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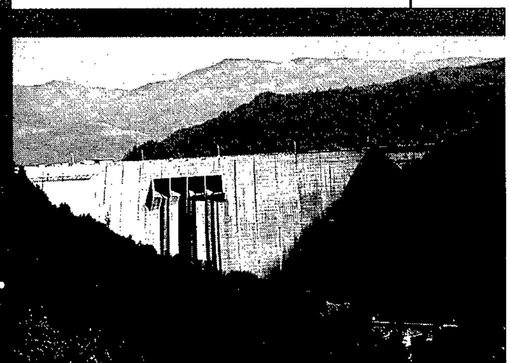
Water Use Conflicts in the West: Implications of Reforming the Bureau of Reclamation's Water Supply Policies



WATER USE CONFLICTS IN THE WEST: IMPLICATIONS OF REFORMING THE BUREAU OF RECLAMATION'S WATER SUPPLY POLICIES

The Congress of the United States
Congressional Budget Office

Preface

Conflict among water users is part of the history of the American West. The conflicts have changed over the years but have not gone away. Environmentalists, who want water to be left in the rivers to preserve threatened species, are now competing with urban and agricultural users for the West's limited water resources. Native American water rights, long ignored, are also receiving more attention.

The federal government is a key player in western water. Through its Bureau of Reclamation, the government developed water supplies that literally made the desert bloom. Developing new sources of water—deciding where the next big water project should be built—has long been the focus of the Bureau of Reclamation. But good options for the large-scale projects are extremely limited, and the federal government now focuses more on the fair and efficient allocation and use of existing supplies. Policy changes that could lead to better use of water are being put in place in parts of California served by the Central Valley Project, the largest water supply project in the United States. Policy changes introduced in California could serve as models for changes throughout the West.

In response to a request from the Ranking Minority Member of the House Committee on Resources, this study analyzes the policy tools slated for use in California, estimates the costs of those reforms to agriculture in the state, and discusses the implications of using those policy tools in the rest of the West.

Marca Weinberg, formerly of the Congressional Budget Office's (CBO's) Natural Resources and Commerce Division, wrote the study under the supervision of Jan Paul Acton and Roger Hitchner. Gary Brown, Coleman Bazelon, and Teri Gullo of CBO; Doug Elmendorf and Aaron Zeisler, formerly of CBO; and Gregory Amacher, Richard Wahl, Daniel Hellerstein, Benjamin Simon, Dennis Wichelns, Noel Gollehon, and Amy Matthews-Amos provided valuable comments and assistance. Michael R. Moore helped develop the agricultural model and also provided general comments.

Sherry Snyder edited the manuscript, and Chris Spoor proofread it. Angela McCollough typed the many drafts. Kathryn Quattrone and Jill Sands prepared the study for publication.

June E. O'Neill
Director

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Summary

The Bureau of Reclamation, an agency within the Department of the Interior, has spent billions of dollars over the past 90 years to develop water supplies for farmers in the western United States. Those federal water projects have "made the desert bloom," but the bureau's policies on supplying water—including subsidized prices, long-term contracts, and restrictions on the sale of water by farmers—have resulted in a rigid allocation of major water resources to agriculture. That allocation often comes at the expense of urban, environmental, and Native American water users, and at a large cost to taxpayers.

Reform of federal water policies that have their roots in the early part of the century could improve the Bureau of Reclamation's ability to meet the demands of today. Properly done, reform could improve economic efficiency in allocating water among commercial water uses, provide more water for public purposes such as the environment or Native American tribes, and could address equity concerns regarding the portion of project costs that the federal government must pay.

In California, where conflicts between agriculture, cities, and environmental interests over scarce water resources are severe, reform has been brought about by the 1992 Central Valley Project Improvement Act (CVPIA). In designing and passing the CVPIA, the Congress created a potential model for reforming federal water policy. The act contains numerous provisions that encourage farmers who receive water from the Bureau of Reclamation's Central Valley Project (CVP) to use less, that facilitate the movement of conserved water to higher-valued uses, and that protect and enhance fish and wildlife populations in California's Central Valley. However, those reforms come at a cost to agriculture. Passage of the act creates an opportunity to analyze the magnitudes of costs and benefits that reform imposes on the agricultural and urban sectors in California and to explore the implications of policy reform for the Bureau of Reclamation's projects throughout the West.

Competition for Limited Water Resources in the West

Conflicts over current and future allocations of surface water resources exist throughout the western United States. Those conflicts typically involve historical patterns of use by irrigated agriculture on the one hand and increasing (or increasingly recognized) needs for urban and environmental uses on the other hand. Many western cities—including Los Angeles, Denver, and Las Vegas—are experiencing rapid population growth that will increase pressure on water supplies that are both uncertain and limited. Fish and wildlife species that depend on river ecosystems for their survival are declining in every major river basin in the West. A total of 184 species listed as threatened or endangered or proposed for listing under the Endangered Species Act may be affected by the Bureau of Reclamation's operations. In addition, the water rights of many Native American tribes have yet to be quantified and allocated.

Historically, increased demand for water has been met by developing additional supplies. However, rising economic costs and environmental sensitivities are likely to preclude future construction of major water supply projects. Instead, reallocating water from existing uses—primarily agriculture—may be the best "new" supply of water for addressing urban, environmental, and Native American needs.

The Role of the Bureau of Reclamation in Resolving Water Conflicts

Participation by the Bureau of Reclamation will be necessary to alleviate water conflicts in many areas of the West for two reasons. The first is the bureau's pervasive presence: reclamation projects are located in all 17 western states and in essentially every major river basin. Because of the sheer volume of water that the bureau controls, the feasibility of addressing many conflicts depends on its participation.

Second, the bureau's water supply policies, which have their roots in the Reclamation Act of 1902 and its 1939 amendments, include below-cost prices and restrictions that inhibit the ability of market forces to move water to its highest-valued uses. Those provisions isolate recipients from the true economic value of water. An inefficient allocation results from making water available to farmers at lower rates than would prevail in a market setting. On average, farmers use more water and for lower-valued uses than they would if they faced higher prices. Likewise, urban users receive less water and pay a higher price. The discrepancy between low values associated with agricultural uses and high values associated with urban uses implies an economically inefficient allocation of water supplies. Thus, allowing farmers to transfer water to other uses and giving them the incentive to do so, or simply mandating a reallocation of water supplies, could improve net social welfare.

Options for Reforming the Bureau of Reclamation's Policies

Many objectives exist for reforming the Bureau of Reclamation's water supply policies, and many policy tools exist for achieving those objectives. Reforms can address economically inefficient water allocations, environmental problems associated with water development, tribal claims to water rights, reimbursement to the federal Treasury, or any combination of those objectives. Broadly defined, the available policy tools include facilitating water markets, directly increasing water prices, directly reallocating water, and requiring that water conservation measures be carried out. Water markets, water price reform, and conservation programs are tools that create incentives for farmers to reduce the quantity of water used in agriculture. Allowing farmers to sell water forces them to consider its value in other uses when making decisions about using water. Increases in water prices also create an incentive to use less water. Finally, encouraging farmers to adopt irrigation practices that use less water can be accomplished by creating goals for using water more efficiently or by developing a list of recommended practices from which farmers must choose. In contrast to incentive-based tools, directly reallocating water involves legislatively or administratively allocating a specific quantity of water to a specific use. With that measure, however, previous users may or may not be compensated for the water that is reallocated.

Water Markets

Water markets are an effective policy tool for improving the allocation of water among competing economic uses. Such markets are the one tool that would leave all participants better off (though some nonparticipants could be made worse off). Sellers would be better off because they would make more money from selling their water than they would from using it, and buyers would be better off because they would get water for a lower price than they would have to pay for the next-best source. The voluntary water transfers that result could alleviate conflicts between urban and agricultural water users and move water to higher-valued uses within the agricultural sector. They would generally be less effective as a tool for addressing environmental concerns.

Water Price Reform

Water price reform can be an effective tool for encouraging water conservation and increasing the return to the federal Treasury from investments in water projects. Water price reform is a broad category that includes increasing water prices, changing the structure of prices (for example, from a uniform price to one that rises as consumption increases), and imposing surcharges that target specific users or earmark funds for specific purposes. Price reform is the only option discussed in this study that would directly address concerns about charging farmers below-cost prices for water.

Many uncertainties, however, could limit the potential benefits of price reforms. First, current reclamation law and water delivery contracts between the Bureau of Reclamation and water users could restrict increases in water prices.

Second, water price reform would be effective in modifying farmers' behavior only if those reforms were passed on to farmers by the water districts holding the bureau's contracts. (Water districts are quasi-governmental entities composed of landowners within district boundaries.) The bureau's influence on the prices that farmers pay is indirect; reform would change the rates the water districts pay to the Bureau of Reclamation. Unless water districts recovered the cost of the higher rates by increasing the prices they charged farmers for water use rather than through land-based charges (for example, charges per acre or per household), the incentive to conserve water that might otherwise be expected from water price reform would not exist. Furthermore, if farmers were unable to obtain as much water as they wanted at the original price, they might not respond to changes in water prices at all.

Third, the disposition of conserved water is uncertain. Water conservation is generally a stepping stone to achieving a broader objective of policy reform and not an objective on its own. If the conserved water is not put to a higher-valued use, the conservation effort may represent a net loss to society. The final disposition of conserved water would depend on a mix of state water laws, federal policies, and rules set by water districts. The water could be left in the river, in which case the environment could benefit, or it could be diverted by other farmers, who may or may not put it to a higher-valued use. Environmental objectives also could be met if the price increase was an environmental surcharge with the receipts earmarked for spending on environmental purposes.

Allocating Water to Public Purposes

Of all policy tools, directly allocating water to public purposes such as the environment and Native Americans is the most likely to protect those uses. It would not, however, address inefficiencies resulting from restrictions on the transfer of water among farmers or from agriculture to urban uses.

Water Conservation Programs

Conservation programs may be appropriate for meeting the objectives of increasing water allocated to environmental purposes, if the conserved water remains in the river. However, as with water price reforms, the effectiveness of such programs will depend on the ultimate disposition of the conserved water.

Conservation programs generally are effective in reducing problems with water quality. For example, programs that encourage or require the use of more efficient irrigation systems could reduce the runoff of salts and chemicals into rivers, lakes, and groundwater aquifers. However, programs that rely on incentives, such as cost sharing for irrigation system improvements, could increase the cost to the Treasury of operating the Bureau of Reclamation's projects.

Combinations of Policy Tools Can Reduce or Enhance the Effectiveness of Individual Policies

Policy tools can be implemented independently or in combinations. If one policy results in a bigger change in costs than another, the latter could become redundant. For example, combining water markets with price increases would render the price increase ineffective in motivating changes in water use if the new price was lower than the market price. However, since no one policy tool effectively addresses all possible reform objectives, combinations of policies may be necessary to meet multiple objectives. For example, combining a water reallocation with a water market would achieve two objectives: increasing the water available for public purposes and increasing the efficiency of water allocations for commercial uses. It would also lessen potential economic inefficiencies associated with reducing the water supply of some users in order to provide water for public uses.

Conflicts and a Solution in California

The Bureau of Reclamation's Central Valley Project, in California, provides an important example of the types of conflicts over water use that may arise and the possible effectiveness of federal reclamation legislation in helping to construct a solution. The CVP is the largest water supply project in the country, serving 2.6 million acres of farmland in the Central Valley. Between 1979 and 1991, the Bureau of Reclamation delivered an average of 5.3 million acre-feet of water to water districts serving farmers in the valley. CVP farmers produce crops worth roughly $3 billion per year. The CVP has helped transform the Central Valley into one of the most productive agricultural regions in the world, delivering roughly 95 percent of its water to agriculture. Since the CVP's inception in the 1930s, the federal government has invested a total of $3.6 billion in the project, of which water users have repaid roughly $500 million.

Conflicts in the Central Valley

Conflicts over water allocation have arisen between agricultural, urban, and environmental uses in California. The successes of the CVP have occurred, to an extent, at the expense of the Sacramento and San Joaquin Rivers and the delta ecosystem, from which the water is diverted. One indicator of poor conditions in the ecosystem is a decline in resident fish populations. The delta region (including San Francisco Bay) supports a total of 37 species of fish, birds, mammals, reptiles, amphibians, invertebrates, and plants that are listed or are candidates for listing under the Endangered Species Act. Another 83 species are declining because of the loss of their habitat in the ecosystem. Significant quantities of CVP water may be necessary to preserve those species.

The severe drought that lasted from 1987 to 1992 exacerbated the conflict between competing agricultural and urban demands. The drought demonstrated the vulnerability of California's urban and agricultural water supply systems to natural fluctuations in hydrologic conditions. Urban areas are anxious to secure supplemental water supplies, both to moderate the effects of drought and to accommodate future growth.

The Central Valley Project Improvement Act

The Central Valley Project Improvement Act, signed into law in October 1992 by President Bush, sets a new standard for operating one of the Bureau of Reclamation's projects. That legislation gives the bureau both a mandate to address environmental problems associated with project development and the ability to address economic inefficiencies in allocating water. The act incorporates each of the policy tools defined above—voluntary water transfers, price increases, direct reallocation of water, and water conservation programs. Specifically, key CVPIA provisions:

- Allow voluntary water transfers. Farmers can sell water to any user for any (beneficial) use, at any price. All sales must have the Secretary of the Interior's approval. Farmers must pay the bureau a higher rate for all water sold to non-CVP users and a surcharge of $25 per acre-foot for all water sold to non-CVP urban users.

- Create tiered, or increasing block-rate, water prices. The bureau will charge water districts low (subsidized) contract rates for the first 80 percent of their water allotment, the average of contract and so-called full-cost rates for the next 10 percent, and full-cost rates for the last 10 percent. Full-cost rates reflect the Treasury's costs of water projects but are not a market price for water.

- Create a fish and wildlife restoration fund. The fund is to total $50 million per year to be spent on projects to enhance habitat. The financing will come from the tiered water prices, the surcharge and rate increases for transferred water, and a set of environmental surcharges to be paid by water users, with any remaining balance charged to power users. The environmental surcharges include a charge of up to $6 per acre-foot on all agricultural water users and $12 per acre-foot on all urban water users (in 1992 dollars). Recipients of water from the Friant division—an isolated portion of the CVP with distinct problems—pay an additional surcharge of $4 per acre-foot until October 1997, then will pay $5 per acre-foot from 1997 to 1999 and $7 per acre-foot after 1999.

- Allocate CVP water for fish and wildlife. The bureau will dedicate 800,000 acre-feet of CVP water to in-stream fish and wildlife uses in normal years —roughly 20 percent of average deliveries to contractors or 12 percent of average available water supplies. That amount declines to 600,000 acre-feet in drought years. The bureau also must allocate or acquire another 400,000 to 550,000 acre-feet for enhancing habitat in the Central Valley's wildlife reserves and in the Trinity River.

The act also requires the bureau to develop criteria for evaluating the adequacy of districts' plans for water conservation. However, the requirements of the provision are vague, and implementation of the districts' plans does not appear to be mandatory.

Effects of CVPIA Provisions

The Congressional Budget Office (CBO) examined the implications of various combinations of CVPIA provisions both conceptually and empirically. Economic principles underlying each provision suggest that each has the potential to be effective in encouraging water conservation and allocating water to urban or environmental uses, but that effectiveness will depend on both the exact levels of price changes relative to the benefits of water use and the combination of provisions enacted.

The impact of the CVPIA will include benefits to the environment, benefits to urban consumers, and costs to agriculture. CBO does not quantify benefits to the environment from the CVPIA, but some studies indicate those benefits could be large. Estimates range up to $21 million per year for increased commercial and recreational fishing from a minimal level of protection and $10 million to $25 million per year in recreational fishing alone for achieving the CVPIA's goal of doubling salmon populations. One study estimates that benefits associated with the provision that allocates approximately 250,000 acre-feet of water to wildlife refuges would be $79 million per year.

The empirical analysis estimates costs to farmers in terms of changes in agricultural revenues and benefits to urban consumers in terms of changes in consumers' welfare caused by various CVPIA provisions. CBO estimates those benefits to be $11 million, $7 million of which would be paid to farmers through the water market.

In an average water year, the CVPIA would reduce farmers' gross revenues by an estimated $100 million—less than 5 percent of average gross revenues. That amount is the change in the value of agricultural output caused by the CVPIA. If changes in input costs were proportional to changes in gross revenues, then farmers' net revenues (revenues net of the costs of variable inputs) would decline by roughly $44 million. The decline in regional economic income as a result of the CVPIA, including income losses for suppliers of agricultural inputs would be roughly $69 million.

Estimates of the economic impact of CVPIA provisions are sensitive to assumptions about water supply conditions (quantity available and price), the regulatory setting, and the capacity of infrastructure for conveying and storing water. A severe drought could significantly increase both the costs and the benefits of the act. Urban consumers would benefit more from the CVPIA in a drought year because the ability to transfer water is more valuable to them when a drought reduces their existing water supplies. However, the incremental cost of environmental water allocations increases as the quantity of water removed from the agricultural sector increases. Consequently, the cost to agriculture of the CVPIA would increase with drought conditions. In wet years, however, the cost of the CVPIA could be minimal. Finally, restrictions that the Endangered Species and Clean Water Acts place on water use could magnify both the costs and benefits of the CVPIA.

Implications for Reform of Federal Water Policies Throughout the West

In other areas of the West, the effectiveness and appropriateness of policies for reforming the Bureau of Reclamation's water supply policies will depend on the nature of competing demands for water and the objectives of the reform action. The profitability and flexibility of the agricultural sector have implications for the cost of shifting water to other uses. Those factors vary among regions and projects.

The results of the CVPIA analysis indicate that the competing demands for water can be balanced with a complicated package of reform options at a relatively small cost to the agricultural sector as a whole in most years. But even in that case, some individual farmers could be significantly affected, and the average cost would be much higher in drought years. The predicted effectiveness of the CVPIA derives in part from the high degree of flexibility CVP farmers have in adjusting cropping patterns and irrigation practices in response to water policy reforms. Farmers in other regions would probably respond differently to CVPIA-types of reforms.

An array of policy tools may be necessary to generate the maximum benefit from reforming the Bureau of Reclamation's policies while moderating the impact on the agricultural sector. Reforming those policies could improve the economic efficiency of water use and moderate or resolve conflicts throughout the West. However, the effectiveness of individual policy tools will vary from region to region and project to project, and even among water districts in a given region. A menu of options that includes a number of policy tools from which the bureau could select would provide the flexibility to adapt the policies to the specific problems and conditions at the regional or project level. The primary provisions of the CVPIA—water markets, water price reforms, an environmental water allocation, and conservation incentives—though not necessarily appropriate in all cases, span the range of effective options for achieving likely reform objectives and reducing conflicts over water use.

Chapter One

Introduction

Water has played a vital role in the development of the western United States. In many areas, agriculture exists only where irrigation water is plentiful and inexpensive; much farmland would be unproductive without access to water. Cities in the West are among the fastest growing in the nation and need additional water for residents and industries. Fish and wildlife need water, too, and such environmental uses have become strong competitors for increasingly scarce water over the past several decades. Native American tribes are also asserting their water rights. The rivers and aquifers, however, cannot supply enough water to satisfy unchecked demands in all sectors.

Conflicts among water users are not new, but they are intensifying as cities grow, environmental needs become more acute (and their advocates gain power), and the courts begin to give stronger support to the claims of Native Americans. Because those demands for water grow at different rates, the historical, relatively rigid allocations of water and the institutions that govern them have become increasingly inefficient and harder to justify. Why, for example, should municipal and industrial users have to pay water prices that are many times what farmers pay? Why should farmers be prohibited from selling water to cities? Why should water be allocated on the basis of seniority rather than on the basis of need or willingness to pay?

Background

Historically, as water became more scarce in the West, new supplies were developed. Dams and canals were built to move water from where it was abundant to where it was needed, or to store it for use during dry seasons. The federal government financed much of that work, and the Department of the Interior's Bureau of Reclamation played a key role. As its name suggests, the goal of that agency was to reclaim arid lands for productive uses by farmers. The big water projects were built to supply water to agriculture, and they succeeded.

But the era of big government water projects is all but over. Now, if more water is to go to some use such as developing urban areas, protecting endangered species, or satisfying the claims of Native Americans, it must come from some other use. The prime candidate is agriculture.

Agriculture is the obvious source of water for other uses for two reasons. First, it is the biggest use of water, accounting for over three-quarters of total use in the West. Second, agriculture can release water for other uses at a relatively low cost. The second point is key: the total value of water in agriculture is high, but the marginal value is low. Some farmers could use less water by making minor changes in their irrigation practices, changing the mix of crops they grow on their land, or investing in water-saving irrigation equipment. None of those changes are without cost, but most observers agree that agriculture could free up some of the water it now uses—and at a substantially lower cost than the bill that municipal or industrial users, for example, would pay to develop new supplies of water.

Reforming water policy in a way that makes more efficient use of current water resources is difficult. Institutional reforms are needed and are under way in some parts of the West. But even if reforms produce net social gains, there will be winners and losers. Farmers could lose if their access to water was reduced. Should they be compensated? Who should pay? Property rights must be considered, though they are not always well defined. Effects on third parties (those not directly affected by the transfer of water from one use to another) must be considered. Rural communities could be hurt if reforms reduced the amount of water available for irrigation.

The Changing Federal Role

Federal involvement has been key to nearly all large-scale development of water resources in the United States, and the Bureau of Reclamation remains the largest purveyor of water in the West. The role of the bureau, which was originally to develop water supplies to facilitate and encourage settlement of the arid West, is changing. Economic and environmental realities that will limit the construction of future projects have caused the bureau to change from an agency that develops water supplies to one that manages them. According to the bureau, its new mission is "to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public."[1] In addition to irrigation, the bureau's responsibilities now include water conservation, hydroelectric power generation, municipal and industrial water supplies, flood control, outdoor recreation, enhancement of fish and wildlife habitats, and research.

The Reclamation Projects Authorization and Adjustment Act of 1992 has been an important step in changing the bureau's mission. The competing forces affecting water policy are evident in the act, as they are in the bureau's mission statement. The act contains several titles that explicitly consider environmental problems associated with water development. Those titles include sweeping requirements to mitigate the effects on fish, wildlife, and recreational users arising from development of the Central Utah Project (title 3) and from the production of hydropower immediately upstream from the Grand Canyon National Park (title 8); a comprehensive Western Water Policy Review (title 30); and the Central Valley Project Improvement Act (title 34), which is discussed in Chapter 4. The act also authorizes construction projects in several western states, including completion of the Central Utah Project, which may be the bureau's last major interbasin transfer project.

1. Daniel P. Beard, *Blueprint for Reform: The Commissioner's Plan for Reinventing Reclamation* (Bureau of Reclamation, November 1, 1993).

Assessing Reform Efforts with a Case Study

The issues that arise in attempts to reform federal water policy are clearly seen in the Central Valley Project Improvement Act of 1992 (CVPIA). Conflicts concerning water are severe in California, and water supplied through the Central Valley Project is often at the center of those conflicts. The project is the largest in the nation. Consisting of 20 dams and more than 500 miles of canals, it is vitally important to California. Nearly 60 percent of the surface water used in the state originates in the Central Valley, and the Bureau of Reclamation controls almost half of that water through the Central Valley Project.

The CVPIA aimed to reduce inefficiencies caused by the bureau's policies on water supply and to resolve environmental problems associated with developing and operating large water projects. The law changed the allocation of water and the rules for pricing it in California. Purposes of the CVPIA include protecting, restoring, and enhancing fish, wildlife, and associated habitats in the Central Valley and Trinity River basins and increasing water-related benefits through expanded use of voluntary water transfers and improved water conservation. The latter purpose reflects a recognition that existing water policy in general, and the operations of the Central Valley Project in particular, have resulted in an inefficient allocation of water among uses and users in California.

The reforms in the Central Valley Project Improvement Act have been both hailed as pathbreaking and subjected to harsh criticism. Some options for reforming the CVPIA have been introduced in the Congress. This study looks at the provisions of the act in detail. It assesses how the individual provisions and combinations of those provisions are likely to affect the efficiency of water use and the welfare of agricultural producers and urban water users. The study contains detailed estimates of the costs the agricultural sector will incur and the benefits the urban sector will receive.

In addition to addressing specific questions about the effects of water reform in California, this study looks more generally at water conflicts in the entire West. It also explains how the reforms begun in California might—or might not—apply in other areas.

Chapter Two

Water Use in the Western United States

First and foremost, western rivers provide water to agriculture to grow crops. They also help cities meet municipal and industrial needs for water and generate electricity. Other benefits that rivers provide—such as habitat for fish and wildlife, recreation, and cultural values for Native Americans—were historically ignored in the water equation but increasingly are considered legitimate and valuable uses. Demand for water by existing agricultural and urban users outstrips available supplies in many cases, however, so demand for water for public purposes or for increased urban supplies necessarily conflicts with existing patterns of water use. Those patterns, and the policies and institutions that guide them, are inextricably linked; that is, allocations have arisen in response to the policies and institutions that provide or encourage those allocations.

Perhaps the most important institution in the use and allocation of western water is the federal Bureau of Reclamation. Today it is at the center of many conflicts throughout the West. Understanding the distortions inherent in reclamation law is integral to understanding how current patterns of use came to be and how best to guide the bureau in alleviating various conflicts. Agricultural water use, in particular, can be understood only in the context of the policies of the Bureau of Reclamation.

Alleviating water conflicts in many areas of the West will require the bureau's involvement for two reasons. The first is its pervasive presence: the bureau's projects are located in all 17 western states and in virtually every major river basin. The sheer volume of water controlled in those projects means that the feasibility of addressing many conflicts depends on the bureau's participation. Second, the bureau's water supply policies, which have their roots in the 1902 Reclamation Act and its 1939 amendments, include below-cost water prices and a preference for agricultural use of water that are embedded in long-term contracts with water districts. Those policies began to evolve almost 100 years ago, when the West was sparsely populated and the government wanted to encourage irrigation and development. Those conditions no longer apply, but one legacy of that era is that, on average, farmers use more water and for lower-valued uses than they would if market forces were allowed to guide the use of water.

Types of Water Use

The diversion or withdrawal of water from river systems and the consumption of water are two related but distinct concepts for describing water use. A third type is in-stream use, which neither diverts nor consumes water.

Diversions and withdrawals are synonymous terms referring to the physical removal of water from its natural course. Water that is diverted from rivers meets several different fates. Some portion of diverted water is consumed by crops, people, or industrial processes, or it evaporates. Water that is consumptively used is lost to future beneficial uses. Water that is not consumptively used may flow back to rivers via overland channels (canals, ditches, or surface runoff) or seep into the ground, ultimately reentering river systems through

Table 1.
Diversion of Surface Water for Various Uses in Western and Eastern United States, 1990
(In percent)

Use	West	East
Irrigation	76	24
Thermoelectric Power	13	60
Municipal	8	9
Industrial	2	7
Livestock	1	0
Total	100	100

SOURCE: Congressional Budget Office using data from Wayne B. Solley, Robert R. Pierce, and Howard A. Perlman, *Estimated Use of Water in the United States in 1990*, U.S. Geological Survey Circular 1081 (1993).

lateral flows of groundwater or through municipal outlets for storm water and wastewater treatment plants. The length of time before diverted water is available for other uses can vary from region to region and even within a relatively small section of a single watershed.

The ratio of water diverted to water consumed varies by use. For example, diversions for thermoelectric cooling affect the water supply differently than those for urban uses. Thermoelectric power plants typically divert water only for cooling purposes, and 97 percent of that water returns to the source, albeit at altered temperatures. Thus, the production of thermoelectric power diverts large quantities of water but consumes very little. In contrast, municipal and industrial uses withdraw smaller quantities of water than thermoelectric uses but consume significantly more.

Water is diverted from rivers and streams for a number of purposes. The primary use of surface water in the western United States is for irrigated agriculture (see Table 1).[1] Diversions for thermoelectric power plants, such as those using fossil fuels or nuclear energy to generate electricity, are a distant second, followed by municipal and industrial uses. Table 1 displays water diversions in the eastern United States as a point of comparison. The significant difference in the percentage of water diverted for agriculture—76 percent in the West and only 24 percent in the East—is the most important characteristic distinguishing water use in those parts of the country.

In-stream water uses, which are nonconsumptive, are an important third category because dedicating water to those uses may reduce the quantity of water available for diversion or consumption. Examples of in-stream water uses include the production of hydroelectric power, fish and wildlife habitat, recreation, and navigation.

Agricultural Uses

In the West as a whole, 76 percent of all withdrawals of surface water are for agricultural purposes.[2] That figure is much higher in many individual western states and river basins. For example, approximately 95 percent of the water diverted from the Rio Grande and the upper basin of the Colorado River is used for irrigating crops or for livestock. In only five of the 17 western states does agriculture account for less than 80 percent of the diversion of surface water. All five—Kansas, Nebraska, North Dakota, Oklahoma, and Texas—are Great Plains states with access to large quantities of groundwater. Total agricultural water use in the West has remained relatively constant over the 1955-1990 period, declining slightly between 1985 and 1990.[3]

Power Production

Thermoelectric power plants use water to cool the reactors and condensers where electricity is generated using fossil-fuel or nuclear energy sources. In the eastern states, thermoelectric power accounts for more than half of all water diversions and is by far the largest single diverter. In the West, however, thermoelectric diversions account for only 13 percent of total withdrawals and are less than one-fifth the amount of water diverted for agriculture there. Although the production of

1. The western United States includes all 17 contiguous states west of the 100th meridian, the approximate line dividing humid regions to the east from those receiving less than 20 inches of rainfall per year. The 17 states are Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

2. Wayne B. Solley, Robert R. Pierce, and Howard A. Perlman, *Estimated Use of Water in the United States in 1990*, U.S. Geological Survey Circular 1081 (1993).

3. Ibid., p. 65.

thermoelectric power accounts for relatively large withdrawals nationwide, it consumes minimal amounts of water; less than 3 percent of water withdrawals for that purpose are consumptively used.

In contrast, producing hydroelectric power generally requires neither the consumption nor the withdrawal of water. Hydroelectric power is created when turbo generators are activated by falling water. Power plants are generally included in the base of large dams to harness the energy created when water is released from the associated reservoir.

Although water need not be diverted or consumed to produce hydroelectric power, achieving the greatest possible financial value from power production for a given quantity of water requires adjusting releases to match daily and seasonal fluctuations in demand. In many cases, the timing of water releases for hydropower production conflicts with environmental and agricultural needs for water. In the Pacific Northwest, for example, peak demand for power occurs in the relatively cold fall and winter months, but the greatest needs of endangered salmon in the region occur in the spring and summer when young salmon migrate to the ocean.

Urban Uses

The use of water for municipal and industrial purposes accounts for a small portion of total water use in the West—only 10 percent in 1990 (see Table 1). Although total quantities remain small, urban water use is growing. Population growth and regional development increase demand for a reliable supply of high-quality water. Municipal water use doubled between 1955 and 1990, increasing 5 percent from 1985 to 1990 alone.[4]

Environmental and Recreational Uses

Direct measures of environmental water use are difficult or impossible to obtain. The amount of water needed to sustain a fish population, for example, is harder to quantify than the amount needed to irrigate a field of cotton or the amount a family of four consumes. Fish may require a minimum amount of water for spawning and migration, or they may require water that is within a certain temperature range. Although those requirements vary by species and river basin, one rule of thumb holds that 30 percent of average annual flows is the minimum amount needed to protect fish populations.[5] Rivers in the southern portions of California and Arizona, the headwaters of the Platte and Arkansas Rivers, rivers in the San Joaquin Valley, the Rio Grande, and rivers in closed basins in Nevada, Utah, and California have failed to meet that standard in most years.[6]

Recreational uses of water include activities that benefit from reservoirs (such as boating, waterskiing, swimming, and fishing) as well as those more suited to free-running rivers and streams (such as whitewater rafting and fishing). Many recreational activities depend on the health of fish and wildlife populations—fishing, bird-watching, and duck hunting are several examples. Thus, the need for water for purely environmental purposes, such as the preservation of a fish species, may be difficult to distinguish from the need for water for recreation.

Although environmental and recreational uses of water are considered nonconsumptive, they may conflict with other uses. In river systems modified by extensive water development, adjusting water regimes to benefit fish, wildlife, and recreation may require reducing the amount of water used for other purposes. For example, adjusting the timing or location of water releases from dams to improve conditions for fish or whitewater boating may reduce the value or quantity of hydroelectric power produced with that water. Similarly, the amount of in-stream flows required to protect fish habitat may restrict the diversion of water for irrigation.

4. Ibid.

5. Donald Tennant, *Instream Flow Regimes for Fish, Wildlife, Recreation, and Related Environmental Resources* (Billings, Mont.: U.S. Fish and Wildlife Service, 1975).

6. Keith Bayha, *Instream Flow Methodologies for Regional and National Assessments*, Instream Flow Information Paper No. 7, FWS/OBS-78/61 (Department of the Interior, U.S. Fish and Wildlife Service, Cooperative Instream Flow Service Group, December 1978), p. 43. Although that study is 19 years old, it remains the most current, comprehensive work on the subject. Total use of surface water has remained relatively constant in the intervening years. Thus, the assessment is probably still valid.

Native American Water Uses

Claims to water rights by Native Americans are another source of conflict in allocating water. Though not technically a distinct use, since tribal water is generally used for agricultural, municipal, or environmental purposes, resolving outstanding claims could reduce the amount of water available for other users and uses. The U.S. Supreme Court ruled in 1908 that in establishing a reservation for Native Americans, the Congress implicitly reserved rights to a quantity of water sufficient to meet the needs of the reservation.[7] The right to the water is based on the date the reservation was created and thus predates existing uses in most cases. The tribes, however, typically have not exercised those rights, and in many cases subsequent users have appropriated the water to which the tribe was entitled.

