IRRIGATION MANAGEMENT TRANSFER IN THE COLUMBIA BASIN

Lessons and International Implications

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and
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INTERNATIONAL IRRIGATION MANAGEMENT INSTITUTE

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Contents

List of Tables ix

List of Figures and Maps xi

Preface xiii

Acknowledgements xv

Executive Summary xvii

Chapter 1. Introduction 1

Chapter 2. Columbia Basin Irrigation **Project** 5

EARLY HISTORY OF IRRIGATION IN THE BASIN 5
PROJECT CONSTRUCTION 6
POWER GENERATION 8
PROJECT PHYSICAL ENVIRONMENT 9
Location 9
Climate 9
Relief 11
Soils 12
Rural Infrastructure 12
IRRIGATION WATER SUPPLY. DELIVERY, AND APPLICATION 13
Project Water Right and Withdrawals 13
System Physical Facilities 13
Water Management Procedures 17
PROJECT SOCIAL ENVIRONMENT 18
Settlement Patterns and Policies 18
Characteristics of Settlers 20
AGRICULTURE 21

Chapter 3. Irrigation Institutions 25

THE U.S. BUREAU OF RECLAMATION 25
IRRIGATION DISTRICTS 26
RELATIONSHIP BETWEEN THE USBR AND THE DISTRICTS 27

Chapter 4. Management Transfer 35
MOTIVATION FOR TRANSFER 35
Fanner Perspectives 35
USBR Perspectives 35
TRANSFER PROCESS 37
TERMS AND CONDITIONS OF TRANSFER AGREEMENTS 38
Dismct Rights 38
District Responsibilities 38
USBR Rights 39
USBR Responsibilities 39
MANAGEMENT CHANGES SINCE THE TRANSFER 40
The USBR 40
The Districts 43

Chapter 5. Results of the Transfer 47
EVALUATION METHODOLOGY 47
CHANGES IN TECHNOLOGY 48
QUALITY OF IRRIGATION SERVICE 48
Adequacy 49
Timeliness 57
Equity 57
HYDROLOGIC EFFICIENCY 60
FINANCIAL VIABILITY 66
Adjusting for Inflation 66
Revenue 68
costs 71
PROFITABILITY 73
MAINTENANCE 77

Chapter 6. Summary and Conclusions 81
IMPACTS OF THE TRANSFER 81
Technology Adoption 81
Hydrologic Performance 81
Financial Performance 83
Farm Profitability 83
General Conclusions 83
ENABLING FACTORS 84
Policy Context 84
Social Context 85
Institutional Context 85
The USBR 86
Irrigation System 86

LESSONS FOR TRANSFER IN DEVELOPING COUNTRIES 86
Policy and Institutional Issues 86
Process Issues 88

References 89

Appendix 93

List of Tables

Table 1 Average monthly temperatures. rainfall and potential evapotranspiration rates for the CBP 11

Table 2. Irrigated land classes in the CBP 12

Table 3. Irrigated area and gross value of crop production. the CBP. 1955-89 22

Table 4. Number of USBR staff assigned to the CBP. by division. 1961-85 41

Table 5. Five-year average values for PET. net supply and net RWS (in feet), the CBP. 1955-89 56

Table 6. Ratio of high and low district net relative water supply values for the CBP. 1960-1989 58

Table 7. Share of total revenue. 5-year averages. the CBP. 1969-89 70

Table 8. Results of the USBR O&M audits in the three districts of the CBP 78

List of Figures and Maps

Figure 1. Area irrigated (acres). the CBP. 1953-89 7

Figure 2. Growth of sprinkler irrigation, the CBP. 1960-89 16

Figure 3. Average value of total crop production per acre. the CBP. 1960-89 (3-year moving average) 24

Figure 4a. Organizational structure of the Quincy District. the CBP 28

Figure 4b. Organizational structure of the East District, the CBP 29

Figure 4c. Organizational structure of the South District. the CBP 30

Figure 5. Number of USBR staff assigned to the CBP, by division. 1961-85 42

Figure 6. Water diverted. delivered and required. the CBP. 1960-89 50

Figure 7. Water diverted. delivered and required for the Quincy District and the East District, the CBP, 1960-89 51

Figure 8. Total system water supply per acre. the CBP. 1960-89 (3-year moving average) 52

Figure 9. Average turnout water delivery per acre. the CBP. 1955-89 (3-year moving average) 54

Figure 10. Crop-weighted potential evapotranspiration for the CBP. 1955-89 55

Figure 11. District ratios of high and low net relative water supply. the CBP. 1960-89 59

Figure 12. Overall efficiency for the three CBP districts, 1960-89 (3-year moving average) 62

Figure 13. Conveyance and tertiary unit efficiency for the three CBP districts, 1955-89 (3-year moving average) 63

Figure 14. Overall efficiency for the CBP. considering reuse. 196089 (3-year moving average) 65

Figure 15. Comparative deflators for irrigation cost series. 1960-89 67

Figure 16. Revenue per irrigated acre. the CBP. 1961-89 69

Figure 17. Total expenditures per irrigated acre. the CBP. 1960-89 72

Figure 18. Per-acre expenditures on staff and O&M, the CBP. 1960-89 74

Figure 19. Per-acre expenditures on reserved works. the CBP. 1960-89 75

Figure 20. Other expenditures per acre. the CBP. 196089 76

Map 1. Location map: The Columbia Basin Project 8

Map 2. The Columbia Basin Project 10

Preface

FROM THE 1950S through the 1970s, massive investments in irrigation development led to a substantial expansion in the area of irrigated agricultural land throughout the world. Without such an expansion in irrigated area and intensified production in existing irrigated lands, the green revolution could not have achieved the impact it had on increasing the world's food supply. However, the first wave of newly constructed irrigation was soon followed by repeated investments to rehabilitate irrigation systems. These investments often had to be made much earlier than initially expected. This widespread failure in maintenance was often combined with maldistribution of water within systems, leading to an absence of water reaching the lower portions of canals. Particularly in developing countries, governments have found it difficult to collect irrigation service fees when a large proportion of farmers are dissatisfied with the service. When governments fail to collect enough revenue to pay for the costs of routine operation and maintenance, irrigation systems deteriorate further, as does the service to the farmers. By the 1980s, it was clear that institutional reform was needed.

Since the advent of the green revolution, the standard of living and literacy rates among rural populations in many developing countries have steadily increased, especially in Asia and Latin America. By the 1980s, debt burdens, inabilities of governments to finance recurring costs, growing dissatisfaction with the performance of government agencies in natural resource management and increased expectations about the capacity of local people to manage resources, have all combined to support various structural adjustment policies. What these policies generally have in common is a desire to expand the role of the private sector in the development and management of natural resources. Presently, irrigation management transfer is perhaps the most prominent structural adjustment policy in the irrigation subsector.

While it has been a policy of such countries as the United States and Taiwan for several decades to transfer management of government constructed irrigation systems to farmers, this is a relatively new policy in most developing countries, where it is largely driven by financial pressure. Since the 1980s, irrigation management transfer has become a national policy in such countries as Chile, Colombia, Peru, Ecuador and Mexico in Latin America; the Philippines, Indonesia, Bangladesh and Nepal in Asia; and Senegal, Niger, Nigeria and Madagascar in Africa. The transition to locally managed irrigation is fraught with many challenges and potential problems. Many countries are pressing ahead with transfer policies in situations where there are no clearly defined water rights for users, where irrigation works were not designed for local management, where systems have already deteriorated, where agriculture is declining in profitability, or where social conditions inhibit the formation of viable water users' organizations. Management transfer is probably not a suitable policy in some circumstances. As with the green revolution, we might expect that if an essential package of "management inputs" is not in place (however specified), the results of management transfer will not be acceptable or sustainable in the long run. It seems fair to assert that a policy is only worth as much as the feasibility of its implementation.

Transfer policy has the potential for fundamental and far-reaching impacts on irrigated agriculture around the world. Therefore, it is important to attempt to define the following, through research and practice: What is the essential "management package" that is needed in order to make the transfer policy successful and locally sustainable? What are the necessary legal and institutional pre-conditions? What are the essential motivating conditions for farmers to corporately take over management of irrigation schemes? What kinds of support systems are needed to make locally managed irrigation viable? And, under what circumstances is a management transfer policy appropriate?

This study of the 1969 management transfer in the Columbia River Basin in the United States is an important contribution toward answering questions about what elements are necessary to make a transfer policy successful and sustainable. This case was selected as an example of a situation where a relatively complete set of preconditions existed for the transfer and where a rather successful result occurred. It is one of the few existing studies which examines in detail the management context within which transfer occurred, the process itself, and the impacts on management performance after transfer. The study makes numerous comparisons with situations in developing countries, pointing out both similarities and differences. The authors do not assert that developing countries should simply adopt policies and processes employed in the United States. The comparisons are meant to stimulate reflection about various aspects of management transfer which might need to be more fully dealt with, in locally appropriate ways, in other settings. It is in this sense that the study has particular value, even for policymakers, implementers and observers in quite different contexts. We hope that other case studies will be forthcoming which will, together, provide more comprehensive insights into what conditions are necessary to support viable locally managed irrigation.

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Executive Summary

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 systems. To understand the implications of such a shift on the performance of a system and the conditions under which such transfers can take place successfully, a case study was undertaken to document the causes and results of such a transfer. The Columbia Basin Project (CBP) in Washington State, USA was selected for this study. This selection was based on the facts that the United States has had a policy mandating transfer of managerial responsibility for publicly developed irrigation to users for almost 100 years, that good quality historical records describing system hydrology and financial performance were available, and that transfer in the CBP occurred more than 20 years ago, providing ample time for the post-transfer situation to stabilize and for longer-term problems to emerge.

The CBP is a large multipurpose, reservoir-based project located on the Columbia River near the Canadian border. Construction of the dam was begun in 1933 and water first reached the command area in 1951. The current irrigated area is about 230,000 hectares (ha), while facilities for a roughly equal area included in the original plan have never been constructed. All water used by the irrigation system must be lifted 85 meters, from which point it is distributed to the command area largely by gravity flow.

The national irrigation development agency, the U. S. Bureau of Reclamation (USBR), constructed the project and operated it from 1951 until 1969, when management was turned over to a set of three farmer-controlled irrigation districts. These districts had been established in 1939 while construction was still underway and they had signed repayment contracts with the USBR obligating their members to reimburse the government for part of the cost of building the system. Each district today consists of 2,000 to 2,500 landowners and is controlled by a 5- to 7-person board elected from among them. The districts operate on a nonprofit basis and are required to cover their own operating costs. The districts purchase water from the USBR and then resell it to their members. Payments to the USBR include an energy charge for basic water lifting from the reservoir, but the rate applied is highly subsidized. The USBR continues to operate some common facilities and retains formal ownership of all system facilities, though the right to operate and maintain them, and to collect revenue from the sale of irrigation service, rests with the districts.

The districts require farmers to pay for basic water service in advance of the season or no water is delivered. The districts have the right to foreclose on farm property in the event of unpaid bills and have done this on a number of occasions. Water delivery to farms is on an arranged-demand basis, and deliveries to individual farms are measured volumetrically for accounting and billing purposes.

The negotiations between the USBR and the districts regarding the terms and conditions of the transfer were complex and occurred over the course of several years. Legal council was involved on both sides and political influence was sometimes used by the districts. The results were embodied in a set of three legally binding transfer agreements, which were in essence contracts between each district and the USBR. These agreements remain in force.

In the wake of the transfer in 1969, the USBR levels fell dramatically, and the USBR assumed new roles as a wholesaler of water, an environmental regulator, and a water resource planner and manager. Many of the staff released by the USBR were subsequently reemployed by the districts, providing some operational continuity. However, the managers of the districts were selected from outside this personnel pool.

The study made a concerted effort to document the hydrologic and financial results of the transfer. In general, there appears to have been little or no effect on the quality of irrigation service received by farmers. Service was of high quality before the transfer and it remained so afterwards. However, conveyance efficiency in the main and branch canals of the three districts declined following the transfer and took 5 or 6 years to recover to previous levels. This is interpreted as a learning period, during which the new managers learned to operate the system efficiently. Subsequently, a long steady decline in conveyance efficiency set in which continued to the end of the study period in 1989. This is thought to be partly the result of a failure to keep up with increasing maintenance demands as the system ages. Even though system operation and management (O&M) expenditures held roughly constant, in real terms, before and after the transfer, an increasing number of maintenance problems were observed as time passed, suggesting that maintenance requirements were accelerating. Also greater on-farm irrigation efficiencies achieved by the introduction of sprinkler irrigation, with a limited ability to adjust at the main system level, probably contributed to the decline in conveyance efficiency.

A sharp increase in the amount of water ordered from the USBR (but not delivered to farms) during the last three years of the study period corresponds with the installation of hydropower-generating equipment in larger system canals by the districts. Because power generation is a highly profitable undertaking for the districts, it is quite possible that this is a factor in the additional water ordered from the USBR.

Following the transfer, the districts moved quickly to develop supplementary sources of income and to reduce operating expenses and water charges to the district members. Supplementary income sources included investment income, power-generation revenues, and sales of water to non-district members. On average, water charges following the transfer were only 78 percent of their level during the USBR period, after adjusting for inflation. Real gross returns to irrigated agriculture have risen steadily in the CBP over the past 30 years with some indication that net returns have risen also. This trend appears unrelated to the management transfer. The fall in water-assessment levels as a result of the transfer, however, appears to have increased the net farm income by about 15 percent.

Overall, the transfer of management from the USBR to irrigation districts in the Columbia Basin Project can be considered a success. While the USBR was able to back out of its partly unwanted role in O&M, the districts gained local control over management and costs. This was an extended process, beginning in 1939, 13 years before water began flowing through the irrigation system, and culminating with the signing of the transfer agreements 30 years later. Analysis indicates that the project has not suffered significant negative impacts due to management transfer in the areas of quality of irrigation service to farmers, management efficiency, agricultural productivity, or farm profitability. At the same time, ***the real level of water charges, on both areal and volumetric bases, has fallen substantially.*** The effect of the transfer 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.

A number of lessons relevant to developing-country policymakers and implementers emerge from the analysis. These do not comprise a prescription for change, but are factors which should receive serious consideration in planning programs involving transfer of irrigation management responsibility to farmer-based groups.

- Put in place a clear and consistent policy mandating irrigation management transfer.
- Do not expect full cost recovery (capital and operational costs) in the first instance.
- Mandate financial autonomy for the new managing entity.
- Provide a strong legal basis for irrigators' organizations.
- Provide a system of secure and well-specified, long-term water rights.
- Invest to bring physical facilities up to standard.
- Create a fair and accessible professional auditing system and mandate its use by managing organizations.
- Provide new employment or compensation for displaced irrigation agency staff.
- Involve farmers early on in the planning for the transfer.
- Empower fanners by giving them power and status to successfully negotiate with the public irrigation agency.
- Use contracts between irrigators' groups and the managing agency to specify roles and responsibilities.
- Develop a locally appropriate water allocation system with volumetric measurement and payment at some level.
- Provide expertise or training in organization and management for farmers and farmer leaders.
- Provide assistance to operating agencies to improve management and human-relations skills, to enhance their ability to support farmers' organizations.
- Specify an ongoing role for the operating agency in "partnership culture," with the fanner-based organizations assuming management responsibility.

CHAPTER 1

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 systems. 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 potential outcomes and wider impacts of such transfers, their institutional and financial sustainability, and the actions required of governments 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 and with possible new roles for their irrigation agencies following the change.

Efforts to accomplish this transition are underway in some developing countries. In the Philippines, the establishment of water users' associations and the devolution of irrigation management responsibility and authority to farmers' groups have moved forward deliberately over a period of years with considerable success (Korten and Siy 1989). In the early 1980s, in Chile, ownership of irrigation systems was "privatized" to irrigators' associations and a national water law established saleable water rights (Bertranou and Schulze 1992). Other countries are pushing ahead rapidly with transfer programs, sometimes with little appreciation of the complexities involved and with scant knowledge of the experience generated in other countries grappling with similar issues.

Some turnover programs, such as those in Indonesia, Nepal, Senegal and Bangladesh, focus on transferring management responsibility for small-scale irrigation systems to fanners. Equally common are programs to transfer responsibility for managing tertiary and secondary levels of large-scale systems to farmers, such as those in India, Nepal, the Philippines, China, and Sri Lanka. Other countries, such as Mexico, Colombia and Madagascar, have launched national programs to transfer management responsibility to water users' associations and gradually federate these associations upward—from field channel to distributary and, eventually, to main system levels (Vermillion 1992).

Irrigation management transfer or turnover is related to a broader process of economic liberalization which has become a central feature of the development landscape over the past few years. Although applied in different forms in different countries, economic liberalization is characterized by market-oriented economic policies, realistic exchange rates, liberalization of international trade, a central role for private enterprise in producing goods and services, reduction of subsidies, and transparency in economic policy instruments, i.e., overt rather than hidden subsidization and taxation (Svendsen and Rosegrant 1994). The purpose of these reforms is to reduce the role of the government in the economy and allow the private sector to take over more of the production of goods and services. It is argued that this will lead to greater efficiency, productivity and responsiveness to demand (Roth 1987).

The term privatization is sometimes used to describe the process of distancing productive activities from direct public control. Savas (1987) defines privatization as the act of reducing the role of the government, or increasing the role of the private sector, in the production of goods and services or in the ownership of productive assets. Most of the transfers of management responsibility mentioned above are subsumed by this definition. However, though privatization has often been relatively successful in more developed countries, it does not follow that it will be equally successful in less-developed countries which have not yet fully liberalized their economies nor developed a pool of skilled local institutions in competition with each other (Cook and Kirkpatrick 1988, 28).

This case study was developed and implemented to document the transfer process for irrigation management and its impacts in a setting of strong institutions. 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 precess is available. In addition, a relatively complete set of public and private-sector institutions supporting the management transfer process is present in the United States. This provides a setting in which the transfer process can be carefully documented ex post, and enabling conditions and institutions can be identified.

The Columbia Basin Project (CBP) in Washington State, USA was selected as the case to be studied. The CBP is one of the larger schemes constructed and turned over to farmers in America. Because of the relatively large landholdings in the United States, it was felt desirable to examine the process in a large scheme where a relatively large number of farmers would be involved. Also, since management transfer in the CBP occurred in 1969, sufficient time had elapsed for longer-term impacts to become evident, while the transfer process was still recent enough to be examined through interviews with participants. In addition, relatively good hydrologic and financial data were available for periods preceding and following the transfer, facilitating quantitative analysis of impacts. Although specific conditions may vary from scheme to scheme, the general issues and outcomes identified in the case study are felt to be broadly relevant to conditions in the western U.S.

In discussing the study of the transfer process, Vermillion (1991) poses four bmad 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, and 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 is undertaken to address these general questions where policy, institutional, and physical conditions are expected to have led to a successful outcome. It is intended to document both the transfer process and its *results* and attempts to evaluate both in terms of their relevance to developing-country situations. In the text, passages with special relevance to developing-country situations are indented and italicized. The first three questions listed are addressed most directly, but because the answer to the fourth question requires analysis across case studies, the study adds an important case to the set available for future analysis addressing this question as well.

The study involved four visits to the site by the authors and numerous visits by a graduate student from the Washington State University engaged to help with data collection. Individual and group interviews were conducted with current and retired USBR staff, district managers and staff, farmers, lawyers representing both parties, and university researchers. Extensive use was also made of secondary data and historical records. Much of the insight gained relating to the impacts of the transfer resulted from analysis of extensive time-series data retrieved from the USBR files. A detailed description of the analytic approach employed in analyzing these data is given in Chapter 5. Following the completion of the draft report, a one-day seminar was held with the USBR staff and the three irrigation district managers at the project site to review and interpret the study findings. This seminar provided a number of very valuable insights which were important in preparing the find version of the paper.[1]

The study report begins with a brief overview of the issues involved, lists the questions guiding the study, and provides a general description of the methodology employed. The second chapter describes the features of the project and discusses its history and its physical and social environment. The third chapter reviews the two main institutions involved in the transfer—the USBR and the three irrigation districts—and their relationship with each other. The fourth chapter describes the transfer process and the management changes which resulted from it. The fifth chapter comprises the main analytic exercise of the study and assesses the results of the transfer in terms of changes in technology, quality of irrigation service, hydrologic efficiency, financial viability, profitability, and quality of maintenance. It contains an initial subsection detailing the methodology used in the analysis. The final chapter summarizes the results of the analysis and examines the factors enabling and facilitating successful transfer. It concludes with a discussion of lessons learned for implementing such policies in developing countries.

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1 A telephone survey of a sample of farmers in one district in the scheme is currently king developed The survey is intended to provide additional information on farmers' water management practices and their evaluation of the irrigation service they receive. Results will be reported separately at a later date.

CHAPTER 2

Columbia Basin Irrigation Project

EARLY HISTORY OF IRRIGATION IN THE BASIN'

EFFORTS AT DEVELOPING irrigated agriculture in the Columbia Basin of Washington State go back to the previous century. In 1898, the Great Northern Railway, in collaboration with a local company, began to develop a small irrigation scheme near Ephrata, Washington, the current headquarters of the Columbia Basin Project **(CBP)**. The venture failed before completing the project, as did a successor company which took over construction. A third undertaking did finally complete the scheme in 1912, briefly bringing 1,200 acres (500 ha) of land under irrigation before failing six years later.

Numerous other attempts at irrigation development were made by companies, private individuals, and cooperatives in the early years of this century. These efforts employed technologies ranging from gravity diversions to pumps powered by gasoline engines, coal-fired steam plants, and even windmills. Many of these schemes set out to produce tree fruit, and most failed within a few years, victims of high pumping costs and fluctuating commodity prices, and sometimes outright chicanery?

As experience with these early, largely unsuccessful experiments with private development began to accumulate, the public sector became more directly involved.[4] Following an investigation, the Reclamation Service' reported in 1903 that 1.5 to 2 million acres (600,000 to 800,000 ha) of land in the region could be brought under irrigation (Warne 1973). In 1907, the Quincy Valley Water Users' Association[6] was formed to attempt to involve the government in the irrigation development process. The association financed a feasibility study by a private consulting engineer which was promising enough to induce the establishment of the Quincy Valley Irrigation District in 1910. The new district proposed that the state of Washington be bonded for US$40 million to irrigate 400,000 to 500,000 acres (160,000 to 200,000 ha) in the Quincy Valley, a proposition the state's voters rejected in a referendum.

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

3 One elaborate scheme initiated in 1909 was secured by mortgages taken out by homesteaders on their land. The scheme went bankrupt in 1912. More than a million dollars and one of the promoters disappeared, and the body of the other was pulled from the Columbia River near the site of the pumphouse.

4 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.

5 The United States Reclamation Service, forerunner to the Bureau of Reclamation. was *established in 1902*.

6 The (mw) Quincy Irrigation District is om of three now operating in the Columbia Basin Project.

The idea for a dam on the Columbia at the Grand Coulee[7] was first formally explored by Grant County, Washington in 1917-18. A deputy county engineer found a dam and irrigation scheme feasible but at a cost which would far exceed the means of the county. In 1919, the Washington State Legislature created the Columbia Basin Commission and appropriated US$100,000 to be used in studying this plan and a rival one calling for gravity flow diversion of water to the area from the Pend Oreille Lake in Idaho. The results of this study and subsequent ones were contradictory and inconclusive. In 1926, the United States Congress appropriated US$600,000 for a new study, this one to be undertaken by the U. S. Army Corps of Engineers. This study was completed in 1931 and recommended a dam on the Columbia and the large-scale lifting of water for irrigation in the Columbia Basin. Rejected by President Hoover in 1932, the project was 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.

PROJECT CONSTRUCTION

The centerpiece of the CBP is the Grand Coulee Dam. When constructed it was the largest concrete structure in the world, reaching 550 feet (191 meters [m]) from bedrock to crest and stretching just a few feet short of a mile across. The dam 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.

With the outbreak of World War II, power generation received first priority in the ongoing construction work, and the construction of the irrigation components of the project was temporarily suspended. The 18 main 108,000 kilowatt generators called for in the original design were commissioned between 1941 and 1951. Construction work on the irrigation portion of the project resumed in 1947 following the war, and in 1951, the first test water flowed toward the 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 ha) per year, reaching a total of 448,000 acres (181,000 ha) in 1967 (Figure 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 being paid for by power revenues, with interest, while 12 percent is being repaid by irrigation fees, without interest.

