Description of the Salt River Project and impact of water rights on optimum farm organization and values

DESCRIPTION OF THE SALT RIVER PROJECT AND IMPACT OF WATER RIGHTS ON OPTIMUM FARM ORGANIZATION AND VALUES

by

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STATEMENT BY AUTHOR

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This study pertains to the Salt River Project in Central Arizona, located in an arid area where precipitation averages only eight inches annually. The Project provides water to land within its boundaries according to water rights of each parcel, and produces electric power, the revenue of which is used in part to subsidize irrigation. The objectives of the study are: 1) to outline the organization and operation of the Project and 2) to analyze the effect of water rights on farm organization and land values.

The Project, comprised of Power District and Water Users' Association, is controlled by a board of governors elected by the shareholders. The administration consists of a general manager, two associate and three assistant general managers for the Power District and one associate general manager for the Association. The latter has five departments, watershed, irrigation operation, irrigation service, engineering

and construction and maintenance, their function being to provide and deliver water to water right holders.

Water rights are of three types: right to normal flow with priorities varying from 1869 to 1909, rights to stored and developed water and rights to pump water. Some farmers also own private wells.

Using four typical water situations, a budget analysis was made of a typical 360 acre farm, using estimated current (1965) and anticipated future (1975) input-output relationships, and alternative acreage combinations of crops. Under current conditions water rights probably have no effect upon the cropping system but probably do affect land values. With cost-price relationships and adoption of technology estimated for 1975 water rights would have an effect on both the cropping system and on land values.

CHAPTER I

INTRODUCTION

When a visitor first comes to Tucson, his attention is quickly attracted to its arid climate and desert vegetation. He will see xerophetic plants, mainly the cactus, and stipulate-leaved plants wherever he goes in the mountain area. All "rivers" that one sees in the valleys are nothing more than dry river beds. Yet, in spite of this, he reads that the Arizona farmer leads the nation as far as returns per farm are concerned,[1] and also that Arizona is an important cotton-producing state. All these things seem to be conflicting. How can an arid place like Arizona with rainfall rarely exceeding eight inches in most of the state produce high farm income and be considered as a major cotton-producing area? One soon learns that irrigation plays a vital role, and that irrigation districts are an integral part of the economy of the state.

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1. Elmer L. Menzie, "Arizona Farm Income leads Nation," <u>Progressive Agriculture In Arizona</u>, March-April, 1964, Vol. XVI, No. 2, College of Agriculture, University of Arizona, Tucson, p. 5.

"In 1962, realized net income per farm in Arizona was $18,142 (net income includes interest on owned capital). The nearest competing state was California with $8,476; the United States average is $3,414."

Description of the Salt River Project

This study pertains to the Salt River Project in Maricopa County, in south central Arizona. Maricopa County is the major agricultural county of the state, having 40 percent of all the irrigated land. The Salt River Project includes a substantial portion of the Salt River Valley and about 43 percent of the irrigated land in Maricopa County.[2] The Salt River Project (hereafter referred to as the Project, except where the full name would add clarity) has an area of about 375 square miles or 240,000 acres. As of 1962, 165,575 acres were under cultivation, 65,000 acres were in residential, commercial and industrial subdivisions, and the remaining 94,250 acres were in farmsteads, ditches and roads. Within its boundaries are the eight incorporated communities of Phoenix, Mesa, Tempe, Scottsdale, Chandler, Glendale, Peoria, and Tolleson.

The climate of this area has favored the production of regular field crops as well as those more intensively cultivated, such as citrus and truck crops. In winter months, the average maximum temperature is in the middle or upper fifties and readings above 60 degrees are not uncommon. Summer temperatures are among the highest recorded in the United States. The average monthly temperature is above 80 degrees. The frost-free period is approximately 300 days, which facilitates

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2. United States Department of Commerce, Bureau of the Census. United States Agriculture Census, Arizona State, 1959. Also, Salt River Project Crops Reporting, Salt River Project, Phoenix, 1959-1963.

production of a wide range of crops. The average dates of last killing frost in spring vary between late January and early February, while those of the first killing frost in autumn vary between late November and early December.

