CHAPTER 5

Performance Impacts of Management Transfer in the Columbia River Basin Project[9]

Mark Svendsen and Douglas Vermillion[10]

INTRODUCTION

CURRENTLY THERE IS keen interest in many developing countries in transferring responsibility for operating large, publicly constructed irrigation systems to the farmer-beneficiaries of the system. The reasons for this interest vary from country to country, but at its root are the high and unrecovered cost of operating and maintaining large, public irrigation systems and the perception that management can be made more efficient, effective, and sustainable by involving farmers directly in the management of the schemes.

While attracted by the promised benefits, policymakers and agency directors formulating irrigation policies are concerned about the outcomes and wider impacts of such transfers, their institutional and financial sustainability, and the actions required of government to facilitate the transfer process and to support and sustain the new managing organizations. Governments are also concerned with the fate of irrigation agency staff whose jobs are eliminated with possible new roles for their irrigation agencies following the change.

In some countries such as the Philippines and Chile (Korten and Siy 1989), the process of devolution of responsibility to farmers has moved forward deliberately and methodically over a period of years with considerable success. Other countries are pushing rapidly ahead with transfer policies and programs, sometimes with little appreciation of the difficulties involved and little awareness of experience which has been gained in other settings. The overall purpose of this paper is to document the largely successful experience of a more developed country with this process and to explore its implications for others following this path.

The United States has had a policy mandating the transfer of managerial responsibility for publicly developed irrigation to users for almost 100 years. As a result, considerable experience with the process is available. This study of irrigation management transfer in the Columbia Basin Project (CBP) in Washington State, USA provides insights into a number of issues of concern to developing-country policymakers and managers and finds greater similarity of issues and responses in the two settings than might be expected. Since management transfer in the CBP occurred in 1969, sufficient time has elapsed for longer-term impacts to become evident, while the transfer process is still recent enough to be examined through interviews with participants. In addition, excellent hydrologic and financial data are available both before and after the transfer, facilitating quantitative analysis of impacts.

9 This is a preliminary report on the research study. A comprehensive, revised report is to be published separately.

10 The authors wish to thank Bernd Maier of Washington State University for his very capable help in assembling secondary data for this study and Martha Sullins of IFPRI for assistance in data analysis.

In discussing the study of this process, Vermillion (1991) poses four broad generic questions regarding management transfer: 1) What are the impacts of transfer on the hydrologic, agricultural and economic performance of irrigation systems? 2) What key legal, policy, infrastructural, or institutional issues must be addressed to support successful management transfer? 3) What kinds of reorientation of agencies and farmers are needed to support turnover? 4) What kinds of turnover processes and self-management models work best in different environments?

The present study approaches the topic with these questions in mind. It is concerned both with the transfer process and with the results of the transfer and addresses the following specific questions: What forces acted on both government and farmers to compel a negotiated transfer of responsibility? What factors seemed most important in the success of negotiation and transfer? What were the impacts of the transfer of management responsibility on system hydrologic performance, hydrologic efficiency, agricultural performance, financial efficiency, and sustainability? And, finally, what lessons can be drawn from this experience to guide and benefit others?

COLUMBIA BASIN IRRIGATION PROJECT

History[11]

Efforts at developing irrigated agriculture in the Columbia Basin of Washington State go back to the turn of the century, when numerous attempts at irrigation development were made by companies, private individuals, and cooperatives. As experience with these early, largely unsuccessful experiments with private development began to accumulate, the public sector became more directly involved.[12] The project was finally approved by the newly elected President Franklin Roosevelt and was included in the new Public Works Administration program the following year. The first surveying stakes for the axis of the dam were driven on 9 September 1933.

The centerpiece of the CBP is the Grand Coulee Dam which blocks the Columbia, the fourth largest river on the North American continent, forming the Franklin D. Roosevelt (FDR) Lake, a reservoir extending 151 miles (244 kilometers [km]) upstream to the Canadian border. The CBP was designed as a multipurpose project for irrigation, power generation, navigation, flood control, and stream flow regulation (Infanger 1974), with recreation and wildlife conservation becoming increasingly important objectives in later years.

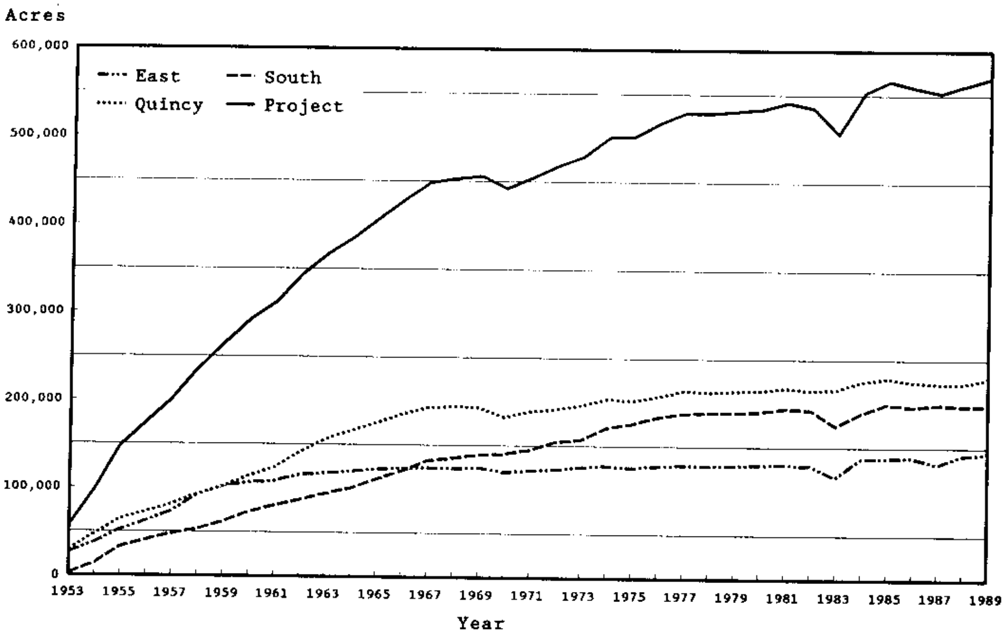
In 1951, the first test water flowed toward Columbia Basin farmland (USDI 1978). Over the next 16 years, the area irrigated by the project increased steadily at a rate of about 25,000 acres (10,000 hectares) per year, reaching a total of 448,000 acres (181,000 hectares) in 1967 (Figure 5.1). Since then growth has continued, but at a much slower pace, and in 1989 the project irrigated approximately 570,000 acres (231,000 ha).

As of 1986, US$1.687 billion had been spent on construction of the Columbia Basin Project, including the dam, irrigation facilities, and the 6,500 megawatt Grand Coulee hydroelectric power plant complex. Eighty-eight percent of the total construction cost is to be paid for by power revenues, with interest, while 12 percent will be repaid by irrigation fees, without interest.

11 This discussion is based largely on material contained in U. S. Department of the Interior, Bureau of Reclamation (1978).

12 According to the Pacific Northwest River Basins Commission (1971), 70 percent of the irrigation development in the region was initiated by individuals, cooperatives, and agencies other than the Federal Government, although a major portion of the irrigated area did receive some federal support.

Figure 5.1. Area irrigated (acres), CBP, 1953–89.



Source: Water Distribution Reports for the CBP, U.S. Bureau of Reclamation.

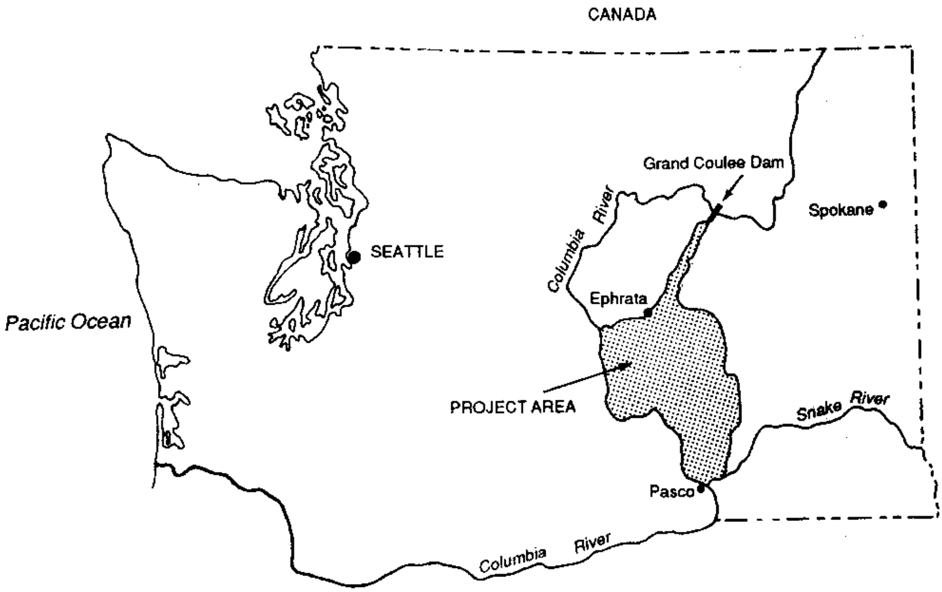
Water allocated to irrigation does not contribute to power generation as it is withdrawn from the reservoir and lifted 280 feet (85 meters) to the top of the escarpment bordering the reservoir without passing through the turbines to the river below. This means that there is no direct competition between releases for power generation and irrigation demands, as the two can operate largely independently.

Physical Environment

Location. The CBP lies in the east central portion of Washington State, in the United States of America, at about 47 degrees north latitude (Figure 5.2). The elevation of the command area varies from 1,400 feet (430 meters) in the upper end of the scheme to about 500 feet (150 meters) in the lower end. The service area begins 45 miles (75 kilometers) south and slightly west of Grand Coulee Dam, spanning about 80 miles (130 kilometers) in a north/south direction and roughly 50 miles (80 kilometers) east to west (Figure 5.3). About half of this area is classed as irrigable, the remainder being rough and unsuitable for irrigation. Irrigated areas are thus separated by uncultivated lands and spread out over a large area.

Climate. The climate in the Columbia Basin is an arid continental type; hot in summer, cold in winter, and extremely dry. The warmest month, August, has an average maximum temperature of 86.4 degrees F (30.2 degrees C) and an average minimum temperature of 52.6 degrees F (11.4 degrees C), while the coldest month, December, has an average daily minimum temperature of

Figure 5.2. Columbia Basin Project in Washington State, U.S.A.



23.6 degrees F (–4.7 degrees C) and a maximum of 37.6 degrees F (3.1 degrees C). Average monthly maximum and minimum temperatures are shown in Table 5.1

Located in the rain shadow of the Cascade Mountains, precipitation ranges from 6 inches (150 millimeters) in the southwestern part of the service area to around 10 inches (250 millimeters) in the northeastern highlands. Average monthly precipitation data for the center of the command area are shown in Table 5.1. It is noted that the amount of rainfall received during the irrigation season, which extends from March to October is extremely small, comprising 3.65 inches (93 millimeters) or 56 percent of the annual total. Minimum values for the year are recorded for the months of July and August — the heart of the growing season — when temperatures are at their maximum values for the year.

Potential evapotranspiration (PET), by contrast, totals 37.09 inches (942 millimeters) for the year, with 93 percent of the annual total occurring during the March-October period. The result is that rainfall supplies just 9.3 percent of the growing season PET requirement in the Basin, and only 2 or 3 percent of the requirement during the peak demand months of July and August. Rainfall is thus a relatively minor factor in meeting crop water requirements.

Relief. As noted above, the project area drops 900 feet (275 meters) from the upper end to the lower, a fall of about 11 feet per mile (2.1 meters per kilometer), or an average slope of about 0.2 percent. This relatively large gradient has several implications for the design and operation of the system. First, it allows the easy inclusion of free-flowing water measurement structures in the design, as the head loss they cause does not create design difficulties. Second, it provides ample opportunipy for reusing drainage water. In fact, the southernmost district of the three districts making up the system is supplied largely by recaptured drainage water from the two higher

Figure 5.3. Columbia Basin Project.

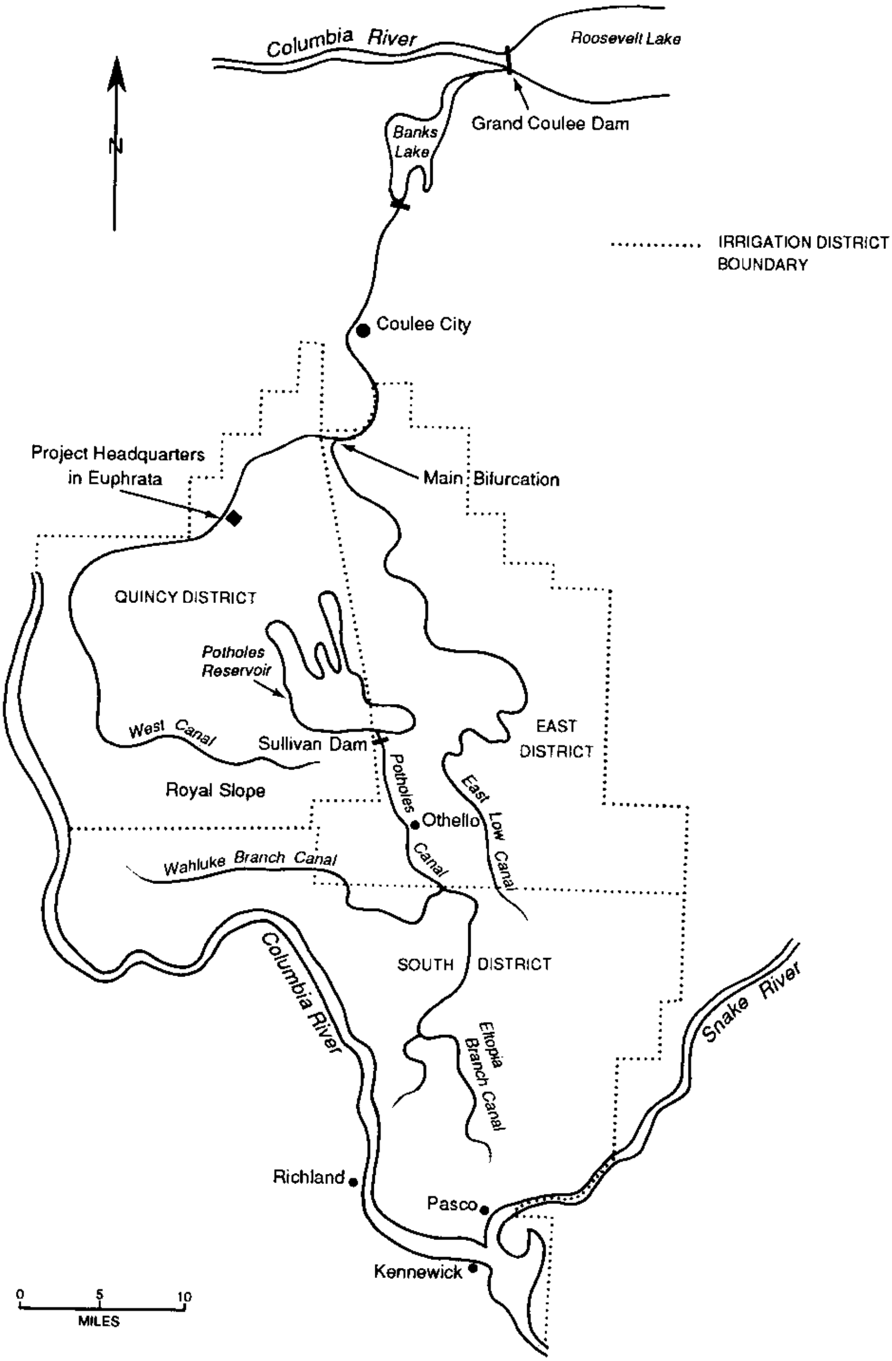


Table 5.1. Average monthly temperatures, rainfall and potential evapotranspiration rates for the Columbia River Basin Project.