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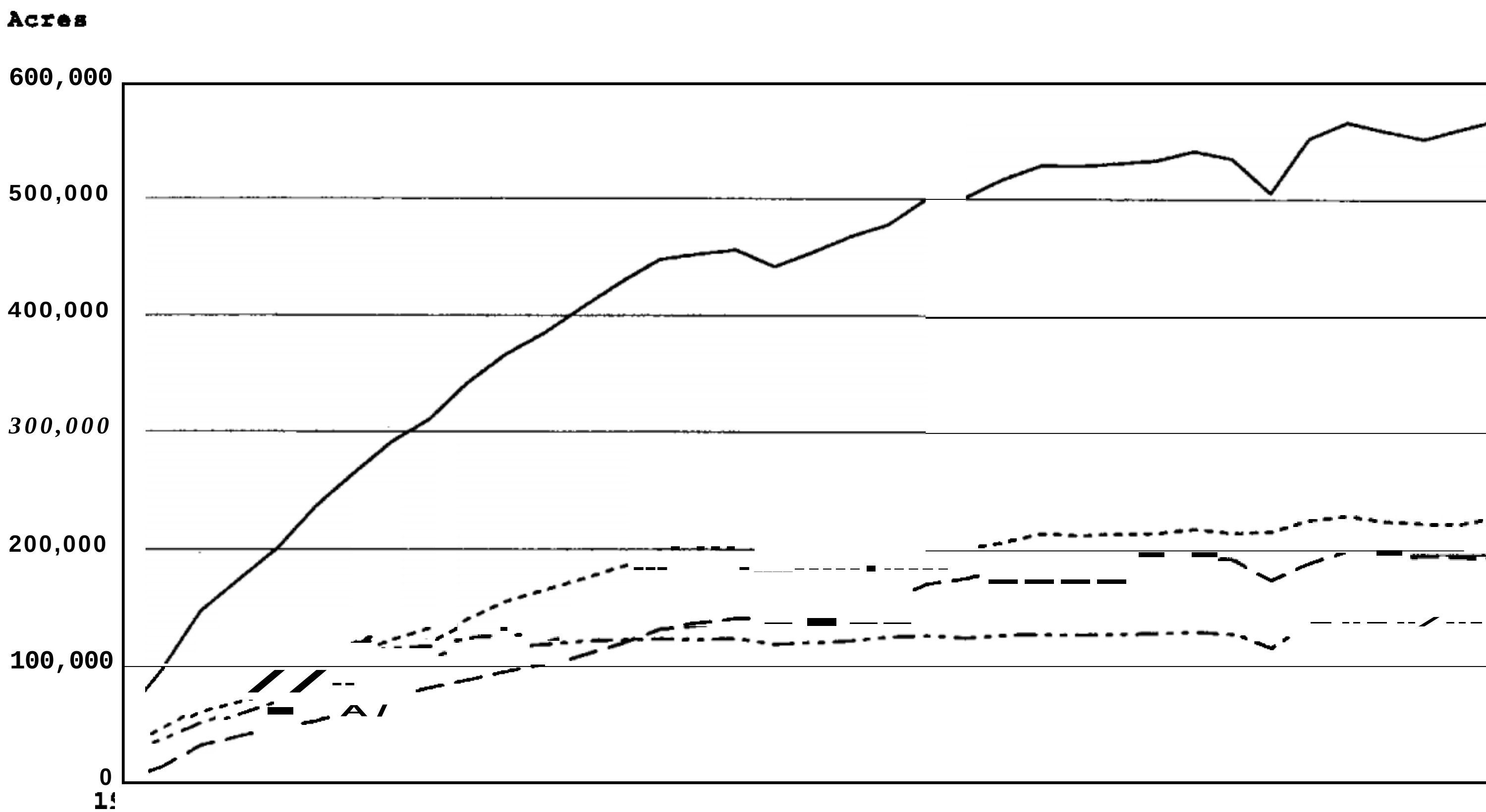
7 A coulee is a deep ravine or valley, and the Grand Coulee is an extremely long and deep coulee formed by waters of the Columbia during the ice age when an ice dam blocked the present course of the river.

Figure 1. Area *irrigated (acres), the CBP, 1953-89.*

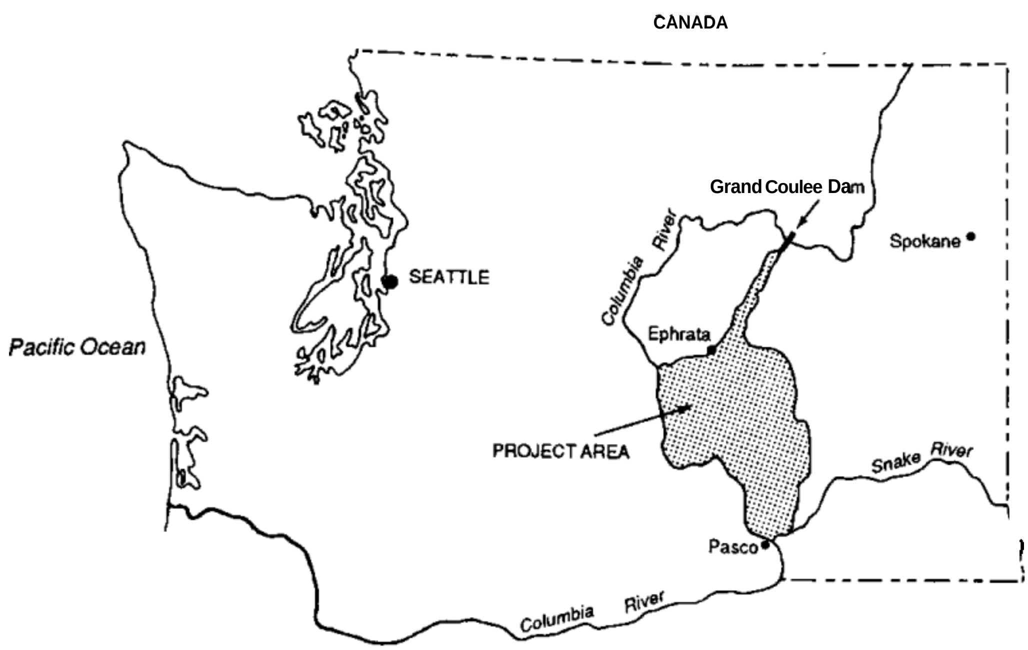


Source: Water Distribution Reports for the CBP. U.S. Bureau of Reclamation

The project was originally designed to serve 1,095,000 acres (443,000 ha) within the "Big Bend" of the Columbia (Map 1). However, the higher and more rolling lands on the eastern side of the proposed project area benefited from a somewhat higher rainfall than other parts of the project area and settlers there were successfully engaged in raising extensive tracts of wheat following the war. They objected to the small size of the farms they would be able to retain once the land was irrigated, as stipulated in the project legislation. About three-quarters of the wheatlands in the East Irrigation District was withheld by the owners before construction began (Warne **1973).** Consequently, the East High Canal, which was to serve this area, was never built.

> *It is imporrant to note that farmers here had the collective oprion to refuse the project. This is unlike the situation in many developing countries, where settlement and irrigation projects are **often** idenrijied and implemented without seeking prior farmer agreemenr or requiring* any *repayment. The requiremenr of a formal agreement no doubt helped engender a sense of commitment* ro *the project among farmers who did finally accept the terms of construction and transfer.*

Map 1. Location map: The Columbia Basin Project.



POWER GENERATION

When the last of the 18 main generators in the left and right powerhouses at the Grand Coulee went into service in **1951,** it was the largest hydroelectric facility in the western hemisphere (USDI **1978).** In **1975,** a third powerhouse was dedicated and, when it became fully operational in the early eighties, the installed capacity of the Grand Coulee power complex stood at an awesome 6,494 megawatts. Current operating rules call for the use of the Grand Coulee to provide peaking power to meet morning and evening periods of maximum demand. In a typical year. the power complex at the dam produces about 20 billion kilowatt-hours of electricity, which is marketed and distributed by the Bonneville Power Administration, a separate public agency. Power generation provides by far the largest share of the economic benefits resulting from the project.

Water allocated to irrigation does not contribute to this power generation as it is withdrawn from the reservoir and lifted 280 feet (85 m) to the top of the escarpment bordering the reservoir without passing through the turbines to the river below. This means that there is little direct competition between the timing of releases for power generation and for irrigation demands, as the two operate largely independently. Some of the potential energy contained in the lifted irrigation water is recovered subsequently through smaller generation facilities located within the project area. On a daily basis, the presence of a reregulating reservoir downstream of the pumps allows pumping to be timed so as not to coincide with peak power demand elsewhere in the grid. Seasonally, the greatest power demand is experienced in winter (December to March) when no irrigation is being practiced. We will see below that the hydroelectric component has been an important asset to the financial viability of the CBP, especially since it does not significantly compete with irrigation water supply.

PROJECT 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 (Map 1). The city of Spokane lies 120 miles (195 km) to the northeast and Seattle 160 miles (260 km) to the west. The area is well-served by road and rail systems. The elevation of the command area varies from 1,400 feet (430 m) in the upper end of the scheme to about 500 feet (150 m) in the lower end. The service area begins 45 miles (75 km) south and slightly west of the Grand Coulee Dam, spanning about 80 miles (130 km) in a north/south direction and roughly 50 miles (80 km) east to west (Map 2). About half of this area is classed as irrigable, the remainder being rough and unsuitable for imgation. Irrigated areas are thus separated by uncultivated lands and spread out over a large area. A number of small towns exist within the boundaries of the project, many of which have grown considerably since the creation of the system. Three larger cities, Pasco, Richland, and Kennewick, are located at the extreme southern end of the command, near the confluence of the Columbia and Snake rivers.

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 °F, (30.2 °C) and an average minimum temperature of 52.6 °F, (11.4 °C), while the coldest month, December, has an average daily minimum temperature of 23.6 °F (-4.7 °C) and a maximum of 37.6 °F (3.1 °C). Average monthly maximum and minimum temperatures are shown in Table 1.

Map 2. The Columbia Basin Project.

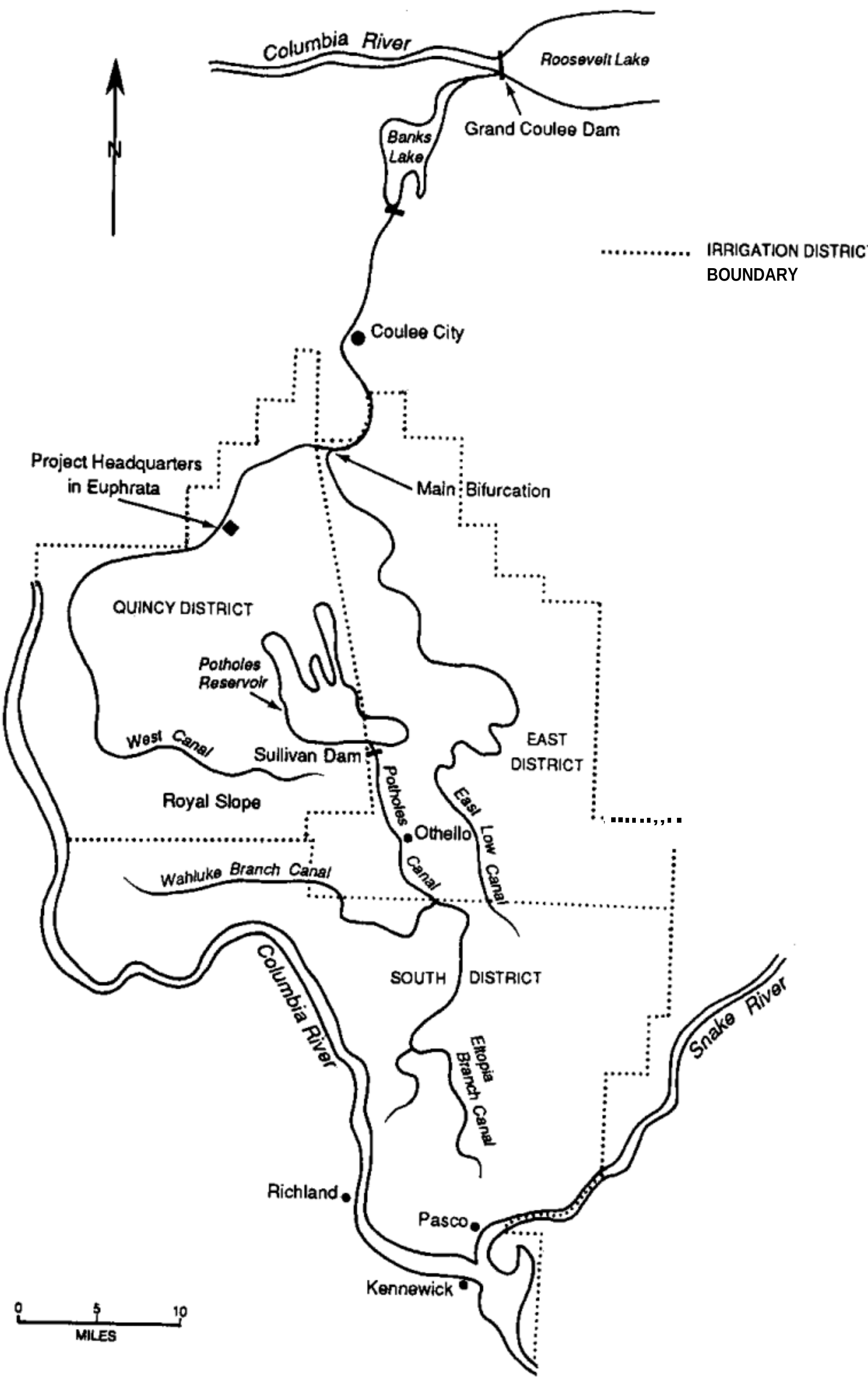


Table I. Average monthly remperatures, rainfall and potential evapotranspiration raresfor rhe CBP.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	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	42.46
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 USBR at the O'Sullivan Dam (the Potholes Reservoir) located in the center of the project area.**

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

Located in the rain shadow of the Cascade Mountains, precipitation ranges from **6** inches (150 millimeters [mm]) in the southwestern part of the service area to around 10 inches **(250 mm)** in the northeastern highlands. Average monthly precipitation data for the center of the command area are shown in Table **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** mm) 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 peak.

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

Relief

As noted above, the project area drops **900** feet **(275** m) from the upper end to the lower, a fall of about **11** feet per mile **(2.1** m per km), 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 allowed the easy inclusion of free-flowing water measurement structures in the design, **as** the head loss they cause did not create design difficulties. Second, it provides ample opportunity for reusing drainage water. In fact, the southernmost district of the three making up the system is supplied largely by recaptured drainage water from the two higher 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.

Soils

Soil composition in the basin varies widely from deep, fine. windblown materials with moderately low clay content to shallow, sandy wind-deposited soils. Long periods of semiaridity resulted in the formation of a very hard calcium carbonate-sulfate caliche deposit in most subsoils. These are usually covered by 18 inches to 15 feet of fertile soil. These soils are generally easily worked and low in alkali and other injurious chemicals (USDI 1978).

Soils in the project area were categorized as irrigable and nonirrigable during the project planningphase. Theirrigablesoils were thendivided into four classes depending on their suitability for agricultural production. Class 1 land is smooth, gently sloping, deep, and fertile, adaptable to a wide range of crops and free of alkali and rocks. Class 2 is average land, good for farming, but not as good as Class 1. Class 3 includes land which can be farmed under irrigation, but is limited in the kind of crops it would grow and is expected to give poorer yields than the other lands. Class 4, because of its rolling topography and low water-holding capacity, is suitable only for sprinkler irrigation.

The distribution of land in various classes across the three districts is shown in Table 2. The East District has the largest share of its land in the preferred classes 1 and 2 (69%), followed by the Quincy District at 59 percent, and the South District at 49 percent. Less than 7 percent of project land is in Class 4, suitable only for sprinkler irrigation, most of which is in the South District where it makes up about 10 percent of the irrigated area.

Table 2. Irrigated land classes in the CBP (land area given in acres).

	Class 1	%	Class 2	%	Class 3	%	Class 4	%	Total
South District	20,860	10.4	77,347	38.5	82,233	41.0	20,340	10.1	200,780
East District	34,541	25.6	58,419	43.2	37,052	27.4	5,141	3.8	135,153
Quincy District	49,759	22.5	80,625	36.4	78,534	35.4	12,853	5.8	221,771
Project	105,160	18.9	216,391	38.8	197,819	35.5	38,334	6.9	557,704

Source: U.S. Bureau of Reclamation data.

Rural Infrastructure

Prior to the first irrigation delivery, there was a coordinated and rapid development of hard-surfaced roads, electricity, telephones, and schools throughout the project area. Electricity remains relatively inexpensive (about 17 mills[8] per KWH). The project is served by an excellent road network and numerous truck lines, railways, and airlines. Farm products can also be loaded directly onto ocean-going barges on the Columbia River in Pasco, at the southern end of the project area. The availability of hydroelectric power from the Grand Coulee facilitated rapid industrialization and population growth in the Northwest Region, and an expanding regional food market. Several thousand people are employed today in agricultural processing plants within the contiguous area of the CBP.

8 A mill is equal to one-tenth of a U. S. cent, or one-thousandth of a dollar.

IRRIGATION WATER SUPPLY, DELIVERY AND APPLICATION

Project Water Right and Withdrawals

The granting of water rights in the United States is a state responsibility. Under Washington state law, once a withdrawal permit is granted, individuals have **3** years, and the Federal Government has 10 years, to put the water to beneficial use. Extensions to this period can be granted. When the project is developed, a certificate is issued specifying three characteristics of the right. These are ***the rate at which water can be withdrawn, the total volume of water which can be withdrawn in a given year,*** and ***the area of land which can be supplied from the right.*** Permits and certificates conferring rights for the CBP are issued by the Washington State Department of Ecology and are held by the USBR.

The original permit granted for the CBP in **1938** was for **13,450** cfs with an annual withdrawal volume of **2.910** million acre-feet to irrigate 590,000 acres. **A** certificate for this right was issued to the USBR in December **1988. A** small additional right for withdrawal of **1,140** cfs and a maximum annual withdrawal of 214,000 acre-feet to irrigate **50,000** acres was certified in **1991** for a newly developed portion of the scheme?

Since **1985** when imgated ***area*** stabilized at around 560,000 acres (227,000 ha), 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 and require about **4** percent of the dam's annual power production.

Water rights are extended to the irrigation districts through repayment contracts between the USBR and the districts. Fanners 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.

Project water rights are translated into "basic water allotments" at the farm level, specified as volume of water per unit area. The size of this basic water allotment depends on the land classification category as described under "Soils" above. Class 1 land (the best) is allowed **3** acre-feet per acre per year, Class **2** land, **3.5** acre-feet per acre, and Class **3** land, **4** acre-feet per acre. Farmers may order an extra 0.5 acre-feet per acre "supplemental allotment," if they wish, at the same unit charge as the basic allotment. At a higher charge, fanners may order "excess water" deliveries over their base and supplemental allotments. Fanners with holdings in different crops or land in different locations often combine their basic water allotments and reallocate the aggregate basic allotment flexibly on their various fields. Only the basic charge applies to all water used as long as the total used does not exceed the farmer's aggregate basic allotment. Hence, water allotments are transferable among fields within the farm of a single owner, even if the fields are not contiguous, hut not among farms and different owners.

System 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. Water management practices are described in a subsequent section.

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9 Rights granted are far "'beneficial use" and the certificate stipulates that the state may refuse to allow the appropriator to use water where "willful neglect to use water in an efficient manner" is demonstrated. In practice, this provision is difficult to apply.

The **supply system** comprises the Grand Coulee Dam and the FDR Lake behind it (Map 2 [p.10]). The lake stores some 9.562 million acre-feet (11.790 billion cubic meters) of water, with 5.232 million acre-feet (6.451 billion cubic meters) of this stored water available for use. The dam is operated by the USBR.

Twelve large pumps lift water 280 feet (85 m) to the top of the escarpment bordering the river channel. Six of these were included in the original design and are rated at 65,000 horsepower and lift 1,600 cubic feet of water per second (cfs). The remaining six are pumpback units which, rated at 67,500 horsepower and 1,750 cfs, were added at the time of the construction of the third power plant in the 1970s. They can function either as pumps or, if water is allowed to flow hack down through them from above, as generators supplying power to the Northwest Power Pool. The intention was to use them to lift water into an upper reservoir during periods of low power demand and then to generate power with that same water during peak demand periods. Today, because the entire Grand Coulee complex is used as a peaking facility, the pumpback units are typically used only as pumps. Pumps are operated in various combinations depending on head conditions, relative efficiencies, and maintenance schedules.[10]

The **conveyance and delivery** system comprises a number of components. Water lifted by the pumps empties into a short (1.6 mile) feeder canal which supplies a second reservoir (the Banks Lake), formed by damming both ends of the Grand Coulee. The Banks Lake has a storage capacity that is small relative to that of the FDR Lake, but at 1.3 million acre-feet (1.6 billion cubic meters) total storage, and 0.715 million acre-feet (0.9 billion cubic meters) active storage. it is still significant. It serves as an equalizing reservoir, allowing the main pumps to operate whenever the system power demand is lowest while permitting continuous operation of the irrigation system beyond.

Various civil works, including a major two-bore syphon and tunnel. then lead water some 21 miles to a bifurcation point where the main canal divides into the 88-mile long West Canal, serving the Quincy Irrigation District, and the 87-mile East Low Canal, which serves principally the East Irrigation District. About 34 miles of each canal are lined with either concrete or clay. Along the main canal, water drops 165 feet, at one point, into a small lake that forms a part of the main conveyancesystem. Originally, water was allowedto fall from this heightovera basalt cliff. Today, this energy is recaptured as hydroelectric power in a 92-megawatt facility developed jointly by the irrigation districts in 1985. With the exception of this generating facility, the system to this point is operated by the USBR. Below the bifurcation, the respective irrigation districts assume responsibility. The districts handle both distribution of water to individual farmers from their primary canals and a network of branch canals and laterals totaling 2,026 miles (3,268 km) in length, across all three districts.

Located in the center of the project area is a 511.700 acre-foot reservoir[11] formed by a 3.5-mile long earthfill dam. This dam captures some natural drainage, but its principal source of water is return flow and drainage water from the surrounding irrigated area, which comprise most of the annual withdrawals from the reservoir. "Natural" inflows can also be supplemented by direct diversions of project water from the East Low Canal if needed. The third district in the CBP, the South Irrigation District, receives its water supply from this reservoir.

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10 The six original pumps are coupled directly, in pairs, to singlegenerators in the left powerplant. The six newerpumpback units come off of the line at the Grand Coulee substation and, in effect. are powered by the entire grid.

11 Active storage is 332,200 acre-fret (409.8 million cubic meters).

In addition to gravity distribution from the Banks Lake, some project water is relifted once or even twice to reach higher-lying lands. For this purpose, the districts operate 240 pumping plants across the project.

Water is measuredextensively throughout the project area. Measurementtakesplaceat all major inflow and bifurcation points, at major wasteways. and at all 7.000 turnouts in the project area. Structures used for making measurements range from rated sections of larger canals to v-notch weirs and double-gated turnouts at the farm level.

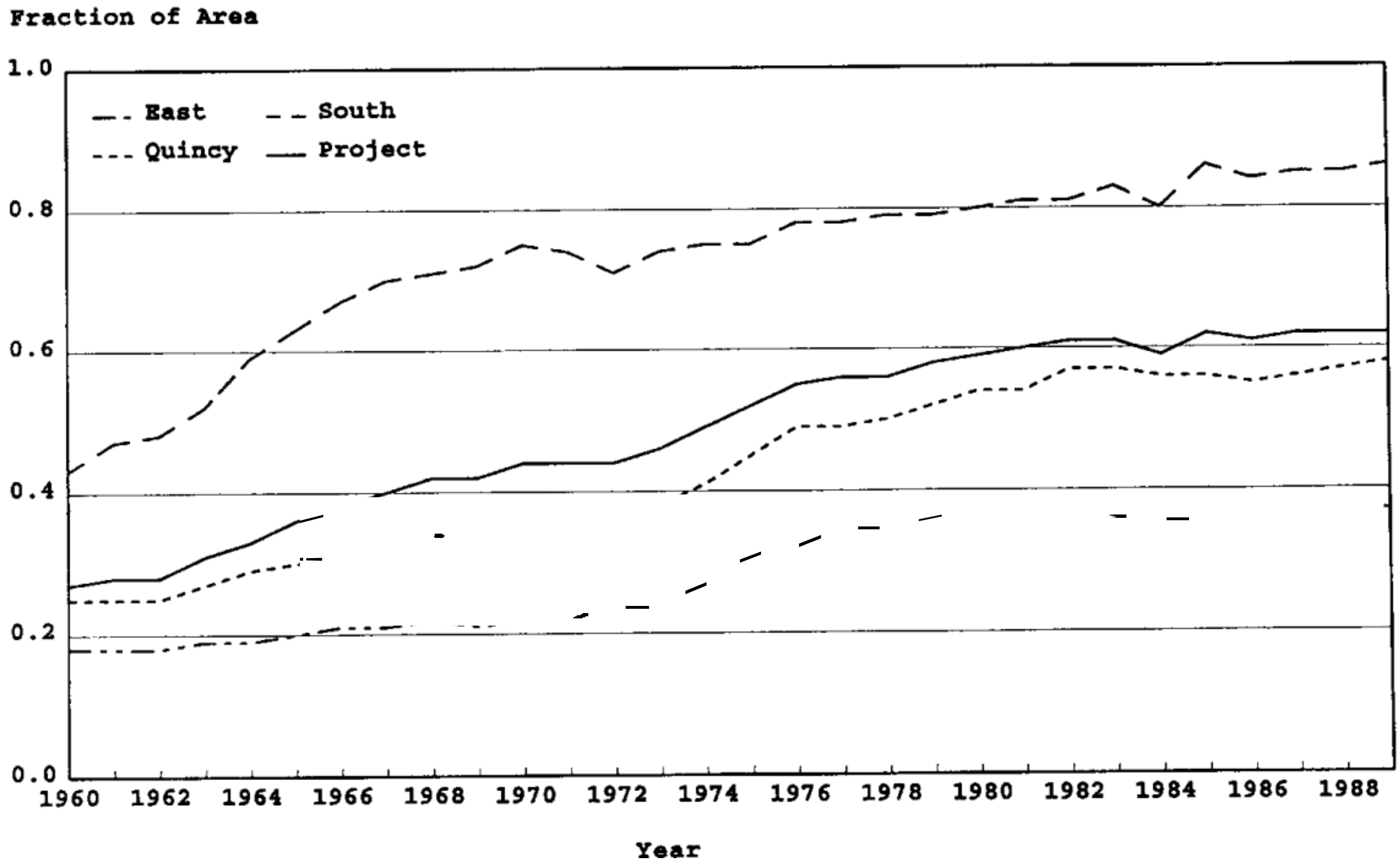
> ***The ability to measure and record water flows ar such a large number of points is a significant feature of the water allocation and charging system employed in the CBP. However, it is not a generic requirement for effecrive fanner management, as many thousands of indigenous farmer-managed systems in Asia will attest. The general inability to measure volumetric deliveries to farmers in developing countries does make a demand system of water delivery, coupled with quasi-volumetric pricing at the level of the individual farm, difficult to implement. Modifications to this allocational system to apply to groups of users would usually be necessary.***

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. When the project first began operation, most water application was done using furrows or corrugations or simply by wild flooding. 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. Growth in sprinkler irrigation over this 30-year period has been continuous but more rapid at some times than at others (Figure 2). In particular, the period between 1972 and 1977 was one of especially rapid growth, with sprinkler irrigated area expanding at a compound annual rate of 7.1 percent. Since 1977, however, sprinkler irrigated area has grown at only 1.5 percent per year. The overall rate of growth for the 30-year period was 5.6 percent.