Precipitation varies from year to year, with an average of eight inches in the Project area. In the mountainous area of the Salt River watershed, precipitation is greater, with an average of 20 inches of precipitation. This watershed precipitation is important for the flow of the rivers and supply of surface water. Winter precipitation is normally much gentler but longer lasting than that of summer. It is associated with storms that move into Arizona from the north Pacific Ocean.

Irrigation in the Salt River Valley is not new. Shadowy tracings of canals over the valley are estimated to have existed since 200 B.C. Because of climatic changes and variability of the water supply, these old cultivators were compelled to abandon agriculture.[3]

As early as 1869 new settlers came to the West and are referred to in the American literature as the pioneers. At that time, the Salt River Valley again enjoyed a certain degree of success through irrigation. Yet the same risks of water shortage that faced agriculture in the pre-Christian era remained. Proper water storage facilities were still lacking.

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3. Salt River Project. Major Facts in Brief. Phoenix, Arizona, 1961.

It was with the dedication of Theodore Roosevelt Dam in 1911 that the Project began to play an important role in the economy of the valley. The years succeeding 1911 witnessed the completion of five more dams. With these dams, the uncertainty of water supply that characterized the agriculture of earlier periods is no longer a problem facing the farmer of the twentieth century. A dependable water supply has been made available to project water users. The water supply has been allotted to each farmer according to the water rights each farm possesses.

The continuity of agriculture year after year in the Project is made possible through the successful operation of this project. How the Project is able to meet its obligations of securing an adequate water supply year after year and at low cost defines the important role it is playing in the economy of the Salt River Valley and of Maricopa County. The water supply is limited to two sources, viz. the surface water supply primarily provided by the watershed area, and the underground water supply provided by the underground water.

Agricultural activities are also undertaken by other irrigation districts in the valley who also have some rights to the surface water and/or the underground water. Because of heavy pumping by all agricultural districts, the water table is declining year after year with the effect that pumping costs per acre foot of water are also increasing. These restraints on underground water and surface water make it more difficult for the Project to secure an adequate water supply for its shareholders.

Net revenues involve returns and costs. In the Salt River Valley, water costs are a factor affecting the progress of agriculture. Increases in water costs naturally cause production costs to increase. When these water costs continue to increase over time, the production costs will also continue to increase and unless the gross returns are matched by equal increases or more, the returns over the production costs will continue to decrease.

The apportionment of water supply to the various parcels of land is done in line with the water rights each farm possesses. The type of water rights (assessment, normal flow, etc.) vary from one parcel of land to the other. Variations in type of rights involve also variation in water costs. Pumped water is more costly than surface water, and "excess" water and normal flow water are more costly than water from assessment. Variations in water rights among farms may have an effect on farm organization and operation. They may have an effect on farm decision-making as to what crops to grow and how much, in order to maximize farm returns from the water available to the farm.

Literature Review on the Problem

Very few studies have been made with regard to the important role of the Project in agriculture and its operation in fulfilling this role. The Project has published a small bulletin stating the major facts in brief.[4] This bulletin, however, does not go into the nature, operation, and organization of the Project, factors which are believed to have a bearing on water availability and cost. Other material may be found in short articles in newspapers and magazines. This material does not cover any one portion of the problem in detail.[5] As to the effect of water rights on farm organization and operation and the impact of these water rights on the cropping system, no analysis has ever been made.

Objectives of the Study

This study has two objectives: First, to investigate the nature, organization, and operation of the Salt River Project and the different water rights belonging to land in the Project. The supporting objectives to this objective are:

a. To describe the nature, organization, and operation of the Project.

b. To describe the different sources of water available to the Project and the variability of supply from these sources.

c. To describe the methods and practices used by the Project in

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4. Salt River Project, Major Facts in Brief, Salt River Project, Phoenix, Arizona, 1961.