	Jan	Feb	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	Nov	Dec	Year
Daily maximum[a] temperature ($F)	38.8	44.3	**55.2**	**63.6**	**71.7**	**77.4**	**85.3**	**86.4**	**75.8**	**62.9**	49.2	37.6	
Daily minimum[a] temperature ($F)	24.3	28.8	**34.2**	**36.8**	**48.4**	**48.9**	**51.9**	**52.6**	**45.5**	**36.1**	32.0	23.6	
Precipitation[b] (PPT) (inches)	0.60	0.66	**0.82**	**0.46**	**0.63**	**0.44**	**0.21**	**0.11**	**0.56**	**0.42**	0.86	0.77	6.54
PET[c] (inches)	0.61	0.98	**2.33**	**3.88**	**5.41**	**6.57**	**7.77**	**6.90**	**4.24**	**2.30**	0.95	0.52	42.4
PPT/PET	0.98	0.67	**0.35**	**0.12**	**0.12**	**0.07**	**0.03**	**0.02**	**0.13**	**0.18**	0.90	1.49	

Note: Bold type denotes the cropping season, which runs from March through October.

[a]Maximum and minimum temperature figures are based on an average of 5 years of daily temperature data (1980–1984) from the Washington State University Experiment Station at Prosser, near Pasco, Washington.

[b]Precipitation figures are based on an 8-year average (1981-1988) of data collected by the United States Bureau of Reclamation (USBR) at O'Sullivan Dam (Potholes Reservoir) located in the center of the project area.

[c]Potential Evapotranspiration (PET) based on estimated incoming solar radiation and average monthly temperature, after Hargreaves and Samani (1986).

elevation districts. Third, it results in the need for drop structures in the major canals, providing opportunity for profitable small-scale hydropower generation within the project.

Irrigation Water Supply, Delivery, and Application

Water Rights and Withdrawals. The granting of water rights in the United States is a state responsibility. Permits and certificates conferring rights for the CBP are issued by the Washington State Department of Ecology and are held by the United States Bureau of Reclamation (USBR). Water rights are extended to the irrigation districts through repayment contracts between USBR and the districts. Farmers are linked to these rights at the district level through membership in the district and through ownership of land in the district service area, as recorded on land plats.

Since 1985, when the irrigated area stabilized at around 560,000 acres (227,000 hectares), withdrawals have been running about 2.6 million acre-feet (3.2 billion cubic meters) annually, just under the quantity allowed by the certificate of right. These withdrawals comprise just 3.3 percent of the 80 million acre-feet of water which flows down the Columbia past this point each year.

Physical Facilities. The irrigation system serving the CBP can be divided into a supply system, a conveyance and delivery system, and, at the farm level, a distribution and application system. Each component has both physical and management components. A brief description of project physical works is provided below.

The **supply system** comprises the Grand Coulee Dam and the FDR Lake behind it (Figure 5.3) operated by the Bureau of Reclamation. Twelve large pumps lift water 280 feet (85 meters) to the top of the escarpment bordering the river channel. The **conveyance and delivery** system comprises a short (1.6-mile) feeder canal, a second small balancing reservoir, and a second length of main canal which conveys water some 21 miles to a bifurcation point where the main canal divides into the 88-mile long West Canal, serving Quincy Irrigation District, and the 87-mile long East Low Canal, which serves principally the East Irrigation District. Below the bifurcation, the respective irrigation districts assume responsibility. Districts handle distribution of water to individual farmers from their primary canals and a network of branch canals and laterals totalling 2,026 miles (3,268 kilometers) in length across all three districts.

In the center of the project area is a 511,700 acre-foot reservoir[13] which captures some natural drainage, but its principal source is return-flow and drainage water from the surrounding irrigated area, which comprise about 70 percent of annual withdrawals from the reservoir. The third district in the CBP, the South Irrigation District, receives the bulk of its water supply from this reservoir.

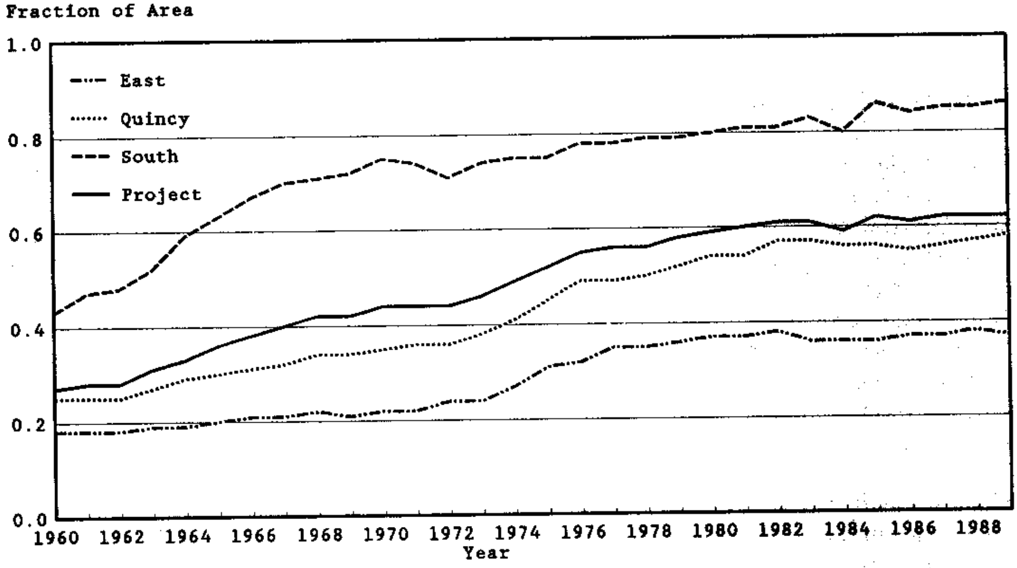
Once water is delivered to the farm turnout, it is typically carried in an earthen channel to a sump where it is pumped into a sprinkler system or led to furrows for surface **application**. In 1959, the first year for which data are available, about three quarters of the system's irrigated area was surface irrigated. By 1989 two thirds of the area was under sprinkler irrigation and only one third remained surface irrigated. Figure 5.4 shows the rate of sprinkler adoption in the three districts.

Water Management Procedures

The basic water management procedures used by the Bureau have been continued by the districts after management transfer. The scheduling process used in the project is referred to by local

13 Active storage is 332,200 acre-feet (409.8 million cubic meters).

Figure 5.4. Growth of sprinkler irrigation, CBP, 1960–89.



Source: Columbia Basin Project, district-level data.

engineers as a "modified demand system."[14] Deliveries are based on requests from users, subject to scheduling and supply constraints. Crop water requirements are not calculated by the districts, but individual farmers may base their water requests on their own scheduling calculations, those of a commercial irrigation scheduling service, or their own experience. Farmers may request deliveries up to the limit of their basic and supplemental allotments at the normal charging rate. Farmers may also order additional "excess" water at a higher rate.

To order water, a farmer leaves a four-by-five inch "water request" card at his turnout, with information on the delivery rate, start time, and duration of the water order. Ditch riders report all orders to the watermaster by 4:00 PM each day and the watermaster "calls in" with the orders to the district office immediately thereafter. By 4:30 PM the district office calls the Bureau project office and the project adjusts the gates in the main system so that adequate water will be available on the following day to fill orders. Main system gates are adjusted remotely. The morning following receipt of new delivery orders, ditch riders adjust lateral gates and turnouts to make their deliveries. There are roughly 100 to 120 farm turnouts per ditch rider and five to ten ditch riders per watermaster, depending on the distance which must be traveled. Watermaster sections are roughly 50,000 to 60,000 acres (20,000 to 24,000 hectares) in extent.

Maintenance work is now planned and executed by the districts and reported to the Bureau. No O&M manuals are used by the Bureau or the districts. New staff are trained on an apprenticeship basis working with senior watermasters and ditch riders.

No water is delivered to a farmer for a new cultivation season until he pays the base water charge to his district. Supplemental and extra water charges may be paid during the season but must be paid off prior to the following irrigation season. Fees are charged by the acre (not by the

14 This system is sometimes called an arranged demand system in the irrigation literature.

acre-foot) so farmers pay the same base rate regardless of the land class, though they receive different amounts of water as their base allotment. Monthly water and financial statements for each farm are kept by the district.

Settlement Patterns and Policies

In the 1920s, just prior to construction of the Grand Coulee Dam, 90 percent of the land in the Columbia Basin was privately owned by early settlers and homesteaders. Most of the active farmland was used for dryland wheat production but there were large tracts of fallow farmland and sagebrush as well.

With the development of the irrigation project, a land ceiling was imposed limiting farm units to between 10 and 160 acres (4.0 and 64.7 hectares) depending on land quality and topography. The intention was to settle large numbers of new farmer families on the land to be subdivided and irrigated. Subsequently, the settlement goals of the project shifted toward providing fewer but more productive farms and offering settlement opportunities for veterans of World War II. Those which did settle in the Columbia Basin Project were generally well-educated, experienced in farming, above-average in wealth, and commercially oriented. They were farmers by choice in a booming postwar economy, a far cry from the earlier depression-era concept of masses of "buckboard pioneers" who would rush in to settle project lands.

Despite their typical independence, Columbia Basin farmers are accustomed to being involved in a variety of social institutions, such as soil and water conservation districts, weed control districts, volunteer fire departments, 4-H Clubs,[15] and civic associations of various sorts. Local government units and county planning commissions developed rapidly during settlement. Among farm families, there was a strong tradition of group action to provide collective goods, such as fire protection, providing a solid base of experience for the organization and operation of irrigation districts later on.

In contrast to the situation of increasingly fragmented landholdings which is common in developing countries, farm sizes in the Columbia Basin have increased over time. Average farm sizes today are in the range of 160 to 240 acres (64.7 to 97 hectares). Roughly 60 percent of farm units are operated by owners and 40 percent by renters.

Agriculture

Since the inception of the project in the early 1950s, four major types of crops have comprised at least 75 percent of the total irrigated area in the Columbia Basin and have contributed 70 percent of the total returns to crop production in the area (see Table 5.2). These crop groups include potatoes, vegetables (for processing and fresh-market sales), hay and silage, and grains (wheat, barley, cereals and feed grain). In addition, fruit crops though representing only 6 percent of the total irrigated area provided 20 percent of total returns in 1985. Irrigated pastureland has consistently remained between 2 percent and 5 percent of total irrigated area since 1955, contributing less than 2 percent to total crop returns.

The cropping pattern across the CBP is clearly complex with a mixture of both high-value and low-value crops. Within this overall pattern, most farmers practice a multi-year rotation on their own farms. Profitability drives the farmers' choice in crop decisions, and cropping-pattern

15 Clubs for rural youth which teach farm-related skills.

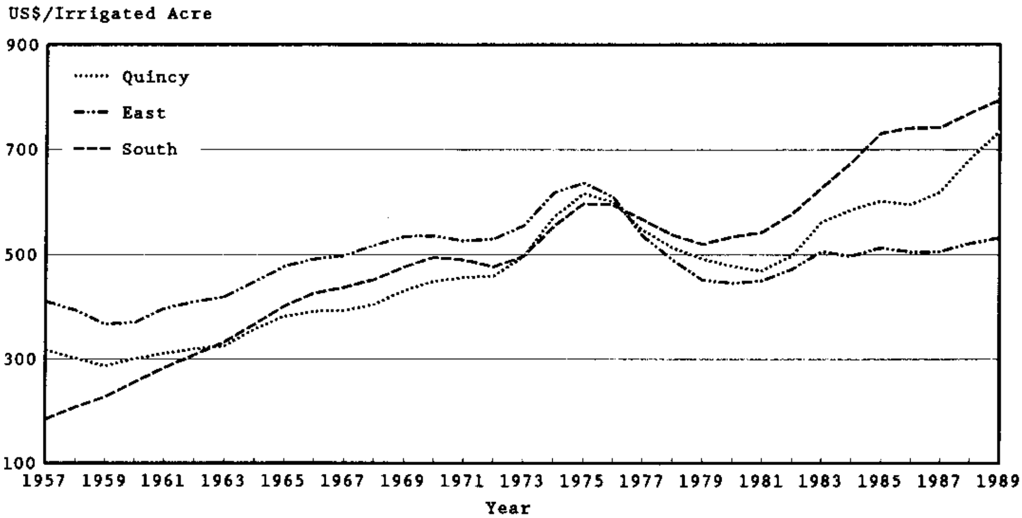
Table 5.2. Irrigated area and gross value of crop production, Columbia Basin Project (CBP), 1955–89.

Year	1955–64		1965–74		1975–84		1985–89	
	% of total irrigated area	% of total value of production	% of total irrigated area	% of total value of production	% of total irrigated area	% of total value of production	% of total irrigated area	% of total value of production
Type of crop								
Hay and silage	26.80	19.38	35.41	23.20	28.89	20.77	28.83	17.10
Vegetable	17.38	17.44	8.47	7.10	11.05	13.61	13.72	16.89
Grain	15.62	11.74	16.21	9.47	25.57	15.66	18.88	8.48
Seed	9.51	7.40	6.71	4.97	6.44	5.52	6.95	5.98
Potatoes	8.44	20.08	9.47	26.55	7.06	21.97	8.83	24.06
Sugar beets	6.21	15.25	8.80	16.78	3.48	4.64	0.00	0.00
Feed grain	4.75	3.59	3.95	2.90	9.11	6.74	8.34	4.04
Irrigated pasture	4.30	1.81	5.13	1.12	3.44	0.72	3.18	0.49
Specialty	0.65	1.16	1.48	2.38	0.86	2.09	1.53	3.02
Fruit	0.38	0.56	1.10	2.22	2.82	7.02	5.93	18.64

Source: Crop Production Reports for CBP, U.S. Bureau of Reclamation.

shifts have resulted in steadily rising total value of output in all the three CBP districts as shown in Figure 5.5.[16] For the system as a whole, annual gross value of output per acre more than doubled, in real terms, between 1960 and 1989, from US$356 to US$828 (1982 prices). This suggests, overall, a system which adapts well to changing external conditions and supports the notion that, at least in a financial sense, the system is sustainable.

Figure 5.5. Average value of total crop production per acre, Columbia Basin Project (CBP), 1960–89 (3-year moving average in constant 1982 prices).



Sources: Crop Production Reports for CBP, U.S. Bureau of Reclamation; *Economic Report of the President,* President of the United States (Washington, D.C.: U.S. Government Printing Office, 1991).

Note: Prices adjusted by index of prices received by farmers in the U.S.A.

IRRIGATION INSTITUTIONS

U.S. Bureau of Reclamation

The U.S. Bureau of Reclamation (USBR) was established by the Reclamation Act of 1902 and charged with the mission of "reclaiming" the arid lands of the western United States for farming through the provision of irrigation. The Bureau was originally conceived as a construction and development agency and had an ambitious agenda for the design and construction of large dams, river basin projects, and irrigation systems. Because of the policy objective of settling barren and sparsely populated land in the West, costs for these expensive projects were primarily borne by federal taxpayers and by hydroelectricity revenues. Typically, farmers were given 50 years to repay

16 The sharp temporary increase peaking in 1974 is probably due to the spike in world wheat prices which occurred in that year.

a minor share of full construction costs and paid very low rates for water (Reisner 1987). Also, because of this policy orientation and the economic rents involved, the Bureau supported numerous laws aimed at limiting the size of irrigated farms and preventing speculative buying and selling of land brought under irrigation over the first several decades of its existence.

The Reclamation Act established that the USBR would transfer management responsibility and authority for system facilities to irrigation districts, once construction was completed. It also established that farmers would be obligated to repay some negotiated portion of construction costs, and all costs associated with project operation.

The U.S. Bureau of Reclamation shares a number of features with water resources departments and ministries in developing countries. Its mandate for irrigation development is underlain by strong social-welfare considerations. Traditionally it has been principally a construction agency, with little enthusiasm for handling operation and maintenance (O&M), and it has channeled heavy public subsidies on irrigation water to farmers. However, the Bureau is differentiated from most of its counterparts in developing countries by its mandate to help create users' irrigation districts and transfer management to them, to negotiate construction repayment schedules, and to levy O&M fees on users prior to the transfer, and its record of success in doing these.

Irrigation Districts

Irrigation districts have long been the predominant institution for managing irrigation systems in the American West. Irrigation districts are quasi-municipal corporations, established under state law for the purpose of supplying and delivering water to irrigable land. They are generally untaxed nonprofit corporations constituted by water users and registered with state governments. Water rights are attached to districts through a process of granting and certification by state governments.

Water users are attached to the districts through their relationship to the irrigable land within the irrigation district. Districts are normally governed by a board which is elected by a vote open to all landholders in the district. Districts are vested with authority for planning and managing irrigation operations and maintenance, raising resources to fully cover the annual costs of operations and maintenance and of capital replacement, and applying sanctions against members who violate district rules or fail to pay water fees. Sanctions may include cessation of water deliveries or seizure of farms of violators.

