obscure important differences among households; thus, they shed only limited light on the argument, made by advocates of boosting federal aid for water infrastructure, that water bills will otherwise become "unaffordable" for many households. Accordingly, CBO went beyond national averages to examine the current distribution of household water bills relative to income and to project future distributions.

Specifically, CBO analyzed the current distribution using a national sample of annualized water bills reported by approximately 2,800 households; those households participated for a year in the Consumer Expenditure Interview Survey some time between the third quarter of 1997 and the first quarter of 1999. CBO's analysis of the data included imputing expenditures for the 39 percent of respondents who did not report their own bills by using data from households with comparable incomes.[7] To project the distributions forward to 2019, CBO scaled up the individual water bills to reflect estimated costs in the two scenarios and extrapolated household income to reflect growth in real income and population.

The results of CBO's analysis can be characterized in several ways, with different measures highlighting different features of the distributions. One summary measure that has received significant attention in discussions of future water costs is the proportion of households whose water bills exceed 4 percent of their income. But 4 percent has no economic significance as the point at which household water bills become "unaffordable," so the measure is no better (or worse) than many others.

In terms of that particular measure, CBO estimates that in the late 1990s, 7 percent of U.S. households spent more than 4 percent of their income on water bills. An

4. Environmental Protection Agency, Office of Water, *Drinking Water Infrastructure Needs Survey: Second Report to Congress*, EPA 816-R-01-004 (February 2001).

5. American Water Works Association, *Reinvesting in Drinking Water Infrastructure: Dawn of the Replacement Era* (Denver, Colo.: AWWA, May 2001).

6. International data are limited to average direct billing costs for typical levels of water use. See Organization for Economic Cooperation and Development, Environment Directorate, Environment Policy Committee, *Household Water Pricing in OECD Countries*, ENV/EPOC/GEEI(98)12/FINAL (Paris: OECD, 1999).

7. That imputation may overstate water costs since most nonreporting households are likely to be apartment dwellers (who do not receive separate water bills), and water use per capita is generally lower in multifamily units than in single-family homes.

additional 16 percent of U.S. households had expenditures greater than 2 percent of their income; 25 percent were spending less than 2 percent but more than 1 percent, and 51 percent were spending no more than 1 percent (*see Summary Figure 2*). If the additional burdens associated with CBO's low-cost and high-cost estimates led to uniform percentage increases in ratepayers' bills, 10 percent to 20 percent of U.S. households might be spending more than 4 percent of their income on water bills in 2019; an additional 19 percent to 23 percent might be spending more than 2 percent.

In the WIN coalition's estimates, water bills account for a much larger share of household budgets, both now and in the future. In 1997, WIN estimates, 18 percent of households spent more than 4 percent of their income on water services; it foresees 22 percent of households having bills at that level by 2009 (halfway through the 2000-2019 period) and a third or more of the population experiencing such costs as rates continue to rise.[8]

Apparently, the discrepancy between WIN's estimate of 18 percent for 1997 and CBO's estimate of 7 percent for the late 1990s derives primarily from the use of different data on household water costs. CBO analyzed actual bills based on water use by households; WIN, however, calculated household water bills using data on charges in 1997 among systems in Ohio for 250 gallons per day. WIN chose to use those charges because, according to the 1990 census, Ohio households' drinking water bills relative to their income matched well those for U.S. households as a whole. (The 1990 census did not have data on household wastewater expenditures.) However, if household water bills nationally cannot be accurately characterized on that basis, then WIN's results may not be representative. If, for example, low-income households tend to use less than 250 gallons per day, then, other things being equal, WIN's estimates overstate the number of households with water bills claiming more than 4 percent of their income.

8. Water Infrastructure Network, *Clean and Safe Water for the 21st Century*, pp. 3-4 and 3-5.

Rationales for Federal Involvement in Water Services

Economic principles suggest that the federal government's intervention in drinking water and wastewater markets may be able to increase the cost-effectiveness of providing and using water when state and local governments and water systems do not have adequate incentives to account for effects that their practices may have on third parties. This CBO study focuses on federal financial support; of course, the federal government also intervenes in water markets through its role in establishing water-quality standards under the Clean Water and Safe Drinking Water Acts. Whether current standards promote the economically efficient use of society's resources is an important question but is not addressed here.

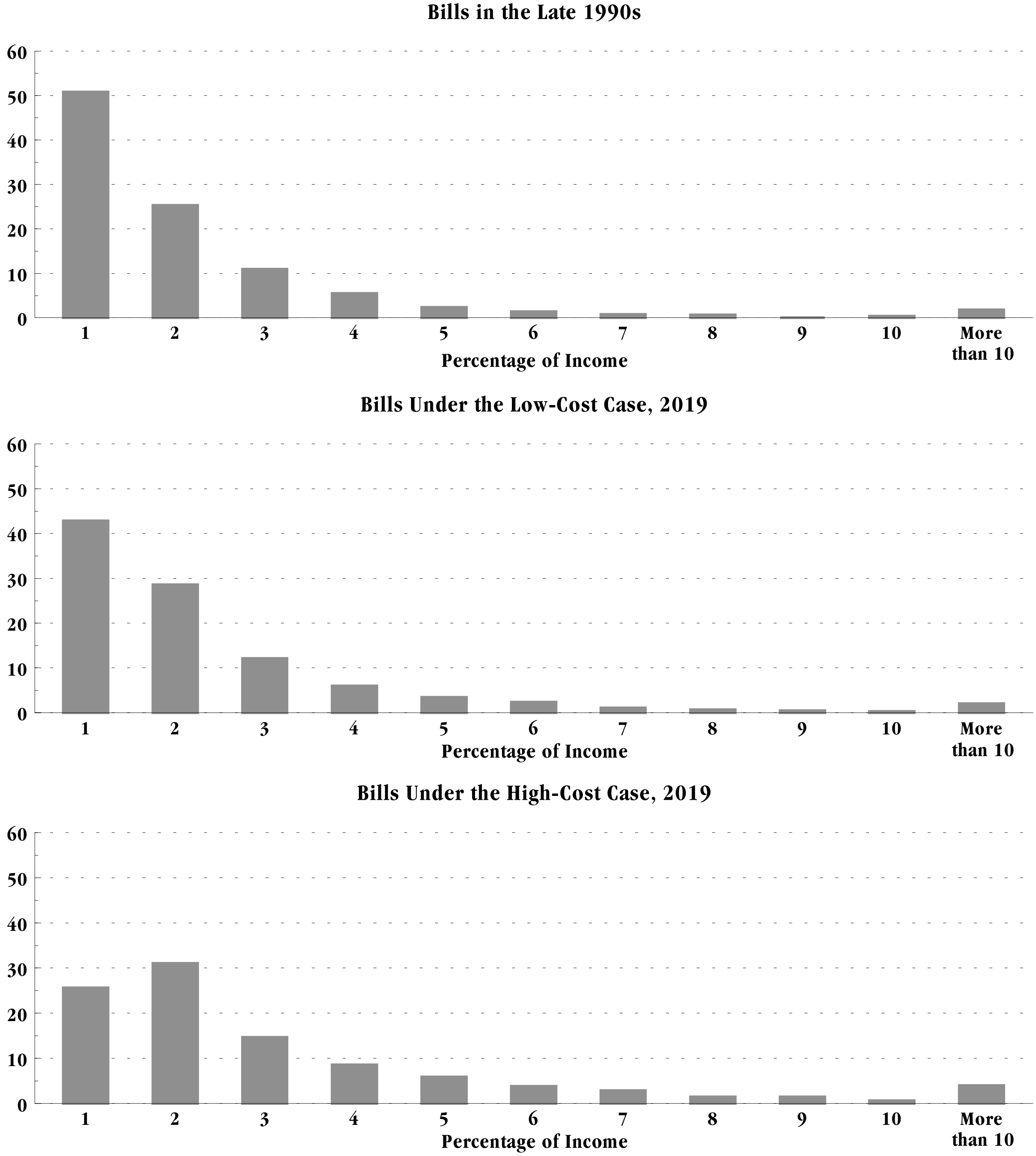
One opportunity for federal funding to improve cost-effectiveness may be by supporting research and development (R&D). Nonfederal entities measure potential R&D expenditures only against the benefits that they themselves could realize, ignoring gains that might accrue to others. Without federal involvement, therefore, funding for the development of new technologies is likely to be lower than is optimal. But determining the right level of federal support in practice is a challenge. It depends on the returns to investment in R&D, which are typically difficult to predict, and the extent to which nonfederal entities reduce their R&D expenditures in response to federal funding.

A similar case might also be made in favor of federal support for disseminating "best management practices." The argument is not simply that such practices can help water systems reduce their costs, although that appears to be true. (On the basis of 136 assessments of water systems since 1997, the consulting firm EMA Associates found that adherence to best practices could reduce operational costs by an average of 18 percent.) Rather, the crux of the argument is the possibility that federal costs for gathering and disseminating information about widely applicable practices would be lower than the total costs that individual system managers would incur in seeking out relevant information. If so, then taxpayer-funded support might yield cost savings.

Summary Figure 2.

Water Bills as a Share of Household Income

(Percentage of U.S. households)



Source: Congressional Budget Office.

Summary Box 2.

Options to Expand Federal Aid for Private Water Systems

Half of all community drinking water systems in the United States are privately owned, as are roughly 20 percent of the wastewater systems that treat household sewage. However, those systems serve only a small share of households: private drinking water systems reach only about 15 percent of households—excluding those using individual wells—and private wastewater systems reach only about 3 percent of sewered households.

Giving private systems access to federal funds on equal footing with public systems may or may not improve cost-effectiveness because of two opposing effects. On the one hand, balanced treatment could result in some cost savings if private ownership can reduce a system's costs in some cases and local decisionmakers can correctly identify those cases. On the other hand, increasing federal aid tends to increase investment costs.

To help equalize federal support, the Congress could modify the Clean Water Act to make private systems eligible for loans from the state revolving funds. On the tax preference side, it could alter policies related to tax-exempt private activity bonds (PABs). Specific options publicized by the Environmental Protection Agency's Environmental Financial Advisory Board include:

- Exempting bonds issued for water systems from the federal limits on the amount of PABs issued in each state;
- Exempting interest earned on those PABs from the individual alternative minimum tax (AMT) and partially exempt it from the corporate AMT;
- Increasing opportunities for PAB issuers to benefit from arbitrage profits—those earned by investing PAB proceeds at a rate above the bond's own yield —by allowing issuers a full two years to spend their bond proceeds; and
- Allowing one-time refinancing of PABs up to 90 days before redemption of the original debt.[1]

One argument for providing private water systems with equal access to federal aid is that it would treat customers of private and public systems equally. Conversely, one argument against equal access is that it would give private water systems unique advantages relative to other types of privately owned firms. Under current law, privately managed enterprises such as airports and solid-waste facilities can be exempt from the PAB limits, but only if they are publicly owned.

1. Environmental Protection Agency, Environmental Financial Advisory Board, *Incentives for Environmental Investment: Changing Behavior and Building Capital* (August 1991).

However, other types of federal support for water services (such as the current spending programs and tax preferences that help fund investment) distort prices and thus undermine incentives for cost-effective actions by water systems and ratepayers. Eliminating those distortions could lower total national costs: for example, system managers might reduce investment costs by undertaking more preventive maintenance and improving the design of their pipe networks, and households might cut water use by fixing leaks and watering lawns less often.

The clearest argument for current policies to subsidize investment in water infrastructure is to shift the costs of water services from ratepayers served by high-cost systems (such as those in small and rural communities) to those served by low-cost systems, or from low-income to high-income households. (Most federal support goes to publicly owned systems, but some goes to privately owned ones; *see Summary Box 2* for options to expand aid to private systems.)

In evaluating the case for subsidizing water services, it is important to recognize that the level and form of the subsidies influence not only the distributional effects but also the extent to which support undermines incentives for cost-effective actions. To preserve those incentives for both water systems and users, the Congress could pursue policies that redistribute income rather than those that distort the price of water.

Implications of Federal Support for Infrastructure Investment

Federal support for water systems can have unintended consequences. For example, an analysis of the federal wastewater construction grants program under the Clean Water Act concluded that it reduced other contributions to capital spending. Thus, total investment in water infrastructure increased only 33 cents for each dollar of federal support; the other 67 cents effectively reduced state and local taxes or was spent on other uses.[9]

Federal support for investment projects also undermines the cost-effective provision of water services by distorting the price signals that systems face and thus affecting managers' choices in many areas, such as preventive maintenance, construction methods, treatment technology, pipe materials, and excess capacity. The resulting losses can be significant, particularly if the subsidies are large. For example, a statistical analysis done for a 1985 CBO study of the wastewater construction grants program estimated that setting the federal cost share at 75 percent initially rather than 55 percent (the reduced level that went into effect that year) raised plant construction costs about 40 percent, on average.[10]

One way to reduce the distorting effects of federal subsidies might be to target increased aid to fewer systems—those judged most deserving, whether because of high costs associated with declining customer bases, federal regulations, or simply high levels of anticipated investment (or investment and O&M spending) in general. However, defining the target group in a way that does not reward systems for poor management and past underinvestment might be difficult. Targeting could even undermine cost-effective practices if it encouraged system managers to let infrastructure deteriorate in hopes of qualifying for aid in the future.

A variety of spending mechanisms—grants, loan subsidies, and credit assistance—are available to deliver and annually readjust a desired level and pattern of aid for water systems, but the design of such programs would influence total costs. For example, federal support such as partial grants, partial loans, or credit assistance would leave investment projects relying on private funds as well, and thus could help keep costs down by subjecting water systems to more market discipline from lenders and ratepayers. Another approach to help system and state authorities make cost-effective choices would be to allow them more flexibility in using the SRFs. That strategy might include eliminating floors and ceilings on funding for eligible activities in the drinking water program, easing restrictions on transferring federal money between drinking water and wastewater revolving funds, and broadening the funds' range of uses to address issues such as nonpoint source pollution.

The federal government can also use tax preferences to aid water systems, but doing so limits its discretion in delivering certain levels and patterns of aid. Public water systems and the interest paid on municipal bonds issued on their behalf are already generally exempt from federal taxes. Options for enhancing the tax preferences include increasing the span of time during which issuers may keep arbitrage profits (earned by investing the proceeds from a bond at a rate above the bond's own yield) and eliminating the partial taxation of interest earned on municipal bonds held by corporations that pay the alternative minimum tax. Such enhancements would aid medium-sized and large water systems; small systems that did not have independent access to the municipal bond market

9. James Jondrow and Robert A. Levy, "The Displacement of Local Spending for Pollution Control by Federal Construction Grants," *American Economic Review*, vol. 74, no. 2 (May 1984), pp. 174-178. The displacement of state and local spending per dollar of federal funds might have been less had the federal share been smaller than 75 percent, its statutory level during the period the authors studied.

10. Congressional Budget Office, *Efficient Investments in Wastewater Treatment Plants* (June 1985).

could benefit indirectly, through cheaper or more plentiful SRF loans. The greater year-to-year stability of tax preferences (compared to spending programs with annual appropriations) would make planning easier for system managers, but enhancing the preferences for water systems and not for other issuers of municipal bonds would make the tax code more complex.

Implications of Direct Federal Support for Ratepayers

An alternative to subsidizing investment in water systems would be to assist low-income households facing high water bills. The federal government does not currently provide such assistance, but it aids low-income households through more general transfer programs and tax provisions; it also subsidizes bills for some other utilities.

Compared with support for investment by water systems, support for ratepayers could address concerns about the impact of water bills on household budgets more precisely and with less loss of efficiency. Unlike investment subsidies, support for ratepayers would not distort the choices confronting system managers; nor would it reduce the water prices faced by households not receiving the direct subsidies.

CHAPTER

1

Drinking Water and Wastewater Infrastructure

Drinking water and wastewater services in the United States are very decentralized; there is a strong history of local control, and the large majority of funding for water services comes from local ratepayers and taxpayers. But over the past three decades, the federal government has taken the lead in regulating such systems and has provided some funding for investment in water infrastructure. Concern over rising needs for such investment has led to calls for increased federal funding and for systematic reforms to encourage cost-effectiveness in the provision of water services.

An Overview of U.S. Water Systems

Most U.S. residents are served by drinking water and wastewater systems that are eligible for federal support through state revolving funds (SRFs). In 1999, roughly 54,000 publicly or privately owned community drinking water systems (defined as those with at least 15 service connections used by year-round residents or otherwise serving at least 25 year-round residents) provided drinking water to some 250 million people.[1] As of 1996, 16,000 publicly owned treatment works collected and processed the wastewater from about 190 million people.

Though the details vary, water systems generally provide the same basic functions: drinking water systems take in, treat (in most cases), monitor, and distribute water to households and other customers, while wastewater systems collect, treat, and typically discharge water after use. Roughly one-third of the households served by community water systems use groundwater, which in some cases does not require treatment. Otherwise, drinking water undergoes one or more of the following processes: flocculation and sedimentation (to coagulate small particles into larger groups and have them settle out of the water stream), filtration (to remove additional particles), ion exchange (to treat hard water and remove a variety of inorganic contaminants), and disinfection by chlorine or ozone (to kill microbes). Ultimately, the water is distributed through a network of pipes; the necessary pressure is supplied by gravity, when the water has been pumped up into a storage tower, or by direct pumping, when the water is from a ground-level storage facility (*see Figure 1-1*).

Publicly owned treatment works collect wastewater through a network of sewers, then process it using various physical, biological, and chemical treatments. So-called "primary treatment" uses screens, settling tanks, and other physical methods to remove sand, grit, and larger solids; it can remove up to 50 percent of the suspended solids and biochemical oxygen demand (a measure of organic matter, defined by the amount of oxygen that bacteria would consume in decomposing it). In 1972, the Clean Water Act required publicly owned treatment works to adopt "secondary treatment" (which stimulates the growth of bacteria to consume the waste materials prior to discharge) in order to reduce the levels of key pollutants by 85 percent (*see Figure 1-2*). In some cases, various types of "advanced treatment" may be required to, for example, reduce the unconventional pollutants like nitrogen and phosphorus (which can promote excessive growth of algae) in order to meet quality goals set for specific bodies of water.

1. "Noncommunity" systems that are not-for-profit, such as those of schools and hospitals, are also eligible for assistance from the revolving funds.

Figure 1-1.

A Drinking Water Plant

Source: Adapted by permission. Copyright American Water Works Association.

Figure 1-2.

A Wastewater Treatment Plant

Source: Congressional Budget Office based on Water Environment Federation, *Clean Water for Today: What Is Wastewater Treatment?* (Alexandria, Va.: WEF, November 1999).

Assisted by federal funding provided since 1972, public wastewater systems have nearly reached the goal of universal secondary treatment: as of 1996, only 176 of the 14,000 public treatment facilities that discharged effluent streams were not meeting the requirement—and some of those were exempt from it because they discharged to sufficiently deep ocean waters or to other facilities that in turn provided secondary treatment. As a result, although the amount of biochemical oxygen demand arriving at treatment facilities rose by more than 25 percent between 1972 and 1996 (which was consistent with population and economic growth), the amount discharged fell about 40 percent.

Most water systems are small. For example, 58 percent of community drinking water systems serve 500 people or fewer, and 85 percent reach no more than 3,300 people (*see Figure 1-3*). Many small wastewater facilities (such as household septic units) are privately owned and thus excluded from statistics on publicly owned treatment works. Even so, 81 percent of the public facilities in operation in 1996 handled no more than 1 million gallons per day (MGD), enough to serve roughly 8,000 people, and 41 percent processed no more than 0.1 MGD (*see Figure 1-4*).[2]

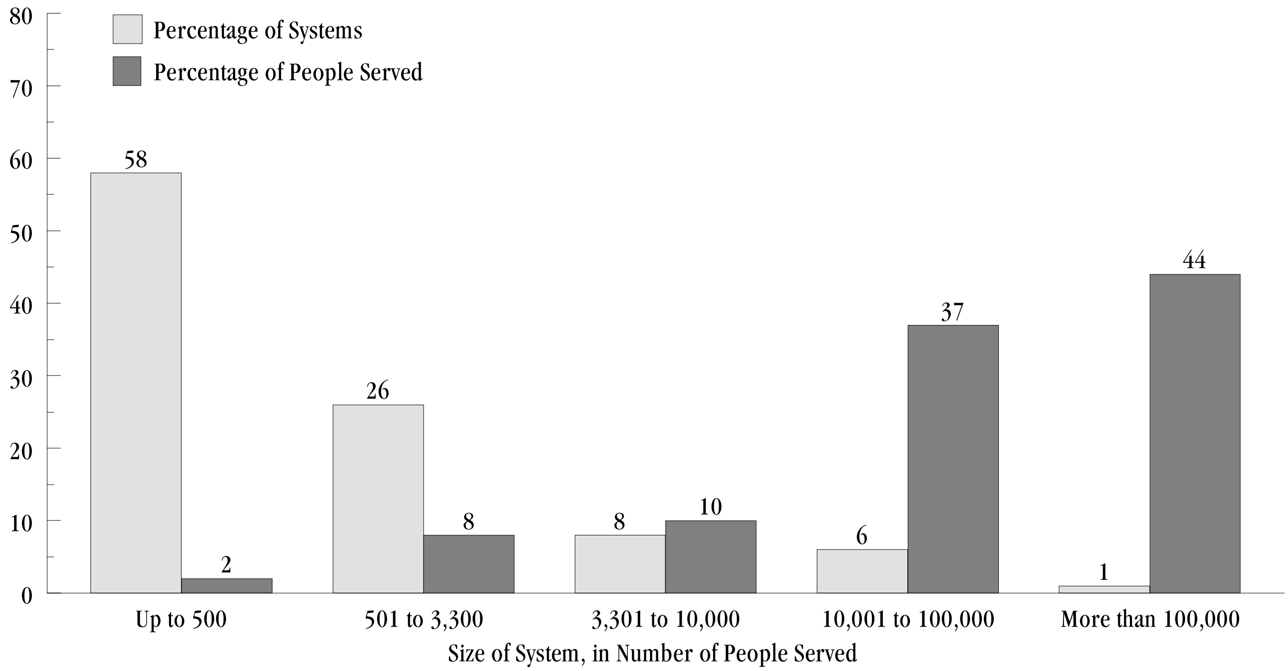
Though outnumbered by the small systems, the relative handful of large systems serve the great majority of people. Just 7 percent of community drinking water systems serve more than 10,000 people each, but they supply 81 percent of those served by such systems; indeed, "very large" sys-

2. The data in million gallons per day are from Environmental Protection Agency, Office of Water, *1996 Clean Water Needs Survey: Report to Congress*, EPA 832-R-97-003 (September 1997), p. C-4. The conversion from MGD to persons assumes 125 gallons per person-day, the low end of a range provided in a personal communication from John Flowers of EPA.