More recently, many tribes have asserted their water rights but for the most part have had only modest success in wresting water from long-established users. Many disputes remain unresolved, and most tribal water rights are unquantified. Other disputes have been settled on the presumption that new water projects, such as the Animas-La Plata Project on the Colorado/New Mexico border and the Central Utah Project, would satisfy water requirements. (The Congress initially authorized both projects in the 1960s, but neither has been completed.) Litigation and negotiation between 1963—the first time tribal rights were quantified in court—and 1992 resolved 16 separate claims for a total of 4.7 million acre-feet of water. (An acre-foot is the volume of water that would cover one acre to a depth of one foot.) Half of those settlements occurred between 1990 and 1992.[8] In a landmark case in 1989, the U.S. Supreme Court affirmed a decision by the Wyoming Supreme Court allocating to the Wind Rivers Tribe 0.5 million acre-feet of water used by local, nontribal users. Litigation is continuing over the manner in which the tribe can take and use that water.

How Native Americans' claims to water rights will affect the supply of water is anybody's guess. According to one estimate, which was based on the amount of water needed to irrigate eligible cropland on the reservations, outstanding tribal claims in 14 western states totaled 45.9 million acre-feet in 1984.[9] That estimate represents 45 percent of the total use of surface water in those states. Actual settlements since 1984 total 3.7 million acre-feet, less than 10 percent of the estimated outstanding claims. It is not clear, however, whether the divergence between potential claims and actual settlements arises because relatively few cases have been settled or because the amounts of water awarded are small relative to the estimate of claims. In any case, resolution of outstanding claims could result in a substantial departure from current patterns of water use in many river basins.

Conflicts Over Water Use in the West

Conflicts between agricultural, urban, environmental, and tribal uses of water exist throughout the West, although the nature of the conflicts and their potential solutions differ from location to location. One common factor is the presence of at least one fish species with federal endangered or threatened species status in all major river basins in the West. Attempts to protect those species could force adjustments in current or future patterns of water use. Urban water needs are acute in some areas but not in others. The specific nature and relative importance of those and other factors vary by region. Examples drawn from California's Central Valley, the Pacific Northwest, the Colorado River basin, and the Great Plains states illustrate that variety.

7. *United States v. Winters*, 207 U.S. 564, 28 S. Ct. 207, 52 L. Ed. 304 (1908). For a discussion of federal reserved water rights and the so-called Winters Doctrine, see David H. Getches, *Water Law in a Nutshell*, 2nd ed. (St. Paul, Minn.: West Publishing Co., 1990), Chapter 8; or Joseph L. Sax, Robert H. Abrams, and Barton H. Thompson, Jr., *Legal Control of Water Resources: Cases and Materials*, 2nd ed., American Casebook Series (St. Paul, Minn.: West Publishing Co., 1991), Chapter 9.

8. Benjamin Simon and Harvey Doerksen, "Conflicting Federal Roles in Indian Water Claims Negotiations," Chapter 2 in Thomas R. McGuire, William B. Lord, and Mary G. Wallace, eds., *Indian Water in the New West* (Tucson: University of Arizona Press, 1993).

9. Western States Water Council, *Indian Water Rights in the West* (study prepared for the Western Governors' Association, Denver, Colo., May 1984).

California's Central Valley

The Central Valley is characterized by large-scale water projects that move water long distances in artificial canals. The largest of the projects is the Bureau of Reclamation's Central Valley Project. The point of diversion for those canals is a delta ecosystem that is home to 37 species that are either listed or are candidates for being listed as threatened or endangered under the Endangered Species Act (ESA).[10] In addition, although the Central Valley Project has the infrastructure to move at least a limited amount of water from relatively low-valued agricultural uses to higher-valued urban uses, such diversions of water have been inhibited by federal policies. Drought and environmental restrictions on water diversions have reduced available supplies of surface water in recent years—a period in which agricultural demand has remained constant and population growth has increased urban demand. Concurrently, the general state of decline in the delta ecosystem has prompted calls for more water for environmental purposes. The Central Valley is discussed in detail in Chapter 4.

The Pacific Northwest

Water conflicts in the Pacific Northwest arise primarily over how to manage the flow of the Columbia and Snake Rivers—to produce hydropower or to protect three salmon species with federal status as threatened or endangered.[11] Most parties concede that efforts to protect and enhance populations of the ESA-listed salmon will require some modification of water allocations in the region. Those changes could affect regional power users, agriculture, and navigation. In contrast to California and the Colorado River basin, urban water supplies in the Pacific Northwest are generally sufficient and are not considered a source of conflict.

Federal water projects are important links in efforts to protect salmon. The Army Corps of Engineers operates the primary reservoirs targeted for lower water levels to help reduce the amount of time it takes young salmon to migrate to the ocean. Bureau of Reclamation projects have been asked to provide water to help the salmon population recover, even though the projects are not directly implicated in problems facing the endangered salmon.[12] The Northwest Power Planning Council—a federal entity responsible for balancing the needs of fish and wildlife in the Columbia River basin with hydropower and other traditional uses of the river—has recommended that the government acquire water from irrigators near the upper Snake River in order to improve conditions in the lower Snake River for the ESA-listed fish.

One prominent proposal calls for a minimum of 0.427 million acre-feet to augment the flow, with the possible addition of another 1.0 million.[13] Unobligated storage space in reservoirs may provide some of that quantity, but as much as 1.127 million acre-feet might need to be obtained from farmers to meet those objectives. Another proposal contains flow objectives for the Columbia and Snake Rivers, rather than the volume objectives for augmenting the flow contained in the earlier proposal.[14] Nevertheless, in years in which the natural flow is low, obtaining water from farmers in the upper Snake River basin may be necessary to meet the flow objectives. One study predicts that as much as 9.6 million acre-feet could be required in an extreme drought and that water purchases could average be-

10. Information provided by the U.S. Fish and Wildlife Service, Sacramento, Calif., July 1996. That number includes seven species that the service has officially proposed listing as threatened or endangered.

11. Snake River sockeye were listed as endangered on November 20, 1991. Two additional runs—the Snake River spring/summer and fall chinook—were originally listed as threatened but are being reclassified as endangered (emergency rule issued August 18, 1994, and proposed rule issued December 28, 1994).

12. The bureau's Grand Coulee Dam on the Columbia River, which is impassable by migrating fish, eliminated all salmon runs that spawned in the stretches of the river above the dam. (The Army Corps of Engineers' Chief Joseph Dam, which is downstream from Grand Coulee and also is impassable by salmon, was constructed 16 years after Grand Coulee was completed.) Because those salmon runs are now extinct, they are not protected by the ESA. The salmon runs currently of most concern travel up the Columbia to its confluence with the Snake River, spawning in tributaries of the latter. The bureau's largest project in Washington—the Columbia Basin Project—is served by the Grand Coulee Dam. Likewise, Hells Canyon Dam on the Snake River in Idaho blocks passage of salmon to the upper Snake River where the bureau's Idaho projects are located.

13. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, *Proposed Recovery Plan for Snake River Salmon* (March 1995).

14. Bonneville Power Administration, Army Corps of Engineers, and Bureau of Reclamation, *Columbia River System Operation Review: Final Environmental Impact Statement* (Portland, Ore., November 1995).

tween 1.1 million and 3.15 million acre-feet per year.[15] Most of that water would have to come from farmers who receive their water from the Bureau of Reclamation. Furthermore, the bureau is the lead agency attempting to purchase that water.

Conflicts also arise between agricultural and hydropower uses of water in drought years. When water is scarce, the value of water used to produce hydropower may be greater than the value that can be generated from agricultural uses.

Local conflicts exist as well. In the Yakima River basin, resolution of claims to water rights made by the Yakima Indian Nation and concerns about the declining stock of native salmon may require adjustments in the amount of water delivered to agriculture, including water managed by the Bureau of Reclamation.

The Colorado River Basin

Conflicts exist in the Colorado River basin between the upper and lower basins and between agricultural, environmental, urban, hydropower, and Native American uses of water. Conflicts between upper- and lower-basin states have been particularly contentious. Those conflicts are international as well; water use in the United States reduces flows and increases the salinity of the Colorado River when it crosses the Mexican border.

The Colorado River is not only fully allocated; it is overallocated. An interstate compact has allocated 17.5 million acre-feet of water among the riparian states, but estimates of actual average annual flows range from 13.5 million to 15.0 million acre-feet. Shortages have not arisen in most years because most states have not yet developed the infrastructure needed to capture their allocation.

Two new Bureau of Reclamation projects could reverse that situation. The recently constructed Central Arizona Project enables Arizona to take its entitlement, and completing the Central Utah Project would do the same for Utah. Based on current expectations of population growth and project development, the states in the basin will be able to take their full entitlement by 2040. The question of how to allocate the shortage between actual flows and the 17.5 million acre-feet in allocations that would occur at that time has not yet been addressed. In addition, demands for water arise from other sources: Native Americans' claims to the rights to an estimated 31 million acre-feet in Arizona alone[16]; environmental requirements for addressing fish and wildlife habitat (28 fish species with habitat in the Colorado River and its tributaries are listed as threatened or endangered under the federal ESA); and the need to address problems related to salinity levels.

The Great Plains Region

Of all the western regions, conflicts over water use are most localized in the Great Plains states. The Bureau of Reclamation's largest project in the region—the Colorado-Big Thompson Project—diverts water from the Colorado River through the Rocky Mountains into the Platte River basin. That out-of-basin diversion may contribute to environmental problems in the Colorado River basin, but the additional water may benefit threatened and endangered species, such as the whooping crane, that have important habitat in the Platte River. Extensive development along the north and south forks of the Platte River, however, could conflict with efforts to protect threatened and endangered species in the area. Similarly, endangered sturgeon in the Missouri River could become the focus of conflicts in that basin.

Other issues include claims by Native Americans, overallocated river basins, and declining groundwater tables. A significant number of claims by Native Americans may remain unresolved; for example, claims for 5.1 million acre-feet of water in Montana and 1.3 million acre-feet in South Dakota were unresolved as of May 1992.[17] Rivers are overallocated, and water rights

15. Daniel D. Huppert and David L. Fluharty, "Economics of Snake River Recovery: A Report to the National Marine Fisheries Service" (draft, School of Marine Affairs, College of Ocean and Fishery Sciences, University of Washington, Seattle, March 1996). This report discusses the economic impact of purchasing water to meet both the flow objectives and the 1.427 million acre-feet volume objective for flow augmentation.

16. Sax, Abrams, and Thompson, *Legal Control of Water Resources*, p. 873.

17. Calculated by the Congressional Budget Office based on information in Sax, Abrams, and Thompson, *Legal Control of Water Resources*; Western States Water Council, *Indian Water Rights in the West*; and Simon and Doerksen, "Conflicting Federal Roles in Indian Water Claims Negotiations," pp. 27-34.

that exist on paper exceed average flows in some basins. Conflicts in the Arkansas River basin are particularly contentious and may affect operations of the Bureau of Reclamation's Arkansas-Fryingpan Project. Finally, groundwater tables that are falling because of excessive pumping for irrigation or municipal uses have increased demands for access to surface water or decreased supplies of surface water (where groundwater aquifers are closely linked to river systems). Those problems are particularly acute in the Texas high plains.

The Role of the Bureau of Reclamation in Developing Water Supplies

The Bureau of Reclamation is firmly positioned near the center of controversies over water allocations throughout the West and therefore must be a component of effective, long-term solutions. Since passage of the Reclamation Act of 1902, the federal government, through the Bureau of Reclamation (and its predecessor, the Reclamation Service), has provided water to encourage settlement of the arid West. In 1996, the Bureau of Reclamation's budget was about $800 million.

The bureau now controls significant shares of river flows throughout the West. The agency diverts between 40 percent and 85 percent of the annual flow of major western river systems such as the Colorado, Rio Grande, Snake, Sacramento, and San Joaquin.[18] To fulfill its mission, the bureau allocated nearly all of that water to agricultural uses and built a number of subsidies into the payment scheme to ensure that the water would be affordable to farmers. The large quantities of water involved and the nearly single-purpose allocation imply that attempts to adjust patterns of water use in any of those river basins will require the bureau's participation.

Use of Water Developed by the Bureau of Reclamation

Agriculture uses most of the water developed by the Bureau of Reclamation, receiving 85 percent in 1992, the last year for which data were published.[19] Municipal and industrial uses received 10 percent, with the Los Angeles area receiving about 45 percent of that quantity. However, municipal and industrial water uses are increasing; between 1970 and 1990, the bureau's delivery of water to those uses more than doubled. Pressure to supply greater quantities of water to urban areas will only increase over time.

Water managed by the bureau is also used to produce electricity. Many of its projects include power-generating facilities. Though not a consumptive use of water, the capability to produce power has implications for the financing of water projects and for the prices farmers pay for water. Power produced from the bureau's projects is used first to provide the electricity needed to pump water into and along distribution canals. Any excess power is then marketed by two federal power marketing agencies housed in the Department of Energy—the Bonneville Power Administration (in the Pacific Northwest) and the Western Area Power Association.

Importance of the Bureau's Water to Western Agriculture

The Bureau of Reclamation is the largest supplier of irrigation water in the United States. Over 150,000 farms in the 17 western states receive water from the bureau annually. Its water irrigates roughly 10 million acres—about half of all cropland irrigated by surface water in the West. Although that acreage represents only 5 percent of western cropland, it accounted for 25 percent of all revenue generated from crop production in western states in 1992.[20] The high per-acre revenues arise from the high yields for staple commodities and the production of high-value specialty crops. For ex-

18. Michael R. Moore and Donald H. Negri, "A Multicrop Production Model of Irrigated Agriculture, Applied to Water Allocation Policy of the Bureau of Reclamation," *Journal of Agricultural and Resource Economics*, vol. 17, no. 1 (July 1992), pp. 29-43.

19. Bureau of Reclamation, *1992 Summary Statistics: Water, Land, and Related Data* (1992).

20. Congressional Budget Office estimate based on data in Bureau of Reclamation, *1992 Summary Statistics: Water, Land, and Related Data*; and Bureau of the Census, *1992 Census of Agriculture* (1993).

Box 1.
Water Districts

Hundreds of local water districts, composed of and directed by district landholders, are chartered under state law to distribute water to their members. Those quasi-governmental entities can appropriate water, construct reservoirs and distribution systems, and enter into contracts with federal or state water suppliers. Most of the Bureau of Reclamation's water is supplied through local water districts.

Districts come in all types and sizes. They may be chartered as water districts, irrigation districts, or mutual water companies, among other types. The duties, rights, and organization are essentially the same for all types. One primary difference involves the criterion for member votes; for example, irrigation districts generally operate under a one landholder/one vote rule, whereas water districts usually allocate votes based on the value of landholdings (for example, one vote per $1 of assessed land value). In California, irrigation and water districts are the most common types. Their sizes vary considerably, from very small districts serving only one farm to one California district that encompasses more than half a million acres. In some states, the most common type of water supply organization is a mutual water (or ditch) company. Mutuals are nonprofit cooperative organizations that generally sell stocks or shares to members. Water and costs are distributed among shareholders in proportion to the size of their share. In this study, the term "water districts" is used generically to describe all types.

Water districts determine retail water prices. Districts can recover their costs by charging per-unit prices for water use, or they can assess charges that are independent of the quantity used, such as a fixed charge per acre or per household. In California, for example, approximately one-third of all irrigation water is distributed on a per-acre fee assessment rather than being priced on a per-unit usage basis. Those pricing procedures reflect the district's need to generate only enough revenue to meet operating expenses and debt without making a profit; under California law, all water districts are not-for-profit entities. Even districts that price water on a usage (per acre-foot) basis may cover some of their costs with land-based assessments. Where charges for water use exist, farm-level (retail) water prices may be much higher than the rates that districts pay to suppliers such as the Bureau of Reclamation.

ample, that acreage produces 60 percent of the vegetables and 25 percent of the fruits and nuts grown in the United States.

The Bureau's Policies for Pricing Irrigation Water

The Bureau of Reclamation supplies water to agricultural water districts with which it has long-term contracts. The water districts are composed of individual farmers (see Box 1). The contracts specify subsidized prices and fixed water allotments. Reclamation law requires that contracts for water delivery be made between the Bureau of Reclamation and a water district organized under state law. That institutional requirement has important implications for the potential effectiveness of policy reforms (discussed below and in the section on price reform in Chapter 3).

Allocation of Costs. The Bureau of Reclamation determines water prices based on a complicated formula for allocating the costs of building and financing a water project among the various groups of users. In so doing, the bureau must determine both the percentage of the costs attributable to each use and then, given the allocation of the total costs, the actual amount it will charge each user group. Both calculations tend to be highly favorable to agriculture.

For multipurpose projects—those whose purposes may include flood control, recreation, hydropower production, and municipal and industrial uses in addition to agriculture—the Reclamation Projects Act of 1939 directs the Secretary of the Interior to allocate costs to each of the uses based on the proportion of the benefits each use receives from the project. However, it is rarely clear exactly what portion of a project's costs or benefits is attributable to a given use, and the ultimate calculation is somewhat subjective. For example, suppose a single dam stores water for irrigation, provides flood control, and generates hydropower. The cost of the turbines for generating electricity are charged to electricity users, and the costs of canals that bring irrigation water to farms are charged to agriculture, but how should the cost of the dam itself be apportioned? Thus, even if agriculture receives 90 percent of the water developed by that project, its share of the costs may be much smaller. Project costs associated with public purposes are not allocated to any user group; the government pays the costs. Such uses include flood control, recreation, fish and wildlife, and Native American uses.

The formula for allocating the costs of financing construction also benefits agriculture. The government pays the interest charges on the portion of costs allocated to irrigation, but electricity users and urban water users must pay interest charges on their portion of the cost of constructing the project. In addition, all users benefit from being able to spread repayment over a long period. The terms of that financing typically allow 40 years to repay the project's costs, and they delay the start of the repayment period up to 10 years from the date the project is completed. For farmers, that is analogous to a 50-year interest-free loan for building irrigation projects.

Finally, in addition to being relieved of the obligation to pay interest charges, farmers may be obligated to reimburse the federal government for only a portion of their share of a project's construction costs. If the bureau determines that the portion of costs allocated to farmers will result in a price that exceeds the farmers' ability to pay—that is, the amount farmers can pay and still realize a minimal profit—the repayment obligation is reduced to the amount the bureau calculates that farmers can pay. Electric power users must pay the difference between the amount of project costs allocated to agricultural uses and the amount that agriculture will pay (based on the reduced repayment obligation).[21]

Substantial federal subsidies for irrigation-related construction costs arose from that combination of pricing policies. The present value of federal outlays made between 1902 and 1986 for such projects was $22 billion to $23 billion (in 1986 dollars).[22] The present value of the money repaid by irrigators over that same period was $2 billion. The repayment figure may ultimately increase by another $1 billion, based on existing contracts. Thus, the federal government's contribution to the cost of constructing and financing irrigation projects amounts to about 85 percent to 90 percent of the total cost allocated to irrigation.

The Relationship Between Costs Allocated to Water Districts and Prices Paid by Farmers. Contracts made with water districts, rather than directly with farmers, create a buffer between the Bureau of Reclamation and farmers that may impede the effectiveness of reforming water prices. Farmers make decisions about water use based on the prices that districts charge them, not on the rates that the bureau charges districts for the water. Districts charge farmers in one of two ways: on the amount of water they use (dollars per acre-foot) or on the size of their farm (dollars per acre) regardless of the quantity of water actually used. Those pricing structures, which are designed simply to generate enough revenue to meet the district's repayment obligations, often provide no incentive to farmers to use water efficiently and may even encourage them to increase their water use.

21. For a more complete description of the historic development and components of the bureau's subsidies of water prices, see Richard W. Wahl, *Markets for Federal Water: Subsidies, Property Rights, and the Bureau of Reclamation* (Washington, D.C.: Resources for the Future, 1989), Chapter 2.

22. Wahl, *Markets for Federal Water*, pp. 34-38, presents these estimates of costs and repayment. The range of costs reflects different assumptions about interest rates.

Chapter Three

Issues in Reforming Federal Water Policy

The problems outlined in Chapter 2 suggest three potential objectives for reforming water policy. The first objective is to improve the efficiency of water allocations among the primary commercial water uses—agriculture, municipal and industrial uses, and production of hydroelectric power. Current allocations often result in vastly different values of water being placed on those different uses. Some reallocation could improve social welfare. The second objective is to increase the amount of water allocated to public purposes, such as meeting environmental needs (improving water quality and providing habitat for fish and wildlife) and satisfying the claims of Native Americans. The third objective is to address distributional issues: Who benefits from current and new policies? Who pays? Should the federal government capture more of the value of water through higher fees?

Different objectives can require different policy tools. Improving the allocation of water among commercial uses, for example, could be accomplished with water markets that allow farmers to sell, or "transfer," their water allocation to the highest bidder. But that policy tool probably would not work as well for addressing environmental concerns, which typically are not well represented in markets. In addition, a policy tool that is best for achieving one objective may actually work against a different objective. For example, an out-of-basin water transfer—that is, the diversion of water from one river basin into another—could improve the efficiency of water use but could hurt fish and wildlife inhabiting the stretch of river below the diversion point.

Policy tools that would be effective individually could become ineffective if implemented in combination with other policy tools. For example, reforming water prices—that is, changing the price the Bureau of Reclamation charges for water—might not motivate changes in behavior if combined with a water market, although it would still raise federal revenues. Because no one policy tool is best at achieving all three objectives, a package of policy tools may be necessary for addressing them.

Tools for Reforming Federal Water Policy

An underlying implication of reform objectives is that farmers use too much water and pay too little for it as a consequence of the Bureau of Reclamation's policies on water supply, and that farmers will continue to do so in the absence of reform. Policy tools in that context are the actions that the bureau can take to require or create incentives for current water users to change their patterns of use.

A critical component in reforming water policy is the effort by farmers to conserve water. Because all options for conserving water are costly, farmers will voluntarily undertake them only if the economic or opportunity cost of using water exceeds the costs of conserving—that is, if water becomes more expensive, if the value of not using water increases relative to conservation costs, or if the cost of conserving water is reduced. An alternative is a mandatory reduction in the quantity of water available. Tools for reforming the bureau's policies on water supply typically address one of those conditions. Broadly defined, those policy tools include:

- Creating water markets,
- Reforming water pricing policies,
- Mandating water reallocations for public purposes, and
- Setting up (or mandating) water conservation programs.

Both the cost and the effectiveness of policy reform will depend on the package of policy tools selected. Moreover, a tool that works well on its own may have little or no effect if combined with other tools.

Creating Water Markets

Water markets can create a win/win situation for participants. Farmers will be better off because they will transfer water only if the benefit from doing so is greater than the cost (or forgone profits) of not using the water. Water users with insufficient supplies—primarily urban customers—will also be better off because purchasing water from farmers can cost significantly less than buying water from the next-cheapest source. The total benefit of using the bureau's water will increase because the transfers allow water to be put to higher-valued uses.

Water markets are most effective for addressing the first objective—improving the efficiency of water allocations among private economic uses. In the southwest regions such as California and the lower Colorado River basin, where excess demand by cities is great, water markets can be particularly effective in moving water from agricultural uses to urban uses. In the Pacific Northwest, the value of water used in producing hydropower may be higher than its value in agriculture in drought years.[1] A water market can, in theory, reduce inefficiencies in allocations between those two uses, although state laws such as those in Idaho may create a greater impediment to water markets in the region than do the Bureau of Reclamation's policies.

Water markets will be less effective for addressing the second and third objectives—public purposes and fairness. Purchases of water for public purposes have occurred and could be encouraged in the future. Environmental advocacy groups occasionally are able to buy water for in-stream uses in much the same manner that the Nature Conservancy, for example, buys land to preserve open space. Government agencies also purchase water for public purposes. The Bureau of Reclamation recently purchased water in California, Nevada, and Idaho to protect endangered fish species in those areas. The Department of the Interior may also buy water as part of a settlement of Native Americans' claims to water rights.

Even so, environmental uses may have great difficulty competing in a water market with uses that carry a high economic value, such as municipal and industrial uses. Environmental uses are inherently public and therefore diffuse or even abstract, whereas the benefits from economic activities are local and observable. In an era of declining agency budgets and financially strapped environmental organizations, water markets may provide water for public purposes only when combined with a tool, such as an environmental surcharge, that provides funds for that purpose. Even if public interests are not represented in the market, the environment can be affected by changes brought about by water markets.

Although a water market is a relatively simple concept, establishing one can be quite complicated. Policymakers will have to resolve such issues as who will receive the water, how much water can be transferred, the legal constraints on the transfer, and the potential effects on local communities, water districts, and the environment. Authorizing legislation and regulations could include provisions to address those concerns.

Whose Water Is It? One question that arises in discussions about water markets is: Who has the right to capture the benefits from the proceeds of water sales? Some analysts argue that the government itself ought to sell federal water rather than allow farmers to capture the windfall profits from the transaction. After all, the argument goes, the water was developed with taxpay-

1. Joel R. Hamilton, Norman K. Whittlesey, and Philip Halverson, "Interruptible Water Markets in the Pacific Northwest," *American Journal of Agricultural Economics*, vol. 71, no. 1 (February 1989), pp. 63-75.

ers' dollars, so taxpayers—not farmers—should benefit from selling it.

The question of ownership has traditionally been resolved in favor of the farmers. Although water rights, which are issued by states, have been obtained by the Bureau of Reclamation in most cases, the U.S. Supreme Court has ruled that those rights are vested in the water user, not the federal government.[2] Moreover, the laws governing the bureau's policies contain many provisions designed to give water districts that have a contract with the federal government long-term rights to water deliveries. For example, the 1956 amendments to the Reclamation Project Act of 1939 give districts the right to renew contracts issued under the act.[3] In addition, once districts have paid the construction costs for which they were obligated, their rights to water deliveries are permanent as long as they continue to pay operation and maintenance costs. Those provisions created an expectation that water deliveries would continue indefinitely. Transfers of water by districts or farmers, rather than transfers by the bureau (that is, sales to noncontractors), are consistent with that expectation.

Allowing contractors to transfer their allotment leaves the government no worse off than it would be under current laws and practices, and it may accomplish societal goals of reducing inefficiencies in water use and allocations. In the absence of a water market, districts would continue to accept delivery of contract allotments. The bureau should be indifferent about whether water is delivered to the districts it has contracts with or to the recipient of a water transfer, as long as any additional transportation costs are paid for and the canals have sufficient capacity to carry the water. In fact, the government (and taxpayers) could benefit from a transfer because the bureau can charge more for water used by nonfederal contractors. For example, if an agricultural water contractor transferred water to an urban water district, that contractor would have to pay the Bureau of Reclamation for the water at the higher municipal and industrial rate, which incorporates interest charges, rather than at the contract rate, which is based on interest-free repayment.

How Much Water Can Be Transferred? The issue of how much water is eligible for transfer typically arises in the context of the effects on third parties. Farmers often divert significantly larger quantities of water than their crops consume. Much of the excess water returns to waterways and is subsequently diverted by farmers downstream. Transfers are typically limited to water that is used consumptively; that restriction avoids penalizing the farmers downstream whose water supply would otherwise be reduced but who would not be compensated for the water transfer. In practice, however, quantifying consumptive use is not a straightforward task.

One approach to defining the quantity of water eligible to be transferred requires that farmers who transfer water leave land fallow and gives them "credit" for the average consumptive use of the crop historically planted on that land. That approach limits the potential benefits of markets because it precludes options for increasing the efficiency of farms' irrigation as a means of freeing up water to be transferred. Water transfers based on improved irrigation systems or management would probably be significantly less disruptive to the agricultural community than would transfers based on fallowing land, and investments in new irrigation systems could even increase regional economic activity.

Are Transfers Consistent with Prevailing Laws? Some states have laws that preclude or limit water transfers. In general, state water law takes legal precedence over federal water policies. Some states—such as Colorado, Arizona, New Mexico, and Wyoming—have allowed relatively active water markets to develop. Other states impose constraints that severely limit the benefits of water transfers. In Idaho, for example, transfers typically operate through the Idaho State Water Bank. The bank limits payments to no more than the cost of the water to the farmer; farmers cannot profit from the transaction. Participating farmers also lose their priority for water deliveries in subsequent years.

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2. The two primary cases addressing the issue are *Ickes v. Fox,* 300 U.S. 82 (1937), and *Nevada v. United States,* 463 U.S. 110 (1983). Those cases and the general issue are discussed in General Accounting Office, *Water Transfers: More Efficient Water Use Possible, If Problems Are Addressed,* GAO/RCED-94-35 (May 23, 1994), pp. 49-50. For more detail, see Brian E. Gray, Bruce C. Driver, and Richard W. Wahl, "Transfers of Federal Reclamation Water: A Case Study of California's San Joaquin Valley," *Environmental Law,* vol. 21, no. 911 (1991), pp. 912-983.

3. Richard W. Wahl, *Markets for Federal Water: Subsidies, Property Rights, and the Bureau of Reclamation* (Washington, D.C.: Resources for the Future, 1989), p. 130. Also, see Chapter 6 for more detail on the relationship between the Bureau of Reclamation's policies and water transfers.

States may also be subject to compacts that guide interstate water allocations and can inhibit water transfers. For example, some water transfers in the Colorado River basin are subject to approval by a multistate commission operating under the Colorado River Compact, which divides available water flows between upper- and lower-basin states.

Even states that allow water markets may have laws that discourage the purchase of water for environmental purposes. Most western states recognize in-stream water uses (only New Mexico, Oklahoma, and South Dakota do not).[4] Nevertheless, the level of protection for in-stream flows varies significantly from state to state. Although case law and legislation are beginning to deal with that issue, the diversion of water remains a necessary condition to obtain an appropriative water right in many states. Consequently, no right can be granted for in-stream uses in those states, and water purchased for that purpose can be diverted by another water user. States can, however, build environmental protection into the laws governing water transfers. In Oregon, for example, water users may transfer water that has become available through conservation. However, only 75 percent of the conserved water may be transferred; the other 25 percent is reserved for in-stream uses.[5]

Are Local Communities, Water Districts, and the Environment Protected? Opposition to water markets often revolves around concerns for local communities, the integrity of water districts, and the environment. Local communities may be hurt if water transfers result in a significant drop in agricultural production. Water districts may feel threatened by water transfers made by farmers. Transfers by individual farmers may adversely affect the district's operations and planning process. In very large districts, the local impact of water transfers may be larger if transfers originate from a single farm than if a reduction in water use is spread over the entire district. In addition, a district's water delivery systems may require a minimum flow to be operative. Thus, water deliveries for farmers who do not participate in a water market could be adversely affected by farmers who do.

Because urban areas can generally outbid farmers in a water market, irrigated farming could be eliminated in many areas, and agriculture-based economies could collapse. However, with more than 80 percent of all water used in the West allocated to agricultural production, even a slight but sudden increase in available water can overwhelm the market; supply can easily exceed demand, causing prices to plummet. For example, adding just 10 percent of agricultural water to the market will increase urban water supplies by nearly half—more than is required under reasonable projections of demand for water in urban areas. Thus, a market will probably not transfer enough water out of agriculture to collapse local economies. For example, experience with the 1991 California Water Bank—a temporary water market established in response to a drought emergency—supports that argument. The bank purchased 800,000 acre-feet of water from farmers for $125 per acre-foot. Even though the bank's participants fallowed 166,000 acres, the negative impact on local economies was small.[6] Even under prevailing drought conditions, much of the water stored in the water bank went unsold.

A major concern about water markets is the potential impact on groundwater supplies. In some cases, farmers will want to substitute groundwater for the allocation of surface water that is transferred. In many areas, more groundwater is being withdrawn than is replenished. The declining supplies of groundwater raise two concerns about the relationship between water markets and groundwater reserves. First, the temptation to replace transferred water with groundwater may increase pressures on a resource that is already under stress. In the extreme, the overdraft of water tables can cause the aquifer to collapse, thus eliminating the possibility of future refill and use. Second, concerns arise about the fairness of one farmer using a common resource, which all farmers rely on, in order to profit from transferring an allocation of water.

The environment may be worse off or better off as a secondary effect of water markets. If water transfers divert water upstream from where it would otherwise be

4. Joseph L. Sax, Robert H. Abrams, and Barton H. Thompson, Jr., *Legal Control of Water Resources: Cases and Materials*, 2nd ed., American Casebook Series (St. Paul, Minn.: West Publishing Co., 1991), p. 160.

5. Ibid., p. 235.

6. Richard E. Howitt, Nancy Moore, and Rodney T. Smith, "A Retrospective on California's 1991 Emergency Drought Water Bank" (report prepared for the California Department of Water Resources, Sacramento, Calif., March 1992).

used, less water will be left in-stream between the old and new diversion points than without the transfer, and the environment will be worse off. That impact will be greatest with new out-of-basin transfers. Conversely, the environment may be better off if the new point of diversion is further downstream than the existing diversion. In addition, the environment will generally be better off if excess demand for water is satisfied by transfers rather than by building a new water supply project.

The environment may also be better off if water is transferred out of an agricultural region experiencing problems with water quality. For example, water markets can serve as an indirect solution to agricultural drainage problems in California or salinity problems in the Colorado River, or they can be used to replace diversions from water sources where the ecological implications would be greater.[7]

Reforming Water Pricing Policies

Price reform is a broad category that generally includes changing the price structure, changing the levels of prices, or changing both. Charging water districts higher prices for federal water may provide taxpayers with a better return on the government's investments in water projects and help efforts to reduce the federal deficit. Price reform is the most direct, and potentially the most effective, tool for reducing subsidies and addressing equity concerns regarding the portion of project costs that the federal government pays.

Higher water prices may also encourage efficient use of federal water. To do so, three conditions must hold:

- o Farmers must pay a per-unit price for water, and the price must not decline with the volume of water used.
- o Reforms must apply to the prices that farmers pay for water rather than simply changing the prices that districts pay.
- o Conserved water must be put to a higher-valued use.