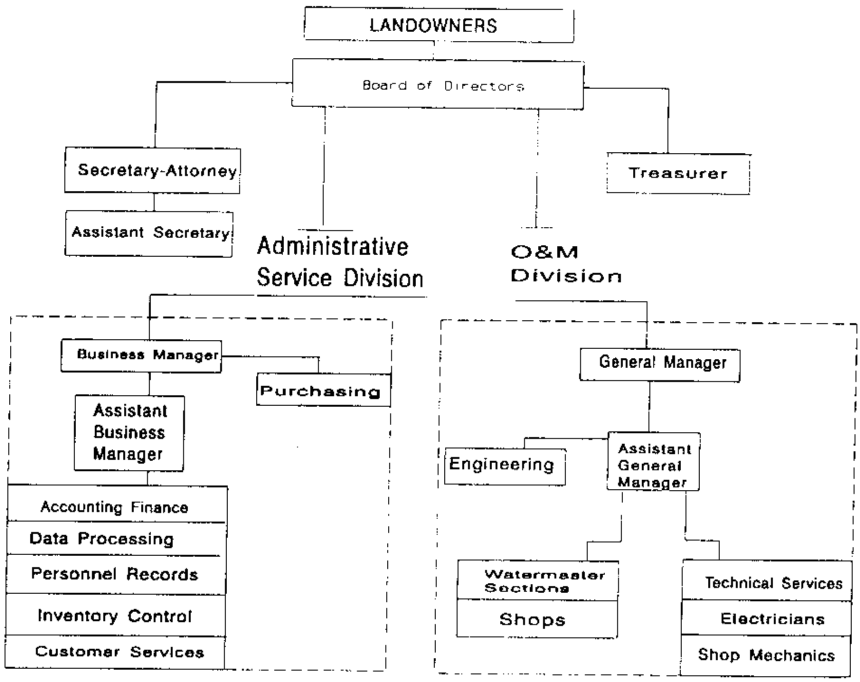
The three irrigation districts comprising the Columbia Basin Project, the Quincy, East, and South Districts, were created in 1939, two years before completion of Grand Coulee Dam and 13 years before water began flowing through the irrigation system. Formation of the districts initiated an extended period of negotiations over repayment contracts for the project. Each district includes between 2,000 and 2,500 land owners and is governed by a board of directors elected by its members. A district is divided into several sections, usually numbering between five and seven, with each section electing a director who sits on the board. Each director must own land in the district, although the land does not have to be developed or irrigated. Board members are elected for overlapping three-year terms and generally run unopposed. They are not remunerated. Incentives for their participation include personal satisfaction, opportunities for expense-paid travel, a stronger political voice, and social prestige. Boards have a wide range of concerns but some of the most significant are financial — raising sufficient revenue to pay for O&M and capital replacement while seeking to keep O&M costs as low as possible.

District management is in the hands of a full-time professional staff. District managers, who are responsible for the day-to-day operation of the districts, are engineers recruited through open notices throughout the West. They are selected by the board of directors and are responsible to it.

Irrigation district management is a well-established career path in the American West and positions are announced in various publications.

Figure 5.6 shows the organizational set-up of the Quincy District and Figure 5.7 that of the other two districts, East District and South District. A district has two main divisions, an O&M Division and an Administrative Service Division. The O&M Division is run by the General Manager and is staffed by watermasters, ditch riders, and other supporting positions. The Administrative Service Division handles budgeting, accounts, data processing, personnel records, inventory control and miscellaneous customer services to farmers, such as providing information or assistance with forms and regulations. Since districts are legally established by the state government, the state requires that their books be audited annually. The auditors are independent certified public accountants.

Figure 5.6. Organizational structure of Quincy District, Columbia Basin Project.

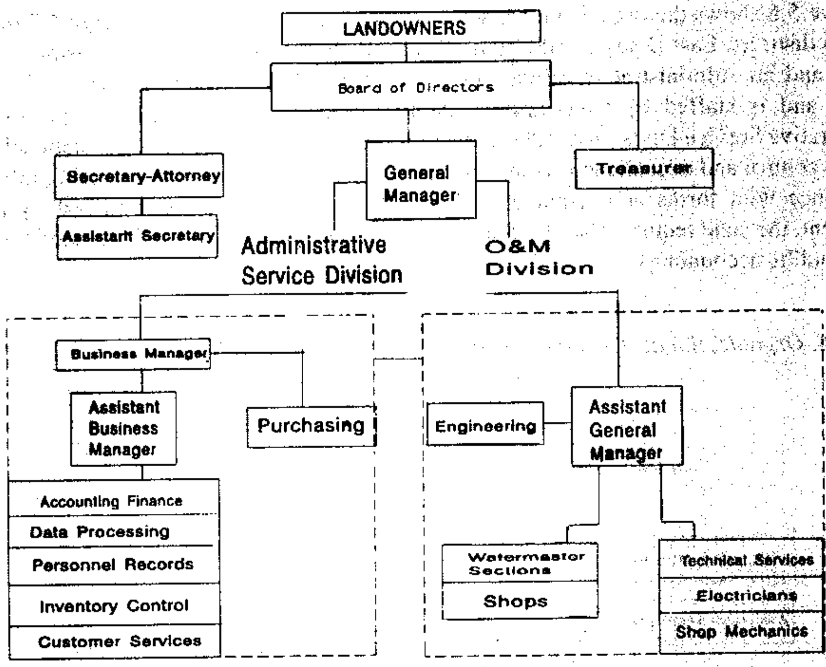


Source: District-level data, CBP.

Relationship between the Bureau and the Districts

Relations between the USBR and the irrigation districts are defined by public law and through negotiations leading to legally binding contracts and agreements. Because of the size, wealth and political influence of irrigation districts in the American West, the Bureau and districts generally relate to each other as political equals, regularly negotiate solutions to problematic issues, and periodically sue one another when agreement is not reached. This contrasts sharply with the

Figure 5.7. Organizational Structure of East and South Districts, Columbia Basin Project.



Source: District-level data, CBP.

situation in many developing countries, where the irrigation agency is clearly in a superior position to irrigators' associations. The official relationship between the Bureau and an irrigation district is established by a "repayment contract," which is an obligation attached to irrigable land lying within the district, and associated landowners, regardless of whether or not available project water is used by the individual.

A common situation in developing countries is for governments to attempt to induce farmers to take on responsibility for managing all or parts of irrigation systems, even though they may not receive concomitant authority for making necessary decisions. Governments first work to organize groups of farmers into formal water users' organizations, after which management is handed over to them according to terms set by the government. In the Columbia Basin, by contrast, there was little of this type of consciousness-raising and inducement of farmer participation. This would seem to stem from the fact that farmers were already experienced in establishing and managing local organizations for other purposes, were on an equivalent legal and political footing with the Bureau, and were already paying for O&M services and thus had an incentive to assume management responsibility to keep down the costs of O&M and make management more "customer-oriented." The result is a trio of strong and well-organized districts, which have their own legal representation, capable of exerting considerable political pressure on the Bureau.

MANAGEMENT TRANSFER

Motivation for Transfer

Farmer perspectives. Since their creation, the districts knew that responsibility for O&M would eventually fall on them. So the districts were interested not in trying to prevent management transfer, which they knew was inevitable, but in trying to get the best terms possible. According to district officers and lawyers, the farmers' primary interests were in obtaining more local control over water allocation, water fee structures, O&M expenditures, and drainageways and minimizing water charges.

The following are quotes from a letter to the US Department of the Interior written in 1964 by a farmer leader in the project (not without some hyperbole, perhaps):

> *"We out here on the project feel that the most of the Bureau employees... are only interested in having a permanent job....They get their paychecks from the government, but we pay the bill. They should be working for us."*
>
> *"...most of the Bureau people are just interested in going by the book and getting a regular paycheck. The last thing they think about is how what they're doing affects the farmer."*
>
> *"We don't want the Bureau spending our O&M money either, just to get things the way they want them — if the turnout is too low — and lots of them are — then they should be fixed with construction money."*
>
> *"Mostly, we want to run our own show, to live with our own mistakes, and not repeat them, and profit by our own actions."*

One clear theme in these statements and in the views of farmers is the assertion of the right to local control over a resource for which they are paying, with the underlying assumption that local management would be both cheaper and more responsive.

Bureau perspectives. A response to the above letter from a representative of the U.S. Department of the Interior contained the following statements:

> *"We would like to reiterate...that the policy of this Department, with the full support of the Congress, has been to maximize local operation and maintenance of federally constructed irrigation facilities....the success of this policy can be assured only if all parties concerned agree on terms and conditions under which the operation and maintenance is to be transferred, and these terms and conditions must be such that the interests of both the United States and the water users are protected."*
>
> *"...the Commissioner of Reclamation...assures me that he is anxious to work out terms and conditions under which the operation and maintenance can be transferred."*

A clear theme implicit in the above statements is the government's acknowledgement that the districts should take over management and its fundamental acceptance of a process of negotiation with the districts as a means for evolving a workable relationship between the two. The farmers didn't like the "red tape" of government management and the Bureau didn't want the headaches of dealing with thousands of individual farmers.

Transfer Process

A protracted period of negotiations began in the early 1960s among the three districts and with the Bureau, and intra-district agreement was often more difficult to achieve than agreement between the districts and the Bureau. Despite the fact that both the Bureau and the districts wanted the transfer to proceed, discussions were sometimes heated. The Bureau often took the initiative to draft plans and agreements and conduct cost studies, and this was sometimes resented by the farmers. It was reported that in one meeting in 1965, a district official stated that "they [the districts], and not the bureau, will be taking the initiative to achieve the take-over" (Othello Outlook 1965).

Over a period of about five years, the districts gradually came to agreement over water, cost allocation and works which should be (a) reserved by the Bureau, (b) managed jointly between districts, and (c) transferred to individual districts. Mutual concessions were made by districts regarding alignment of O&M responsibilities and apportionment of costs. Agreements accomplishing the transfer were signed in December 1968 and took effect on January 26, 1969. This was one of the largest management transfers the Bureau had undertaken.

Terms and Conditions of Transfer Agreements

It was the "care, operation and maintenance" of the irrigation system which was finally transferred to the Quincy, East, and South Irrigation Districts, and not ownership itself. The following are the more important terms and conditions which were agreed to.

District Rights

- The districts can determine basic and excess-water charges to farmers, although charges for the basic allocation remain related to land productivity classes.

- Districts can enter into water services contracts to supply excess water to farmers outside the districts. However, districts may not sell water rights since the transfer of water rights from one landholding to another is prohibited.

- The districts have rights of eminent domain and foreclosure on land. They are not liable for damages resulting from the storage, conveyance, seepage, overflow, and discharge of water either to other districts or to individuals.

- Districts are allowed to purchase heavy equipment and supplies from the project with a ten-year payment schedule. This included such vehicles as tractors, road graders, and pickup trucks.

- The districts have the right to obtain revenues by developing power generation stations within the system or by other "miscellaneous" means. The right to generate power was considered as concessional by the Bureau, since the districts pay an extremely low, highly subsidized rate for the primary lifting of water from the FDR Reservoir.

District Responsibilities

- Districts must comply with the agreed construction repayment schedule, which includes partial repayment for drainage construction.

- Districts are responsible for all operations and maintenance for facilities used individually and jointly by the districts, in accordance with Bureau standards of performance and financial viability.

- Districts are responsible for paying their mutually agreed proportions of the recurrent costs of special "reserved works" which were retained for management by the Bureau.

- Districts are responsible for making annual payments into a capital replacement reserve fund at a rate equal to 30 percent of five-year average annual O&M costs. They must eventually replace deteriorated facilities with this fund.

- Districts must report maintenance plans annually, in advance, to the Bureau.

Bureau Rights

- The Bureau has the right to resume direct management of the system if the districts failed to make their construction repayments, pay for the O&M of reserved works, or properly maintain the system.

- Bureau staff affected by the management change would be transferred either to other Bureau projects (as was the case with most construction staff) or to the districts themselves (as was the case with most O&M staff). Most of the initially employed district management staff were former Bureau, CBP employees.

- Salaries and benefits of transferred bureau staff members such as ditch riders and watermasters remained at the levels prevailing before transfer. Federal retirement plans for transferred staff were cashed in or suspended and new district retirement plans were started, although without seniority.

Bureau Responsibilities

- The Bureau has responsibility to manage the "reserved works" which serve the entire project. These included the Grand Coulee Pumping Plant, Banks Lake, the Main Canal, and Potholes Reservoir.

- The Bureau conducts operation and maintenance reviews (or "examinations") every three years to audit O&M performance standards of the districts and make recommendations for improvements.

- The Bureau retains ownership of the facilities operated by the districts at least until completion of repayment or replacement of facilities by the districts. However, under current law, wholesale transfer of ownership of system facilities to the districts would require an act of Congress. The districts favor the retention of legal title for facilities by the Bureau, since they believe this protects them from certain legal liabilities.

- The Bureau must report, in advance, its maintenance and repair plans for its reserved works to the districts on an annual basis.

- The government will acquire needed rights-of-way for water movement within the project area.

Management Changes since the Transfer

The Bureau. Since the transfer, the Bureau has drastically curtailed its direct O&M activities and taken on new roles in environmental regulation and land management. About 210 Bureau project staff positions, mostly in O&M, were abolished by the transfer and 80 to 90 percent of Bureau staff occupying these positions were transferred to the districts. Others retired or were transferred to other Bureau projects (see Table 5.3).

Today there are only seven Bureau positions in O&M, compared with 12 handling land and environmental regulation and water rights. One of thase positions is a new one, established to handle coordination between the project and the district offices for operation and maintenance activities, water service contracts, land and water rights, licenses and permits, and so on.

The Districts. Just prior to management transfer, each of the districts had only a handful kf staff. South District, for example, had a manager, an administrative assistant, and a bookkeeper. The first district managers were not transferred from the CBP but were openly recruited by district boards. However, all three new managers had previous district or Bureau experience. Most of the staff from the level of watermaster and below were transferred from the Bureau to the districts.

Staff densities in the three districts average about one person per 2,000 acres (809 ha). Since transfer, staff levels in each of these districts are reported to have declined by 10 to 15 staff members. Districts can and do fire staff. Quincy District has released about five staff members in the past two years, even though ditch riders and O&M service staff are unionized.

District O&M personnel handle all water allocation functions down to the farm turnout with little farmer interference reported. Quincy District reports about 6 cases a year where farmers cut locks on their turnouts to change settings. This is normally done when a farmer wants to stop the flow of water quickly, as when a center pivot breaks down. Districts have the power to stop delivery of water in the event of nonpayment of water assessments by farmers and have exercised this power rigorously. For example, since management transfer, Quincy District has foreclosed and sold more than 20 landholdings due to nonpayment of water charges.

All three districts have established excess-water-use policies. Owing to increasing concern about possible damage to lands and drainageways resulting from over-irrigation, the districts have raised the charges for use of water in excess of the base allotment. Because of the high thresholds involved, these graduated charging schemes are largely symbolic at present, but they do suggest an area of concern and a willingness to act.[17]

Each of the districts is involved in granting water service contracts to landholdings not included in the irrigation district. Districts argue that the water used for this purpose is mostly derived from existing allocations to the districts for waste, seepage, return flows, or water draining to adjoining lands. The regular water service contract normally guarantees allotments for a limited time period at the same O&M-assessment level applying to district members, together with a partial

17 Some California water districts have implemented much steeper rate schedules which do have practical impacts on a wider range of irrigators.

construction repayment requirement. A second class of interruptible contracts does not *guarantee* water delivery and the fee includes only a partial O&M assessment.

Table 5.3 Number of Bureau of Reclamation staff assigned to the Columbia Basin Project, by division, 1961–1985.

Year	Power	Irrigation and Land	Engineering and Construction	Adminis-tration	Project Management	Full-time, Regular Total
1961	329	277	119	85	7	817
1962						824
1963	316	300	133	83	7	839
1964						
1965	273	300	159	82	10	824
1966						829
1967[a]	295	309	160	75	11	850
1968	299	301	163	67	11	841
1969	297	103	150	53	9	612
1970	0	92	121	27	7	247
1971	0	92	98	23	8	221
1972	0	89	91	19	9	108
1973	0	28	147	21	8	204
1974	0	28	132	21	7	188
1975	0	28	136	22	7	193
1976	0	28	112	21	8	169
1977	0	26	114	20	8	168
1978	0					
1979	0	24	55	18	4	101
1980	0	25	82	20	6	133
1981	0	26	77	18	6	127
1982	0	24	72	16	5	117
1983	0	22	61	15	5	103
1984	0					
1985	0	22	43	13	5	83

Source: U.S. Bureau of Reclamation data.