5. Stephen C. Shadegg, The Phoenix Story, an Adventure in Reclamation, Phoenix, Arizona.

order to maintain and make available water supply for agricultural use.

d. To describe the water agreements between the Project and other districts or parties having rights to water.

e. To describe the water rights within the Project and the classification of these rights.

The second objective of this study is to analyze the impact of water rights on farm organization. This objective is investigated at two points in time, 1965 and 1975.

The choice of the two periods included in this study is made in order to bring forward the effect of water rights in an immediate future period, 1965, when there is little or no change and this effect ten years in the future, 1975, when some changes in production, costs and returns may take place. Moreover, analysis in these two periods will give the farmer a basis for judgment when analyzing the future aspects of his farm business.

Accomplishment of the above objective involves the following aspects:

a. Determination of the production costs per acre for each crop with each water source. (The term "water source" is introduced to distinguish water from assessment, excess, normal flow, project pump, or private pump (taken separately from each other) from the term "water situation" which is defined to mean a combination of these water sources at the farm level.)

b. Determination of yields, commodity prices and gross returns per acre for each crop.

c. Determination of returns over variable costs per acre for each crop with each water source.

d. Determination of the most profitable crops for the area and ranking them on the basis of their highest returns over variable costs per acre with each water source.

e. Determination of the most profitable cropping system for each water situation.

f. Determination of the returns to real estate in each water situation. These are defined as the returns over and above the variable costs, overhead cash costs and overhead non-cash costs other than land.

g. Determination of the indicated value of land (from the income approach) and noting the changes in this value if any, between the two periods chosen in this study.

Procedure

The procedure used in carrying out the first objective is to describe what has happened or what is happening. Description of the various aspects of the Project pertaining to the availability of water, operation and organization of the Project is done in fairly complete detail.

In carrying out the second objective, budget analysis was made of a typical medium-sized commercial farm of 360 acres. Assuming different water situations typical of the project, the analysis is made in terms of the two periods, 1965, and 1975. Resources which are not varied in the 1965 period are land, "assessment water", improvements, machinery, and management. Water other than assessment is variable because the farmer can buy any amount he wants within the limits provided by the water rights of his farm. This period, however, is long enough to allow variation in the quantities of such resources as labor, fuel and oil, repair and maintenance for the machinery, and raw materials such as seeds, fertilizers, and insecticides.

In the 1975 period, factors of production were classified as fixed and variable, the same as in the 1965 analysis. It was assumed that farmers would be operating with a complement of fixed resources, including machinery, similar to 1965. Adjustments were made in some of the production, price and cost items as explained in detail in Chapter III to account for anticipated relative changes over the decade.

The same calendars of operations for crop production are assumed to prevail in each of the water situations. The operating costs however, may differ depending on the type of water used in each water situation.

Presently known technology is assumed for 1975. However, the response of the farmer in 1975 may be greater than in 1965. More farmers in 1975 may use the fertilizer programs and new varieties of hybrid alfalfa, barley and sorghum which, as the agricultural specialists believe, may increase yield.

The Economic Model

The theoretical framework for analysis of the impact of water rights on the cropping system involves three basic relationships in production economics.[6] These relationships are the factor-factor relationships, the factor-product relationships, and the product-product relationships. Factor-factor relationships are concerned with the relative amounts of two or more factors used to produce a given product. These factors may be combined at different levels to produce the same amount of product. The most efficient use is attained when their marginal rate of substitutability is equal to the inverse ratio of their prices:

$$\frac{\Delta X_1}{\Delta X_2} = - \frac{P_{x2}}{P_{x1}}$$

where ΔX_1 means infinitesimal change in X_1 and ΔX_2 means infinitesimal change in X_2.

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6. Earl O. Heady, Economics of Agricultural Production and Resource Use. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1961.