Several factors make it difficult to design a federal water pricing policy that addresses the objective of allocating water more efficiently. First, as discussed in Chapter 2, the Bureau of Reclamation charges districts for water, but the farmers decide how the water is used. Furthermore, the bureau has no control over how districts pass the costs on to farmers. Some districts may not even have the capability to charge per-unit water prices. To do so, districts must have or install devices for measuring water use and a system of accounting for it. Without information about the exact level of water use, farmers would be unable to respond to price signals. To facilitate the use of per-unit water prices, the bureau could require districts to install measuring devices.[8]

Even if districts charge farmers per-unit water prices, however, those prices may not incorporate reform of the prices that districts pay the Bureau of Reclamation. For example, districts could charge farmers a single price for all water used based on the average of tiered rates, or they could cover the additional costs of price increases with a per-acre charge. Under either option, the price farmers paid would be lower than the price implied by the policy reform and thus would diminish the intended effect.

Second, whether water price reform will achieve efficient water allocations or environmental objectives will depend on the ultimate disposition of the conserved water. Even if districts charge farmers higher prices and farmers respond by using less water, the resulting greater efficiency in water use would not necessarily improve the allocation of water. Depending on federal and state law and district policy, that water could be left

7. For information about drainage reduction from water markets, see Gray, Driver, and Wahl, "Transfers of Federal Reclamation Water"; Marca Weinberg, Catherine L. Kling, and James E. Wilen, "Water Markets and Water Quality," *American Journal of Agricultural Economics*, vol. 75 (May 1993), pp. 278-291; and Ariel Dinar and John Letey, "Agricultural Water Marketing, Allocative Efficiency, and Drainage Reduction," *Journal of Environmental Economics and Management*, vol. 20 (May 1991), pp. 210-223. For information about salinity reduction from water markets, see J.F. Booker and R.A. Young, "Modeling Intrastate and Interstate Markets for Colorado River Water Resources," *Journal of Environmental Economics and Management*, vol. 26 (January 1994), pp. 66-87. An example of the potential for water markets to offset disparate environmental problems appears in Richard Coniff, "A Deal That Might Save a Sierra Gem," *Time*, April 3, 1989, pp. 8-12.

8. This requirement is included in the Central Valley Project Improvement Act and has been proposed for inclusion in conservation plans required under the Reclamation Reform Act of 1982 (discussed later in this chapter).

in-stream for environmental purposes, appropriated by another farmer in the basin, or used to irrigate additional cropland within the district.

A third factor is relevant to all three objectives. Contractual and legal restraints may inhibit the ability of the Bureau of Reclamation to impose water price reforms in some cases. The bureau has authority to revise prices only when contracts are new, renewed, or amended in response to a request by the contracting district.[9] The authority to impose environmental surcharges on existing contracts may be less restricted.

Reforming Price Structures. Changes in the price structure relate to how prices are conveyed to districts or farmers. Prices can be the same regardless of the quantity of water used or the type of use, or they can vary according to those factors. They can increase or decrease as the quantity consumed increases. Public utilities, for example, may offer lower prices to larger customers (bulk discounts), or they may charge higher prices for quantities consumed above a basic level. In the water arena, reclamation law includes a pricing preference for agricultural water users, who do not have to pay interest charges, over urban users, who do.

There are three types of price structures: uniform, tiered, and a per-acre or per-household charge. Uniform price structures charge the same per-unit price no matter how much water is used. Tiered, or block-rate, prices rise or fall in discrete jumps as the total quantity purchased rises. For example, the price might be $10 per unit for the first 10 units, $15 each for the next 10 units, $20 per unit for the next 10 units, and so on. An individual purchasing 13 units would pay $145 ($10 x 10 units plus $15 each for the next three). The marginal price—the price for the last unit—would be $15. By comparison, the average price would be $11.15.

Uniform prices can motivate farmers to use water efficiently if the price is set correctly. Tiered price structures can motivate the same decisions as uniform prices, but tiered prices have a smaller impact on farmers' income. According to economic theory, farmers decide whether to apply an additional unit of water based on the relative benefits and costs of using that unit. That decision is independent of the price of earlier units. Therefore, raising the price for all units or only for applications that exceed a specified number of units can encourage farmers to reduce their water use.

From a farmer's perspective, the advantage of a tiered pricing structure over a uniform price increase is that the higher price has to be paid on a smaller quantity of water. In addition, tiered water prices may seem fairer to farmers because they penalize the least efficient farmers most. Farmers who conserve water may pay the higher price on very few units, or on none at all. As with any policy-motivated price increase, the effectiveness of tiered water prices depends on the price levels and quantities in each tier.

If the objective of the policy reform is to reduce federal subsidies of water prices, the uniform price increase can be significantly more effective than tiered prices. Depending, of course, on the level of the price increases, tiered prices can preserve existing subsidies on a large portion of the water.

A per-acre or per-household charge is independent of the quantity of water used. In that case, the marginal price is zero. Such charges can never motivate an efficient decision about water use unless the supply of water exceeds demand.

Reforming Price Levels. The relative effectiveness of a price increase will depend on the level of the new price or prices. If target prices are below the value that farmers place on using water, increasing prices to that level will probably not change decisions about water use. The highest price that the Bureau of Reclamation can charge for water under reclamation law is the full-cost price, which covers the cost of construction (and the interest paid on the financing) and operation and maintenance. But that rate is an option only in limited cases (see Box 2). Once projects are repaid, the bureau can charge rates that cover only operation and maintenance costs.[10] For older projects, prices that reflect the full cost of water use are generally lower than prices that reflect the opportunity cost (the forgone value of water used for its best alternative purpose). For new

9. For an excellent discussion of the issue, see Duane Meacham and Benjamin M. Simon, "Forging a New Federal Reclamation Water Pricing Policy: Legal and Policy Considerations," *Arizona State Law Journal*, vol. 27, no. 2 (Summer 1995), pp. 507-557.

10. Ibid.

projects, however, full-cost prices may be significantly higher than most farmers can afford.

Environmental Surcharges. Environmental surcharges are price increases that can be applied generally or targeted toward certain user groups. They can be designed to discourage water use that is particularly damaging locally, or they can be intended simply to raise funds for environmental restoration projects. The Bureau of Reclamation can add surcharges to the rates it charges water districts and earmark the money for specific environmental purposes. The general principle behind environmental surcharges is to require the beneficiaries of a project (the water users) to help fund activities to alleviate any environmental damage the project creates.

Box 2.
Terms Relating to Water Prices

Rates Used by the Bureau of Reclamation

Contract Rate: Refers generally to the price of water specified in contracts between the Bureau of Reclamation and water districts for the delivery of water; that is, the price that districts are obligated to pay the bureau. Contracts will generally be one of two kinds: water service contracts or repayment contracts. Rates established in water service contracts typically were fixed in the contract at a level (specified in dollars per acre-foot) that was expected to cover operation and maintenance (O&M) costs associated with delivering water and to repay a portion of the construction costs. However, because of inflation, most rates do not currently cover even the O&M costs. Some newer contracts specify adjustable prices to be set at the cost-of-service rate (see below). Contract rates under repayment contracts were designed to recover the portion of project costs allocated to agriculture over the life of the contract and are not based on the quantity of water delivered in a given year.

Operation and Maintenance Rate: Covers the bureau's variable costs for operating and maintaining a project in order to deliver water to districts.

Cost-of-Service Rate: Covers the O&M and construction costs.

Full-Cost Rate: Covers all costs included in the cost-of-service rate, plus a component to cover interest charges for financing construction costs. A full-cost rate is defined in the Reclamation Reform Act of 1982 as the annual rate that amortizes, with interest, the outstanding (nonreimbursed) portion of expenditures allocated to irrigation facilities. Note that that price may be adjusted downward based on irrigators' ability to pay the costs. Thus, it includes the cross-subsidy from power users to irrigators.

Transfer Rate: Used in this report to refer to the price that water districts must pay to the Bureau of Reclamation if the district transfers water to another user. For example, under the Central Valley Project Improvement Act, districts that transfer water to farmers who did not previously receive federal water must pay the bureau the full-cost rate for the portion of water transferred, even if they would have paid only the contract rate had they used that water themselves.

Economic Concepts

Marginal-Cost Prices: Prices that reflect the change in the total cost associated with water use resulting from a one-unit increase in the quantity of water consumed. Prices equal to the marginal cost of a resource (including private costs and social costs, such as the cost to the environment) would motivate economically efficient decisions about water use.

Average-Cost Prices: Prices that spread the total cost associated with water use equally among all units. Prices are calculated as the total cost divided by the total quantity consumed. Those prices mask the fact that developing the last unit for consumption typically costs significantly more than developing the first unit.

Opportunity Cost: The forgone value of water used in its best alternative use. Suppose, for example, that a farmer pays $10 for an acre-foot of water and uses it to produce $10 worth of tomatoes. If that water could have been used for a different purpose valued at $100 an acre-foot, the opportunity cost of using it for tomatoes is $100 even though the out-of-pocket cost is only $10.

The two possible objectives for imposing environmental surcharges—financing environmental restoration projects and encouraging farmers to conserve water—can conflict. For example, setting a surcharge high enough to promote water conservation could result in lower total collections for the restoration project (see Appendix B).

As with other price reforms, achieving the second objective requires that the surcharges be added to the prices that farmers pay for water. Districts could decouple the surcharges from decisions about water use by imposing per-acre charges sufficient to cover the district's payment obligation to the bureau. In that case, farmers' water use would not change.

Mandating Water Reallocations for Public Purposes

Directly reallocating water from current uses may be the best way to obtain water for public purposes. If water is taken without compensation, however, that tool is potentially costly for current water users, primarily agriculture. The environmental impact of projects that develop the water supply and divert water for irrigation, for example, might best be addressed by increasing the amount of water that must be left in-stream.

The most direct manner of providing that water would be to mandate the allocation.[11] A mandate would probably arbitrarily reduce agricultural water supplies and would almost certainly be more expensive, or less economically efficient, than an alternative approach to securing the water that incorporates its worth to different farmers. Farmers would respond to economic incentives to reduce water use by eliminating the lowest-valued uses (for example, less profitable crops, such as wheat, or fields with low yields), and farmers with lower-valued uses would cut back more than farmers with higher-valued production (for example, more profitable specialty crops such as fruits and vegetables). In contrast, a mandatory reduction in water supply could affect high- and low-valued farming operations equally.

11. The Congress would probably first have to reauthorize the project and define fish and wildlife protection and enhancement as a purpose of the project.

Setting Up or Mandating Water Conservation Programs

Conservation programs can range from requirements to improve the efficiency of irrigation to incentives for farmers to use less water, such as cost sharing for improvements in irrigation technology. The Reclamation Reform Act of 1982 requires all agricultural water districts to have water conservation plans that have been approved by the Bureau of Reclamation, but implementation of those plans typically has not been enforced. The bureau is now revising the rules and regulations necessary to fully implement and enforce the act's provisions. It released an environmental impact statement for the proposed rules and regulations in February 1996 that addressed conservation plans.[12]

The proposed rule for the water conservation programs identifies four critical components that all plans must include. They are:

- A system for measuring and accounting for all water delivered by districts;
- A water pricing structure for farmers that is designed to encourage more efficient use of water;
- An information and education program for farmers that also promotes efficiency; and
- Designating a district coordinator for water conservation.

The first two were identified above as critical to an effective policy for reforming water prices. The ultimate disposition of conserved water is uncertain. The documents from the water conservation program clearly state that the bureau will leave that decision to the district.

12. Bureau of Reclamation, *Final Environmental Impact Statement: Proposed Acreage Limitation and Water Conservation Rules and Regulations* (February 1996). The proposed rules and regulations are published in the *Federal Register*, vol. 60, no. 63 (April 3, 1995), pp. 16922-16960.

Implications of Policy Combinations: Interactions and Redundancies

Policy tools can be implemented independently or in combinations, with varying effects. Different combinations of water markets, water allocations, and water price reforms can result in different outcomes. To be effective, economic incentives to motivate water conservation must change costs relative to benefits. If one policy results in a bigger change in costs than another, the latter policy could become redundant and therefore ineffective.

Combination 1: Water Markets and Tiered Water Prices

Combining tiered water prices with provisions for transferring water may render the tiered prices ineffective as a tool for encouraging water conservation. As long as the price at the top tier is below the market price, the tiered prices will not affect either the water market or a farmer's decisions about using or transferring water. As a result, less water may be allocated for environmental uses when water markets are combined with tiered water prices than when tiered prices are implemented alone.[13] The water market creates an alternative, higher-valued use for water that might have gone unused in response to the tiered prices. Thus, the incentive that tiered water prices may create to leave water in-stream may be eliminated when the tiered prices are combined with a water market.

Combination 2: Water Markets, Tiered Water Prices, and Repayment Rates

Combining a water market with the requirement that contractors reimburse the Bureau of Reclamation at a higher rate for water that they transfer—referred to as the repayment rate provision—than for water that they use themselves will increase agricultural water use and reduce water transfers relative to a scenario with a water market alone. The one case in which adding tiered water prices might affect the level of water transfers is when they are combined with the repayment rate provision. By increasing the cost for water that is used, the tiered prices will probably decrease agricultural water use and increase water transfers relative to a scenario with only a water market and repayment rates. However, that effect holds only for the portion of water subject to higher-priced tiers.

Combination 3: Water Markets, Tiered Water Prices, and Environmental Surcharges

Environmental surcharges on agricultural and urban users impose opposite incentives to change patterns of water use. By effectively imposing a tax on water used for agriculture, a surcharge tends to reduce the incentive to use water and increases the incentive to transfer it. Compared with a scenario with a water market alone, imposing a surcharge on agricultural water use but not on municipal and industrial use will probably cause agricultural water use to decline and transfers to increase.

If surcharges are in place for both agricultural and urban users, the impact will be driven by the larger charge. The addition of surcharges and repayment rates that are higher for water transferred than for water used in agriculture tends to reduce the incentive to transfer water. Farmers will use more water and transfer less than in a scenario with water markets and tiered water prices but no surcharges. That impact is determined by the surcharge; the tiered water prices have no additional effect on water use or transfers as long as the top tier is below the market price. An agricultural surcharge in that case reduces the magnitude of the changes in quantity relative to a scenario with a surcharge for urban users but not for agricultural users.

Combination 4: Water Markets and Water Allocations for Public Purposes

Water allocations for public purposes guarantee that water will be available for environmental uses and Na-

13. This discussion assumes that state water laws are consistent with allowing water conserved in response to tiered water prices (or other policy tools) to remain in-stream. In some states, other irrigators would have the right to divert that water.

tive American tribes. Because most developed water is fully allocated, allocations for "new" uses generally must be taken from current users. Uniform methods for taking the water, such as across-the-board decreases in water for current users, generally do not result in a least-cost approach to acquiring that water. Combining the water reallocation policy with a water market allows for an efficient allocation of the remaining water between agricultural and urban uses and within agriculture.

Matching Reform Objectives with Policy Tools

Whether any single policy tool or combination of tools is appropriate will depend on the objective of the policy reform. The actual effectiveness of a policy will depend on a myriad of details regarding the nature of the problem and the specific provisions of the regulation or legislation. Nevertheless, some general conclusions can be drawn. Table 2 summarizes the probable effectiveness of different tools for meeting the three objectives of reform.

Encouraging voluntary water transfers through a water market will be most effective in improving the allocation of water among competing economic uses. Water markets may alleviate conflicts between urban and agricultural water users as well as facilitate the movement of water to higher-valued uses within the agricultural sector. They will be much less effective in areas where urban and agricultural water users are not competing for a given water source. In some areas, environmental groups or government agencies might purchase water for environmental purposes, but because environmental water uses typically do not generate revenues, society's preferences for environmental water may not be fully represented in a water market. Water markets can help increase payments to the federal Treasury because water transferred to municipal and industrial purposes is repaid at higher rates than irrigation water, but that return to the Treasury would probably be small.

Water price reform can be an effective tool for encouraging water conservation and increasing the return to the federal Treasury from investments in water projects. However, a legal foundation for price increases may not exist under current laws and contracts. Moreover, the disposition of conserved water is uncertain. It could be diverted by other farmers. If a water market is in place, it could go to urban communities. Price increases would be effective in addressing environmental problems only if water use was reduced in response to the price increase and the conserved water remained in-

Table 2.
Potential Effectiveness of Selected Policy Tools for Alternative Conflicts and Reform Objectives

	Policy Tools			
Reform Objectives	Water Markets	Water Price Reform	Environmental Allocation	Conservation Programs
Address Inefficient Allocations Between Economic Uses				
Intra-agriculture	Strong positive effect	Possible positive effect	No effect	Possible positive effect
Agriculture/urban	Strong positive effect	Probably no effect	No effect	Uncertain effect
Address Public-Purpose Needs	Possible positive effect	Possible positive effect	Strong positive effect	Possible positive effect
Address Fairness Issues/Deficit Reduction	Probably no effect	Positive effect	Negative effect	Negative effect

SOURCE: Congressional Budget Office.

stream, or if the price increase was an environmental surcharge and the receipts were earmarked for spending on environmental purposes. A surcharge would not reduce the deficit, however, unless those funds financed environmental projects that the federal government would otherwise have undertaken.

Combining an environmental surcharge with a water market creates a source of revenue for the environment that can increase the potential of water markets to address environmental objectives. However, that combination can reduce the effectiveness of price increases and surcharges in encouraging farmers to conserve water.

Of all the policy tools, allocating water for public purposes is the most likely to protect those uses. In contrast, reallocating water from current users reduces the system's flexibility to address inefficiencies in allocating water among agricultural users or between agricultural and urban users. In addition, if the allocation for fish and wildlife increases the nonreimbursable portion of project expenses, returns to the Treasury will decrease and the federal deficit might increase under that policy.

Conservation programs may be appropriate for meeting environmental objectives in allocating water if the conserved water remains in the river, but the water might not stay there. For example, if a farmer who conserved water on one field used it to irrigate another, total water consumption could increase and water for environmental uses could decrease. Furthermore, states' water rights may allow other irrigators to divert any water freed up through conservation programs. In that case, conservation programs could be effective in addressing intra-agricultural inefficiencies but would be less so in addressing the environmental objectives.

Conservation programs, however, generally help reduce problems with water quality. Contaminants such as salinity and agricultural chemicals typically are moved to rivers by excess irrigation water. Encouraging or requiring more efficient irrigation practices would reduce that transport mechanism. Conservation programs that rely on incentives, such as cost sharing for improvements in irrigation systems, could increase the cost of operating the Bureau of Reclamation's programs.

Chapter Four

Water Development, Use, Conflicts, and Reform in California's Central Valley

Conditions in California's Central Valley illustrate both the success and the problems associated with the development of large-scale water projects by the Bureau of Reclamation. California's agricultural and urban economies are fueled by water imported from northern California. As in many other arid states, the location of demand for water does not coincide with supplies: 75 percent of water use in California occurs south of Sacramento, but 75 percent of water supplies are north of the city. Nearly 60 percent of the surface water used in California originates in the Central Valley rivers, and half of that is controlled by the Bureau of Reclamation in its Central Valley Project.

Conflicts over the allocation of water in California arise between agricultural water users, who historically have received federal water and have built economies based on having access to it; urban water users, who increasingly are facing water shortages and restricted opportunities for growth; and environmental uses, which are suffering from insufficient water supplies. Those conflicts are pressing on two fronts: among water uses and between geographic areas. Urban water districts outside the Central Valley recently joined forces with environmental interests in an attempt to gain access to water currently allocated to farmers in the Central Valley.

Several urban water districts developed secure, high-quality municipal water supplies early in the century. In each case, however, regional population growth has exceeded the system's capacity or is projected to do so within the planning horizon. In addition, each system is vulnerable to drought or environmental concerns. The Los Angeles metropolitan area is a case in point: the combination of population growth, reduced supplies of water from the Colorado River, and reduced diversions from the Mono Lake region have increased the pressure on remaining supplies.

Conflicts and conditions in California include a majority of those found in other western states. For that reason, and because it was the focus of recent legislation attempting to address those conflicts, the Central Valley Project (CVP) is the subject of a case study, presented here and in Chapter 5, designed to measure the potential impact of water policy reform.

In addition to describing historical water use and conflicts, this chapter provides context for empirical analysis of provisions of the Central Valley Project Improvement Act by describing base conditions in the agricultural and urban sectors directly affected by the act. Base conditions include historical levels of water supply in different uses and regions in California, and the crops that farmers produce with the water allocated to them. The conditions of supply and demand for urban water districts not currently using CVP water create a foundation for analyzing how municipal water districts might take advantage of the act's provisions for water transfers.

The Central Valley Project and Its Stakeholders

By many measures, the Central Valley Project dominates all other projects and most states in its importance to the Bureau of Reclamation. Initially authorized in 1935, the CVP now consists of 20 dams and more than 500 miles of major canals that, in years with a normal water supply, store and deliver 7 million to 8 million acre-feet of water. It is the largest, most ambitious water supply project in the country. Federal costs for constructing it totaled \$3.6 billion. Agricultural water users are obligated to repay \$1.3 billion, or 40 percent. Municipal and industrial and power customers are obligated to repay another \$1.1 billion. The remainder is nonreimbursable and must therefore be paid by taxpayers.[1] Thus far, water users have paid roughly \$500 million of their share of the costs.[2]

Agriculture in the Central Valley

Water supplies developed by the Central Valley Project have been instrumental in turning the valley, much of which is essentially a desert, into one of the world's most fertile agricultural regions. The CVP service area encompasses 2.6 million acres of cropland managed by 16,000 full-time farmers and 6,000 part-time farmers. Those farmers produce at least 60 different crops; three dozen are produced in significant quantities.

Most CVP farmers are organized into water districts that contract with the Bureau of Reclamation for CVP water and operate the distribution systems that deliver water to farms (see Box 1 in Chapter 2). Districts receive an average of 4.3 million acre-feet of project water in years without restrictions caused by droughts. Another 2.3 million acre-feet are delivered to farmers who hold their own rights to the water.[3] In an average year, roughly 90 percent of the water the CVP delivers is for agricultural uses.[4]

Table 3.
Selected Crops Produced with Water from the Central Valley Project as a Percentage of Total U.S. Production, 1987

Crop	CVP Production	Percentage of U.S. Production
Alfalfa Hay	1,726,000 tons	2
Almonds	106,000 tons	32
Apricots	86,000 tons	76
Barley	2,933,000 bushels	1
Beans (Dry)	1,134,000 cwt	4
Cotton	1,422,000 bales	10
Grapes (Table)	377,000 tons	7
Grapes (Wine, raisins)	1,253,000 tons	31
Honeydew Melons	2,702,000 cwt	56
Lettuce	5,087,000 cwt	7
Onions (Dry)	6,708,000 cwt	15
Peaches	172,000 tons	14
Prunes	152,000 tons	16
Rice	12,100,000 cwt	9
Sugar beets	1,331,000 tons	5
Tomatoes (Processing)	3,653,000 tons	48
Walnuts	44,000 tons	18
Wheat	11,219,000 bushels	1

SOURCE: Congressional Budget Office based on data from Bureau of Reclamation, *1987 Summary Statistics: Crop, Land, and Related Data* (1987); and Department of Agriculture, *Agricultural Statistics* (1990).

NOTES: To avoid distortions brought about by drought conditions, the table presents data for 1987, the most recent year for which data are available and normal water conditions prevailed. However, figures for 1992—a drought year—are very similar to those presented here.

CVP = Central Valley Project; cwt = hundredweight.

Annual revenue from the sale of crops produced with CVP water typically exceeds \$3 billion. In 1990, the CVP accounted for 41 percent of the gross value of crops produced with the bureau's water throughout the

1. Bureau of Reclamation, Mid-Pacific Region, *Central Valley Project: Plant in Service Cost Allocation* (Sacramento, Calif., September 30, 1994).

2. Smith Barney, "Central Valley Project Acquisition: Preliminary Valuation Analysis" (review draft prepared for the Central Valley Project Authority, Sacramento, Calif., September 11, 1995).

3. Farmers with rights to water from the Sacramento and San Joaquin Rivers before the CVP was established are generally in districts known as water rights holders (Sacramento River) or exchange contractors (San Joaquin River). To obtain permission to divert the San Joaquin River's flows to farmers on the east side of the valley, the Bureau of Reclamation offered water from the delta to preexisting rights holders in exchange for those water rights. Similarly, the bureau had to guarantee water to rights holders along the Sacramento River to gain permission to dam the river's flows. The bureau is obligated to deliver water without charge to those districts. In addition, the bureau's ability to reduce the quantity of water delivered is strictly limited. For example, when drought necessitated reductions of 75 percent for project contractors, deliveries to rights holders and exchange contractors were reduced by only 25 percent.

4. Congressional Budget Office estimate based on information contained in Bureau of Reclamation, *Summary Statistics: Water, Land, and Related Data* (1979-1991).

West, 21 percent of the acres irrigated by its projects, and 9 percent of the water it delivered to farms.

Crop Production. Much of the CVP water and acreage is devoted to producing staple commodities such as cotton, rice, alfalfa hay, and small grains. CVP farmers grow roughly 10 percent of all U.S. cotton and rice (see Table 3). Processing tomatoes (used for canned tomato products such as paste, sauce, and ketchup), melons, and grapes are also produced in large quantities and represent a large share of the U.S. supply of those crops. Smaller shares of the acreage produce a myriad of higher-valued vegetables, fruits, and nuts.

The CVP has three regions: the Sacramento Valley, the western portion of the San Joaquin Valley, and the eastern portion of the San Joaquin Valley served by the Friant division (see Figure 1). Although CVP farmers have much in common, significant differences exist among the regions in such characteristics as the water supply conditions (price and quantity), climate, and soils. Differences in those factors manifest themselves most obviously in cropping patterns. For example, nearly all the rice grown in California, but virtually none of the cotton, is produced in the Sacramento Valley (the northern third of the Central Valley). To the south, in the San Joaquin Valley, the growing season is longer, warmer, and drier—conditions that are more conducive to growing crops such as cotton, grapes, and citrus trees. Average revenues and prevailing irrigation practices also vary by region.

Prices of CVP Irrigation Water. The Bureau of Reclamation's water supply policies, described in Chapter 2, combine with California's state water laws to create the particular set of conditions in the CVP. CVP water contractors are parties to renewable 40-year water service contracts that provide for the delivery of water but not necessarily for having the contractors repay the bureau for their share of the cost of the project by the end of the contract term. More than 200 entities contract with the bureau for water deliveries. The first of the original contracts expired in 1989, more than one-third have already expired, and nearly all will be up for renewal by 2008. Contract renewal presents the best opportunity to modify water prices.

Prices for water in the CVP contracts range from \$2 to \$31 per acre-foot. Those prices were intended to cover operation and maintenance expenses as well as a portion of construction costs. Nearly all prices were fixed in the original contracts and are not adjustable. However, contract rates were insufficient to cover O&M expenses, which have increased over the past four decades. Thus, payments were not made for construction costs, and deficits accrued in the O&M accounts. Since 1986, water districts have been subject to interest charges for O&M deficits. Nevertheless, those deficits continue to grow. Outstanding O&M deficits were \$57 million for irrigation and \$162 million for municipal and industrial uses as of 1995.[5]

The contract prices the districts pay are below the government's costs for the project as a matter of policy. That policy evolved during the first half of this century, when the bureau was attempting to develop water supplies to encourage settlement in the West. Full-cost prices—prices that include construction costs, operation and maintenance charges, and interest charges for payment obligations outstanding as of 1982 (see Box 2 in Chapter 3)—also are less than the government's total cost, but they are closer to it than contract rates. Full-cost prices vary based on the location of the district and the age of the project component that is serving the district. In the CVP, full-cost prices range from \$8 to \$255 per acre-foot, but those in 92 percent of all districts fall between \$10 and \$40 per acre-foot.[6] Districts in the Sacramento Valley are nearest the water source and are charged the lowest prices—the contract rate for most districts is \$2 per acre-foot, and the full-cost price is roughly \$15 per acre-foot. The high value of \$255 per acre-foot is for a suburban district in the Sierra foothills that drastically reduced its supplies of water for irrigation when renewing its contract. The second highest value is \$188 per acre-foot for out-of-basin transfers in the San Felipe division, the project's newest component. Its costs more closely reflect the marginal costs of project development than do other cost measures because it is the only division whose costs were not averaged with those of other CVP divisions.

Approximately one-third of all irrigation water in the CVP is priced by water districts on a per-acre fee assessment rather than on a per-unit usage basis.

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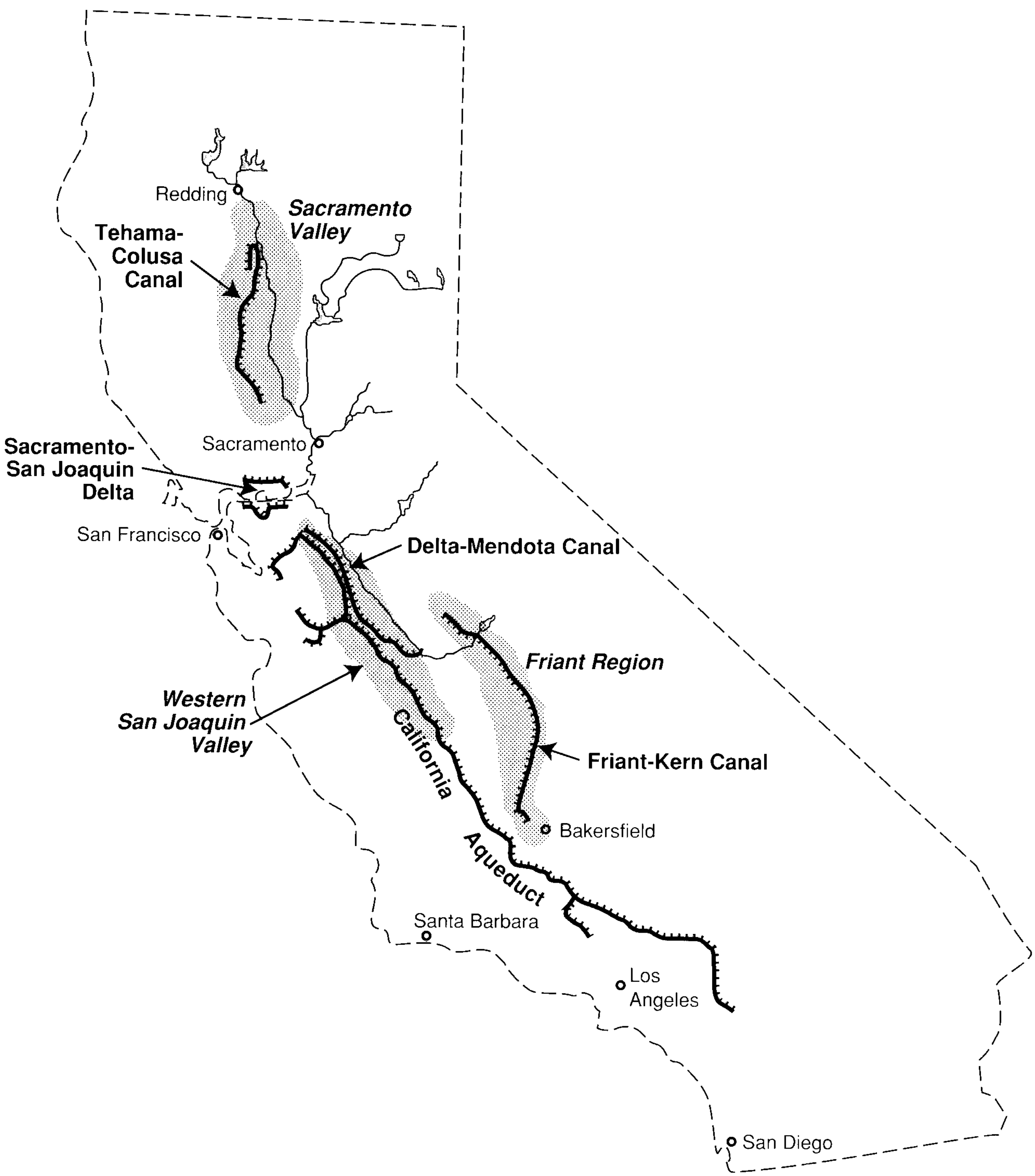
5. Bureau of Reclamation, Mid-Pacific Region, *1997 Irrigation Water Rates: Central Valley Project* (Sacramento, Calif., 1997); Bureau of Reclamation, Mid-Pacific Region, *1997 Municipal and Industrial Water Rates* (Sacramento, Calif., January 27, 1997).

6. Bureau of Reclamation, *1997 Irrigation Water Rates.*

Figure 1.
Water Projects and Agricultural Regions of California's Central Valley



SOURCE: Congressional Budget Office adapted from California Department of Water Resources, *California Water Plan Update*, vols. 1 and 2, Bulletin 160-93 (Sacramento, October 1994).

Where charges are based on usage, however, the prices that farmers pay are often significantly greater than the contract rates that water districts pay to the Bureau of Reclamation. Nevertheless, prices do not necessarily reflect either the value of water in alternative uses—a factor that defines prices in well-functioning markets—or the environmental costs associated with water development and use.

Water Supply for Irrigation. Crop production in the Central Valley depends on the availability of water supplies. Average rainfall for the summer growing season is generally less than two inches, but the minimum amount of water needed to produce most crops is two to four feet. The CVP is designed to move water both temporally (to store winter runoff for use in the summer and fall and to store water in wet years for use in dry ones) and spatially (from the wet north to the drier south). Nevertheless, six consecutive years (1987-1992) of drought stretched the ability of even that massive project to produce uniform quantities of water in each year.