Note: Data are missing for the years 1962, 1964, 1966, 1978 and 1984.
[a] In 1967, staff reporting shifted from December to January.

Districts contract with the Bureau for some management functions which fall within their area of responsibility under the transfer contract agreements. East District, for example, contracts with the Bureau to manage the district main canal, although the other two districts handle main canal operations themselves. The main computer and telemetry receiver for the automatic data acquisition and control system bought by the districts has been installed in the Bureau office in Ephrata rather than in one of the district offices, and Bureau staff members monitor system status and manage this data system. This indicates the close working relationship which has evolved in the wake of the transfer.

District boards are continually looking for ways to keep water charges down. One strategy has been to raise revenue through secondary enterprises to cover part of the O&M cost and to supply reserve fund requirements. In 1980, the districts agreed on a joint power-development plan and have jointly developed seven hydroelectric power stations throughout the system. These facilities have been developed by municipal power and light companies which provided the US$160 million financing and contracted to purchase the power produced. Districts receive two mills (two tenths of a US cent) per kilowatt hour currently, with the remainder of the districts' share being retained by the power companies to retire construction debt obligations. When these obligations are fully satisfied, the revenue to the districts from power production will increase sharply. Amortization schedules for the power installations range from 10 to 40 years.

Under the original repayment agreement of 1945, irrigation districts were charged 0.5 mill per kilowatt-hour (KWH) for water pumping costs at Grand Coulee. This rate continues in effect, despite the rise in summertime market value of power to about 17 mills per KWH. The Bureau is seeking to raise the rate charged to the districts to 0.95 mill per KWH, claiming that this is the cost of generating the power, and the issue is currently in court.

Surprisingly, district managers report that a sizeable number of project farmers still think that the districts are part of the Bureau of Reclamation. Only a minority of farmers generally attend district meetings. Despite this indication of some detachment, farmers generally appear to be satisfied with the performance of the irrigation districts. Matters of district policy and management are generally left to the board or managers. The districts have continued to successfully manage daily operation of this intensive, "arranged demand" management system since 1969, with the exception of one day — the day four inches of volcanic ash from Mount St. Helens fell on the project.

RESULTS OF THE TRANSFER

Data Sources

Data for this portion of the analysis were obtained principally from the Bureau of Reclamation office in Ephrata and from the three irrigation districts. Annual time series data were obtained on area irrigated,[18] discharge at various points in the conveyance system, aggregate discharge at system turnouts, area under various water application technologies, area planted by crop, gross value of agricultural output by crop, revenues by source, expenditures by category, and personnel levels by function. Aggregate potential evapotranspiration (PET) data were computed from cropped area figures and multi-year average crop-specific PET values for sites within the project area obtained from Washington State University. Most data were available on an irrigation district

18 Area figures from USBR Water Distribution Reports often did not agree exactly with similar figures from the Crop Production Reports. For most purposes, figures from the Water Distribution Reports were used in the analysis.

basis, though the analysis is concentrated on the project as a whole. Periods of record vary, but for most variables a time series of 20 or 30 years is available.

Changes in Technology

It is the view of the district managers that adoption of innovative technologies such as hydraulic excavators, telemetry, and sprinkler irrigation was facilitated by management transfer. Their argument is that districts were more open to new ideas and technologies, more flexible, and able to make quicker decisions than was the Bureau.

This argument is easier to accept in the case of main-system operation and maintenance technologies than in the case of water-application technology. The widespread adoption of center-pivot sprinkler irrigation has been one of the most dramatic technological changes occurring in the project in the past 25 years. However, sprinkler systems are owned and operated by individual farmers and their adoption is driven more by financial factors, such as rising labor costs and the higher yields often obtained under sprinkler irrigation, than by the management mode of the irrigation system. Even in the case of the main system, it is difficult to know what would have happened had the Bureau continued to manage the scheme. At the very least, one can say that the adoption of new technology does not appear to have been hampered by the transfer of management responsibilities to districts, and may well have been accelerated.

Quality of Irrigation Service

One of the most important potential impacts of the transition to self-management is the effect on the quality of irrigation service to farmers. Quality of irrigation service can be defined in terms of three characteristics — adequacy of water supplied by the irrigation system, timeliness of the supplies, and equity of distribution across system subdivisions. In each case, a useful indicator must consist of a cardinal or ordinal measure and a means of standardizing the measure to allow comparison across units or over time. If qualitative judgements are to be made about the measure, then some standard is also required, along with rules for evaluating the indicator against the standard.

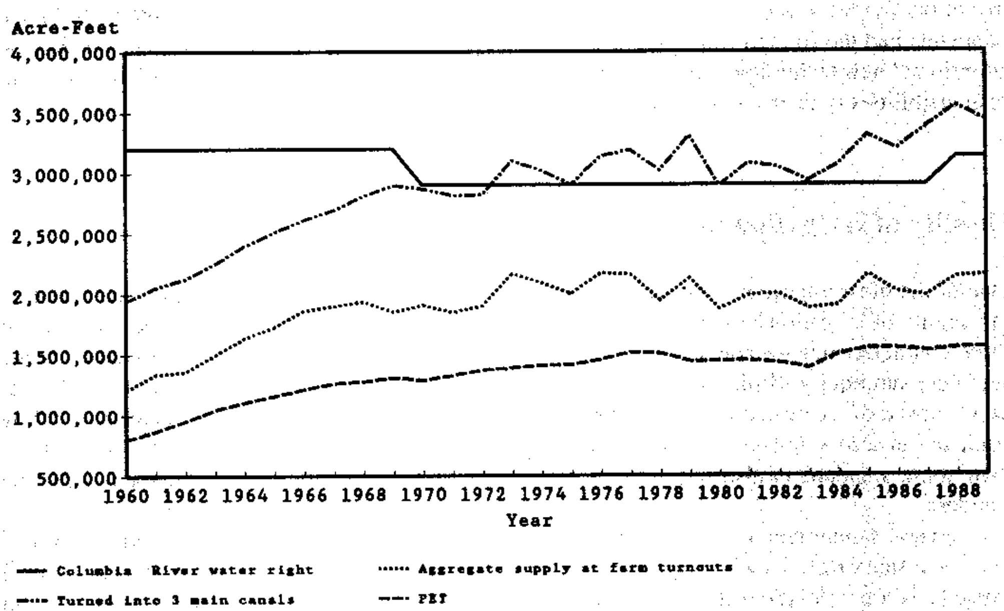
Several salient features of the CBP underlie the following analysis. First, the CBP is a water-surplus system. Both its water right and its main pumping capacity exceed current demand. Canal capacity is a potential constraint to increasing supplies, but has not been an active constraint in recent years. Second, the CBP is a demand-driven system. Farmers place orders for water, specified in terms of discharge, duration, and delivery date and the system delivers water, also specified in these terms.

Consequently, it is assumed here that farmers place orders for water based on the potential evapotranspiration (PET) requirements of their crops. PET is assumed to represent the expressed demand for water. Ideally, an evaluation like this would take place in two stages. First, the orders placed would be compared with crop water requirements to determine the appropriateness of the orders. Then, orders would be compared with actual deliveries to determine the system's effectiveness in meeting the farmer-specified demand for water. In this case, although information on individual orders and deliveries is available in district files, it was deemed too expensive and time consuming to sample, retrieve, and analyze it. As a result, a one-stage analysis was used employing the assumption that PET represents the approximate farmer demand for water.

Adequacy.

Figure 5.8 shows the quantity of water turned into the system's three main canals at the bifurcation and from the Potholes Reservoir, and the project water right at the Columbia River. The fact that supply exceeds the water right does not indicate a violation of the right, as the total includes Potholes water which consists largely of irrigation return flows. It is thus "counted twice" with respect to the withdrawal permit. The quantity turned into system main canals shows a steady increase with time as irrigated area expanded, until about 1973. It is roughly stable from then until 1985 when it again begins to rise. Figure 5.8 also shows the aggregate amount of water delivered to farm-level turnouts over time. This value too shows a steady rise until 1973, when it stabilizes at around 2 million acre-feet (2.5 billion cubic meters) and holds constant at that level until the end of the period. It does not show the pronounced rise in level that the main-canal supply does after 1985. Aggregate PET demand is less volatile, exhibiting steady growth throughout the period,[19] but at a rate which declines with time.

Figure 5.8. Water diverted, delivered and required, CBP, 1960–89.

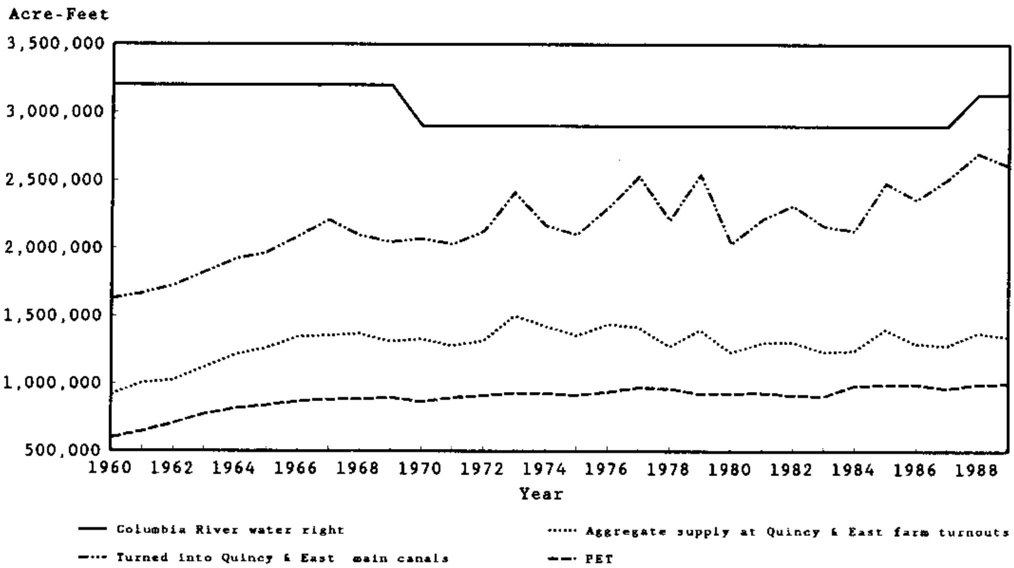


Sources: Water Distribution Reports for CBP, U.S. Bureau of Reclamation. PET calculated from data in James, Erpenbeck, Bassett, and Middleton, *Irrigation requirements for Washington — estimates and methodology* (Pullman: Washington State University, 1989), pp 6–13.

19 To some extent, this is an artifact of the computational procedure used, since longer-term average values of PET for particular crops are used in the computation. Year-to-year changes in aggregate water demand thus reflect variations in crop mix and total area irrigated only.

In Figure 5.9, data on supplies from Potholes Reservoir have been deleted so that the two supply curves and the demand line relate only to virgin water pumped from the Columbia. Now it is seen that water withdrawals have remained comfortably within the water right limit.[20] The maximum withdrawal, 2.7 million acre-feet (3.3 billion cubic meters), occurred in 1988, the year in which incremental area was added to the system and the water right was increased. Seen again in this figure is the steady divergence between main-canal supplies to the two districts and the aggregate deliveries to farm turnouts. This divergence will be explored further in the discussion of system efficiency.

Figure 5.9. Water diverted, delivered and required for Quincy and East Districts, CBP, 1960–89.



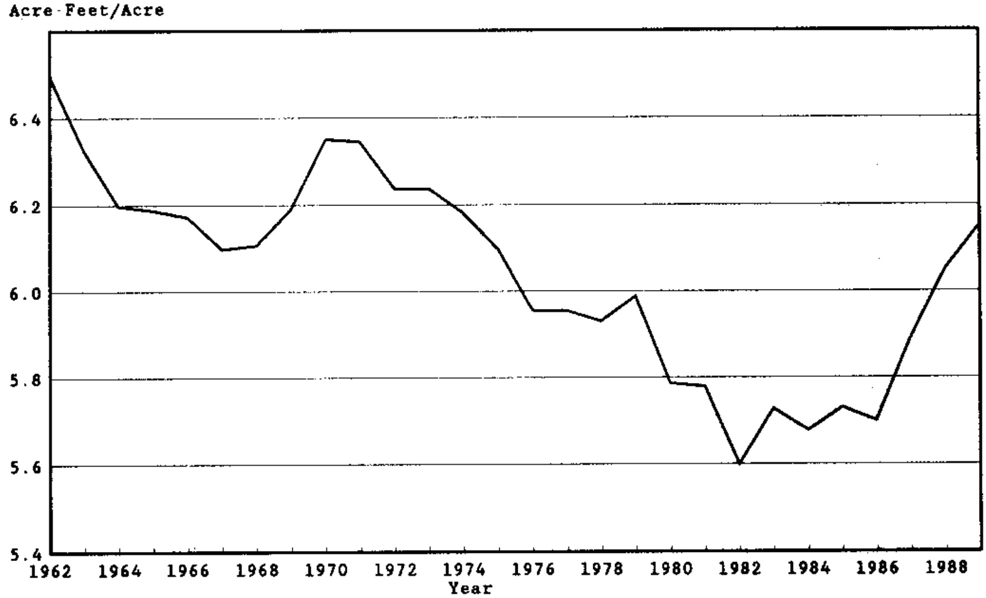
Sources: Water Distribution Reports for CBP, U.S. Bureau of Reclamation. PET calculated from data in James, Erpenbeck, Bassett, and Middleton, *Irrigation requirements for Washington - estimates and methodology* (Pullman: Washington State University, 1989), pp 6–13.

While the volume of water supplied was steadily growing, the area served was also expanding (see Figure 5.1). In order to understand what happened to water deliveries on a unit-area basis, it is necessary to standardize water volume by dividing by area served. When this is done for total aggregate supply at the heads of the three main canals, the result is shown in Figure 5.10. It is seen that the amount of water supplied to the three districts increased sharply in 1969 and 1970, the first two years of district management. In 1971, a steady decline from this peak of just over 6.3 acre,

20 This assumes no net, year-to-year change in storage in Banks Lake, no net inflows to Banks Lake not lifted from the Columbia, and negligible conveyance losses between the pumping plant and the bifurcation.

feet/acre begins which continues for the next 15 years, ending at a value of around 5.7 acre, feet/acre, a drop of about 10 percent. In 1986, a puzzling and extremely rapid rise commences in the amount of water supplied to the three districts per unit area irrigated which lasts until the record ends in 1989. The implications of this rise will be explored later in the analysis.

Figure 5.10. Total water supply per acre, CBP, 1960–89 (3-year moving average).



Source: Water Distribution Reports for CBP, U.S. Bureau of Reclamation.

Note: Years shown on graph are final years in each 3-year period.

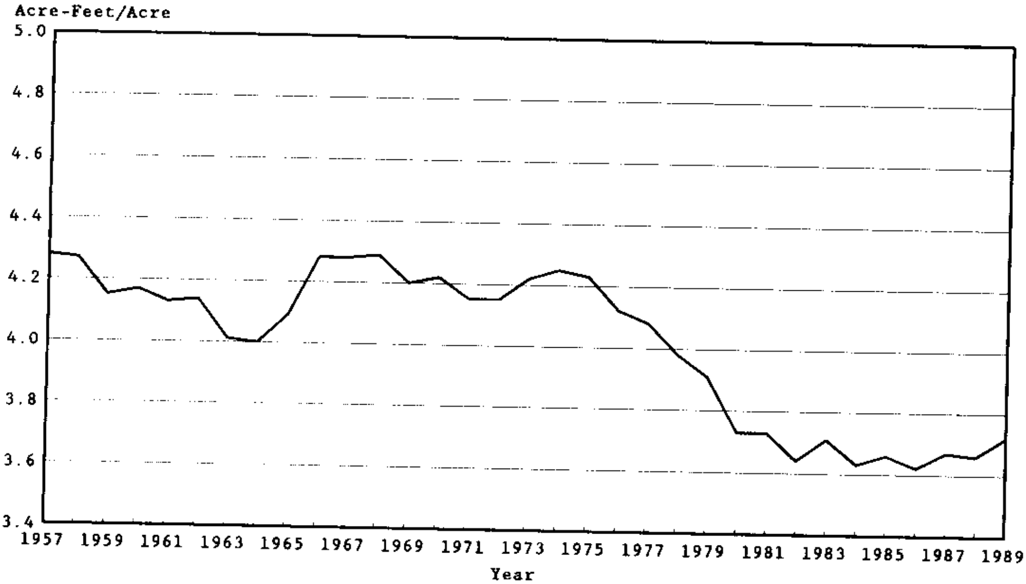
When aggregate supplies to turnouts are similarly put on a per-unit-area basis, it is apparent that water deliveries per unit area have declined continuously, from about 4.5 feet in the early 1950s to about 3.7 feet in the late 1980s (Figure 5.11). There is no obvious discontinuity in this trend associated with the 1969 transfer of management responsibility,[21] indicating that the additional water ordered by the districts in the years immediately following the transfer did not reach farm turnouts and was lost in district distribution systems. The most pronounced decline in per-acre water deliveries to farm turnouts occurred during the 1970s, coinciding with the period of most rapid growth in area under sprinkler irrigation (Figure 5.4) and the decline may be related to the shift to more efficient application technology.