Figure 1-3.

Community Water Systems and Population Served by Size of System, 2001

(Percentage)



Source: Environmental Protection Agency, "Factoids: Drinking Water and Ground Water Statistics for 2001" (January 2002).

Note: The total number of water systems is 53,783. The total number of people served is 264,145,129.

tems, defined by the Environmental Protection Agency (EPA) as ones with more than 100,000 customers, represent 1 percent of systems but 44 percent of all people served. Similarly, the largest 3 percent of wastewater plants handled 68 percent of the total flow processed by all such plants nationwide.

For both drinking water and wastewater, systems owned by the public sector—by local governments or special local or regional government authorities—serve the large majority of households. Although community drinking water systems owned by the private sector account for over half of all such systems, they serve only about 15 percent of households; private wastewater systems that treat household sewage account for roughly 20 percent of the total, but serve few households—perhaps 3 percent.[3] In a hybrid arrangement, a small but growing number of publicly owned systems have contracted with private firms to operate and maintain them.

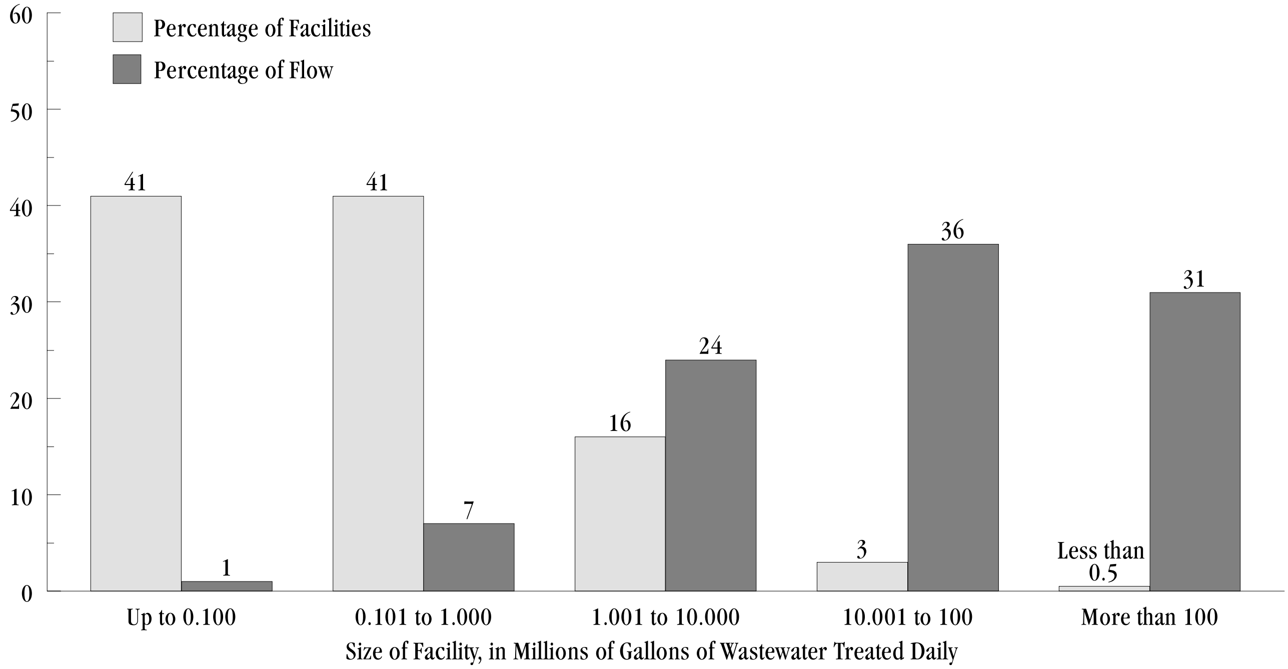
The U.S. pattern of decentralized, local control of water systems is also common abroad, but an increasing number of industrialized countries have moved to consolidate operations or ownership, and some are emphasizing the role of the private sector. In Great Britain, for example, just 10 regional private companies provide almost all wastewater services and most of the drinking water in England and Wales, and fewer than 20 smaller companies

3. EPA's data show that roughly 4,200 private facilities have permits to discharge treated household sewage (by comparison, there are about 16,000 publicly owned treatment works). Private wastewater systems are not eligible for assistance from SRFs (unlike their drinking water counterparts), so they are not included in some of EPA's data-collection efforts, such as the *Clean Water Needs Survey*. Consequently, precise data on the percentage of the population that they serve are not readily available; the estimate of 3 percent reflects common thinking in the industry.

Figure 1-4.

Wastewater Treatment Facilities and Population Served by Size of Facility, 1996

(Percentage)



Source: Congressional Budget Office based on Environmental Protection Agency, Office of Water, *1996 Clean Water Needs Survey: Report to Congress*, EPA 832-R-97-003 (September 1997).

Note: The total number of facilities is 15,986; the total daily flow is 32,175 million gallons per day. Totals exclude 38 facilities for which data were unavailable.

supply most of the remaining drinking water[4]; three public authorities provide the water and sewer services in Scotland.[5] Australia, Canada, and Ireland also have regional systems that provide both drinking water and wastewater services.[6] France has 15,500 municipally owned water systems, but most of those systems contract out their operations to one of a handful of private companies.[7]

The costs of providing water services can vary widely, depending on the size of the system, the proximity and quality of the local water sources, and other factors. Treatment costs in particular are subject to economies of scale. For example, EPA's data on the costs of monitoring and treatment to comply with the Safe Drinking Water Act standards in force as of September 1994 suggest that the average cost per household was on the order of $4 per year in systems serving more than 500,000 people, but

4. Organization for Economic Cooperation and Development, Environment Directorate, Working Party on Economic and Environmental Policy Integration, *Industrial Water Pricing in OECD Countries*, ENV/EPOC/GEEI(98)10/FINAL (Paris: OECD, 1999), pp. 9, 192, 197.

5. Web site of the North of Scotland Water Authority, www.noswa.co.uk.

6. Organization for Economic Cooperation and Development, *Industrial Water Pricing*, pp. 9 and 27.

7. Organization for Economic Cooperation and Development, *Industrial Water Pricing*, p. 91; and Liana Moraru-de Loe, "Privatizing Water Supply and Sewage Treatment Services in Ontario," *Water News*, vol. 16, no. 1 (March 1997), available at www.cwra.org/news/arts/privatisation.html.

$300 per year for systems serving no more than 100 people.[8]

The large majority of funding for water services comes from local sources, as can be seen in the detailed data reported by the Association of Metropolitan Sewerage Agencies in its *AMSA Financial Survey, 1999*. Of the revenues reported by 112 medium-sized and large wastewater systems, 55 percent came from user charges or hookup fees, 15 percent from reserves and interest, 15 percent from bond proceeds, 4 percent from property taxes, 3 percent from SRF loans, 2 percent from federal and state grants, and the remainder from various smaller categories.[9] Excluding reserves, interest, and bond and loan proceeds, all of which derive or must be repaid from other sources, the local funding provided by user charges, hookup fees, and property taxes made up 88 percent of the "underlying" revenues, while federal and state grants contributed just 3 percent.[10] However, federal aid plays a larger role in the financing of small and rural systems not included in the AMSA survey, as discussed below.

The AMSA's data do not categorize user charges by type of customer, but EPA has some information on that subject for drinking water systems. Results from the agency's 1995 *Community Water System Survey* indicate that residential customers accounted for three times the sales volume of commercial and industrial customers—55 percent versus 18 percent. Another 4 percent of sales were to wholesale customers (who in turn sold to final users), and 23 percent were described as "other," including sales to governmental and agricultural customers and sales by systems that did not disaggregate by customer type.[11]

8. New calculation based on data in Congressional Budget Office, *The Safe Drinking Water Act: A Case Study of an Unfunded Federal Mandate* (September 1995), pp. 16-17.

9. Association of Metropolitan Sewerage Agencies, *The AMSA Financial Survey, 1999* (Washington, D.C.: AMSA), p. 36.

10. Those percentages do not account for the federal and state contributions through subsidized interest rates on SRF loans.

11. Environmental Protection Agency, Office of Water, *Community Water System Survey, Volume 1*, EPA 815-R-97-001a (January 1997), pp. 13-14.

The Federal Role

Except as a builder of dams and other major public works used to supply water, the federal government played a relatively minor role in funding or regulating local water systems before 1972.[12] The Public Health Service had published drinking water standards as early as 1914 and updated them in 1925, 1946, and 1962, but those standards were federally enforced only for the water supplies of interstate carriers. Matching grants for 30 percent to 50 percent of the cost of constructing wastewater treatment facilities became available in 1956, but initially the amount of funding was small and there were no federal requirements for such facilities.

With the passage of the Federal Water Pollution Control Act Amendments of 1972, later designated the Clean Water Act, the Congress adopted the goal of restoring and maintaining the chemical, physical, and biological integrity of the nation's waters, thereby ensuring that they would be fishable and swimmable. Toward that goal, the legislation established a requirement that municipal wastewater discharged to surface waters be given secondary treatment, increased the federal matching share to 75 percent for constructing publicly owned treatment works, and greatly expanded the amount of the available funding. Consequently, federal outlays for wastewater treatment grants rose tenfold in real (inflation-adjusted) terms during the 1970s, reaching a high of $9.1 billion (in 2001 dollars) in 1980.[13]

The expansion of aid was seen as a temporary infusion of capital to allow publicly owned wastewater systems to construct secondary treatment facilities—and, indeed, funding has declined sharply since its real peak in 1980. In 1981, amendments to the Clean Water Act cut the authorization for wastewater grants in half and reduced the federal matching share to 55 percent for facilities built after 1984. Then in 1987, legislation was enacted to phase out the construction grant program by 1991 and replace

12. Issues involving federal water projects and the adequacy of water supplies are outside the scope of this study. But see Congressional Budget Office, *Water Use Conflicts in the West: Implications of Reforming the Bureau of Reclamation's Water Supply Policies* (August 1997).

13. Congressional Budget Office, *Trends in Public Infrastructure Spending*, CBO Paper (May 1999), pp. 102-104.

it with a period of grants to capitalize state revolving funds, with the states matching 20 percent of each federal dollar. The SRFs provide several types of financial support —including loans at or below market interest rates, purchase of existing local debt obligations (bonds), and guarantees for new debt —but they do not make grants. The 1987 law envisioned that loan repayments would allow the SRFs to operate without ongoing federal support and authorized contributions only through 1994; however, the Congress has continued to appropriate funds each year since then, including $1.35 billion for 2002.[14] In nominal dollars, appropriations from 1973 through 2002 have totaled $73 billion.

The federal government's primary involvement with drinking water began with the Safe Drinking Water Act in 1974. Among the factors leading to its passage were concerns that the Public Health Service's drinking water standards were based on inadequate and obsolete data, that state and local officials were not adequately monitoring water systems, and that pollutants found in drinking water were carcinogenic. EPA issued few standards for drinking water contaminants in the law's first decade, and the Congress amended it in 1986 to require the agency to develop standards for 83 specified contaminants and for 25 others every three years. As amended, the law called for the standards, deemed "maximum contaminant levels," to be set as close as feasible to levels at which no adverse health effects were known or anticipated—taking cost into consideration in defining feasibility. EPA considers a standard feasible if the cost of meeting it is "reasonable" for large water systems.[15]

Neither the original Safe Drinking Water Act nor the 1986 amendments authorized federal funding, but as the number of standards and the costs of meeting them grew, so did support for providing drinking water systems with financial assistance. Thus, a key provision of the law's 1996 amendments created a program of drinking water SRFs modeled after the existing wastewater program and authorized $9.6 billion through fiscal year 2003 in capitalization grants, again requiring a 20 percent state match. (Appropriations through fiscal year 2002 for the drinking water funds have totaled $5.3 billion.) Other major provisions revoked the requirement that EPA regulate an additional 25 contaminants every three years, authorized the agency to adopt less stringent contaminant standards if necessary to keep costs from exceeding benefits, and required it to identify "variance technologies" that could be approved for use by small systems judged unable to afford to comply with the relevant standards. The amendments also called on states to establish programs to certify and develop the technical, financial, and managerial capacity of drinking water systems to comply with all federal requirements.

Federal spending programs outside of EPA also provide financial support for investments in water infrastructure. The Rural Utilities Service of the Department of Agriculture provides a mix of loans and grants for water and waste disposal projects in communities with fewer than 10,000 people; the program received $647 million in 2002. Drinking water and wastewater projects may also receive funding through the Public Works and Development Facilities Program (administered by the Economic Development Administration in the Commerce Department) or the Community Development Block Grants program (administered by the Department of Housing and Urban Development) if they meet the relevant criteria: the former program focuses on job creation and the latter on community development that benefits low- and moderate-income people. Still other programs focus on assistance to specific groups or locations, such as Indian tribes, native Alaskan villages, Appalachia, and unincorporated *colonias* on the U.S.-Mexico border.

The federal government also supports water infrastructure indirectly, through tax preferences. Because the interest paid on state and local bonds is generally excludable from taxable income, municipalities and other public water authorities can issue bonds at lower rates than they would otherwise have to pay. Also, bonds issued for privately owned drinking water and wastewater systems are considered "qualified private activity bonds" eligible for tax-exempt status; however, the federal government limits the

14. In addition, for 2002 the Congress earmarked $344 million in grants for wastewater and drinking water projects.

15. See, for example, Environmental Protection Agency, "National Primary Drinking Water Regulations: Arsenic and Clarifications to Compliance and New Source Contaminants Monitoring, Final Rule," *Federal Register*, vol. 66, no. 14 (January 22, 2001), p. 6981.

volume of tax-exempt private bonds that each state can issue annually. Issues of municipal and tax-exempt private bonds for municipal utilities—primarily drinking water and wastewater systems but also some solid and hazardous waste facilities—totaled $14.0 billion in 2000 and $29.3 billion in 2001.[16] The Joint Committee on Taxation estimates that the exemption will save bondholders $0.6 billion in fiscal year 2002.[17]

The Need for Increased Investment

Dramatic incidents in recent years have called attention to the importance of water infrastructure. In 1993, contamination of the Milwaukee water supply by cryptosporidium caused 400,000 cases of gastrointestinal illness and an estimated 50 to 100 deaths. That same year, two people in Atlanta were killed by falling into a sinkhole created by the collapse of a storm sewer. Baltimore had two sinkholes of 30 feet or more in 1997, and a Manhattan sinkhole caused millions of dollars in damage in 1998.

Less catastrophic failures demonstrate the widespread nature of the problems. According to EPA's data, 880 publicly owned treatment works receive flows from "combined sewer systems" which commingle stormwater with household and industrial wastewater and frequently overload during heavy rain or snowmelt. EPA estimates that such overflows discharge 1.2 trillion gallons of stormwater and untreated sewage every year. Even "sanitary" systems with separate sewers for wastewater can overflow or leak because of pipe blockages, pump failures, inadequate maintenance, or excessive demands. According to a draft EPA report, overflows from sanitary sewers alone result in a million illnesses each year.[18] Moreover, according to industry experts, many urban and rural drinking water systems lose 20 percent or more of the water they produce through leaks in their pipe networks.[19]

In part, those problems result from the aging of the nation's water infrastructure, particularly its pipes. Though less visible than treatment facilities, pipes actually account for the majority of both drinking water and wastewater systems' assets.[20] According to estimates, drinking water systems have 800,000 miles of pipes, and sewer lines cover more than 500,000 miles.[21] The rule of thumb is that a sewer pipe lasts 50 years (although actual useful lifetimes can be significantly longer, depending on maintenance and local conditions), and a 1998 survey of 42 municipal sewer systems found that existing pipes averaged 33 years old, suggesting that many are, or soon will be, in need of replacement.[22] Similarly, a study by the American Water Works Association that analyzed 20 medium-sized and large drinking water systems concluded that the need to

16. Personal communication from Amy Resnick, editor, *The Bond Buyer*, citing data from Thomson Financial.

17. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 2002-2006*, JCS-1-02 (January 17, 2002), p. 21.

18. Environomics, Inc., and Parsons Engineering Science, Inc., *Economic Analysis of Proposed Regulations Addressing NPDES Permit Requirements for Municipal Sanitary Sewer Collection Systems and Sanitary Sewer Overflows* (draft prepared for the Environmental Protection Agency, March 24, 2000), p. 3-1.

19. Personal communications from John Young, Vice President for Engineering, American Water Works Services Company, and Buzz Teter, Research and Development Specialist, American Leak Detection.

20. For example, a recent study of 20 medium-sized and large drinking water systems found that water mains accounted for more than 60 percent of the current value of the systems' capital stock. American Water Works Association, *Reinvesting in Drinking Water Infrastructure: Dawn of the Replacement Era* (May 2001), p. 11, available at www.awwa.org/govtaff/infrastructure.pdf.

21. American Society of Civil Engineers, *Drinking Water,* Issue Brief (no date); Parsons Engineering Science, Inc., Metcalf and Eddy, and Limno-Tech, Inc., *Sanitary Sewer Overflow (SSO) Needs Report* (prepared for the Environmental Protection Agency, Office of Wastewater Management, May 2000), p. 2-2. The estimate for sewer lines is for systems with separate sanitary sewers; given the same assumptions, systems that combine sanitary wastewater and stormwater add roughly 140,000 more miles to the overall total.

22. American Society of Civil Engineers, *Optimization of Collection System Maintenance Frequencies and System Performance* (prepared for the Environmental Protection Agency, November 1998).

replace pipes will rise sharply over the next 30 years as previous generations wear out.[23]

Although treatment plants represent a smaller share of water systems' assets than pipes do, they too are aging. Equipment in many plants built under the Clean Water Act and Safe Drinking Water Act will need to be replaced in the next decade or two. Moreover, many drinking water systems will have to make additional investments in treatment equipment to satisfy forthcoming regulations under the Safe Drinking Water Act.

In short, costs to construct, operate, and maintain the nation's water infrastructure can be expected to rise significantly in the future. Less clear, however, are the amount and timing of the increases. Estimates of future costs and the uncertainties surrounding them are discussed in Chapter 2; sources of funding to pay those costs are considered in Chapter 3.

23. American Water Works Association, *Reinvesting in Drinking Water Infrastructure.*

CHAPTER

2

Estimates of Future Investment Costs and Their Implications

Any estimate of costs for future investment in water systems reflects not only the current state and future depreciation of the existing infrastructure but also the goals—such as the regulatory requirements and the levels of customer satisfaction—that water systems seek to achieve and the efficiency with which they pursue those goals. An underlying assumption, about which there appears to be general consensus, is that customers will continue to expect high-quality service. Less consensus exists, however, regarding the future costs of regulatory requirements and potential efficiency savings.

Given the limitations of the available data, which begin with uncertainties about even the amount and condition of the current infrastructure, in this study the Congressional Budget Office (CBO) does not provide a single point estimate of 20-year investment costs. Instead, it discusses estimates for two scenarios—a low-cost case and a high-cost case—that it believes span the most likely possibilities. CBO derived those estimates by applying specific new assumptions to the same modeling framework that the Water Infrastructure Network (WIN)—a coalition of groups representing water systems, elected officials, engineers, construction companies, and environmentalists—used to develop its own estimates. Like WIN's analysis, CBO's scenarios cover the years 2000 to 2019; data on actual investment in 2000 and 2001 are not yet available.

The two scenarios yield estimates of average annual investment costs ranging from $11.6 billion to $20.1 billion for drinking water systems and from $13.0 billion to $20.9 billion for wastewater systems.[1] Those estimates measure investment volume in 2001 dollars (as do all other dollar figures in this chapter not identified otherwise) and in terms of costs as financed, taking into account the use of borrowing to spread the investment burden over time. In particular, the estimates reflect the full capital costs of investments made each year on a pay-as-you-go basis and the debt service (principal and interest) paid on prior financed investments. Costs as financed are particularly relevant to policy debates about affordability because they reflect the current burden on water systems. (One could also measure investment volume in terms of economic resource costs; *see Box 2-1.*)

By comparison, spending on investment in states' 1998-1999 fiscal year (calculated using similar assumptions to the ones underlying the projections of future investment) was $11.8 billion for drinking water and $9.8 billion for wastewater. Thus, the projected overall shortfall between current spending and future costs is $3.0 billion per year in the low-cost case (-$0.2 billion for drinking water and $3.2 billion for wastewater) and $19.4 billion in the high-cost case ($8.3 billion for drinking water and $11.1 billion for wastewater).

1. The estimates for drinking water and wastewater are not strictly comparable because the methods CBO used to derive them were not identical, as discussed below.

CBO has also analyzed the impact of those projected increases on household budgets. Assuming for simplicity that both the level of taxpayer-financed support and the distribution of costs between household and other water ratepayers remained constant, CBO estimates that by 2019, average bills for drinking water and wastewater services combined would account for 0.6 percent of average household income under the low-cost case and 0.9 percent under the high-cost case, up from 0.5 percent in the late 1990s. Of course, many households would pay

Box 2-1.

Alternative Measures of Investment Spending

This study measures investments in water systems in terms of costs as financed because that measure best reflects the impact on water rates and hence on the affordability of household water bills. The alternative and more common measure is economic costs—the quantity of real economic resources required by the investments.

In particular, economic costs reflect the capital costs of all investments, whether financed by bonds or loans or paid for from funds on hand; that measure omits interest payments on bonds and loans, which represent mere transfers of funds. Thus, it differs in two ways from the measure describing costs as financed: by excluding interest costs and by focusing on the full capital costs of new financed investments rather than the current principal payments on previous financed investments (*see the table*). Although less relevant than costs as financed for judging the affordability of water services, economic costs are the preferred measure for policy questions that focus on the efficient use of society's resources, such as questions about the costs and benefits of water-quality regulations.

The Water Infrastructure Network's (WIN's) estimates reflect neither economic costs nor costs as financed. For each of the 20 years analyzed, the estimates combine the capital costs for all investments made that year—that is, the economic costs—and the sum (in real dollars) of all future interest costs for the portion of the investments financed by borrowing. In other words, each year's estimate adds the cost of that year's pay-as-you-go investments and the total debt service (principal plus interest) to be paid in later years for the new financed investments. Thus, whereas costs as financed include the current debt service paid on past investments, WIN's estimates include future debt service on current investments. The impact of that difference is discussed in *Box 2-3* on page 19.