In addition, conditions in the environmentally sensitive Sacramento-San Joaquin Delta constrain the movement of water to farms and cities south of the delta (see Figure 1). The delta region includes dozens of islands and hundreds of miles of rivers, sloughs, and channels and spans nearly 1,200 square miles. It has a population of 200,000, contains more than 500,000 acres of farmland producing an average of $375 million worth of crops per year, and supports 200 species of birds, 115 species of fish and wildlife, and 150 species of flowering plants.[7]

The delta region is also the hub of the CVP and an important bottleneck for moving water south. The CVP relies on the Sacramento River to move water as far south as the delta, but to move the water farther south—to the western San Joaquin Valley region or to urban areas—it relies on massive pumps that lift water out of the delta and into artificial canals. Water moving through the delta to the pumps can reverse the river's natural flow, thus allowing salt water from San Francisco Bay to move deep into the delta. Measures to protect the delta ecosystem from reverse flows, problems with water quality, and the presence of endangered fish limit the operations of CVP pumps.

Characteristics of the water supply vary by region. Significantly more water is available in the Sacramento Valley than in the other regions. That area is north of the delta and thus is less subject to disruptions in water supplies to protect the delta's ecosystem. The Friant region is served by the Friant-Kern Canal, which diverts the San Joaquin River. It is not directly linked to the water supply of other CVP units, however, and so Friant farmers are not affected by the limits on pumping at the delta. Because the Friant region is a relatively small drainage basin, its water supplies are more variable than those of other CVP regions, but groundwater is more plentiful. Many water districts also have rights to water from local streams.

Districts in the western San Joaquin Valley region are most vulnerable to policy-induced reductions in water supply. Those districts depend on water exported from the delta. They have fewer alternative water sources than districts in the Friant region, have a lower priority for Sacramento River water than most districts in the Sacramento Valley, and are south of the delta and therefore most affected by environmental restrictions on water pumped from the delta.

Urban Water Use in California

Most of California's population lives outside the Central Valley, in regions with insufficient local water supplies. The state's population has been growing rapidly, nearly doubling between 1960 and 1990. Broadly defined, the most populous areas are the southern California and the San Francisco Bay regions; in 1990, those regions accounted for 22 million people, or 73 percent of the state's total population.

Much of the water used for municipal and industrial purposes is supplied by regional wholesalers. Those wholesalers generally develop water elsewhere in the state and import it to the region. Several also receive water from at least one of the two big water projects in the state—the CVP and California's own State

7. California Department of Water Resources, *Sacramento-San Joaquin Delta Atlas* (Sacramento, Calif., August 1987), p. 60.

Water Project (SWP).[8] Although the Bureau of Reclamation historically has delivered less than 5 percent of CVP water supplies to urban uses, nearly all major cities have or are developing the capability to receive CVP water.

The reliability of the water supply is perhaps the biggest issue facing the managers of urban water districts in California. For many, water supplies are sufficient unless drought or policy-induced reductions in water deliveries occur. Several urban water districts, however, forecast water shortages. Unique conditions facing each district include water supplies, the system's capacity and reliability, and current and projected demand.

At least conceptually, urban district managers have several options for increasing their water supply, including developing new supplies by building new dams, reclaiming saline water or wastewater, and purchasing water from current users. Because the cost of developing new supplies exceeds the value of water used in agriculture, the most economical of those options is to purchase water from current agricultural users. For example, the central coast city of Santa Barbara constructed an ocean desalinization plant in the mid-1980s to meet its needs for a secure water source, and other coastal communities are considering that option. The cost of current technology for producing water of drinking quality from ocean water ranges from $900 to $2,500 per acre-foot.[9] Likewise, the estimated cost of water from the proposed Auburn Dam ranges from $416 to $451 per acre-foot.[10] In contrast, the Bureau of Reclamation will provide irrigation water to CVP water districts for $2 to $31 per acre-foot in 1997.

Those costs, however, are not directly comparable. Providing drinking water to municipal areas in the southern and coastal portions of the state involves additional transportation, including pumping the water over the Tehachapi or Coast Range Mountains and treating the water. Those costs, which are not incurred in providing water for agriculture, may be significant—$40 to $80 per acre-foot for treating the water and another $70 to $200 per acre-foot for transporting it.[11] Nevertheless, the marginal value of water for agricultural use is clearly below that for municipal use, and conserving agricultural water generally represents a lower-cost alternative to developing new water supplies.

Southern California. The Metropolitan Water District of Southern California (MWD) provides wholesale water for cities and counties serving 16 million people throughout the southern part of the state. MWD receives most of its water from two sources: 1.2 million acre-feet from the Colorado River via the Bureau of Reclamation's Boulder Canyon Project, and 1.0 million to 1.3 million acre-feet from the Sacramento River via the California State Water Project. Water supplies from both sources are uncertain.[12]

In many years, MWD will have sufficient supplies to meet its needs. However, in drought years, it may come up short. MWD hopes to purchase water from the Central Valley to help make up possible shortfalls in its existing supplies, and it projects the need for that water as often as one year in four (25 percent of the time). Its objective is to purchase 300,000 acre-feet of water, primarily through option contracts.[13] Option contracts take many forms but generally involve MWD paying farmers a certain amount for the guarantee that it can purchase a specified amount of water, at a given price, if and when it needs it, or with a given frequency—for example, five times in a 20-year contract. Those arrangements reduce the expense and uncertainty involved in attempting to purchase water in a spot (current-year) market during a drought, when demand

8. In the 1960s, California built the State Water Project to parallel the CVP. The SWP provides water to farms on the eastern side of the Central Valley and supplements water supplies for the Los Angeles metropolitan area. The SWP is the second largest water system in California, with one-third the capacity of the CVP.

9. Metropolitan Water District of Southern California, *Southern California's Integrated Water Resources Plan*, vol. 1, *The Long-Term Resources Plan*, Report No. 1107 (Los Angeles: MWD, March 1996), pp. 3-12.

10. Sacramento Metropolitan Water Authority and Bureau of Reclamation, *American River Water Resources Investigation* (draft environmental impact report/environmental impact statement, January 1996).

11. Personal communications from Dan Masnada, Executive Director, Central Coast Water Association, May 13, 1994, and February 18, 1997; and Brent Walthall, Metropolitan Water District of Southern California, February 18, 1997.

12. MWD is legally entitled to only about 500,000 acre-feet from the Colorado River but will continue to take about 1.2 million acre-feet as long as other states are taking less than their allocation. SWP deliveries are in flux because of state and federal proceedings (discussed at the end of this chapter) that may place constraints on the SWP for releases of freshwater and restrict pumping to protect water quality and habitat in the delta.

13. Metropolitan Water District of Southern California, *Southern California's Integrated Water Resources Plan.*

and prices are high and supplies are low, while simultaneously avoiding the cost of purchasing permanent water rights that would be surplus in many years.

San Francisco Bay Region. Several local water districts serve nearly 5.5 million residents in the San Francisco Bay region. That region comprises about 3 percent of the state's land mass and nearly 20 percent of its population. The region imports roughly 66 percent of the water used for urban purposes from surface water systems developed in the Sierra Nevada Mountains 150 miles east of San Francisco and by hooking into the CVP and SWP systems. Total water use in the region is 1.2 million acre-feet per year. Supplies are generally sufficient in normal years but are extremely vulnerable to drought.

Water Uses for Fish and Wildlife

As regional water development and withdrawals have increased over time, so have the environmental consequences. Those consequences affect not only fish and wildlife dependent on the quantity or quality of river flows but also waterfowl and other wildlife dependent on off-stream wetland habitat. Fish populations in the Central Valley have suffered significant declines: of 29 fish species native to the Sacramento and San Joaquin Rivers and the delta, two species are extinct, three species are listed (or proposed for listing) as endangered or threatened under the Endangered Species Act, three more are listed by the state as a "species of special concern," another five are rare, and nine others are declining. Reduced outflows of freshwater from the delta—resulting in part from the CVP's water diversions—are a primary cause of decline in many of those species.[14] Adult winter-run chinook salmon returning to the Sacramento River to spawn numbered 120,000 as recently as 1969, but only 191 adults returned in 1991. In addition, the striped bass population, a species used as an indicator of the health of the delta, was at an all-time low in 1990, in part because of the extreme drought conditions present at that time. However, those species may be more vulnerable to drought conditions because modifications in their habitat associated with water development had critically depleted population levels even before the drought.

Other problems for fish and wildlife related to water development include depletion of wetlands (with consequences for migratory birds along the Pacific Flyway—the route most migratory birds follow when traveling over the western states) and, in the early 1980s, selenium poisoning of waterfowl at the Bureau of Reclamation's Kesterson Reservoir and the Kesterson National Wildlife Refuge. The selenium was traced to the storage of agricultural drainage water discharged from farms in the San Joaquin Valley.

Large portions of the Central Valley were originally wetland habitat, but most have since been drained and developed for agriculture. The first survey, in 1906, identified 3.7 million acres of wetlands in the Central Valley.[15] Wetland acreage has been declining since the mid-1800s. The Swamp Lands Act of 1850 encouraged the conversion of wetlands to farmland. Dams and levees constructed for flood control, irrigation, municipal water supplies, and power production contributed to the decline of natural wetlands.

As of 1986, only 319,000 acres of freshwater wetlands remained, less than 10 percent of the original quantity. Of that total, 86,700 acres are contained in eight national wildlife refuges and four state wildlife management areas. Central Valley wetlands provide habitat for nearly 20 percent of the wintering waterfowl in the continental United States. Approximately three million ducks annually—half the duck population of the Pacific Flyway—wintered in the Central Valley between 1981 and 1990. Species dependent on those wetlands include eight species listed as endangered or threatened under the Endangered Species Act.

The Central Valley Project Improvement Act

The Central Valley Project Improvement Act has largely been hailed as pathbreaking legislation. After

14. Department of the Interior, Fish and Wildlife Service, *Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes* (Portland, Ore., November 1996).

15. This section draws heavily from material in Chapter 11 of Department of the Interior, *The Impact of Federal Programs on Wetlands*, vol. 2 (report to the Congress by the Secretary of the Interior, March 1994).

years of debate, the Congress passed the CVPIA as title 34 of the Reclamation Projects Authorization and Adjustment Act of 1992.[16] Despite many reservations, primarily directed at the CVPIA, President Bush signed the omnibus water bill, which has 39 separate titles, into law on October 30, 1992. Purposes of the CVPIA include protecting, restoring, and enhancing fish, wildlife, and associated habitats in the Central Valley and Trinity River basins and increasing water-related benefits provided by the CVP through expanded use of voluntary water transfers and improved water conservation, among others. The latter purpose reflects a recognition that the Bureau of Reclamation's water policy generally, and operations of the CVP in particular, have resulted in an inefficient allocation of water among uses and users in California.

The provisions of the act span a broad range of policy tools. All options for reforming the Bureau of Reclamation's water supply policies identified in Chapter 3 are present in the CVPIA. The act's many provisions make it a good case study of the implications of various options for reforming the bureau's water policies.

Provisions of the CVPIA

The various provisions of the Central Valley Project Improvement Act generally fall into one of two categories: those that directly address the objective of preserving fish and wildlife and their habitats, and those that address the objective of enhancing the CVP's benefits by increasing efficiency in all water uses. To accomplish those objectives, the CVPIA allows the project's contractors to participate in water markets, changes the pricing structure for them, creates a restoration fund to finance activities that enhance fish and wildlife and their habitat, and allocates water for instream uses. These and other provisions of the act are discussed in detail in Appendix A.

Voluntary Water Transfers. The CVPIA grants any CVP contractor the right to sell water to any user for any (beneficial) use at any price.[17] Contractors repay the Bureau of Reclamation at rates that include interest charges on all sales to non-CVP contractors and pay a surcharge of $25 per acre-foot on all sales to non-CVP urban uses. Transfers are subject to approval by the Secretary of the Interior, who must ensure that the transfer does not damage the areas from which the water originates, contracting districts, groundwater, and fish and wildlife habitat. Transfers are also subject to approval by the district if they involve more than 20 percent of the CVP water within that district. Transfers are limited to water that would have been consumptively used or otherwise lost to future beneficial uses.

Tiered Water Prices. The CVPIA specifies tiered prices for both agricultural and urban water users. The first 80 percent of the water allotment is repaid at the contract price (the price the bureau charges districts), the next 10 percent at the average of the contract and the full-cost price (which includes costs for construction and for operation and maintenance (O&M) as well as an interest charge for financing construction costs), and the last 10 percent at the full-cost price. Tiered prices are imposed on districts rather than on individual farmers. In addition, they do not go into effect until long-term contracts are renewed, which cannot occur until a programmatic environmental impact statement (PEIS) is completed, currently scheduled for fall 1997.

Fish and Wildlife Restoration Fund. The CVPIA establishes a fund to finance the restoration, improvement, and acquisition of habitats for fish and wildlife. It authorizes appropriations of up to $50 million per year for the Central Valley Project Restoration Fund. The tiered water prices and surcharges on water transfers noted above, including the difference in repayment rates, are deposited into the fund. In addition, the act imposes surcharges of up to $6 per acre-foot on all agricultural water users and $12 on all urban water users (in 1992 dollars—for example, those rates are $6.70 and $13.39 for 1997 and 1998); an additional charge of

16. For more information on the debate, see U.S. House of Representatives, Committee on Natural Resources, *Legislative History, Miscellaneous Articles, and Background Information Related to Public Law 102-575, Reclamation Projects Authorization and Adjustment Act of 1992*, Committee Print No. 4, parts 1 and 2 (prepared by the majority staff of the House Committee on Natural Resources, November 1993).

17. The bureau's policy has evolved to the point that many water transfers would have been allowed before the CVPIA. The main contribution of the CVPIA in this regard may have been to allow transfers as a matter of law rather than policy, to publicize that capability, and to make clear the conditions under which transfers would be allowed. In addition, the CVPIA specifies that individual farmers, and not simply water districts, have the right to transfer water. It may allow transfers from exchange contractors, which would have been more difficult without the CVPIA. That potential benefit is somewhat controversial, however. In contrast to the bureau's interpretation of the act, the exchange contractors do not believe that the CVPIA applies to them.

$4 per acre-foot on all contractors in the Friant region (increasing to $5 as of October 1, 1997, and $7 after 1999); and an annual charge of approximately $9 per acre-foot on districts that wait until their contracts expire before renewing them.[18] The remainder of the funding comes from power users.

Allocation of Water to Fish and Wildlife. Three separate provisions could eventually provide an annual total of approximately 1.30 million to 1.40 million acre-feet of water for fish and wildlife. First, the act allocates 800,000 acre-feet of water to protect and enhance fish and wildlife habitat in Central Valley rivers and the delta ecosystem. That water "comes off the top" of CVP water supplies and is to be dedicated, in consultation with the Fish and Wildlife Service, to meeting the needs of fish and wildlife in the Sacramento River/Delta system.

Second, the act allocates another 400,000 acre-feet for wildlife in wetland reserves in the Central Valley. Of that total, 260,000 acre-feet of CVP water are allocated immediately, bringing the total mandatory CVP environmental allocation to 1.06 million acre-feet. The remaining 140,000 acre-feet for the wetlands are to be secured from voluntary transactions at the rate of 10 percent a year over the 1992-2002 period. The water for fish and wildlife and for the reserves may be reduced by as much as 25 percent in drought years.

Third, the act protects water that comes from the Trinity River. The CVP currently diverts water from that river into the Sacramento River. Thus, increasing in-stream flows in the Trinity River could require reducing the volume of water diverted out of the basin and consequently would reduce CVP water supplies. However, the CVPIA's Trinity River provision does not specify a water quantity, and it is not yet clear what its impact will be on CVP water supplies. The Fish and Wildlife Service and the Bureau of Reclamation are establishing objectives for in-stream flows in the Trinity River. In years with average rainfall, the in-stream flow objectives would result in reductions in CVP supplies of 100,000 acre-feet to 200,000 acre-feet of water under several alternatives being considered.[19] The analysis in Chapter 5 uses the midpoint of those values, or 150,000 acre-feet, as the estimate of the impact of the CVPIA's Trinity River provision.

Implementing the CVPIA

Implementation of the CVPIA is proceeding steadily. The water transfer provisions are in effect, and the fish and wildlife fund is active. Litigation by water contractors, however, initially impeded the allocation of water for fish and wildlife. Many other provisions were designed to go into effect only over time. Several key provisions, such as those involving water pricing structures and contract terms, cannot go into effect until contracts are renewed. The act directs the Bureau of Reclamation to complete a programmatic environmental impact statement before renewing or writing any long-term contracts. The bureau is working on the PEIS but is behind schedule and did not meet the act's targeted completion date of fall 1995. The PEIS is now scheduled for completion in fall 1997. Implementation of provisions dependent on completing the statement has likewise been delayed.

The Bureau of Reclamation has not yet promulgated any formal rules and regulations for implementing the act. It has written interim guidelines for many CVPIA provisions, and those guidelines will form the basis for the formal rules and regulations. However, they have proved to be quite controversial in many cases. Completion of the rulemaking process clearly will be an important phase in fully implementing the CVPIA.

The bureau delayed the rulemaking process to accommodate an administrative review of its options for implementing key CVPIA provisions. The review, commonly referred to as the Garamendi Process because it was initiated by Deputy Secretary John Garamendi, identified 12 priority areas for consideration:

- Water transfers,
- Management of the restoration fund,

18. Contract prices cannot be adjusted until the contract has been renewed. The annual charge provides an incentive for districts to renew their contracts before they expire, if possible. See Appendix A for a more detailed discussion of the early-renewal incentive.

19. Department of the Interior, Fish and Wildlife Service, *Trinity River Activities Update* (Sacramento, Calif., September 1996).

- o Management of the 800,000 acre-feet of water allocated to fish and wildlife,
- o Criteria for water conservation,
- o Contracting policies,
- o Water supplies for wildlife refuges,
- o Reliability of urban water supplies,
- o Trinity River,
- o Stanislaus River,
- o San Joaquin River,
- o Anadromous Fish Restoration Program, and
- o Stakeholder process.

After several months and numerous meetings between agency personnel, interested members of the public, and agricultural, environmental, and urban stakeholders, the bureau released draft proposals on each topic.[20] Those proposals identify areas of consensus as well as areas of continuing disagreement. In some cases, they also identify areas in which Congressional direction is needed to resolve an issue. The first three issues—water transfers, the restoration fund, and the allocation of water for environmental purposes—were among the most controversial and are discussed below. The final issue—the stakeholder process—arose in recognition of the desirability of a formal process through which stakeholders would have input into the bureau's decisions about implementing the CVPIA. An ongoing stakeholder "roundtable" is being formed to meet that need.

Water Transfers. As of January 1997, no long-term transfers of CVP water or transfers to a non-CVP contractor had occurred. Thus far, the bureau has received only one proposal for a long-term transfer. In June 1994, the Metropolitan Water District and Arias Farms (a dairy farm in the San Joaquin Valley) agreed that MWD would purchase 4,600 acre-feet of water in seven of 15 years at a price of $175 per acre-foot delivered, exclusive of transportation costs. MWD would also have paid the surcharge of $25 per acre-foot that the CVPIA imposed on transfers of water to urban users. However, the proposal proved to be so controversial that the parties withdrew it. Controversial issues included the potential impact on the local community and how Arias Farms' proposal to use groundwater to replace the quantity of water transferred would affect groundwater reserves.

Numerous short-term transfers have occurred between CVP water contractors within the same portion of the CVP service area. Many probably would have occurred without the CVPIA authority, but several others—for example, the transfer of 35,000 acre-feet of water from exchange contractors to Westlands Water District in 1993—were possible only because of the act.

Many factors have contributed to the relative lack of water transfers since the CVPIA was enacted. The program is still new, and long-term deals are often quite complicated. Inherent uncertainty in water supplies and the system's capacity to conduct transfers must be addressed in negotiations about the quantity and price of water to be transferred. Furthermore, in order to secure the Secretary's approval, contractors must be able to show that the potential local and environmental implications of transfers will be minimal. The bureau recently issued blanket approvals for short-term transfers of water within two distinct CVP service areas—the Friant division and the western San Joaquin Valley—but no such approval exists for transfers between regions or outside the CVP. Very few potential participants have experience with negotiations for long-term water transfers, and they need time to understand the act and learn how to take advantage of its provisions. The uncertain implications of regulations regarding endangered species and water quality in the delta may also have contributed to the lack of transfers in the first five years of the program.[21]

The necessary learning process may be prolonged by confusion about the interpretation of certain portions of the transfer provision. For example, the Bureau of

20. The proposals are available on the bureau's Mid-Pacific Region Web page at http://www.mp.usbr.gov/cvpia.html.

21. Note, however, that the State Water Bank operated in 1991, 1992, and 1994 (an extremely wet year made it unnecessary in 1993) and successfully transferred water from north of the delta to buyers south of the delta in each year. Also see Richard W. Wahl, "Market Transfers of Water in California," *West-Northwest Journal of Environmental Law, Policy, Thought*, University of California, Hastings College of Law, vol. 1, no. 1 (Spring 1994), pp. 45-69.

Reclamation identified four primary issues relating to water transfers that need to be clarified in the formal rules and regulations.[22]

Two issues involve the role of the contracting district in transfers negotiated with individual farmers: the 20 percent threshold that triggers a review and approval of a transfer by the district (section 3405(a)(1)), which was one of the sticking points in the failed transfer of water between MWD and Arias Farms; and the requirement that transfers have "no unreasonable impact on the water supply, operations, or financial conditions of the transferor's contracting district" (section 3405(a)(1)(k)). Those issues point to a more general question of the role of individual farmers in relation to contracting districts in negotiating and approving transfers. District managers generally would prefer that the district conduct the negotiations. In that case, the benefits from water transfers could be spread among all district farmers. Many farmers, however, would prefer to conduct their own negotiations; they may feel that interference by the district would inhibit their ability to benefit financially from water transfers.

A third issue identified as needing clarification is how to calculate the amount of water that is consumptively used or irretrievably lost to beneficial use. That issue must be resolved before potential market participants can discern the quantity of water eligible to be transferred.

The fourth issue is the right of first refusal granted to entities within the CVP service area for any agreement to transfer water outside the service area. Under that provision, a CVP contractor agreeing to abide by the terms and conditions of the agreement can take the water instead of the transferee who is a party to the agreement. The rulemaking process will attempt to clarify the phrase "terms and conditions."[23]

The Central Valley Project Restoration Fund. The Central Valley Project Restoration Fund is well established. In the first fiscal year of the program (1993), the bureau collected $8.8 million in surcharges in the Friant region. That money carried over to 1994, when collections totaled $21 million, including an estimated $6 million in Friant surcharges. Collections for 1995 and 1996 were $34 million and $47 million. Power users accounted for slightly more than one-quarter of those amounts. Actual 1994 outlays were $9.3 million. Outlays were $24 million in 1995 and $30 million in 1996.[24]

As required in the act, approximately two-thirds (67 percent) of the outlays in each year are used for restoring and improving the habitat and acquiring more water, with the remainder used for other restoration activities that benefit fish and wildlife. The latter category contains specific activities defined in the act. Most such activities involve structural improvements to control water temperatures or minimize damage at diversion dams, intake canals, and pumps and include requirements for cost sharing by the state. The Bureau of Reclamation intends to use $11 million to acquire water for the environment. However, many stakeholders are unhappy with the bureau and the Fish and Wildlife Service's priority-setting policies for fund expenditures. Issues of greatest concern involve the inflexibility and inefficiency of annual expenditure goals.[25] For example, the benefit of purchasing water in wet years is minimal, but it may be quite high, and quite expensive, in dry years. Carrying the money over from wet years for use in dry ones could increase the total benefit of the fund. Similarly, the money might be spent more efficiently if the 67/33 split was met on a multiple-year, rolling-average basis rather than in each year.

22. These issues, and others, were raised during the Garamendi Process meetings. A summary of the issues and the bureau's response are available on the bureau's Web page (http://www.mp.usbr.gov/cvpia/proposals/transfer.html).

23. For another discussion of issues to be addressed, see Wahl, "Market Transfers of Water in California," pp. 49-69.

24. *Budget of the United States Government, Fiscal Year 1997: Appendix*, pp. A-568 and A-569.

25. Bureau of Reclamation, *CVPIA Administrative Proposal: Restoration Fund* (draft, May 31, 1996), available at http://www.mp.usbr.gov/cvpia/proposals/restfnd.html.

Allocation of Water for Environmental Purposes. The Bureau of Reclamation allocated the required 800,000 acre-feet to in-stream fish and wildlife purposes in 1993. In 1994, however, it dropped the allocation by the maximum 25 percent, to 600,000 acre-feet, because of the drought conditions. The impact of that water allocation was borne almost exclusively by contracting districts in the western San Joaquin Valley because they are south of the delta. In addition, the bureau has increased the amount of water it diverts from rivers for wildlife refuges—wetlands that benefit ducks, birds, and other wildlife as well as fish—as specified in the CVPIA and is actively seeking to acquire additional water for them.

The allocation of water for fish and wildlife is perhaps the most contentious of all CVPIA provisions. Several water districts in the western San Joaquin Valley have challenged those allocations in court. In the spring of 1994, a federal district court judge issued a preliminary injunction against the bureau's implementation of those provisions.[26] However, the federal government won its appeal of the decision, and the allocation of water for fish and wildlife proceeded on schedule.[27]

Debate is ongoing about the intent of the in-stream water allocations for fish and wildlife under the CVPIA in relation to those under the Endangered Species Act. Some people interpret the CVPIA as stating that all water used to protect ESA-listed fish (including water not delivered because of constraints on pumps or fish screens) should be counted against the 800,000 acre-feet of water set aside in the act. Others argue that water allocated under the ESA should be in addition to the 800,000 acre-feet. The latter view is based on the assumption that the CVPIA was designed to provide additional protection for fish and wildlife. If the 800,000 acre-feet is credited to the ESA, then the CVPIA is redundant and gives no more water than could have been taken under existing laws. The act itself appears to take a middle ground. Sections 3406(b)(1)(c) and 3406(b)(2) state that the water is to be used to improve anadromous fish populations (those that leave the sea to breed in fresh water), which would include the ESA-protected salmon, as well as to meet "additional obligations under the Federal Endangered Species Act." Yet another aspect of the debate is whether water that is used to enhance fish habitat in the upper stretches of the river but is then diverted for agriculture farther downstream is counted against the 800,000 acre-feet.

In practice, the answer will probably lie between those competing views. In the act's first year, approximately half of the 800,000 acre-feet were used to protect threatened or endangered fish. For example, the Bureau of Reclamation had to shut down the pumps because too many endangered winter-run chinook salmon had been drawn into the pumps and killed. That shutdown caused a loss of 300,000 acre-feet of water that otherwise would have gone to farmers in the San Joaquin Valley. The formal rulemaking process will attempt to clarify the system for managing and accounting for the water. On December 15, 1994, representatives of all relevant parties signed an agreement—the Bay/Delta Accord—that provides guidance on that issue for a three-year period. However, this is one area in which the Garamendi Process was unsuccessful in attaining consensus and, with the accord expiring at the end of 1997, is likely to be hotly contested in the near future. The bureau is planning public meetings and discussions with stakeholders in an attempt to resolve this issue.

The Regulatory Environment for Implementing the CVPIA

Other federal and state legislation and regulatory actions, such as those involving the Endangered Species Act or the Clean Water Act, will influence both the allocation of water in California and the health of fish and wildlife populations and their habitat. By affecting

26. The judge held that the bureau must comply with the National Environmental Protection Act before it can allocate to fish and wildlife any water that would otherwise go to agricultural uses. That act requires completion of an environmental impact statement before undertaking any federal action with potentially negative environmental impacts. The districts argued that removing water from agriculture could adversely affect the environment in the agricultural service area. The CVPIA provisions involved in the lawsuit are section 3406(b)(2), which sets aside 800,000 acre-feet of water for fish and wildlife purposes, and section 3406(d), which guarantees increased water deliveries for national wildlife refuges and wildlife management areas in the Central Valley. Those provisions are discussed in greater detail earlier in the chapter and in Appendix A.

27. The appellate court judge ruled that language in the CVPIA requiring the Secretary of the Interior "upon enactment of this title" to allocate and manage the water for fish and wildlife indicates that the Congress did not intend for the allocation to be postponed while the bureau was completing an environmental impact statement.

baseline levels of water, those laws and regulations may significantly change the impact of various CVPIA provisions. In addition, obligations to allocate water to fish and wildlife will overlap, and attributing specific consequences to a given piece of legislation will be difficult.

Endangered Species Act

Two fish species with habitat in the Sacramento River have been listed under the federal Endangered Species Act—the winter-run chinook salmon as endangered, and the delta smelt as threatened. An "endangered" species is in danger of extinction throughout all or a significant portion of its range; a species listed as "threatened" is likely to become endangered within the foreseeable future. The California splittail has also been proposed for listing as a threatened species.

As a federal agency, the Bureau of Reclamation must operate its facilities in a manner that will not further jeopardize the survival of those species. The ESA also prohibits any action that leads to a "take," loosely defined as the harming or killing of a member of a listed species. Consequently, water must be released at certain times of the year to help flush juvenile fish downstream and to maintain a hydraulic barrier to prevent salt water from San Francisco Bay from entering the delta; more water must be stored in Shasta Dam to maintain the cold water temperatures necessary to protect salmon eggs; and operation of pumps that convey water south of the delta into the San Joaquin Valley and to urban areas in southern California may be curtailed if the number of fish drawn into the pumps, which is considered a take, exceeds acceptable levels.

As a result of takes that exceeded acceptable levels, only 50 percent of water deliveries to which CVP contractors south of the delta were entitled were made in 1993, a year classified hydrologically as a wet year. In other words, water supplies in 1993 were sufficient to meet all contractual and environmental obligations, but agricultural water supplies were reduced because the pumps were shut down at key points in the year. The ESA also was invoked in 1991 to reduce water supplies to the Glenn-Colusa Irrigation District in the Sacramento Valley after fish screens on its canal intake failed to prevent endangered fish from being drawn into the system that delivers water for irrigation.[28] Similarly, districts receiving water from the CVP's Tehama-Colusa Canal may be adversely affected by restrictions on the operation of the Red-Bluff diversion dam that are necessary to protect endangered winter-run salmon.[29]

The extent to which the requirements of the CVPIA will overlap with those of the ESA is unclear. Depending on the ultimate resolution of that issue, implementing the ESA could increase the quantity of water allocated to fish and wildlife beyond that required by the CVPIA.

The Clean Water Act and the State's Bay/Delta Proceedings

After nearly a decade of unsuccessful attempts to establish standards for water quality for the San Francisco Bay/Sacramento-San Joaquin Delta regions, as required by the Clean Water Act, the California State Water Resources Control Board initiated the so-called Bay/Delta estuary proceedings in 1987. The central purpose of the proceedings was to develop and implement water quality standards needed to protect beneficial uses within the Bay/Delta estuary and by users who divert water from rivers flowing into the delta.

The first step in the proceedings was to establish water quality standards. The next step is to identify the water flows necessary to achieve the quality objectives. In that step, the board will also determine which water users will be required to help meet those standards and how the standards are to be implemented. In other words, the outcome of those proceedings could alter existing water allocations. Thus, so long as the process is ongoing, districts' water supplies will remain uncertain.

California's inability to establish water quality standards for the bay and delta automatically triggered a

28. Bureau of Reclamation, Mid-Pacific Region, *Biological Assessment for U.S. Bureau of Reclamation Long-Term Central Valley Project Operations Criteria and Plan* (Sacramento, Calif., October 1992), pp. 7-4 and 7-5.

29. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, "Biological Opinion for the Operation of the Federal Central Valley Project and the California State Water Projects" (Silver Spring, Md., February 12, 1993).

requirement under the Clean Water Act that the Environmental Protection Agency (EPA) step in and set standards of its own. In December 1993, it did just that, issuing a draft ruling on water quality to protect beneficial uses in the Sacramento-San Joaquin Delta. That action was the culmination of a lengthy process in which environmental groups sued EPA, claiming that it had been negligent in its responsibility to find California's water quality standards inadequate and issue standards of its own. EPA estimates that approximately 450,000 acre-feet of water will have to be released to meet water quality standards in the delta.[30] Whether part of the 800,000 acre-feet set aside by the CVPIA can be used to meet those requirements is unclear.

30. Environmental Protection Agency, Region 9, Water Management Division, *Regulatory Impact Assessment of the Final Water Quality Standards for the San Francisco Bay/Delta and Critical Habitat Requirements for the Delta Smelt* (San Francisco, December 15, 1994), with technical assistance from Jones & Stokes Associates, Sacramento (JSA 94-130).

Bay/Delta Accord

The Bay/Delta Accord is a federal/state agreement that protects water quality for the San Francisco Bay/ Sacramento-San Joaquin Delta environment for three years, through 1997. Signed by California Governor Pete Wilson, Secretary of the Interior Bruce Babbitt, EPA Administrator Carol Browner, and several representatives of interested parties on December 15, 1994, the agreement is the outcome of negotiations between state and federal agencies and representatives of interested agricultural, urban, and environmental organizations. It specifies guidelines for pumping water from the delta that vary with water supply conditions. The agreement also addresses the regulatory environment. It supersedes EPA's 1993 decision on water quality for the Bay/Delta area; EPA withdrew the standards set pursuant to the Clean Water Act after the state adopted a plan consistent with the agreement (as required by the agreement). The agreement also specifies that CVP water used to meet those new standards will be credited against the 800,000 acre-feet the CVPIA allocates to fish and wildlife. It also guarantees that no additional water will be taken to protect any species not currently protected by the ESA, even if that species is listed as threatened or endangered in the three years covered by the agreement.

Chapter Five

Quantitative Analysis of the Central Valley Project Improvement Act

The provisions of the Central Valley Project Improvement Act that are most likely to affect agricultural and urban water use include facilitating water markets, allocating water to environmental purposes, and directly increasing water prices (environmental surcharges, tiered water prices, and adjustments in the repayment rate). The Congressional Budget Office's (CBO's) analysis finds that water markets would benefit both farmers and urban consumers. The largest impact arises from the environmental water allocations. Farmers' income falls in years when the water supply has to be reduced to provide water for fish and wildlife. In contrast to the environmental water allocations, price changes and surcharges have only minor effects. Urban consumers are better off with the entire CVPIA package but not as well off as they would be with water markets alone.