However, cropping patterns also changed during this time, and it is possible that a shift to less water-intensive crops may have reduced the aggregate crop demand for water. To examine this

21 The amount of water delivered to farm turnouts was actually less in 1969 and 1970 than in 1968, the last year of Bureau management.

possibility, crop weighted aggregate annual PET for the CBP was plotted as in Figure 5.12.[22] The graph shows two distinct periods — a rising trend between 1955 and 1972 and a declining one from 1973 to the end of the period.[23] The second period can also be subdivided into a period of sharp decline from 1973 to 1981 and a period of relatively constant PET thereafter. The major drop between 1978 and 1979 is associated with the complete phasing out of sugar beet production, the most water- intensive crop grown in the basin, and its replacement with vegetables, one of the least water-intensive crops grown.

Figure 5.11. Total water delivery per acre, CBP, 1955–89 (3-year moving average).



Source: Water Distribution Reports for CBP, U.S. Bureau of Reclamation.

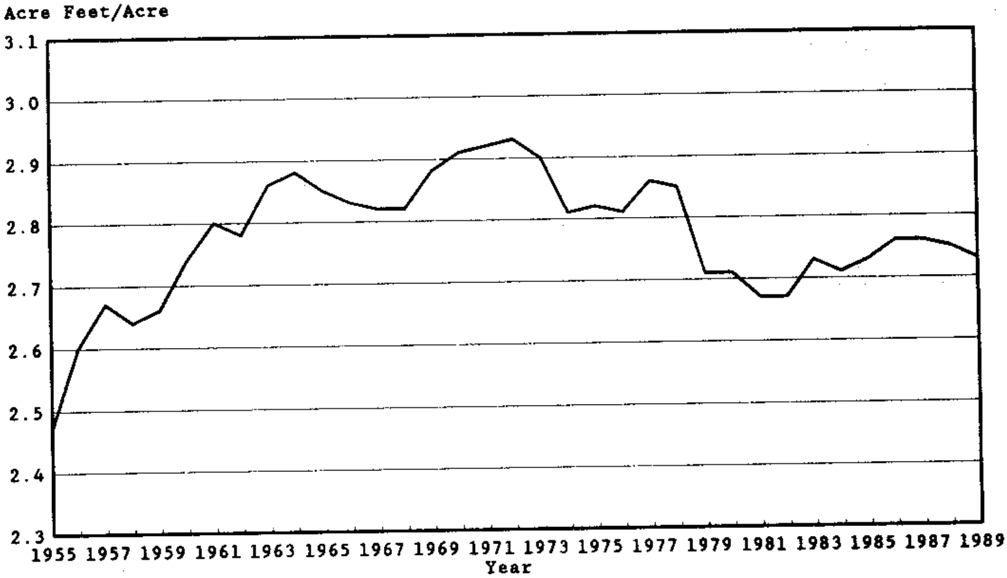
Note: Years shown on graph are final years in each 3-year period.

Between 1973 and 1981, the period of rapid decline, unit-area PET fell by 7.6 percent as a result of cropping pattern shifts, while water deliveries per unit area, shown in Figure 5.11, fell by 10.1 percent. This suggests that about three quarters of the reduction in farm demand for water during this period was a result of cropping pattern shifts, and only about one quarter resulted directly from increased water application efficiency occasioned by the shift to sprinkler irrigation. At the same time, it is likely that the introduction of the center pivots was instrumental in permitting farmers to make the shift to certain new crops because of their lower water application rates and more precise water control. The main water-saving effect of improved application technology thus appears to have operated indirectly during this period of rapid change.

22 Here and throughout this study, PET as reported is the net of effective precipitation. Because summertime effective precipitation in the CBP is very small, this modification makes little difference in practice.

23 Changes in PET do not reflect changes in climatological demand, because a common set of average crop-specific PET demand figures are used for each year in the series.

Figure 5.12. Crop-weighted potential evapotranspiration for CBP, 1955–89.



Source: Computed from data in James, Erpenbeck, Bassett, and Middleton, *Irrigation requirements for Washington — estimates and methodology* (Pullman: Washington State University, 1989), pp 6–13.

Going one step further, the aggregate water supply at the farm turnout can be standardized using the PET of the particular crop mix grown in each year. This resulted in an indicator termed the net Relative Water Supply (RWS_n). RWS_n is seen in Table 5.4 to decrease over the past 30 years, with an average value of 1.46 for the period.[24] This means that, on average, the amount of water delivered to the farm turnouts was 1.46 times the weighted average crop water requirement.

As indicated earlier, to evaluate an indicator and make value judgements about its level, it is necessary to have a standard against which to compare it. What then are standards of acceptable water adequacy in the CBP? For the individual farmer, the avoidance of water stress would likely be a principal objective, suggesting that adequacy and timeliness of deliveries are paramount. Since districts are farmer-owned and operated, it is reasonable to assume that the district managers generally share this value, though they may have other values as well, such as maximizing power revenues or minimizing district operating costs. This suggests that districts would have implicit RWS_n standards similar to those of their farmer members. The value placed on meeting full crop PET requirements by Bureau personnel prior to the transition to self-management is uncertain, though by most accounts Bureau personnel were highly professional and dedicated to providing farmers with the irrigation service they requested.

24 Note that this formulation does not include a leaching requirement. Under arid conditions, leaching of salts is necessary and important and would add something to the denominator of the RWS were it considered. Off-season rainfall would provide for some of this requirement. The leaching fraction would probably not vary substantially across the basin or over time, however, and so its absence does not compromise relative comparisons.

Table 5.4. Five-year average values for PET, net supply and RWS_n (in feet), CBP, 1955–89.

5-Year period	PET	Net supply	RWS_n			
	CBP	CBP	CBP	Quincy	East	South
1955–59	2.61	4.30	1.65	1.67	1.69	1.55
1960–64	2.81	4.15	1.48	1.53	1.46	1.42
1965–69	2.84	4.24	1.49	1.51	1.54	1.43
1970–74	2.89	4.23	1.46	1.53	1.48	1.36
1975–79	2.81	3.99	1.42	1.49	1.41	1.35
1980–84	2.70	3.61	1.34	1.36	1.35	1.31
1985–89	2.75	3.72	1.35	1.40	1.28	1.35
1955–89	2.77	4.03	1.46	1.50	1.46	1.40

Sources: PET computed from data in James, Erpenbeck, Bassett, and Middleton, *Irrigation requirements for Washington — estimates and methodology* (Pullman: Washington State University, 1989), pp 6–13. Net supply computed from data in U.S. Bureau of Reclamation Water Distribution Reports for CBP.

With respect to water adequacy, a farmer would require a RWS_n of at least 1.11 at his farm turnout to meet the full PET demand if his application system operated at an efficiency of 90 percent, or 1.25 if it operated at 80-percent efficiency.[25] An average RWS_n value of around 1.5 would imply that the adequacy objective is generally being met, assuming reasonably even distribution of water within each district.

While avoidance of crop water stress is a prime objective, farmers also want to minimize water and pumping costs. This generally means ordering and applying no more water than is necessary to meet crop PET. Farmers would therefore be expected to try to bring the amount of water delivered to their farms down as close as possible to the target RWS_n value dictated by the design parameters of their water application system. Final period (1985–89) RWS_n values of 1.35 are approaching the range of assumed target or standard levels, suggesting that deliveries to farms cannot be reduced too much further unless cropping patterns evolve further toward less water-intensive crops. This issue can also be addressed in the context of efficiency of water use, and is discussed from this perspective in a subsequent section.

Timeliness.

Timeliness would be best considered by comparing seasonal PET curves with records of water orders and then comparing the water orders with the timing of water deliveries in a two-stage process similar to the one described in the case of adequacy. However, reports from both farmers and district officials indicate that water orders have almost always been satisfied promptly both before and after transfer. Substantiating this perception is the result of a recent study of a large irrigation district in Arizona. Here Palmer, Clemmens, and Dedrick (1990) found that 72 percent of water orders were filled within 24 hours of the order date. It was, therefore, felt unlikely that the time-consuming analysis necessary to assess this dimension of performance, and assembly of

25 It is possible that some farmers might try to operate below the peak of the production function curve if economic optimality was achieved by applying less than the full PET requirement to reduce operating costs. It is assumed that because costs of water and energy are relatively low in the CBP and the costs of miscalculation are high, this would not be an attractive strategy there.

the large volume of data it would require, would yield useful insight into the transfer process in the CBP. Consequently, it was deleted from the analysis.

Equity.

In the absence of information on distribution of water within districts, equity of distribution was assessed in a simple way by creating a series of ratios of the high and low RWS found among the three districts each year. Since this ratio is based on relative water supply, it has already been adjusted for the differing areas of the districts and their different cropping patterns. In a sense, it thus represents the ratio of the water supply made available to the best supplied and the worst supplied of the three districts, if they were to have identical areas and cropping patterns.

The equity index can be computed in two different forms, from the available data. The first uses the total diversions into each district main canal as the supply, together with the in-field demand represented by the weighted average PET. In the second formulation of the index, losses and wastage in the conveyance system are netted out, and the numerator is the aggregate delivery at the farm turnout while the denominator is the weighted average PET. The second index is examined here, since it is considered to be the most consistent with the operational objectives of both the districts and the Bureau, which are based on the meeting of irrigators' requests for water as measured at the farm turnout.

The average value of the equity index for the 1960 to 1989 period is 1.10, a remarkably low value by international standards (Table 5.5). Although this index says nothing about the distribution among farms within a district, it shows that, on average, the best watered district received only about 10 percent more water relative to its crop needs than did the district with the lowest RWS. East and Quincy Districts took turns as the "high" district, while South District was consistently the "low" RWS district.

The behavior of this equity index over time is shown in Figure 5.13. A rising index accompanying the expansion of the system in the 1960s indicates decreasing intradistrict distributional equity. Following management transfer in 1969, the index remained at peak levels for several years before beginning to move downward in 1975. After a ten-year period of decrease, indicating increasing equity, the ratio rose quickly again to the levels of the early 1970s. It is clear that management of water allocation and distribution by districts does not have a negative effect on interdistrict equity of water distribution. Districts appear to have managed and coordinated their operations in such a way that interdivisional equity increased steadily under their stewardship during the late 1970s and early 1980s. The reason for the rise in the index in the late 1980s is unknown, but may relate to physical deterioration within some districts and a consequent reduction in control over deliveries. It must be borne in mind that the differences in RWS which underlie the equity index are quite small and that even the highest equity index levels reached during the period are extremely low (indicating a high level of equity) compared to situations in most developing countries.

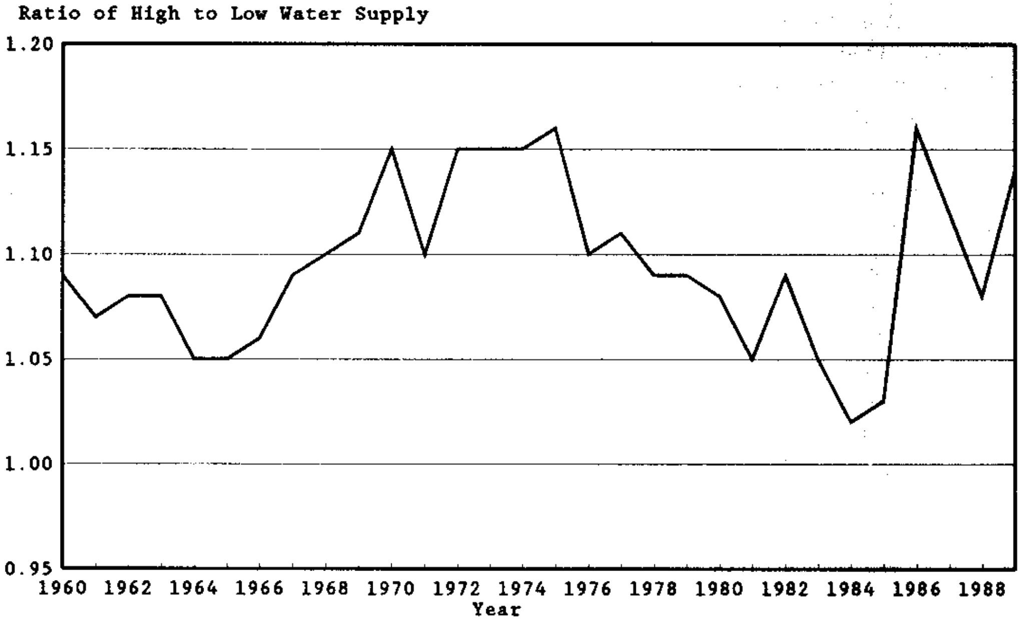
The interpretation of equity index values is somewhat different in an arranged-demand system, such as the CBP, than it is in a supply-driven system like those typically found in South and Southeast Asia. In the latter case, inter-unit equity is often established as an explicit operational goal and achievement of this goal can be considered as a direct measure of the effectiveness of the irrigation system. Additionally, the equity objective would often be framed in terms of water supply per unit area, rather than in terms of the supply relative to crop demand though this is not always the case. For the CBP, measures of equity can be computed *ex post*, but they do not serve, in any direct sense, as operational performance guides or indicators, since operational objectives relate to satisfying farmers' expressed requests for water, which presumably are related to the water requirements of the crops they are growing. It is interesting to note, though, that excellent equity of distribution, at least at the district level, appears as a byproduct of a water allocation plan aimed at satisfying farmers' expressed demands. It must be remembered that variable costs of production in the CBP are related to the volume of water used, directly through water charges paid to the districts and indirectly through private pumping costs for operating sprinkler systems. This type of cost-linkage mechanism exerts downward pressure on water orders across the system, which can lead to high levels of intradistrict equity as crop-related water demand levels are approached.

Table 5.5. Ratio of high-district and low-district net relative water supply values for the CBP, 1960–1989.

Year	High district	Low district	Ratio
1960	Quincy	South	1.09
1961	Quincy	South	1.07
1962	Quincy	South	1.08
1963	Quincy	South	1.08
1964	Quincy	South	1.05
1965	Quincy & East	South	1.05
1966	East	South	1.06
1967	East	South	1.09
1968	East	South	1.10
1969	Quincy & East	South	1.11
1970	East	South	1.15
1971	Quincy	South	1.10
1972	Quincy	South	1.15
1973	Quincy	South	1.15
1974	Quincy	South	1.15
1975	Quincy	South	1.16
1976	Quincy	South	1.10
1977	Quincy	South	1.11
1978	Quincy	South	1.09
1979	Quincy	South	1.09
1980	East	South	1.08
1981	Quincy	South	1.05
1982	Quincy	South	1.09
1983	East	Quincy	1.05
1984	Quincy & South	East	1.02
1985	Quincy	South	1.03
1986	Quincy	East	1.16
1987	Quincy	East	1.12
1988	Quincy	East	1.08
1989	South	East	1.14
Period Averages			
1960–1968	(pre-transfer)	1.08	
1969–1989	(post-transfer)	1.10	
1960–1989	(total period)	1.10	

Source: Calculated from U.S. Bureau of Reclamation water distribution data.

Figure 5.13. District ratios of high and low net relative water supply, CBP, 1960–89.



Source: Computed from Water Distribution Reports for CBP, U.S. Bureau of Reclamation.