In recent years, farmers have shown a strong preference for center pivot systems, locally called "circles," over other types of moveable sprinkler systems. Earlier, wheel roll systems were far more common than they are now. According to one irrigation equipment dealer in Othello, headquarters of the East Irrigation District, his dealership now installs 60 to 70 new center pivot systems for every wheel system sold. According to a senior USBR engineer, new wheel roll systems are purchased mainly to replace existing ones, but not to irrigate new land. Most new center pivots are designed to operate in a quarter-section of land, 160 acres (65 ha), though the circle they inscribe covers only about 137 acres. Their attractiveness is largely due to their lower labor costs. Orchards are mainly irrigated with solid set systems.

Surface irrigation remains the primary method of irrigating some crops, such as corn. It was also used to irrigate sugar beets, though this crop has now disappeared from the basin. Most surface irrigation relies on syphon tubes to bring water out of a channel and onto the field, where it flows into furrows or corrugations. Gated pipe is also used for the same purpose and there is some cablegation—an automated system for opening and closing the openings in a distribution pipe. Flood irrigation is uncommon today, even on pasture (Jensen 1991).

Figure 2. *Growth of sprinkler irrigation, the CBP, 1960-89.*



As Figure 2 shows, there are sharp differences in the adoption of sprinkler application technology among the three districts. The South District was the earliest to employ sprinklers extensively and, today, it is nearly completely sprinkler irrigated. This can be accounted for by the rougher terrain found there and its light, extremely erosive soils.[12] The slowest adoption of sprinklers has been in the East District. The slopes there are flatter and soils heavier, making furrow irrigation more feasible. In addition, the variety of crops grown is more limited, with fewer orchard, vineyard, and seed crops. This may, in part, be a result of the limited area under sprinkler irrigation as well as a cause for continued reliance on surface irrigation techniques.

The Quincy District is intermediate in sprinkler adoption. Sprinkler irrigated area in the district which was around 23 percent in 1959, has grown to around 63 percent in 1989. Initial growth in Quincy was much slower than in the South District, but since 1972, it has accelerated and continues to grow rapidly. Sprinklers here are said to be particularly concentrated in the Royal Slope area in the southern part of the district where soils are lighter and slopes steeper.

The project also contains 1,221 miles (1,965 km) of open drains and several thousand miles of buried pipe drains, with additional tile drainage being installed each year by the USBR. Although internal soil drainage is generally good, intensive irrigation has caused waterlogging problems in some areas. As of September 1991, 115,970 acres of project land were drained, about three-quarters of the estimated 153,140 acres requiring artificial drainage.

Water Management Procedures

The basic water management procedures used by the USBR have, with some adjustments, been continued by the districts after management transfer. The scheduling process used in the project is referred to by engineers interviewed as a "modified demand system."[13] 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. Fanners 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. Excess water orders are limited by the system conveyance capacity and by drainage capacity. If the use of excessive amounts of water causes drainage problems for field neighbors, the district may restrict the quantity of excess water a farmer may order.

To order water, a fanner leaves a four-by-five inch water request card at his turnout (often kept in a lidded fruit jar). This has information on the delivery rate, start time, and duration of the water order. The card must be posted at the turnout by the time the ditchrider normally passes by or else the farmer must telephone the watermaster's office with an order by 3:00 P.M., in order to have an order filled the next day. If the order is called in by telephone, the fanner is expected to submit a signed card the following day. The cards are used for scheduling water deliveries and for billing.

Ditchriders report all orders to the watermaster by 4:00 P.M. each day and the watermaster "calls in" with the orders to the district office immediately thereafter. By 4:30 P.M. the district office calls the USBR 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 by a "Supervisory Control and Data Acquisition" system, which is a computer-centered system

12 A break in a lateral on a hillside there can quickly erode a gully 15 to 20 feet deep. The soil's consistency is that of sugar, in the words of one farmer.

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

involving automatic stage recorders, radio telemetry and remote gate-control devices. The morning following receipt of new delivery orders, ditchriders adjust lateral gates and turnouts to make their deliveries. There are roughly 100 to 120 farm turnouts per ditchrider, which must be inspected daily, and 5 to 10 ditchriders 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 ha) in extent.

Maintenance work is now planned and executed by the districts and reported to the USBR. Although general maintenance schedules are available, detailed O&M manuals are not used by the USBR or the districts. It is felt by both the USBR and the district engineers interviewed that manuals were largely unnecessary, because "too many problems are unique" and because the level of skills and experience of the operations staff make them unnecessary. Field operational activities are fast-paced, and district managers argue that ditchriders simply do not have time to consult operations manuals. New staff are trained on an apprenticeship basis working with senior watermasters and ditchriders.

> ***This may seem somewhat ironic to engineers in developing countries who often face donors who require the production of O&M manuals for most large-scale projects. Such manuals are often little used after they are produced. The experience of the CBP suggests that perhaps more emphasis should be placed on skill development and in-the-field training than on manual development.***

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 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.

The modified demand system used by irrigation districts in the CBP has three key aspects which work together to provide effective management control. First, water rights are defined volumetrically. Second, water delivery is measured down to the user level. Third, basic water allocations to the user must be paid in advance of deliveries. If payment is not made, water delivery can be, and is, prevented.

These three conditions normally do not exist in developing countries and are difficult to implement because of the small holding sizes and the high resulting transaction costs. In some places in developing countries however, such as in the Kakrapar Left Bank Canal, Gujarat, India, water can be measured and sold volumetrically at a canal or group level (Datye and Patil 1987).

PROJECT SOCIAL ENVIRONMENT

Settlement Patterns and Policies

In the 1920s, just prior to the 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 farmland was used for dryland wheat production. Severe droughts and economic depression prior to the project often left large tracts of farmland fallow, and, after several years, such land reverted to sagebrush.

As construction of the Grand Coulee Dam began in 1933, numerous studies, termed "Joint Investigations," were conducted which led to the enactment of land tenure laws and regulations aimed at providing opportunities "for the maximum number of small farms to support families'' (Warne 1973, 135). Reflecting this social welfare policy concern, the Anti-Speculation Act of 1937 was passed to limit farm sizes to 40 acres (16.1 ha). However, this provision was supplanted hy the Columbia Basin Act of 1943 which permitted “farm units” to vary from 10 to 160 acres (4.0 to 64.7 ha), depending on land quality and topography. The sizes were based on an estimation of the landholding’s potential to provide a “suitable level of living” for an “average family” of two parents and two children. The law required all land to he appraised at dryland value. ***Landowners having more than the amount permitted were required to sell their “excess” land at the dryland rate before any water could be delivered to them*** to prevent windfall profits from accruing to existing landowners (Doka 1979, 74-75).

> ***The original goals of the CBP were similar to those of many settlement and irrigation projects in developing countries—to provide a modest livelihood to a large number of small farmers. Restrictions which attempt to prevent the value of irrigation works developed largely at public expense from being capitalized into land values for the favored, should generally be a standard part of new project development plans. However, they have proved difficult to enforce, both in developing countries and in the United States, and in the CBP they proved only partially erective.***

Subsequently, the settlement goals of the project shifted toward providing fewer hut more productive farms and offering settlement opportunities for veterans after World War II. Preferences for veterans expired in 1960. New settlers in the project area bought approximately 90 percent of their irrigable land from existing private owners and the rest from the Federal Government (Doka 1979, 106). By the 1960s, the rising pressures from farmers seeking greater economic opportunity, commercialization of farms, and the increasing use of labor-saving technologies created pressures to increase again the allowable size of farms (Warne 1973). In 1962, Congress revised the 1943 Act to allow a husband and wife to own 320 acres (129.5 ha) of land, while allowing an individual owner a 160-acre (64.7-ha) farm.

In contrast to the Anti-Speculation Act of 1937, the Acts of 1943 and 1962 emerged out of an interest in profitability for the farmer. Following the passage of the 1962 Act, the price of irrigated land increased markedly. From a base of 100 in the 1958-62 period, land values jumped to an index value of 156 in the period 1963-65 (Warne 1973,133). Through this period, politicians were quite responsive to pressures from the farmers and the districts actively lobbied for this and other causes.

The Reclamation Reform Act of 1982 again raised the allowable irrigated farm size. It allowed a husband and wife or a corporation with less than 25 shareholders to receive subsidized irrigation water for a farm of up to 960 acres (388.5 ha) of Class 1 land, or its productive equivalent on lower class land. According to USBR sources, only 2 percent of the farmers exceeds this limitation and pays the unsubsidized rate, though these 2 percent controls 7 percent of the land in the project. Farmers complain however, about the heavy burden of paperwork required by the new act for all farmers operating units larger than 40 acres. The act gives the USBR the right to refuse water to farmers not complying with its reporting requirements. Farmers indicate, however, that the system is ineffective in enforcing the new regulations.

The effect of the policy changes has been to revise the equity orientation of the project, which intended to provide an “adequate living” to a maximum number of small farmers, to one of providing greater economic opportunity to a smaller number of larger-scale farmers. This shift is both the result of political pressures exerted by farmers and the economic specialization which occurred after World War II (Warne 1973, 136).

In contrast to the situation, common in developing countries, of increasingly fragmented landholdings, farm sizes in the Columbia Basin have increased over time. In 1948, 80 new farm units were created from 5,790 acres, for an average of 72.4 acres (29.3 ha) per farm. Twenty-eight years later, in 1976, 79 new farm units were created from 11,065 acres, for an average of 140.1

acres (56.7 ha) per farm (Doka 1979, 100). In 1958, 50 percent of the total irrigable acreage (74 percent of the farms) of the CBP was in farm units less than 160 acres in size. In 1973, only 24 percent of the total irrigable area (52 percent of the farms) was in farm units in this category, the remainder being larger (Doka 1979, 104).

In addition, the number of farm units worked by a single operator has increased steadily over time. USBR data show that, in 1960, the average full-time operator worked 2.26 farm units, while by 1989, the average had increased by a quarter to 2.89 units. Average farm sizes today are in the range of 160 to 240 acres (64.7 to 97 ha). Owners operate roughly 60 percent of farm units while renters operate 40 percent. At the same time, there has been a sharp increase in the number of landowners in the 160-acre-or-less class. Most of these landowners have holdings of one acre or less, which suggests that growth in this category is a result of subdivision for residential and other nonagricultural purposes.

Several factors are responsible for the growth in unit sizes of working farms. Expanding off-farm employment opportunities have drawn some families out of agriculture altogether, making farms available for sale to other farmers. In addition, agricultural mechanization, scale requirements of economic viability, relaxed legal restrictions on farm size, and the extension of the project into less-favorable land which required larger holdings to be economically viable have all played a role. Farmers have also expanded farm units beyond legal limits, using various means to consolidate farms and distribute ownership to avoid land-ceiling restrictions.

As a result of the expansion in farm sizes, population density in the irrigated area of the project in the 1970s, at 152 persons per 1,000 acres, was less than half of pre-project projections of 350 to 400 per 1,000 acres. In 1952, the on-farm population was only 1,060. By 1960, it had grown to 8,414, after which it peaked at 12,066 in 1970 and declined slightly during the 1970s.

According to USBR data, there were 7,928 landholders registered in the three irrigation districts of the project in 1990 1.979 in the East District, 2,548 in the Quincy District, and 3,401 in the South District. Of all landholders, 70 percent has less than 160 acres of irrigated land in the project. Only 7 percent has 640 acres or more. Not all of these landholders are farmers, however. Although accurate records are lacking, local informants estimate that there are roughly 2,500 farmers on the project today.

> ***Study informants reported that there are numerous cases where fanners exceed farm-size limits by various means such as registering holdings in the names of relatives. This makes it difficult to specify exactly what the land tenure distribution is and how many farmers there are in the area. Such regulatory weaknesses are clearly not limited to developing countries.***

Characteristics of Settlers

According to a study conducted in 1956, early in the settlement process, the "average" Columbia Basin farmer was about 40 years old and married, with two or three children. The man and wife had an average of 12.3 years of schooling, compared with the national average of the time for farmers of 8.6 years. About half were military veterans. Twenty-five percent of the farmers had attended college. About 20 percent had been in farm training programs. Ninety-four percent of the men and 60 percent of the women were raised on farms, and only 1 percent had no prior farm experience. The proportion of highly skilled farmers, i.e., those with postgraduate, professional or managerial training, was well above the national average for farmers (USBR 1978, 32-33). Settlers arrived in the project with average assets of about US$24,000 (Warne 1973, 134). In short, settlers in the Columbia Basin Project were 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 1930's conception of masses of poor "buckboard pioneers" who would rush in to settle in 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,[14] church groups, 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 and weed control. This provided a solid base of experience in the community for the subsequent organization and operation of irrigation districts.

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 3). These crop groups include potatoes, vegetables (for processing and fresh market sales), hay and silage, and grains (wheat, barley, cereals and feedgrain).

From 1955-89, hay, forage crops and feedgrain represented 30-45 percent of the total irrigated area, but usually produced less than 30 percent of the total gross returns. Vegetable production was more important in the late 1950s, covering 25 percent of the total irrigated area and generating more than 25 percent of the total returns to crop production. Following a sharp decline in both area planted and the total returns during the late 1970s, vegetable crops again increased to 15 percent of the total irrigated cropland by 1989 and to approximately 17 percent of the total crop returns.

Potatoes have consistently covered 7 percent to 9 percent of the irrigated area in the Columbia Basin, yet have generated at least 20 percent of the total value of all crops produced. On the other hand, wheat, barley and small grain production averaged 15-20 percent of the irrigated area over the study period, producing highly variable returns ranging from 5 percent (late 1960s) to 20 percent (late 1970s).

Until 1975, sugar beet was a major commodity for Columbia Basin fanners, covering as much as 12 percent of the irrigated area and often producing more than 15 percent of the total returns. However, following a decline in sugar beet prices in the mid-1970s and the closing of the Utah and Idaho sugar processing factory in Moses Lake in 1978, farmers substituted for sugar beet production with wheat, feed corn, and dry bean crops. Beet production ceased in 1979.

Fruit crops represented less than 5 percent of the irrigated area and the total crop returns until the mid-1970s, after which production grew steadily, reaching 6 percent of the total irrigated area and 20 percent of the total returns by 1985.

14 Clubs for rural youths which teach farm-related skills.

Table 3. Irrigated area and gross value of crop production, the CBP, 1955-89.

Year	1955-64		1965-74		1975-84		1985-89	
	% of total irrigated area	% of total value of produc- tion	% of total irrigated area	% of total value of produc- tion	% of total irrigated area	% of total value of produc- tion	% of total irrigated area	% of total value of produc- tion
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
Feedgrain	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 the CBP. U.S. Bureau of Reclamation.

Other categories of crop production include seed, specialty crops and irrigated pastureland. Seed production (vegetable, grain and herb seed) has declined in importance since the 1950s, representing less than 7 percent of both irrigated area and total returns during the 1980s. Specialty crops (herbs and flower bulbs) covered less than 3 percent of the irrigated area and produced less than 4 percent of the total returns during the study period. Irrigated pastureland has consistently remained between 2 percent and 5 percent of the total irrigated area since 1955, contributing less than 2 percent to the total crop returns.

The cropping pattern across the CBP is clearly complex with a mixture of both high- and low-value crops. Increased diversification in recent years is said, by district managers interviewed, to have made canal maintenance and operations more difficult because of the longer cropping season of some vegetable crop rotations and more varied water requirements. Within this overall pattern, most farmers practice a multiyear rotation of crops on their farms.

One interesting feature of the picture that emerges is the heavy emphasis on livestock feed production. Since 1965, more than 40 percent of the project area has been devoted to growing hay, fodder, silage, feedgrain and irrigated pasture. The market value of this output is rather low, making up less than 30 percent of the total value of gross project output. Moreover, the ratio of livestock-oriented crops' share of the total value to their share of the total area planted has fallen to a low of 0.54 in the 1985-89 period, compared with a high of 0.69 for the 1955-64 period, suggesting that animal-oriented production may be becoming less profitable. This is said, by district managers interviewed, to be a consequence of the practice of including alfalfa in the rotation as a measure for enhancing soil fertility and because some project lands are not suitable for producing higher-value crops. Alfalfa is a more remunerative crop than small grains, and it is less risky because prices are more stable. Farmers contract to supply alfalfa hay to dairy operators in the Puget Sound area in the western part of the state and also export cubed hay[15] to Japan.

Nevertheless, profitability is the fundamental force driving farmers' crop decisions, and cropping pattern shifts have resulted in the steadily rising total value of output in all three CBP districts, as shown in Figure 3.[16] For the system as a whole, the 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.

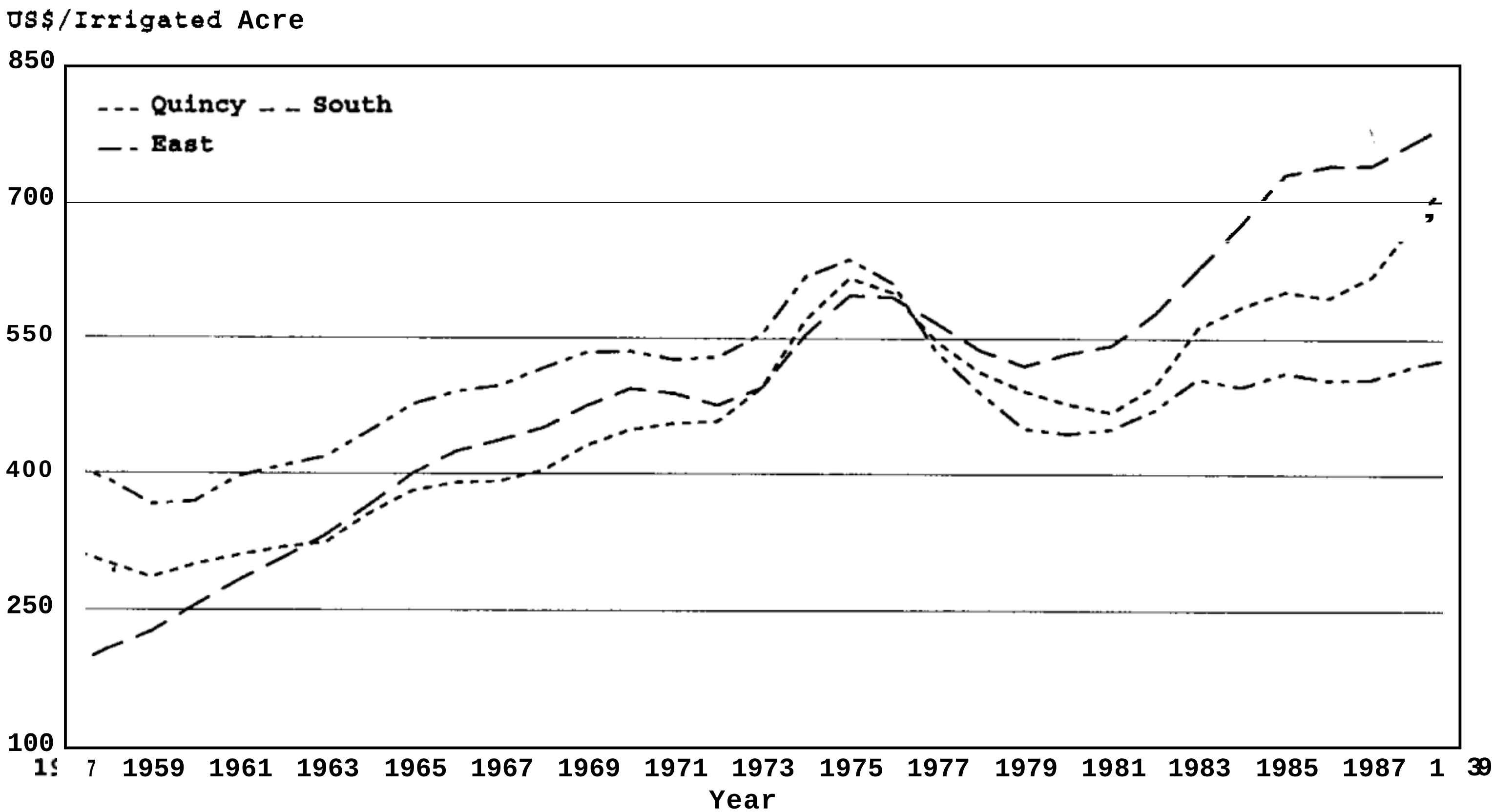
The growing share of permanent crops in the project, such as apples, has resulted in pressure to provide water earlier and later in the season than previously. In addition, more complex cropping patterns which sometimes involve growing more than one crop in a year. also create pressure on system managers to supply water earlier and later in the season. This tendency is particularly strong in the South District, where higher temperatures allow a slightly longer growing season. Since this district is at the far end of the CBP, water must pass through the entire east main canal before being taken off for use. This leads to reducing the system conveyance efficiency during these periods.

It is interesting to note that the South District, which was the least productive of the three districts in the early years of the project by a wide margin, is now the most productive. A possible explanation for this is found in Figure 2 (p.16), where growth in sprinkler irrigation in the South Dismct is seen to be much stronger than in either of the other two districts. The South District also suffered from drainage problems which have been ameliorated by recent tile drainage programs. The East District, which had the soils best adapted for surface irrigation, has been the slowest to adopt pressurized water application systems and has seen its initial lead in value of output per irrigated hectare diminish until it is now the least productive of the three districts. The Quincy District, which has been intermediate in sprinkler adoption, now occupies the middle position in terms of productivity, as it did in the late 1950s.

15 Hay compressed to a very high density for more economical shipping.

16 The sharp temporary increase peaking in 1914 is probably due to the spike in world wheat prices which occurred that year.

Figure 3. Average value of total crop production per acre, the CBP, 1960-89 (3-year moving average).



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

Note: Prices adjusted by index of prices received by farmers in the U.S.A.. (1982=100).

CHAPTER 3

Irrigation Institutions

THE U.S. BUREAU OF RECLAMATION

THE U.S. Bureau of Reclamation (USBR) was established by the Reclamation Act of 1902 and was charged with the mission of "reclaiming"[17] the arid lands of the Western United States for farming through the provision of irrigation. Before World War II, the USBR had three broad goals: 1) to provide settlement opportunities in the American West for as many settlers as possible, 2) to provide subsidized and interest-free funding of irrigation projects, and 3) to promote the family farm as a way of life in rural America (Infanger 1974, 56). The provision of irrigation was seen as a principal mechanism for providing settlement opportunities and for promoting family farm agriculture in the arid West.

The USBR 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 a minor share of full construction costs and they paid very low rates for water. Also because of this policy orientation, and the economic rents involved, the USBR 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. These were only partially successful (Reisner 1987).

The USBR is organized by watershed region across the Western U.S., with project managers in charge of particular projects under the regions. From the beginning, 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 USBR has constructed more than 521 major water-control structures during its lifetime, with the Grand Coulee Dam being one of the largest. Around the time management was transferred in the Columbia Basin Project, however, a shift was underway in the USBR's role from that of a developer of large water and power projects to other tasks (Opie 1989.15). As construction activity diminished, the USBRs role shifted to include supplying municipal and industrial water, river and reservoir regulation, flood control, and environmental regulation and management of recreation lands and wildlife habitats.

> ***The U.S. Bureau of Reclamation shares a number of these features with water resources departments and ministries in*** developing ***countries. Its mandate for***

17 The word "reclaiming" implies that the land was previously used for agriculture. which was generally not the case.

irrigation development was originally underlain by strong social welfare considerations. Throughout most of its life, it has been primarily a construction agency, with little enthusiasm for handling operations and maintenance, and it has channeled heavy public subsidies on irrigation water to farmers. However, the USBR differs from most of its counterparts in developing countries by its mandate (a) to help create users' irrigation districts and transfer management to them, (b) to negotiate construction repayment schedules, and (c) to levy O&M fees on users prior to the transfer, and by its record of success in doing these things.

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. They are often able to obtain restricted powers of eminent domain from the state for acquiring land to build essential irrigation facilities and may have legal immunity from liability for certain hazards associated with their operations. Water rights are attached to districts through a process of grant and certification by state governments.

Water users are attached to the districts through their relationship to the irrigable land within the irrigation district. The districts are normally governed by a board which *is* elected by a vote open to all landholders in the district. The 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 and sale of farms of violators by the district.*

By comparison with developing countries, irrigation districts in the CBP are strong legally, and even politically. Irrigators' associations in developing countries generally do not have the power of eminent domain or foreclosure of landholdings. In many developing countries, irrigators' associations lack the ability to cut off water deliveries as a sanction, to let contracts, and to obtain loans from banks. These legal powers have been essential in enabling the CBP to collect 100 percent of water duties, minimize water theft, and attain financial viability.