For the entire package of CVPIA provisions, CBO estimates that farmers' gross crop revenues would decline by $105 million a year (or about 5 percent) under normal water supply conditions and in the absence of other regulatory effects on the water supply. Given that reduction in gross revenues, farmers' net revenues (gross revenues less the cost of inputs) could drop by $44 million. Offsetting that cost would be the $7 million in proceeds that farmers would gain from water transfers. Regional income, which includes farmers' income as well as that of people directly and indirectly involved in the agricultural sector, would decrease by $69 million. The environment would benefit from the water allocated to it. CBO did not estimate the value of those environmental benefits, but some studies indicate that they could exceed $100 million a year. The benefit to urban consumers would increase by $11 million relative to a pre-CVPIA base case, although $7 million of those benefits would be paid to farmers. In addition, the Central Valley Project Restoration Fund collects $30 million from the agricultural and urban sectors to benefit fish and wildlife.

Although the CVPIA's effect on farmers may be relatively small on average—average gross crop revenues could fall by 5 percent in a year with average rainfall—the effects are not distributed uniformly. The resource base varies among geographically distinct agricultural regions. Thus, farmers' flexibility to address changes in the water supply also varies. In general, farmers with more options for selecting which crops to grow, how to irrigate, and where to get their water will better withstand reductions in water supply and increases in prices. Farmers with a larger initial water supply and those who are protected from reductions in supply by institutional priority or geographic separation from problem areas will probably receive a greater share of benefits from the provisions governing water transfers.

Estimates of the costs of CVPIA provisions are sensitive to assumptions about hydrologic conditions and the regulatory environment. In a dry year, the cost of the CVPIA to agriculture could double, but the benefits to urban consumers would be higher than in a year with an average water supply. In a wet year, however, the cost to agriculture could be significantly less, perhaps limited to moneys paid into the restoration fund.

For example, in 1995, the Bureau of Reclamation delivered all of its water allocations under contract to agriculture and met all water allocations for environmental purposes under the CVPIA. In 1996, all users received 100 percent of supplies, except for agricultural contractors in the western San Joaquin Valley, who received 95 percent.

The estimates of the cost of CVPIA provisions are also sensitive to assumptions about the amount of water allocated to the environment by other laws. The Clean Water and Endangered Species Acts could require water flows to protect water quality in the delta in addition to the 800,000 acre-feet of water set aside by the CVPIA for fish and wildlife. If so, the cost of the CVPIA provisions could increase.

The environmental sector will benefit from increased water flows and expenditures on the CVPIA's projects to restore wildlife habitats. As fish and wildlife populations increase, benefits associated with those resources will also increase. Benefits will accrue to people who use the resource—such as participants in commercial and recreational fishing industries, birdwatchers, and duck hunters—as well as to those who derive benefits simply from knowing that the resource exists and is healthy. Because such benefits are inherently difficult to evaluate, CBO does not attempt to do so. Rather, the analysis describes variations in costs associated with achieving specific objectives for providing water and money for environmental purposes. It also describes the least-cost approach for achieving a given environmental objective. Although CBO has not estimated the benefits, this chapter describes the environmental services provided by resources in the Central Valley, along with alternative estimates of possible benefits.

Empirical Framework

CBO developed a computer model to simulate economic responses to the provisions of the CVPIA. The model focuses on three agricultural regions (the Sacramento Valley, the west side of the San Joaquin Valley (western SJV), and the Friant division) and two urban regions (the southern California urban sector served by the Metropolitan Water District and the San Francisco Bay region).

The agricultural component of the model describes changes in gross revenues from crop production associated with changes in water deliveries to the three agricultural regions.[1] That measure does not incorporate the impact of changes in the cost of inputs, such as irrigation technology and management, in response to changes in levels of water use, but it does incorporate adjustments in cropping patterns (including fallow acres) and yields and any resulting changes in the price of agricultural products. It also allows farmers to change their mix of inputs and estimates the effect of that adjustment on gross crop revenues. The advantages and disadvantages of using changes in gross rather than net revenues as a measure of the impact on agriculture are described in Box 3.

The value of water to urban users is measured as the amount that urban districts pay for the water plus the amount that urban consumers would be willing to pay over and above the amount they actually do pay. For urban areas in southern California, the estimate of demand is based on analysis by the Metropolitan Water District.[2] For the San Francisco region, the estimate is based on two studies of the East Bay Municipal Utilities District, adjusted by CBO to reflect regional water use.[3]

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1. For this portion of the model, CBO used a time-wise autoregressive and cross-sectionally heteroskedastic method to econometrically estimate multioutput revenue functions for each of the three regions. Econometric analysis is a statistical means of examining the impact of a change in one variable (water) while holding the effects of all other variables constant. The data for this analysis are crop and water use reports submitted by water districts to the Bureau of Reclamation for the 1979-1991 period. Those data are summarized in Bureau of Reclamation, *Summary Statistics: Water, Land, and Related Data* (1979-1991). Districts in the Friant region that receive only small portions of their total water use from the CVP were excluded from the analysis.

2. Metropolitan Water District, *Municipal and Industrial Water Use in the Metropolitan Water District Service Area: Interim Report No. 4* (report prepared by Planning and Management Consultants, Ltd., Carbondale, Ill., June 1991), updated with 1990 census figures provided by Grace L. Chan, Principal Engineer, Water Supply and Demand Branch, Metropolitan Water District, June 1994.

3. The resources used to develop the estimate of the demand function include Anthony Fisher and others, *Optimal Response to Periodic Shortage: Engineering/Economic Analysis for a Large Urban Water District*, Working Paper 629 (Berkeley: University of California, Department of Agricultural and Resource Economics, June 1992); Jack A. Weber, "Forecasting and Measuring Price Elasticity," *Journal of the American Water Works Association*, vol. 81 (May 1989), pp. 57-65; and California Department of Water Resources, *California Water Plan Update*, vols. 1 and 2, Bulletin 160-93 (Sacramento, October 1994).

Box 3.
Using Changes in Gross Revenues as a Measure of the Impact of Water Policy Reform on Agriculture

Whether the change in gross revenues or net revenues (profits) is the preferred measure of the impact of policy reform depends on the objective of the analysis and the mobility of resources. Net revenues are better when the impact on farmers is of most interest, but gross revenues may be a better measure of the change in income for the agricultural sector as a whole that would arise directly from policy changes.

The difference between changes in gross and net revenues is the change in production costs. The real question, then, revolves around how changes in costs should be accounted for. Changes in costs represent a real cost (or saving) to farmers but may not reflect a net change for the regional economy. Increased costs to a farmer—for example, the cost of additional fertilizers, pesticides, or irrigation technology—imply increased sales for the input supplier. Conversely, reduced purchases of inputs may imply lower costs to the farmer (and thus produce higher net revenues for a given change in gross revenues) but can reduce revenues in the supply industry. The impact on input supply and processing industries (canning, packing, and freezing) is an important component of the regional economic effects of policy reform but should be counted only after adjusting for the portion of the industries' revenues that is spent outside the region.

Inferring Regional Economic Effects and Farmers' Net Revenues from Changes in Gross Revenues. If total costs do not change, a change in net revenues is identical to a change in gross revenues. If total costs change in proportion to the change in gross revenues, the change in net revenues can be deduced from the change in gross revenues. For example, production costs average 54 percent of gross revenues in the Central Valley, so net revenues average 46 percent of gross revenues. If that percentage remains constant, a $100 million change in gross revenues implies a $46 million change in net revenues.

Changes in gross revenues are the appropriate measure for examining the regional economic impact of policy changes. When multiplied by relevant factors (multipliers), a change in gross revenues indicates the total benefit from agricultural production as it moves through processing and trade channels. Effects on employment, induced effects of changes in household income (demand for goods and services from the community), and secondary effects (including changes in income and expenditures by individuals participating in the processing and input industries) can all be inferred from changes in gross revenues. A secondary-effects multiplier, which incorporates the effects on input suppliers and their employees but does not include induced effects, accounts for the fact that input supply and processing industries spend a portion of their revenues outside the region. For example, if an input supplier sells $100 worth of fertilizer to a farmer in the Central Valley but purchases that fertilizer from a firm in Iowa, only the difference between what the farmer pays and what the input supplier pays adds to the valley's economy. Thus, a multiplier of 0.66 implies that for every $1 change in gross farm revenues, the direct regional economic impact is 66 cents.

Changes in Production Costs. The total variable cost of production will probably change for most farmers in two ways as they adjust to water policy reforms. First, as water becomes more scarce or more expensive (either because real prices rise or because the opportunity cost of using water rises), farmers may fallow a portion of their land. Although farmers will still pay fixed costs associated with fallowed land, variable costs will decline significantly. Savings from forgone input expenses will offset the reduction in revenue resulting from forgone crop output. In that case, the change in gross revenue will overstate the impact on farmers.

The second type of adjustment occurs on land remaining in production. On those acres, production costs will probably increase. In the face of water policy reform, farmers will probably adjust their crop mix toward crops with a higher value and a lower level of water use. Those crops often have higher input costs.[1] Farmers might also choose to irrigate remaining crops more carefully, either by increasing management and labor for a given technology or by switching to more efficient irrigation technologies such as specialized pipes, sprinklers, or drip systems.[2] If those adjustments increase total costs, the change in gross revenues will understate the policy's effect on farmers.

Implications of Input Mobility. If inputs are geographically mobile, changes in input expenses may imply only short-term or distributional effects; they may not result in changes in the nation's economic efficiency. For example, farm labor is typically thought to be relatively mobile. If farmers hire fewer laborers because of reductions in the water supply in the Central Valley, employment might decline there, but those laborers could move to other agricultural regions in the Southwest or Northwest. If they find jobs in those other regions, the full value of their forgone wages in the Central Valley will overestimate the cost of the adjustment. Other inputs, such as capital, are less mobile. In the very long run, only land is a truly immobile input.

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1. For information on average input costs, see Environmental Protection Agency, Region 9, Water Management Division, *Regulatory Impact Assessment of the Final Water Quality Standards for the San Francisco Bay/Delta and Critical Habitat Requirements for the Delta Smelt* (San Francisco, December 15, 1994), with technical assistance from Jones and Stokes Associates, Sacramento, Calif. (JSA 94-130), p. 5-4.

2. For information on irrigation technology costs, see Dennis Wichelns and others, "Labor Costs May Offset Water Savings of Sprinkler Systems," *California Agriculture*, vol. 50, no. 1 (February 1996), pp. 11-18.

Results of the Empirical Analysis

The model estimates the annual costs and benefits of the CVPIA's provisions for allocating and transferring water under several scenarios incorporating institutional and physical constraints. The costs of changes in water allotments are modeled as estimates of forgone agricultural revenues from crop production resulting from reductions in water use in the agricultural sector.

Table 4.
Effect of the Central Valley Project Improvement Act on Agricultural Water Use and Revenues

	Western San Joaquin Valley		Sacramento Valley		Friant		Total Agriculture		Water Market	
Scenario	Water Use (Thousands of acre-feet)	Crop Revenues (Millions of dollars)	Water Use (Thousands of acre-feet)	Crop Revenues (Millions of dollars)	Water Use (Thousands of acre-feet)	Crop Revenues (Millions of dollars)	Water Use (Thousands of acre-feet)	Crop Revenues (Millions of dollars)	Water Transfers[a] (Thousands of acre-feet)	Water Revenues (Millions of dollars)
Baseline	1,906	1,111	2,045	344	1,198	1,191	5,149	2,645	n.a.	n.a.
					Change from Baseline					
Water Markets	-120	-8	-123	-9	0	0	-243	-17	243	18
					Change from Scenario with Water Markets					
Water Markets and Water Allocated for Environmental Purposes										
800,000 acre-feet	-375	-31	-383	-32	0	0	-758	-62	-42	0
1.2 million acre-feet	-541	-47	-594	-52	0	0	-1,134	-99	-66	0
1.35 million acre-feet	-595	-52	-668	-60	-12	-1	-1,276	-113	-74	0
					Change from Scenario with Water Markets and 1.2 Million Acre-Feet of Water Allocated for Environmental Purposes					
Surcharges	35	3	47	5	0	0	82	8	-82	-9
Surcharges and Rate Increases[b]	47	5	64	6	0	0	110	11	-110	-11
					Change from Baseline					
Package of CVPIA Provisions[c]	-613	-51	-653	-54	0	0	-1,266	-105	66	7

SOURCE: Congressional Budget Office.

NOTE: n.a. = not applicable.

a. To urban areas in southern California.
b. Tiered water prices and repayment rates.
c. Includes 1.2 million acre-feet of water allocated for environmental purposes.

The effects on the agricultural economy will not be uniform. The benefit from using water is greater in some areas than in others. Farmers in the regions where water is scarce may purchase water from farmers in regions where it is more plentiful and may subsequently see increases (or smaller decreases) in their crop revenues. However, most of the benefits from water markets will accrue in urban areas.

Baseline

For its analysis, CBO developed a baseline scenario that describes levels of water use and associated benefits using estimates from the simulation model for a year with average rainfall under pre-CVPIA conditions. Gross revenues from crop production using 5.15 million acre-feet of CVP water total $2.6 billion (see Table 4). As a result of institutional constraints that inhibit the movement of water between regions, the marginal value of water differs for each region. The implicit value of water in the Friant region is significantly higher (over $100 per acre-foot) than in the western SJV and Sacramento regions ($65 to $70 per acre-foot). Baseline levels of water use in the urban areas generate consumer benefits of $4.5 billion (see Table 5). Of that amount, $3.3 billion accrues in southern California and $1.2 billion in the San Francisco Bay region.

Table 5.
Effect of the Central Valley Project Improvement Act on Urban Water Use

	Benefits to Urban Consumers (Millions of dollars)	Water Transfers[a] Amount (Thousands of acre-feet)	Water Transfers[a] Price (Dollars per acre-foot)	Cost of Water (Millions of dollars)
Baseline	4,500	n.a.	n.a.	n.a.
Change from Baseline				
Water Markets	30	243	74	-18
Change from Scenario with Water Markets				
Water Markets and Water Allocated for Environmental Purposes				
800,000 acre-feet	-3	-42	91	0
1.2 million acre-feet	-6	-66	101	0
1.35 million acre-feet	-7	-74	105	0
Change from Scenario with Water Markets and 1.2 Million Acre-Feet of Water Allocated for Environmental Purposes				
Surcharges	-10	-82	99	9
Surcharges and Rate Increases[b]	-14	-110	98	11
Change from Baseline				
Package of CVPIA Provisions[c]	11	66	98	-7

SOURCE: Congressional Budget Office.

NOTE: n.a. = not applicable.

a. To urban areas in southern California.

b. Tiered water prices and repayment rates.

c. Includes 1.2 million acre-feet of water allocated for environmental purposes.

CBO developed a set of policy scenarios to examine the effects of the CVPIA provisions. The first scenario models a water market. Each subsequent scenario adds a provision or increases the level of one of the provisions. The scenarios are:

- o Water markets alone;
- o A combination of water markets and three different levels of water allocations for fish and wildlife (800,000 acre-feet, 1.2 million acre-feet, and 1.35 million acre feet);
- o A combination of water markets, an allocation of 1.2 million acre-feet of water for fish and wildlife, and surcharges (includes charges of $6 per acre-foot for agricultural water use, $12 per acre-foot for urban water use, and $25 per acre-foot for water transferred to urban regions); and
- o A combination of water markets, an allocation of 1.2 million acre-feet of water for fish and wildlife, surcharges, and other water rate increases (tiered water prices and higher repayment rates for water that is transferred). This scenario represents the full set of CVPIA provisions analyzed in this study.

Economic Impact of Water Markets

The first set of policy simulations examines the implications of CVPIA provisions that allow for water transfers. CBO assumes that water can be transferred out of and within the Friant region but not into it because of physical constraints of the delivery system. The capacity of the system also limits the quantity of water transferred into urban areas. According to the California Department of Water Resources, limited capacity exists for transferring water to the San Francisco Bay region. Water districts in that area will probably purchase water only if drought or other environmental legislation limits their ability to take their full allotment. During a drought, the system can transfer about 300,000 acre-feet a year. Capacity for transferring water to the Metropolitan Water District in southern California ranges from 600,000 to 1.4 million acre-feet, depending on the quantity of water available.[4]

4. California Department of Water Resources, *California Water Plan Update*, vol. 1, p. 317.

Given the system's constraints, CBO estimates that farmers would transfer 243,000 acre-feet of water, or 5 percent of the water used for agriculture in the baseline, to urban uses at a price of $74 per acre-foot (see Table 5). Those sales would reduce gross agricultural crop revenues by $17 million from baseline levels (see Table 4); farmers' revenues from the water sales would be $18 million.

The benefits of urban areas would increase by $30 million in that scenario. Of those benefits, $18 million would be transferred from urban consumers in southern California to agriculture as water payments.

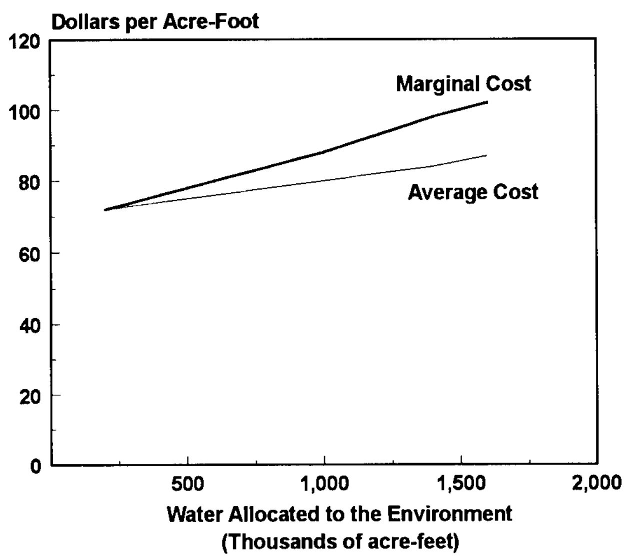
Economic Impact of Allocating Water for Fish and Wildlife

This scenario examines the costs and adjustments related to the allocation of water to fish and wildlife. The baseline for this analysis is a scenario that allows water transfers but allocates no additional water to fish and wildlife uses. The cost to agriculture of allocating water for environmental uses is expressed as forgone gross crop revenues. Both average and marginal costs increase as environmental allocations increase (see Figure 2). CBO did not analyze the benefits of providing water for fish and wildlife purposes, but those benefits are discussed at the end of this chapter.

Three sets of environmental water allocations, based on various CVPIA provisions, are examined in more detail: 800,000 acre-feet for fish and wildlife, 1.2 million acre-feet that includes protected water from the Trinity River and an increase in water for wildlife refuges (level-2 supplies), and 1.35 million acre-feet that includes a higher volume of water that must be purchased for wildlife refuges (level-4 supplies).[5] The

5. Level-2 and level-4 water needs are defined in Bureau of Reclamation, *Report on Refuge Water Supply Investigations* (March 1989). They represent 66 percent and 100 percent, respectively, of the water supply needed for full development of habitats in the Central Valley refuges and wildlife management areas. The CVPIA requires that refuges be guaranteed level-2 water supplies immediately and level-4 supplies by 2002.

Figure 2.
Cost of Environmental Water Allocations Under Average Water Supply Conditions, as Measured by Reductions in Agricultural Revenues



SOURCE: Congressional Budget Office.

cost of providing the first 800,000 acre-feet of water for the environment is $62 million in forgone agricultural revenues (see Table 4). That value represents 2 percent of the net benefits realized without the environmental water allocation. Agricultural water use declines by 758,000 acre-feet in that scenario, and water transfers to urban areas in southern California decline by 42,000 acre-feet from the 243,000 acre-feet that would be transferred without the environmental allocation.

The cost of allocating an additional unit of water to the environment (the marginal cost) will increase as the total quantity allocated increases. In fact, increasing the environmental allocation by 50 percent, from 800,000 acre feet to 1.2 million acre-feet, increases the cost to agriculture of that allocation to nearly $100 million—an increase of $37 million, or approximately 60 percent. Efficiently allocating the reduction of 1.2 million acre-feet in the water supply within agriculture reduces the use of water by 541,000 acre-feet in the western San Joaquin Valley and by 594,000 acre-feet in the Sacramento Valley. Water transfers to southern California decline by 66,000 acre-feet, from 243,000 acre-feet to 177,000 acre-feet. That allocation reduces crop revenues by 16 percent in the Sacramento Valley and by 4 percent in the western SJV region. Payments for the remaining water transfers to urban areas at a price of $101 per acre-foot increase net agricultural benefits by $18 million.

Allocating 1.35 million acre-feet of water for environmental uses reduces agricultural revenues by $113 million. That represents a reduction of 4 percent relative to revenues realized without such an allocation.

Economic Impact of Provisions for Pricing Water

Provisions that increase water rates—surcharges for the fish and wildlife restoration fund, tiered water prices, and requirements that transferred water be repaid at different rates—will have two general effects: they will reduce net benefits to the agricultural and urban sectors by the amount paid in additional charges, and they will change the relative benefits of agricultural and urban water use. Consequently, the quantity of water used in the two sectors also will change. Those changes, however, are estimated to be relatively small.

Adding surcharges to the scenario with water markets and an environmental water allocation reduces water transfers to urban uses by 82,000 acre-feet (see Table 4). Keeping that water in agriculture increases revenues from crop production by $8 million. Gains in farmers' revenue are offset by a loss of $9 million from water sales. That loss arises because a small reduction in the market price reduces the payment for each unit transferred and because fewer units are transferred.

Urban benefits from water use decrease by $10 million, but urban consumers pay $9 million less for water transfers. The net decrease in consumers' benefits is thus $1 million. In addition, agricultural and urban water users pay $23 million in surcharges for the restoration fund. Despite levels of water use that are similar to the other regions, payments to the fund are lowest in the Sacramento Valley because tiered prices and surcharges apply only to deliveries of CVP water to regular contractors (termed project water). On average, nearly two-thirds of all CVP water delivered to farmers in the Sacramento Valley is delivered to water rights holders. That so-called nonproject water would not be subject to the price increases.

Adding rate increases (tiered water prices and repayment rates) to the scenario with surcharges, water markets, and an environmental water allocation amplifies the results described above. Water transfers fall by an additional 28,000 acre-feet—a total of 110,000 acre-feet less than without the surcharges or rate increases (see Table 4). Urban benefits fall another $4 million, to $14 million less than without the additional charges (see Table 5). Payments to the restoration fund increase to $30 million.

Economic Impact of a Package of CVPIA Provisions

In a year with average rainfall, the total cost to CVP farmers of the combined provisions for a water market, for allocating 1.2 million acre-feet of water for environmental purposes, and for imposing all rate increases is about $125 million (5 percent of baseline revenues). That number includes a reduction of $105 million in revenues from agricultural production, partially offset by $7 million in proceeds from water sales. In addition, farmers contribute $27 million to the restoration fund.

The decline of $105 million in gross revenues implies a reduction of $44 million in net revenues, assuming that cost and revenue changes move in tandem.[6] Thus, the direct cost to farmers of using less water is roughly $38 million. The direct cost of the CVPIA results in a chain reaction of purchases among firms, caused by and including the changes in farmers' purchases of inputs and sales of crops.

A comprehensive measure of those direct and indirect effects of the CVPIA on the regional economy should include effects on suppliers of agricultural inputs as well as changes in farmers' revenues, but it should not include the portion of revenues that is spent outside the state (see Box 3). The Department of Commerce's regional earnings multipliers translate changes in gross revenues into one such measure.[7] The regional earnings multiplier for agriculture in California is 0.6557, which means that household earnings in California will fall by 66 cents for every $1 decrease in gross revenues from crops. Thus, the $105 million reduction in gross revenues caused by the CVPIA translates to a reduction of roughly $69 million in state income. That measure does not include induced effects —that is, the changes in purchases by households resulting from changes in the income of employees of affected firms.

The total benefit to urban consumers is $11 million, but $10 million of that is used for water purchases and CVPIA surcharges. A total of $3 million is paid to the restoration fund for the $25 surcharge, the surcharge of $12 per acre-foot that municipal and industrial users pay, and repayment rates for water transfers. Another $7 million compensates agricultural contractors for the water transfers. Thus, the increase in net benefits to consumers from those provisions is $1 million.

Throughout this analysis, total water use in the Friant region remains unchanged. Despite the impact of the reduced availability of water in the western San Joaquin Valley and the Sacramento Valley and the price increases, the implicit value of water in the Friant region remains higher than that for the other regions. The CVPIA prohibits taking water from the Friant region to comply with the provisions that allocate water to fish and wildlife. In addition, Friant's geographic location inhibits its ability to transfer water. For that reason, and because of the relatively high values for water use, transferring water out of the region is not economically efficient. The Friant region is not completely unaffected, however; water is transferred within the region, and restoration payments are higher there than in other regions.

The package of CVPIA provisions also benefits the environment. It increases the amount of water for instream flows and temperature control (approximately 1 million acre-feet intended primarily for fish habitat), increases the water available for wetlands (250,000 to 400,000 acre-feet intended primarily for waterfowl hab-

6. CBO calculates net revenues to be 36 percent of gross revenues in the Sacramento Valley and 49 percent in the San Joaquin Valley. Those calculations rely on Bureau of Reclamation figures reported in Environmental Protection Agency, Region 9, Water Management Division, *Regulatory Impact Assessment of the Final Water Quality Standards for the San Francisco Bay/Delta and Critical Habitat Requirements for the Delta Smelt* (San Francisco, December 15, 1994), with technical assistance from Jones and Stokes Associates, Sacramento, Calif., (JSA 94-130), p. 5-4.

7. Department of Commerce, Bureau of Economic Analysis, *Regional Multipliers: A User Handbook for the Regional Input-Output Modeling System (RIMS II)* (May 1986).

itat), and improves the habitat for fish and wildlife with money from the restoration fund. The costs of the CVPIA can be viewed as a lower bound to the environmental benefits the act needs to provide to achieve positive net social benefits. If environmental benefits (including benefits derived from the restoration fund) equal or exceed the impact on agricultural and urban water users, the act's net value to society will be positive. In a recent paper on the subject, Loomis estimates the value of providing 260,000 acre-feet (level-2 water) to wildlife refuges alone to be $79 million.[8]

The CVPIA mandates that the 1.2 million acre-feet of water allocated for environmental purposes be taken "off the top" of CVP water supplies. In contrast, the additional 140,000 acre-feet needed to provide wildlife refuges with the higher level-4 water supplies must be acquired voluntarily. The Bureau of Reclamation must compete with urban districts and water-short agricultural districts to acquire that water. The analysis suggests that if that water comes solely from CVP water users, the bureau will have to pay roughly $14 million—the difference between gross revenues with 1.2 million acre-feet of environmental water and those with 1.35 million acre-feet—to fully compensate those users for the additional 150,000 acre-feet of water for wildlife refuges.

Sensitivity of the Results to the Availability of Water

The CVPIA's impact on agricultural and urban users is likely to be sensitive to factors that change initial water supply conditions. For the analysis reported above, CBO assumed an average water supply and the absence of other legislation that might alter the availability of water. Such assumptions isolate the effects of the CVPIA from those of a drought, the Clean Water Act, and the Endangered Species Act. To determine how those assumptions affect the results, CBO repeated the analysis using alternative assumptions.

The Implications of a Fluctuating Water Supply. Hydrologic conditions vary significantly from year to year. Conditions range from critically dry years, such as those experienced in California between 1987 and 1992, to wet years, such as 1983 and 1995, in which significant flooding may occur.

Large water projects provide some degree of protection against those fluctuations. Figure 3 illustrates fluctuations in CVP water supplies over time. The CVP's storage capabilities isolated most farmers from reductions in the water supply during the first three years of the drought (1987-1989). By 1990, however, reservoirs were at extremely low levels, and the Bureau of Reclamation was forced to limit water deliveries. Water supplies to farmers in the western San Joaquin Valley were cut by 50 percent in 1990 and were only 25 percent of contract allotments in 1991 and 1992. Supplies for water rights holders in the Sacramento Valley, urban water districts, and wildlife refuges were between 25 percent and 100 percent of historical averages in those years. In the Friant region, only water with the highest priority was delivered from 1988 to 1992.

In contrast, 1995 was an extremely wet year, and water supplies to all users were 100 percent of normal, even after satisfying all of the CVPIA's allocations for fish and wildlife. Thus, in wet years, the cost the CVPIA imposes on agriculture may be limited to payments to the restoration fund; the act would not reduce crop revenues in those years.

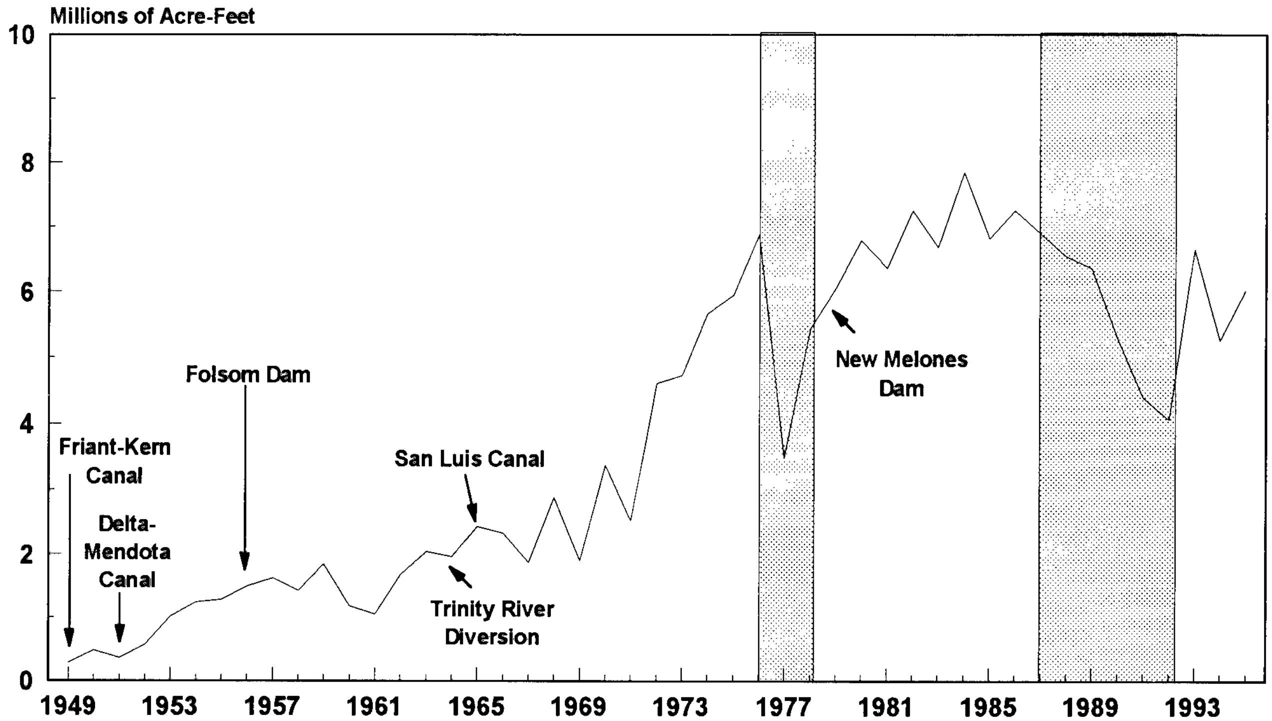
The costs of the act's provisions would be significantly greater than those estimated above if drought conditions persisted, although transfers would have a bigger net benefit.[9] To illustrate potential differences in results under drought conditions, CBO repeated the analysis using the following assumptions:

- CVP water supplies to agricultural contractors are reduced by 50 percent.
- Water rights holders and exchange contractors receive 75 percent of their allocations.
- Urban contractors in the San Francisco Bay region receive 75 percent of their entitlements.

8. John Loomis, "Water Transfer and Major Environmental Provisions of the Central Valley Project Improvement Act: A Preliminary Economic Evaluation," *Water Resources Research*, vol. 30, no. 3 (March 1994).

9. Environmental damages related to water projects also increase in drought years. Therefore, benefits from the CVPIA would probably increase in those years. However, CBO has not estimated those benefits.

Figure 3.
Total Amount of Water Delivered by the Central Valley Project, 1949-1995



SOURCE: Congressional Budget Office using data from the Bureau of Reclamation, Mid-Pacific Region, Water Operations Record Keeping (WORK) system for applicable years; and personal communication from the Public Affairs Office, July 18, 1996.

NOTE: The shaded vertical bars indicate periods of drought. The arrows indicate the year in which a project was completed.

- The Metropolitan Water District's water supplies are reduced by 10 percent (reflecting a 75 percent allocation from the State Water Project).

Under those conditions, the water allocation for environmental uses is also reduced by 25 percent, and the constraints on water imported to the San Francisco region are relaxed by 50,000 acre-feet.

CBO developed a drought baseline to isolate the impact of a drought from that of the CVPIA. The drought baseline shows that the cost of a drought of the severity outlined above would be $266 million relative to the original baseline. Implementing the CVPIA under extreme drought conditions raises the cost to agriculture—including lost crop revenues, proceeds from water sales, and payments to the restoration fund—by $258 million, an 11 percent reduction from the drought baseline. Crop revenues decline by $275 million in that scenario. Even though a relatively small quantity of water (only 50,000 acre-feet) is transferred, farmers' proceeds from water sales are $23 million—higher than in any other scenario—because of the high marginal values for water. Payments from agriculture to the restoration fund total $6 million.