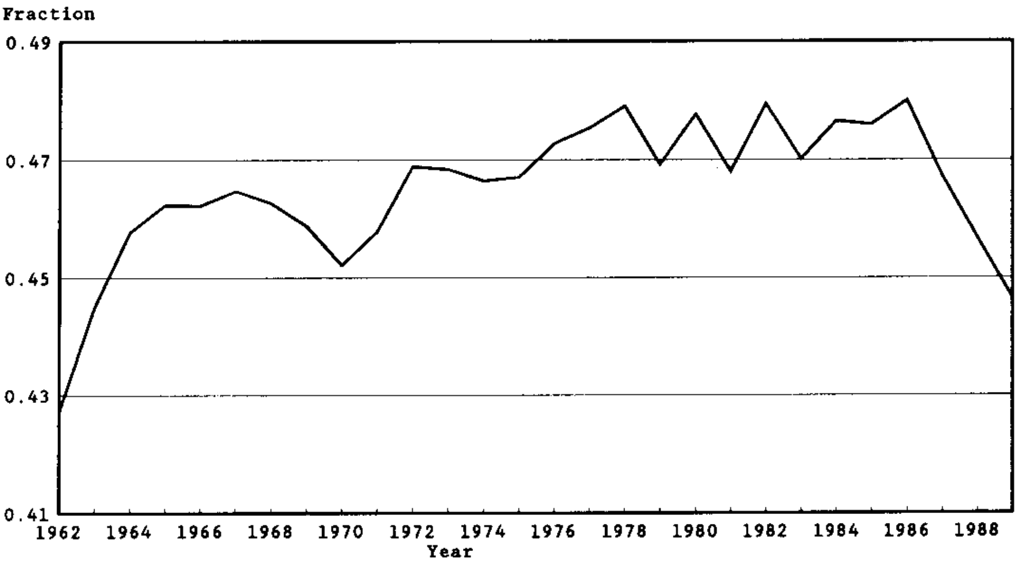
Hydrologic Efficiency

Efficiency is usually defined as a measure of the output of a process divided by the input used in the process. "Hydrologic efficiency" refers to the water delivered to a particular point in the system, or used in some way by agricultural operations and processes, divided by the water supplied from some upstream point. It does not measure the quality of irrigation service provided to irrigators, but reflects the amount of water lost in the process. Moreover, it is only a partial measure of irrigation efficiency, because it considers a single input (water) to a process which has many inputs (money, personnel, equipment). Nevertheless, hydrologic efficiency has often been taken as the key indicator of the performance of an irrigation system, and measures of hydrologic efficiency often yield very useful insights into system operating characteristics.

Tertiary unit efficiency, *conveyance efficiency*, and *overall* or *project efficiency* of the CBP are assessed following the terminology used by Bos and Nugteren (1990). In the absence of system deliveries for nonirrigation purposes, tertiary unit efficiency (e_u) can be defined as PET divided by aggregate water deliveries to farm turnouts; conveyance efficiency (e_c) as the quantity of water turned into system main canals divided by aggregate deliveries to farm turnouts; and overall efficiency (e_p) as PET divided by the quantity of water turned into system main canals (or e_u e_c). In general, e_u is a function of the type and condition of technology used on the farm and the quality of an individual farmer's management. The other efficiency, e_c, is a function of the management exercised by the irrigation district and the lining and water control technology it employs, as well as its state of repair. Both efficiency measures are also dependent on soil characteristics, such as infiltration rates and evaporation rates, which are assumed to be constant from year to year.

Figure 5.14 shows the overall efficiency of the CBP over a 27-year period as a series of three-year moving averages. Efficiency is defined as system-wide PET divided by net supply at the bifurcation. This means that the effects of return flow reuse in South District are already included in the efficiency calculation.[26] It is seen that maximum efficiency levels are achieved in 1978, 1982, and 1986, well after the transfer to district management. Beyond that simple observation, however, the figure suggests several distinct periods that bear further scrutiny. These are: (a) the rising portion from 1962 until 1968; (b) two sharply falling years, 1969 and 1970; (c) a period of rising efficiencies from 1971 until 1978; (d) generally high but variable values from 1979 to 1986; and (e) a sharp decline in overall efficiency from 1987 to 1989.

Figure 5.14. Overall efficiency of CBP, 1960–89 (3-year moving average).



Sources: Water Distribution and Crop Production Reports for CBP, U.S. Bureau of Reclamation. PET calculated from data in James, Erpenbeck, Bassett, and Middleton, *Irrigation requirements for Washington — estimates and methodology* (Pullman: Washington State University, 1989), pp 6–13.

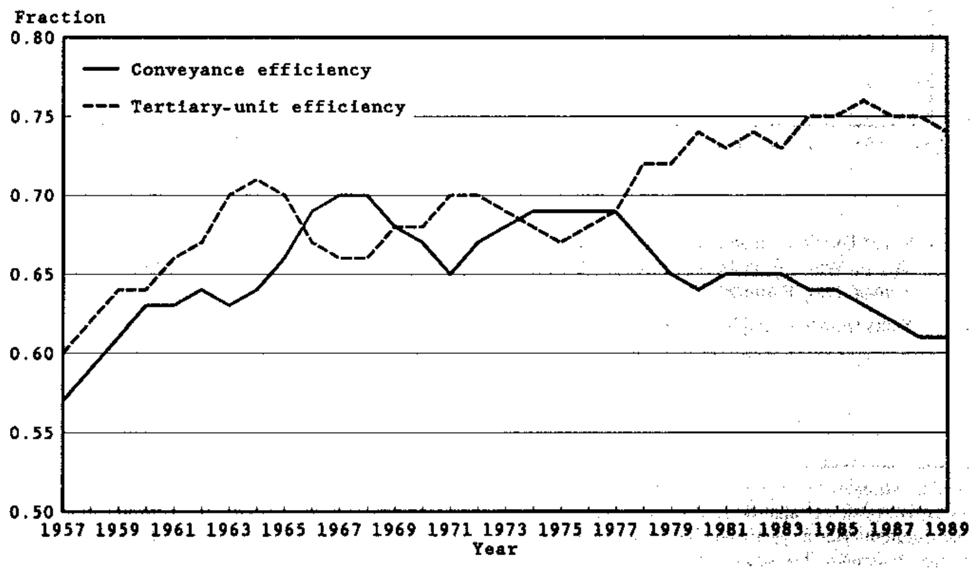
Note: Years shown on graph scale are final years in each 3-year period.

26 Keller estimates the overall efficiency of irrigation water use along the lower Nile to be about 70 percent, when the extensive reuse of canal-derived surface drainage flows and groundwater is considered. Ignored in this discussion of the Columbia Basin system are the extraction and use of CBP-derived water by groundwater districts within the overall project boundary. The source of this groundwater is recognized by both parties and compensatory payments are made by groundwater districts to CBP irrigation districts, but the volume of such reuse is not known and is not considered in the efficiency calculations. On the other hand, natural rainfall-derived inflows to the Potholes Reservoir are also not included in the calculations and would offset, to some extent, the gains in overall efficiency which would result from a consideration of groundwater reuse. The point is that boundary definition and consideration of reuse can generate large differences among alternative determinations of project "efficiencies."

When it is recalled that most of the CBP was turned over to the irrigation districts to operate in January 1969, the following interpretation emerges. The early sixties were a period of rapid system expansion and learning for both farmers and Bureau managers, resulting in steadily improving overall efficiency. When transfer took place in early 1969, efficiency of operation suffered, both because districts were new to canal management, and perhaps because less predictable or reliable deliveries also affected farmers' ability to manage tertiary-level distribution and application efficiently. A learning process quickly set in again, however, coupled with physical improvements mandated by the transfer agreements and improved application technology at the farm level, resulting in generally improving efficiencies for the next 16 years. There is no obvious explanation for the sharp decline which set in 1987. Possible reasons include: an underfunding of system maintenance by the districts, which was implied in some interviews with district managers; a general age-dependent system deterioration which could not be offset even by generally adequate maintenance expenditures; and changes in system operating rules, perhaps to accommodate newly installed hydropower generating capacity within the command.

To explore this interesting scenario further, overall efficiency was disaggregated, and the two component efficiencies are shown in Figure 5.15 as three-year moving averages. The figure shows that conveyance efficiency increased steadily from 1957 until 1968, rising by about 13 percentage points. In 1969, it fell sharply and is clearly responsible for the precipitous fall in overall efficiency in the same year. This behavior supports the hypothesis that the decline in overall efficiency is related to the transfer, because such a decline would be expected to show up most directly as reduced conveyance efficiency. After three years of decline, during which it dropped 5 points from 0.70 to 0.65, conveyance efficiency again increased for several years climbing back to about 0.69. During this period, it was once again responsible for a net rise in overall efficiency. From 1975, conveyance efficiency for the CBP declined continuously until the end of the period in 1989, ending at about 0.60.[27]

Figure 5.15. Conveyance and tertiary-unit efficiency, CBP, 1955–89 (3-year moving average).



Source: Water Distribution and Crop Production Reports for CBP, U.S. Bureau of Reclamation.

Note: Years shown on graph scale are final years in each 3-year period.

27 Bos and Nugteren (1990, 33) present data showing average conveyance efficiencies of about 0.53 for schemes larger than 100,000 hectares. The sample is drawn from nonrice growing irrigation systems in a mixture of developed and developing countries.

Tertiary-unit efficiency, on the other hand, also rose smartly from 1957 and then fell before beginning a four-year rise in 1969, the year of the transfer, from 0.65 to about 0.70.[28] From 1975, six years into the district management period, until 1986, steadily rising tertiary-level efficiency offset falling conveyance efficiency, holding overall efficiency generally constant. As tertiary efficiency levels off, however, and conveyance efficiency continues to fall, overall efficiency drops sharply for the last 3 years of the period resulting in the 3-percentage-point decline in overall efficiency recorded between 1987 and 1989.

The evidence presented above suggests a post-transfer acclamation period lasting about 7 years before system conveyance efficiency was restored to levels prevailing prior to transfer. This was the case with a staff largely made up of the same individuals who had operated the scheme before 1969. If it had been necessary to recruit and train O&M personnel from outside the system, this period could conceivably have been longer. It should be noted that there is no evidence that the adequacy or timeliness of water deliveries to farmers suffered during this period, or that interdistrict equity deteriorated. It is only the hydrologic efficiency of the canal system operations which was obviously affected.

The long, steady slide in conveyance efficiency which has lasted from 1975 until the present raises additional questions. First, is this a matter of concern to system managers? If quality of irrigation service to CBP farmers has not suffered, and this is the direct connection with the productivity of the system, it may be that reduced conveyance efficiency is a step consciously taken to make system management easier and to reduce field staffing requirements, and hence operating costs. Alternatively it may be that the conveyance system is simply leakier and less manageable than it was in the mid-1970s, as a result of inadequate maintenance and replacement work on system canals, linings, and control structures. A third possibility is that system operational rules and procedures have not been appropriately adapted to the decline in aggregate crop water demand which has occurred since the early 1970's and the corresponding decline in the aggregate volume of water orders, adjusted to a per-acre basis. In this case, more water in main-canal systems is simply running to waste. These questions will be explored further as additional information is presented to illuminate them from different angles.

Financial Viability

Adjusting for Inflation.

In the following financial analyses, three price indices are used to remove nominal increases attributable to inflation from project and farm-level costs and returns. All values reported in the analysis of revenues and costs are in constant 1989 US dollars unless otherwise indicated.

Value of crop output was adjusted to constant dollars using the index of prices received by farmers, and the farm-level price of water was adjusted by the index of prices paid by farmers, both taken from the Economic Report of the President (1991). Operation and maintenance (O&M) costs, as well as other CBP revenues and expenditures were adjusted using the Producer Price Index (PPI) from the same report. The PPI is a generalized index of prices paid by producers of goods and services for inputs, calculated for the entire United States.

The USBR maintains its own deflator series for O&M expenditures, based on changes in per-acre O&M expenses in a sample of its own projects. The USBR sample excludes projects whose total area varied by more than 20 percent from the previous year and whose O&M costs

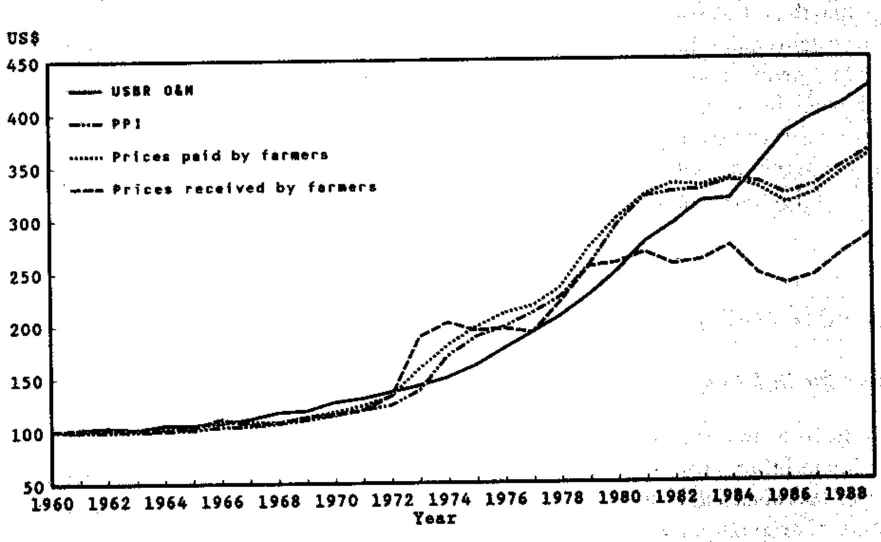
28 Bos and Nugteren (1990, 55) report an average e_u value of 0.70 for six sprinkler-based systems. The sample is drawn from irrigation systems in a mixture of developed and developing countries.

varied more than 50 percent from the previous year. Sample projects are allowed to have only minimal changes in management, system physical condition, or maintenance standards for that year. An index is first calculated for each project and the individual indices are averaged to obtain a general index. The cost streams upon which the USBR index is based are specific to USBR projects and include any real changes in O&M expenditures as well as inflation-induced changes.

The four series are shown together in Figure 5.16. Comparison of them reveals several interesting trends. First, the index reflecting prices paid by farmers tracks the PPI closely, making the two interchangeable for practical purposes. Second, both of these measures leveled off in 1982, reflecting the onset of a recessionary period in the United States, and remained stagnant for the next 5 years.

During the same period, the USBR O&M index appears unaffected by medium-term trends in the larger economy. Its resolute rise during both inflationary and noninflationary times suggests that either the cost structure of the Bureau is pre-programmed for a particular level of inflation and therefore unresponsive to real outside events, or that, because of the way the index is constructed, it is being driven upward by real-cost increases in O&M expenditure in addition to inflationary ones. Consequently, the Bureau index was felt to be insufficiently independent of sampling biases and the impacts of real changes in system O&M costs to be used in deflating CBP O&M expenditures.[29]

Figure 5.16. Comparative deflators for irrigation cost series, 1960–89 (1960=100).



Sources: President of the United States, *Economic Report of the President* (Washington, D.C.: U.S. Government Printing Office, 1991); O&M Cost Index calculated by U.S. Bureau of Reclamation.

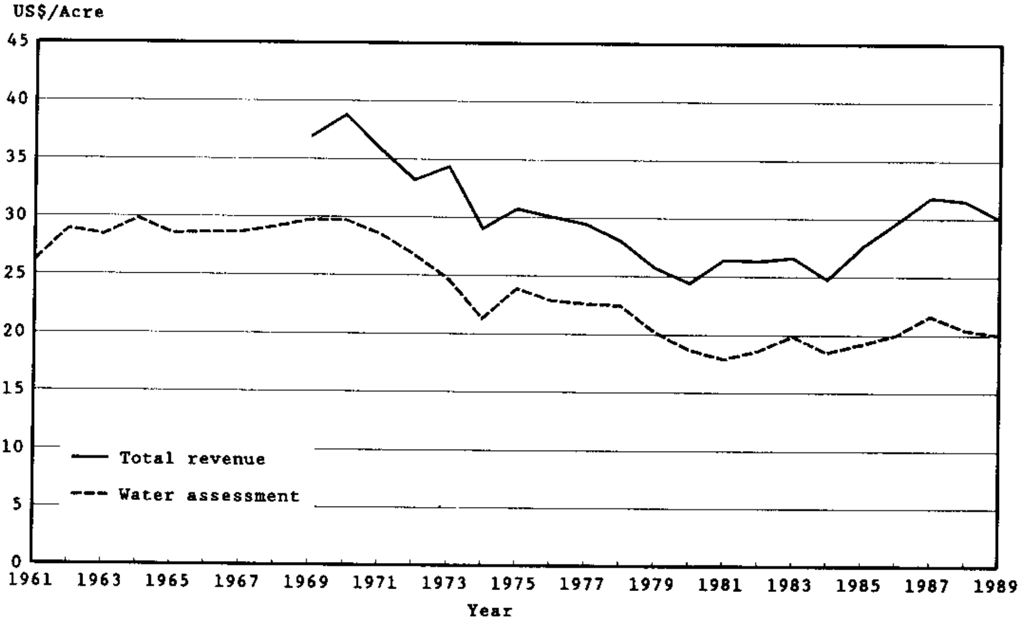
Revenue

Total revenues to the three districts averaged US$37.15 per acre, in constant 1989 dollars, for the three-year period 1969–1971 immediately following the districts' takeover of operational

29 Note also that prices received by farmers leveled off in 1980 while other indices continued to rise steadily, highlighting the cost/price squeeze in which farmers were caught for almost a decade.

responsibility. Revenues fell steadily over the next decade, reaching a low of US$25.53 per acre for the 1979–1981 period. Income then rose again during the eighties, reaching US$31.09 per acre in 1987–1989 (Figure 5.17).