Note that the distinction between the two measures of cost does not apply to spending on operations and maintenance (O&M). Since O&M is paid for from current funds, the real resource costs to the economy are the same as the immediate burden on water systems and their ratepayers.

Costs Included in Measures of Investment Spending

	Costs as Financed	Economic Costs	WIN's Estimates[a]
Capital Costs of Current Pay-As-You-Go Investments	yes	yes	yes
Current Principal for Old Financed Investments	yes	no	no
Total Future Principal for Current Financed Investments	no	yes	yes
Current Interest on Old Financed Investments	yes	no	no
Total Future Interest on Current Financed Investments	no	no	yes

Source: Congressional Budget Office.

a. As published. Elsewhere in this study, CBO has converted WIN's estimates to costs as financed, using detailed results from WIN's analysis to include and exclude component costs, as needed.

less than those averages, and many others would pay more. For example, in CBO's two cases an estimated 10 percent to 20 percent of households would be paying more than 4 percent of their income for water services by 2019, compared with 7 percent doing so in the late 1990s.

CBO's estimates of future investment costs appear to be significantly below those published in the WIN report; however, the two are not directly comparable because WIN's estimates do not reflect costs as financed. When expressed in comparable terms, the estimates from CBO's high-cost case and WIN's analysis are similar. That similarity is not surprising because CBO used WIN's basic modeling approach and, in the high-cost case, similar assumptions. Thus, CBO's high-cost case does not lend independent support for WIN's estimates; rather it suggests that estimates of that magnitude require relatively pessimistic assumptions. Studies that project national investment costs by aggregating data from individual water systems have yielded estimates that are lower than those of CBO's low-cost case.

CBO's estimates do not include the costs of additional investments in infrastructure security prompted by the September 2001 attacks on the World Trade Center and the Pentagon. As this report was written, the drinking water and wastewater industries were in the early stages of assessing their vulnerabilities (*see Box 2-2*). Preliminary indications are that capital costs for security will not add much to the investment costs described here. CBO's estimates also exclude investments in drinking water systems that serve only future growth; such investments are not eligible for funding under the state revolving fund program.

Bottom-Up and Top-Down Estimates of Investment in Water Systems

To interpret CBO's scenarios and estimates, it is useful to understand the basic approaches underlying previous estimates of investment in water systems—particularly those used in WIN's analysis, which CBO adapted. The approaches can be divided into two categories: bottom-up estimates reflect assessments of the needs of individual systems—either all systems nationwide or a sample of systems—whereas top-down estimates are based on analyses of aggregate national data. Top-down studies are simpler and less expensive, but their results are sensitive to a number of assumptions required because of the limitations of the aggregate data—particularly the lack of a national inventory of pipes' age and condition.

Bottom-Up Estimates

EPA's periodic needs surveys provide the most comprehensive bottom-up estimates.[2] The 1999 drinking water survey, published in February 2001, estimates total investment costs from 1999 to 2018 to be $159.5 billion (*see Table 2-1*).[3] The agency's latest available wastewater survey estimates 20-year costs to be $147.0 billion, if $13.2 billion for projects not involving infrastructure per se is excluded.[4] Expressed as average annual costs, those estimates are $8.0 billion for drinking water systems and $7.3 billion for wastewater systems; both estimates reflect capital costs alone, excluding financing.

One key limitation of both surveys, acknowledged in EPA's reports, is that many respondents may have been unable to supply adequate documentation for investments later in the 20-year survey period because they relied on

2. Some of the estimates identified here as "bottom-up" contain minor top-down components and vice versa.

3. Environmental Protection Agency, Office of Water, *Drinking Water Infrastructure Needs Survey: Second Report to Congress*, EPA 816-R-01-004 (February 2001), p. 12. The report expressed the estimate as $150.9 billion in January 1999 dollars. The survey included on-site analyses at 599 small systems (serving up to 3,300 people) randomly selected from the roughly 45,000 such systems and questionnaires mailed to all of the 1,111 systems serving more than 40,000 people and a random sample of 2,556 of the 7,759 systems serving 3,301 to 40,000 people. The return rate on the questionnaires was 96 percent. Ibid., pp. 18-19.

4. The original figures, in January 1996 dollars, were $128.0 billion and $11.5 billion; EPA derived the national totals after reviewing documentation submitted by the states. Environmental Protection Agency, Office of Water, *1996 Clean Water Needs Survey: Report to Congress*, EPA 832-R-97-003 (September 1997), pp. 1-2, 20. The excluded categories cover projects addressing nonpoint source pollution involving agriculture and silviculture; urban runoff; and groundwater, estuaries, and wetlands.

Box 2-2.

Security Investments for Water Systems

Although utility, government, and academic experts can identify generally what measures are needed to safeguard water services, a reliable assessment of the total potential costs of addressing those needs is not yet available.

Environmental Protection Agency officials and outside security experts generally view a terrorist attack on physical infrastructure (dams, treatment plants, pipes, and computer systems) as the scenario warranting the most attention. In some cases, successful attacks, such as one that would destroy any of the 93,000 "high hazard" dams, could not only disrupt service but also immediately cause human deaths. Contamination of drinking water at a reservoir or treatment plant is considered relatively unlikely to cause a large-scale health problem because of the volume of contaminants needed and because of the screening involved in treatment.[1] Contamination of the water once it was in the distribution system would be more direct but would affect fewer people.

In the short term, water systems are focusing on securing or eliminating toxic chemical stockpiles at treatment plants; installing basic surveillance and security equipment such as fencing, lighting, motion sensors, closed-circuit television, locks, and alarms; and conducting background checks and security training programs. Also, the water industry's Information Sharing and Analysis Center (ISAC)—a Web-based tool providing threat alerts, a mechanism for systems to report incidents, and training resources—is scheduled to be launched in December 2002. The ISAC will help water systems, law enforcement agencies, and emergency response organizations share information.

For longer-term improvements in security, the nation's water systems are working to finish vulnerability assessments and to adapt their emergency response plans to include terrorist acts. Moreover, research and development is under way to identify ways to combat physical vulnerabilities and contamination (chemical, biological, or radiological) and to identify the interconnections with other critical services such as those of the energy, telecommunications, and transportation sectors and emergency services.

As the vulnerability assessments and research projects are completed, investment needs will become clearer, and perhaps much larger than those identified today. Nonetheless, on the basis of conversations with industry experts, CBO anticipates that those needs will be small compared with the widespread needs to replace and improve the water infrastructure. For example, the American Water Works Association has estimated national costs of $450 million to complete vulnerability assessments for all systems serving more than 3,300 people and $1.6 billion for initial security improvements (access controls such as fences, lighting, cameras, and alarms). Combined, those one-time amounts represent less than 1 percent of CBO's estimates of the 20-year capital costs of investment in drinking water systems.

1. For a contrary view, see www.amsa-cleanwater.org/advocacy/security/articles.cfm, which cites an article from the November 17, 2001, *St. Louis Post Dispatch* quoting two government officials who believe that the potential risk from bacterial contamination is high.

planning documents covering one to 10 years.[5] The report on wastewater also argues that the survey underreports future investments to correct problems with sanitary sewer overflows (SSOs).[6] Indeed, a subsequent top-down report placed the investment costs of controlling SSOs at $92.4 billion, well above the figures found in the

5. Environmental Protection Agency, *Drinking Water Infrastructure Needs Survey*, p. 43; and *1996 Clean Water Needs Survey*, p. 7.

6. Environmental Protection Agency, *1996 Clean Water Needs Survey*, p. 7.

Table 2-1.

Summary of Estimates of Investment Costs for Water Systems

(In billions of 2001 dollars)

	Drinking Water		Wastewater		Total	
	As Published	Per Year	As Published	Per Year	As Published	Per Year
			Bottom-Up Estimates			
Environmental Protection Agency						
Clean Water Needs Survey	n.a.	n.a.	147.0 over 20 years	7.3	n.a.	n.a.
Drinking Water Infrastructure Needs Survey	159.5 over 20 years	8.0	n.a.	n.a.	n.a.	n.a.
American Water Works Association	255 over 30 years	8.5	n.a.	n.a.	n.a.	n.a.
			Top-Down Estimates			
Stratus Consulting (Investments in distribution systems only)	348.3 over 20 years	17.4	n.a.	n.a.	n.a.	n.a.
Water Infrastructure Network						
Capital only	20.9 per year	20.9	19.2 per year	19.2	40.1 per year	40.1
Capital and financing	26.3 per year	26.3	24.2 per year	24.2	50.5 per year	50.5

Source: Congressional Budget Office based on Environmental Protection Agency, Office of Water, *1996 Clean Water Needs Survey: Report to Congress*, EPA 832-R-97-003 (September 1997); Environmental Protection Agency, Office of Water, *Drinking Water Infrastructure Needs Survey: Second Report to Congress*, EPA 816-R-01-004 (February 2001); American Water Works Association, *Reinvesting in Drinking Water Infrastructure: Dawn of the Replacement Era* (Denver, Colo.: AWWA, May 2001); Stratus Consulting, Inc., *Infrastructure Needs for the Public Water Supply Sector* (unpublished report for the American Water Works Association, December 22, 1998); and Water Infrastructure Network, *Clean and Safe Water for the 21st Century: A Renewed National Commitment to Water and Wastewater Infrastructure* (Washington, D.C.: WIN, April 2000).

Note: n.a. = not applicable.

corresponding categories of the survey.[7] Replacing those figures reported in the survey with the top-down estimate raises total costs from $147.0 billion to $198.2 billion.

The perceived shortcomings of EPA's surveys helped spur the American Water Works Association (AWWA) to conduct an in-depth analysis of 20 large and medium-sized drinking water systems. On the basis of the actual age and estimated lifetimes of the pipes, treatment plants, and other assets, the analysis found that the 20 systems would need to spend about $6 billion (in 2000 dollars) above their current levels over the next 30 years.[8] The corresponding annual costs per household ranged from about $18 to $77. On the basis of those 20 systems, the report extrapolated a national total of $255 billion over 30 years, implying an annual average of $8.5 billion (in 2001 dollars)—very similar to the $8.0 billion average reported in EPA's drinking water survey.

Top-Down Estimates

The top-down estimates reviewed for this study are larger than the bottom-up estimates (*see Table 2-1*). The differences could reflect incomplete coverage of costs over the 20-year period and other limitations of the existing bottom-up studies, inaccurate assumptions in the top-down studies, or both.

7. Parsons Engineering Science, Inc., Metcalf and Eddy, and Limno-Tech, Inc., *Sanitary Sewer Overflow (SSO) Needs Report* (prepared for the Environmental Protection Agency, Office of Wastewater Management, May 2000), pp. 1-7, 5-3. As presented in the report, the estimate was $87.3 billion in December 1998 dollars.

8. American Water Works Association, *Reinvesting in Drinking Water Infrastructure: Dawn of the Replacement Era* (Washington, D.C.: AWWA, May 2001), p. 18.

A top-down study done by Stratus Consulting for the AWWA (not to be confused with the association's recent 20-system study) estimated 20-year costs for investments in drinking water distribution systems to be $348.3 billion, roughly four times the amount reported in EPA's survey.[9] The total from the Stratus study translates to average annual costs of $5.1 billion for large systems and $9.9 billion for medium-sized systems, reflecting point estimates or probability distributions for five factors: the number of systems nationwide (classified by size and region), the miles of pipe per system, the distribution of pipe mileage by size category, the replacement cost of pipes in each size category, and the average annual rate of replacement.[10] Many uncertainties surround those factors. For example, two databases cited in the study yielded estimates of 828 miles and 713 miles of pipe in the average large system.[11] Simply using the lower figure instead of the higher would have reduced estimated investment costs for large systems by 14 percent, or $15 billion over 20 years. And major uncertainty accompanied the assumptions regarding future replacement rates, as discussed in the next section.

WIN's April 2000 report combined data and estimates from existing sources with a new top-down analysis.[12] For drinking water, WIN borrowed estimates related to water distribution from the Stratus study and estimates for all other categories (treatment, storage, water sources, and "other") from EPA's 1995 needs survey for drinking water, the predecessor to the 1999 survey discussed above.

For wastewater, WIN's approach distinguished investments to replace existing infrastructure from all other investments, such as those to build new treatment plants or new structures to contain stormwater runoff. The analysis calculated the cost each year for replacing infrastructure as the product of net capital stock in that year and a fixed depreciation rate.[13] WIN estimated other investment costs on the basis of EPA's needs survey, adjusted using the agency's revised estimate for controlling sanitary sewer overflows. However, because the survey captured some replacement projects also, WIN's analysts subtracted a percentage to avoid double-counting. Again, some key assumptions, such as those about the depreciation rate and the correction factor for double-counting, were accompanied by significant uncertainty.

The WIN report went beyond the studies discussed above by also estimating financing costs and operation and maintenance (O&M) costs. To estimate financing costs, WIN's analysts assumed that water systems would pay for 25 percent of investment costs from internal funds, with the rest financed for 20 years at a real interest rate of 3 percent. They estimated O&M costs by extrapolating a linear trend through data on actual spending: for drinking water, they used 1985-1994 data on O&M spending itself; for wastewater, they used 1972-1996 data on O&M spending per dollar of estimated net capital stock. Both estimates apparently subtract 20 percent for efficiency savings, phased in over 10 years. Those approaches are discussed in more detail in Appendix A.

9. Stratus Consulting, Inc., *Infrastructure Needs for the Public Water Supply Sector* (unpublished report for the American Water Works Association, December 22, 1998). The study estimated costs only for large and medium-sized systems; for small systems, it adopted the estimate from EPA's 1997 needs survey.

10. The report provided 80 percent confidence intervals—that is, the ranges that cover the central 80 percent of the possible outcomes, omitting only the bottom 10 percent and the top 10 percent. For large systems, the 80 percent confidence interval (in 1998 dollars) covered $0.9 billion to $9.7 billion. For medium-sized systems, the distribution was somewhat less diffuse, spanning $5.8 billion to $13.6 billion. Ibid., p. 3-10.

11. Ibid., p. 3-2.

12. Water Infrastructure Network, *Clean and Safe Water for the 21st Century: A Renewed National Commitment to Water and Wastewater Infrastructure* (Washington, D.C.: WIN, April 2000), available at www.win-water.org. The following description of WIN's methods comes from an unpublished appendix to the report and from several sets of oral or written statements from Kenneth Rubin, PA Consulting, who served as lead analyst developing the model for WIN.

13. WIN constructed its estimate of the capital stock of wastewater infrastructure that existed in 1999 from a 1990 estimate prepared for the Federal Infrastructure Strategy Program of the Army Corps of Engineers, information on annual investments for 1990 to 1999 obtained or extrapolated from census data, and the assumed depreciation rate. That depreciation refers to the annual reduction in the useful economic life of an asset, not to the related accounting concept of the credit allowed for tax or regulatory purposes.

Table 2-2.

CBO's Estimates of the Likely Range of Average Annual Costs for Water Systems, 2000 to 2019

(In billions of 2001 dollars)

	Drinking Water	Wastewater	Total
Debt Service on Pre-2000 Investments	4.4 to 4.4	4.3 to 4.3	8.7 to 8.7
Capital Costs (Paygo + Financed Principal) on New Investments	5.3 to 12.1	6.5 to 12.9	11.8 to 25.0
Interest on New Financed Investments	1.9 to 3.6	2.3 to 3.7	4.1 to 7.3
Total Investment	11.6 to 20.1	13.0 to 20.9	24.6 to 41.0
Operations and Maintenance	25.7 to 31.8	20.3 to 25.2	46.1 to 57.0

Source: Congressional Budget Office.

Note: Ranges reflect CBO's low-cost and high-cost cases.

CBO's Estimates of Future Costs

CBO's two sets of projections of 20-year costs for water systems differ significantly. Under its low-cost case, the estimate for average annual investment costs for both drinking water and wastewater is $24.6 billion ($11.6 billion for drinking water and $13.0 billion for wastewater —*see Table 2-2*), 40 percent less than its estimate of $41.0 billion under the high-cost case ($20.1 billion for drinking water and $20.9 billion for wastewater). Again, the estimates are measured in terms of costs as financed, reflecting the average annual capital costs for pay-as-you-go (or more briefly, paygo) investments and the debt service (principal and interest) paid on prior financed investments.[14] The divergent estimates reflect nine differences in the assumptions used in the two scenarios and illustrate the uncertainty inherent in top-down analyses of 20-year investment needs.

For operations and maintenance, the range of estimates between the two cases is narrower—the smaller total of $46.1 billion is just 19 percent below the larger figure of $57.0 billion. Those estimates reflect a relatively narrow range of modeling assumptions and may understate the true range of uncertainty.

CBO's estimates of future investment under its high-cost scenario are similar to those from WIN's analysis, when the latter are measured in terms of costs as financed (*see Table 2-3*). (WIN's report does not provide costs-as-financed estimates, but CBO was able to calculate such estimates using more-detailed results provided by WIN's analysts; *see Box 2-3*.) WIN's operations and maintenance estimates are directly comparable to CBO's and fall within the upper half of the range between the two cases.

Note that because of the nature of the underlying data sources, CBO's estimates of future costs, like WIN's, exclude some investments associated with new customers and expansion, at least for drinking water. The estimates for investments in drinking water distribution, which are based on the analysis by Stratus Consulting, cover only the cost of replacing the existing infrastructure and exclude the effects of any increases (or decreases) in capacity. The estimates for other categories of investments in drinking water systems reflect the eligibility criteria used in EPA's needs survey and thus include investments to serve new customers only if those investments are necessary to respond to a public health problem (for example, bringing service to homes served by contaminated wells) or if they represent components of projects triggered by the needs of existing customers (such as increased capacity

14. As Table 2-2 shows, debt service on pre-2000 projects accounts for roughly one-third of total investment costs in the low-cost case and one-fifth in the high-cost case.

Table 2-3.

Comparison of CBO's and WIN's Estimates of Average Annual Costs, 2000 to 2019

(In billions of 2001 dollars)

	Drinking Water	Wastewater	Total
Investment (Costs as financed)			
CBO[a]	11.6 to 20.1	13.0 to 20.9	24.6 to 41.0
WIN (Calculated by CBO)	21.4	18.9	40.3
Operations and Maintenance			
CBO[a]	25.7 to 31.8	20.3 to 25.2	46.1 to 57.0
WIN	29	24	53

Source: Congressional Budget Office based in part on data from the Water Infrastructure Network.

Note: CBO recalculated WIN's estimates for investment to convert them to costs as financed.

a. Ranges reflect CBO's low-cost and high-cost cases.

of a treatment plant due for replacement anyway).[15] Those exclusions tend to bias estimated future costs downward; however, both CBO's and WIN's analyses of the impact of future costs on water systems and ratepayers also neglect related factors that could increase revenues, such as population growth and increased reliance on hookup fees and developers' contributions.

The Low-Cost and High-Cost Scenarios

CBO's goal in assembling the assumptions for each scenario was to choose sets of plausibly (not extremely) low and high values that have a reasonable chance of occurring together. The resulting low and high estimates are thus intended to span most of the distribution of possible outcomes but not its extreme tails.

In total, 11 assumptions distinguish the low-cost and high-cost cases from each other or from WIN's analysis (*see Table 2-4*). The three assumptions most responsible for the difference in estimates of investment costs in CBO's scenarios are those concerning the rate at which drinking water pipes will need to be replaced, the costs associated with addressing combined sewer overflows (CSOs), and the potential savings in investment costs from gains in efficiency. Those assumptions are outlined here; a more comprehensive discussion of all 11 assumptions is available in Appendix A.

Replacement Rate for Drinking Water Pipes. The aging of existing water infrastructure is the single largest factor driving projected increases in investment spending.[16] But how much of the infrastructure will need to be replaced over the next 20 years is a difficult question. Again, for purposes of this analysis, CBO assumes that managers maintain service standards and make efficient choices in trading off investment and maintenance; clearly, one could reduce replacement costs over a span of 20 years by delaying appropriate investments, at the cost of lower standards of service, excessive maintenance expenditures in the meantime, or both.

15. The estimates of investment costs for wastewater systems are probably also incomplete, though in a less systematic way. The estimates of costs for replacement do not directly include the incremental costs of any increases in capacity or capability. In principle, those incremental costs could be reflected in the needs survey data that underpin the estimates of other costs (because wastewater projects to serve new customers are eligible for SRF assistance and are thus covered in the needs survey); as explained, however, it is doubtful that the survey data capture such costs for the full 20-year period.

16. Of course, such investments cannot always be assigned a unique cause. For example, some replacements of deteriorated sewer pipes can be viewed either as triggered by a need to comply with regulations on sewer overflows or as ordinary replacements of depreciated capital stock.

Box 2-3.

The Water Infrastructure Network's Published Estimates of Investment Needs and the "Funding Gap"

The Water Infrastructure Network's (WIN's) published estimates of total investment needs (capital plus financing) do not reflect costs as financed: they include total debt service on new investments from 2000 to 2019, regardless of when those payments occur, rather than the debt service (on both pre-2000 and new investments) actually paid during the period. The difference is important because the investments financed from 1980 to 1999 and still being paid off from 2000 to 2019 are smaller than the investments projected to be financed during the latter period. Therefore, as the table shows, recalculated to express the costs of investment as financed—the true burden facing water systems and ratepayers during the 20-year period—WIN's results drop by 20 percent: from the published annual average of $50.5 billion (in 2001 dollars) for both drinking water and wastewater to $40.3 billion.

Not only do WIN's published estimates not represent costs as financed, they also do not measure the same things covered by the Census Bureau's data on water systems' current spending (discussed below in the text). Thus, subtracting the census data from WIN's estimates, which WIN did to derive what it termed the "funding gap," does not yield an internally consistent estimate of the difference between current spending and future needs. In particular, whereas WIN's projections of needs in any year include all interest paid over time on that year's investments, the census data for a given year include interest payments made in that year on preexisting debt for drinking water systems and exclude interest on debt for wastewater systems. When both future investment needs and current spending are measured in terms of costs as financed, the estimated funding gap that WIN refers to averages $18.6 billion per year for drinking water and wastewater combined.[1]

1. That estimate uses 1999 as the base year for "current" spending, whereas WIN's published estimate used 1996. CBO has not pursued the data far enough to estimate 1996 spending in terms of costs as financed; doing so would require estimating 1996 debt-service payments on investments going back to 1976 (assuming 20-year borrowing). Nonetheless, it is safe to say that the funding gap measured in costs as financed would be similar with 1996 as the base year: costs as financed reflect debt service on many previous years of investment and thus are a kind of moving average that smooths out year-to-year changes in investment volume.