In contrast to the previous scenarios, the drought scenario includes reduced water use in the Friant region because neither the Sacramento Valley nor the western San Joaquin Valley can provide the amount of water needed. The least-cost solution to the problem of providing water for fish and wildlife is to significantly reduce water deliveries in the Sacramento Valley, but the bureau's obligation to holders of senior water rights (farmers whose rights to the water predate the Bureau of Reclamation's) means that those deliveries will probably be reduced by no more than 25 percent. The burden of providing that water therefore falls most directly on farmers in the western San Joaquin Valley. However, the drought baseline includes less than 900,000 acre-feet of water—the quantity the CVPIA allocates to environmental uses in drought years—for that region.

Therefore, at least some portion of the environmental water must come from elsewhere in the Central Valley Project.

Moreover, farmers in the Friant region have better access to alternative water sources—both groundwater and surface water from local streams—than do farmers in the western SJV region and thus will lose less revenue from reductions in the water supply in the short run. Consequently, the least-cost solution to that problem includes reducing water use in both the Friant region and the western San Joaquin Valley. Because Friant water users are not directly liable for water for fish and wildlife, reductions in their water use would probably come in the form of water transfers purchased by western SJV farmers.

The cost of the drought scenario would be lower if rights holders in the Sacramento Valley contributed a greater share of the environmental water. Although the authority for taking that water may exist under the Endangered Species Act, a more likely outcome is that voluntary water transfers would occur between Sacramento water rights holders and western SJV farmers. That benefit is not attributed to the CVPIA, however, because the right of water rights holders to transfer that water conveys from state law rather than the CVPIA in most cases.

The value of water transferred to urban use is significantly higher under drought conditions. Because demand for water in urban areas is relatively inflexible, the impact of drought-reduced base supplies in the San Francisco region is quite large. The benefit to urban users of offsetting those losses with transfers of CVP water is therefore quite large as well; benefits increase by $31 million for transfers of 50,000 acre-feet. In the drought scenario, transferring water to urban areas in southern California is not optimal. The Metropolitan Water District's water supply from the Colorado River buffers it from the effects of the drought felt in northern California, so the value of water for MWD consumers is lower than that for urban consumers in the San Francisco region or for the more severely water-constrained farmers in the San Joaquin Valley.

Additional Regulatory Obligations. Both the Clean Water Act and the Endangered Species Act could inhibit the ability of the Bureau of Reclamation to divert CVP water—for example, by placing restrictions on pumps drawing water from the delta for export. The ESA prohibits the taking of any member of a species listed as threatened or endangered. However, the federal agencies responsible for carrying out the ESA—the National Marine Fisheries Service and the Fish and Wildlife Service—often issue incidental take permits, thus recognizing that a certain number of accidental takes may be unavoidable. The agencies have issued incidental take permits for a fixed quantity of fish for the delta pumps. Those pumps inadvertently draw juvenile winter-run chinook salmon, an endangered species, along with water during normal operations. If the permitted incidental take is reached, the pumps may be shut down until the juveniles are thought to be no longer present near the pumps. Restrictions on pumping are also imposed to minimize reverse flows in the delta that can confuse migrating fish and cause them to swim toward, rather than away from, the pumps.

Restrictions on delta pumping may reduce the supply of water for farmers in the western San Joaquin Valley and limit the capacity for north-to-south transfers of water for agricultural or urban uses. The pumping restrictions would generally not affect water use in the Sacramento Valley, although they would limit the region's ability to participate in water transfers. Friant districts would also be unaffected, except that their water might become more valuable for transfer to urban uses because of their location south of the delta.

Another possible impact of regulation is a requirement to increase outflows from the delta. Water flowing west out of the delta helps to maintain a hydraulic barrier to salt water intruding from San Francisco Bay, thus improving water quality in the delta. It can also help flush juvenile salmon out of the Sacramento River and delta systems, thus improving survival rates. Water used for that purpose may be unavailable for diversion south of the delta. Both the CVP and the California State Water Project would probably be required to contribute water for that purpose. If CVP contractors contributed water to protect the delta environment in addition to the water dedicated to environmental purposes by the CVPIA, their costs could rise.

Environmental Benefits and Issues in Estimating Their Values

Environmental benefits from the CVPIA will include improved habitat for flora and fauna that spend at least a portion of their life cycle in the rivers and wetlands of the Central Valley. Central Valley watersheds support more than 120 distinct fish species. Some, such as the fall run of the Sacramento River chinook salmon, have commercial importance. Others are not plentiful or valuable enough to support a commercial fishing industry but are valued as recreational and sport fisheries. Still others, such as the federally protected delta smelt, provide neither commercial nor recreational values but may be important links in the food chain or serve as indicators of the general health of the aquatic ecosystem. The health of those fisheries depends on the volume, temperature, salinity, and timing of water flows in the Central Valley's rivers and the delta. Central Valley wetlands also provide important habitat for waterfowl wintering in California. As with riverine ecosystems, the quality and quantity of wetland habitat is directly affected by the quality and quantity of available water supplies.

Economic benefits of the CVPIA will arise from increases in economic activities making use of the fish and wildlife populations affected by the act. A primary example of a use value is the commercial fishing industry. Revenues from commercial fishing activities will probably increase if improvements in the habitat brought about by the CVPIA result in large fish populations and thus in larger harvests. Benefits from economic activities are relatively straightforward to measure because the market establishes a value for the activity. Recreational activities, such as sportfishing and duck hunting, also generate economic values, but those values cannot be measured directly.

Values not related to use may also increase. Nonuse values are based on the awareness of the existence of a good that is not a function of the actual use of that good. For example, people may derive benefits from knowing that an endangered species is saved from extinction (existence value), even if they never come in contact with it. Other benefits accrue to people who do not actually use a resource but want the option of doing so in the future (option value) or want their children and future generations to have that option (bequest value). Several methods exist for estimating the value of nonuse benefits, but the procedures are even less straightforward than those for calculating use values.

CBO does not quantify benefits to the environment from the CVPIA, but some studies indicate that those benefits could be large. The nature of those benefits and some estimates of their economic value are presented below to provide context for the cost analysis above. However, the range of estimated values is extremely large. Moreover, the biological relationships describing changes in fish and wildlife populations associated with changes in water flows or habitat restoration projects are not yet available. For example, the CVPIA includes a stated goal of doubling the anadromous fish population. It is not clear, however, whether the CVPIA provisions examined in this study will be sufficient to achieve that goal. Nor are estimates available of changes in salmon populations as a result of those provisions. For those reasons, CBO does not attempt to tie estimates of environmental benefits to CVPIA provisions.

Use Values

The CVPIA's environmental provisions may significantly improve the quality of commercial and recreational fisheries in central California. Important commercial fisheries whose populations may increase as a result of the CVPIA are salmon, striped bass, starry flounder, bay shrimp, and Pacific herring. Important recreational fisheries include salmon, striped bass, green and white sturgeon, American shad, white catfish, and starry flounder. The CVPIA may also improve wetlands.

Commercial Fisheries. Several fish species have been plentiful enough to sustain commercial and recreational fishing industries, but annual catch rates have fallen dramatically in recent years. Between 1976 and 1992, for example, commercial fishers caught an average of 580,000 chinook salmon along the California coast annually.[10] Historically, an estimated 66 percent of those

10. Marc B. Carey, Mark E. Evans, and James E. Wilen, *Water and California's Salmon Resources: A Review* (report prepared for the U.S. Department of Agriculture, Economic Research Service, Natural Resources Division, September 30, 1994).

fish originated in the Central Valley.[11] In recent years, Central Valley salmon have become even more important, accounting for 90 percent of chinook salmon caught by commercial fishers in California waters between 1990 and 1995. Statewide, the value of the commercial salmon fishery peaked at $42 million in 1988 but plummeted to $9 million in 1991. Those values represent 21 percent and 7 percent, respectively, of the total value for all fish commercially caught in California in 1988 and 1991.[12]

A 1994 study by the Environmental Protection Agency provides estimates of the value of increased water flows in the delta for commercial and recreational fisheries. In that study, EPA estimated that protecting water quality in the delta and designating an average of 450,000 acre-feet of water for environmental uses there would increase the salmon population enough to raise the commercial salmon catch by between 7 percent and 81 percent—an increase of 41,000 to 468,000 fish. The large variance in that range reflects scientific uncertainty about the relationship between water flows and the abundance of salmon. The average value per salmon is estimated to be $41. The direct benefits of improved water quality to the commercial salmon fishery are thus $2 million to $19 million annually.[13] Those numbers convert to a benefit of roughly $4 to $43 per acre-foot.

Recreational Fisheries. According to one study, people in northern and central California took 2.5 million saltwater sportfishing trips in 1985 and 1986.[14] Of that total, 38 percent were for salmon or striped bass, the two recreationally important species most dependent on water conditions in the Sacramento River/Delta.

Estimates of the value of water for recreational fisheries are lower than those for commercial fisheries. The EPA estimates that the increase in the salmon population resulting from the CVPIA provisions protecting the delta would increase sportfishing trips for salmon by between 4,000 and 39,000 per year, or roughly 0.4 percent to 4.0 percent of historical averages. The annual value of those additional recreational fishing trips ranges from $300,000 to $2.4 million.[15] Those values imply an estimated benefit of $1 to $5 per acre-foot. Another study estimates the value of in-stream water to recreational fishers in the Central Valley at $4 to $38 per acre-foot (in 1980 dollars), depending on the location.[16]

A different study examines benefits from achieving the CVPIA's goal of doubling the anadromous fish populations. It estimates that doubling the salmon populations would increase benefits for recreational fishers by $10 million to $25 million per year.[17]

Wetlands. Available wetland habitat can be improved by acquiring land and using it to create new habitat or by providing water to improve the quality of existing wetlands. The CVPIA partially addresses the latter need by providing guaranteed water supplies for wildlife refuges in the Central Valley. Incentives to encourage farmers to manage cropland as a wetland habitat in winter may also enhance wildlife populations.

Estimated values of the benefit to hunters of increased water deliveries for wildlife refuges in the San Joaquin Valley range from $1 to $20 per acre-foot, according to one study.[18] Another study estimates the benefit of increased water supplies at all Central Valley wildlife reserves for hunters, fishers, and bird-watchers at $300 per acre-foot.[19] Both studies measure use values only.

11. Congressional Budget Office estimate based on data in Pacific Fishery Management Council, *Review of 1995 Ocean Salmon Fisheries* (Portland, Ore.: PFMC, February 1996).

12. Environmental Protection Agency, *Regulatory Impact Assessment of the Final Water Quality Standards*, p. 6-10.

13. Ibid., p. 6-14.

14. Ibid., p. 6-17.

15. Ibid., p. 6-21.

16. LeRoy T. Hansen and Arne Hallam, "National Estimates of the Recreational Value of Streamflow," *Water Resources Research*, vol. 27, no. 2 (February 1991), pp. 167-175.

17. Carey, Evans, and Wilen, *Water and California's Salmon Resources*, p. 44.

18. Joseph Cooper and John Loomis, "Testing Whether Waterfowl Hunting Benefits Increase with Greater Water Deliveries to Wetlands," *Environmental and Resource Economics*, vol. 3 (1993), pp. 545-561.

19. Michael Creel and John Loomis, "Recreation Value of Water to Wetlands in the San Joaquin Valley: Linked Multinomial Logit and Count Data Trip Frequency Models," *Water Resources Research*, vol. 28, no. 10 (October 1992), pp. 2597-2606.

Nonuse Values

The presence of endangered and threatened species in Central Valley rivers and wetlands, as well as the international importance of the wetlands to the Pacific Flyway, suggest that nonuse values may be an important component of benefits from the CVPIA. Estimates of nonuse values tend to be significantly larger, and more controversial, than estimates of use values. In contrast to use values, which typically accrue to residents within a limited area near the site, nonuse values may accrue to a much larger portion of the population.

The estimate of a relatively small value per person may become quite large when it is multiplied by the number of people potentially affected. For example, one study estimated an average annual benefit of $254 per household for use and nonuse values from improving Central Valley wetlands and $183 per household from restoring the San Joaquin River salmon fishery.[20] Multiplying those figures by 9.8 million households in California yields estimates of $2.5 billion and $1.8 billion for the total annual benefit from improving wetlands and the salmon fishery, respectively. Those values convert to estimates of $6,100 per acre-foot for all use and nonuse values (including existence, option, and bequest values) associated with improved Central Valley wetlands and $41,000 per acre-foot for water to restore salmon to the San Joaquin River.

Caution should be taken in evaluating those estimates of nonuse benefits, for two reasons. First, recent studies have shown that values from alternative environmental programs within a region may be substitutes for each other. Consequently, it would be misleading to add estimates for the value of improving habitat in different areas in the Central Valley. For example, researchers using the same data as Loomis and colleagues found the average household value for *both* improved wetlands and improved salmon fishery to be $229 per household.[21] Using the same conversions provided by Loomis and colleagues yields estimates of benefits ranging from $4,800 to $5,000 per acre-foot for allocating enough water to complete the projects for improving the wetlands and the salmon habitat.

A second issue involves a potential upward bias in estimates of nonuse benefits. At one point, the Department of Commerce recommended that estimates of nonuse values derived with contingent valuation methods be multiplied by 0.5.[22] The department dropped that recommendation in the final rules and regulations defining the appropriate use of that method. But even with that calibration factor, the estimates for nonuse values reported here are two orders of magnitude greater than the estimates for use values.

20. John Loomis and others, "Willingness to Pay to Protect Wetlands and Reduce Wildlife Contamination from Agricultural Drainage," in Ariel Dinar and David Zilberman, eds., *The Economics and Management of Water and Drainage in Agriculture* (Boston: Kluwer Academic Publishers, 1991). That study used a telephone survey to derive an estimate of the value for an average California household.

21. John P. Hoehn and John Loomis, "Substitution Effects in the Valuation of Multiple Environmental Programs," *Journal of Environmental Economics and Management,* vol. 25, no. 1 (July 1993), pp. 56-75.

22. Department of Commerce, National Oceanic and Atmospheric Administration, "Oil Pollution Act of 1990: Proposed Regulations for Natural Resource Damage Assessments," *Federal Register*, vol. 59, no. 5, part 2 (January 7, 1994), pp. 1062-1191.

Chapter Six

Lessons for the West

The Central Valley Project Improvement Act contains many policy tools with which to address the problems related to the Bureau of Reclamation's policies throughout the West. However, the extent to which lessons from the analysis of the CVPIA extend to policy changes for the bureau's other projects is an open question. The answer depends, in part, on regional similarities and differences in underlying factors.

In general, urban water users, the environment, Native Americans, and taxpayers can all benefit from reforms that allow market forces to allocate water, that allocate water to public purposes, and that increase returns to the Treasury from water projects. The real question in evaluating the potential success of water policy reform concerns the magnitude of those benefits relative to the costs that would almost certainly be borne by the agricultural sector.

The Congressional Budget Office estimates that in a year with average rainfall, CVPIA provisions that protect and enhance the habitat of fish and wildlife and reduce economic inefficiencies in water allocations would impose relatively modest costs on the Central Valley's agricultural sector as a whole. Gross revenues would fall by less than 5 percent of pre-CVPIA levels (see Chapter 5). That estimate reflects the generally high value of crops produced in the CVP service area and the relative flexibility that CVP farmers have to adjust cropping patterns and irrigation practices in response to changes in water supply policies. Farmers in other areas, however, may not have the same degree of flexibility. Local institutions and conflicts about water use, both of which differ from river basin to river basin and state to state, also have an important effect on the appropriateness and applicability of carrying out CVPIA-type reforms in other regions.

Three factors are critical in considering whether the results of the CVPIA can apply to other regions. First, the goals of policy reform may be different from those embodied in the CVPIA. Because problems vary from region to region, the objective of the policy reform may vary as well. A policy option that addresses problems in one region may be inappropriate in another simply because that problem does not exist there.

The second factor is the extent to which the policy tool motivates farmers to change their patterns of water use. Although all farmers should respond to an increase in water price by using less water, farmers in one region may be more or less sensitive to a price change than those in another. At the extreme, farmers who have less water than they want may not respond at all to small changes in price. Examining the variables likely to influence farmers' response to price changes may help predict whether policy tools will elicit the intended response.

The third key factor is the level of the policy tools. One lesson of the analysis in Chapters 3 and 5 is that the levels of policy tools (specific prices and water quantities) are as important as the type of policy (price increases, water transfers, and environmental water allocations) in driving the ultimate response to the reforms. The CVPIA contains many elements explicitly stated in quantitative terms. For example, it imposes agricultural surcharges of $6 per acre-foot and water transfer charges of $25 per acre-foot, and it allocates

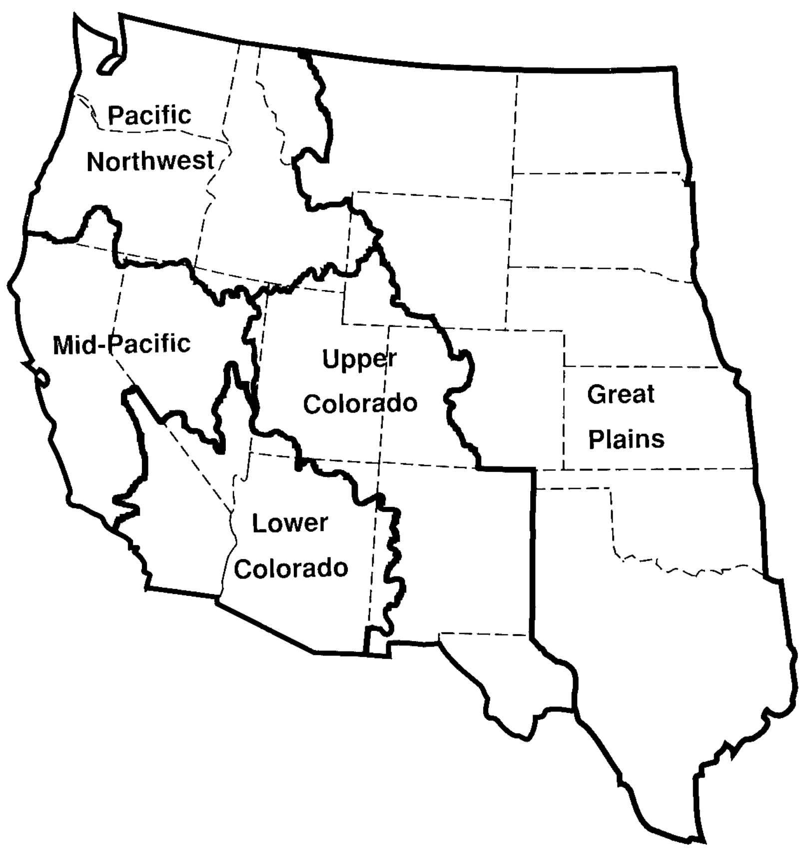
800,000 acre-feet of water to fish and wildlife. Different levels would elicit different responses.

Regional Differences in Variables That Influence Farmers' Response to Reform

The Bureau of Reclamation has divided its jurisdiction into five geographic regions, each roughly coinciding with a major river basin (see Figure 4).

- The Pacific Northwest Region includes projects in Idaho, Montana, Oregon, Washington, and Wyoming.
- The Mid-Pacific Region includes the Central Valley Project as well as smaller projects in California, western Nevada, and southern Oregon. The CVP accounts for about three-quarters of federal funds to that region.
- The Lower Colorado Region includes projects serving Arizona and southeastern portions of California and Nevada.
- The Upper Colorado Region includes projects in Colorado, southeastern Idaho, New Mexico, Utah, and Texas.
- The Great Plains Region includes projects in the Missouri River basin and the Arkansas River basin serving eastern Colorado, Montana, Nebraska,

Figure 4.
The Bureau of Reclamation's Five Regions in the Western United States



SOURCE: Congressional Budget Office based on information from the Bureau of Reclamation.

North Dakota, South Dakota, and Wyoming, as well as small projects in Kansas, Oklahoma, and eastern Texas.

No two of the Bureau of Reclamation's project areas are alike; economic, agronomic, climatic, hydrologic, and institutional settings all may differ. Without conducting an in-depth study of each project, it is impossible to predict how farmers in a given project will respond to a specific policy change. Nevertheless, some variables can serve as indicators of potential similarities and differences between the predicted response of CVP farmers and that of farmers in other regions. Ideally, analysts would like to know exactly how much water is being applied on each crop, the bureau's share of total water supplies, water's share of total production costs, and net returns to land and management from crop production. However, that information is not available. Data that are available include averages of gross revenues, land values, patterns of crop production, and the amount of water the bureau supplies.

No region clearly dominates the others in terms of farmers' ability to adjust to water policy reform. In addition, within each region, some farmers face more favorable conditions than others. However, enough variables indicate favorable conditions for CVP farmers that they are more likely, on average, to adapt to water policy reform with less disruption to the agricultural economy than farmers in other regions. Based on such variables as the concentration of high-revenue crops and the volume of water delivered, farmers in the Lower Colorado and Pacific Northwest Regions are most likely to make adjustments that are similar to those predicted for CVP farmers in response to the CVPIA. The Great Plains Region appears to be the most dissimilar of all the regions, and the results of the CVPIA analysis are least likely to hold there.

The Role of Key Variables as Predictors of Farmers' Response to Water Supply Policies

Revenues from crop production, the value of land, patterns of crop production, and the volume of water delivered by the Bureau of Reclamation are variables that may predict farmers' response to water supply policies, and data on them are readily available.

Crop Revenues

Gross revenues per irrigated acre are one measure, albeit an imperfect one, of the ability of farmers to survive changes in the price and availability of water. In general, the higher the value of the crops produced, the better the farmers can absorb increases in water prices and finance improvements in irrigation systems.

Gross revenues are an imperfect measure of the financial strength of an individual farming operation because they do not reflect costs, but average gross revenues are one indicator of the potential capability of a region to tolerate modifications in the price and availability of water. Clearly, a farm that generates $300 per acre and uses three acre-feet of water per acre to irrigate the crop could not remain profitable in the face of water charges of $100 per acre-foot. In other words, relatively high revenues may be necessary to adapt to changes in water prices without major disruptions in production, but they may not always be sufficient to do so. Likewise, high gross revenues may be necessary to justify and finance expensive new irrigation systems that allow farmers to maintain levels of crop production with reduced water supplies.

Based on average gross revenues alone, farmers in the Lower Colorado Region would probably respond most similarly to CVP farmers, and reform would be less disruptive to agriculture there than in other regions. Revenues per acre are highest in California and Arizona. In 1990, California ranked first with an average of $2,050 in gross revenues per acre irrigated with water from the Bureau of Reclamation, followed by Arizona with $1,384 per acre and Washington with $1,251 per acre (see Figure 5).[1] The average for all 17 western states was $643, but nine states averaged less than $500 per acre. Thus, gross revenues in more than half the western states were less than 25 percent of those received in California.

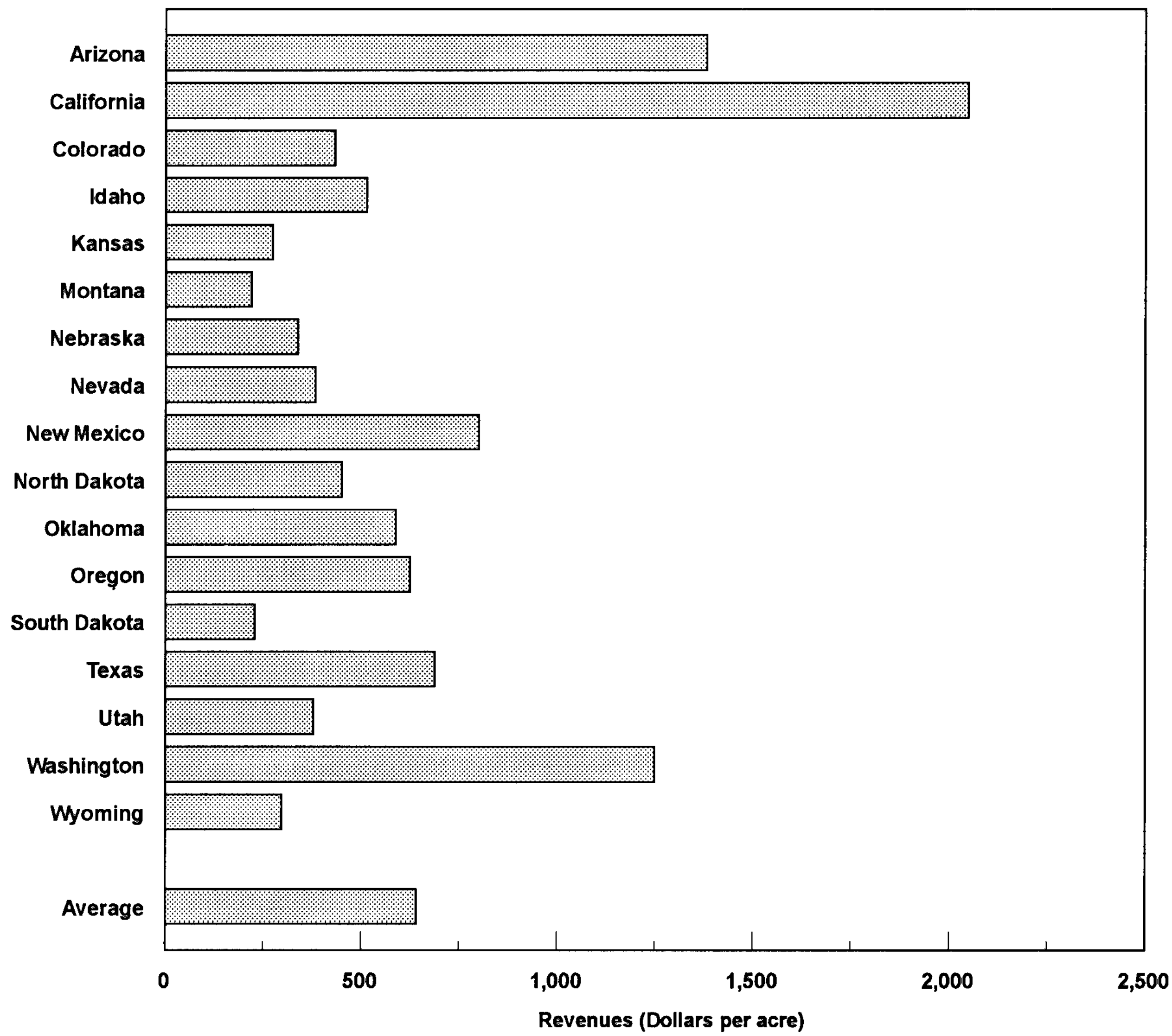
1. The relative rankings of California and Arizona may be somewhat skewed by the drought conditions present in both states in 1990. Arizona ranked first in years before 1990. For example, average values in 1987 were $1,750 per acre in Arizona and $1,501 per acre in California.

Regional rankings correspond to state rankings. Average values were highest in the Mid-Pacific and Lower Colorado Regions, and the Pacific Northwest Region ranked third. Average revenues were lowest in the Great Plains Region, with a regional average of $383 per acre in 1990.

Land Values

High values for irrigated farmland may signify that farmers will be able to adapt to changes in water policy over the long run, but adjustments may not be easy in the near term. Figure 6 presents average values for

Figure 5.
Average Gross Revenues from Crops Irrigated with Water from the Bureau of Reclamation's Projects in 1990, by State

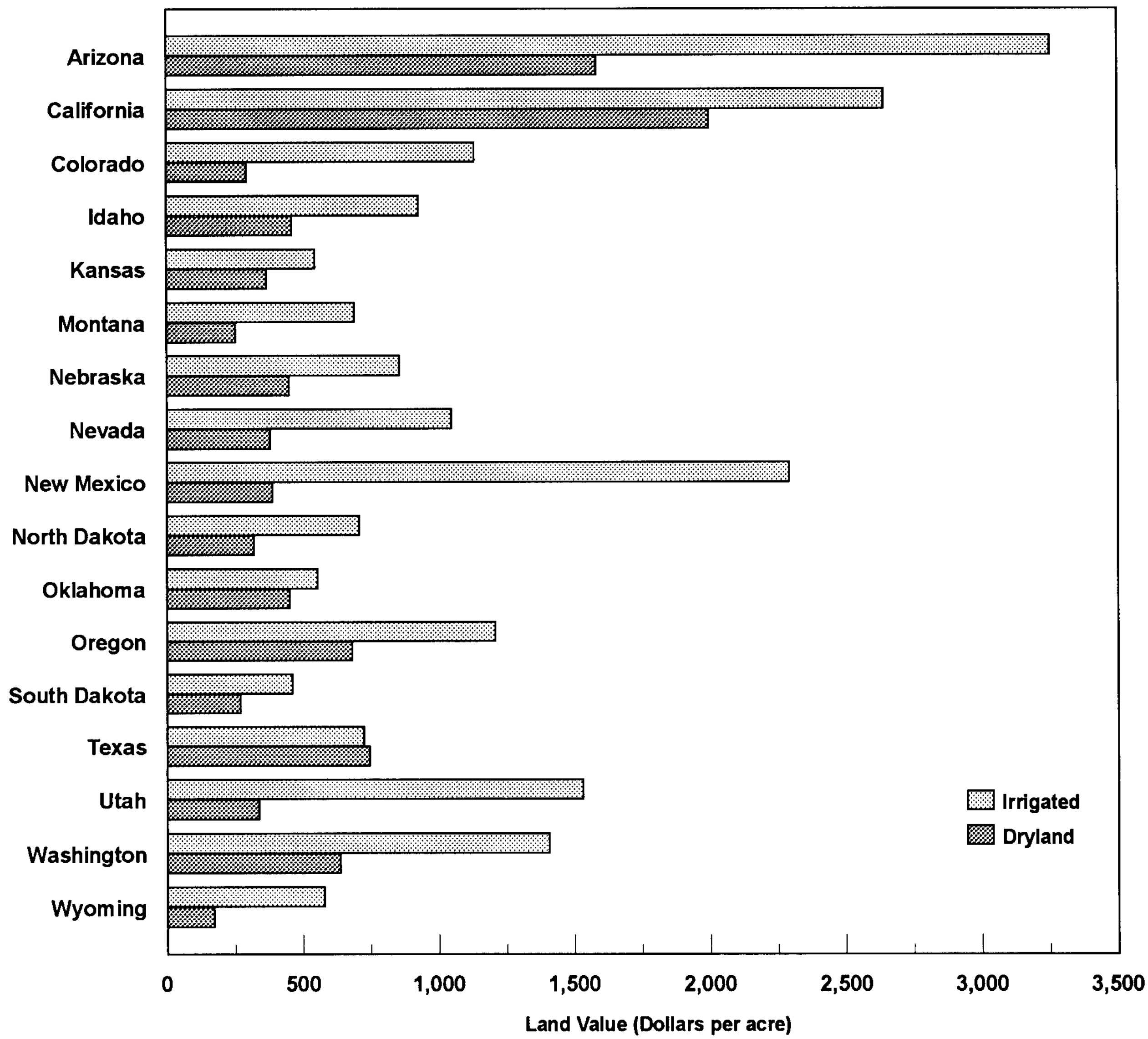


SOURCE: Congressional Budget Office using data from Bureau of Reclamation, *1990 Summary Statistics: Water, Land, and Related Data* (1990).

farmland in the 17 western states. Values for irrigated land are highest in the southwestern states (Arizona, California, and New Mexico). The difference between land values for irrigated farms and those for dryland or grazing uses indicates the value farmers place on access to irrigation water at prevailing quantities and prices. In other words, the benefit of access to irrigation water is reflected in higher prices for buying and renting land. Consequently, land values could fall if reforms significantly reduced the water supply or increased its price. If so, farmers who have paid the higher price for their land could be hurt by the policy change.

In the long run, agriculture could remain profitable. Reform that either significantly increases water prices or reduces available water supplies may temporarily

Figure 6.
Agricultural Land Values for Irrigated and Dryland Uses in 1988, by State



SOURCE: Congressional Budget Office using data from Rajinder S. Bajwa and others, *Agricultural Irrigation and Water Use*, Agriculture Information Bulletin No. 638 (Department of Agriculture, Economic Research Service, January 1992).

disrupt land markets, but economic theory suggests that land markets will return to equilibrium after a permanent change in water supply policies. Thus, although policy changes could have a dramatic effect on some individual farmers in the short run, the long-run effect on the agricultural sector as a whole could be more moderate. Regions with lower land values might be less able to adjust both in the near term and over the long run.

High land values imply high profits (revenues net of production costs). Only when profits are high will farmers be willing and able to pay high prices for land. High gross revenues do not necessarily imply high profits, but they often coincide. In the West, they also coincide with the availability of cheap and plentiful water supplies. The high correlation between gross revenues from farmland irrigated with the bureau's water and average values for irrigated farmland in each state can be seen by comparing Figures 5 and 6. Other important factors that determine the value of irrigated land include pressures from urban development and the profitability of dryland agriculture.

The relationship between revenues from crop production and the value of irrigated land suggests a qualification to the result that large crop revenues increase an area's ability to adapt to changes in water policy (discussed in the previous section). That result may be true only in the long run. In the near term, if farmers with high crop revenues are paying higher prices for land, those farmers may not have any more flexibility to adjust to changes in water prices and availability than a farmer with low revenues who pays relatively little for the land. In the long run, however, the price of land should fall, which would increase the ability of the farmer to adjust.

Cropping Patterns

Both the variety of crops produced and the concentration of the dominant crops affect how farmers respond to changes in water policy. As a rule, the more practical options farmers have for adjusting crops in response to changes in water supply, the less disruptive policy shifts will be.

Variety of Crops Produced. The number of crops produced in each region is quite large, ranging in 1990 from a high of 69 in the Mid-Pacific Region to a low of 38 in the Great Plains Region. (Those figures include all crops to which farmers have allocated at least 160 acres.) Favorable climatic conditions may provide more options for farmers in some regions than in others. Crops vary in their water requirements, length of growing season, cultivation needs, and profitability. Being able to adjust cropping patterns while accounting for those factors should allow farmers to moderate the consequences of changes in the price and supply of water.