Figure 5.17. Revenue per irrigated acre, CBP, 1961–89 (1989=100).



Sources: U.S. Bureau of Reclamation and CBP irrigation districts.

Driving these changes were variations in income from water assessments charged to Basin farmers, which make up 70 to 80 percent of total revenue. As seen in Figure 5.17, total revenue closely tracks the water assessment curve during the 1969 to 1989 period, with some divergence toward the end of the period. Data on water assessments are available from 1961 and provide an opportunity to compare trends in assessments before and after management transfer. From a level of US$26.16 per acre in 1961, the assessment rose rapidly to US$29.10 in 1968, the final year of Bureau management. Following management transfer to districts, assessments fell steadily, reaching a low of US$17.91 in 1981 before beginning to rise slowly again reaching US$20.00 per acre in 1989. It seems clear that the management shift triggered a series of reductions in real water assessment rates and reversed the rising trend which had been prevailing prior to that time. Farmers, through their districts, appear to place a higher premium on holding down fee assessments than does the Bureau. The increasing trend of the early 1980s may represent a realization that maintenance was being underfunded, but this point requires further exploration. Another interesting feature of Figure 5.17 is the expanding divergence between total revenue and water assessment curves after 1984, suggesting the increased importance of other sources of income to the districts after that time.

Table 5.6 shows shares of total revenue derived from different sources. Farm water assessments, the major component, declined from 80.6 percent in 1969 to an average of 67.4 percent during the last half of the 1980s. On the other hand, power revenues became appreciable only in 1985, and, in the last half of the decade, made up 4.5 percent of total revenue. The category "interest and other revenue" also shows an increase during the last 5-year period, rising to 14.8 percent of the total.[30] Income from water-service contracts grew steadily throughout the 20-year period of district management, representing system expansion into adjacent lands not formally included in the district. The growth in these other income sources caused the total income to the districts to climb rapidly from 1984 onward, while allowing districts to restrict water assessment increases to relatively modest levels. Total real income grew at a compound rate of 4.1 percent during the 1984 to 1989 period, while water assessments increased only at a rate of 1.9 percent per year.

Table 5.6. Shares of total revenue, 5-year averages, CBP 1969–89.

Year	Water assessment	Water service contracts	Excess water charges	Interest and other income	Power revenue	Total
1969	0.806	0.003	0.122	0.070	0.000	1.000
1970–74	0.764	0.014	0.126	0.095	0.000	1.000
1975–79	0.778	0.033	0.116	0.075	0.000	1.000
1980–84	0.729	0.042	0.060	0.166	0.004	1.000
1985–89	0.674	0.057	0.076	0.148	0.045	1.000

Source: Data from CBP irrigation districts.

Three salient conclusions emerge from this analysis. First, districts were effective in substantially reducing the absolute level of irrigation rates after they assumed management control. That they would wish to do this is not surprising, though their effectiveness is notable. Second, all three districts have succeeded in diversifying their activities to generate a larger share of their revenue from sources other than their member farmers. Each district now gets more than one quarter of its total revenue from non-member sources. In addition to new sources of income such as small-scale hydropower generation, districts have reduced their own water use, and hence revenue from excess water sales, and sold this water to other farmers on the margins of the districts, boosting revenue from water service contracts. Third, interest earnings has become an increasingly important source of income for the districts, suggesting prudent financial management and the accumulation of sinking and other reserve accounts.

Costs

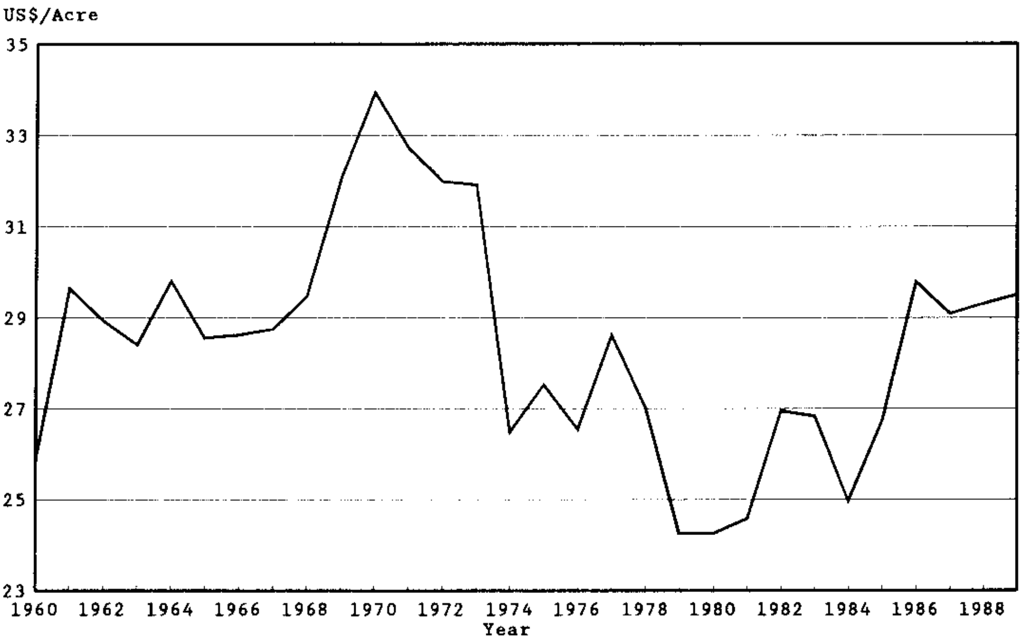
The cost of operating the CBP during the period 1960 to 1989 averaged US$28.43 per acre (US$70.22 per hectare). Counted are financial (not economic) costs which include district

30 For the period 1983 to 1989 for which disaggregated data are available, more than half (55.8%) of the income in this category consists of interest income on funds held on account, and reserve funds. The balance of the income shown comes from groundwater recharge payment from groundwater districts and transfers from reserve funds (16.7%), payments by the USBR for services provided by the districts (11.7%), miscellaneous collections (9.5%), and equipment rental (6.3%). These figures are averages over seven years. Proportions for individual years fluctuate substantially.

operating expenses and the district payment to the Bureau for operating and maintaining reserve works, but not subsidies provided through the Bureau. Most notable among the latter is the exceptionally low rate paid by the districts for lifting water from the FDR Reservoir, relative to commercial rates for power.

Figure 5.18 shows the behavior of operating costs over time. Immediately following the shift from Bureau to district management, costs are seen to have increased substantially. During the period prior to the transfer (1960 to 1968) the average operating cost was US$28.67 per acre, while during the five-year period following transfer (1969 to 1973) it averaged US$32.51 per acre, an increase of about 13 percent. In 1974, it plunged decisively and remained relatively low for the next 8 years before showing a rising trend throughout the 1980s. For the entire post-transition period (1974 to 1989), the average operating cost was US$27.02 per acre, only slightly below its value under Bureau management. It is reasonable to regard the increase in operating costs immediately following transfer as temporary and to attribute it to the transition process itself. Although the Bureau covered many of the costs involved, the districts must have incurred start-up costs of establishing or expanding offices, setting up databases and accounting systems, and the like.

Figure 5.18. Total expenditures per acre, CBP, 1960–89.



Sources: U.S. Bureau of Reclamation and CBP Irrigation Districts.

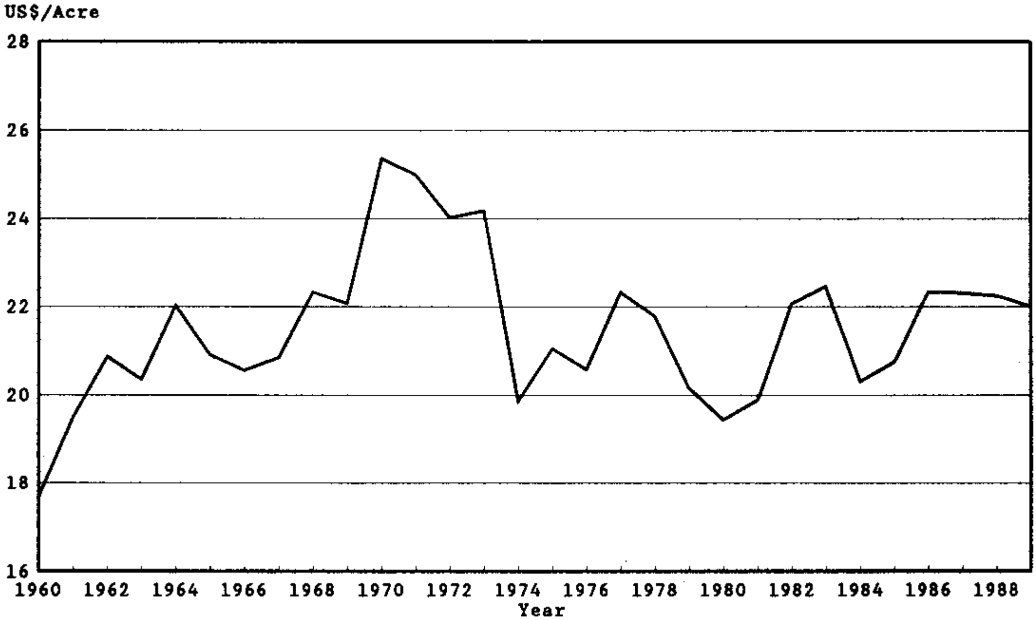
In general, about three quarters of total operating costs (76 %) are made up of district staff and O&M expenses (Staff/O&M).[31] Payments to the Bureau for "reserve works" O&M make up another 13 percent, and "other" costs amount to 10 percent of the total. The Staff/O&M category

31 Given the various sources of the data used in this analysis, it was impossible to disaggregate this category in a consistent way.

includes staff salaries and benefits, and such items as maintenance on buildings and canals, lateral construction and repair, weed control, staff field expenses and equipment expenses. "Reserve works" includes payments to USBR for operation, maintenance and repair of canals, dams, and pumping plants used in common by the three districts and power charges for pumping from the FDR Reservoir. The "other" category includes contracted construction work, insurance claims, drainage claims, unrecovered assessments and charges, and administrative expenses.

Figure 5.19 shows Staff/O&M costs to be remarkably constant over time, if the transition period is ignored, with costs before and after transfer being quite similar. This is consistent with the earlier observations that operational procedures changed little after transfer and that most of the operational staff simply switched employers. Although year-to-year variations in Staff/O&M costs can be seen reflected in the total expense graph, the reduced *level* of total expenditures during the late 1970s is explained by the steady reduction in reserved works expenditures shown in Figure 5.20. With the exception of the transition period, these expenditures show a long-term decline over 25 years from about US$5.50 per acre in 1960 to around US$2.00 per acre in 1984. Subsequently, there was a near doubling of the expenditure rate during the late 1980s. The fall in this category of expenses is a result, in part, of falling per-acre water supply levels and consequent reduced power charges. This trend is mirrored, in more muted fashion, by "other" expenditures (Figure 5.21).

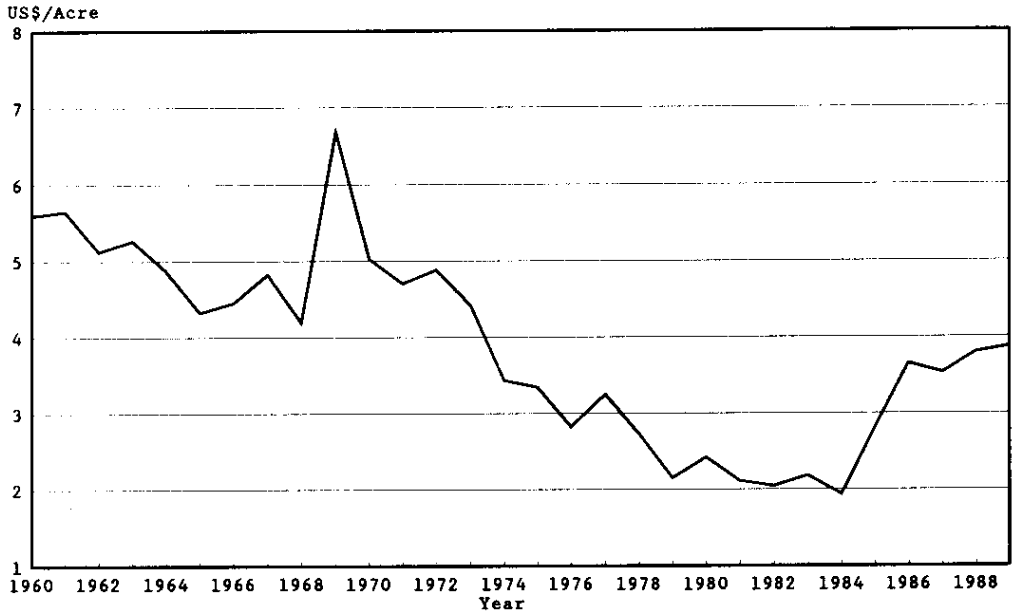
Figure 5.19. Per-acre expenditure on staff and O&M, CBP, 1960–89.



Sources: U.S. Bureau of Reclamation and CBP irrigation districts.

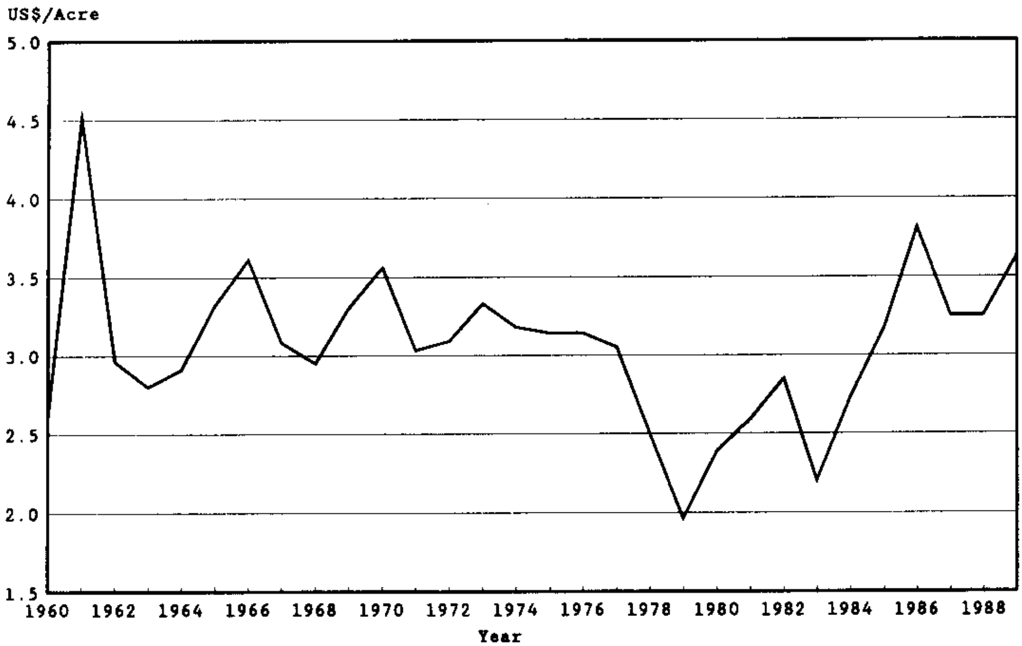
The general pattern which emerges is of relatively little permanent change in expenditure patterns as a result of the transfer of management to the districts. Staff/O&M and "reserve works" expenditures both experienced temporary, transition period increases following transfer, following which staff/O&M costs settled back to their previous range while "reserve works" assessments continued to fall until the mid-1980s. Total O&M expenditures also show this transition spike and

Figure 5.20. Per-acre expenditures on reserved works, CBP, 1960–89.