WIN's Estimates, as Published and in Costs as Financed
(In billions of 2001 dollars)

	Drinking Water	Wastewater	Total
WIN's Estimates as Published			
Total investment	26.3	24.2	50.5
Increase above 1996 level	12.2	13.5	25.7
WIN's Estimates in Costs as Financed (Calculated by CBO)			
Total investment	21.4	18.9	40.3
Increase above 1999 level	9.4	9.2	18.6
Memorandum:			
CBO's Range of Estimates			
Total investment	11.6 to 20.1	13.0 to 20.9	24.6 to 41.0
Increase above 1999 level	-0.2 to 8.3	3.2 to 11.1	3.0 to 19.4

Source: Congressional Budget Office based in part on Water Infrastructure Network, *Clean and Safe Water for the 21st Century: A Renewed Commitment to Water and Wastewater Infrastructure* (Washington, D.C.: WIN, April 2000).

Table 2-4.

Assumptions Used in CBO's and WIN's Analyses

	CBO's Assumptions		
	Low-Cost Case	High-Cost Case	WIN's Assumptions
Capital Factors			
Savings from Increased Efficiency in Investment by Drinking Water and Wastewater Systems (Percent)	15.0	5.0	0
Drinking Water Systems			
Annual percentage of pipes replaced	0.6	1.0	1.0
Average annual cost for regulations not yet proposed (Billions of 2001 dollars)	0	0.53	0
Wastewater Systems			
Annual percentage depreciation	2.7	3.3	3.3
Share of investments in EPA's needs survey for replacing existing capital (Percent)	25.0	15.0	20.5
Average annual cost for abating combined sewer overflows (Billions of 2001 dollars)	2.6	5.4	2.6
Financing Factors			
Real Interest Rate (Percent)	3.0	4.0	3.0
Repayment Period	30 years	25 years	20 years
Pay-As-You-Go Share of Total Investment (Percent)	15.0	30.0	25.0
Average Annual Debt Service on Pre-2000 Investments (Billions of 2001 dollars)	8.7	8.7	9.5
Operations and Maintenance	Linear extrapolation of 1980-1998 trend, less 20 percent efficiency savings phased in from 1995 to 2004	Linear extrapolation of 1980-1998 trend	Drinking water: Linear extrapolation of 1985-1994 trend, apparently less 20 percent efficiency savings phased in from 1997 to 2006 Wastewater: Linear extrapolation of 1972-1996 trend per unit of net capital stock, less 20 percent efficiency savings phased in from 1997 to 2006

Source: Congressional Budget Office based in part on data from the Water Infrastructure Network.

In the case of drinking water pipes, both of CBO's scenarios assume replacement rates drawn from the aforementioned study by Stratus Consulting, whose findings were later incorporated in the WIN coalition's analysis. The Stratus study assumed that 1 percent of pipe mileage is replaced each year on average, and CBO adopted that assumption in its high-cost case.[17] However, that study also presented a plausible alternative approach in which a pipe is replaced when its age reaches its service life, and growth in pipe mileage since 1880 has been proportional to growth in the U.S. population. On the basis of that approach, CBO's low-cost case adopted an average annual replacement rate of 0.6 percent.[18]

Abatement of Combined Sewer Overflows. After the deterioration of existing infrastructure, regulatory requirements are probably the second largest factor driving investments in water systems. Wastewater systems in particular face major investments to reduce the incidence of sewer overflows—from both combined sewers, which commingle stormwater with domestic sewage and industrial wastewater, and separate sanitary sewers.[19] As noted in Chapter 1, combined sewer systems—found in roughly 900 wastewater systems nationwide, about 4 percent of the total—frequently exceed their collection and treatment capacity during periods of heavy rain or snowmelt, discharging the excess flow directly into receiving waters.

The low-cost case assumes that investments to control CSOs will total $51.3 billion nationally, as estimated in EPA's *1996 Clean Water Needs Survey*. That estimate comes from a top-down statistical analysis, supplemented by communities' documentation of specific plans when available. The analysis assumed that communities would need to capture and treat 85 percent of their rain and snowmelt and calculated the cost of constructing basins and disinfection facilities to do so.

For many communities, however, 85 percent will not be enough, given their state's designated uses for water bodies and associated quality standards. Thus, analysts generally regard EPA's estimate of CSO control costs as too low under current standards.[20] For example, the CSO Partnership—a coalition of communities with combined sewer systems and firms expert in designing controls—believes that EPA's estimate is a reasonable one only if states make wide use of their legal option to revise the standards but that meeting current standards could cost on the order of $100 billion.[21] CBO adopted that figure in its high-cost scenario.

17. More precisely, the study assumed a range of annual replacement rates from 0.5 percent to 1.5 percent, averaging 1.0 percent. The study used repeated random sampling from that range and ranges for other uncertain factors to calculate a probability distribution for investment costs. Stratus Consulting, *Infrastructure Needs for the Public Water Supply Sector*, p. 3-9.

18. Under that simple historical approach, annual replacement rates between 2000 and 2019 would average 0.9 percent if pipes last 50 years, just 0.3 percent if they last 75 years (because it assumes that relatively few pipes were laid during the Depression and World War II, when the population grew slowly), and about 0.6 percent if they last 100 years (ibid., p. 3-5). CBO averaged those three rates to obtain the 0.6 percent rate assumed in its low-cost case. Each of the three rates is well below the long-run average set by the inverse of the lifetime (that is, 2.0 percent for 50 years, 1.3 percent for 75 years, and 1.0 percent for 100 years), indicating that pipe networks remain relatively young until after 2019. Thus, the approach does not support the perception of an imminent crisis in drinking water pipes.

19. Although investment costs to address sanitary sewer overflows are also uncertain, CBO's two scenarios both use EPA's estimate of those costs, largely for lack of information to underpin an alternative estimate.

20. In some cases, however, emerging innovative approaches that remove stormwater from the centralized sewer system—such as decentralized wastewater treatment (which emphasizes reusing treated flows where practical) and restorative redevelopment (which reintroduces stormwater to the soil and vegetation)—might result in costs lower than those reflected in EPA's estimates.

21. States are authorized to modify the designated uses of and quality standards for their water bodies if they demonstrate that meeting the old standards is technically infeasible or would have "substantial and widespread economic and social impacts." Examples of changes that could reduce costs for addressing CSOs include allowing a higher number of days that swimming may be suspended because of elevated bacteria levels; allowing less stringent standards in the winter when swimming is less popular; and applying water quality standards at the site of human contact, rather than the site of the discharge from the combined sewer system.

Efficiency Savings. Many water systems are realizing significant savings in operational and capital costs per unit of service by focusing on such things as demand management, labor productivity, system consolidation, asset management, and innovative construction contracting (*see Appendix B*).[22] However, the amount that systems will save from efficiency gains over the next 20 years—or could save, if given the right incentives—is uncertain.

CBO's low-cost and high-cost cases assume that efficiency savings reduce future investment by 15 percent and 5 percent, respectively. Those assumptions reflect several types of indirect or anecdotal evidence—data on potential and observed savings in O&M costs, estimates of investment savings from studies of water systems abroad, and individual case studies of domestic systems—and are within the range cited by some industry experts.[23]

Evidence that water systems are already reaping savings in O&M costs and could continue to do so comes from comparing a consulting firm's assessments of 97 medium-sized and large water utilities conducted through 1997 with 136 later assessments. In the initial group, potential savings in operational costs through the use of six types of best practices averaged 25 percent; for the later group, the distance from the efficiencies of best practices had narrowed, averaging only 18 percent.[24] Similarly, a 1996 report from the Association of Metropolitan Sewerage Agencies said that it is "not unusual" for systems that undertake efficiency initiatives to reap savings of 20 percent to 25 percent in operational costs.[25]

Fewer data are available on the potential impact of efficiency savings on investment costs. Some of the best evidence comes from overseas. One study of urban water systems in New South Wales, Australia, estimated potential investment savings of 12 percent to 14 percent within five years; also, executives from two Australian systems report anecdotally that they have already realized savings of 30 percent.[26] In the United Kingdom, the latest rates from the government regulator of water companies assume capital savings averaging 13 percent over five years, on top of savings already achieved in the past decade.[27] Here in the United States, two well-documented examples of innovative contracts giving a single firm the responsibility to design, build, and operate a treatment plant have yielded estimated savings of about 20 percent and 40 percent, the latter including discounted O&M costs (*see Appendix B*).

Comparing CBO's Estimates with Those of Others

One measure of the importance of the above assumptions is the impact each one would have had on the estimate of investment costs for drinking water and wastewater

22. For examples of the methods systems are using to identify potential savings, see Terry L. Atherton, "Success Through Mock Competition," and Mark Premo, "Rebuilding a Utility with Employee Involvement and Peer Input," both in Association of Metropolitan Water Agencies, *Making Waves: Competitiveness Strategies for Public Water Utilities*, vol. 1 (Washington, D.C.: AMWA, undated).

23. For example, one expert has testified to the Congress that "The cost profiles of the water and wastewater industries suggest the potential for cost reductions in the range of five percent or more in *each* of the following areas: efficiency practices (planning, management, and operations), integrated resource management (supply side and demand side), technological innovation (capital and operating), and industry restructuring (consolidation, privatization, and market-based approaches)" (emphasis in original). Supplemental answers from Dr. Janice A. Beecher, Beecher Policy Research, Inc., in Senate Committee on Environment and Public Works, Subcommittee on Fisheries, Wildlife, and Water, *Water and Wastewater Infrastructure Needs*, Committee Print 107-316 (March 27, 2001), p. 95. Of course, some of those categories would apply more to operational costs than to capital costs.

24. Personal communication with Alan Manning, EMA Associates.

25. Association of Metropolitan Sewerage Agencies, in collaboration with Apogee Research, Inc., *Evaluating Privatization: An AMSA Checklist* (Washington, D.C.: AMSA, 1996), p. 11.

26. Halcrow Management Sciences Limited, *New South Wales Water Agencies' Review: Summary* (December 1999), p. 53, available from the Independent Pricing and Regulatory Tribunal at www.ipart.nsw.gov.au under "What's New–Updates," January 28, 2000; and personal communication with Claude Piccinin, Deputy Executive Director, Water Services Association of Australia, July 26, 2001.

27. Office of Water Services, *Final Determinations: Future Water and Sewerage Charges 2000-05* (undated), p. 98, available at www.ofwat.gov.uk/final_determinations.htm.

systems if it had been used individually in WIN's analysis. For example, if that analysis had used 0.6 percent instead of 1.0 percent for the average annual rate of replacement for drinking water pipes, as in CBO's low-cost case, WIN's estimate in costs as financed would have been reduced by $5.4 billion per year (*see Table 2-5*). Thus, that factor alone accounts for more than one-third of the total difference between the estimates from WIN's analysis and CBO's low-cost case. Conversely, the higher costs for abating combined sewer overflows assumed in CBO's high-cost case would have raised WIN's estimate of average annual costs by $2.2 billion. CBO's assumptions about efficiency would also have had significant impacts: the assumed savings of 5 percent to 15 percent would have reduced estimated annual costs by $1.5 billion to $4.6 billion.

Despite some different assumptions, CBO's estimate from its high-cost case is very close to WIN's because savings from a longer borrowing term, on old debt service, and from efficiency are almost entirely offset by larger costs to address combined sewer overflows, to fund to in-

Table 2-5.

Contributions of Individual Assumptions to Differences Between CBO's and WIN's Estimates

(In billions of 2001 dollars per year)

	Low-Cost Case	High-Cost Case
WIN's Estimate (one case)	40.3	40.3
CBO's Estimate	24.6	41.0
Difference to Be Explained (WIN minus CBO)	15.7	-0.7
Capital Factors		
Savings from Increased Efficiency by Drinking Water and Wastewater Systems	4.6	1.5
Drinking Water Systems		
Annual percentage of pipes replaced	5.4	n.a.
Average annual cost for regulations not yet proposed	n.a.	-0.4
Wastewater Systems		
Depreciation rate	0.8	n.a.
Share of investments in EPA's needs survey for replacing existing capital	0.5	-0.6
Average annual cost to control combined sewer overflows	n.a.	-2.2
Total Savings from Capital Factors	11.4	-1.7
Total Capital Savings, Including Interactions	10.4	-1.7
Financing Factors		
Real Interest Rate	n.a.	-2.0
Repayment Period	5.0	3.0
Pay-As-You-Go Share of Total Investment	1.2	-0.6
Average Annual Debt Service on Pre-2000 Investments	0.8	0.8
Total Savings from Financing Factors	7.1	1.3
Total Financing Savings, Including Interactions	7.8	1.1

Source: Congressional Budget Office.

Notes: n.a. = not applicable (when assumptions do not differ from WIN's).

Because of interaction effects, the sum of the dollar impacts from each assumption individually—or from all capital factors and all financing factors—does not equal the overall difference between CBO's and WIN's estimates. For example, the impact of investment efficiencies is smaller when the rate of investment is reduced by lower rates of depreciation and replacement.

Table 2-6.

Estimates of Average Annual Capital Costs for Investment in Water Systems, 2000 to 2019

(In billions of 2001 dollars)

	Drinking Water	Wastewater
CBO[a]	12.0 to 20.5	14.9 to 22.3
Water Infrastructure Network	20.9	19.2
Environmental Protection Agency		
Clean Water Needs Survey[b]		
As published	n.a.	7.3
Adjusted for more recent estimate of costs to control sanitary sewer overflows	n.a.	11.4
Drinking Water Infrastructure Needs Survey[c]		
As published	8.0	n.a.
Adjusted for estimated underreporting	11.1	n.a.
American Water Works Association[d]	8.5	n.a.

Sources: Congressional Budget Office; Environmental Protection Agency, Office of Water, *1996 Clean Water Needs Survey: Report to Congress*, EPA 832-R-97-003 (September 1997); Environmental Protection Agency, Office of Water, *Drinking Water Infrastructure Needs Survey: Second Report to Congress*, EPA 816-R-97-003 (February 2001); American Water Works Association, *Reinvesting in Drinking Water Infrastructure: Dawn of the Replacement Era* (Denver, Colo.: AWWA, May 2001); Water Infrastructure Network, *Clean and Safe Water for the 21st Century: A Renewed National Commitment to Water and Wastewater Infrastructure* (Washington, D.C.: WIN, April 2000).

Note: n.a. = not applicable.

a. Ranges reflect CBO's low-cost and high-cost cases.
b. Estimate for 1996 through 2015.
c. Estimate for 1999 through 2018.
d. Estimate for 2000 through 2029.

vestments in wastewater systems for purposes other than replacing existing infrastructure, and to meet drinking water standards, along with a higher interest rate and larger paygo share. In contrast, CBO's low-cost case differs sharply from WIN's largely because of the replacement rate assumed for drinking water pipes, the assumed savings from efficiency, and the longer borrowing term; other assumptions, such as a smaller paygo share and lower estimate of old debt service, have smaller but still significant effects.

Evidence from the available bottom-up studies—EPA's needs surveys and the American Water Works Association's study of 20 systems—does not support estimates of the magnitude produced by CBO's high-cost case and WIN's analysis. Indeed, estimates from the bottom-up studies are well below those from CBO's low-cost case (when expressed in comparable terms). Specifically, EPA's survey estimated average annual capital (that is, real resource) costs of $8.0 billion for drinking water, and AWWA's study put that figure at $8.5 billion. For wastewater, EPA's figure was $7.3 billion. By comparison, CBO's estimates of real resource costs in the low-cost case are $12.0 billion for drinking water and $14.9 billion for wastewater (*see Table 2-6*). The estimates based on EPA's surveys remain somewhat lower even after (perhaps incomplete) adjustments to better capture investment needs over the full 20-year horizon, which raise the figure for drinking water to $11.1 billion and the figure for wastewater to $11.4 billion.[28]

28. The adjustment for drinking water systems applies the percentage amount of underreporting that EPA found in follow-up visits to 200 medium-sized and large systems after the 1995 needs survey. The adjustment for wastewater systems substitutes EPA's later model-based estimate of costs to address SSOs for the estimates from the survey—specifically, those for projects to prevent inflows and infiltration and to replace or rehabilitate sewers.

For O&M costs, the differences between CBO's and WIN's estimates involve fewer factors. The approach that CBO used in its low-cost case to estimate O&M costs for drinking water systems is essentially the same as WIN's, differing only in extrapolating from 19 years of data instead of 10 and phasing in the assumed 20 percent efficiency savings two years sooner. Those factors account for a minor part of the difference in the two estimates; most appears to reflect differences in data sources.[29] For wastewater systems, one additional difference between CBO's low-cost case and WIN's analysis is that the latter extrapolates the trend in the ratio of O&M to capital stock, not in O&M itself (see the discussion in Appendix A). For both drinking water and wastewater, CBO's high-cost case estimates exceed WIN's because they assume no efficiency savings (beyond those already reflected in the 1980-1999 trend).

Comparing Current Spending and Future Costs

Large future investment costs are relevant to policymakers primarily because of the prospect that they will require large increases above current investment levels and hence large increases in the rates charged to households and other water users. WIN's report, EPA officials, and water industry representatives have referred to the difference between current (or recent) spending and future costs as a "funding gap." But the difference does not reflect the ability of local water systems to generate additional resources on their own to pay for increased future investment, so it does not reflect a gap that can only be filled by federal funds.

CBO estimates that investment spending in 1999 was $11.8 billion for drinking water and $9.8 billion for wastewater (in 2001 dollars). Those figures are estimates because the available data do not measure spending in terms of costs as financed. The most comprehensive data, from the Census Bureau's annual surveys of state and local government finances, show total capital outlays (whether financed through borrowing or paid from funds on hand) for both drinking water and wastewater systems and interest payments for drinking water systems. Thus, the census data do not capture costs as financed because they lack information on interest payments for wastewater systems (which the survey classifies as municipal departments, not utilities) and because they include the capital costs for new financed investments rather than the current principal payments made on past investments.

CBO's estimates of 1999 baseline spending for drinking water and wastewater combined include estimates of spending on new paygo investments and on debt service for earlier investments financed through borrowing. CBO calculated the former as an assumed share of all investments made in 1999; the latter reflects assumptions regarding interest rates and paygo shares from 1979 through 1998.[30] (CBO used the same approach to estimate the future costs of debt service on pre-2000 investments; *see Appendix A* for details.) The resulting estimates are necessarily somewhat uncertain, given the large number of assumptions involved.

Those estimates of 1999 spending imply that future investment costs represent an annual average increase for drinking water and wastewater systems combined of $3.0 billion under the low-cost case and $19.4 billion under the high-cost case (*see Table 2-7*). The former figure represents just 14 percent of the current financial burden of water investments. That result is contrary to the conventional wisdom that the nation's water systems will soon be straining to fund a large increase in investment, but CBO considers it reasonable, given the uncertainty about how soon existing infrastructure will need replace-

29. For example, whereas CBO took the data it used to convert nominal O&M spending to 2001 dollars from the GDP price deflator, WIN appears to have used the *Engineering News-Record*'s Construction Cost Index, which both WIN and CBO used for capital spending.

30. CBO's analysis also involved scaling up the census data on investments in drinking water systems by 15 percent to capture spending on privately owned systems. For lack of information, however, CBO did not adjust the data downward to omit investments to serve future growth. As noted above, growth-related investments are excluded from EPA's needs survey and thus from CBO's estimates of future investment costs; consequently, their inclusion in the census data lends a downward bias to CBO's projections of the difference between current spending and future costs. WIN's analysis of baseline spending made those same choices.

Table 2-7.

Estimates of the Difference Between 1999 Spending and Future Costs for Investments in Water Systems

(In billions of 2001 dollars per year)

	Drinking Water	Wastewater	Total
CBO[a]			
Future costs	11.6 to 20.1	13.0 to 20.9	24.6 to 41.0
1999 spending	11.8	9.8	21.6
Difference	- 0.2 to 8.3	3.2 to 11.1	3.0 to 19.4
WIN (Costs as financed)			
Future costs	21.4	18.9	40.3
1999 spending (Approximate)	12.0	9.7	21.7
Difference	9.4	9.2	18.6

Source: Congressional Budget Office.

Note: The figures for 1999 spending are estimates, reflecting assumptions about debt service payments on investments from earlier years. For the purpose of comparison, CBO recalculated WIN's results in terms of costs as financed and approximated WIN's estimate of 1999 spending.

a. Ranges reflect CBO's low-cost and high-cost cases.

ment, the prospects for increased efficiency, and the potential for water systems to fund more of their investment through borrowing and to borrow for longer terms. In contrast, the $19.4 billion difference estimated under the high-cost case, which CBO considers equally possible, nearly matches the current financial burden of investments in water systems.

Expressed in costs as financed, WIN's results show a difference between 1999 spending and average future costs of $9.4 billion for drinking water and $9.2 billion for wastewater (*see Table 2-7*).[31] Again, the implied estimates from WIN's analysis are close to those from the high-cost case and much larger than those from the low-cost case (while significantly below WIN's published figures, shown in *Box 2-3* on page 19). The main novelty here is that subtracting baseline spending makes the differences between WIN's estimates and CBO's larger in relative terms.

The Impact of Projected Water Costs on Households' Budgets

Ultimately, individuals bear the costs of investments in water systems and expenditures for O&M—directly through households' drinking water and wastewater bills and indirectly through the prices they face for goods and services produced using water and through local, state, and federal taxes supporting water systems. The distribution of costs among individuals depends on their water use, their system's characteristics (including rate structures and external funding), their consumption of water-intensive goods and services, and their tax bills.

Given the availability of data on households' water bills, but not on indirect expenditures on water through taxes and consumption of other goods and services, CBO has analyzed the impact that projected levels of investment and O&M spending would have on households' budgets in the absence of increased support from taxpayers. For simplicity, the analysis assumed that all residential, com-

31. CBO did not obtain enough information to directly calculate WIN's estimate of 1999 debt service, a key component of baseline spending in terms of costs as financed. Instead, CBO approximated WIN's estimate by using a proxy model based on WIN's methods and assumptions. To improve the approximation, CBO adjusted the proxy model's estimate of 1999 debt service in proportion to the difference between WIN's known estimate of average annual debt service from 2000 to 2019 and the corresponding estimate from the proxy model.

Box 2-4.

CBO's Analysis of Household Water Bills

CBO's data come from the quarterly responses of approximately 2,800 households participating in the national Consumer Expenditure Interview Survey, carried out by the Bureau of the Census under contract with the Bureau of Labor Statistics. Households in CBO's sample began their yearlong participation in the survey no earlier than the third quarter of 1997 and no later than the second quarter of 1998. To obtain national-level results, CBO weighted the data to adjust for the fact that not all surveyed households participated for the full course of a year.