X_1 and X_2 are two inputs. P_{x1} and P_{x2} are prices of the two inputs X_1 and X_2, respectively.

Factor-product relationships involve the relationships between resources used and the product which is produced. Again the equilibrium point is reached when the additional output produced relative to the additional units of resources used is equal to the inverse ratio of their prices:

$$\frac{\Delta Y}{\Delta X} = \frac{P_x}{P_y}$$

where ΔY is infinitesimal change in output, and ΔX is infinitesimal change in input associated with ΔY.

P_y and P_x are prices of Y and X respectively.

Product-product relationships are concerned with allocation of a given amount of resources among two or more enterprises. This assumes that a given resource, or package of resources are held constant--iso-resources--while different combinations of crops can be produced with that given level of resources. The optimum allocation of given resources between the enterprises can be made only if the choice criterion is known.[7]

For farm profit maximizations, product price ratios provide the choice indicator. Maximum profits are attained with costs or resources fixed, when the marginal rate of substitution of products is inversely

7. <u>Ibid</u>., p. 239.

equal to the product price ratio:

$$\frac{\Delta Y_1}{\Delta Y_2} = - \frac{P_{y2}}{P_{y1}} \qquad \text{I}$$

$$(\Delta Y_1)\ (P_{y1}) = (\Delta Y_2)\ (P_{y2}) \qquad \text{II}$$

where ΔY_1 and ΔY_2 are infinitesimal changes in the production of enterprises Y_1 and Y_2, respectively.

Once the substitution and price ratios have been equated, the following conditions of equal productivities are attained:

Equation II derived from equation I states that with resources allocated to maximize profits, the marginal value product of a unit of resource allocated to Y_1 is equal to the marginal value product of a unit of resource allocated to Y_2. As long as the marginal rate of product substitution $\Delta Y_1/\Delta Y_2$ is less than the inverse price ratio P_{y2}/P_{y1}, profits can be increased by substituting Y_1 for Y_2.

Optimum production combinations can be illustrated geometrically by drawing iso-cost and iso-revenue curves on a production cost surface. Figure 1 shows a production cost surface with varying rate of substitution. The iso-cost curves indicate various combinations of the two products Y_1 and Y_2 which can be produced with a given quantity of resources. The iso-revenue lines indicate the combinations of two crops which produce a constant revenue. The points of tangency of iso-cost