The three irrigation districts comprising the Columbia Basin Project, the Quincy District, the East District, and the South District, were created in 1939. two years before completion of the Grand Coulee Dam and 13 years before water began flowing through the irrigation system.[18] 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 landowners and is governed by a

18 The Quincy Valley Water Users' Association, formed in 1907 and discussed earlier in the paper, was an early forerunner and namesake to the current Quincy Irrigation District, but it bears no direct institutional connection to the present irrigation district.

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. The Quincy District has seven board members, while the two other districts each has five. 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, according to district managers and staff, some of the most significant are financial —raising sufficient revenue to pay for O&M and capital replacement while seeking to keep water assessments as low as possible.

The district management is in the hands of full-time professional staff members. The district managers, who are responsible for the day-to-day operation of the districts, are engineers recruited through open competition. They are selected by the board of directors and are responsible to it. They are not landowners in the project and are typically recruited from outside the district they manage. Both the district managers and the USBR respondents anticipate problems arising in the event a project manager did own land within the district he managed. Managers are not board members, but do report frequently to the boards, though in smaller districts elsewhere in the region, managers sometimes sit as regular board members. Irrigation district management is a well-established career path in the American West and positions are announced in various publications.

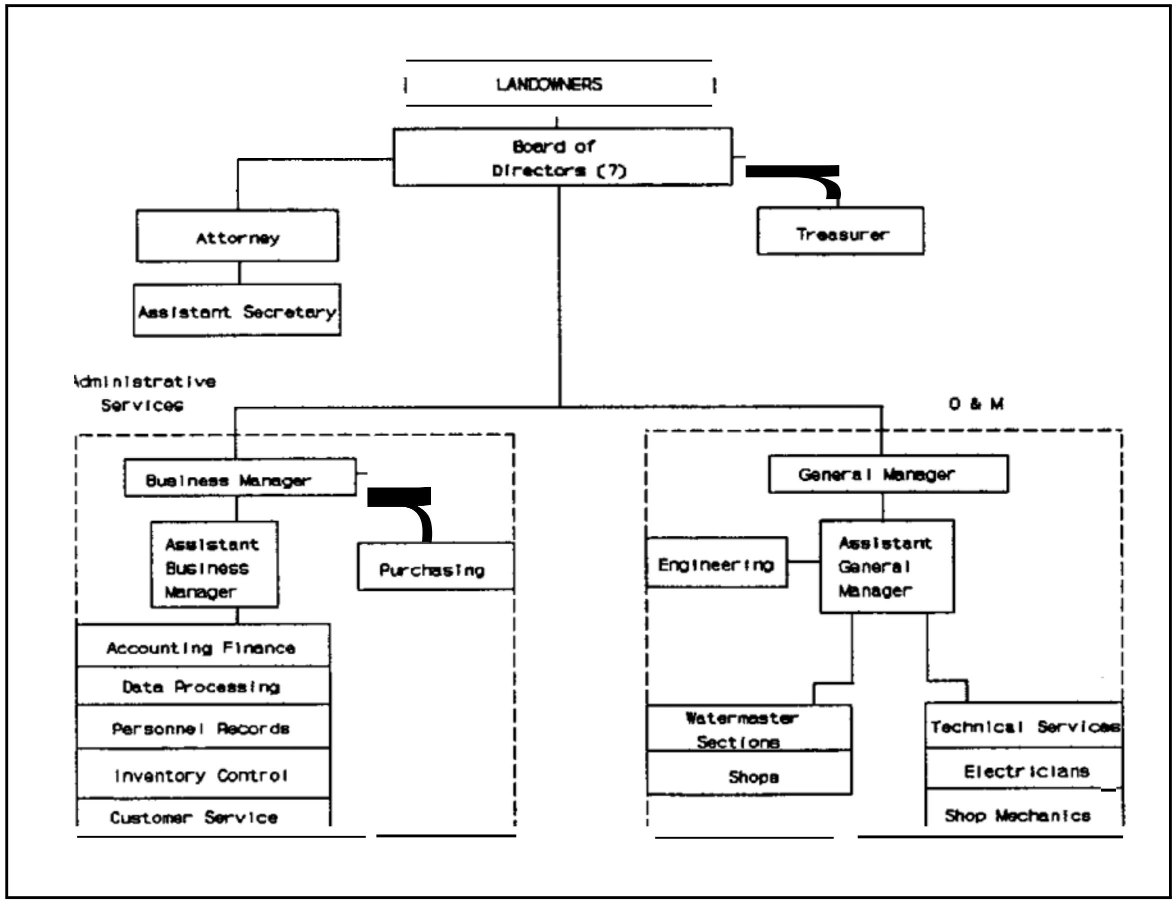
> ***Typically, developing countries do not have career paths for private-sector irrigation managers or community organizers. However, in countries such as Bangladesh and China, nongovernmental organizations or small contractors are increasingly important in supplying O&M management services. In Colombia and Chile, irrigation managers are now recruited from the open labor market. This mobility and flexibility may be important for supporting sustainable management transfer in developing countries as well. Researchers have noted that institutional development and diversification often "prepare the terrain for privatization" (Nellis and Kikeri 1989, 670: Van De Walle 1989).***

Figures 4a. 4b and 4c show organizational charts of the three districts. Each district has two main divisions, an O&M Division and an Administrative Service Division. The O&M Division is staffed by watermasters, ditchriders, and other supporting positions. The posts of watermaster and ditchrider are normally long-term career 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. The Quincy District differs from the other two districts in that the Business Manager reports directly to the board of directors and not to the General Manager, who is principally concerned with O&M. Since the districts are legally established by the state government, the state requires that their books be audited annually by independent certified public accountants.

RELATIONSHIP BETWEEN THE USBR AND THE DISTRICTS

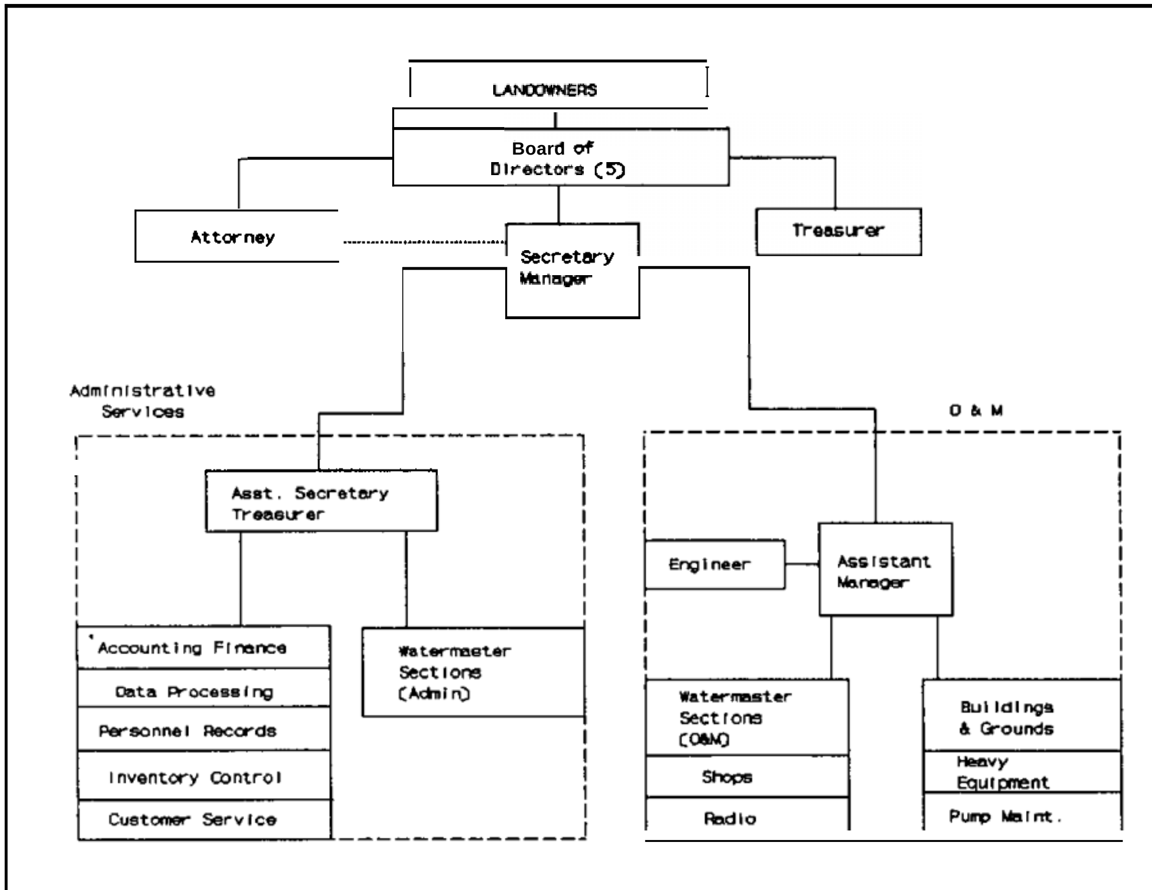
Relations between the USBR and the irrigation districts are defined by public law and through negotiations leading to legally binding contracts and agreements. The working relationship between the districts and the USBR project personnel is generally cordial and is characterized by regular communication. The USBR representatives are invited to sit in on district board meetings, and there are frequent phone calls between district managers and the USBR personnel.

Figure 4a. Organizational structure of the Quincy District, the CBP.



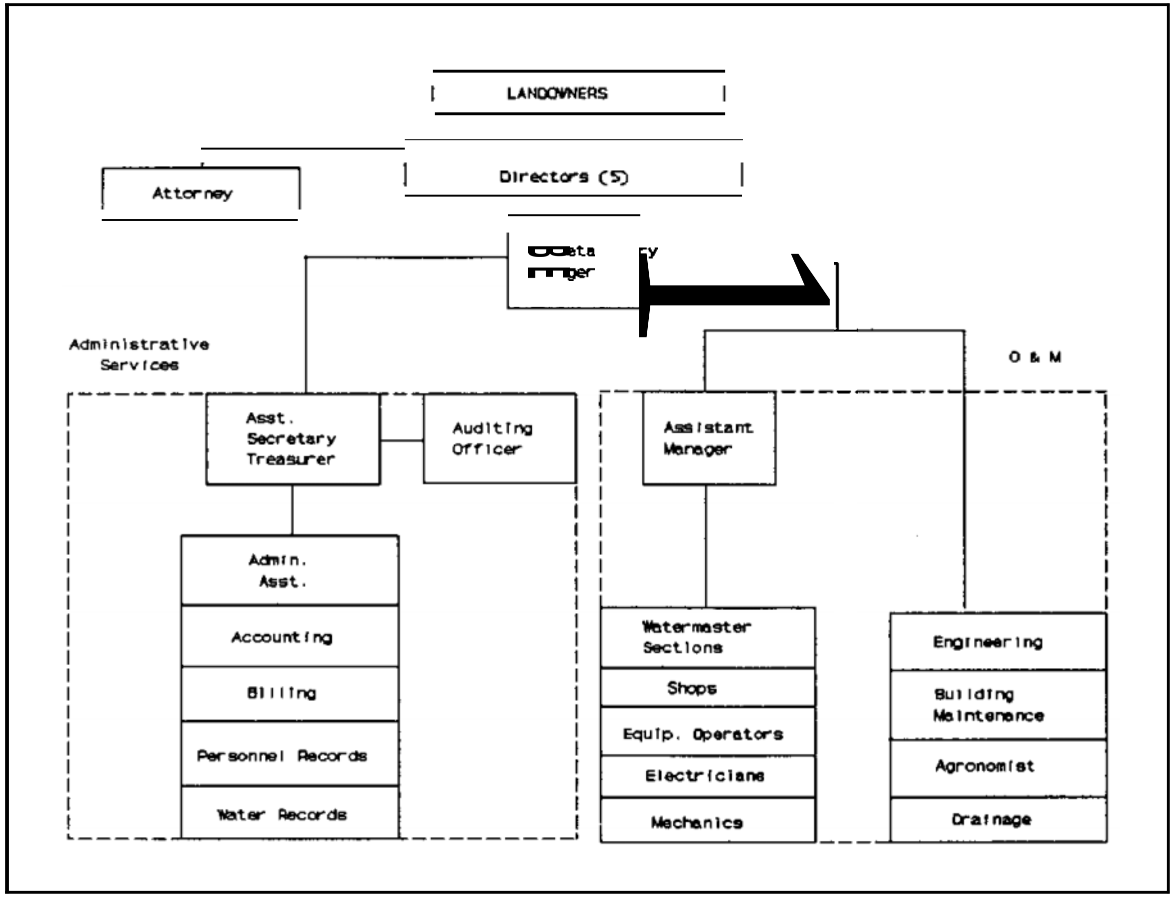
Source: District-level data, the CBP..

Figure 4b. Organizational structure of the East District, the CBP.



Source: District-level data, the CBP..

Figure 4c. Organizational structure of the South District, the CBP.



Source: District-level data, the CBP.

Because of the size, wealth and political influence of imgation districts in the American West, the USBR 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.

Throughout much of the period under discussion, the CBP farmers enjoyed the assistance of the powerful U.S. Senators Jackson and Magnuson.[19] This led to such favorable terms for farmers as:

- repeated relaxation of farm size limits,
- renegotiation of repayment contracts reducing by one-thud the proportion of total project costs to be repaid by farmers,
- highly subsidized power rates for lifting water from the FDR Reservoir,
- assumption of responsibility by the USBR for drain installation with farmers to repay under the 50-year repayment schedule, and
- favorable conditions for transfer of management to the districts in 1969 (discussed below).

This contrasts sharply with the situation in many developing countries, where the irrigation agency tends to be in a superior political position to irrigators' associations. However, manipulation of politicians for greater access to irrigation benefits also occurs in more democratic developing countries, such as India, Sri Lanka and the Philippines.

The official relationship between the USBR 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. Longstanding reclamation law requires landholders to repay the federal government, at no interest, for their apportioned share of costs of construction of dams, imgation structures and drainage systems. During the repayment period, the USBR generally has the right to resume direct management of the system if it chooses, primarily upon grounds of failure by the districts to follow the repayment schedule or to adequately maintain the system. Even after the repayment period is completed, however, title to the facilities remains with the USBR, unless otherwise specified by the U. S. Congress. According to the CBP irrigation district lawyers, this provision is valued by the districts as a way of insuring continuing immunity from certain kinds of legal liability to which they would otherwise be exposed.

In the Columbia Basin Project, system construction plans, water supply contracts, and the imgation districts' repayment share were all negotiated between the USBR and the three irrigation districts in 1944 and 1945—well before the canal networks were constructed and any water was delivered. Prior to completion of project construction, water users also agreed to pay the "full" cost of O&M, exclusive of implicit subsidies such as below-market rates for pumping lift energy.

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19 Senator Magnuson represented Washington State fmm 1944 until 1981. Senator Jackson occupied the other Washington senate seat from 1953 until 1981. The pair thus represented the state during much of the active history of the CBP and, because of their seniority, were in powerful positions at the time the management transfer contracts were being negotiated.

Following the period of negotiations, **98** percent of the imgation district farmers accepted the **1945** Repayment Contracts.[20] These agreements, one with each district, provided that water users would pay an average of US$85 per acre for project construction costs, repayable over 40 years. Rules allowed a 10-year "development period" for deferral of repayment, which effectively extended the repayment period to 50 years. The initial **1945** repayment contracts with the districts were subsequently revised or amended in **1951, 1952, 1953, 1958, 1962, 1963, 1965, 1966**, and **1969.** The **1963** renegotiation extended the repayment period to 50 years, *in addition to* the 10-year deferral period. Since the CBP fanners did not begin making repayments until **1960,** repayment will continue until the year 2010.

The project remains incomplete, with roughly half of the originally envisioned area still unimgated. The development of Phase Two of the project has been discussed repeatedly over the past **40** years without agreement among the involved parties. In **1968,** expansion plans were shelved indefinitely when fanners refused to agree to repayment terms being proposed by the USBR. As an alternative to the development of the full 1.1 million acre area. the enlargement of the East Low Canal area by developing an additional 87,000 acres of irrigated land has also been discussed, but not implemented. **Full** cost recovery, as calculated by the USBR, depends on the development of the full project *to* cover the cost of the shared facilities. Responsibility for this share of project costs, if Phase Two is ever formally abandoned, is not clear.

The main resistance to additional development now comes from environmental interests. The State of Washington, which would be required to foot a significant portion of the bill under new federal legislative guidelines, has generally favored this additional development, though its position is not unified. Moves by the state to issue a new water permit for the expansion would almost certainly generate fierce controversy. Some fanners in the already completed part of the project are also reluctant to *see* additional development, fearing that the resulting increase in agricultural production from the area would depress local commodity prices. Local food processing industries tend to support development for the same reason, and the business community is naturally supportive. Landholders who would receive irrigation benefits are also generally supportive.

Under the **1945** repayment agreement, irrigators were responsible for all subsequent drainage construction. By the 1960s, farmers were becoming concerned about the expected costs of a growing need for subsurface drainage and had requested the USBR to assume responsibility for drainage construction. In return, the districts agreed to "cover" additional costs to the **USBR** by increasing the repayment amount to US$131.60 per acre (US$325 per ha), up from the previous rate **of** US$85 per acre. This increase, amounting to US$46.60 per acre, would generate an additional US$26,550,396 if payment were forthcoming from the entire **569,751** acre area of the system. As of 30 September **1991, US$118,150,000 had been spent by the USBR to drain 115,970** acres, with an estimated **37,170** acres which require drainage remaining at an estimated cost of US$61,413,000. The total cost of installing the required drainage would then amount to US$179,563,000, of which repayments would cover ahout 15 percent. The actual share of the repayment is somewhat less than this, however, since these are "book values" which do not consider the time value of money.

In total, the new repayment contracts obligate district farmers to pay US$2.63 per acre (US$6.50 per ha) per year toward capital costs. Assuming a peak irrigable area of **569,751** acres, the total

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20 **This figure is not as impressive as it might appear. since the vast majority of farms now occupying the CBP** land **did not exist in 1945. Doka (1979) indicates hat the total number of farm units in the CBP area in 1948 was 80 and that the total project farm population in 1950 was 140. This suggests that less than 100 people m y have voted an these contracts.**

recovery will be US$74,979,231. This has a present value of US$8,547,632, assuming an 8 percent discount rate and the money being paid back in 11 to 50 yews (Doka 1979). Under the original agreement, farmers were to pay approximately 18 percent of construction costs. Under the revised 1963 agreement, the proportion of total project construction cost to be repaid by the districts was reduced to about 12 percent. Such favorable terms for the districts reflect their powerful political clout with elected officials, as well as long-standing public policy respecting irrigated agriculture.

A common situation in developing countries is a relative absence of strong formal local organizational structures. 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 USBR, and had accepted their obligation to pay for O&M services themselves. They thus had an incentive to assume management responsibility to keep down the costs of O&M and make management more "customer-oriented."

CHAPTER 4

Management Transfer

MOTIVATION FOR TRANSFER

Farmer Perspectives

SINCE THEIR CREATION, the districts knew that responsibility for O&M would eventually fall to them. The Fact-Finder's Act of 1927 established that after 50 percent of a **USBR** project is constructed, O&M should be transferred to irrigation districts. 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 interviewed, farmers' primary interests were in obtaining more local control over water allocation, water fee structures, **O&M** expenditures, and drainageways and in minimizing water charges.

The following are quotes from a letter to the U.S. 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 ... 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 ihey'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 roo 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.*

USBR Perspectives

A response to the above letter from a representative of the U.S. Department of the lnterior 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 statement 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.

Budgetary pressures in the late 1960s related to the war in Vietnam and the Federal Government's 'War on Poverty" prompted renewed interest at top levels of the USBR in transferring management responsibilities to the districts as soon as possible.

At the regional and project levels, in addition to a need to be responsive to superiors in Washington, the USBR was also interested in shedding responsibility for farm-level water deliveries and water service contracts to enable it to focus on its development mission and on basin-level regulatory activities. These interests were reciprocal. The farmers did not like the "red tape" of government management and the USBR did not want the headaches of dealing with thousands of individual fanners.

> *In developing countries, the most prevalent motive for irrigation management transfer is to relieve financial pressures in a sector where it is presumed that fanners can assume additional costs. Because of the financial pow patterns which typically prevail, the initiative for turnover tends to come from finance or planning departments rather than from irrigation agencies themselves. Unlike the situation in the CBP, farmers in developing countries often pay only a token amount for irrigation service prior to management transfer. Nevertheless, farmers in developing countries sometimes opt for private-sector management when a choice is available (Vermillion 1992). If reduced costs can be promised, farmers clearly have an interest in supporting the transfer concept. Governments are in a more challenging situation if management transfer involves an increase in farmer costs for irrigation, since they must then demonstrate that irrigation service will improve as a result of the change (Gerards 1992).*

The perception of the CBP farmers that the USBR was inefficient and unresponsive to local needs resembles a frequent perception of farmers in developing countries about irrigation agencies.

When agency management is poor, fanners sometimes supplement it informally with their own resources (IIMI 1989).

The proliferation of private tubewells throughout South Asia is, in part, a response to ineffective public-sector irrigation management.

Fanners are often willing to pay several times more for private tubewell water than for water from public tubewells or canal systems for the perceived value of improved control over the amount and timing of irrigation (Chambers et al. 1989; Repetto 1986).

TRANSFER PROCESS

In the early 1960s. Floyd Dominy, Commissioner of the USBR of Reclamation. gave the CBP a strong push to move ahead quickly with transfer negotiations. The districts hired lawyers who, together with elected district board members, entered into a protracted process of negotiation, hydrologic and economic studies, and legal analysis with project staff. The research helped reduce some of the uncertainties about the cost and equity implications of various options being considered. Negotiations began in earnest in 1966, and transfer agreements were drafted between 1967 and 1968.

Negotiations were complicated by the fact that there were three independent districts taking over management. Moreover, some project facilities were shared among two or three of the districts. There were six primary issue areas which had to be settled among the three districts and the USBR. These were:

1. Determining which parts of the system should be transferred to the districts and which kept within the USBR's responsibility as "reserved works."
2. Deciding whether management should be handled by a single federated body or carried out individually by each of the districts.
3. Realigning the district boundaries to facilitate district accountability for management and payments.
4. Deciding how to allocate between the districts' primary pumping costs and the costs of operating and maintaining several "joint works," which are facilities used by two or more districts, such as the Banks Lake, the Potholes Reservoir, and the main supply and drainage canals. Cost allocation issues were complicated by factual questions concerning the extent of return flows, conveyance losses, and the quality of waste water.
5. Establishing maintenance standards for facilities to be turned over.
6. Setting personnel policies including salaries, severance payments, and retirement plans for the USBR staff transferred to the districts.

Issues one through four involved considerable negotiation among the three districts, and agreement among the districts was often more difficult to achieve than that between the districts and the USBR. Despite the fact that both the USBR and the districts wanted the transfer to proceed, discussions were sometimes heated. The USBR often took initiative to draft plans and agreements and to 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 USBR, will be taking the initiative to achieve the takeover" (Othello Outlook 1965).

Over a period of about five years, the districts gradually came to agreement over water and cost allocation and over which works should be (a) reserved by the USBR. (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. One of the last obstacles was overcome when the USBR dropped its insistence that the districts cover severance payments for the USBR staff transferred to the districts. This permitted completion of the final transfer agreements, which are unglamorously referred to as "Amendatory, Supplemental, and Replacement Repayment Contracts.'' They were signed on December 1968 and took effect on January 26,1969. This was one of the largest management transfers the USBR had undertaken.

> ***In contrast to many transfer programs in developing countries, the transfer process in the CBP was characterized** not **by efforts** to **organize and motivate farmers to comply with government programs, but by extended negotiation until terms and conditions mutually acceptable for the government and the farmers were agreed upon.***

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 the 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.

- The districts can enter into water service contracts to supply excess water to farmers outside the districts. However, the 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.

- The 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 pick-up 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 concessional by the USBR, since the districts pay an extremely low rate for the primary lifting of water from the FDR Reservoir.

District Responsibilities

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

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

- The districts are responsible for paying their mutually agreed proportions of the recurrent costs **of** special "reserved works" which were retained for management by the USBR.

- The dismcts are responsible for making annual payments into a capital replacement reserve fund at a rate equal to 30 percent of 5-year average annual O&M costs. They must eventually replace deteriorated facilities with this fund.

- The districts must report maintenance plans annually, in advance, to the USBR.

USBR Rights

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

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

- Salaries and benefits of transferred USBR staff members such as ditchriders 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 considering seniority.

USBR Responsibilities

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

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

- The USBR 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 take an act of Congress. The districts favor the retention of legal title for facilities by the USBR, since they believe this protects them from certain legal liabilities.

- The USBR 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.

The strong legal position of the farmer irrigation districts and the protracted period of negotiation between them and the USER resulted in a relative balance between district rights and responsibilities. In developing countries, there is a tendency for governments to emphasize transjer of responsibilities to the neglect of transfer of rights (Ambler 1992). A balance between transferred

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> ***responsibilities and rights, and expected increase in local control and net financial gain to the farmers, were motivating conditions which made the transfer acceptable to the CBPfarmers. Wherethis is not the case, considerably greater resistance to transfer on the part of farmers is probable.***

MANAGEMENT CHANGES SINCE THE TRANSFER

The USBR

Since transfer, the USBR has drastically curtailed its direct O&M activity and has taken on new roles in environmental regulation and land management. About 210 USBR project staff positions, mostly in O&M, were abolished by the transfer, and 80 to 90 percent of the USBR staff occupying these positions transferred to the districts. Others retired or were transferred to other USBR projects. In 1968, the year before the handover, the USBR project staff numbered 841 (Table 4). The year following the transfer, this number had dropped to 612, a decline of 27 percent. The most abrupt change came in the Irrigation and Land Division, which is mainly concerned with system O&M.