Participants report "cash" income from all sources, including food stamps. To guard against an overly conservative estimate of the proportion of household income spent on water bills, CBO incorporated all incomes as reported to the Consumer Expenditure Survey even though 3 percent of households in the sample have an annual income of less than $5,000 and a small fraction have large negative incomes. Some analysts question the reliability of such reported incomes because expenditures by those households often exceed their pretax income.[1]

Participants also report water expenditures on the basis of bills received exclusively for drinking water and sewer services. For the 39 percent of respondents not reporting their own water bills, CBO imputed their expenditures by using the average values of water bills from reporting households in comparable income classes. Those income classes covered $10,000 segments up to $100,000; the last income class consisted of households earning at least $100,000. Again, that imputation errs on the side of overstating the share of household income spent on water since most nonreporting households are probably apartment dwellers who do not receive separate water bills. Water use per capita is generally lower in multifamily units, which, compared with single-family homes, tend to have fewer water-using appliances and to share landscaping and swimming pools.[2]

1. Geoffrey D. Paulin and David L. Ferraro, "Imputing Incomes in the Consumer Expenditure Survey," *Monthly Labor Review*, vol. 117, no. 12 (December 1994), pp. 23-31.

2. Duane D. Baumann, John J. Boland, and W. Michael Haneman, *Urban Water Demand Management and Planning* (New York: McGraw-Hill, Inc., 1998).

mercial, and industrial water customers would face the same percentage increase in their bills, notwithstanding the fact that investment and O&M requirements vary among systems.

CBO's Estimates

CBO estimates that total household water bills represented 0.5 percent of total household income in the late 1990s, when customers paid about $58 billion directly to water systems (*see Box 2-4*). To pay for future infrastructure expenditures and O&M costs without increased support from taxpayers, direct funding from customers in 2019 would have to reach $84.7 billion in the low-cost case and $121.9 billion in the high-cost case, implying average annual rates of increase between 1999 and 2019 of 1.62 percent and 3.48 percent, respectively. Taking into account projected growth in income over that time, water bills in 2019 would equal 0.6 percent of national household income in the low-cost case and 0.9 percent in the high-cost case.[32] The best available data suggest that such shares would not be high compared with those in many other industrialized countries (*see Box 2-5*).

32. The percentages reflect a projected 19.2 percent increase in real household income between the late 1990s and 2019 on the basis of CBO's July 2001 forecast through 2011 for taxable personal income for earners age 20 and over (with married couples counting as one earner) and the Social Security trustees' midrange assumptions for population growth. The simple analysis leaves out several factors, including potential changes in the spread of the income distribution or in the allocation of water costs between household and other users.

Box 2-5.

Water Bills in Various Industrialized Countries

Compared with households in other countries, U.S. households typically enjoy relatively low-cost water bills. Without information on household costs associated with tax-financed subsidies for water systems, international comparisons of drinking water and wastewater costs at the household level are limited to examining bills that users pay for typical quantities of water services. By that measure, U.S. households' water bills as a share of personal financial resources, on average, currently rank third-lowest among those of 16 industrialized countries of the Organization for Economic Cooperation and Development (*see the table*).

By 2019, under the Congressional Budget Office's high-cost case, U.S. households' average costs (as a percentage of per capita gross domestic product) would nearly double if the increases in investment and O&M expenditures were passed along entirely to customers in their water bills. If households' water bills in other countries rose no faster than per capita GDP, the United States' ranking would fall from third- to tenth-lowest. Even with those assumptions, direct billing for water services relative to personal financial resources would still be lower in the United States, on average, than in France or England.

Households' Average Bills for Typical Levels of Water Consumption in OECD Countries in the Late 1990s (Percentage of per capita GDP)

Korea	0.64
Italy	0.72
United States	1.00
Japan	1.04
Turkey	1.32
Belgium	1.44
Sweden	1.48
Spain	1.52
Denmark	1.60
Australia	1.72
Finland	2.16
France	2.20
England and Wales	2.28
Netherlands	2.52
Czech Republic	3.84
Hungary	6.20

Source: Congressional Budget Office based on Organization for Economic Cooperation and Development, Environment Directorate, Environment Policy Committee, *Household Water Pricing in OECD Countries,* ENV/EPOC/GEEI(98)12/FINAL (Paris: OECD, May 1999).

Note: The table reflects the best indicator of households' water bills that CBO can construct, given limitations on international data. It draws on two data sources that incorporate information from different years. The first reports 1996 data on average drinking water charges for a household using 200 cubic meters of water per year relative to per capita GDP; the second reports average drinking water and sewer charges per cubic meter for a year between 1994 and 1999, depending on the most recent data available for each country.

However, shares of income nationwide can obscure important differences among households and thus shed only limited light on the argument, made by advocates of increased federal aid for investment in water systems, that rising costs will make bills unaffordable for some households.[33] Certainly, households at different income levels

33. Other summary measures of water costs consider the share of income spent by individual households. For example, the median share of income spent on water services in the late 1990s was 0.98 percent, meaning that half of all households spent less than that amount and the other half spent more. Another summary measure—the average of the individual household shares—cannot be calculated in a nonarbitrary way because of the very small, zero, and negative incomes reported by some surveyed households (*see Box 2-4*). One arbitrary approach is to cap all shares at some maximum level; with a cap of 10.1 percent, the average household share becomes 1.6 percent. Another way is to ignore the data from all households reporting zero or negative income; under that approach, which accepts all small but positive incomes as accurate, the average share is 4.8 percent.

Table 2-8.

Percentage Shares of Households' Average Expenditures in the Late 1990s, by Category

	Annual Household Expenditures (Thousands of dollars)					
	Under 10	10 to 20	20 to 30	30 to 40	40 to 90	Over 90
Water and Sewer	2.49	1.67	1.27	1.09	0.80	0.56
Other Utilities	10.75	8.62	7.39	6.70	5.24	3.74
Shelter, Household Operations, and Supplies	34.86	35.05	30.63	28.75	26.48	26.68
Food	20.97	17.31	15.50	14.59	12.35	10.13
Health Care	6.70	7.43	5.76	5.52	4.21	3.16
Other Identified Expenditures[a]	24.41	29.33	35.65	37.24	41.68	40.41
Taxes (Nonproperty)	-0.19	0.60	3.80	6.11	9.25	15.33
Total for Identified Expenditures	100	100	100	100	100	100

Source: Congressional Budget Office based on data from Bureau of the Census, Consumer Expenditure Interview Survey, third quarter 1997 through first quarter 1999.

a. Apparel and personal care, transportation, personal insurance and pensions, recreation, entertainment, alcohol, smoking, education and reading, and cash contributions.

devote different proportions of their total spending to water services—as they do to other utilities, food, medical care, and housing. For example, households with total expenditures under $10,000 devoted an average of 2.5 percent to water bills in the late 1990s and thus would generally have to adjust more to accommodate rate increases than would households with expenditures of, say, over $90,000, which devoted an average of just 0.56 percent to water bills (*see Table 2-8*).[34] For comparison, the share of total spending going to everything other than food, housing, medical care, utilities, and taxes averages 22 percent for the former group and 40 percent for the latter.

Of course, the share of a household's income spent on water bills also depends on its water use and local rates. Sorting individual households specifically by the share of income going to water bills, CBO found that in the late 1990s, half of all households spent 1 percent of income or less for water services, while others spent significantly more (*see Figure 2-1*).[35]

Distributions such as those CBO found can be characterized in many ways, emphasizing different features. One measure that has received significant attention is the fraction of households billed more than 4 percent of income for their water services—but that is simply one of many potential summary measures. Four percent has no particular economic significance as the point at which households' water bills become "unaffordable." (For the origin of the 4 percent measure, *see Appendix C*.)

34. To avoid the problems associated with the very low and negative income reported by some households in the survey, *Table 2-8* compares spending in each category not to income but to total spending. For households that are net savers, water bills represent a larger share of spending than of income; for households that are net borrowers, the opposite is true.

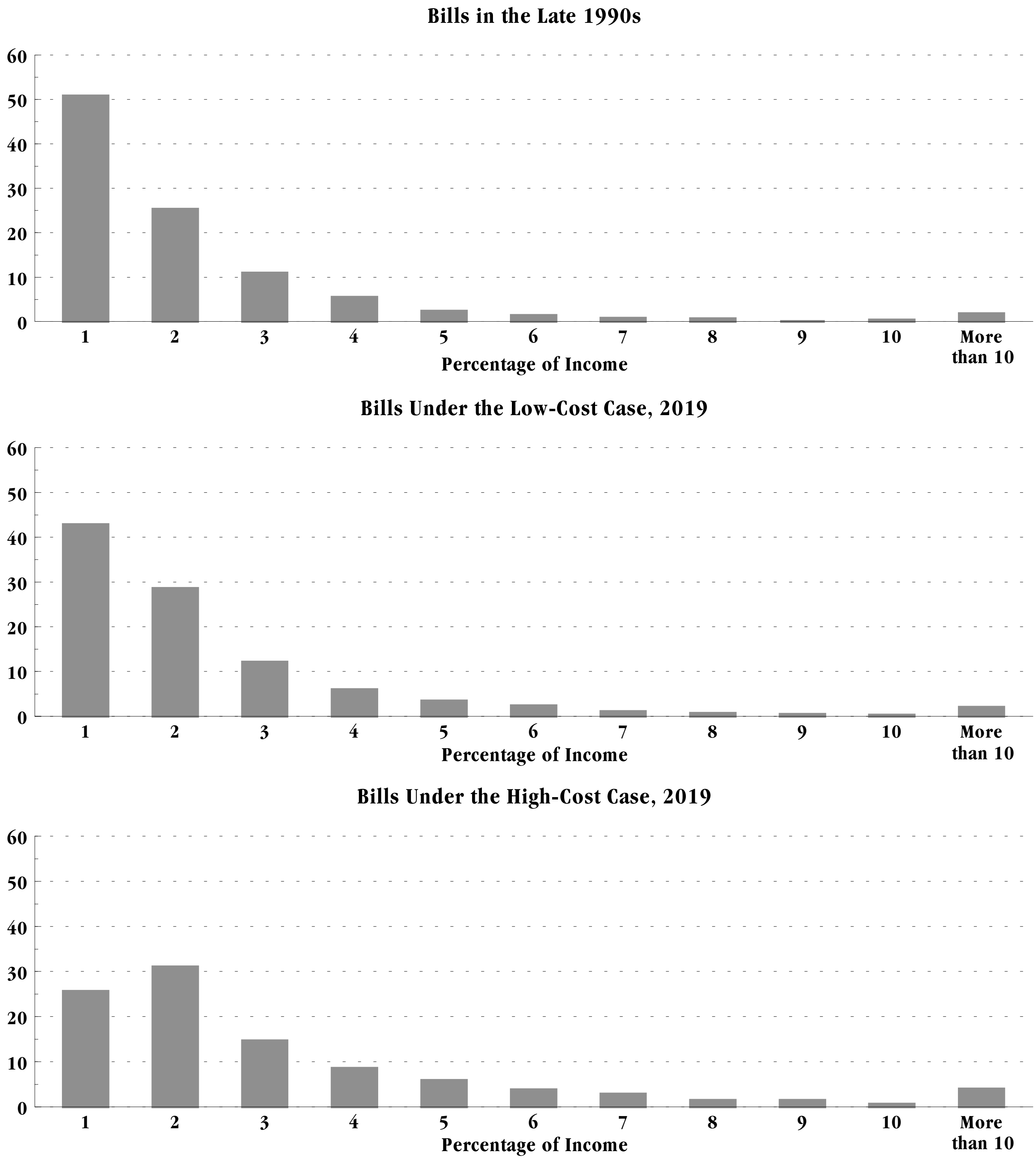
Households' adjustments to higher rates would reflect not only their income and expenditures but also their potential for reducing water use. A 1984 assessment of 50 peer-reviewed studies concluded that a 10 percent increase in price, with everything else unchanged, would prompt a 2 percent to 4 percent decline in residential water demand. John J. Boland, Benedykt Dziegielewski, Duane D. Baumann, and Eva M. Opitz, *Influence of Price and Rate Structures on Municipal and Industrial Water Use*, Institute for Water Resources Report 84-C-2 (Fort Belvoir, Va.: U.S. Army Corps of Engineers, 1984).

35. The figure treats households that reported zero or negative income as spending more than 10 percent of their income for water.

Figure 2-1.

Water Bills as a Share of Household Income

(Percentage of U.S. households)



Source: Congressional Budget Office.

However, using that particular measure, CBO estimates that in the late 1990s, 7 percent of U.S. households spent more than 4 percent of their income on water; an additional 16 percent spent more than 2 percent. Twenty-five percent spent less than 2 percent but more than 1 percent, and 51 percent spent no more than 1 percent.[36] The distribution in the late 1990s represents a modest shift from the late 1980s, when only 4.7 percent of U.S. households were spending over 4 percent of their income on water bills. In 2019, given uniform increases in charges associated with CBO's low-cost and high-cost estimates, 10 percent to 20 percent of U.S. households might be spending more than 4 percent of their income on bills for the services they now use; an additional 19 percent to 23 percent might be spending more than 2 percent.

Comparing CBO's and WIN's Estimates

Compared with CBO, WIN found water bills accounting for a much larger share of household budgets, both now and in the future. The coalition's estimate that 18 percent of U.S. households spent more than 4 percent of their income on water bills in 1997 is more than twice as high as CBO's estimate of 7 percent. WIN projected that 22 percent of households would spend over 4 percent of their income on water bills by 2009 (halfway through the 2000 to 2019 study period) and stated that a third or more of the population would have bills reaching that level as costs continued to rise.[37]

The discrepancy between CBO's estimate for the late 1990s and WIN's for 1997 apparently exists because WIN did not analyze actual bills based on water use by individual households as CBO did. Instead, WIN calculated households' water bills using data on Ohio systems' 1997 charges for the equivalent of 250 gallons per day.[38] (The other possibility would be that WIN's estimates of household income were lower than CBO's, but comparing average income by percentile across WIN's and CBO's data sources suggests that household income was higher in WIN's analysis.) The accuracy of WIN's results rests on the extent to which households' water bills nationally can be characterized using only data on charges for consumption of 250 gallons per day in Ohio. If, for example, low-income households tend to use less water than that, then, other things being equal, WIN's estimates overstate the number of households with water bills claiming more than 4 percent of their income.[39]

36. The distribution appears to be similar for urban and rural areas. For example, CBO estimates that 7 percent of urban households and 8 percent of rural households were paying more than 4 percent of their income for water bills. However, the urban-rural comparison is hampered by the large share (47 percent) of rural households that did not report water bills. Since CBO imputed spending for nonreporters using average bills of all rural and urban households with similar income, estimated bills for rural households may be too low if actual bills for rural nonreporters exceeded the imputed averages. Alternatively, estimated bills for rural households may be too high if the imputed costs exceeded the actual costs—if, for example, many of the rural nonreporters used private wells and septic tanks.

37. Water Infrastructure Network, *Clean and Safe Water for the 21st Century*, pp. 3-4 and 3-5.

38. Although WIN's *Clean and Safe Water for the 21st Century* report states that its analysis is based on "individual fees (not average)," it is actually based on the 1997 rates that Ohio households would have faced if they used the equivalent of 250 gallons per day, according to Ken Rubin of PA Consulting.

39. WIN considered Ohio households' expenditures for drinking water and wastewater services (relative to income) as representative of such expenses nationwide because in the 1990 census such data on spending for drinking water in that state matched well with the information for the United States as a whole. (The 1990 census data do not include wastewater expenditures.)

CHAPTER

3

Options for Federal Policy

Federal intervention in drinking water and wastewater markets may be designed to serve various purposes, such as protecting the environment or ensuring that drinking water meets certain standards everywhere in the country. All such policy objectives can be viewed as efforts to increase the cost-effectiveness of providing and using water or to achieve a certain distribution of the benefits and costs.

Economic principles suggest that federal action may be able to increase cost-effectiveness when other entities do not have adequate incentives to account for the extrajurisdictional, or "spillover," effects that their decisions have on third parties. For example, standards for wastewater treatment may improve cost-effectiveness by reducing costs to downstream users by more than the costs of treatment. However, whether current standards established under the Clean Water and Safe Drinking Water Acts are consistent with the economically efficient use of society's resources is an important question that is outside the scope of this study.

A main opportunity for federal involvement that may improve cost-effectiveness is sponsoring research and development (R&D). Private firms and state governments that may fund R&D for water systems have little incentive to consider the spillover benefits that would accrue to other parties and thus are likely to forgo some research opportunities that would be worthwhile from the national perspective.[1]

Federal intervention in water markets can also be intended to serve distributional purposes—to shift costs from people who have low income, use a lot of water, or are served by high-cost systems to people who have high income, use relatively little water, or are served by low-cost systems. The drawback of such interventions through federal funding and tax preferences, however, is that they generally distort prices and thereby undermine incentives for cost-effective actions by producers and consumers of water services. Eliminating the distortions could lower total national costs: without federal support, the prospect of rising costs and accountability to ratepayers would give managers of water systems strong incentives to look for ways to control costs in both their operational and investment choices. Similarly, the increased rates themselves, better reflecting the true costs of water services, would tend to encourage water users to adjust their behavior—for example, to use less water or to pretreat industrial wastewater—in order to cut costs.

Both the distributional effects of subsidies for water services and the extent of their adverse impact on incentives for cost-effective actions depend on the subsidies' level and form. To preserve incentives for cost-effective actions by water systems and users, the Congress could pursue policies that redistribute income—such as aid to water systems based on a predetermined formula not tied to current investments or direct subsidies to needy households for a basic level of water use—rather than policies that distort the price of water, such as the present subsidies for investment in infrastructure.

1. See Congressional Budget Office, "Investing in Physical Capital and Information," in *Budget Options* (February 2001). Even broad-based coalitions may not be able to support the appropriate level of research through coordinated voluntary contributions.

Federal Support for Research and Development and Its Implications

Technical R&D into new pipe materials, construction and maintenance methods, and treatment technologies can lead to significant savings. One of the many successful innovations that could be cited here is pipe bursting, a method for replacing pipes that does not require trenches to be cut along the entire length of the replacement. Instead, using a single access point, the construction crew sends equipment into a section of pipe to burst it from within and feeds a flexible new pipe in to take its place. By using pipe bursting, the drinking water system in Columbus, Georgia, reduced its costs for replacing water mains by an estimated 25 percent.[2] A less tested but promising technology for wastewater treatment, supercritical water oxidation, could achieve superior environmental results and reduce operating costs by one-third, according to one study. Capital costs could be somewhat higher than those for existing technologies but might fall as the method is further developed or used at larger scales.[3]

Despite the potential for technological progress to provide cost savings, the level of R&D spending on drinking water and wastewater currently seems low compared with that for electrical power according to the limited data available. The combined budgets of the American Water Works Association Research Foundation (AWWARF) and the Water Environment Research Foundation (WERF), the main research organizations for the drinking water and wastewater industries, are on the order of $25 million per year. That amount represents roughly 0.05 percent of current spending for investment in water systems and their operations and maintenance. In contrast, spending in 2000 by the Electric Power Research Institute was 0.14 percent of total electricity sales (which roughly corresponds to spending on investment and O&M). The Environmental Protection Agency funded an additional $7 million of R&D in 2002, excluding grants to AWWARF and WERF.[4]

To try to speed the development and adoption of less costly materials and methods, the federal government could increase its financial support of technical R&D. The increase could take the form of additional research projects managed by EPA, larger federal grants to private organizations such as AWWARF and WERF, or both. One specific proposal, advanced by the Water Infrastructure Network coalition, calls for federal funding of $250 million per year for a new Institute of Technology and Management Excellence.[5] As the name suggests, that institute would support not only technical R&D but also the dissemination of good management practices.

While additional federal funding for R&D may have the potential to lower total national costs for water services, in practice it may be difficult to determine an appropriate increase, since the line between a useful response to a market failure and a wasteful subsidy is not always clear. Federal funding may be subject to various influences not related to the cost-effective provision of water services and may allow others to reduce their own research funding. Thus, a compelling case for increased appropriations for water research cannot rest at the theoretical level but must include the details of the proposed uses of the additional funds and the capabilities of other funders.

In many cases, the key to improving the cost-effectiveness of a particular drinking water or wastewater system may lie not in developing new technologies but in improving the way system managers deploy existing and emerging technologies. Notwithstanding important differences in local conditions that are beyond managerial control, it is clear that some systems operate less efficiently than others, whether because of ignorance, system-level problems (such

2. Steve Allbee, Environmental Protection Agency, "The Infrastructure Investment Gap Facing Drinking Water and Wastewater Systems" (speech to the Association of Metropolitan Water Agencies, St. Pete Beach, Fla., October 24, 2000).

3. "New Wastewater Treatment Good for the Environment," *WaterTechOnline*, October 9, 2001, available at www.watertechonline.com/news.asp?mode=4&N_ID=26205.

4. Personal communication with Terry Grindstaff, EPA, September 27, 2002. The figure includes $6.2 million for research on drinking water treatment and $0.7 million on wastewater treatment.

5. Water Infrastructure Network, *Water Infrastructure Now: Recommendations for Clean and Safe Water in the 21st Century* (undated), available at www.win-water.org, p. 12.

as poor leadership, featherbedding, or operation on a small scale), or simply a lack of concern over current water costs. As noted in Chapter 2, according to recent assessments of 136 systems, the industry is becoming more efficient but still could reduce operating costs by an average of 18 percent through more widespread use of "best practices."[6]

Of course, rising costs for investment and O&M can be expected to motivate system managers to acquire knowledge and overcome local constraints in order to reduce the pressure for higher rates. So whether federal support for the dissemination of information on best practices could further improve systems' efficiency is unclear.

Federal Support for Infrastructure Investment and Its Implications

Through different spending programs, including the state revolving funds, federal funds paid for about 11 percent of the nationwide investment in water infrastructure in 1999, and federal tax preferences provided a subsidy equivalent to perhaps 3 percent more. Again, Congressional action to increase such support would affect both the national costs for water services and the distribution of those costs, but the specific effects would depend on choices about the amount of the increase, the degree of targeting to particular categories of water systems, and the mechanisms used to provide the support. Similarly, the effects of cutting back federal assistance would depend on the details of the cuts.

Current Federal Support for Water Systems

As noted in Chapter 1, the federal government supports investment in water infrastructure through a variety of spending programs and, to a lesser extent, through tax preferences. Small and disadvantaged communities benefit disproportionately from the spending, through either explicit targeting at the federal level or states' allocations of loans from the revolving funds. In contrast, larger communities (which can access the municipal bond market more easily) are the primary beneficiaries of the tax preferences. Privately owned water systems have less access to federal support than their publicly owned counterparts do (*see Box 3-1*).