Concentration of Dominant Crops. The less concentrated the crop production is in a region, the more flexibility farmers are likely to have for changing cropping patterns and thus minimizing the cost of adjusting to water policy reform. Despite the large variety of crops produced, production in each region is concentrated in relatively few crops. Table 6 presents the top five crops in each region, ranked by acreage and revenues.

The top five crops in the Mid-Pacific Region account for only half the irrigated acreage in that region, indicating the relative flexibility of CVP farmers in choosing among various crops. Fully half of the project's service areas in the Mid-Pacific Region produce dozens of other crops in significant quantities. Similarly, only 57 percent of the acreage in the Pacific Northwest Region is devoted to producing the top five crops, compared with 70 percent to 80 percent in the remaining three regions. That strong reliance on a relatively small number of crops implies that farmers in those regions have fewer practical options for adjusting to changing policies on water supply than those in the Pacific Northwest and Mid-Pacific Regions.

Equally compelling is the relationship between acreage shares and shares of regional revenues. In all but the Great Plains Region, crops that account for the largest acreage shares contribute significantly less to total revenues. For example, the top five crops by acreage account for 77 percent of total acreage in the Upper Colorado Region but only 45 percent of total revenues (see Table 6). Conversely, the five crops that contribute most (59 percent) to revenues in that region are produced on only 39 percent of the acreage.

The relatively large discrepancy between the acreage share and the revenue share for top-ranked crops indicates that some changes in water use could occur at a relatively low cost. In the Lower Colorado Region, wheat and hay other than alfalfa account for 19 percent of the acres but contribute only 3 percent of the revenues. A large reduction in the production of the lower-valued crops, such as irrigated pasture and hay (other than alfalfa), could occur with much smaller, proportionate reductions in revenues. Both crops require large quantities of water, so reducing their production could yield greater than proportionate savings in total water use.

Farmers' Dependence on Water from the Bureau of Reclamation

The relative importance of the Bureau of Reclamation's water for producing crops will be an important determinant in how changes in the bureau's water supply policies affect farmers. Both the number of water sources and the quantity of water matter. The quantity of water the bureau makes available to farms varies significantly

Table 6.
Ranking of Crops in the Bureau of Reclamation's Five Regions, by Acreage and Revenues, 1990

Rank	Pacific Northwest	Mid-Pacific	Lower Colorado	Upper Colorado	Great Plains
		Crops Ranked by Acreage			
1	Alfalfa Hay	Cotton	Alfalfa Hay	Alfalfa Hay	Corn
2	Wheat	Alfalfa Hay	Cotton	Pasture	Alfalfa Hay
3	Pasture	Rice	Wheat	Other Hay	Dry Beans
4	Potatoes	Grapes (Wine/raisins)	Lettuce	Cotton	Barley
5	Barley	Tomatoes (Processing)	Other Hay	Barley	Sugar Beets
Share of Total Acreage in Region (Percent)	57	50	79	77	70
Share of Total Revenues in Region (Percent)	34	38	44	45	71
		Crops Ranked by Revenues			
1	Apples	Grapes (Wine/raisins)	Lettuce	Alfalfa Hay	Corn
2	Potatoes	Cotton	Alfalfa Hay	Pecans	Alfalfa Hay
3	Alfalfa Hay	Oranges	Cotton	Cotton	Sugar Beets
4	Sugar Beets	Almonds	Table Grapes	Dry Onions	Dry Beans
5	Wheat	Tomatoes (Processing)	Cantaloupes	Peppers	Silage/Ensilage
Share of Total Revenues in Region (Percent)	55	50	55	59	73
Share of Total Acreage in Region (Percent)	49	41	67	39	68

SOURCE: Congressional Budget Office based on data from Bureau of Reclamation, *1990 Summary Statistics: Water, Land, and Related Data* (1990).

throughout the West. In addition, some farms have access to other water sources and some do not. That variation occurs within regions as well as between them. A farmer who relies completely on the bureau's water will have fewer options for adjusting to a smaller water allocation or higher prices than would one with access to other sources. Similarly, if two farms are identical except that one has a larger water allocation, the one with the larger allocation will have more options for adapting to changes in water policy.

Availability of Alternative Water Sources. The Bureau of Reclamation's water projects may be farmers' sole source of water or may supplement another source. In general, the better the access to alternative water sources, the lower the impact of the bureau's policy shifts. Acreage in the bureau's service areas is classified as eligible for full service, supplemental service, or temporary service. Full-service acreage has no other water source. Acreage with supplemental service presumably has at least one other source (locally developed surface water or groundwater). Temporary service is a minor category that includes acreage eligible for water service under a temporary agreement.

Categorizing acreage as full service conveys information about the total dependence of farmers on the bureau's water. Table 7 presents the percentage of acreage in each region classified as full service. That measure of relative dependence ranges from 15 percent in the Mid-Pacific Region to 77 percent in the Lower Colorado Region; in other words, three-fourths of the acreage irrigated with the bureau's water in the Lower Colorado Region has no other water source. In contrast, farmers operating 85 percent of the acreage in the Mid-Pacific Region may have access to at least one other water source. Roughly 40 percent to 50 percent of the eligible acreage in the remaining regions is full service.

Considering only the percentage of full-service acreage, the cost of adjusting to changes in water policy should be highest in the Lower Colorado Region and lowest in the Mid-Pacific Region. However, the nature and extent of the dependence of farmers with supplemental service on the bureau's water is not readily discernible. Some districts with supplemental service contracts actually have no practical alternative to the bureau's water for irrigation. Moreover, the volume of nonbureau water available to districts that have other sources may be small or large relative to the bureau's water allocation, but that information is not generally available.

Table 7.
Regions' Dependence on Water Deliveries by the Bureau of Reclamation, 1989-1990

Region	Percentage of Acreage with No Other Water Source[a]	Amount of Water the Bureau Delivers (Acre-feet per acre)[b]
Pacific Northwest	53	4.1
Mid-Pacific	15	1.6
Lower Colorado	77	5.0
Upper Colorado	39	1.9
Great Plains	43	1.4

SOURCE: Congressional Budget Office based on data from Bureau of Reclamation, *Summary Statistics: Water, Land, and Related Data* (1989 and 1990).

a. Full-service acreage reflects 1990 data.

b. Water delivered by the Bureau of Reclamation is the average for 1989 and 1990.

Quantity of Water Delivered. Another measure of the relative importance of water service to farmers is the volume of water delivered per acre. Farmers receiving just enough water per acre to meet plants' minimum requirements will have to adjust cropping patterns—substituting crops that consume less water for those with greater water needs—or increase fallowed acreage in response to a reduction in water supply. At the other extreme, a farmer using large quantities of water may be able to adjust to less water by simply monitoring water applications more carefully. Most farmers are between those extremes. Nevertheless, some will have more and better options to adjust irrigation technology and management for a given set of cropping patterns than will others.

Determining whether a given water application contains excess water requires information on the crop produced, the location of the district, and the irrigation technology used. Water requirements—the amount of water a plant must absorb to reach maturity—vary by crop and by climate. In the CVP service area, the average water requirement for alfalfa hay is 3.1 acre-feet per acre, 2.5 for cotton, roughly 2.0 for tomatoes, 1.6 to 2.1 for grapes, and 0.6 to 0.9 for wheat.[2] In California's Imperial Valley (Lower Colorado Region), which is hotter and receives less rain than the CVP area, those requirements are roughly 1.0 acre-foot per acre greater.

Water requirements are biologically and climatologically determined; a fixed quantity of water must be available for consumption by the plant to produce a successful crop. However, the amount actually applied may bear little relation to that requirement. For maximum crop yield, farmers must apply more water than crops actually need; it is virtually impossible to apply only the quantity of water consumed by the plant. Irrigation that provides twice the amount of water that crops actually require is not uncommon in western agriculture.

The larger the difference between the quantity of water applied to a field and the quantity consumed by the crop, the lower the probability that changes in water policy will be disruptive to farmers. The amount of the difference depends on the irrigation technology used and how efficiently it is managed. For a given cropping pattern, farmers could respond to incentives or requirements to reduce water use by improving the efficiency of the existing technology or by switching to a technology that is generally more efficient. Farmers who already are quite efficient—that is, their water applications are close to what their crop needs—would have fewer remaining options for improving irrigation efficiency, and the remaining options would probably be significantly more expensive than those available to farmers with large water applications.

Interregional Variations in Water Supplies. The average volume of water that the Bureau of Reclamation delivers to districts varies significantly among the five regions (see Table 7, which presents the average amounts of water the bureau delivered to each region during the 1989-1990 period).[3] Larger deliveries correspond roughly with greater percentages of full-service acreage. On the basis of the bureau's water deliveries only, resolving water conflicts by transferring water out of agriculture would be least disruptive, on average, in the Pacific Northwest and Lower Colorado River Regions. However, those regions have the highest percentages of full-service lands and thus the greatest proportion of acreage without another water source. Nevertheless, average water applications appear to be much greater than the minimum quantity necessary to produce the current crop mix, so there may well be opportunities to conserve water with minimal disruption to the agricultural sector in those regions.

Intraregional Variations in Water Supplies. The amount of the bureau's water that is distributed to districts varies within each of the five regions. A region's average water delivery may mask important differences in the distribution of water to individual districts. Average water deliveries to districts are highest in the Lower Colorado Region and lowest in the Mid-Pacific Region. Distribution in the Upper Colorado and Great Plains Regions is similar to that in the Mid-Pacific Region, where more than 70 percent of the districts receive deliveries of less than 2.5 acre-feet per acre.

Some districts receive water quantities that are significantly larger than crop requirements, on average, and some receive quantities that are insufficient to produce any crop. For example, 20 percent of the districts in the Mid-Pacific Region receive between 2.5 and 3.5 acre-feet of water per acre (see Figure 7). In the Pacific Northwest, 35 percent of the districts receive between 2.5 and 3.5 acre-feet per acre, though 14 percent receive more than 5.5 acre-feet and 20 percent receive less than 2.5 acre-feet per acre. In the Lower Colorado Region, nearly 60 percent of all districts receive more than 4.5 acre-feet per acre (including 44 percent that

2. Lloyd S. Dixon and Larry L. Dale, *The Impact of Water Supply Reductions on San Joaquin Valley Agriculture*, DRU-892-EPA (prepared for the Environmental Protection Agency, Region 9, December 1994); and California Department of Water Resources, *California Water Plan Update*, vol. 1, Bulletin 160-93 (Sacramento, Calif., October 1994), Table 7-6.

3. Total water deliveries—including both project and nonproject water—are probably larger than those displayed. Nonproject water use is reported by districts in their annual water use reports to the Bureau of Reclamation. Ideally, that category would include all water used for irrigation other than that delivered under Bureau of Reclamation contracts. However, that does not appear to be the case. Reported nonproject deliveries average 0.5 acre-feet per acre in the Mid-Pacific Region, 0.9 acre-feet per acre in the Upper Colorado Region, and zero for the remaining regions for the 1989-1990 period. CBO examined the data for selected districts for which alternative sources of data on water use are available and found that groundwater use generally is not reported. Moreover, many districts report average water applications per irrigated acre that are clearly insufficient to produce the reported crop mix.

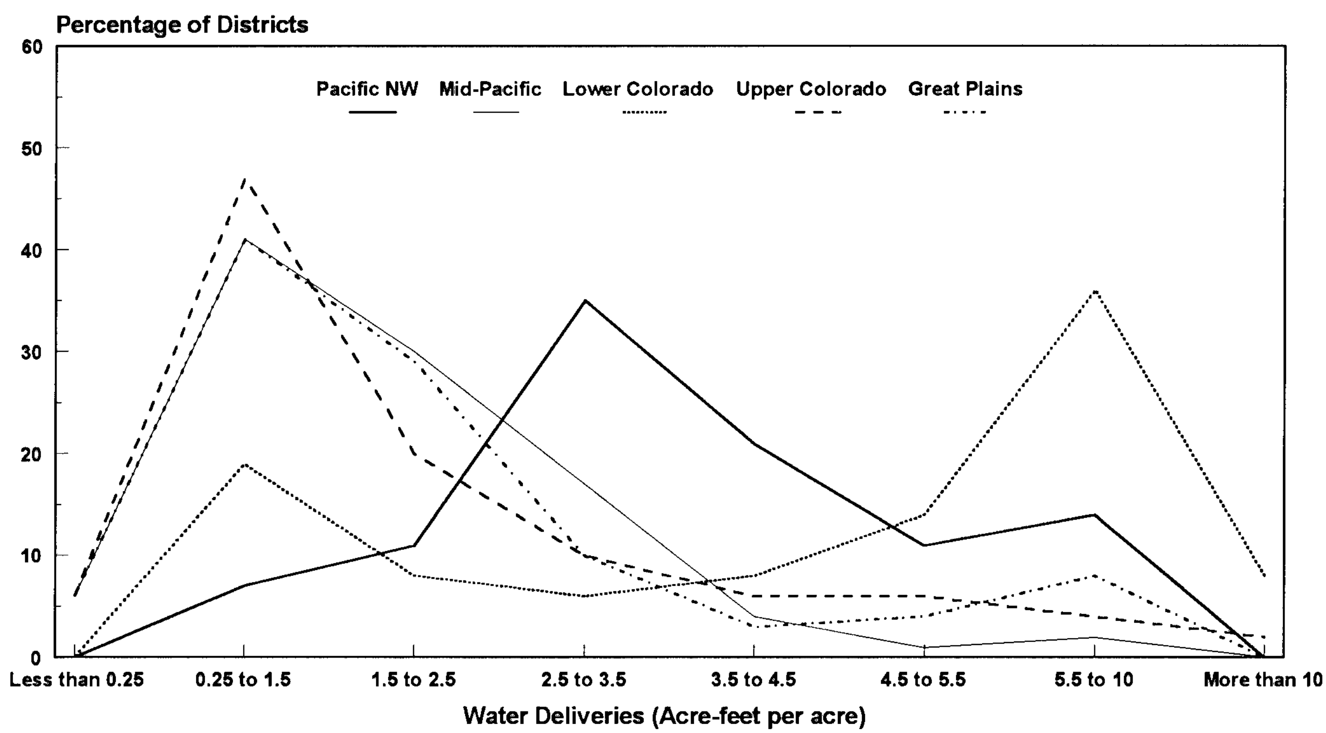
get more than 5.5 acre-feet), but 20 percent receive less than 1.5 acre-feet per acre. Those cutoffs are significant, because 4.5 acre-feet per acre is more than the crop requirement for any crop in any region, and 1.5 acre-feet per acre is insufficient for most of the crops produced in the Lower Colorado Region.

The large variance in deliveries to districts within a region indicates that policies applied uniformly throughout a region could have different effects on farmers. Many factors could explain the range in deliveries by districts, including the age of districts and projects (older districts generally have water rights with a higher priority as well as larger water quantities) and access to alternative water sources.

Nevertheless, some generalizations can be made. First, the higher the percentage of districts receiving large water quantities, the greater the potential for efficiency gains from reforming the bureau's policies in that region, and the lower the cost to farmers, on average, of adjusting to policy changes. If all other factors are the same, a farmer with a larger per-acre water supply will always have more options for adjusting to policy reform than a farmer with a smaller supply, and therefore, the cost of making that adjustment will be smaller.

Second, the greater the spread in a district's water supplies, the greater the distributional implications of uniform policy changes. Because farmers with larger supplies can adjust to policy changes at a lower cost than farmers with smaller water supplies, a policy that reduces all districts' water supplies by the same quantity will affect some farmers more than others. For example, in the Lower Colorado Region, average water supplies are high, and more than half the districts receive more than 5.5 acre-feet per acre, so water policy reform could probably occur with relatively little disruption in that region. However, unless they have other

Figure 7.
Average Amount of Water Delivered to Districts in 1989 and 1990, by Region



SOURCE: Congressional Budget Office based on data from Bureau of Reclamation, *Summary Statistics: Water, Land, and Related Data* (1989 and 1990).

sources of water, the 20 percent of districts receiving less than 1.5 acre-feet per acre may be severely affected.

A Role for Flexibility

A recurring theme in this study is the diversity in the problems facing the Bureau of Reclamation's projects and in the performance of the bureau's farmers across the West. Because of that diversity, a policy instrument that effectively addresses the problems in one region may be much less effective in another: the problems to be addressed could be very different, or the farmers in one region could respond in a different manner than those in another. Water markets generally can address a broader range of reform objectives than other policy options but may not be able to achieve all objectives; they may elicit little or no response in some areas. Giving the bureau's managers a menu of policy tools—including water markets, water price reforms, environmental water allocations, and conservation incentives—from which to choose may be necessary to provide the flexibility to adapt the policies to the specific problems and conditions that the various regions or projects face.

Appendixes

The Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA) contains numerous provisions that direct the Bureau of Reclamation's operations for the federal Central Valley Project (CVP) in California. The various provisions of the act generally address one of two objectives: preserving fish and wildlife and their habitats or enhancing the project's benefits with incentives to use agricultural water more efficiently. To accomplish those objectives, the CVPIA allows contractors to participate in water markets, changes the pricing structure for the bureau's water contractors, creates a restoration fund to finance activities that enhance fish and wildlife and their habitat, and allocates water for environmental uses. This appendix describes the general features of those provisions. It is not meant to be inclusive; several CVPIA provisions are omitted from the discussion or are discussed only in general terms.

Water Transfers

Section 3405(a) of the CVPIA authorizes all individuals or districts that receive water from the CVP to transfer some or all of their allocation to any beneficial use within, or outside, the CVP service area. All transfers must be approved by the Secretary of the Interior. The CVPIA also imposes other conditions on transfers. First, all water transferred outside the CVP is subject to a set of higher rates and surcharges, depending on the intended use of the water. The CVP contractor must pay the full-cost rate for all water transferred to irrigators who have never been CVP contractors, or pay the municipal and industrial (M&I) rate if the transferred water is to be used for that purpose by non-CVP contractors.[1] If tiered water prices (described below) are in effect, the price the contractor pays to the bureau is the higher of the relevant tiered water price and the agricultural full-cost rate if the transferred water is to be used for irrigation, or the higher of the tiered price and the M&I cost-of-service rate if the water is to be used for urban purposes. In addition, water transferred to non-CVP M&I uses is subject to a surcharge of $25 per acre-foot. Other surcharges, which are discussed below, must be paid at higher M&I rates if water is transferred to M&I uses.

Second, to reduce the potential impact on third parties, the act specifies that the water transferred "be limited to water that would have been consumptively used or irretrievably lost to beneficial use during the year or years of the transfer" (sec. 3405(a)(1)(I)).[2] The precise manner in which the bureau interprets that condition

1. Some provisions in that section merely codify existing policies of the Bureau of Reclamation. For example, the bureau does allow water transfers, although they have not been made very often. Also, water transfers from agriculture to municipal and industrial uses were subject to the M&I rates under pre-CVPIA reclamation law.

2. The Bureau of Reclamation has interpreted that provision in the following manner: (1) crop's consumptive use of water is the total evapotranspiration of applied water minus effective precipitation and does not include transportation losses, return flows, leaching, frost protection, or deep percolation to usable groundwater basins; (2) project water irretrievably lost to beneficial use shall mean deep percolation to an unusable groundwater aquifer (for example, a saline sink or a groundwater aquifer that is polluted to the degree that water from that aquifer cannot be directly used). See Bureau of Reclamation, Mid-Pacific Region, *Interim Guidelines for Implementation of the Water Transfer Provisions of the Central Valley Project Improvement Act (Title XXXIV of Public Law 102-575)* (Sacramento, Calif., February 25, 1993).

will have important implications for whether being able to transfer water encourages farmers to conserve. For example, suppose a farmer who was applying 4 acre-feet per acre to irrigate a field of sugar beets could increase irrigation efficiency through improved technology and management such that 3 acre-feet per acre would be enough water to produce the same crop with the same yield.[3] The opportunity to sell the conserved water provides both the incentive and the capital to improve the irrigation system. However, if transfers were limited to only the amount of water the crop actually consumed, that scenario would be ruled out. In that case, the only means of freeing up water for sale would be to adjust cropping patterns—substituting crops that have relatively low water requirements (such as vegetables, seed crops, or small grains) for those that have relatively high water needs (including sugar beets, alfalfa hay, and rice)—or to fallow land. Water transfers would be more disruptive to the agricultural community under those conditions.

The implications of the clause that refers to water irretrievably lost to beneficial use will depend on the bureau's rulings on the precise areas with unusable groundwater aquifers. Groundwater aquifers underlying much of the CVP service area in the western San Joaquin Valley are highly saline and in some areas contain toxic concentrations of naturally occurring elements such as selenium and molybdenum. That water can be used to irrigate crops, if necessary, but generally must first be blended with fresh water to reduce salinity concentrations and even then is applied only on salt-tolerant crops. In addition, problems with water quality in local wetlands, rivers, and sloughs resulting from discharge of contaminated drainage water are prevalent in the region. Thus, determining that water that infiltrates the aquifer is "not lost to beneficial uses" could reduce the incentive to conserve and transfer that water. The paradox here is that since applying more water than crops consume in that region may be particularly damaging to the environment, transferring it away from the region could be especially beneficial.

Other conditions protect areas of origin, contracting districts, groundwater, and fish and wildlife habitat from degradation resulting from water transfers. One impediment to transfers has been uncertainty about the status and possible forfeiture of the transferror's water rights. The CVPIA addresses that concern by specifying that "all transfers . . . shall be deemed a beneficial use of water by the transferor . . . " (sec. 3405(a)(1)(E)).

3. Irrigation efficiency is typically defined as the percentage of applied water that is beneficially used by the crop (and typically includes a minimum leaching fraction).

Tiered Water Prices

The CVPIA specifies tiered prices for both agricultural and M&I water users (sec. 3405(d)). Under that provision, the Bureau of Reclamation will charge the contract (subsidized) rate for the first 80 percent of contract water quantities. The last 10 percent is provided at full-cost rates. Water quantities between 80 percent and 90 percent of the contract entitlement are the average of the contract rate and the full-cost rate.

The tiered pricing schedule defined in the CVPIA applies to the prices that districts pay for water. The conservation incentive created by that policy will depend, in part, on whether the water district passes the tiered schedule on to the farmer. Some districts may use a modified schedule or alternative rate to cover the increased cost of receiving water from the bureau. For example, a district could simply charge an average price to all farmers for all water: price = [0.8 x contract rate] + [0.1 x 0.5(contract rate + full cost)] + [0.1 x full cost]. Districts without the management infrastructure and measuring devices necessary to implement the tiered pricing schedule defined by the CVPIA will be more likely to use a simpler price structure. The act requires districts to install metering devices capable of measuring the quantity of water delivered within district boundaries (sec. 3405(b)). But the act does not necessarily specify that the devices be capable of measuring the amount of water delivered to each field or each farmer within the district, which would be necessary to implement tiered prices at the farm level.

The CVPIA specifies that the tiered pricing schedule (and the metering requirement) be used when long-term contracts are renewed and in new or amended contracts. Sixty-seven contracts expired between October 1992 (when the CVPIA became law) and the end of 1996, and nearly all will be up for renewal by 2008. However, contracts can be renewed only on an interim —one- to three-year—basis until a programmatic environmental impact statement (PEIS) has been completed (sec. 3404(c)(1)). The bureau currently expects the PEIS to be completed in the fall of 1997. Thus, the earliest those rates must go into effect is late 1997, and some districts may not face them until 2008, when the last of the current contracts are up for renewal. Those rates have, however, been included in some interim and amended contracts and are included in the bureau's guidelines for districts' water conservation plans, which are required under section 3405(e).

The CVPIA exempts from the tiered water rates any water used to produce crops that provide habitat for waterfowl. In practical terms, that exemption implies that rice growers will be eligible for a waiver from the higher rates of the second and third tiers. Significantly, rice is among the most water-intensive crops produced in the Central Valley. However, if farmers keep their rice fields flooded in the winter rather than following traditional practices that dictate draining the fields and burning the rice stubble, those fields will provide needed wetland habitat for waterfowl on the Pacific Flyway.

Fish and Wildlife Restoration Fund

The CVPIA establishes a fish and wildlife restoration fund to finance activities to restore, improve, and acquire fish and wildlife habitat. The act earmarks one-third of the funds for specific restoration projects (detailed in sec. 3406(b)); the remainder is to be spent at the discretion of the Secretary of the Interior for similar purposes. The fund is to be paid for by project water and power users. However, the use of moneys from the fund must be appropriated by the Congress. Section 3407 authorizes collections of up to $50 million per year. Sources of funds include revenues from tiered water rates and surcharges on water transfers, such as the $25 surcharge and transferred water rates. In addition, irrigators must pay surcharges on all CVP water of up to $6 per acre-foot (conditioned on farmers' ability to pay and indexed to October 1992 price levels) and up to $12 per acre-foot for all M&I uses (also indexed to October 1992 price levels). An additional surcharge is imposed on all contractors receiving water from the Friant-Kern Canal. The surcharge in the Friant division is $4 per acre-foot for deliveries before October 1, 1997; $5 between October 1, 1997, and September 30, 1999; and $7 as of October 1, 1999.

Total surcharges paid by districts and farmers will depend on the ultimate use of the water, as depicted in Table A-1. Consider, for example, a hypothetical district in the Friant division with an entitlement of 60,000 acre-feet, and suppose that it renewed its contract in 1995 (contracts for all irrigation districts in the Friant division expired by or in 1995). If the Bureau of Reclamation delivers the entire allotment for agricultural purposes in the 1997 growing season, which ends October 1, that district will pay tiered water prices plus approximately $10 per acre-foot for the agricultural and Friant surcharges. The district currently pays $22 per acre-foot for water, and its full-cost rate is $34 per acre-foot. The impact of the CVPIA, therefore, would be to double the cost of 6,000 acre-feet; prices would increase by approximately $22 per acre-foot ($10 in surcharges plus $12 for the tiered water prices). The cost of another 6,000 acre-feet would increase by $16 per acre-foot ($10 in surcharges plus $6 for the second-tier water rate). Rates for the remaining 80 percent would increase by the $10 surcharge.

Now suppose that the same district uses 75 percent of the entitlement and transfers 25 percent (15,000 acre-feet) to a non-CVP district for urban uses. Further assume, for simplicity, that the M&I cost-of-service rate (the transfer rate) is the same as the agricultural full-cost rate. The surcharges in that case would be $10 per acre-foot for water used and $53 per acre-foot for water transferred ($12 M&I surcharge + $25 transfer surcharge + $4 Friant surcharge + $12 difference between full-cost and contract rates).

Allocating Water for Fish and Wildlife

Section 3406 dedicates specific quantities of project yield (defined below) for fish and wildlife. In total, the CVPIA directly allocates approximately 1.2 million acre-feet of water—nearly 20 percent of deliveries in a normal year—to environmental purposes. Three different provisions provide 800,000 acre-feet of water to help regulate water flows and temperatures in the Sacramento and San Joaquin Rivers and the delta to benefit resident fish and wildlife, allocate water to sustain wetland habitat in wildlife refuges, and protect water flows in the Trinity River.

Project yield refers to the minimum quantity of water that can be expected to be available—that is, the quantity that could have been delivered during the record drought of 1928-1934 (if the project had existed then) after meeting preexisting federal and state requirements for releases. In practice, that means the water for the environment comes "off the top"; water will be delivered to CVP contractors only if total water sup-

Table A-1.
Applicable Charges to Finance the Restoration Fund, by Type of Water Use

		Purpose for Water Deliveries				
		Use in District for Agricultural Production	Transfer Within CVP		Transfer Outside CVP	
Type of Charge	Rate (Dollars per acre-foot)		Agriculture	M&I	Agriculture	M&I
Restoration Payment						
Agricultural rate	6[a]	✔	✔	*	✔	*
M&I rate	12[a]	*	*	✔	*	✔
Friant Surcharge[b]	4 to 7	✔	✔	✔	✔	✔
Tiered Water Rates[c]	Variable	✔	✔	✔	✔[d]	✔[d]
Early-Renewal Incentive						
Agricultural rate	9[a]	✔	✔	*	✔	
M&I rate	18[a]	*	*	✔	*	✔
M&I Transfer Surcharge	25[a]	*	*	✔	*	✔
Transferred Water Rates[e]	Variable	*	*	*	✔[d]	✔[d]

SOURCE: Congressional Budget Office.

NOTE: CVP = Central Valley Project; M&I = municipal and industrial; * = charges do not apply.

a. October 1992 prices levels. For example, the 1997-1998 restoration payment rates are $6.70 and $13.39 per acre-foot for agricultural and M&I uses, respectively. Agricultural rates may be adjusted downward on the basis of the user's ability to pay. The early-renewal incentive charge is 1.5 times the applicable restoration payment rate.

b. Applies only to contractors receiving or transferring water from the Friant division. Charges are $4 per acre-foot for deliveries before October 1, 1997; $5 from October 1, 1997, to September 30, 1999; and $7 thereafter.

c. Tiered prices go into effect when existing contracts are renewed or amended, or new contracts are written. The tiered rates are contract rates for deliveries up to (and including) 80 percent of entitlements; halfway between the contract and full-cost rates for deliveries between 80 percent and 90 percent of entitlements; and the full-cost rates for deliveries greater than 90 percent of entitlements, for agricultural or M&I use as appropriate. That provision may be waived if the water is to be used to produce a crop that provides habitat for waterfowl.

d. The contractor must pay the higher of the tiered rate or transferred water rate when both are in effect.

e. Transferred water rates are full-cost rates for water transferred to agricultural uses and cost-of-service rates for water transferred to M&I uses.

plies exceed obligations to water rights holders (a pre-CVPIA condition) plus the environmental allocation. But it also means that agricultural water deliveries will decline only if water supplies are insufficient to meet all obligations. Thus, the CVPIA's environmental allocations probably will not reduce agricultural water supplies in wet years. However, wet years occur only infrequently, and contractors can expect reduced water supplies in many years.

Section 3406(b)(2) dedicates 800,000 acre-feet of CVP yield for restoring fish and wildlife habitat. The act also provides water for national wildlife refuges and state wildlife management areas in the Central Valley. Approximately 260,000 acre-feet above pre-CVPIA guaranteed supplies for refuges (so-called level-2 water requirements) were required upon enactment (sec. 3406(d)(1)). A greater level of protection (level-4 water supplies) is to be met by 2002. The Bureau of Reclamation must acquire the additional water necessary to meet level-4 water requirements (roughly 140,000 acre-feet) at a rate of 10 percent a year over 10 years (sec. 3406(d)(2)). In contrast to the 800,000 acre-feet and the level-2 water, the increment between level-2 and level-4 water must be acquired voluntarily —that is, through water transfers, voluntary water conservation measures, and land purchases, among other options. Another provision protects in-stream flows in the Trinity River (sec. 3406(b)(23)). CVP water supplies could be reduced by the quantity that the bureau would otherwise have diverted from the Trinity River into the Sacramento River and the CVP.

Water Conservation Measures

Water conservation activities are those that allow the same beneficial use to occur with less water. Increasing farms' irrigation efficiency and improving districts' delivery systems are two approaches to conserving water. Increases in irrigation efficiency allow farmers to produce the same crop and yield with less applied water and, thus, less water diverted from rivers. Examples include changes in irrigation technology—for example, switching from furrow to sprinkler systems and improving the management of existing systems. Improved delivery systems, such as specialized pipe rather than unlined ditches, allow districts to deliver exact quantities of water on demand and reduce losses from evaporation and seepage. Water conservation measures are likely to be costly and thus must either be mandatory or be motivated directly with economic incentives or indirectly with decreased water supplies. Two provisions specifically address objectives for conserving agricultural water.

First, the act creates an office of Water Conservation Best Management Practices and directs it to develop criteria for evaluating districts' water conservation plans (sec. 3405(e)). The 1982 Reclamation Reform Act (RRA) requires that all districts develop such a plan. However, the RRA requires only that plans be drafted, not implemented. The CVPIA extends the RRA provisions by requiring the Secretary of the Interior to develop best management practices and to use them as a basis for evaluating water conservation plans. The criteria, which are now available in draft form, were to be designed to promote the "highest level of water use efficiency reasonably achievable by project contractors using best available cost-effective technology and best management practices" (sec. 3405(e)(1)).

The title of that section notwithstanding, it is not clear that the act mandates implementation of an approved plan. Moreover, phrases such as "reasonably achievable" and "best available cost-effective" often lead to ambiguity and difficulty in interpreting and carrying out legislation.

Second, to encourage water users to adopt projects and measures for conserving water, section 3408(i) authorizes the Secretary of the Interior to pay up to 100 percent of the costs of those modifications. Modifications may range from district projects, such as the lining of delivery canals, to farmers' adopting improved irrigation technologies, depending on the interpretation of that provision. Water saved under that provision will be made available to the Secretary, in proportion to the percentage of the costs paid by the Secretary, for supplementing water dedicated to fish and wildlife under the act.

Contract Renewals

Besides changes in the price of water and the quantity available that can be made when contracts are renewed, the CVPIA shortens the maximum term for new, renewed, or amended contracts. Current contracts between the Bureau of Reclamation and CVP water districts were set for 40 years, as authorized by the 1939 Reclamation Projects Act. Renewed contracts will extend for no more than 25 years (sec. 3404(c)). Furthermore, as discussed above, no long-term contracts will be written until completion of the PEIS, projected for late 1997. Until then, contracts may be renewed only for one to three years.

The length of a contract can affect farmers' ability to finance long-term investments. Banks are reluctant to make loans to Central Valley farmers unless they have secure water supplies. Having a long-term, reliable water supply is especially important for farmers wishing to establish perennial crops such as tree fruits, nuts, and vineyards or to invest in new irrigation systems.