The strength of this division declined by nearly two-thirds, from 301 to 103 staff members. The next year, the power division was transferred to an independent office, which, coupled with continuing declines in all other employee categories, further reduced the number of project employees to 247. In 1973, a number of staff in the Irrigation and Land Division who were involved in constructing drainage works were transferred into the Engineering and Construction Division, making the Irrigation and Land Division almost entirely devoted to main system management and land issues and leaving it with 28 staff members. By 1985, the total project staff strength had declined to 83, with 22 of these in the Imgation and Land Division.

Today, there are only 7 USBR positions in O&M, compared with 12 handling land and environmental regulation and water rights. One of these positions is a new one, established to handle coordination between the project and the district offices for operations and maintenance activities, water service contracts, land and water rights, licenses and permits, and so on. Figure 5 shows the dramatic overall drop in the USBR CBP staff which occurred in 1969 and 1970 and the sustained, gradual decline thereafter.

Table 4. Number of USBR staff assigned to the CBP, by division, 1961-85.

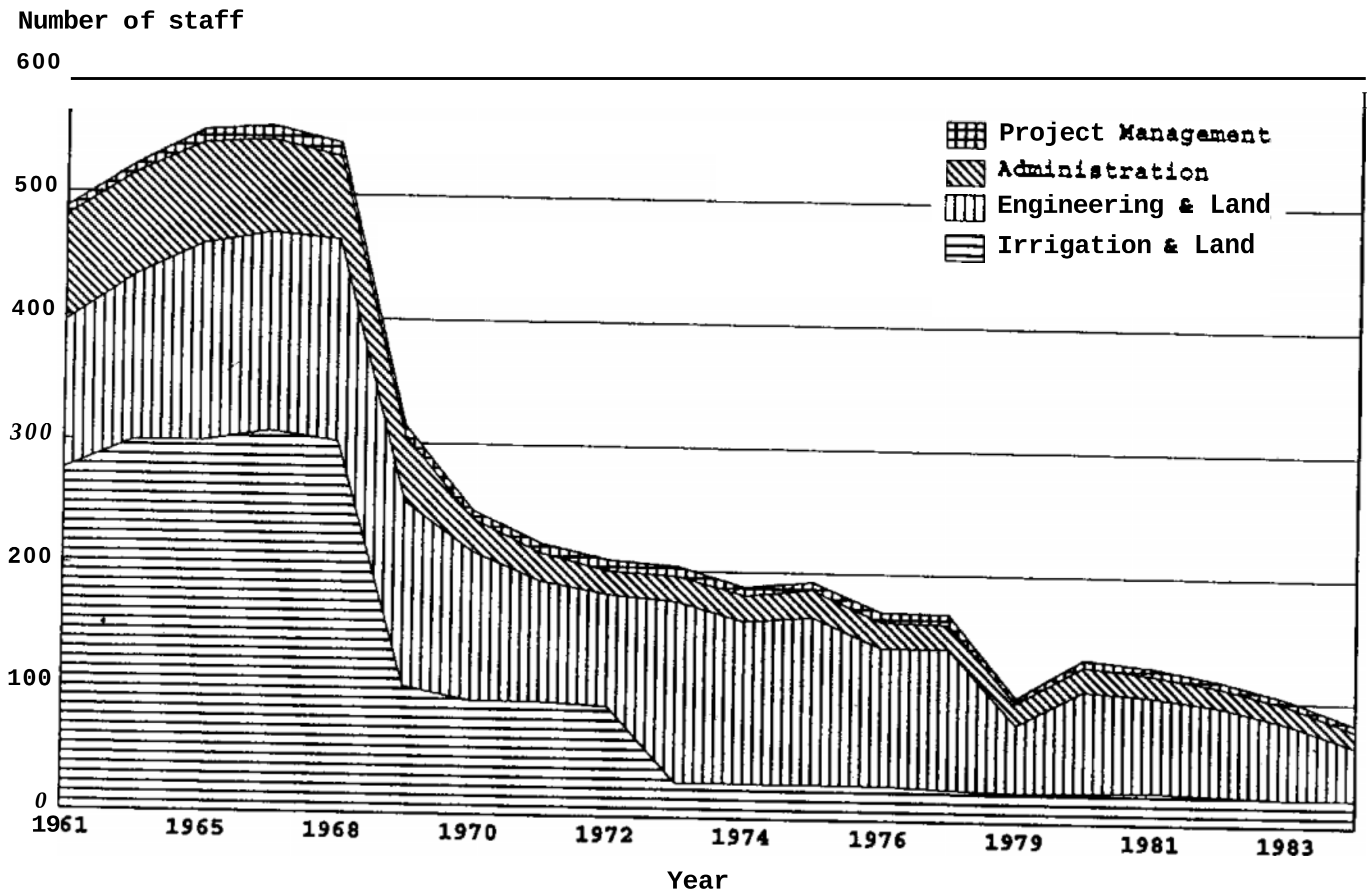
Year	Power	Irrigation and Land	Engineering and Construction	Adminis-tration	Project Manage-ment	Full-time Regular Total
1961	329	277	119	85	7	817
1962						824
1963	316	300	133	83	7	839
1964						
1965	273	300	159	82	10	824
1966						829
1967[a]	295	309	160	75	11	850
1968	299	301	163	67	11	841
1969	297	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.

Figure **5.** *Number of USBR staff assigned to the CBP, by division, 1961-85.*



Source: U.S. Bureau of Reclamation data.

Note: Data are missing for the years 1962, 1964, 1966. 1978 and 1984. Figure excludes Power Division which became independent in 1969.

The Districts

Just prior to management transfer, each of the districts had only a handful of staff. The 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 the district boards. However, all three new managers had previous district or USBR experience. Most of the staff from the level of watermaster and below were transferred from the USBR to the districts.

Immediately following management turnover in 1969, the South District had 65 staff members. By 1991, because of expanding service area, the district staff had grown to 90 paid employees serving 200,781 acres, an average of 2,231 acres (903 ha) per staff member. In the same year, the Quincy Dismct had 94 employees for 221,593 acres, or 2,357 acres (954 ha), per employee, and the more concentrated East District area had 68 employees serving 135,154 acres, or 1,988 acres (804 ha) per staff member. Staff levels in each of these districts is said, by district managers, to have declined in recent years. According to the East District manager, staff reductions in the mid-1980s reduced the staff share of the operating budget in his district from around 61 percent to about 53 percent of the total. One district manager noted that staffing in his district was "thin" after the cutback, implying that they may have gone too far.

Improved technology is a major factor in these reductions. Extensive use of two-way radios, personal computers in each watermaster's station and at district headquarters, and telemetry for reporting system status information have all reduced the need for staff. In addition, center pivot sprinklers now used by most farmers require fewer changes in delivery schedules. Offsetting these increases in staff productivity to some extent are increased reporting requirements, such as those mandated by the Reclamation Reform Act.

The districts can and do fire staff. The Quincy District has released about five staff in the past two years, even though ditchriders and O&M service staff are unionized. However, one district manager argues that unions have stymied further shrinkageof staff levels which would have taken place otherwise.

The district O&M personnel handle all water allocation functions down to the farm turnout with little farmer interference reported. Measurement of deliveries at the turnout has largely eliminated water-related disputes among farmers and between farmers and the district. The Quincy District reports about six 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 sprinkler breaks down. The district managers understand such needs and do not regard this as a major problem. On occasions when locks have been cut for other purposes, the districts have been less tolerant but are able to fine farmers only for the cost of replacing the lock. Higher fines have been held by the courts to be illegal. The 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, ***the Quincy District hasforeclosed and sold more than 20 landholdings due to nonpayment of water charges.***

The districts have established excess water use policies. Owing to increasing concern about possible damage to lands and drainageways resulting from overirrigation, the districts have raised the charges for use of water in excess of the base allotment. As an example, in 1987, the Quincy District established new rules imposing graduated excess charges ranging from 20 percent more than the base rate for 2 acre-feet in excess of the water allotment, up to 500 percent over the base rate for an unlikely 6.5 to 8.5 acre-feet in excess of the water allotment. Previously, a flat rate was charged for all excess water deliveries. Because of the high thresholds involved, this graduated charging scheme is largely symbolic for the moment. It does suggest an area of concern and a tentative willingness to act however.[21] The Quincy Board resolution also allows the district manager to refuse to deliver excess water if he determines that the excessive water application by the farmer is causing damage to adjoining lands or is exceeding the drainage capacity of the district.

One change in operating rules mandated by the transfer agreements was the establishment of a "share design capacity" principle in making water deliveries. Under this rule, the project and the districts guarantee allocation of at least 25.3 percent of a fanner's annual basic allotment within a given 30-day period. The rule was designed to insure that a minimum proportion of the annual water supply to which a farmer is entitled is available in any given month of the growing season. Most other aspects of the water management system and the organization of maintenance were continued with surprisingly little interruption after the management transfer. This can be explained by the fact that new district O&M positions were filled largely by ex-USBR staff and that water allocation procedures in place prior to the transfer worked reasonably well.

Each of the districts is involved in granting water service contracts to landholdings not included in the imgation district. The 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 construction repayment requirement. A second class of interruptible contracts does not *guarantee* water delivery, and the fee includes only a partial O&M assessment. The districts now collect fees directly from fanners receiving service from the district. Prior to the transfer, water assessments were collected by county assessors.

The districts contract with the USBR for performance of some management functions which fall within the district's area of responsibility under the transfer contract agreements. The East District, for example, contracts with the USBR 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 have been installed in the USBR office in Ephrata rather than in one of the district offices, and the USBR 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.

The 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. The largest is a 92-megawatt station at the 165-foot Summer Falls located at the outflow from the Banks Lake. These facilities have been developed by municipal power and light companies which provided the US$167 million financing and contracted to purchase the power produced. The districts receive about two mills (two-tenths of a 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, imgation districts were charged 0.5 mill per kilowatt-hour (KWH) for water pumping costs at the Grand Coulee. This rate continues in effect, despite the rise in summertime market value of power to about 17 mills per KWH. The USBR 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.

21 In contrast, some California water districts have implemented much steeper rate schedules which do have practical impacts on a wider range of irrigators.

Only a minority of farmers generally attend district meetings. However, despite this indication of some detachment, district managers and lawyers for the districts report that farmers are generally satisfied with the performance of the irrigation districts. The district managers indicate that they take this as a sign of approval, and that when there are problems with water deliveries in the district, farmers turn out for district meetings in strength. Routine matters of district policy and management are generally left to the board and the professional managers. The districts have continued to successfully manage daily operation of this intensive arranged-demand system since 1969, with the exception of one day—the day four inches of volcanic ash from Mount St. Helens fell on the project.

Development professionals often treat attendance at organizational meetings as an indication of the strength of the organization and of the effectiveness of its management. The CBP experience suggests that this may be an unreliable indicator and that, when the opportunity cost of farmers' time is high, the opposite may be true.

With respect to management impacts of transfer, the most significant changes appear to be the introduction of secondary revenue sources and downward pressure on staff and staffing costs.

Operational management changed very little, partly because most of the field operations staff remained in the system after transfer.

This was also the case with irrigation management transfer in Colombia, in South America, although in this case farmers had less opportunity to fire unproductive staff This is generally a thorny problem in most developing countries. especially where the private sector has limited capacity to absorb the personnel released. In some countries, such as the Philippines and Indonesia, farmers themselves may take over some management tasks.

CHAPTER 5

Results of the Transfer

EVALUATION METHODOLOGY

IN THIS CHAPTER of the paper, interrupted time series analysis is employed to assess the impact of the change in management mode on system performance. Following the approach outlined in Small and Svendsen (1992), important parameters of the evaluation are specified here, keyed to the outline reproduced in the Appendix to this paper: (a) The evaluation is focused primarily on the irrigation system, though the agricultural system and the agricultural economic system are also considered, (b) The distribution and application subsystems receive primary attention, (c) Planning, design, and construction processes are described but not analyzed. Primary focus is on the processes of system operation, maintenance and support, (d) The purpose of carrying out the evaluation is to assess the results of a large-scale management change, (e) Performance measures employed primarily measure irrigation system outputs and impacts, rather than the internal processes of the system, (f) Both achievement and efficiency measures are employed, (g) Since most of the comparisons made are across time within the same system, it is usually necessary to know only the desired direction of change. Standards are derived from positive values placed on increased irrigation efficiency, increased farm incomes, reduced public and private costs, and sustainable operation of the system. Further insight might result from a more elaborate treatment based on the possibly differing values of the different actors involved, and (h) A number of years of experience are involved in specifying both before-change and after-change performance.

Data for the analysis were obtained principally from the USBR office in Ephrata and from the three irrigation districts. Annual time series data were obtained on area irrigated,[22] 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, district revenue by source, O&M expenditure by category, and personnel levels by function. Aggregate potential evapotranspiration (PET) data were computed from cropped area figures and multiyear crop-specific PET averages for sites within the project area obtained from the Washington State University. Most data were available on an irrigation district 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 to 30 years is available.

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

CHANGES IN TECHNOLOGY

It is the view of the district managers that adoption of new technologies such as hydraulic excavators, two-way radios, telemetry, and sprinklers was facilitated by management transfer. Their argument is that the districts were more open than the USBR to new ideas and technologies, were more flexible and were able to make quicker decisions.

This argument is more relevant 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. It is difficult to know what would have happened had the USBR 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 the districts, and may well have been enhanced.

The conversion to center pivot sprinkler systems does have main system management and efficiency implications though. On the one hand, sprinklers tend to operate steadily for long periods of time thus requiring ditchriders to make fewer changes in turnout settings, and on the other, when problems occur with a center pivot sprinkler system, the fanner wants the water turned off immediately, and will do this himself if necessary. This can create large unplanned fluctuations in system laterals and lead to more water running to waste. In addition, center pivot sprinklers with swing spans at the ends to fill in the corners of square fields do not operate continuously, turning on and then off as the system rotates through a comer. Because the full supply requirement must be available to the center pivot sprinklers when required, this can result in 10 to 15 percent of the water turned out being wasted, according to the district managers.

QUALITY OF IRRIGATION SERVICE

One of the most important potential impacts of the transition to self-management is the effect on 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 general, a useful indicator must consist of a performance measure, a standard, and rules for evaluating the measure against the standard. When inter-temporal comparisons involving a single system are intended, it is necessary only to know the desired direction of change for a particular indicator.

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 apotential 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 as specified in these terms.

Consequently, it is assumed here that farmers place orders for water, based on their perceptions of the 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 farmer demand for water.

Adequacy

Figure **6** 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 imgated area expanded, until about **1973.** It is roughly stable from then until **1985** when it begins to rise again. Figure **6** 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 main canal supply does after **1985.** Aggregate **PET** demand is less volatile, exhibiting steady growth throughout the period,[23] but at a rate which declines with time.

In Figure **7,** data on supplies from the Potholes Reservoir have been deleted so that the two supply curves and the demand line relate only to virgin water pumped from the Columbia River.[24] Now it is seen that water withdrawals have remained comfortably within the water right limit.[25]

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.

While the volume of water supplied was steadily growing, the area served was also expanding (see Figure **1** [p.7]). 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 8. 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-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 rapid rise commences in the amount of water supplied to the 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.

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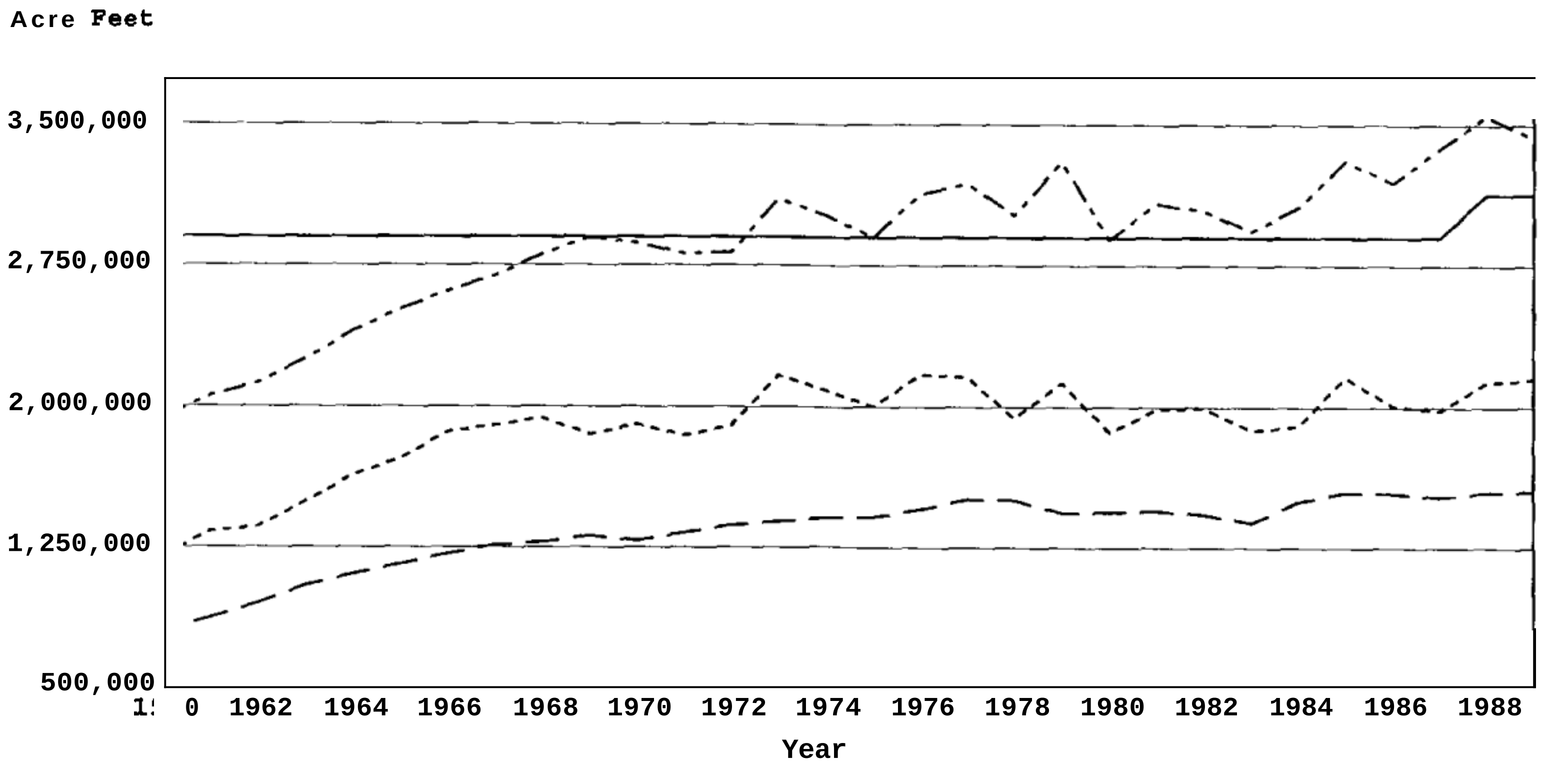
23 **To some extent. this is an artifact of the computational procedure used, since longer-term average values of PET for particular crops are used in the computation. Year-lo-year changes in aggregate water demand thus reflect variations in crop mix and total *area* irrigated only.**

24 **The raw supply to the East Main Canal, in fact, includes a small amount of feedwater delivered to the Potholes Reservoir for use in the South District. Feedwater has averaged about 5 percent of total supply delivered to the bifurcation since 1972. This amount is included in the amount diverted shown in Figure 7, but is deducted from the East Main Canal supply shown in *Figure 6* since deliveries from the Potholes Reservoir to the South District are explicitly included in the amount turned into the three main canals.**

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

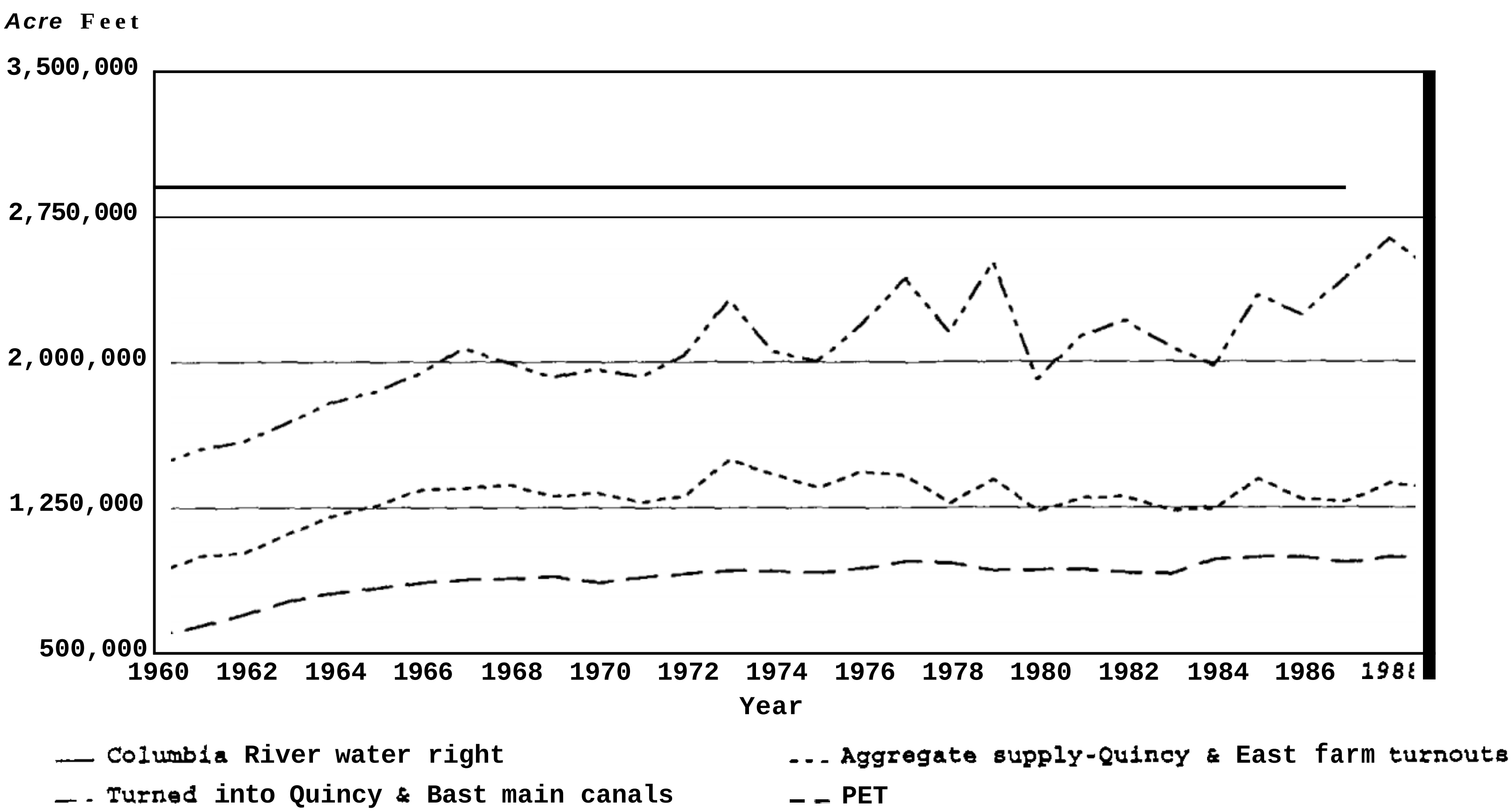
Figure 6. Water *diverted, delivered and required, the CBP, 1960-89.*



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

Note: The East Main Canal supply excludes feed water to the Potholes Reservoir.