Federal tax law aids investment in water systems primarily through the general exemption of interest on municipal bonds, which makes the bonds more attractive to buyers and thus reduces the interest rates that water systems must offer. The exemption applies to personal and corporate income taxes but not to the alternative minimum tax (AMT) for corporations; firms that pay the AMT must include interest on the bonds in calculating their "adjusted current earnings," which effectively makes 75 percent of the interest subject to that tax. Two other provisions of the federal tax code related to municipal bonds also help water systems: bond issuers can keep some arbitrage profits (made by reinvesting bond proceeds at a higher interest rate) and can refinance the bonds up to 90 days before redeeming the original debt.[7] The Joint Committee on Taxation estimated that the interest exemption and related provisions saved bondholders $0.6 billion in 1999 on bonds issued for both municipal and privately owned water systems and hazardous waste facilities.[8] That figure, including the unknown but relatively small share associated with hazardous waste facilities, corresponds to roughly 3 percent of the investment in water systems in 1999, the latest year for which data are available.

Federal spending programs support water infrastructure in several ways, including direct grants for investment projects, capitalization grants to the SRFs, and credit subsidies in the form of loans and loan guarantees. On the

6. Personal communication with Alan Manning, EMA Associates.

7. To keep any arbitrage profits, systems must spend the bond proceeds within four phased deadlines over two years. Also, they can use the "advance refunding" option only once for each original bond issue.

8. Joint Committee on Taxation, *Estimates of Federal Tax Expenditures for Fiscal Years 1999-2003*, staff report JCS-7-98 (December 14, 1998), p. 16. This figure covers bonds backed by water systems' revenues but not municipal "general obligation" bonds. Note that the committee's estimate of the "expenditure" associated with a tax preference is somewhat larger than the corresponding estimate of the increased federal revenue associated with eliminating it: the former takes the existing level of the taxed activity as given and thus does not reflect behavioral adjustments that taxpayers would make if the preference was changed.

Box 3-1.

Federal Support of Privately Owned Water Systems

The large majority of households are served by publicly owned, or municipal, drinking water and wastewater systems. Although nearly half of all community drinking water systems are privately owned, they reach only about 15 percent of the households served. Roughly 20 percent of wastewater systems that treat household sewage are privately owned, but they serve only about 3 percent of households.[1] Various federal and state restrictions limit private systems' access to federal aid provided through the state revolving fund (SRF) programs and to federal tax preferences.

Private wastewater systems are not eligible for loans from SRFs, and although private drinking water systems are eligible under federal law, they may be blocked by provisions in some states' constitutions. In other states, private systems' access to SRF loans can be inhibited simply because the states leverage their SRF money. If enough of the proceeds from bonds issued to leverage SRF money are used to make loans to private systems, the bonds are considered private activity bonds (PABs), which are subject to several restrictions.[2]

The most important of those restrictions is the cap on each state's annual volume of tax-exempt PABs. Federal tax law sets the limits at the greater of $75 per resident of the state or $225 million in calendar year 2002, after which those figures will be indexed for inflation. To date, the limits have restrained the issuance of PABs in most states.[3] And within those limits, water systems' needs compete for allocations against many other purposes, such as housing, industrial development, student loans, mass commuting facilities, and local electricity and gas facilities. Indeed, all "exempt facilities"—the subset of eligible facilities or purposes that includes water infrastructure—accounted for less than 10 percent of PABs in 1999.

Even when private water systems are allocated a share of a state's PABs, three other provisions of federal tax law raise their financing costs relative to those of municipal systems. First, interest on PABs remains subject to the alternative minimum tax (AMT) for both corporations and individuals, which reduces the demand for such bonds by potential investors who pay the AMT and thus raises the interest rate that issuers must offer.[4] (As discussed in the body of this report, interest on municipal bonds can be partially taxed under the corporate AMT.) Second, privately owned systems must spend bond proceeds within six months, whereas public systems have four phased deadlines that allow spending to occur over two years. The shorter spendout period reduces the time during which private systems can earn "arbitrage profits" by investing bond proceeds at rates above the bond's own yield and may also force them to incur higher transaction costs for a phased series of smaller bond issues. Third, private systems have somewhat less flexibility in refinancing bonds to take advantage of favorable interest rates: PABs cannot be refinanced with new tax-exempt bonds unless the proceeds are used immediately to retire the original debt,

1. The estimate of 3 percent is commonly cited within the industry, but precise data on the households served by private wastewater systems are not readily available.

2. See Environmental Protection Agency, Environmental Financial Advisory Board, *Funding Privately Owned Water Providers Through the Safe Drinking Water Act State Revolving Fund* (July 1998). Private activity bonds are those for which 10 percent or more of the proceeds are used directly or indirectly by a nongovernmental entity and 10 percent or more are secured directly or indirectly by property used in a trade or business. Formally, the definition applies to both taxable and tax-exempt bonds; typically, however, the term "private activity bond" is used to refer to the latter.

3. States may carry forward allowances under the cap for designated projects for three years. Frequently, a state that appears to have not issued PABs up to its limit in a given year will actually be using that option to save allowances for a large project or to wait for more favorable market conditions.

4. The impact on PAB rates is estimated to be 15 to 25 basis points (that is, 0.15 to 0.25 percentage points). See Environmental Protection Agency, Environmental Financial Advisory Board, *Funding Privately Owned Water Providers.*

Box 3-1.

Continued

whereas governmental bonds can be "advance refunded" once, up to 90 days before redemption of the original debt.

The Congress could eliminate most of those provisions that place privately owned systems at a disadvantage relative to municipal systems—the exception being obstacles in states' constitutions that disallow aid from SRFs.[5] For example, it could amend the Clean Water Act to allow SRF loans to private wastewater systems. It could also reclassify bonds for projects that served public needs for water services as governmental bonds rather than PABs (thus sidestepping all of the differences in tax treatment), or it could partially or fully exempt bonds for water systems from the annual caps on PABs. There is no precedent for such tax treatment of privately owned utilities, however. PABs for airports, docks, wharves, solid-waste facilities, and environmental enhancements of hydroelectric generating facilities are exempt from the volume caps, as is 75 percent of the value of PABs for high-speed intercity rail facilities, but only if the facilities are publicly owned, with private parties restricted to serving as operators or lessees.[6]

A commonly heard argument for equalizing both the access to funding and the tax treatment of private and municipal water systems is that water users should not be denied the benefits of federal aid simply because their service comes from a privately owned system. Opponents of aid to private systems sometimes argue that the government should not support private profits; however, state regulation of rates charged by private utility monopolies such as water systems constrains profits and can ensure that most of the gains from federal aid flow to customers.[7]

The overall cost impact of treating publicly and privately owned systems equally is not clear. On the one hand, equal treatment could be beneficial to the extent that private ownership reduces investment or operating costs in at least some cases and that local decisionmakers can generally identify the efficient arrangements. On the other hand, equalizing the treatment would in all likelihood mean increasing federal aid to private systems rather than reducing aid to public systems; thus, as with the options to increase aid to water systems in general, it could contribute to higher total national costs by distorting water companies' own choices—such as choices between equity and bond financing and between investment and maintenance.

One final argument sometimes made for equalizing treatment—or more broadly, for encouraging or reducing barriers to direct private investment in water systems—is that the private sector can tap large additional sources of funding for infrastructure needs. That argument is flawed, however, since the funds for both publicly and privately owned systems ultimately come from the ratepayers (and perhaps taxpayers). A more compelling version of the argument is that private owners may have access to cheaper financing in some cases.

5. Of course, the Congress could give states incentives to amend their constitutions. One proposal for doing so calls for modifying the calculation of each state's share of the annual federal appropriations for drinking water SRFs, which reflect the findings of the Environmental Protection Agency's needs survey, to exclude the needs for privately owned systems in states that do not make loans to such systems.

6. Moreover, the contract or lease for such a facility is subject to several restrictions: it must not allow the private operator to claim depreciation or investment tax credits, extend beyond 80 percent of the useful life of the assets financed by the bonds, or allow assets to be sold to the operator for less than fair market value; and compensation to the operator must be primarily in the form of a fixed periodic payment. Also excluded from the volume cap on PABs are bonds for veterans' mortgages and for certain nonprofit organizations. Bonds for public educational facilities have their own cap, equal to the greater of $10 per person or $5 million.

7. Small water systems, such as those owned by small housing developments, homeowners' associations, resorts, summer camps, and trailer parks, are not always subject to rate regulation. Even when not regulated, however, many such systems are likely to pass the benefits of federal support on to water users, whether because of their ownership structure (in the case of homeowners' associations) or because of market competition on overall rates (in cases such as camps and trailer parks).

basis of a mix of data on appropriations, obligations, and outlays, the General Accounting Office reported that federal support in 2000 included $1.5 billion in project grants, nearly $2.2 billion in SRF grants, and $780 million in the face value of loans and loan guarantees from the Department of Agriculture (USDA).[9] Of course, SRF grants do not flow directly to water systems but rather to state pools from which loans are made, and only a small portion of the face value of loans and loan guarantees represents a subsidy to the recipient water systems. Taking into account the actual volume of SRF loans, the average interest rates charged in the SRF program and USDA's program, and the market-based rates that borrowers would otherwise have to pay, the Congressional Budget Office estimates that federal and federally supported spending provided a subsidy equivalent to 10.8 percent of the total investment in drinking water and wastewater systems in 1999.[10]

Some federal spending on water infrastructure is targeted to particular categories of systems. The drinking water SRF program allows states to use up to 30 percent of their capitalization grants to subsidize the loans to systems serving disadvantaged communities, as defined by state affordability criteria, and requires states to give at least 15 percent of the loan dollars to systems serving no more than 10,000 people, if enough eligible projects are available. Through 2000, systems of that size had received 39 percent of the loan funds (and 74 percent of the loans).[11] USDA's program exclusively aids communities of no more than 10,000 people. Under that program, communities with a lower median household income receive loans carrying lower interest rates; eligibility for grant assistance is restricted to projects that would otherwise exceed an affordability guideline.[12] Various smaller federal programs target aid on the basis of location (as with grants from the Appalachian Regional Commission), local economic distress (for example, the Public Works Program of the Commerce Department), or other factors.

In contrast, neither the clean water SRF program nor the federal tax preferences draw formal distinctions between small and large water systems. Nonetheless, a November 2000 report noted that states had given wastewater systems serving up to 10,000 people 23 percent of the money loaned under the SRF program (and 58 percent of the loans) since 1990, whereas systems of that size accounted for 11 percent of the 20-year needs documented in EPA's 1996 survey.[13] Conversely, because many small communities have no credit rating and cannot issue their own bonds, drinking water and wastewater systems owned by such communities cannot directly take advantage of the tax preferences; instead, they benefit indirectly to the extent that they receive assistance from a state revolving fund or other pooling mechanism that taps the bond market.

General Implications of Federal Investment Support for Water Systems

Federal investment support for water systems can have unintended consequences, such as a reduction in comparable spending by state or local governments. Evidence from

9. General Accounting Office, *Water Infrastructure: Information on Federal and State Financial Assistance*, GAO-02-134 (November 2001). The figures are in 2000 dollars.

10. This calculation of the value of the subsidy received by water systems is partly analogous to the calculation of the subsidy value under the Federal Credit Reform Act of 1990 for the purpose of determining the impact on the federal budget. The latter would use the federal government's borrowing rate (instead of the market rate) and make allowances for default risk. (Neither calculation reflects any illiquidity or undiversifiability associated with the debt.)

11. Mary Tiemann, *Safe Drinking Water Act: State Revolving Fund Program*, CRS Short Report for Congress 97-677 (Congressional Research Service, updated January 10, 2002).

12. Subject to additional eligibility requirements, projects may receive grant funding if the ratio of the median household income (MHI) in the service area to the statewide median for nonmetropolitan areas is no greater than 80 percent and the project's debt service per household would exceed 0.5 percent of the local MHI or if the ratio is between 80 percent and 100 percent and the debt service would exceed 1.0 percent of the local MHI. Because that guideline focuses on the debt service associated with an individual project rather than local costs in total—and on MHI rather than individual household income—it sheds little light on the question, discussed in *Appendix C*, of the fraction of income above which water bills might be considered unaffordable.

13. Claudia Copeland, *Rural Water Supply and Sewer Systems: Background Information*, CRS Report for Congress 98-64 ENR (Congressional Research Service, November 30, 2000).

the federal wastewater construction grants program under the Clean Water Act suggests that large increases in federal aid can lead to significant displacement. Between 1970 and 1980, federal support for wastewater plants rose by $8.2 billion, but state and local funding fell by $1.9 billion, effectively negating about one-quarter of the federal increase. A more detailed analysis, taking into account factors that might otherwise have led to increased state and local investment, concluded that federal construction grants reduced other capital spending by 67 cents on the dollar.[14] The exact relationship between federal funding and displacement of spending by state and local governments is not known; for instance, displacement per dollar could be smaller at lower levels of federal involvement. But to the extent that state and local governments cut their funding for water systems, federal support intended for water infrastructure benefits state and local taxpayers instead through increased spending on other services or through lower nonfederal taxes.

A second unintended consequence of federal aid for investment projects is that it distorts price signals for system managers—and thus affects their decisions about such things as preventive maintenance, construction methods, treatment technology, pipe materials, and excess capacity —and for ratepayers, affecting their decisions about usage. The overall effect is to undermine the cost-effective provision and use of water services. Evidence from a 1985 CBO study of wastewater treatment plants indicates that the effects can be significant, at least at high levels of subsidization. Case studies of four plants, financed with various levels of governmental assistance, showed that higher subsidies led to the selection of more costly treatment technologies, the construction of significant reserve capacity, and longer construction periods.[15]

In that same study, a statistical analysis of cost data on 68 plants indicated that reducing the nonlocal share of investment funding from 75 percent to 55 percent, as occurred in 1985 under the construction grant program, would reduce capital costs by an average of roughly 30 percent. That estimate implies that the federal burden for the same number of projects would be almost twice as high at 75 percent support as at 55 percent, with more than four-fifths of the difference going to cover higher costs and less than one-fifth going to reduce the burden on local systems.[16] Thus, at least for wastewater treatment plants, high levels of subsidization appear to be a very inefficient way to reduce local investment costs.

The study was less able to quantify the effects that lower subsidy levels would have on cost-effectiveness. It is plausible that the impact of an additional dollar of federal aid depends on the base level of subsidy—for example, that raising the subsidy from 5 percent to 10 percent, with recipient systems still bearing 90 percent of capital costs, would lead to a smaller increase in costs than raising it from 50 percent to 55 percent would. But efforts to map the relationship between external support and project costs in more detail were inconclusive, in part because of the small data set.

One way to reduce the distortions associated with federal aid to water systems, of course, would be to reduce the aid itself. Doing so would encourage system managers to find greater efficiencies in their investment and operations and prompt ratepayers to reduce low-priority uses. Consequently, total nationwide costs for water services would be lower than they would if federal support remained steady or increased. But despite the savings, total costs would probably still rise, given the projected increases in replacement and new investment—and a larger share of those total costs would be paid more visibly through water bills, rather than taxes. Opponents of cutting federal aid for water infrastructure also argue that national funding

14. James Jondrow and Robert A. Levy, "The Displacement of Local Spending for Pollution Control by Federal Construction Grants," *American Economic Review*, vol. 74, no. 2 (May 1984), pp. 174-178.

15. Congressional Budget Office, *Efficient Investments in Wastewater Treatment Plants* (June 1985), pp. xi-xii. According to some analysts, another factor responsible for raising costs in the construction grant program was the industry's inability to design and build treatment plants rapidly enough to accommodate the sudden, large infusion of additional federal dollars.

16. For example, a treatment plant that cost $10 million to build with a 75 percent federal subsidy would have a federal share of $7.5 million and a local share of $2.5 million, while a plant that cost 30 percent less and had a 55 percent subsidy would entail federal costs of $3.85 million and local costs of $3.15 million. So the higher subsidy rate raises federal spending by $3.65 million but reduces local spending by only $0.65 million.

should continue to help local systems pay for the costs of meeting water quality standards set or directed by the federal government.

Another way to reduce the distortions would be to deliver the aid to water systems differently—according to some formula that does not involve systems' current investments or activities and thus does not distort the marginal costs seen by system managers. Such a formula could include factors related to systems' size (such as miles of pipes and investment spending over some fixed historical period), investment needs (for example, average age of pipes and treatment plants), and local financial capacity (such as the population and average income of the service area). By leaving marginal costs largely untouched, formula-based aid reflecting such independent factors would redistribute revenue to water services without undermining managers' incentives for cost-effective choices, at least in the short run.[17] However, it would not address the issue of federal support displacing funding from state and local governments.

Targeting Investment Aid for Water Systems

Still another way to limit the negative incentives of increased federal support for water systems is to target the aid. All things being equal, the fewer systems eligible for aid, the smaller the undesired consequences. Aid could be given to systems facing high costs (relative to the population served or relative to the aggregate income of the population served) for investment (or investment and O&M) in general or for narrower categories of costs, such as those to comply with federal regulations or to maintain or replace investments "stranded" by shifts in population. But defining the target group in a way that does not reward systems for poor management and low spending in the past, and does not encourage such laxness in systems hoping to qualify for aid in the future, could be difficult.

Implementation would be another challenge. One of the two main choices would be to establish a formula to determine the amount of aid to be given to a system with certain characteristics; the other would be to specify general criteria and then have systems submit funding applications that would be judged against the criteria, allowing a system to present whatever information supports its case. On the one hand, case-by-case review avoids the use of rough proxies and arbitrary thresholds and could allow for aid to systems with ongoing weaknesses to be tied to specific requirements for improvement. On the other hand, the administrative costs of preparing and evaluating the applications would be higher, and the lower predictability would give more systems reason to defer investing on their own in hopes of gaining outside funding.

Advocates of maintaining or increasing the current targeting of small systems in any expansion of federal aid point to a backlog of requests for USDA's assistance and high projected per capita investment costs, at least for drinking water systems.[18] Some opponents argue that the states' emphasis on small systems in allocating SRF money makes additional federal targeting unnecessary. Moreover, it could be ineffective: increasing the statutory targeting within the SRF programs would merely codify what many states are already doing, and providing increased support through other programs (such as USDA's program) might lead states to readjust their SRF portfolios to maintain the current distribution of aid between small and large systems. Some opponents also question whether current programs do enough to ensure that small systems do not remain dependent on external funding indefinitely.

Grants, Credit Subsidies, and Tax Preferences

As noted earlier, subsidies to investments in water systems may be delivered through spending on grants or credit

17. Some factors included in an aid formula could be influenced by the choices of system managers over a longer period of time. For example, the level of investment activity in a system would affect the average age of its infrastructure. Even in that case, however, the incentives to invest would be only modestly distorted if the formula reflected not the current average age of infrastructure but, say, the average age five years earlier.

18. In January 2000, USDA reported a backlog of $3.3 billion in requests for water loans and grants. EPA's latest survey of drinking water needs reported that 20-year needs per household averaged $3,000 in systems serving up to 3,300 people, nearly four times the $790 average for large systems (those serving more than 50,000 people). Similarly, for wastewater, EPA has stated that the smallest systems lack economies of scale and are likely to face the largest percentage increases in user charges and fees; however, results from the 1996 *Clean Water Needs Survey* found that small systems accounted for 11 percent of both needs and population, implying equal costs per capita.

subsidies (such as loans with subsidized interest rates, loan guarantees, and bond insurance) and through tax preferences. Despite the seeming diversity, each of those approaches serves to reduce investment costs to the water system, and for a given reduction in the cost of a particular project, each is likely to have the same impact on the recipient. For example, a 10 percent reduction in the local cost of a $12 million treatment plant that would otherwise be financed by 30-year bonds paying 5 percent interest could be accomplished by providing a grant of $1.2 million, a loan for the full cost of the project at 4.1 percent interest, or bond insurance or tax preferences that reduced the bond interest rate to that same 4.1 percent.

But some levels and patterns of federal subsidy may not be easily attained through all of the mechanisms. For example, providing large increases in aid to publicly owned water systems through tax policy alone would be difficult, given that such systems and the interest paid on municipal bonds are generally exempt from federal taxes already. (Significantly increasing the tax preferences available to privately owned systems would be easier; *see Box 3-1.*) Where tax preferences and spending programs are viable alternatives to achieve the desired level and pattern of support to water systems, the two can be contrasted in several ways. One argument in favor of tax preferences is that they provide more year-to-year stability, which can facilitate planning by system managers. However, spending programs are more readily reviewed and adjusted by the Congress. And changing the tax rules to benefit water systems alone could raise questions about the treatment of other users of municipal bonds while adding complexity to the tax code and increasing administrative costs.

Federal spending programs also differ from tax preferences in that they make it easier for the Congress to specify detailed conditions under which the aid is to occur. Such conditions can have both positive and negative effects on cost-effectiveness. In some cases, incentives or requirements associated with federal funds—"carrots and sticks"—may prompt recipients to take cost-effective actions that they would not otherwise. But conditions on spending that are truly beneficial may be rare: broad, general provisions may have little impact, and specific, detailed conditions may be cost-effective for some systems but not for others. Currently, one prominent stick is the requirement that drinking water systems receiving SRF assistance demonstrate the technical, managerial, and financial capacity to comply with the Safe Drinking Water Act over the long term. In keeping with that requirement, some states give priority to SRF loans that address capacity problems by consolidating two or more systems.[19] Various additional carrots and sticks have been proposed, such as giving priority to systems that adhere to certain best practices or to states that have or adopt laws allowing water treatment plants to be designed and built using integrated contracts (discussed earlier in *Box 2-3* on page 19).

More generally, however, restrictions on the use of federal dollars can reduce cost-effectiveness by limiting the recipients' flexibility in addressing their goals for water services. To increase such flexibility, the Congress could reduce the amount of money earmarked for special-purpose projects and provide those funds to the SRFs instead. Also, the SRFs themselves could be made more flexible by eliminating floors and ceilings on funding for eligible activities in the drinking water program, allowing states to transfer more of their grant money between the drinking water and the wastewater SRFs, and broadening the range of uses—as in a proposal from EPA's Environmental Financial Advisory Board to combine the existing SRFs into environmental state revolving funds (ESRFs).[20] Designed to address a broad set of issues affecting water quality, the ESRFs could fund a wider range of projects to control nonpoint source pollution (particularly projects on private property) and contamination problems associated with landfills, "brownfields," and air pollution.[21]

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19. Environmental Protection Agency, Office of Water, *The Drinking Water State Revolving Fund: Financing America's Drinking Water,* EPA-816-R-00-023 (November 2000), p. 7.