Many CVPIA provisions, such as the tiered water prices, can be implemented only with new, renewed, or amended contracts. To encourage districts to renew their contracts early—or, rather, to discourage districts from waiting until their current contracts expire before seeking renewal—the bureau will assess a fee on all districts failing to renew before October 1, 1997, or January 1 of the year following completion of the PEIS, whichever comes first (sec. 3404(c)(3)). The fee is set at one and a half times the restoration charge and is imposed for each year between the start date and the date at which the contract is renewed. For example, assume that the restoration charge is $6 per acre-foot and that a hypothetical district has a contract for 50,000 acre-feet of water for irrigation purposes that expires in 1999. If the PEIS is completed in 1997, the charge for not renewing until the contract expires will be $9 x 50,000 x 2 years = $900,000, payable before the contract is renewed. If the PEIS is not completed by October 1997—so that no long-term renewal is possible, as discussed above—districts can avoid the early renewal incentive by signing an agreement that binds them to renewing their contract upon completion of the PEIS.

Mitigating the Impact on Fisheries

The CVPIA calls for many projects to restore the local fisheries, including repairing, improving, and constructing facilities. The reimbursable portions of those projects are typically 37.5 percent of the costs and are to be allocated between the CVP's water users and power users. Revenues from tiered water prices will be credited to the water users' portion of those costs. Nevertheless, this provision could result in additional charges to water users.

Appendix B

The Economics of Tools for Reforming Federal Water Policy

Numerous policy tools are available to change the way federal water is priced and allocated. This appendix addresses the extent to which each policy tool individually, and in combination with other tools, can be expected to achieve the objectives of reform. Related issues are how reforms will affect relevant parties and change the way water is used.

In particular, this appendix provides an economic framework for predicting whether a particular policy tool or set of tools will help or hinder the efficient allocation of water. Provisions of the Central Valley Project Improvement Act (CVPIA), which were described in Appendix A, form a point of departure for that analysis. Water markets and tiered water rates are examined first as tools to motivate, rather than to require, improved management and allocation of federal water. Other provisions, such as environmental surcharges and the allocation of water to fish and wildlife, are also introduced. Policy tools are examined first alone and then in combination with others. The last section explores the implications of simultaneously implementing all the provisions contained in the CVPIA.

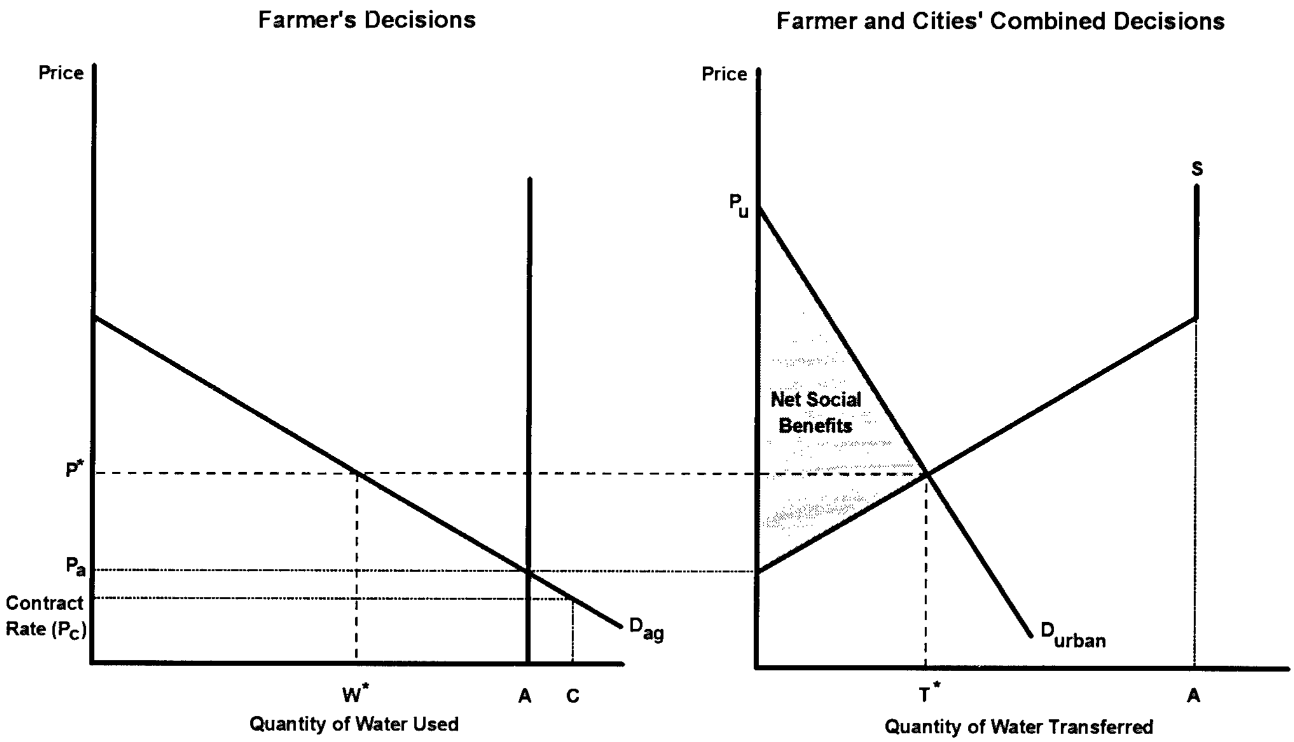
Farmer's Decision Framework

Given subsidized water rates and the absence of market forces or limits on quantity, farmers will use more water than is socially desirable. Economic theory says that farmers will use water to the point that the economic gain from the last unit is just equal to its price. If that price is low relative to the true cost of the water, as in the Bureau of Reclamation's contracts, the quantity farmers use will probably be greater than optimal.

That principle is illustrated in the first panel of Figure B-1, which portrays the decision framework for a single farmer. The benefits to the farmer from water use are reflected in the linear demand curve D_{ag}, which shows the increase in crop revenues from each additional unit of water. A farmer with access to an unlimited supply of water at a contract price of P_c will choose to apply a quantity of C—the quantity for which the marginal value in use is just equal to its price. Suppose the true social value of water is P*. A farmer facing that price would choose to use a quantity W*—the optimal level of water use for that farmer—and would forgo using the rest of the allotment. In the absence of a water market, farmers base their decisions about water use solely on the value of the water in production and their own costs; the value of water in other uses does not enter the decision process. Thus, as illustrated in this example, farmers may rationally use considerably more water than is optimal.

The quantity of water used may be determined by a constraint rather than by a prevailing price. The supply of water delivered to districts is typically set at a quantity specified in their contracts with the bureau. That quantity implies a vertical supply curve at the allotment quantity, depicted as A in Figure B-1. If the farmer is constrained to use no more than A, the value of the last unit used is P_a. In that case, the value of using the water is greater than the price paid (P_c), indicating that

Figure B-1.
The Effects of a Water Market on a Farmer's Decisions About Water Use



SOURCE: Congressional Budget Office.

the farmer would be willing to pay more than the contract price to purchase an additional unit.

Water Markets: Interactions Between Farmers and Cities

Water markets leave both farmers and cities better off, as the second panel in Figure B-1 shows. For diagrammatic purposes, the figure assumes that farmers who have an allotment of water from the Bureau of Reclamation are the only supplier to the market and that cities are the only source of demand—that is, there are no unmet environmental or other agricultural needs. The market supply curve (S) for water transfers made by the bureau's farmers is presented as the mirror image of the demand curve (D_{ag}) in the first panel. It describes the quantity of water that farmers would be willing to sell for any given price. The supply curve becomes vertical at a quantity of A because farmers cannot transfer more water than they have—their allotment—no matter how high the price goes. The point at which urban demand for the farmers' water (D_{urban}) and the farmers' supply intersect describes both the quantity of water that would optimally be transferred from agricultural uses to cities and the value of water at that quantity.

Prices and Quantities

Water markets can lead to an efficient allocation of water among uses and will define a single price that represents the marginal value of water to society, even if the water is initially allocated to a single use at a subsidized price. The initial allocation involves zero transfers of the bureau's water between agricultural and urban uses. The price of water at the initial allocation, in which agriculture uses its entire allotment, is much lower in agriculture than in urban uses; the price of water for urban uses is denoted P_u. The difference between agricultural and urban prices indicates that both groups could benefit from a trade. Only when the value for water is the same in both agricultural and urban uses will all possible benefits from trading be exhausted. The "true value" of water is the price that would clear a fully functioning water market, the point at which supply and demand intersect, P*.[1] In that case, the farmer would use W* and transfer a quantity T* (T* = A - W*) on the market. To see that that is indeed the equilibrium, note that using a quantity greater than W* would generate a value less than P*. The farmer would be better off selling that water for P*. Conversely, using less than W* would mean forgoing production worth more than P*, and simultaneously transferring more than T* would result in a transfer price lower than P*. The farmer would be better off using that increment.

In summary, prices and quantities of water used and transferred will be efficient if determined by a water market. Economic efficiency requires that all participants use water until the point that the benefit of using it is the same in all uses.[2] That same condition describes the equilibrium point in a water market. Thus, a water market can be an effective tool for achieving an optimal allocation of water among all uses.[3]

Net Benefits

Net social benefits from a water market are positive because the gains to urban consumers from the transfer are greater than the costs to farmers. The net social benefit associated with moving from the initial allocation, with farmers using A and transferring zero, to the optimal allocation, in which farmers use W* and transfer T*, is depicted by the shaded area in the second panel of Figure B-1. In that area under the demand curve, the benefits from the transfer that urban consumers enjoy are greater than the cost in terms of forgone revenues for farmers (the area under the supply curve, which is identical to the area under the farmer's demand curve in the first panel between W* and A and above P_a). That reduction in the benefits from crop production is based, in part, on the value of selling crops—a value set in the agricultural markets and representing consumers' demands for those crops.

Payments for Water Transfers

The final aspect of the market is the payments made to farmers for water transfers. Figure B-1, which illustrates the social gains from the water market, does not reflect those payments because they do not increase social output or the value of water. Rather, they represent a transfer payment—a gain in one sector (agriculture) exactly offset by a loss in another sector (urban). Thus, the payments affect the allocation of income but not the economic efficiency of using water. Nevertheless, those payments are critically important to the functioning of a voluntary market. Without them, no water would be transferred.

The value of the payments for water transfers is P* times T* and can be seen in the second panel as the rectangle traced out by moving from the origin up the price axis to P*, across to the intersection of the market supply and demand curves, down to T*, and then back to the origin. The fact that farmers are better off with the water market can be seen by comparing the area of that rectangle (the benefit farmers receive from participating) with the area under the supply curve between the origin and T* (the cost to farmers from participating). The rectangle is bigger by that portion of the shaded area below the line representing P*. Urban consumers are also better off, despite having to make the payments. Their gain is seen by subtracting the payment rectangle from the area under the urban demand curve between the origin and T*. That difference is depicted by the portion of the shaded area above P*. Thus, the portion of the social gain (the entire shaded area) captured by each sector can also be seen in the second panel as the relative sizes of the triangles above (gain to urban consumers) and below (gain to agriculture) P*.

In that diagram, urban consumers appear to capture most of the benefit. In fact, the relative sizes of the triangles depend on the slopes of the supply and demand curves. If the supply curve is steeper than the

1. In practice, P* will probably vary among and between sellers and buyers. Differences in transportation costs, reliability of the water supply, and costs of forging the transaction will result in different prices within user groups. Other policies, such as surcharges that are paid by only one user group, can drive a wedge between the price paid by buyers and received by sellers.

2. The previous footnote describes important exceptions to this notion.

3. That point is true as long as all uses are represented in the market. For example, fish and wildlife interests typically are not well represented, so a water market will tend to allocate too little water to that use.

demand curve, the triangle representing gains to agriculture will be larger than that representing gains to urban consumers. The actual size of the gains is an empirical question. Chapter 5 addressed that question in a case study of the Central Valley Project Improvement Act in California.

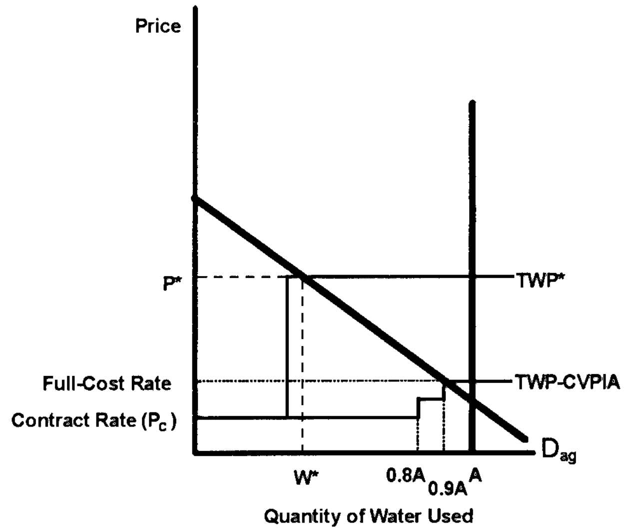
Tiered Water Prices

Tiered water prices (TWP) can motivate optimal decisions about water use by charging the true price for the last units of water consumed. Efficient decisions will be made only when the decisionmaker faces the true cost of the resource. Three different policy tools can ensure that appropriate price signals are observed: water markets, a uniform price increase, and tiered (increasing block-rate) water prices.

Because decisions about the use of inputs are made on the margin—that is, the last unit will be used only if the benefits to the user exceed the cost—optimal decisions about how much water to use can be motivated by ensuring that the true price is signaled for just the last unit. The price schedule (TWP*) in Figure B-2 is an example of that type of policy. The farmer's water allotment and demand for water are the same as that depicted in the first panel of Figure B-1. Under the two-tiered scheme, the current price the farmer pays for water is charged for most (say, 90 percent) of the optimal levels of water use. The price then rises to P* for all additional units of water used. The farmer would respond to that policy by reducing water use from A to W*—the same quantity induced by a price of P* for all units—but would pay P* for only 10 percent of the total quantity used rather than for each unit used, thus incurring a much smaller financial burden.

Tiered prices can be effective tools for achieving objectives of water conservation, even if the information necessary to design an optimal price schedule is unavailable. To achieve the optimal design of a tiered pricing schedule, the policymaker must know the true price and the optimal quantity to be used. The price schedule denoted "TWP-CVPIA" in Figure B-2 is an example of a policy that, although it does not motivate optimal behavior, could motivate a small reduction in water use. The figure illustrates the three-tiered schedule specified for agricultural water users in the Central Valley Project Improvement Act. The farmer pays the contract (subsidized) rate for the first 80 percent of the water allotment and the full-cost rate for the last 10 percent. For quantities between 80 percent and 90 percent of the water allotment, the farmer pays a rate halfway between the contract rate and the full-cost rate. That policy would prompt the farmer to use 10 percent less of the allotment (A), or 0.9A.

Figure B-2.
The Effects of Tiered Water Prices and a Water Market on a Farmer's Decisions About Water Use



SOURCE: Congressional Budget Office.

NOTE: TWP = tiered water price; CVPIA = Central Valley Project Improvement Act.

The incentive that tiered prices give a farmer to conserve water will depend on the relative levels of the upper tiers and the marginal benefits from water use for that farmer. A demand curve farther from the origin—a horizontal shift to the right—might indicate no change in water consumption, and a demand curve shifted to the left, so that it intersects the second tier, could imply more than a 10 percent reduction in water use. Likewise, if the same farmer was in a district with a lower full-cost price, the tiered prices might have no effect; if the full-cost rate was higher, the tiered prices would have a greater effect.

Environmental Surcharge

Surcharges are like price increases and, thus, reduce consumption unless the water allotment is less than the amount the farmer wants to use at the new price. As described above, a simple price increase can motivate optimal behavior if it is large enough. The implications of a surcharge will depend on the level of the new price (the contract price plus the surcharge) relative to the value of water use given the allotment (see the first panel of Figure B-1). If the new price is less than P_a (the value to the farmer of using the last unit of water available), the surcharge will not affect how much water the farmer uses. However, if the new price is greater than P_a, then the surcharge gives farmers an incentive to use less water. In either case, the surcharge raises revenue for environmental purposes.

Economic theory suggests that the best design for a schedule of surcharges depends on the objective of the surcharge program. Surcharges can be imposed to generate revenues for environmental projects and encourage water conservation. Although the primary motivation for the CVPIA surcharge is probably to raise revenues, its potential to encourage farmers to conserve water should not be ignored. In some situations, a surcharge may be a useful tool for increasing in-stream flows, which may benefit fish and wildlife. The two objectives could work against each other, however: increasing the surcharge from some positive level, for example, would tend to decrease the quantity of water used (that is, increase water conservation) and thus to reduce the quantity of water on which the surcharge was assessed.

If the sole objective in establishing a surcharge is to raise revenues, economic theory suggests that the best approach is to charge a relatively high price to users that are less responsive to price changes (those that will not significantly change the amount of water they use as prices change) and a lower price to the most price-responsive users. That form of price discrimination is termed "Ramsey pricing." It is "'best" in the sense that it distorts, or changes, users' behavior less than any other option that raises the same amount of revenue.

Whether they intended to or not, the authors of the CVPIA created a rough example of Ramsey pricing when they established a $6 surcharge for agricultural users, a $12 surcharge for municipal and industrial (M&I) users, and a $25 surcharge for water transferred to M&I use. Agricultural users are generally more responsive to price changes than urban users, primarily because they use more water and have a wider range of options for adjusting to reduced water supplies.

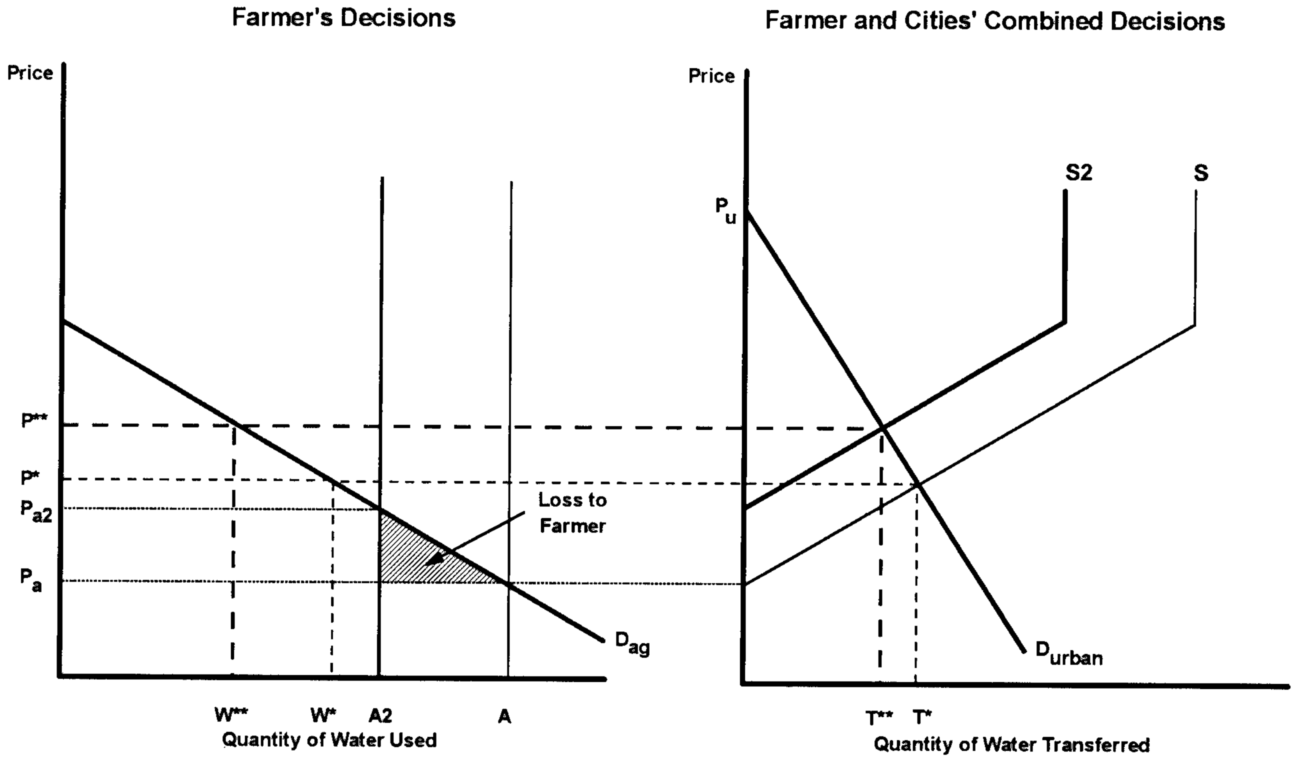
If the sole objective is to encourage water conservation, however, the optimal pricing structure is to reverse the order of the surcharges. A high surcharge on price-responsive users will prompt them to use much less water. In contrast, increasing the surcharge on nonresponsive users will not motivate them to change the amount of water they use, so imposing a surcharge on them yields no advantage. Those differences could be shown by changing the slope of the demand curve in Figure B-2. If demand is very steep—indicating a lack of response to price changes—even a relatively large price increase results in only a small change in the quantity of water used. If demand is very flat, however, a small price increase can motivate a large change in the quantity used.

Environmental Water Allocation

Allocating water to the environment would probably reduce the total value of agricultural production activities. Assuming that the environmental water would come first from farmers' water supplies, allocating the bureau's water to environmental uses would be the equivalent of shifting the agricultural allocation to the left, from A to A2, as illustrated in the first panel of Figure B-3. That action could have three effects: it could generate increased environmental benefits; it could reduce farmers' benefits; and, if a water market existed, it could reduce the benefits that urban consumers gain from water transfers.

An obvious implication of allocating more water for the environment is a reduction in the amount of water available to farmers and a subsequent reduction in their benefits (see the shaded area in Figure B-3). Another implication is an increase in the marginal value of water used in agriculture, from P_a to P_{a2}. As discussed below, that increase in turn influences whether

Figure B-3.
Water Prices and Quantities with a Water Market and an Allocation for Fish and Wildlife



SOURCE: Congressional Budget Office.

and to what extent price increases affect farmers' decisions about how to use their water allotment.

In the presence of a water market, agricultural and urban areas would share the costs of an environmental water allocation. Reducing the supply of water *to* agriculture would reduce the supply of water *from* agriculture. Farmers facing a reduced supply and a higher value for water would be willing to transfer less of it at any given price than they would if they had a full allotment (illustrated in the second panel of Figure B-3 as a shift up and to the left in the market supply curve, from S to S2). Therefore, farmers would use less water, urban consumers would receive less water, and the market-clearing price would be higher than with the water market but no environmental allocation. (The benefit to fish and wildlife from increased water for in-stream uses is not shown in Figure B-3.)

Assuming that the environmental allocation accurately reflects the value society places on improving the habitat for fish and wildlife, a water market combined with an environmental allocation would provide socially optimal levels of water for each use. The set of outcomes—illustrated in Figure B-3 as (A2 to A) for fish and wildlife, W** for agriculture, T** for transfers to urban use, and a price of P**—would generate the highest total value possible from the Bureau of Reclamation's water supply. Whether those allocations actually reflect the true social optimum depends on the benefits to the environment of increased in-stream water use relative to the costs of reduced supplies in other sectors.[4]

4. Several combinations of policy tools could generate the same solution. The purpose of this discussion is to define an optimum and examine deviations from that point, not to declare water markets and an environmental allocation as the best combination.

Economic Implications of Combining Policy Tools

The remainder of this analysis examines potential deviations from the optimal water allocation. Adding policy tools that change water prices or allotments to a reform package that already includes water markets and an environmental allocation could result in allocations that deviate from optimal allocations. This discussion, using the package of provisions contained in the CVPIA as a framework, examines the incremental implications of adding other policy tools and describes the likely outcome of several possible combinations of tools.

The CVPIA contains water transfers, environmental water allocations, tiered water prices, and several different kinds of surcharges. In addition, as is true under general reclamation law, the Bureau of Reclamation must be repaid at rates that include interest charges—full-cost or municipal and industrial rates—for any water transferred to a user who has not previously held a contract with the bureau. Because the exact combination of policy tools that might be described for other regions is unknown, this analysis describes several different combinations.

Combination 1: A Water Market, an Environmental Water Allocation, and Surcharges

The CVPIA imposes several additional charges on water transferred from agriculture to non-CVP M&I users: the act increases the environmental surcharge from $6 to $12 per acre-foot, imposes a $25 per acre-foot surcharge, and requires farmers to repay the bureau at the M&I cost-of-service rate.[5] Those charges reduce the benefits of the transfer to both the purchaser and the transferror: urban districts pay more for a water transfer, and farmers receive a lower price for it. For example, if the urban district agreed to pay $100 per acre-foot, the effective price received would be only $69 per acre-foot because the farmer or district transferring the water would have to pay surcharges of $31 per acre-foot to make the transfer.

Who bears the burden of those additional charges depends on the relative elasticities (price responsiveness) of the parties involved. In other words, although the surcharges would drive a wedge of $31 per acre-foot between the price paid and the effective price received, it is not clear who will "pay" the $31. Because urban water users tend to be less responsive to price changes than agricultural users, they will probably bear the largest share of that burden.

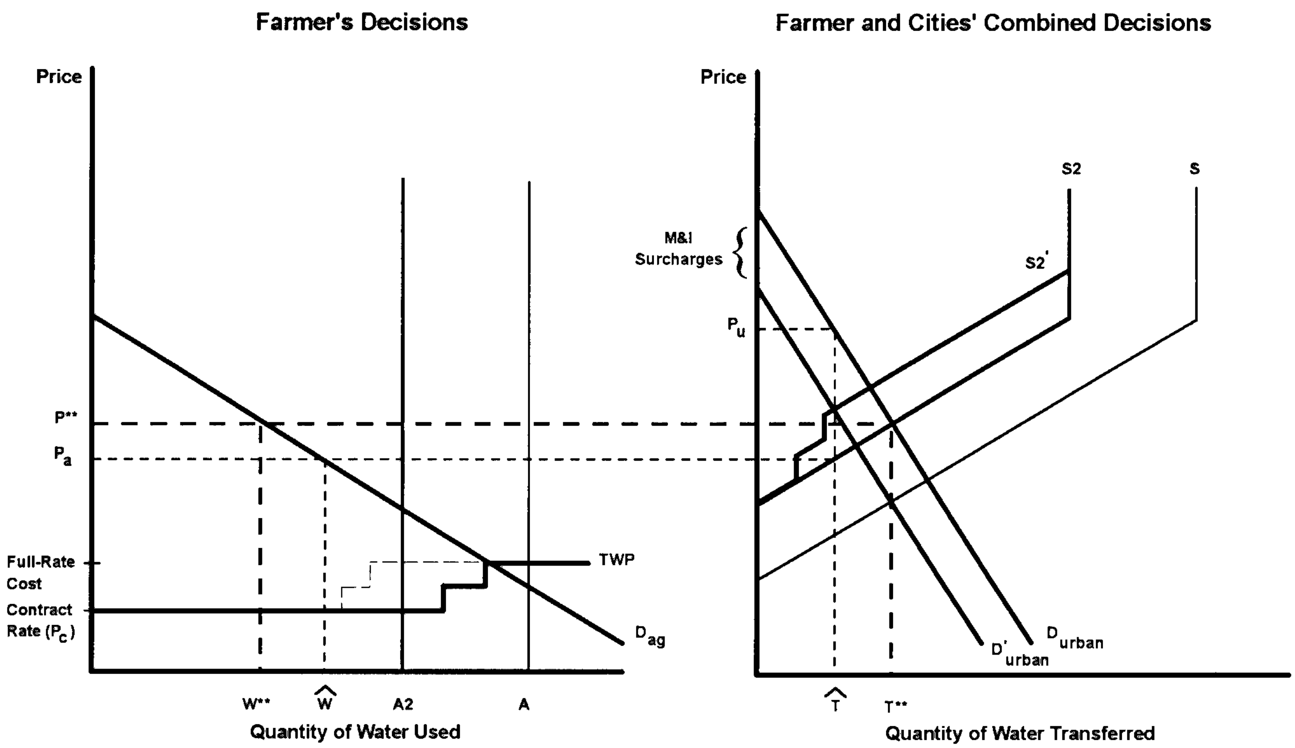
Having an increased price to purchasers and a decreased price to sellers biases the water allocation toward agricultural use. The surcharges increase the divergence between the price that farmers must pay to the bureau if they use the water for agriculture and the price they must pay if they transfer the water. Graphically, that impact would result in a shift up in the market supply curve; for any given market price, farmers would be willing to sell less than they would have without that provision. Thus, the surcharges tend to increase water use and decrease water transfers relative to a water market without the surcharges. However, the magnitude of the change is smaller because of the agricultural surcharge than it would have been if surcharges were imposed only on M&I use.

Combination 2: Adding Tiered Water Prices to a Water Market, an Environmental Water Allocation, and Surcharges

Combining the tiered water prices with water transfer provisions and possible changes in the amount of water available to contractors resulting from the reallocation of water for fish and wildlife, as the CVPIA does, may render the tiered prices ineffective. For example, if a water market resulted in a price to farmers of P**, the farmer depicted in the first panel of Figure B-4 would sell a quantity of (A2 - W** = T**), the same quantity that would be sold if the farmer faced a water market without tiered water prices. As long as the price at the top tier is below the market-clearing price, the tiered

5. The Bureau of Reclamation has interpreted that provision as implying that the repayment rate must be the higher of the M&I cost-of-service rate and the prevailing agricultural repayment rate. See Bureau of Reclamation, *Revised Interim Guidelines: Restoration Fund Payments and Charges* (Sacramento, Calif., October 1993).

Figure B-4.
Water Prices and Quantities with CVPIA Provisions



SOURCE: Congressional Budget Office.

NOTES: The Central Valley Project Improvement Act (CVPIA) contains provisions for a water market, an allocation for fish and wildlife, surcharges for municipal and industrial uses, a repayment rate, tiered water prices and agricultural surcharges.

TWP = tiered water price; M&I = municipal and industrial.

prices will not affect an individual farmer's decisions about using or transferring water. Thus, the water market is unaffected by the presence of the tiered water prices. Conversely, the tiered prices, which may encourage water conservation when implemented independently, are rendered ineffective when combined with a water market. As illustrated in Figure B-2, the tiered water prices alone motivate farmers to conserve 10 percent of their water allocation.[6] With the water market, however, farmers' water use is reduced more than 10 percent. The tiered water prices are redundant in that case.

Two caveats condition the above statements. First, some farmers may choose not to participate in water markets for philosophical reasons; some believe very strongly that the water belongs in agriculture or fear that their way of life will change if water transfers become common. Tiered water prices may encourage those farmers to conserve even in the presence of a water market.

Second, the manner in which the tiered prices and the fish and wildlife allotment will be implemented in relation to each other is unclear. Two options exist: reduce the contract allotments by the amount of water dedicated to fish and wildlife, or keep the contract allotments approximately where they are with the understanding that full allotments are not likely to be delivered in many years. The significance in that context is the link between tiered water prices and the size of the allotment. If allotments are reduced, the quantities at which the higher prices are imposed are also reduced (depicted as the lightest dashed line in Figure B-4).

6. As noted previously, the actual quantities involved depend on the relative values of the tiers as well as on market forces. The tiered water prices alone could motivate conservation of zero to 20 percent.

That might imply that farmers conserve more water in the absence of a water market.

If water allotments are not reduced, the tiered price schedule will have no effect on farmers—regardless of price levels or the presence of a water market—unless actual deliveries exceed 80 percent of allotments. Most observers believe that in many years, deliveries to farmers south of the delta will probably not exceed that amount, in part because of the CVPIA. Protection provided by the Endangered Species Act and the Clean Water Act may also inhibit the bureau's ability to pump water south of the delta.

Combination 3: Adding Higher Repayment Rates for Transferred Water to Tiered Water Prices, a Water Market, an Environmental Water Allocation, and Surcharges

Combining tiered water prices with a provision for higher repayment rates for water transferred is the one case in which adding tiered prices might affect the amount of water transferred. As discussed above, the repayment rate provision drives a wedge between the price that farmers must pay the bureau for water used and the price they receive for water transferred. That price differential shifts the market supply curve up and in (to the left). By increasing the cost for water use, the tiered prices reduce that divergence and tend to bring the supply curve back in line with the supply curve for the case in which only a water market and an environmental allocation are implemented. The resulting supply curve exhibits discrete jumps associated with the three tiers (depicted as S2' in the second panel of Figure B-4). Thus, although the combination of a water market, water allocation, transfer rates, surcharges, and tiered water prices can be expected to increase agricultural water use and lower water transfers relative to the case of only transfer rates and an environmental water allocation, those changes may be smaller than they would have been without the tiered water prices. That shift will be observed only for the 20 percent of water included in the tiered price provisions, however, and so it will influence the final result only if the volume of water transferred is below that amount.

Combination 4: The CVPIA Package

The final combination examined is the entire package of CVPIA provisions considered here: a water market, a fish and wildlife allocation, M&I surcharges, a repayment rate provision, tiered water prices, and agricultural surcharges. That combination results in higher agricultural water use and lower water transfers to urban users than if the CVPIA included only a water market and the fish and wildlife allocation. The fish and wildlife allocation guarantees water for that sector. The water market allows for an efficient allocation of the remaining water between agricultural ($\hat{W}$ in Figure B-4) and urban ($\hat{T}$) uses and within agriculture. The addition of surcharges and repayment rates that are higher for water transferred than for water used in agriculture will tend to reduce the incentive to transfer water. Those rate differentials are depicted in Figure B-4 as leftward shifts in both the urban demand for water (from D_{urban} to D'_{urban}) and the supply curves (from S2 to S2'): CVP contractors use more water and transfer less than without the additional provisions. However, those differences in the resulting water allocations are closer to optimal than if the M&I surcharges and repayment rates are added but the tiered water prices and the agricultural surcharge are not.

Interaction Between the Fish and Wildlife Fund and Water Transfers

The above analysis does not address the possibility that the Bureau of Reclamation might purchase water for environmental purposes with money from the environmental surcharges. Using those funds to purchase water would shift the demand curve in the second panel of Figure B-4 to the right. That action would probably increase in-stream water use and decrease water used in agriculture and transferred to M&I uses, relative to the case with a water market and the fish and wildlife allocation but without the restoration fund.