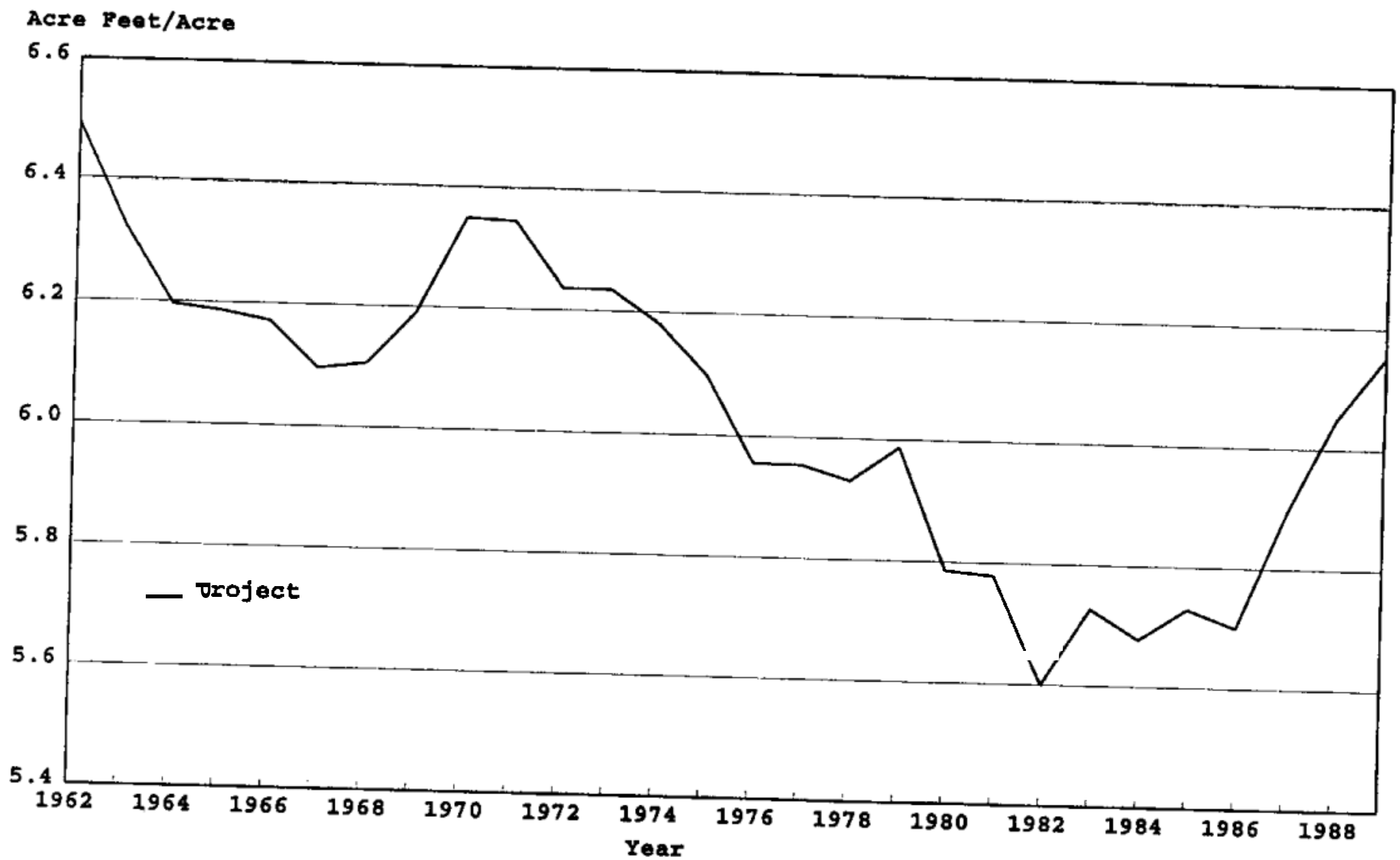
Figure 7. *Water diverted, delivered and required for the Quincy District and the East District, the CBP, 1960-89.*



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

Note: Water turned into the Fast Main Canal includes feed water to the Potholes Reservoir.

Figure 8. *Total system water supply per acre, the CBP, 1960-89 (3-year moving average).*



Source: Water Distribution Reports for the 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 put on a similar per unit area basis, it is apparent that water deliveries per unit area have declined continuously, from about 4.2 feet in the late 1950s to about 3.7 feet in the late 1980s (Figure 9). There is no obvious discontinuity in this trend associated with the 1969 transfer of management responsibility,[26] 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 the district distribution systems. A pronounced decline in per acre water deliveries to farm turnouts occurs during the 1970s, coincident with the period of most rapid growth in area under sprinkler irrigation (Figure 2 [p.16]). This decline may be related to the shift to a 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 possibility, crop-weighted aggregate annual PET for the CBP is plotted in Figure 10.[27] 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.[28] 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 beets, the most water-intensive crop grown in the basin, and its replacement with vegetables, one of the least water-intensive crop groups grown.

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 9, 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 pivot sprinkler 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.

Taking the analysis one step further, 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 (Table 5 [p.56]) to have decreased over the past 30 years, with an average value of 1.46 for the period.[29] This means that, on average, the amount of water delivered to the farm turnouts was 1.46 times the weighted average crop water requirement.

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

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

28 Changes in PET do not reflect *changes* in climatological demand since a common set of average crop-specific PET demand figures is used for each year in the series.

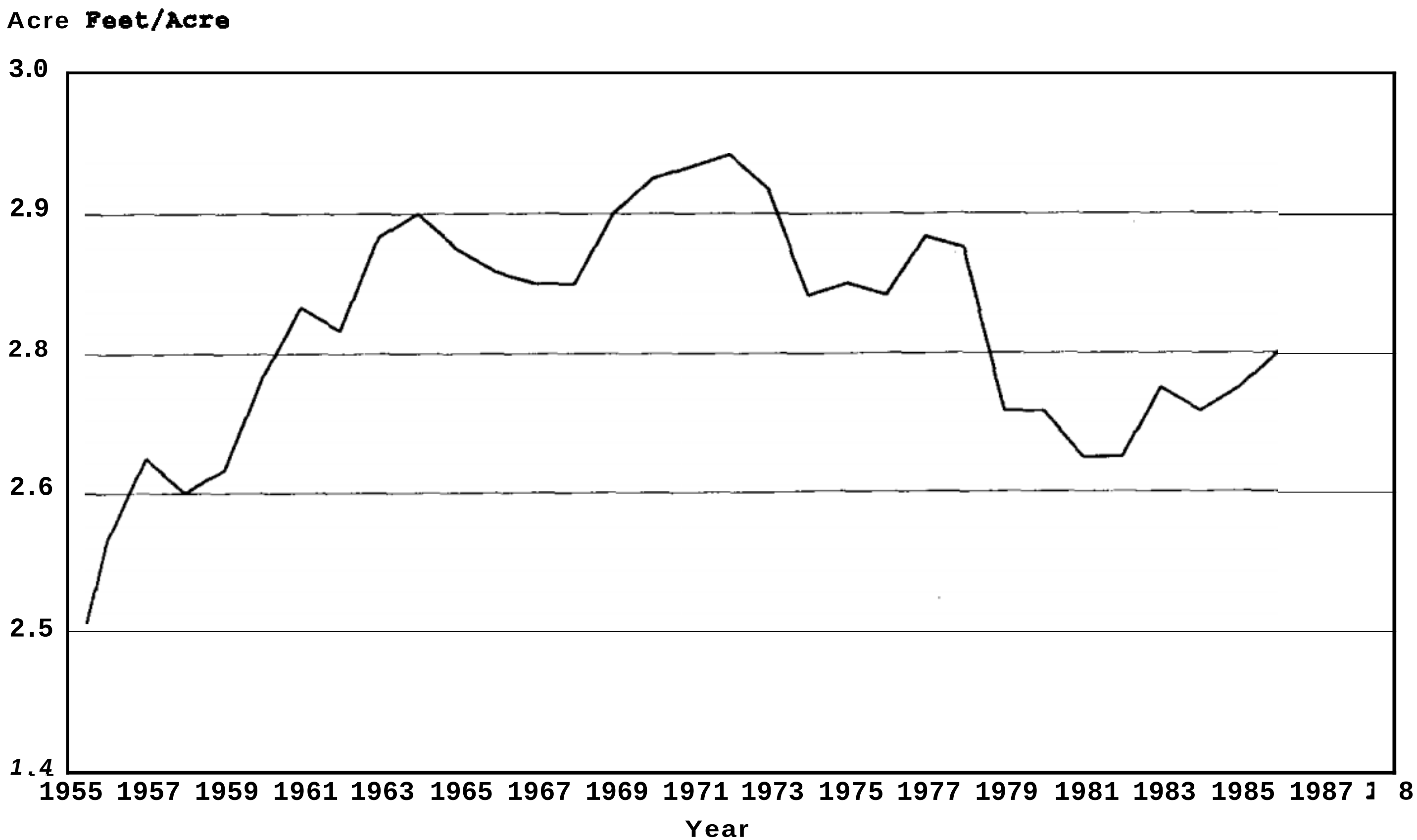
29 Note that this formulation does not include a leaching requirement. Under arid conditions, leaching of salts is necessary and important and would add something to the denominator of the RWS were it considered. Off-season rainfall would provide far some of this requirement. The leaching fraction would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

Figun 9. Average turnout waferdelivery per acre. the CBP, 1955-89 (3-year moving average).

Source; Water Distribution Reports for ¶heCBP, U.S. Bureau of Reclamation.

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

Figure 10. Cmp-weighted potential evapotranspiration for the 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). 6-13.

Table 5. Five-year average values for PET, net supply and net RWS (in feet), the 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

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

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 the districts are owned and operated by farmers, 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 the district operating costs. This suggests that the districts would have implicit RWS_n standards similar to those of their farmer members. The value placed on meeting full crop PET requirements by the USBR personnel prior to the transition to self-management is uncertain, though by most accounts the USBR personnel were highly professional and dedicated to providing farmers with the irrigation service they requested.

With respect to water adequacy, a farmer would require an RWS_n of at least 1.11 at his farm turnout to meet full PET demand if his application system operated at 90 percent efficiency or 1.25 if it operated at 80 percent efficiency.[30] 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 private 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 down the amount of water delivered to their farms down as close as possible to the target RWS. 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

30 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 casts 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.

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 the fanners and the district officials indicate that water orders have almost always been satisfied promptly both before and after transfer. Supporting this perception is the result of a recent study of a large irrigation district in Arizona, where Palmer, Clemmens, and Dedrick (c. 1990) found that 72 percent of water orders were filled within 24 hours of the order date. It was felt unlikely, therefore, that the time-consuming data assembly and analysis effort necessary to assess this dimension of performance would yield useful insight into the transfer process in the CBP.

Equity

In the absence of information on distribution of water within the 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 districts in each year. Since this ratio is based on RWS, 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 districts if they were to have a standard area and cropping pattern.

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 USBR, which are based on meeting 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 6). 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. The East District and the Quincy District took turns as the "high" district, while the South District, at the far end of the distribution system, was consistently the "low" RWS district.

> ***In developing-counrry irrigation systems, it is typical for head-end sections to obtain three or four times as much water per unit area as the tail-end sections resulting in an equity index of 3.0 to 4.0.***

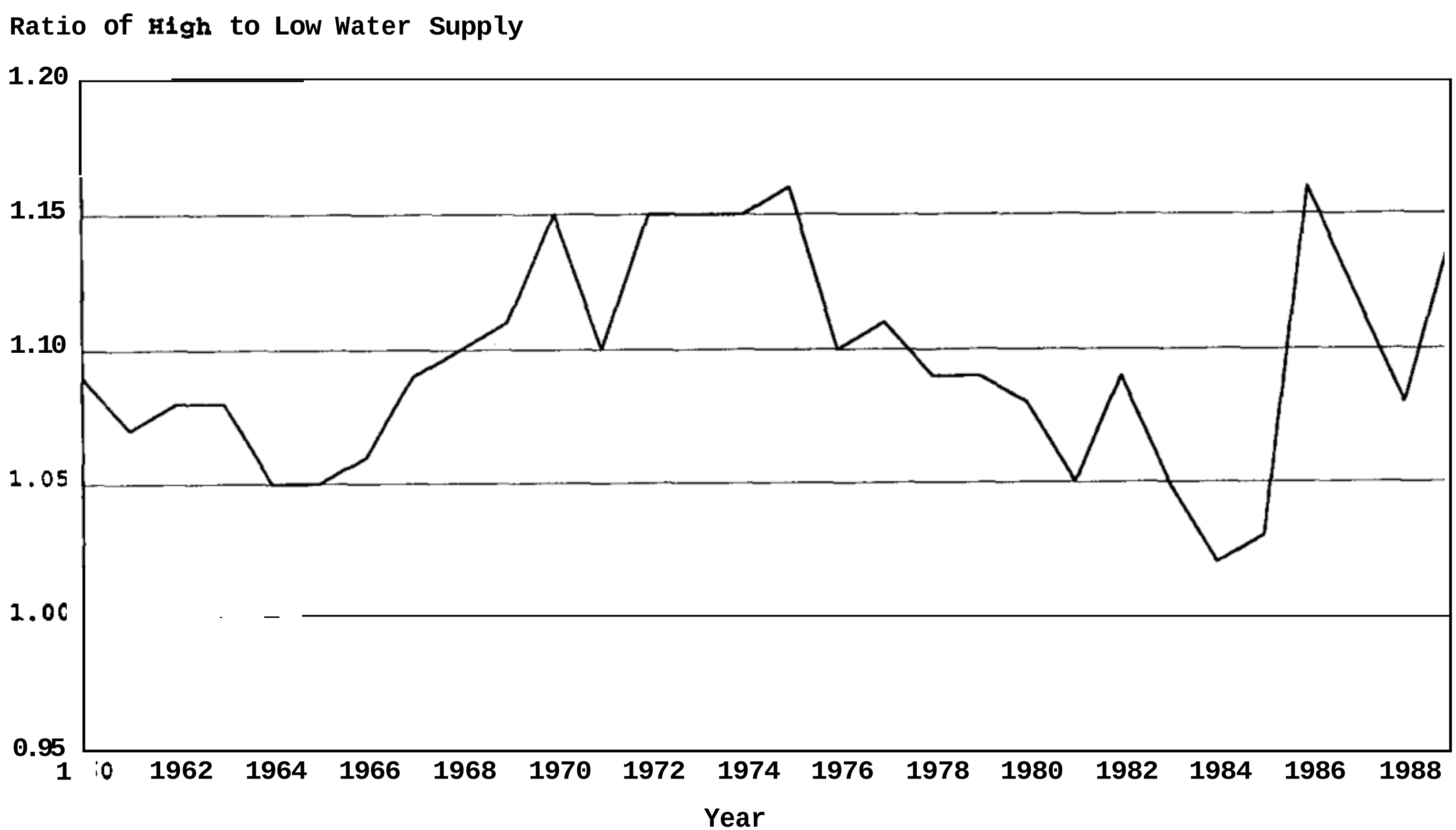
The behavior of this equity index over time is shown in Figure 11. A rising index accompanying the expansion of the system in the 1960s indicates increasing interdistrict disparity in water supplied. Following the management transfer in 1969, the index remained at peak levels for several years before beginning to move downward in 1975. After a 10-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 the districts does nor have a negative effect on interdistrict equity of water distribution.*** The districts appear to have managed and coordinated their operations in such a way that interdivisional equity improved steadily under their stewardship

Table 6. Ratio of high 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 and East	South	1.05
1966	East	South	1.06
1967	East	South	1.09
1968	East	South	1.10
1969	Quincy and 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 and 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 Water Distribution Reports** for **the CBP, U.S. Bureau** of **Reclamation.**

Figure 11. District ratios of high and low net relative wafersupply, the CBP, 1960-89.



Source: Computed from Water Distribution Reports for the CBP, U.S. Bureau of Reclamation 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 substantial 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 supply-driven systems like those typically found in South and Southeast Asia. In the latter case, interunit 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 in these supply-driven systems 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, both directly through water charges by 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 intra-district equity as crop-related water-demand levels are approached.

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 quality of irrigation service provided to irrigators, but reflects the amount of water lost in the process of providing the service. Moreover, it is only a partial measure of irrigation efficiency, since 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.

We assess ***tertiary unit efficiency, conveyance efficiency,*** and ***overall*** or ***project efficiency*** of the CBP following the terminology used by Bos and Nugteren (1990). In the absence of system deliveries for nonirrigation purposes, we can define tertiary unit efficiency (e_u) as PET divided by aggregate water deliveries to farm turnouts; conveyance efficiency (e_c) as aggregate deliveries to farm turnouts divided by the water turned into system main canals; 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 component 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.

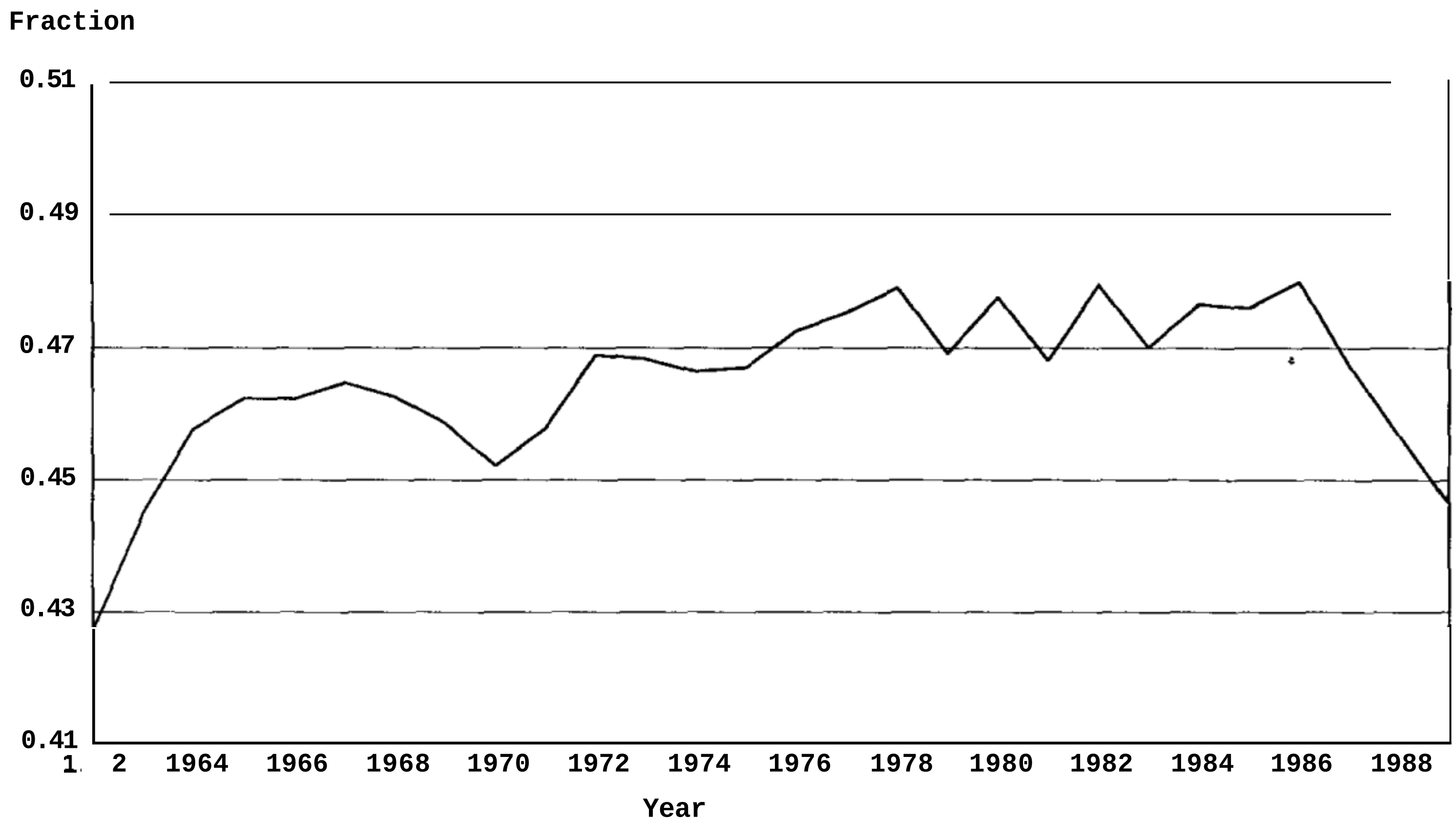
Figure 12 shows the overall efficiency (e_p) of the CBP over a 27-year period as a series of 3-year moving averages. Efficiency is defined as system-wide PET divided by the aggregate net supply turned into the three district main canals. It is seen that maximum efficiency levels are achieved in 1978, 1982, and 1986, well after the transfer to the 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.

When it is recalled that most of the CBP was turned over to the irrigation districts to operate in January of 1969, the following interpretation emerges. The early sixties was a period of rapid system expansion and learning for both the fanners and the USBR managers, resulting in steadily improving overall efficiency. When transfer took place in early 1969, efficiency of operation suffered, both because the districts were new to canal management, and perhaps because less predictable or reliable deliveries also affected fanners' 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.

To explore this interesting scenario further, we have disaggregated overall efficiency, and the two component efficiencies are shown in Figure 13 as 3-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, since 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.[31]

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

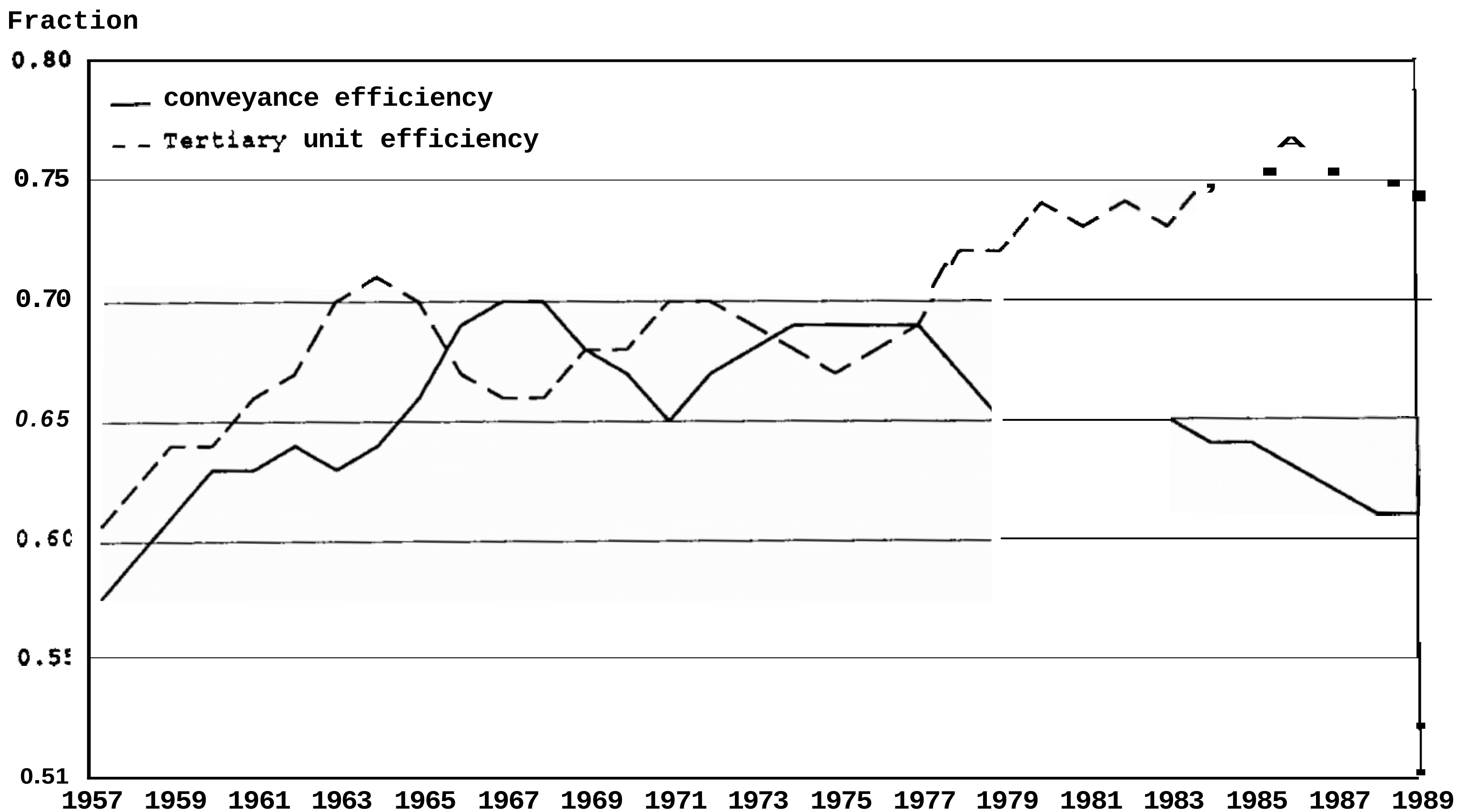
Figure 12. Overall efficiency for the three CBP districts, 1960-89 (3-year moving average).



Source: Water Distribution and Production Reports for the 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), 6-13.

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

Figure 13. Conveyance and tertiary unit efficiency for the three CBP districts, 1955-89 (3-year moving average).



Tertiary unit efficiency, on the other hand. also rose smartly from 1957 and then fell before beginning a 4-year rise in 1969, the year of the transfer, from 0.65 to about 0.70.[32] From 1975, 6 years into thedistrict-management period, until 1986, steadily rising tertiary-level efficiency offset falling conveyance efficiency, holding overall efficiency generally constant. As tertiary efficiency leveled off, however, and conveyance efficiency continued to fall, overall efficiency dropped 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* abour 6 years *before system* conveyance efficiency *was* restored ***to*** levels prevailing prior ro 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 he 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.