20. Under current law, states may shift up to one-third of each year's drinking water SRF grant to the clean water program or an equal amount in the other direction. For the proposal to create ESRFs, see Environmental Protection Agency, Environmental Financial Advisory Board, *Environmental State Revolving Funds: Developing a Model to Expand the Scope of the SRF* (June 2001).

21. Of course, allowing greater flexibility in the use of SRF money might be said to dilute the original Congressional intent to support infrastructure, and some of the gains expected from broadening the SRF programs may not materialize if the state agencies administering the funds lack the technical expertise to accurately evaluate new kinds of proposals.

Within the set of spending options, the distinctions among grants and credit subsidies arguably have less policy significance. Grants are sometimes said to be more appealing because they are simpler to explain to local ratepayers. Conversely, it is sometimes argued that in comparison to grants, credit subsidies have a lower federal cost per dollar of support seen by the recipient—that argument, however, holds only under the assumption that the government's cost should not be measured using a discount rate reflecting the same risk premiums that private lenders require.[22] Finally, investment projects that rely at least in part on private funding can help keep costs down by subjecting systems to more market discipline; that argues against traditional loans covering 100 percent of capital costs and in favor of grants or partial loans or loan guarantees.

In terms of tax preferences, one approach that could benefit both municipally owned systems and private systems would be to relax the restrictions on arbitrage profits—the gains state and local governments make from the difference between the tax-free rate of interest that they pay bondholders and the higher rates they can earn on taxable bonds and other assets. To avoid encouraging state and local governments to issue bonds simply to take advantage of the spread in interest rates, the federal government restricts such arbitrage profits. In particular, current rules require that systems rebate to the government arbitrage profits on bond proceeds not spent on schedule within a two-year deadline (or for private systems, a six-month deadline). Extending the deadline or otherwise increasing the arbitrage earnings that water systems could keep would reduce their net cost of borrowing.[23] Another option would be to eliminate the partial taxation of interest on municipal bonds held by corporations that pay the alternative minimum tax.

Direct Federal Support for Ratepayers and Its Implications

The federal government supports low-income households in various ways, notably through income-based welfare programs and the earned income tax credit, but does not currently provide direct funding to assist households with their water bills. Existing payment assistance programs for water services are organized locally—some by individual utilities, others by local authorities using tax revenues for support or by community organizations using donated funds—and are much less common than those for home energy and telecommunications services.[24] The federal government does provide some assistance for other utility bills. In particular, the Low-Income Home Energy Assistance Program (LIHEAP), established in 1981, provides states with over $1 billion in block grants each year to subsidize low-income households' heating and cooling costs. Also, the Low Income Program of the telecommunications Universal Service Fund, authorized in its current form in 1996, has used approximately $600 million per year (from fees charged to firms that provide interstate telecommunications services) to provide eligible households with discounts on telephone services.

Federal aid to households could address distributional objectives with more precision and less loss of efficiency than can be achieved from aid for investment in water systems. A program that aided households directly could be more cost-effective in achieving a given distributional objective because fewer households would face reduced water prices and water system managers would not face distorted choices.[25] A program designed to defray the

22. The argument is that the federal government has a lower discount rate (based on its lower borrowing cost), which gives the same loan repayment stream a higher present value for the Treasury than for the local system—and thus that the net federal cost of making the loan is smaller than the net support it provides. Paul K. Marchetti, *The Programmatic and Financial Integration of Grants and Loans Within the State Revolving Funds*, Council of Infrastructure Financing Authorities Monograph no. 11 (September 2001), pp. 11-13.

23. A variant option would be to maintain the current time limits during which proceeds on tax-exempt bonds may earn arbitrage profits but extend the period during which the proceeds must be spent. That alone could lower investment costs by reducing the number of cases in which systems would have to use a phased series of smaller bond issues.

24. For a comprehensive discussion of payment assistance programs for water services, see American Water Works Association Research Foundation, *Water Affordability Programs* (Washington, D.C.: AWWARF, 1998).

25. H.R. 3930 and S. 1961 in the 107th Congress would allow states to use a certain portion of federal SRF grants to buy down the interest rate or otherwise increase the subsidy on SRF loans to local water systems, if the systems in turn directed the bene-

expense of basic water use—one that provided a dollar amount determined by the number of members in the household instead of paying benefits as a proportion of water bills, for example—would not affect households' marginal costs of water consumption, thus preserving incentives for consumers to avoid overusing water services.[26] A consumption subsidy could also be designed to support conservation measures—for example, by subsidizing repairs to fix leaky plumbing. However, beneficiaries (and others allocating funds on their behalf) are likely to prefer direct assistance over conservation measures with even moderately long payback periods.[27]

Delegating most implementation responsibilities to subfederal entities and providing the consumption subsidy to service providers on behalf of households could minimize the federal government's administrative costs and allow more people to be served for a given amount of funding. For example, delegating to the states would allow for cost-effective variations, taking advantage of existing state institutions and programs, in the methods used to identify, notify, and deliver benefits to eligible households. But some of the federal costs "saved" would be merely shifted to nonfederal parties, such as service providers.

State governments shoulder most of the responsibility for administering LIHEAP, and most states exercise their authorization to make consolidated payments on behalf of households to utility companies and fuel dealers.[28] In the Low Income Program for telecommunications, all payments from the fund go to companies on behalf of the households receiving the subsidized services. Administrative costs for the program are about $1.7 million annually, less than one-half percent of the program's fiscal year 2000 outlays of $553 million (in current dollars). The costs incurred by service providers to identify eligible households and apply the appropriate benefits are unknown.

Concluding Note

Water pipes and treatment plants last for decades. Consequently, today's infrastructure represents a cumulation of investment choices and maintenance practices over many years past, and today's investments will affect operating costs and service quality for many years into the future. The magnitude and especially the timing of future investments are uncertain, as discussed in Chapter 2, but barring major breakthroughs in technology, investment costs will certainly rise for decades to come as more and more of the existing infrastructure wears out. Although this report has focused on the costs of water services through 2019, if the drinking water and wastewater industries continue to fall short of self-sufficiency, the consequences for the federal budget may last not two decades, but five or 10.

fits of the additional subsidy to needy households through adjustments in user charges. The increases in the subsidy component of SRF loans should not significantly increase the distorting effects of federal support for investment itself. From the point of view of water systems receiving the loans, the savings in repayment costs would be offset by reduced revenues from beneficiary households.

26. The Universal Service Fund's Low Income Program illustrates that approach: each of its three types of benefits is capped at a level essentially unrelated to the volume of service used by a particular household. The "Link-Up" benefit subsidizes half of the customary connection fee, up to a maximum of $30. "Lifeline" reduces monthly service bills by $5.25 to $7.85, depending on a number of factors, including whether the state has a matching program. "Toll Limitation Service" covers the cost to providers of allowing consumers to block or set a predetermined limit on long-distance (toll) calls. In the case of LIHEAP, under which states have significant discretion in determining household benefits, questions about inefficient consumption have arisen: the Securing America's Future Energy Act of 2001, passed by the House, calls for the General Accounting Office to determine the extent to which those benefits encourage or discourage energy conservation and investments in energy efficiency. It also requests that that agency examine the extent to which the goals of conservation and assistance to low-income households could be achieved through cash income supplements that do not specifically target energy.

27. Federal rules for LIHEAP allow states to use 15 percent of their grants for low-cost residential weatherization or other energy-related home repairs. Each year, states may also apply for permission to raise that share to as much as 25 percent; however, on average, only five states have done so in recent years.

28. From 1995 through 1999, aggregate state administrative costs averaged close to 9 percent of total spending under LIHEAP.

APPENDIX

A

Assumptions the Congressional Budget Office Used In Its Low-Cost and High-Cost Cases

As with all modeling exercises, the Congressional Budget Office's (CBO's) analysis of future costs for investment in water infrastructure rests on the quality of the data used as inputs and the validity of the many assumptions used in converting the data into estimates. The most readily apparent assumptions are the 11 specific numerical values that differ between CBO's low-cost and high-cost cases and between those cases and the analysis done by the Water Infrastructure Network (WIN). Those assumptions include a factor describing savings from improved efficiency in investment by both wastewater and drinking water systems; three factors pertaining to capital costs for wastewater systems alone; two specific to capital costs for drinking water systems; four involving financing costs; and one pertaining to operations and maintenance (O&M). The goal in selecting the assumptions was not to determine the lowest and highest possible values of each one, but to identify reasonably low and high values that might realistically occur together in the scenarios.

Aside from the 11 distinguishing assumptions (*see Table 2* on page 20), CBO's scenarios and WIN's analysis have much in common, including primary data sources and "structural" assumptions about which factors influence other factors. The effects of those common elements is unknown. For example, CBO cannot quantify the extent to which differences in the available data and modeling approaches used to analyze investments for drinking water and wastewater affected the estimated costs.

Savings from Increased Efficiency in Investment

Although quantifying the potential impact of improved management and better technology on future investment is difficult, CBO considers it likely that U.S. systems could achieve savings of 10 percent or more, given incentives to do so. Evidence for that assumption comes from Australia and the United Kingdom, where water systems have been pressed to become more efficient. Accordingly, CBO reduced estimated costs for capital investment in both drinking water and wastewater systems by 15 percent in the low-cost case and by 5 percent in the high-cost case.[1]

Capital Costs for Wastewater Systems

In light of the limited data available and the resulting uncertainty, the two scenarios differ in the depreciation rates for wastewater infrastructure, the shares of investment for replacing infrastructure that CBO assumed were

1. Both scenarios implicitly assume that the data collected in the Environmental Protection Agency's needs surveys do not already reflect future efficiency savings. The other sources of estimated capital costs—the Water Infrastructure Network's analysis of investment in wastewater systems for replacing infrastructure and Stratus Consulting's report on investment in drinking water distribution—are explicitly based on current prices and valuations and thus do not reflect potential efficiency gains.

included among the needs estimated in the Environmental Protection Agency's (EPA's) survey, and the costs for dealing with combined sewer overflows (CSOs). The costs to address sanitary sewer overflows (SSOs) are also uncertain, but CBO used the same estimate of those costs for both scenarios, largely for lack of information on which to base contrasting estimates.

WIN's rule-of-thumb assumptions about the lifetimes for sewer pipes, treatment plants, and vehicles—50 years, 20 years, and 5 years—seem reasonably conservative (in other words, short). Reflecting those assumptions and the relative importance of the three types of capital stock, CBO adopted a weighted (economic) depreciation rate of 3.3 percent for its high-cost case. Those rules of thumb could in principle underestimate replacement costs if wastewater systems have built up an investment backlog; presumably, however, most overdue investments would be affecting service quality and thus would probably be included in EPA's needs survey and reflected in WIN's estimate of costs for investments besides those for replacing infrastructure.

Conversely, some experts have suggested to CBO that reasonably optimistic lifetimes for pipes and treatment plants would be 75 years and 30 years, respectively. Moreover, replacement rates over a period of 20 years could fall below the average level implied by those lifetimes, depending on the age of the existing stock. In the absence of better data on actual lifetimes and current ages, however, the low-cost case assumes lifetimes of only 60 years for pipes, 25 years for treatment plants, and 7 years for vehicles, and uses the corresponding weighted overall depreciation rate of 2.7 percent.[2]

The low-cost and high-cost scenarios assume, respectively, that 25 percent and 15 percent of the investments in the relevant categories of EPA's needs survey—secondary and advanced treatment, new collector and interceptor sewers, combined sewer overflows, and stormwater management —represent replacement of existing infrastructure. Since such investments are captured in the analysis by applying the depreciation rate to the total capital stock, that 15 percent to 25 percent overlap must be subtracted from the total in the needs survey to avoid double-counting. CBO chose those percentages to illustrate the uncertainty surrounding WIN's estimate of 20.5 percent—which was derived by assuming that investments to replace existing infrastructure represented 50 percent of the investments cited in EPA's survey for addressing SSOs and zero percent of the investments in other survey categories.

CBO's low-cost case takes its estimate of the costs for addressing CSOs from EPA's needs survey. WIN's analysis uses the same figure, but WIN argues that EPA's estimate is too low and is a significant source of downward bias in its analysis. The CSO Partnership believes that EPA's estimate is a reasonable one if states exercise the maximum flexibility in reviewing and revising their water quality standards, but costs could reach $100 billion if states maintain the current standards. Consequently, CBO's high-cost case incorporates that latter figure.[3]

Capital Costs for Drinking Water Systems

The main factor responsible for the difference between the two scenarios' estimates of investment costs for drinking water is the assumed rate of pipe replacement. The Stratus Consulting report that underlies WIN's analysis

2. Because the modeling framework that WIN developed derives its estimate of the value of the existing stock of wastewater infrastructure by cumulating past investments and subtracting depreciation, the lower the rate of depreciation in the past, the larger the current capital stock. For consistency, therefore, CBO calculated an alternative estimate of the 1999 capital stock for the low-cost case, using the lower depreciation rate assumed in that scenario. The alternative estimate is 12.3 percent larger, which partly offsets the impact of the lower depreciation rate on estimated future investment.

   Also, CBO's analysis, like WIN's, calculated each year's investment for replacing infrastructure by applying the depreciation rate to the current net stock of capital, not the gross stock. That approach is clearly not a literal description of replacement at the level of individual investments: a pipe or treatment plant does not cost less to replace simply because it is older and thus has depreciated more. Rather, it should be viewed as a way of approximating the total amount of replacement needed for a large capital stock containing assets of various ages.

3. The assumptions in both scenarios are "gross" costs—that is, the costs before subtracting anything for overlap with investments to replace infrastructure or efficiency savings.

focused on an average rate of 1.0 percent per year (averaging over rates randomly selected from a uniform probability distribution from 0.5 percent to 1.5 percent), but it also presented an alternative analysis that related historical investment in pipes to population growth. CBO's high-cost case, like WIN's analysis, adopts Stratus's assumption of 1.0 percent as a plausible though marked increase above recent rates. The low-cost case focuses on the alternative "demographic" analysis and assumes a replacement rate of 0.6 percent—the average of the six rates calculated for the 2000-2010 and 2010-2020 decades using 50-, 75-, and 100-year pipe lifetimes.[4] Here, as elsewhere in its analysis, CBO assumes for simplicity that the relevant replacement rate (1.0 percent or 0.6 percent) holds steady throughout the 2000-2019 period. In reality, replacement is likely to accelerate as existing pipes age, so the rates are best viewed as averages over the period.

The other assumption pertaining to investment for drinking water concerns the costs associated with future federal regulations. EPA's estimates of compliance costs for drinking water regulations are frequently controversial, with water systems claiming that they are grossly understated. Often, assumptions about compliance methods are at the heart of the controversy. For example, a study issued by the American Water Works Association Research Foundation estimated that national annualized costs to comply with an arsenic standard of 10 micrograms per liter could be as low as $230 million, close to EPA's estimate of $180 million to $206 million, if each system affected by the standard was able to achieve compliance by using the least costly technology.[5] However, using professional judgments about the likely performance of various technologies under different conditions, the study's "best estimate" of compliance costs was much higher—$585 million. Conversely, an EPA contractor's report looking retrospectively at compliance with regulations for nitrate and atrazine found that many systems used cheaper compliance methods than EPA had assumed in its regulatory impact analyses.[6] That finding suggests that the agency's estimates may overstate costs rather than understate them, at least in some cases.

Even if the estimates in EPA's impact analyses were known to be perfectly accurate, uncertainty would still remain about the costs of regulations not yet promulgated or proposed, for which no such analyses exist. Agency sources do not currently anticipate proposing high-cost rules beyond those already part of the regulatory agenda, but some new development in the next five to 10 years could lead to regulations that would have significant cost impacts by 2019. In the low-cost case, CBO assumes incremental costs of zero for future regulations (as does WIN's analysis), on the grounds that those already proposed or promulgated could reflect most of the compliance costs that systems will incur through 2019, with efficiency savings on those "known" regulations roughly balancing any costs during the period for subsequent requirements. In the high-cost case, CBO adds $10 billion (in January 1999) dollars over the 20-year period —the equivalent of $0.53 billion per year in 2001 dollars—on the assumption that the estimate of compliance costs for known regulations expressed in EPA's needs survey ($9.3 billion in January 1999 dollars) covers roughly half of total costs through 2019 for both known and future regulations. That assumption takes into account the possibility that costs for the known regulations will exceed EPA's estimate as well as the possibility of spending on later requirements. Somewhat higher figures could also be justified as plausible but would not have a major additional impact on total estimated costs.

Financing

In consultation with a half-dozen experts from the water and municipal bond industries, CBO derived pairs of

4. One factor that could keep pipe replacement rates low is the use of new techniques to identify pipes that are redundant and can be abandoned, given existing or potential alternative routes in the pipe network.

5. Michelle M. Frey and others, "Cost Implications of a Lower Arsenic MCL," AWWA Research Foundation Project #2635 (October 2000), p. ES-20, available at www.awwarf.com/exsums/2635.htm. The study does not specify the type (nominal or inflation-adjusted) or year of the dollars used in the estimates.

6. Abt Associates, Inc., *Predicting Community Water System Compliance Choices: Lessons from the Past* (submitted to the Environmental Protection Agency, Office of Policy, Economics, and Innovation, September 2000).

assumptions about future interest rates, borrowing terms, and the use of debt financing versus pay-as-you-go (or paygo) for capital investment. CBO used related assumptions to estimate the average annual spending to service debt on "old" (that is, pre-2000) investments in drinking water and wastewater systems; the resulting estimates are common to both of CBO's scenarios but somewhat lower than those used in WIN's analysis.

The low-cost case uses a real interest rate of 3 percent (as does WIN's analysis), and the high-cost case uses 4 percent. CBO chose those assumptions on the basis of an estimated 3.2 percent weighted average covering market-rate bonds and subsidized rates on state revolving fund (SRF) loans. The estimate took into account CBO's long-run projections for inflation and the nominal interest rate on 30-year Treasury bonds, traditional spreads between Treasuries and municipal bonds, projections of potential assistance from SRFs, and current interest rates on SRF loans. That range from 3 percent to 4 percent may understate the true uncertainty about average interest rates over the 2000-2019 period; however, once those figures are combined with the many other pairs of low-cost and high-cost assumptions, CBO believes that they yield suitably low and high estimates of investment spending.

CBO assumes the average repayment period on borrowed funds to be 30 years in the low-cost case and 25 years in the high-cost case; WIN's analysis assumes a shorter period of 20 years. Although some (mostly smaller) municipalities continue to borrow at terms as short as 10 years and loans from state revolving funds must still be amortized over no more than 20 years, industry experts told CBO that water bond maturities have lengthened overall and that 30 years is now the standard term. Even within the wastewater SRF program, EPA now interprets its regulations to allow SRFs themselves to borrow 30-year money and use it to buy local systems' debt. As investment programs increase, stretching out debt service will be increasingly important as a way to contain rate increases; indeed, the Boston-area Massachusetts Water Resources Authority is now borrowing 40-year money. Accordingly, CBO considers 30 years a cautiously optimistic assumption for the average dollar borrowed over the 2000-2019 period and 25 years an adequately pessimistic alternative.

Similarly, keeping rates low in the face of rising investments will also mean reducing the use of paygo financing in favor of borrowed funds. In two small 1999 surveys of drinking water and wastewater systems, indirect data appear to suggest average paygo shares of roughly 40 percent and 50 percent.[7] Nonetheless, according to industry experts, systems undertaking large amounts of investment generally use paygo financing very little (often a share of just a few percent), suggesting that the national average paygo share will fall as capital spending rises. Reflecting the uncertainty about how quickly and how far the average will fall through 2019, the high-cost and low-cost cases use paygo rates of 30 percent and 15 percent, respectively. WIN's analysis assumes a paygo share of 25 percent.

Assumptions about borrowing terms, paygo shares, and interest rates are also relevant in estimating the costs of "old" debt service—that is, the financing costs associated with previous investments still being paid off during the 2000-2019 period. For simplicity, CBO uses the same assumptions about those costs in both scenarios.[8] In

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7. In the one survey, 76 privately owned drinking water systems (many belonging to the same parent companies) reported total construction expenditures of $846 million and total gross cash flow from financing activities (before subtracting debt repayment and dividends) of $526 million. Presumably, paygo accounted for the remaining $320 million, or 38 percent, of construction spending. See National Association of Water Companies, *1999 Financial and Operating Data for Investor-Owned Water Utilities* (Washington, D.C.: NAWC, 2000).

   In the survey of wastewater systems, bond proceeds and SRF loans accounted for 46 percent of capital spending; interest earned and other revenue sources provided another 7 percent. Depending on the classification of those latter two sources, the residual paygo share lay between 47 percent and 54 percent. Only 40 to 69 systems provided responses other than zero to the survey's questions about capital spending, however, so the sample may not have been representative of all medium-sized and large wastewater systems. See Association of Metropolitan Sewerage Agencies, *The AMSA Financial Survey, 1999: A National Survey of Municipal Wastewater Management Financing and Trends* (Washington, D.C.: AMSA, 1999).

8. Using two sets of assumptions would have complicated the problem of matching assumptions about paygo shares with each of CBO's scenarios. Lower paygo shares on new investments imply lower up-front costs; conversely, if paygo shares also vary

particular, CBO assumes that the repayment period on funds borrowed before 2000 is 20 years (shorter than the 25-year and 30-year periods used going forward) and that the assumed paygo shares decline by 1 percent each year, from 50 percent in 1980 to 31 percent in 1999. The latter assumption is broadly consistent with the theory that paygo shares decrease as investment programs increase; a higher trajectory of paygo rates could have been justified by the available (limited) survey data, but would have implied larger discontinuities between 1999 and 2000. Finally, rather than assume a fixed real interest rate, CBO's analysis used each year's average nominal rate for 10-year Treasuries, reduced by spreads ranging from 5 percent to 15 percent between municipal and Treasury bonds. CBO then converted total annual payments for debt service to constant dollars using the gross domestic product (GDP) deflator. For federal loans through EPA's state revolving funds and the U.S. Department of Agriculture's (USDA's) rural utilities program, the analysis used those same interest rates less 2 percent.[9]

The estimates of average annual costs for "old" debt service resulting from those assumptions are somewhat lower than WIN's: $4.4 billion instead of $5.1 billion for drinking water and $4.3 billion instead of $4.4 billion for wastewater.[10] The differences are primarily attributable to CBO's higher paygo shares and differences in data sources; the use of variable interest rates and the different method of converting to real dollars did not have much impact.