Sources: U.S. Bureau of Reclamation and CBP irrigation districts.

Figure 5.21. Other expenditures per acre, CBP, 1960–89.



Sources: U.S. Bureau of Reclamation and CBP irrigation districts.

subsequent fall to values below pre-transfer levels. During the last half of the 1980s, rising reserve works assessments and increasing administrative and other costs pushed total expenditures back to the level prevailing prior to transfer.

An interview with the Quincy district manager indicated that farmers' top priority is a "lean" operation to keep water charges down. Reportedly, the board restricts costs tightly and the district is "right on the line" between maintaining the system in adequate operating condition and letting it deteriorate. Others interviewed in that district felt the system is being allowed to deteriorate. For the system as a whole, the figures examined do not reveal an overall decline in the amount spent in the critical Staff/O&M category, a decline which might suggest that short-term economies are being sought at the expense of long-term sustainability. However, as system facilities and equipment age, it may be that the expenditures *required* to hold the system at a particular level of operational performance increase. Hence, constant real levels of expenditure would become increasingly inadequate.

Profitability

Time series data on farm expenditures and production were not available to allow the calculation of annual farm profitability. From a farmer's perspective, profitability is the ultimate measure of the performance of his operation, but it is a measure obviously influenced by a large number of variables besides the quality and cost of irrigation service. The major effect on profitability of the shift to farmer management of the CBP was probably felt through the one-third reduction in per-acre irrigation assessments which took place following the transfer. For a 160-acre farm, this would amount to an increase in gross margin of around US$1,600. The more precise water control provided by center pivot sprinklers, which facilitated a shift to higher-value crops, probably had a much greater impact on profitability, but this change was a farm-level decision and largely independent of the management transfer.

Several existing studies carried out with somewhat different purposes in mind do provide interesting snapshots of profitability in different years. A study by the Washington State Department of Conservation in 1964 compared net annual returns per acre on sample farms on the unirrigated wheatland on the East Side (where farmers had refused irrigation when the project was being developed) with returns in the irrigated area of the CBP. Average net annual returns on the unirrigated land were US$6.54, compared with a range of US$17.60 to US$41.33 per acre on the irrigated farms. Unsurprisingly, irrigated land has been substantially more profitable per acre than adjacent unirrigated land. East side farmers objected to the introduction of irrigation due to their collective opposition to the accompanying farm-size limitations. Because these farmers did retain larger holdings, however, these per-acre figures do not reflect respective farm income levels for the two groups.

A 1978 study (Holland and Young) concluded that farm units of 160 acres were economically viable and profitable. Using average prices and crop yields for the period 1973 to 1977, the profit maximizing wheat-potato rotation yielded a net annual after-tax income of US$29,000. The less-intensive but more common rotation of sugar beets, wheat, alfalfa, and potatoes, which was considered more consistent with maintaining soil fertility, yielded a much lower average net annual income of US$10,000. Both levels were considered "adequate" to support an average family of two parents and two children. Put into 1989 dollars, these net incomes work out to US$31,958 and US$11,020 respectively. If the 1964 figures for irrigated farms from the Department of Conservation study are put on a similar footing, net income in that year spanned a range of

US$4,618 to US$10,845, or an average of US$7,732. This suggests that net farm incomes did rise, in real terms, between 1964 and 1978.

A final illustrative comparison relates a farmer's water cost savings due to the post-transfer drop in assessment levels to net farm income. From Figure 5.17, the change in per-acre assessment levels between the 1960s and the 1980s is seen to be about US$10 (1989 dollars). This amounts to US$1,600 for a 160-acre farm. Assuming that the real after-tax farm family income in the 1980s remained at the 1978 level, savings in water charges are seen to have comprised about 15 percent of the farm family's income. In other words, average farm income would have been roughly 15 percent lower had management transfer not occurred. This calculation is crude, but it does suggest the order of magnitude of the savings involved, which is substantial.

As indicated earlier, the gross returns from CBP farms have increased steadily, in real terms, since the project was constructed (Figure 5.5). Because the behavior of production costs is unknown, however, the authors are unable to make judgements on this basis about net income.

Maintenance

Under the terms of the management transfer agreement, the USBR is to conduct an O&M audit of system network facilities and operations in each of the districts every two years. Such audits generally involve three days of field inspections by a team of USBR and consulting engineers.

Table 5.7 shows the results of six O&M audits conducted after management transfer, between 1973 and 1988. Audits of pumping stations were conducted during alternate years. There were 37 recommendations made during the six audits in the three districts, an average of 2.05 recommendations per audit per district. Remedial action in response to 13 of these recommendations was not completed prior to a subsequent audit. This yields an average of 0.72 uncompleted recommendations per audit per district.

Recommendations are divided into three categories by the auditors. Category 1 recommendations are those where urgent remedial maintenance is required. There were no recommendations made in this category. Category 2 recommendations call for important, preventive maintenance work. This was the most common type of recommendation made to the districts, constituting 30 of the 37 recommendations. Category 3 recommendations are for less important, preventive maintenance work. Seven of the 37 recommendations were in this category.

The recommendations covered a variety of types of work. Some of the more frequently made recommendations called for repair of structures and mechanical devices, painting, better on-farm irrigation management — especially to prevent silt-laden farm run-off,[32] weed control, canal seepage control, and improving drainage capacity. Operational practices were rarely commented upon. All three districts were commended for the quality of their overall O&M practices. The 1986 audit report for East District noted that all facilities reviewed were in "good operating condition" and that the district was continuing to "look for new ways to improve the operation" of the system. The 1990 audit report for Quincy District commended district staff for their "progressive O&M program" and noted that all structures observed were in good condition.

The overall view of operation and maintenance activities carried out by districts provided by the audits is positive. The number of recommendations is relatively small, given the total number of structures and length of canals across the three districts. The districts were engaged in a program of preventive maintenance which successfully kept the system from requiring emergency remedial maintenance.

32 This recommendation was more common in the earlier audits.

Table 5.7. Results of USBR O&M audits in three districts of the CBP.

	Number of recommendations				
	Previous recommendations uncompleted	New recommendations			
		Category 1	Category 2	Category 3	Total
1973	2	0	0	0	0
1975	0	0	5	1	6
1977	3	0	0	1	1
1979–81[a]	4	0	12	2	14
1982–84	1	0	8	2	10
1986–88	3	0	5	1	6
Total	13	0	30	7	37

Sources: O&M audits, USBR, Columbia Basin Project.

Note: Category 1: Urgent remedial maintenance required; Category 2: Important preventive maintenance needed; Category 3: Less important, preventive maintenance would help improve O&M.

[a]In later years, audits were not conducted in each district during the same year.

The question of the drop in conveyance efficiency beginning in 1975 remains, however. Attributing such a change to particular causative factors is difficult as several factors are likely to be involved, because the effects of neglect are cumulative, and because time lags exist between neglect and deterioration. The level of Staff/O&M funding is a logical proxy for maintenance adequacy, but as seen in the analysis of costs, it has shown no persistent downward trend and small year-to-year variations would not be expected to show up as fluctuations in hydraulic efficiency. The possibility of increasing O&M requirements with time remains, however.

The O&M audits shown in Table 5.7 offer a proximate variable between inadequate maintenance and conveyance efficiency. These audits do show a higher level of new and uncompleted recommendations in the period after 1979, most of which were classed as "important preventative maintenance needed" which is roughly consistent with the timing of the decline in conveyance efficiency shown in Figure 5.15. This offers some limited support to the idea that O&M expenditures ought to be increasing if efficiency declines are to be arrested.

CONCLUSIONS

From many angles, the transfer of management from the US Bureau of Reclamation to irrigation districts in the Columbia Basin Project can be considered a success on a large scale. While the Bureau was able to back out of its mostly unwanted role in O&M, the districts gained local control over management and costs. Data suggests that the project has not suffered significant negative impacts due to management transfer in the areas of management efficiency, agricultural productivity, profitability of agriculture for farmers, or economic viability of districts. The effect on long-term sustainability of the system is less clear, and there is some indication that the physical system may be experiencing some net deterioration. That management of irrigation for approximately 557,528 acres (225,626 hectares) can be handled by three local irrigators' organizations is an impressive achievement. It is a recurring pattern throughout the American West, even on larger scales. The King's River Irrigators Association in Fresno, California irrigates more than 450,000 hectares of land.

The aspects of the CBP which accounted for its ability to transfer such a sophisticaped and large-scale management regime to local irrigators' organizations may be summarized as given below.

Social Context

In contrast to the situation in many developing countries, the CBP consisted of a relatively homogeneous population of settlers, which was highly educated and commercially oriented. There were virtually no landless poor or others with insecure tenure. Farmers and their districts had considerable legal and political power and secure land and water rights. Farmers were able to negotiate as equals with the government and obtain numerous favorable concessions for themselves, such as low power and construction repayment rates and relaxed limits on farm sizes. Such concessions ensured that farming would be a relatively stable and profitable enterprise.

From the outset of construction, irrigation districts were invited to negotiate and agree on whether or not they wanted the irrigation system to be constructed. The offer could be rejected and was by some. To obtain water, farmers established districts and entered into agreements with the government to repay construction costs, cover the "full" cost of O&M (which was in fact highly subsidized), and eventually take over management of the system. This initial collective understanding about responsibilities of individual farmers and the districts created the perception among farmers that management transfer was both desirable and inevitable. The essential practices of continual negotiating and making binding agreements no doubt strengthened the districts and their legitimacy in the eyes of the farmers.

Institutional Context

The system of contract law and the strong legal basis of the districts and their land and water rights provided the necessary confidence for farmers to accept responsibility for managing the system. Strong institutions also made possible the credible threat of strong sanctions. The "partnership culture" between the districts and the Bureau permitted joint problem-solving, as in deciding on continued Bureau management of jointly used "reserved works," contracting by the districts for technical work to be performed by Bureau staff, and the creation of satisfactory Bureau-to-district personnel transfer arrangements. The Bureau also provides sovereign immunity for the districts, acts as repository for the system's water rights, and has ultimate oversight responsibility for ensuring that standards of O&M and financial performance are maintained. The state ensures that standard accounting procedures and practices are followed.

No doubt management transfer would have been much more difficult to achieve had the Bureau and districts not been able to come up with an acceptable plan for rapid staff disposition. The districts were able to absorb the large majority of displaced O&M staff. They were already paying Bureau O&M staff costs prior to transfer, so transfer did not introduce additional major costs to the farmers. Bureau staff did not seriously resist the move, because transferred staff received the same salary levels and insurance and pension benefits as they did before transfer. The Bureau was able to reassign remaining staff elsewhere and also began to take on new roles to use its staff, which included land and environmental management and monitoring.

Results

Technology Adoption.

There has been substantial technological change in the CBP since transfer of management in 1969. Some of this change, such as the widespread shift to center pivot systems, has resulted from the individual decisions of farmers responding to prices and returns. Other changes, such as installation of automatic gauging stations and telemetry systems, have been put into place by the districts. It seems clear, at a minimum, that the transfer to district management has not hindered the adoption of new technology in the CBP and may have accelerated it.

Causes of technological change are sometimes complex and indirect. For example, the reduction in water demand which accompanied the rapid shift to sprinkler irrigation in the 1970s was shown to be largely a result of a shift to crops with lower water demand, rather than to the adoption of sprinkler systems *per se*. However, it is quite likely that the installation of the center pivots contributed to improved water control which made the shift to new, less water-intensive, often higher-value crops possible. And the willingness of farmers to invest in expensive new water application technology is itself, in part, a function of their confidence in the reliability of water supplies delivered by the district.

Hydrologic Performance

The quality of irrigation service received by CBP farmers does not appear to hare been affected significantly by the change to district management. Quantity of water delivered did not change markedly after 1969 and reducpions in water supply in later yaars can be explained largely by reductions in aggregate water demand resulting from changing cropping patterns. Demand adjusted equity of water distribution among the three districts did decline in the 1970s and the 1980s following transfer, but then rose again and, on average, equity at the district level was about the same before and after transfer. The CBP operates on an arranged demand system of allocation, and so timeliness of water deliveries must be measured against the timing of orders for water. Farmers appear to have been satisfied with the timeliness of deliveries both before and after transfer and generally rate this aspect of service highly.

An examination of the hydrologic efficiency of the system does reveal some interesting changes, however. It appears that the system's new managers required a period of 5 or 6 years after transfer before they were able to operate the conveyance system as efficiently as did the Bureau prior to transfer. This demonstrates the complex and subtle nature of the control that is required to operate a large system like the CBP efficiently. Farmers, for their part, increased tertiary-level efficiency steadily from the mid-1970s. Improvement was driven by a shift from surface to sprinkler irrigation across much of the project area. That rise has now stopped and overall tertiary-level efficiency may even be declining slightly at present.

One very puzzling aspect of system hydrology is the continuing 15-year decline in conveyance efficiency which set in 1978, accentuated by a strong upward surge in the amount of water turned into the three districts beginning in 1986. This recent increase is not reflected either in supplies actually delivered to farm turnouts or to any change in crop-based demand for water, both of which have held constant. Possible explanations for this overall deterioration in system conveyance efficiency include, (a) deterioration in the condition of major system canals resulting in increased water conveyance losses, and (b) increased water orders to the Bureau to allow greater power generation through turbines installed in a number of system canals.

In considering the second scenario, it is noted that the efficiency decline commenced well before power generation by districts began in 1985 and is clearly not responsible for the longer-term trend. However, power to pump water into their distribution systems costs the districts less than one twentieth of what they earn from the commercial sale of the power they generate, on a per-unit basis. It would thus be quite rational for them to increase their water orders from the Bureau in order to increase revenues from the sale of power, simultaneously holding down the water rates assessed to district members. This would explain the sharp increase in deliveries to the districts beyond 1986. Such a move might have the added benefit of making the system easier to manage, especially toward the tail, by keeping more water flowing through it.

Financial Performance.

Upon assuming management responsibility, districts moved quickly to cut water assessments to district members. On average, real per-acre assessments under district management were just 78 percent of their level during the Bureau period. At the same time, districts diversified income sources, increasing the share of revenue from hydropower generation and interest on deposited funds, partially offsetting lost water assessment income. Sale of water conserved to non-members of the district also increased sharply, demonstrating the power of vested water rights, financial autonomy, and quasi-volumetric pricing to shift water to more profitable uses within the irrigation sector.

On the average, costs of operating the system do not exhibit well-defined shifts associated with management transfer, and average expenditure levels before and after 1969 are roughly similar. Although it is impossible to know what expenditure patterns would have been had the Bureau retained operating responsibility, the Bureau's agency-wide O&M cost index provides one clue. It shows that the cost of operating Bureau systems increases in an extremely regular way, in nominal terms, and is only loosely related to the underlying rate of inflation. Overall, since 1960, the Bureau's cost index has grown to a somewhat higher level than more general cost indices, suggesting that operating expenses under Bureau management might have been higher than they presently are, other things being equal.

Three quarters of operating expenses are made up of staff and O&M costs, and these have held remarkably constant across the transition. Major expenditure components show peaks just after transition, reflecting the one-time costs of the transfer. A ten-year decline in total expenditure from the 1969 peak is largely attributable to falling reserve works costs. During the last decade, total costs have risen again to around their long-term average, driven by increases in reserve works expenditures and administrative and other costs.

The cost analysis does shed a little more light on the question of declining hydrologic efficiency raised earlier. Because district O&M costs have not shown a declining trend since transfer, it can be assumed that maintenance levels at the district level have not been reduced appreciably. Changes in reserved works payments to the Bureau do not enter the argument, since the observed decline in conveyance efficiency occurred within areas of responsibility of the districts. A remaining possibility is that, while district expenditures on O&M have held constant, they should in fact be increasing to counter accelerating deterioration as the system ages. Some support for this hypothesis is provided by an analysis of maintenance audits, which show an increasing number of problems being flagged in recent years.

Farm Profitability.

Gross returns to irrigated agriculture have risen steadily in the CBP over the past 30 years. Although information on net returns is sketchy, there is some indication that real net returns have also risen.

Water assessment levels have fallen by about one third since districts assumed management responsibility. This is estimated roughly to comprise about 15 percent of the average farm income.

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