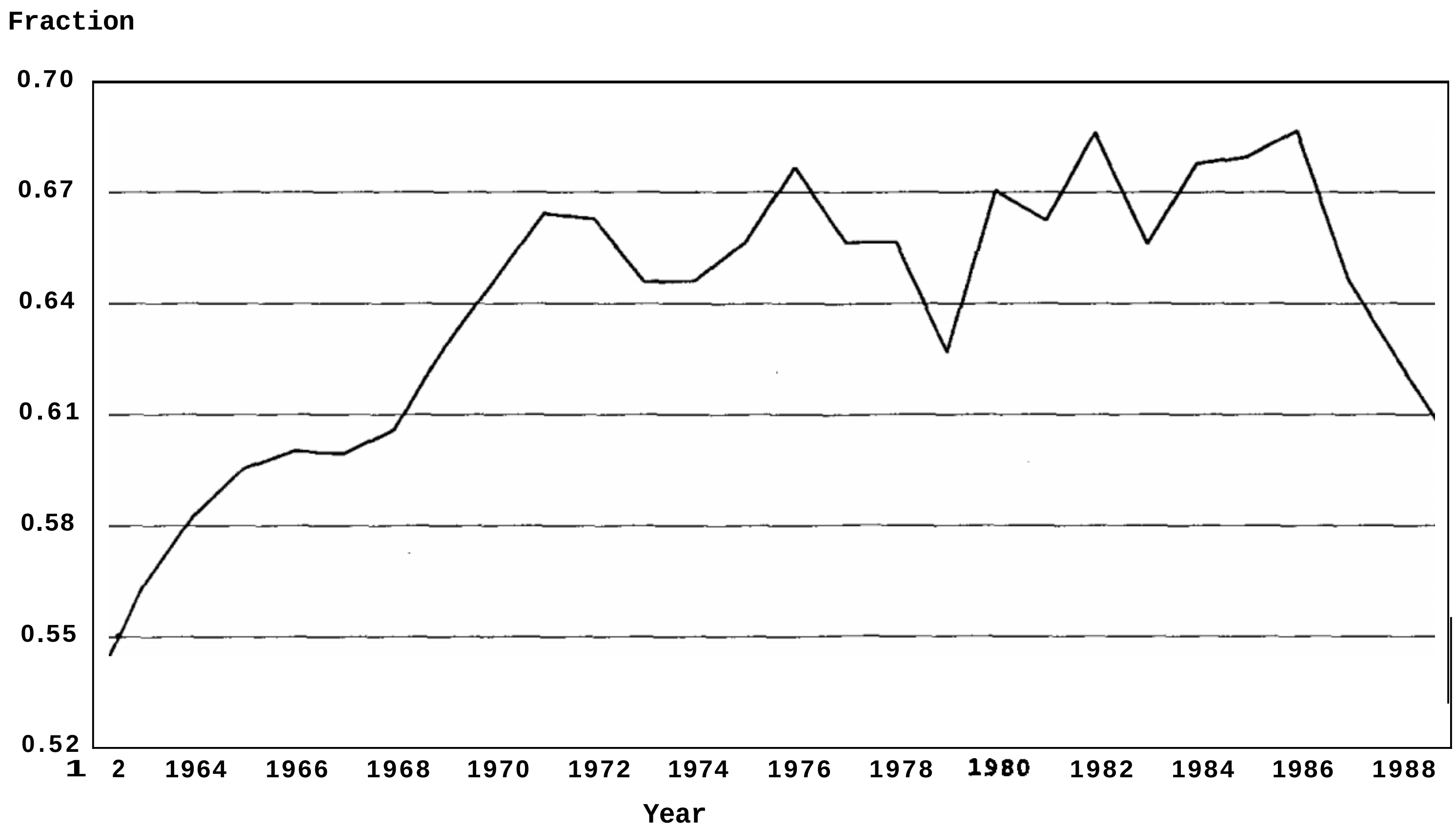
The long steady slide in conveyance efficiency which has lasted from 1975 until the present raises additional questions. First, is this a matter of concern to system managers? If quality of irrigation service to the CBP farmers has not suffered, it may he that reduced conveyance efficiency is a step 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 deferred 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 and the changed nature of that demand which has occurred since the early 1970s. In this case, more water in main canal systems is simply running to waste. A fourth alternative, related to the third, is that the shift from surface to sprinkler irrigation. with its different pattern of water demands, while saving water at the tertiary level, increases waste and inefficiency at the system level. These questions will be explored further in subsequent sections as additional information is presented to illuminate them from different angles.

One interesting and important point relating to system efficiency remains to be developed. It will be recalled that the South District obtains the bulk of its water supply from return flows from the two upstream districts. The overall efficiency calculations reported above fail to consider this effect and as a result reported, in effect, a set of weighted average efficiencies for the three subcomponents of the CBP. For the purpose of examining quality of management by the three districts, this was appropriate. If overall system efficiency is examined with respect only to virgin water inflows from the Columbia River, a somewhat different picture emerges,[33] as seen in Figure 14 where several things are seen. First, overall efficiency, instead **of** falling in the 45 to 50 percent range, is seen to range between 60 and 70 percent, a considerable improvement dependent simply

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

33 **Ignored in this discussion is the extraction and use of CBP-derived water by a groundwater district within the boundaries of the Quincy District. The source of this groundwater is acknowledged by both parties and compensatory payments are made by groundwater districts to the CBP irrigation districts. However, 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**

Figure 14. Overall efficiency for the CBP, considering reuse, 1960-89 (3-year moving average).



Source: Water Distribution and Crop Production Reports for the 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), 6-13.

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

on a revised frame of reference.[34] Second, there is a more pronounced increase in overall efficiency after 1969. amounting to about 5 percentage points. Finally, the sharp drop in efficiency after 1986 is still present. The story told by this figure is thus consistent with that presented in Figure 12 (p.62). In addition, it brings two additional features to light. First, it shows a more pronounced improvement in overall efficiency following management transfer, illustrating that dividing management responsibility among three independent entities does not necessarily impair efficient operation. In fact, quite the contrary seems to be the case here. Second, it represents more fairly (and more favorably), the overall efficiency of the system in comparison with other irrigation systems and with respect to potential efficiency levels. In an important and cautionary methodological teaching, it also illustrates the great sensitivity which measured system performance can exhibit in response to changes in boundary definitions.

FINANCIAL VIABILITY

Adjusting for Inflation

In the following financial analyses, three price indices were 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 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 fanners, both 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.

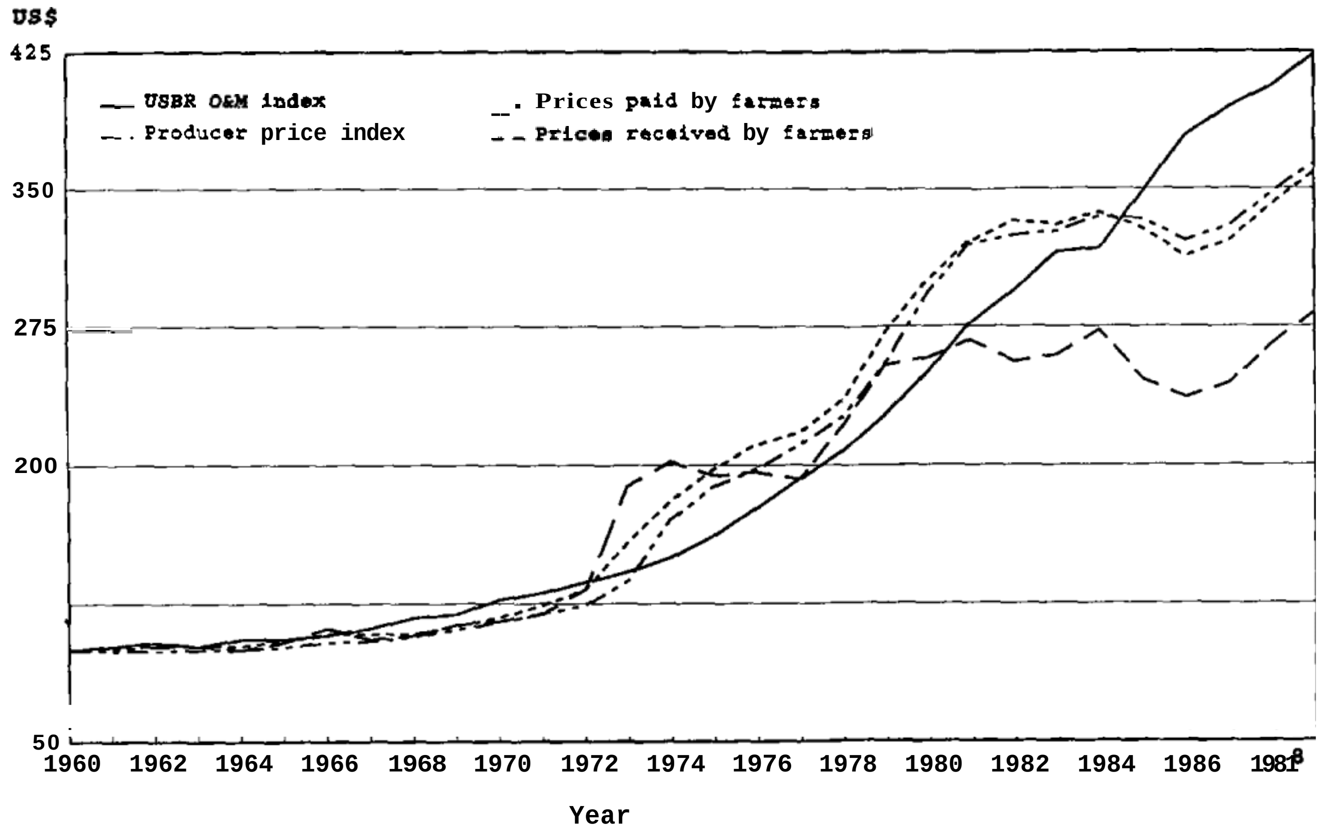
The USBR maintains its own deflator series for O&M expenditures, based on changes in per acre O&M expenses in a sample of its own projects. The USBR sample excludes projects whose total area varied by more than 20 percent from the previous year and whose O&M costs varied more than 50 percent from the 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 the 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 15. 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 USBR is preprogrammed for a particular level of inflation and therefore unresponsive to real outside events, or it is being driven upward by real cost increases in O&M expenditure in addition to inflationary ones. Consequently, the USBR index

34 Keller estimates the overall efficiency of irrigation water use along the lower Nile River Basin to be about 70 percent when the extensive reuse of canal-derived surface drainage flows and groundwater is considered. This would place it in approximately the same category as the CBP.

Figure 15. Comparative deflators for irrigation cost series. 1960-89.



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

Note: Indices adjusted with 1960 as base year.

was felt to be insufficiently independent of sampling biases and the impacts of red changes in system O&M costs to be used in deflating CBP O&M expenditures.[35]

Revenue

Total revenues to the districts averaged US$37.15 per acre (US$91.76 per ha), in constant 1989 dollars, for the 3-year period 1969-1971 immediately following the districts' takeover of operational responsibility. Revenues fell steadily over the next decade, reaching a low of US$25.53 per acre (US$63.06 per ha) for the 1979-1981 period. Income then rose again during the eighties, reaching US$31.09 per acre (US$76.79 per ha) in 1987-1989 (Figure 16).

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 16, total revenue closely tracks the water assessment curve during the 1969 to 1989 period, with some divergence toward the end of the period.[36] 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 to US$29.10 in 1968, the final year of the USBR 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. On average, the per acre water assessment fell by 21.9 percent between the pre- and post-1969 periods. On a per unit water basis, the cost of water fell 15.9 percent, from US$6.77 to US$5.70 per acre-foot, a drop which was smaller but still considerable.

It seems clear that the management shift triggered a series of reductions in real water assessment rates and reversed the rising trend which was prevailing prior to that time. Farmers, through their districts, appear to place a higher premium on holding down fee assessments than did the USBR. 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 16 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.

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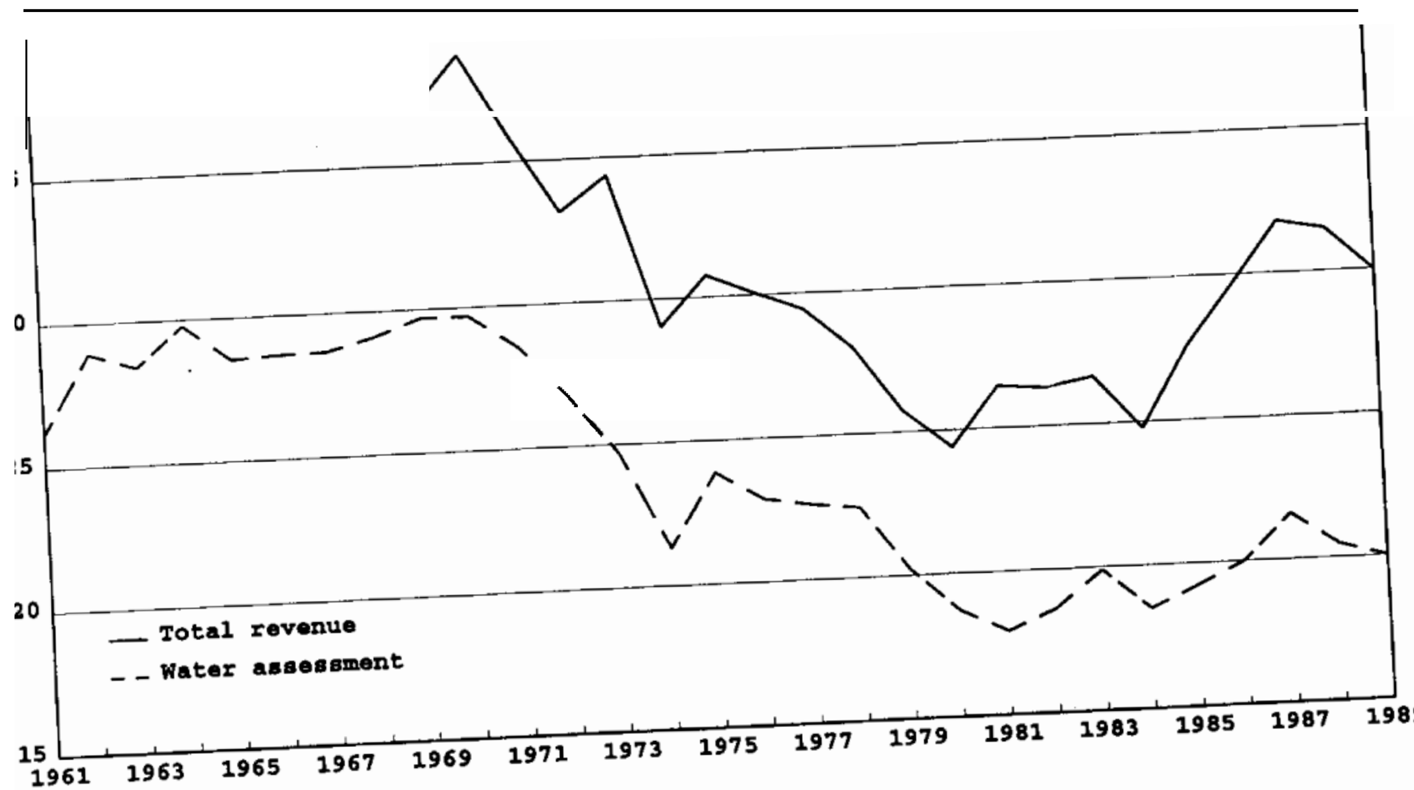
35 Note also that prices received by farmers leveled off in 1980 while other indices continued to rise steadily, highlighting the cost/price squeeze in which farmers were caught for almost a decade.

36 Although most of the water used in the South District comes from irrigation return flows collected in the Potholes Reservoir, water assessments in all three districts are very similar in magnitude, implicitly recognizing the mutual dependence of the three districts on a single source of water.

Figure 16. Revenue per irrigated acre, the CBP, 1961-89.



Source: U.S. Bureau of Reclamation and the CBP irrigation districts.

Note: Series adjusted with 1989 as base year.

Table 7 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?' 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 dismct. Beginning from a minuscule two-tenths of one percent in 1969, the share of income derived from water service contracts increased to nearly 6 percent of the total income in 1989, while land covered by water service constructs comprised about 9 percent of the total project service area. 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. The 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 7. Share of total revenue, 5-year averages, the 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 districts hove succeeded in diversifying their activities to generate a larger share of their revenue from sources other than their member farmers.*** Each now gets more than one-quarter of its total revenue from nonmember 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 have sold this water to other fanners on the margins of the districts, boosting revenue from water service contracts. ***Third, interest earnings have become an increasingly important source of income for the districts, suggesting prudent financial management and the accumulation of reserve funds.***

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37 For the period 1983 to 1989 for which more 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.

> *The generation of irrigation O&M revenues from secondary sources is also often important in developing countries. Irrigation districts in China generate income from fisheries, tree crop production in reservoir watershed areas and sale of water to municipalities and industrial concerns (Svendsen and Liu 1990). in Tamil Nadu, India, irrigators' associations auction fishing rights to tanks. In Indonesia, village-irrigation officials are allocated land usufruct rights for compensation for their services. In the Philippines, the semiautonomous National irrigation Administration obtains revenuesfrom equipment rental and interest on construction funds not yet spent (Small and Carruthers 1991:148-49). However, the weak legal bases for irrigators' associations existing in many countries may limit their ability to generate secondary sources of revenue.*

Costs

The cost of operating the CBP during the period 1960 to 1989 averaged US$28.43 per acre (US$70.22 per ha). Counted are financial (not economic) costs which include district operating expenses and the district payment to the USBR for operating and maintaining reserve works, but not subsidies provided through the USBR. 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 17 shows the behavior of operating costs over time. Immediately following the shift from the the USBR 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 5-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 USBR 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 USBR covered many of the costs involved, the districts incurred start-up costs of establishing or expanding offices, setting up databases and accounting systems, and the like.

In general, about three-quarters of the total operating costs (76 percent) are made up of district staff and O&M expenses (staff/O&M).[38] Payments to the USBR for "reserved works" O&M make up another 13 percent. and "other" costs amount to 10 percent of the total. The staff/O&M category 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. "Reserved works" includes payments to the USBR for operation, maintenance and repair of canals, dams, and pumping plants used in common by the 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.

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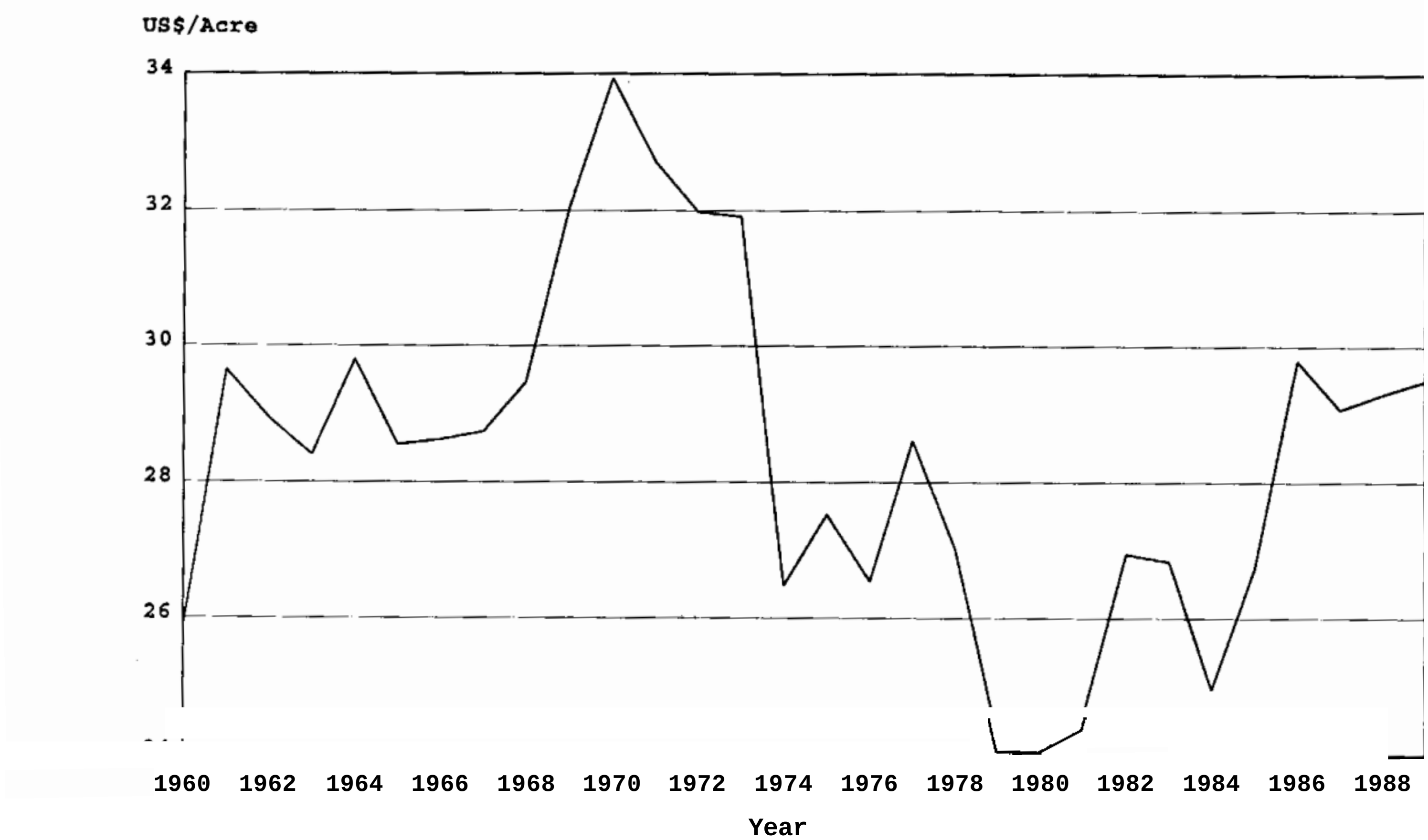
38 Given the various sources of the data used in this analysis, it was impossible to disaggregate this category in a consistent way.

Figure 17. Total expenditures per irrigated acre, the CBP, 1960-89.



Source: U.S. Bureau of Reclamation and the CBP irrigation districts

Note: Series adjusted with 1989 as base year.

Figure 18 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 19. 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 results, in part, from falling per-acre water-supply levels and consequent reduced power charges. This trend is mirrored, in more muted fashion, by "other" expenditures (Figure 20).

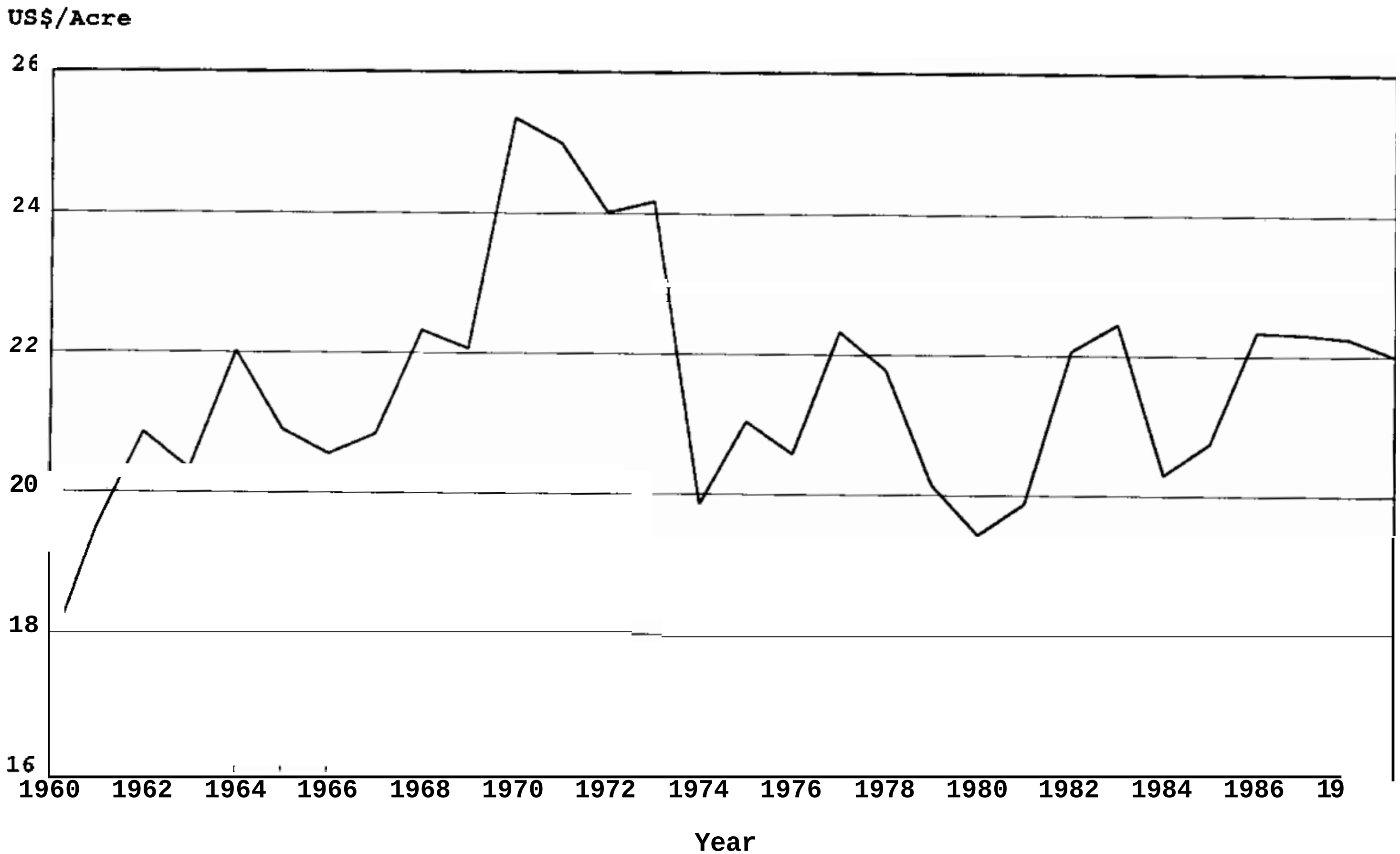
The general pattern which emerges is of relatively little permanent change in expenditure patterns as a result of the transfer of management to the districts. Staff/O&M and "reserved works" expenditures both experienced temporary transition period increases following transfer, following which staff/O&M costs settled back to their previous range while "reserved works" assessments continued to fall until the mid-1980s. The total O&M expenditures also show this transition spike and 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 the total expenditures hack to the level prevailing prior to the 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. The South District manager feels that his district is "over the line" and is deteriorating gradually. 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, if present, 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. In this case, 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 the annual farm profitability. From a farmer's perspective, profitability is the ultimate measure of the performance of his operation, hut it is a measure obviously influenced by a large number of variables besides the quality and cost of irrigation service. The major effect on the 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 greater impact on profitability, but this change was a farm-level decision and largely independent of the management transfer.