Operations and Maintenance

Although the focus of this study is on investment costs, spending for operations and maintenance is relevant in that it contributes to the total financial burden facing water systems and their ratepayers. CBO used comparatively simple approaches to model future O&M costs. Under the high-cost case, both drinking water and wastewater systems' O&M are modeled by extrapolating a linear trend through estimated spending (in constant dollars) from 1980 through 1998.[11] The approach used in the low-cost case starts from the same trend lines but assumes that increased efficiency yields savings of 20 percent, phased in 2 percent each year from 1995 to 2004.

The rationales for those scenarios are straightforward. The trend lines for both drinking water and wastewater systems' O&M fit the 1980-1998 data extremely well (explaining 99 percent of the variation from the means) and thus appear to be reasonable bases for extrapolating future spending. At the same time, cost savings of 20 percent seem well in line with the experience of systems that

on previous investments, then lower shares imply higher costs for old debt service. Thus, whether lower assumptions about past and future paygo shares should be assigned to the low-cost or the high-cost case would have been an empirical question, subject to changes in those shares or in other, interacting assumptions.

9. Data for the analysis came from several sources, including Congressional Budget Office, *Trends in Public Infrastructure Spending* (May 1999), which in turn drew on the Census Bureau's annual surveys of *State and Local Government Finances*; General Accounting Office, *Water Infrastructure: Information on Federal and State Financial Assistance* GAO-02-134 (November 2001); and data from EPA on loan volumes and federal outlays for the state revolving funds. Data on drinking water systems derived from the census survey, which covers only publicly owned systems, are scaled up by 15 percent to account for spending by privately owned systems. That adjustment roughly reflects the population served by privately owned systems; WIN, too, makes that adjustment in its analysis.

   For lack of information, however, CBO did not scale the census data down by a percentage reflecting investments in drinking water infrastructure to serve growth, which are not covered in the estimates of future costs. That factor is one of two that tends to overstate relevant investment spending in 1999 and future debt service on pre-2000 investments. The other is the neglect of any refinancing that systems did as interest rates fell in the 1990s. Two other limitations of the data act in the opposite direction: they do not distinguish USDA loans from local systems' spending of their own funds before 1991, and they understate local spending starting in 1992 by an amount equal to the federal budget cost (that is, the subsidy value) of those loans.

10. WIN's analysis used the same assumptions for pre-2000 investments as for new investments: a 20-year borrowing term, 25 percent paygo share, and 3 percent real interest rate.

11. The estimates were derived from data in the Census Bureau's surveys of government finances. CBO averaged data from successive surveys to convert from state fiscal years (typically July 1 to June 30) to calendar years and used the GDP price index to convert from nominal dollars to constant 2001 dollars. Again, CBO increased the estimates for drinking water systems by 15 percent to account for privately owned systems not covered by the surveys.

have begun to emphasize efficiency and competitiveness and also broadly consistent with significant decreases in the average annual growth in O&M spending seen in the last four years of available data (1995 through 1998).

The approach CBO took in its low-cost case echoes that used in WIN's analysis, which also appears to modify linear extrapolations by phasing in 20 percent efficiency savings over 10 years.[12] For drinking water systems' O&M, the low-cost case differs from its WIN counterpart only in the data sources: WIN's analysis based its extrapolation on data from 1985 to 1994, and, to convert from nominal to 1997 dollars, appears to have used the *Engineering News-Record*'s Construction Cost Index (which focuses on only the prices of labor, structural steel shapes, cement, and lumber) rather than the more general GDP price index. For wastewater systems' O&M, an additional factor distinguishes the two approaches: WIN's linear extrapolation (using 1972-1996 data) was not on O&M spending itself but on spending per dollar of net capital stock.

Although the size of the capital stock is plausibly related to the amount of O&M, CBO did not see a compelling case for WIN's more complicated approach. It is not obvious that each additional dollar of capital stock should be associated with an ever-increasing (rather than a steady) amount of additional O&M spending. Specific factors that contributed to steady increases in wastewater systems' O&M spending (in comparison to capital stock) between 1972 and 1996, such as a major increase in the use of secondary treatment methods and increased requirements for handling biosolid residues, may have largely played themselves out by now. And the linear trend line through the data on spending per dollar of net capital stock, while a very good fit, was no better than the trend line through the data on O&M spending itself.

Of course, the simple approaches CBO used could understate the uncertainty surrounding O&M costs by failing to capture some ways in which the future could differ from the past. For example, tighter effluent standards or additional drinking water regulations might raise O&M costs faster than projected in the high-cost case, while more aggressive efficiency campaigns or faster technological progress might yield savings larger than projected in the low-cost scenario.

12. The documentation available to CBO did not show that efficiency savings were applied to the trend for drinking water systems' O&M; however, by experimenting with the data that WIN used, CBO found that including such savings and phasing them in over the same 1997-2006 period specified for the savings by wastewater systems roughly reproduced WIN's published estimate of average annual costs over the 2000-2019 period. Although WIN's report said that its model assumed 25 percent savings, the consultant who led the analysis has confirmed that the correct figure is 20 percent.

APPENDIX

B

Major Sources of Efficiency Savings

Faced with increased pressure from ratepayers and local government officials to control costs, drinking water and wastewater systems around the country are looking for ways to improve the efficiency of their investment, operations, and maintenance activities. Their efforts have identified many sources of efficiency savings, most of which are captured under one or more of the categories discussed below.

Demand Management

Efforts to influence the demand for water services may take a variety of forms, including increases in prices to better reflect the full costs of water services, rebates for purchases of equipment that uses less water, and campaigns to promote voluntary reductions in water use.

One important application of demand management is to reduce peak usage and thereby postpone expensive increases in capacity. For example, after determining that higher demand for water in the summer, driven primarily by residential landscape watering, cost four times as much to satisfy as average annual demand ($0.97 versus $0.22 per hundred cubic feet, in unspecified dollars), Seattle Public Utilities implemented several methods—including a media campaign, appearances by speakers, demonstration gardens, bill inserts, zoning codes, and seasonal rate increases ranging from 50 percent to 160 percent—to reduce summer watering. According to the utility, the measures have cut the maximum amount demanded on any one day of the year by almost one-third despite an increase of 20 percent in the population served. The measures yielded savings of millions of dollars from postponed expansions in distribution and supply facilities and additional savings in energy and labor costs and increased flexibility in routing water through the distribution system.[1]

On the wastewater side, pricing based on marginal-cost principles to reduce cross-subsidies between different classes of users can improve efficiency not only by alleviating pressure for investments in overall capacity but also by reducing costs associated with treating particular types of wastes—as these examples show: fats, oils, and greases (as from restaurants and auto shops) can raise a wastewater system's costs for keeping its sewers unclogged; and metal contaminants can raise the costs of disposing of treated biosolids by making them unfit for application on nearby agricultural land.[2] By analyzing the cost impacts of such wastes and charging accordingly, system managers can give users incentives to "pretreat" them on-site or avoid creating them whenever the cost of doing so is lower than the cost of treating them in the wastewater system.

Labor Productivity

Labor costs are a major focus of efforts to improve efficiency because they represent the largest single compo-

1. Allan Dietenmann, "A Peek at the Peak: Reducing Seattle's Peak Water Demand" (Seattle Public Utilities, Resource Conservation Section, Feburary 9, 1998).

2. For examples and discussion, see Industrial Economics, Inc., *Cost Accounting and Budgeting for Improved Wastewater Treatment* (prepared for the Environmental Protection Agency, Office of Policy, Planning and Evaluation and Office of Water, February 1998).

nent of water systems' operational costs. For example, according to a 1999 survey of medium-sized and large wastewater systems by the Association of Metropolitan Sewerage Agencies (AMSA), "in-house" wages and benefits accounted for 48 percent of operational costs, on average. In comparison, services that the wastewater systems purchased from other municipal departments or private contractors accounted for another 28 percent, and electricity and other utilities, chemicals, parts, and supplies, the remaining 24 percent.[3]

But the AMSA survey also shows evidence of the progress wastewater systems are making in increasing labor productivity. Responding systems had an average of 4.7 full-time-equivalent (FTE) workers per 10,000 people served, down from 5.6 FTEs in the 1996 survey and 6.8 FTEs in the 1990 survey. Because the set of responding systems changes with each survey, however, those figures may obscure the actual change over time. A smaller comparison, focusing on the 45 systems that answered both the 1996 and 1999 surveys, shows FTEs per 10,000 people served falling from 5.0 to 4.7 over those three years, a reduction of 6 percent.[4]

One method that systems are using to improve productivity is cross-training to increase the flexibility of their workforce—for example, by reducing or eliminating the distinction between "operators" and "maintenance staff." Another is reducing staffing, particularly for off-peak shifts, through more use of automation and communication technologies to allow equipment to operate unattended under normal circumstances.[5]

Consolidation of Systems

As discussed in Chapter 1, the large majority of drinking water and wastewater systems are small. All things being equal, small systems incur much higher unit costs for treatment and other functions. For example, the Environmental Protection Agency's data on the costs of monitoring and treatment to comply with the Safe Drinking Water Act's standards in force as of September 1994 suggest that the average cost per household was about $4 per year in systems serving more than 500,000 people but about $300 per year for systems serving no more than 100 people.[6] Among the difficulties small systems face are a shortage of staff and financial resources to stay current with the latest technologies and management practices and the small scale of their purchases of chemical supplies and other materials.

Many small water systems, including roughly half of all small drinking water systems, lie within one of the nation's roughly 275 metropolitan areas (defined using census data), and a subset of those may be good candidates for physical consolidation or merger.[7] Some states have used SRF assistance as leverage to induce small systems to consolidate and to help larger regional systems absorb smaller neighbors.[8] Alternatively, where the distances make physical connections impractical and thereby preclude savings from centralized treatment, some efficiencies may still be obtained through consolidating

3. Association of Metropolitan Sewerage Agencies, *The AMSA Financial Survey, 1999: A National Survey of Municipal Wastewater Management Financing and Trends* (Washington, D.C.: AMSA, 1999).

4. Ibid., pp. 12, 67. An alternative measure of staffing—FTEs per million gallons of water treated per day—also fell by roughly 6 percent, from 3.5 to 3.3, for 41 systems responding in both 1996 and 1999.

5. Apogee Research/Hagler Bailly, Inc., and EMA Services, Inc., "Thinking, Getting, & Staying Competitive: A Public Sector Handbook" (prepared for the Association of Metropolitan Sewerage Agencies and the Association of Metropolitan Water Agencies, Washington, D.C., undated), pp. 35-36. Many water systems are finding ways to economize on other operational costs, notably those for electricity and chemicals. Some of those savings are found through asset management—in particular, through the use of life-cycle costing to identify efficient investments in improved technology.

6. Estimates are in 1992 dollars, based on data in Congressional Budget Office, *The Safe Drinking Water Act: A Case Study of an Unfunded Federal Mandate* (September 1995), pp. 16-17.

7. American Water Works Association, *Reinvesting in Drinking Water Infrastructure: Dawn of the Replacement Era* (Washington, D.C.: AWWA, May 2001), p. 15.

8. The drinking water SRF program prohibits assistance to any system that cannot demonstrate "the technical, financial, and managerial capacity to ensure compliance with the [Safe Drinking Water Act] over the long-term." Environmental Protection Agency, Office of Water, *The Drinking Water State Revolving Fund: Financing America's Drinking Water*, EPA-816-R-00-023 (November 2000), p. 7.

management, staff, and administrative functions. Even systems that continue to operate independently may be able to cooperate in, for example, hiring a "circuit rider" to provide technical expertise on a shared basis.

Asset Management

As the words suggest, "asset management" refers to efforts to get the maximum benefit from an organization's assets, usually its fixed physical assets. For existing assets, the key to maximizing the benefits is making efficient choices about maintenance and replacement. For new assets, the key is to evaluate total life-cycle costs—not only initial capital costs but also subsequent operational, maintenance, and disposal costs—to ensure that the investment is optimally cost-effective.

Active asset management in a large water system is challenging; it requires paying attention to the condition of equipment and the performance of the system and analyzing the discounted costs of different investment and maintenance strategies. But the potential for managing assets efficiently has increased with the advent of sophisticated analytical tools that help optimize the design of pipe networks (in some cases, identifying links that can be abandoned rather than replaced) and evaluate the trade-offs involved in maintaining equipment versus replacing it. The payoffs of such effort can be significant, by extending the life of equipment, eliminating redundant equipment, reducing O&M costs by as much as 40 percent, and improving the reliability of the system by roughly 70 percent.[9]

Innovative Construction Contracting

Some water systems have found that when the time comes to construct a new treatment plant (or significantly expand or update an old one), they are able to reduce costs significantly through the use of "design/build" or "design/build/operate" (DB or DBO) contracting. Whereas traditional practice involves using one firm (often selected without competition) to do the engineering design and then competitively awarding the actual construction to the lowest bidder, both DB and DBO procurements bundle the design and construction phases into a single contract, awarded on the basis of competitive bids that are judged on cost and quality together. Done properly, the approach may save time, increase accountability, and reduce costs (in part by allowing design firms to incorporate more proprietary or specialized methods and technologies and by reducing the need to "overdesign" to avoid later errors in construction or operation). According to EPA's Environmental Financial Advisory Board, some DBO contracts have yielded savings of 35 percent to 40 percent of project costs.[10] Savings claims for DB contracts are commonly around 10 percent or 15 percent.

Two examples of DBO projects that provide clear evidence of cost savings are a 120-million-gallon-per-day (MGD) filtration plant for drinking water for Seattle, Washington, and a 1.2 MGD wastewater treatment plant for Washington Borough, New Jersey. In the Seattle case, a conventional design was substantially complete by the time Seattle Public Utilities decided to switch to the DBO approach, and so more information than usual is available about the costs of the forgone alternative. On the basis of engineering estimates in the conventional design, Seattle Public Utilities has calculated that that approach would have cost $171 million (in discounted present value, using 1998 dollars) for construction and 25 years of operations, compared with $101 million under the DBO contract.[11] The savings of 41 percent may be somewhat overstated, however, because engineering estimates of construction costs do not necessarily reflect the lowest qualified bid that will subsequently be received.[12]

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9. Apogee Research/Hagler Bailly and EMA Services, "Thinking, Getting, & Staying Competitive," p. 12.

10. Environmental Protection Agency, Environmental Financial Advisory Board, "Private Sector Initiatives to Improve Efficiency in Providing Public-Purpose Environmental Services" (July 2001).

11. See "The Solicitation Process" on Seattle's "Project Summary" Web page for the Tolt Treatment Facilities, at www.cityofseattle.net/util/DW/TOLT/summary.htm.

12. David Higgens and Frank Mangravite, "Comparison of Design-Build-Operate and Conventional Procurements on Washington Borough, N.J., Wastewater Treatment Plant," *International Supplement to RCC's Public Works Financing* (July-August 1999), p. 1.

In the Washington Borough case, the conventional approach was taken one step further, and actual construction bids were received. Using alternative assumptions for such things as the costs of construction change orders under the forgone approach, the borough and its advisers estimate that the DBO contract reduced design and construction costs by between 17 percent and 25 percent and lowered annual operating costs by 4.2 percent.[13]

13. Ibid., p. 6.

APPENDIX

C

The 4 Percent Benchmark for Affordability

The Environmental Protection Agency has never adopted a measure to indicate how much an individual household can pay for water services before they become unaffordable. Yet participants in the current debate use (and attribute to EPA) the assumption that any household with water bills in excess of 4 percent of its income is experiencing a hardship. In adopting that notion, they mistakenly apply to individual households "affordability criteria" that the agency developed for whole water systems.

The distinction is important because EPA's criteria compare the revenues collected by a water system to the median household income (MHI) in a service area, not to individual household income. Certainly, average household costs that correspond to 4 percent of a community's MHI represent an even higher percentage of the income of an individual household earning less than the median. Thus, EPA's (subjective) judgment that 4 percent of MHI is a reasonable ceiling on a water system's yield does not translate into a judgment that each individual household served by that system should pay no more than 4 percent of its income for water services.

The 4 percent benchmark reflects EPA's separate figures of 2 percent each for wastewater and drinking water. The origins of those individual figures highlight the subjectivity inherent in setting affordability criteria.

EPA's Affordability Criterion for Wastewater Systems

EPA's guidance on the affordability of investment in wastewater systems uses an average household rate of 2 percent of MHI as one assessment factor in conjunction with measures of the system's debt, socioeconomic conditions of the area, and financial management conditions.[1] The focus on affordability at the system level is also reflected in the guidance's reference to a 1988 study examining municipal governments' ability to issue revenue bonds to finance environmental compliance. EPA assumed that lending institutions would initially be reluctant to accept ratios of user fees to income that were much above those already in existence in most communities, but the agency was clearly not concerned about whether individual households could afford higher rates —it asserted that as new environmental regulations gained wider acceptance, lenders would not be put off by higher ratios.[2]

1. See Environmental Protection Agency, Office of Water, Office of Wastewater Management, "Combined Sewer Overflows—Guidance for Financial Capability Assessment and Schedule Development," EPA 832-B-97-004 (February 1997).

2. Financial markets do not use a household-level affordability criterion in determining a system's overall financial condition and credit capacity. But they do consider whether rates that are comparatively low for a region may constrain asset maintenance and whether rates that are too high may limit expansion of the industrial customer base. Rate assessments allow for timely capital improvement plans and rates that reflect the full cost of service. In addition to rates, financial analysts examine the diversity and breadth of a system's customer base, the strength of the local economy, the system's governance and organizational structure, the quality of its management and strategic focus, and its liquidity. See Mary Francoeur, Chee Mee Hu, and Thomas Paolicelli, *Rating Methodology: Analytical Framework for Water and Sewer System Ratings* (Moody's Investor Service, Municipal Credit Research, August 1999). Conversation with Chee Mee Hu, December 17, 2001.

EPA's Affordability Criterion for Drinking Water Systems

EPA was led to establish an affordability criterion for drinking water systems by the 1996 Amendments to the Safe Drinking Water Act. The amendments specified that small public drinking water systems would be allowed to use less effective pollutant control technologies when designated technologies capable of achieving a maximum contaminant level for a pollutant or satisfying a treatment technique requirement were not "affordable." EPA judged that a technology was not affordable for a small system if the associated average expense per household served exceeded 2 percent of the service area's MHI.

EPA settled on 2 percent after seeking a value that would be "closer to the cost of other utilities, and not significantly less than the cost of specific discretionary items."[3] Consumer expenditures on alcohol and tobacco represented 1.5 percent of 1995 pretax MHI, and expenditures on energy and fuels accounted for 3.3 percent.[4] From that range, the agency selected 2 percent, in part because it was roughly consistent with the premium that some households were choosing to pay when installing a drinking water treatment device or purchasing bottled water.[5]

EPA recently decided to raise the value to 2.5 percent of MHI, which highlights the subjective underpinnings of the agency's affordability criterion. The change allows EPA to designate point-of-use treatment devices as "compliance technologies" because it ensures that average household charges by small systems installing such devices would remain below the affordability criterion. In effect, the change limits the recourse of small drinking water systems to less effective pollutant control technologies.

3. See International Consultants and others, "National Level Affordability Criteria Under the 1996 Amendments to the Safe Drinking Water Act (Final Draft Report)," USEPA Contract 68-C6-0039 (August 1998), pp. 6-2, 4-6; and Environmental Protection Agency, Office of Water, "Variance Technology Findings for Contaminants Regulated Before 1996," EPA 815-R-98-003 (September 1998), p. 19.

4. Environmental Protection Agency, Office of Water, "Variance Technology Findings," p. 45.

5. International Consultants, "National Level Affordability Criteria," p. 4-3.

APPENDIX

D

Acknowledgments

Many people assisted the authors of this study, by typing drafts, reviewing drafts, providing helpful information, editing and proofreading the study, and preparing the final version for printing and for posting on the Congressional Budget Office's Web site (www.cbo.gov). Taking responsibility for any remaining errors, the authors want to express their appreciation to the people listed below for their contributions.

Congressional Budget Office
Christine Bogusz
Tracy Foertsch
Ed Harris
Annette Kalicki
Angela Z. McCollough
Susanne Mehlman
John Peterson
John Skeen
Eric Warasta
David Weiner
Kathryn Winstead
Rae Wiseman
Dennis Zimmerman

Environmental Protection Agency
Steve Allbee
George Ames
Veronica Blette
Alvin Edwards
Kit Farber
John Flowers
Terry Grindstaff
Sandra Perrin
David Travers
Kevin Weiss

Other

Janice Beecher, Beecher Policy Research
Mel Blackwell, Universal Service Administrative Company
Larry Bowman, U.S. Department of Agriculture
Caroline Carbaugh, U.S. Census Bureau
Peter Cook, National Association of Water Companies
Claudia Copeland, Congressional Research Service
John Cromwell, PA Consulting
Michael Deane, United Water
Andreas Deppe, formerly of Hagler Bailly Services
Rick Farrell, Council of Infrastructure Financing Authorities
Lee Garrigan, Association of Metropolitan Sewerage Agencies
Jim Gebhardt, New York Environmental Facilities Corporation
Barbara Gottschalk, formerly of the Massachusetts Water Resources Authority
Jon Harcum, Tetra Tech, Inc.
Thomas Holtmann, Joint Committee on Taxation
Eric Keil, Bureau of Labor Statistics
Ken Kirk, Association of Metropolitan Sewerage Agencies
Jim Land, Federal Communications Commission
Amy Laskey, Fitch Ratings
Robert Lenna, Maine Municipal Bond Bank
Randall Lutter, American Enterprise Institute
Steven Maguire, Congressional Research Service
Alan Manning, EMA, Inc.
Guy Nagahama, First Albany
Charles Noss, Water Environment Research Foundation
Tom Paolicelli, New York City Municipal Water Finance Authority
Mark Poland, CSO Partnership
Kirby Posey, U.S. Census Bureau
George Raftelis, Raftelis Consulting
Bill Reinhardt, Public Works Finance
Glenn Reinhardt, Water Environment Research Foundation
Haydn Reynolds, Haydn Reynolds and Associates
Kenneth Rubin, PA Consulting
Margot Saunders, National Consumer Law Center
Jon Schellpfeffer, Madison Metropolitan Sewerage District
Nick St. Angelo, Department of Health and Human Services
Buzz Teeter, American Leak Detection
Steve Via, American Water Works Association
Marcelo Vieira, Bond Market Association
Al Warburton, American Water Works Association
Wolf Weber, Bureau of Labor Statistics
Colleen Woodell, Standard & Poor's
John Young, American Water Works Services Company