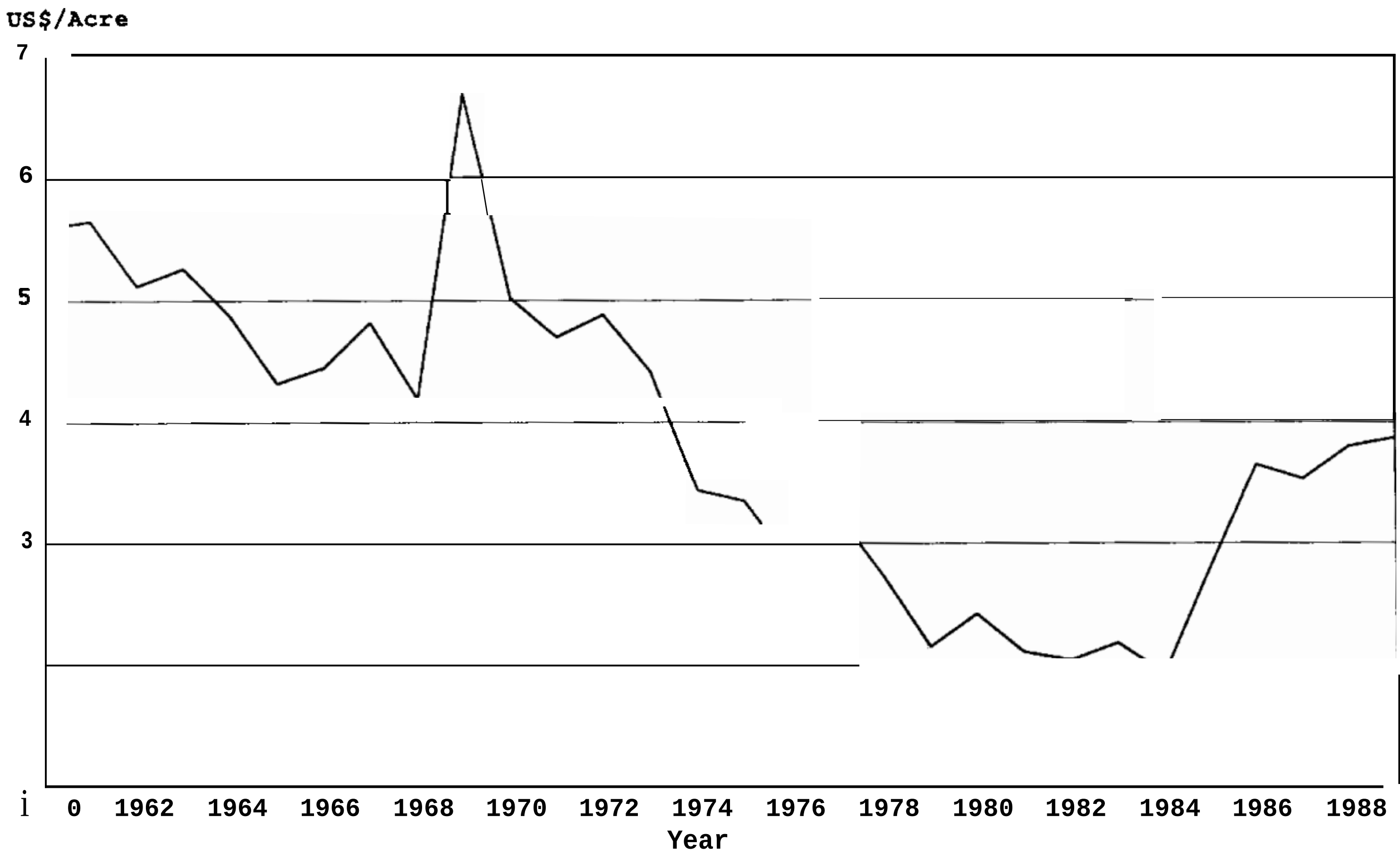
Figure 18. Per-acre expenditures on staff and O&M, the CBP, 1960-89.



Source: U.S. Bureau of Reclamation and the CBP irrigation districts.

Note: Series adjusted with 1989 as bare year.

Figure 19. Per-acre expenditures on reserved works, the CBP, 1960-89.



Source: U.S. Bureau of Reclamation and the CBP irrigation districts

Note: Series adjusted with 1989 as base year.

Figure 20. Other expenditures per acre, the CBP, 1960-89.

Source: U.S. Bureau of Reclamation and the CBP irrigation districts

Note: Series adjusted with 1989 as base year.

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 with returns in the imgated area of the CBP. The average annual net returns on the unirrigated land were US$6.54, in current dollars, 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. The East Side farmers had 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, in current terms. 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 16, the change in per acre assessment levels between the 1960s and the 1980s is seen to be about US$10 (in 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 would 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 the CBP farms have increased steadily, in real terms, since the project was constructed (Figure 3 [p.24]). Because the behavior of production costs is unknown, however, if is not possible 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 facilities and operations in each of the districts every two years. Such audits generally involve two or three days of field inspections by a team of USBR and consulting engineers.

Table 8 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, 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. No recommendations were 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 31 recommendations. Category 3 recommendations are for less important preventive maintenance work. Seven of the 37 recommendations were in this category.

Table 8. Results of the USBR O&M audits in the three districts of the CBP.

Number of Recommendations					
		New Recommendations			
Year/s	Previous Recommendations Uncompleted	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
Totals	13	0	30	7	37

Source: **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 recommendations covered a variety of types of work. Some of the more frequently made recommendations called for the repair of structures and mechanical devices, painting, better on-farm irrigation management–especially to prevent silt-laden farm run-off,[39] weed control, canal seepage control, and improving drainage capacity. Operational practices were rarely commented upon. All the districts were commended for the quality of their overall O&M practices. The 1986 audit report for the 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 the Quincy District commended the 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 the districts provided by the audits is positive. The number of recommendations is relatively small, given the total number of structures and the length of canals across the districts. The districts carried out a program of preventive maintenance which successfully kept the system from requiring emergency remedial maintenance. Still, facilities in at least one of the districts are deteriorating, in the opinion of its manager.

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39 **This recommendation was more common in the earlier audits**

Attitudes toward maintenance appear to have changed somewhat over time, at least in some districts. Under its first manager and board, the South District operated under a "breakdown maintenance" philosophy. After 1984, following changes in board membership, more emphasis was placed on preventive maintenance. Availability of power revenues as an income source after 1985 is said to have made the directors more ready to spend for maintenance. That philosophy continues. In the words of the present manager, "I would rather tell a group of fanners how I spent their money than why I couldn't deliver water."

Such maintenance audits also occur in developing countries. In one large system in the Philippines, the managers of the four divisions of the scheme jointly tour the scheme once a year and a trophy is awarded to the division which the managers agree was the best maintained. Often, maintenance audits are treated rather casually, as in parts of India, for example. On the other hand, if O&M auditing becomes roo overbearing, it can interfere with the decision-making autonomy needed by irrigators' associahons. This appears to have been the case in Colombia, South America, where the irrigation agency, HIMAT, continues to review and approve annual O&M workplans and budgets in systems where management transfer has taken place (Vermillion 1993).

The question of the drop in conveyance efficiency beginning in 1975 remains, however. Attributing such a change to particular causative factors is difficult, because 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 8 offer a proximate variable between O&M expenditures 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 consistent with the timing of the decline in conveyance efficiency shown in Figure 13 {p.63}. This offers limited support to the idea that O&M expenditures ought to be increasing if efficiency declines are to be arrested.

CHAPTER 6

Summary and Conclusions

THIS CHAPTER FIRST draws together and summarizes the results of the analysis of the impacts of the transition to farmer management in the Columbia Basin Project. It organizes the discussion into four topics—technology adoption, hydrologic performance, financial performance, and farm profitability—and then offers several general conclusions. The chapter goes on to identify conditions believed to have influenced and facilitated the successful transfer. Finally, it suggests important lessons for those attempting similar transfers in developing countries.

IMPACTS OF THE TRANSFER

Technology Adoption

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

Causes and effects 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 more efficient sprinkler systems per se. However, it is quite likely that the installation of center pivot sprinklers 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. Additionally, the district managers assert that the shift to center pivot irrigation, though motivated by private benefit/cost considerations, has also had implications for main system management, requiring less-frequent changes in turnout settings, but causing larger, more-abrupt changes in demand, leading to increased main system losses.

Hydrologic Performance

The quality of irrigation service received by the CBP farmers does not appear to have been affected significantly by the change to the district management. The quantity of water delivered did not change markedly after 1969 and reductions in water supply in later years can be explained largely by reductions in aggregate water demand resulting from changing cropping patterns. Demand-adjusted equity of water distribution among the districts did decline in the 1970s and 1980s following transfer, but then improved again and, on average, equity at the district level was about the same before and after the 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 the transfer and generally rate this aspect of service highly.

An examination of the hydrologic efficiency of the system reveals some interesting changes. It appears that the system's new managers required a period of 5 or 6 years after the transfer before they were able to operate the conveyance system as efficiently as did the USBR prior to the 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 somewhat puzzling aspect of system hydrology is the continuing 15-year decline in conveyance efficiency which set in in 1978, accentuated by a strong upward surge in the amount of water turned into the districts beginning in 1986. This recent increase is not reflected either in the supplies actually delivered to farm turnouts or in any change in the crop-based demand for water, both of which have held constant. Possible explanations for the overall deterioration in system conveyance efficiency include, (a) deterioration in the condition of major system canals resulting in increased conveyance losses, (b) inability of system managers and the infrastructure to adapt fully to changes in water application technology and cropping patterns and calendars, (c) increased water orders to the USBR to allow greater power generation by turbines installed in system canals, and (d) increased water orders to the USBR to make management easier and reduce staff costs.

Evidence from the maintenance audits conducted by the USBR, supplemented by statements by project managers, lends support to the idea that system facilities are deteriorating. Whether or not this has resulted in increased conveyance losses is not known with certainty but this is reasonable to assume.

The second possible explanation is based on statements made by project managers and is also a reasonable one. Managers argue that limitations imposed by system design constrain their ability to respond to the fluctuating patterns of water demand generated by center pivot operation. Conversion to sprinklers may have been a contributing factor to the decline in conveyance efficiency; however, the pattern of conversion, with its period of most rapid growth in the early 1970s and relatively little change since 1980, does not match well the pattern of decline in conveyance efficiency. Some of the decline of the 1970s may be attributable to this cause, but other factors are obviously at work during the 1980s as conversion to sprinklers and tertiary unit efficiency leveled out while conveyance efficiency continued to decline.

In considering the third scenario, it is noted that power generation by the districts began only in 1985, well after the decline in overall efficiency commenced, 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 the gross income they earn from the commercial sale of the power they subsequently generate. It would thus be quite rational for them to increase their water orders to the USBR to increase revenues from the sale of power while simultaneously holding down the water rates assessed district members. The sharp increase in deliveries to the districts beyond 1986, coinciding exactly with the onset of power generation, is highly consistent with this scenario. 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. Both the district managers and the USBR operations personnel deny strongly that water supply increases have been driven by this motive, but the financial benefit to the districts is clear and no convincing alternative explanation for the increase is apparent.

Financial Performance

Upon assuming management responsibility, the districts moved quickly to cut water assessments to the district members. On average, real per acre assessments under the district management were only 78 percent of their level during the USBR period. At the same time, the 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 nonmembers 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 prevailed had the USBR retained operating responsibility, the USBR's agency-wide O&M cost index provides one clue. It shows that the cost of operating the USBR 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 USBR's cost index has grown to a higher level than more general cost indices, suggesting that the CBP operating expenses under the USBR 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 reserved-works expenditures and administrative and other costs.

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 USBR do not enter the argument, since the observed decline in conveyance efficiency occurred within the districts' areas of responsibility. It remains possible that, while the 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 shows an increasing number of problems being flagged in recent years. This would suggest that ***if O&M expenditures continue to hold constant, system deterioration will continue*** and that more general rehabilitation will be required in the future.

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 the districts assumed management responsibility.*** This is very roughly estimated to comprise about 15 percent of the average net farm income.

General Conclusions

From many angles, ***the transfer of management from the USBR to irrigation districts in the Columbia Basin Project can be considered a success on a large scale.*** While the USBR was able to back out of its partly unwanted role in O&M, the districts gained local control over management and costs. This was an extended process, beginning in 1939, 13 years before water began flowing through the irrigation system, and culminating with the signing of the transfer agreements 30 years later. Analysis indicates that ***the project has not suffered significant negative impacts due to management transfer*** in the areas of quality of irrigation service to farmers, management efficiency, agricultural productivity, or farm profitability. At the same time, ***the real level of water charges, on both areal and volumetric bases, has fallen substantially.*** The effect of the transfer on the long-term sustainability of the system is less clear, and there is some indication that ***the physical system may be experiencing some net deterioration.***

> ***Similar to the situation in many developing countries, the implementation of the project was marked by many delays.***

The idea of an irrigation scheme on the Columbia was evaluated repeatedly over a period of 30 years before construction was finally authorized. After that it was another 20 years before water started to flow, and yet another 20 years before lands under the first phase of the project were fully utilized. Even today, 60 years after construction began, half of the originally planned project remains unbuilt.

Still, it is impressive that management of irrigation for more than half a million acres (200,000 ha) can be handled by three local irrigators' organizations. Indeed this is a recurring pattern throughout the American West, even on larger scales. The King's River Irrigators' Association near Fresno, California, for example, successfully services an area more than twice as large as the CBP. To conclude this discussion, some of the factors which characterized the context of transfer in the CBP are identified, and areas which seem to require particularly close attention in undertaking such transfers in a developing country context are pointed out.

ENABLING FACTORS

Policy Context

The established federal government policy mandating transfer to farmer management of all irrigation systems constructed by it gave the transfer an air of inevitability. It also meant that considerable experience with the transfer process had accumulated before transfer was attempted in the CBP. ***Farmers were brought into the picture at the outset*** through their irrigation districts. Their agreement to participate in the project, to undertake partial capital repayment, assume eventual management of the project, and to cover the "full" cost of O&M (which in fact is only partial) was required. The offer could be refused and was, in fact. refused by some. The legally binding nature of the agreements reached no doubt strengthens the legitimacy of the districts in the farmers' eyes and permits strong sanctions to be applied by the district on its members when required.

Federal policy also requires a continuing USBR presence in the project as a repository for the project water right, the legal owner of the system physical facilities, and provider of ultimate oversight. This presence is also valued by the districts as it offers certain sovereign immunities and an ongoing relationship with the USBR. The "partnership culture" between the districts and the USBR permitted joint problem-solving during the transfer, leading to a mutual decision to continue USBR management of jointly used reserved works, contracting by the districts for technical work to be performed by the USBR staff, and the creation of satisfactory USBR-to-district personnel transfer arrangements. The relationship is currently being utilized in implementing a program of artificial drainage installation within the project and could possibly facilitate future assistance for system rehabilitation or major repairs.

Federal water resource policy allows ***cross-subsidization of irrigation construction costs by power revenues*** and this tends to increase the profitability of irrigated agriculture under the **USBR** projects. In addition, by providing power for lifting water at rates which are many times less than current market rates, the government continues to subsidize system operating costs. However, within this overall context, the irrigation districts are required to operate with balanced budgets.

Perhaps most importantly. ***federal irrigation policy has remained fairly constant since its inception.*** Although there have been changes in particular features from time to time, the basic outlines and the principle of system management by financially autonomous irrigation districts have remained. This consistency provides farmers with the confidence to make investment decisions and other longer-term commitments which might otherwise seem excessively risky. It also provides the assurance that private investments which they might decide to make will not be duplicated or provided to others at no cost at some future date.

Social Context

By contrast to the situation in many developing countries, the project area consisted originally of a ***relatively homogeneous population*** of settlers who were well-educated and commercially oriented. There were few landless poor or others with insecure tenure resident in the project area, although in the beginning, some landless settlers arrived and were allocated land. Fanners were experienced at creating voluntary associations for a variety of purposes and appreciated the usefulness of joint action. ***Fanners and their districts had considerable legal undpoliticul power and secure land and wafer rights.*** Farmers were able to negotiate as equals with the government and obtained numerous favorable concessions for themselves, such as low power and construction repayment rates and relaxed limits on farm sizes. Such concessions ensured that fanning would be a relatively stable and profitable enterprise. Initially, fanners employed their considerable political clout to influence the **USBR** decisions through their elected national representatives. More recently, fanners have begun to rely more heavily on legal action to pursue and promote their interests in the public arena.

Institutional Context

A number of important institutions undergird the successful assumption and execution of management responsibilities by the three CBP irrigation districts. Fundamental is the existence of ***a reliable system for specifying, allocating and recording rights to the use of water.*** Without this, it is unlikely that fanners would have been willing to assume responsibility for the common irrigation facilities and make the requisite corollary private investments in on-farm equipment and facilities. The ***strong legal basis underlying the creation of quasi-municipal irrigation districts*** also contributed to the successful devolution and management by the districts. The relative autonomy of the districts allows them flexibility to control costs and todiversify sources ofincome. The relationship between the **USBR** and the districts rests on a set of repayment ***contracts*** which spell out the duties and obligations of each party. The legitimacy and enforceability of these contracts is an important feature of transfer. Supporting and enabling all three of these institutions—firm water rights, legally constituted quasi-municipal irrigation districts, and contract law—is a relatively ***impartial andaccessible legal system*** which provides a mechanism for enforcing contracts and adjudicating disputes.

Another area in which underlying institutions are important is that of financial probity. The state, which charters the districts, requires that regular audits of the district accounts be carried out by certified public accountants. This system of ***mandatory external audits*** is another important element in the institutional environment facilitating the viability of the irrigation districts.

The USBR

The US Bureau of Reclamation has been characterized by a high degree of competence and professionalism both before and after the transfer. The USBR staff receive salaries which provide for an adequate standard of living and enjoy job security under the federal civil service system. That security was preserved during the transfer process, since most ***staff were transferred*** to ***new positions with the districts,*** retaining former salary levels and insurance and pension benefits. The remaining staff were reassigned elsewhere, accepted early retirement, or were given new roles within the USBR. These steps no doubt helped limit opposition on the pan of affected USBR employees which might otherwise have been considerable.

It is noted that the USBR is not financially autonomous, in the sense that its operating expense budget is unconnected with the revenue its activity generates, while the three CBP irrigation districts do meet this criterion. ***Financial autonomy of the fanner districts has been an important incentive to both manage the system cost-effectively and keep a reserve fund*** for future repair and rehabilitation.

> ***Financial autonomy of the managing entity has been a key attribute of effective irrigation service providers in developing countries (Small and Carruthers 1991; Svendsen, Adriano, and Martin 1990) and appears to play a critical role here as well.***

Irrigation System

The physical elements and basic operating rules of the imgation system also form a relevant part of the transfer context. First, the system has an ***ample and reliable water supply.*** Second, ***allocation has been capably handled*** on an arranged-demand basis both before and after the transfer. This permits considerable flexibility and responsiveness to market conditions by farmers in choosing crops and cropping patterns. Third, there are ***clear points of demarkation of responsibility*** and control where transfers of ***measured quantities*** of ***water*** are undertaken according to ***widely accepted agreements and rules,*** including payment rules. Deliveries to districts and to individuals are thus treated as contractual obligations and water is regarded as an economic good rather than a social entitlement. Fourth, the system has ***adequate conveyance capacity*** to deliver required amounts of water throughout the system. Fifth, ***system physical facilities were upgraded*** as a part of the transfer agreements and were received by the districts in good working order. The transfer was thus not the disposal of a dilapidated public property, but rather the concessional sale of a valuable and productive asset. Additionally, much of the technical expertise needed to operate the system was transferred with it through the hiring of the USBR staff members by the districts.

LESSONS FOR TRANSFER IN DEVELOPING COUNTRIES

Lessons which can be taken from the CBP experience for use in developing-country settings can be grouped into two categories. The first of these comprises policy and institutional issues which can affect the success of a transfer program. The second relates to the process of transfer itself.

Policy and Institutional Issues

An assessment of the relative effectiveness of the various policies and conditions supporting the successful transfer of management responsibility in the CBP is beyond the scope of this study.

Moreover, large public irrigation systems occur in a tremendously wide range of situations around the world, and even if such an assessment were carried out, the lessons learned could not be conveyed directly to new settings.

Nevertheless, it is possible to identify from the preceding analysis some policies which appear to have been influential in enabling a successful transfer of management responsibility. Some of these factors will be important only in the context of this particular case, or a relatively narrow range of cases, while others will have more wide-ranging importance. Listed below are policy conditions which are judged to be important and to possess a measure of general applicability. They are recommended not for immediate and uncritical implementation but for careful consideration of their relevance for particular situations by planners and managers of management transfer programs in developing countries.

- Put in place a clear and *consistent policy* mandating irrigation management transfer. Transfer is a slow and deliberate process, and basic outlines of policy governing transfer must remain relatively constant for an extended period to elicit desired responses. Where policy on transfer shifts repeatedly, meaningful and sustainable change is unlikely to occur. On the other hand, the USBR experience in general, and the CBP experience in particular, demonstrate that where sustained commitment to the practice of transferring system management responsibility exists, the process can work effectively.

- Do not *expect full cost* recovery (capital and operational costs) in the first instance. In most cases, such insistence will result in such a drastic upward revision in the farmers' payment obligations for irrigation service that any proposed management transfer program will be swamped in a sea of political unrest. Cross-subsidizing irrigation service delivery costs with other water-resource-related revenue streams, such as power generation or aquaculture, is a practicable way of accomplishing this.

- *Mandate financial* autonomy for the managing *entity*. This has been shown to be effective and critically important in a wide variety of circumstances in both higher- and lower-income countries. Causing the irrigation district or fanners' organization to generate sufficient income to cover its costs in operating the system provides an essential set of feedback links needed to make system management accountable to its members. It is not necessary that no public subsidies be involved, but only that they be specified in such a way that they do not increase automatically to make up shortfalls in revenue from irrigation operations.

- Provide a strong legal basis for irrigators' organizations

- Provide a system of secure *and* well-specified *long-term* water rights which can be assigned to irrigation systems to offer security for investments of time and money.

- Invest to bring physical facilities up to standard. Experience in a number of countries, including the United States, has shown that programs which couple physical upgrading with transfer are most likely to succeed

- Create a fair and accessible professional auditing system and mandate its use by managing organizations. This system can be established in either public or private sectors, but should be carefully regulated to ensure its integrity.

- ***Provide new employment or compensation for displaced irrigation agency staff.*** Civil service employees of public inigation agencies often have considerable political influence and must not see themselves as losers in the transfer process. They should be integrated into the planning for the transfer and compensated for lost employment through early retirement inducements or transfers to new positions.

Process Issues

The following issues relate to the processes employed in facilitating management transfer. Some of these have policy and institutional implications as well which should not be ignored. Although there is a well-developed literature and body of experience with the process of organizing farmers into associations (FAO 1985; Uphoff 1986; Korten and Siy 1989; Upboff 1992), less attention has been devoted to some of the other factors listed below.

- ***Involve farmers early on in the planning for the transfer.*** Real participation and involvement in "agenda setting" among farmers in the transfer process are essential for successful assumption of responsibility.

- ***Empower farmers*** by giving them the role and status to successfully negotiate with the public irrigation agency. This is difficult to do, though one new approach worth exploring is the vesting of farmers' groups with water rights, rather than granting them to the managing agency.

- ***Use contracts*** between irrigator groups and the managing agency to specify roles and responsibilities. This can be a very powerful tool as it implies a voluntary relationship between equals and creates mutual obligations and rights, i.e., mutual dependencies.

- Develop a locally appropriate water allocation system with ***volumetric measurement and payment*** at some level. Measurement does not have to be at the level of the farm turnout, as in the CBP, but can apply to groups of farms and farmers.

- ***Provide experience*** with organization and management for farmers and fanner leaders. This is a central subject of the farmer organizational literature mentioned above.

- ***Provide assistance*** to operating agencies to improve management and human relations skills. Technically trained personnel often lack this kind of expertise which they need to work effectively in a decentralized management environment.

- Specify an ***ongoing role for the operating agency*** in "partnership culture" with the farmer-based organizations assuming management responsibility. Experience has shown that there often remain tasks which a public agency is better equipped to perform. Relative comparative advantage should be clearly identified and means for continued cooperation worked out.

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Appendix

Outline of the Conceptual Framework for Evaluating
Irrigation Performance

I. DELINEATING BOUNDARIES ON WHAT IS TO BE EVALUATED

A. System
1. Irrigation system only
2. Irrigated agriculture system (including irrigation system)
3. Other systems (including irrigated agriculture system)

B. Irrigation subsystems (system functions)
1. Acquisition
2. Distribution
3. Application

C. Life-cycle processes
1. Planning
2. Design
3. Construction
4. Operation
5. Maintenance
6. Support

D. Geographic extent
1. Physical basis
   a. Design area
   b. Service area
   c. Net irrigated area
2. Social basis

II. DELINEATING TYPES OF EVALUATION. CONCEPTS OF PERFORMANCE ASSESSMENT

A. Models of performance
   1. Goal-oriented
      a. Goals of society
      b. Goals of external constituents
      c. Goals of internal constituents
   2. Natural system

B. Rationale for assessment
   1. Operational performance monitoring
   2. Accountability
   3. Intervention

C. Types of performance measures
   1. Level
      a. Process
      b. Output
      c. Impact
   2. Scope
      a. Achievement
      b. Efficiency
   3. Relationship to conceptual indicator
      a. Direct
      b. Indirect

D. Source of performance standards
   1. Internal
   2. External
   3. Relative

E. Time dimension of assessment
   1. Single point in time
   2. Multiple points in time

Source: **Small, L. E. and M. Svendsen, *A framework for assessing irrigation performance*, Working Papers on Irrigation Performance 1 (Washington, DC: IFPRI, 1992).**