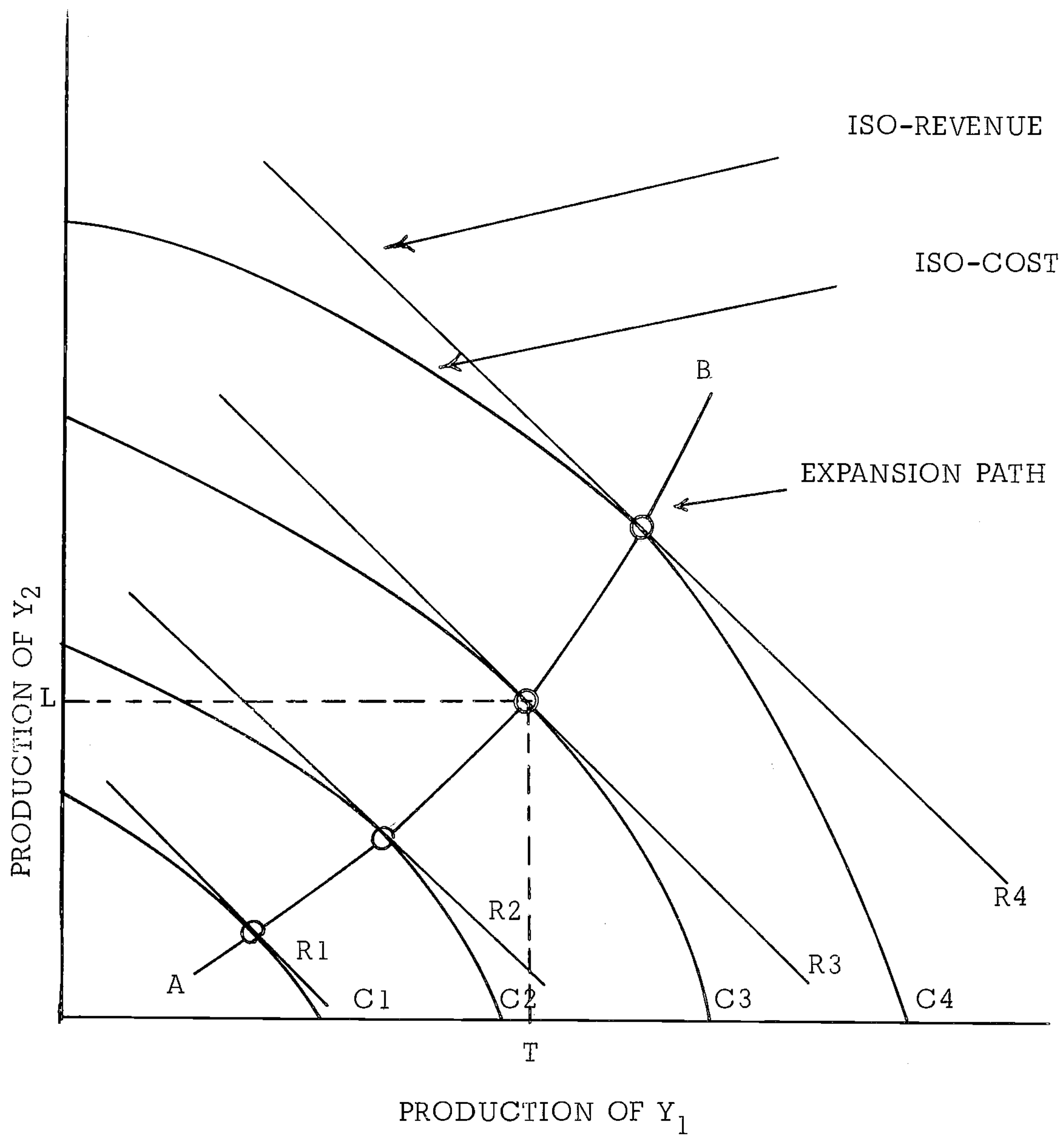

Figure 1. Optimum production combination of Y_1 and Y_2 enterprises at four levels of resource inputs with varying rates of substitution (hypothetical).

curves with iso-revenue curves indicate optimum combination of enterprises. At these points, the marginal rate of substitutability of the two crops is equal to the inverse of their prices ratio. However, these points may not give the most profitable level of production--the most profitable level of production as is indicated by the expansion path AB (Fig. 1), is attained by climbing up the cost surface along the expansion path until marginal revenue equals marginal cost. The expansion path is the line connecting all points of tangency of iso-cost and iso-revenue. The optimum combination of enterprises Y_1 and Y_2 for the given iso-resource C_3 is OL of Y_2 and OT of Y_1 as given by the point of tangency of iso-cost C_3 and iso-revenue R_3. (See Figure 1.)

The above illustration assumes varying rates of substitution but sometimes product-product relationships involve a constant rate of substitution. As the price ratio is the choice indicator, then whenever this ratio is less than the marginal rate of substitutability between the two crops, it will be most profitable to use all resources to produce the crop that has the greater marginal rate of substitutability and low price ratios, and leave the other crops (for example when $\frac{\Delta Y_1}{\Delta Y_2} = \frac{4}{3}$ and $\frac{P_{y2}}{P_{y1}} = \frac{2}{5}$).

In Figure 2, the optimum levels of production are illustrated by the intersection of the iso-cost and the iso-revenue curves. When the iso-revenue curve intersects two iso-cost curves at the two axes, then the optimum level of production is given by the point where the iso-revenue intersects

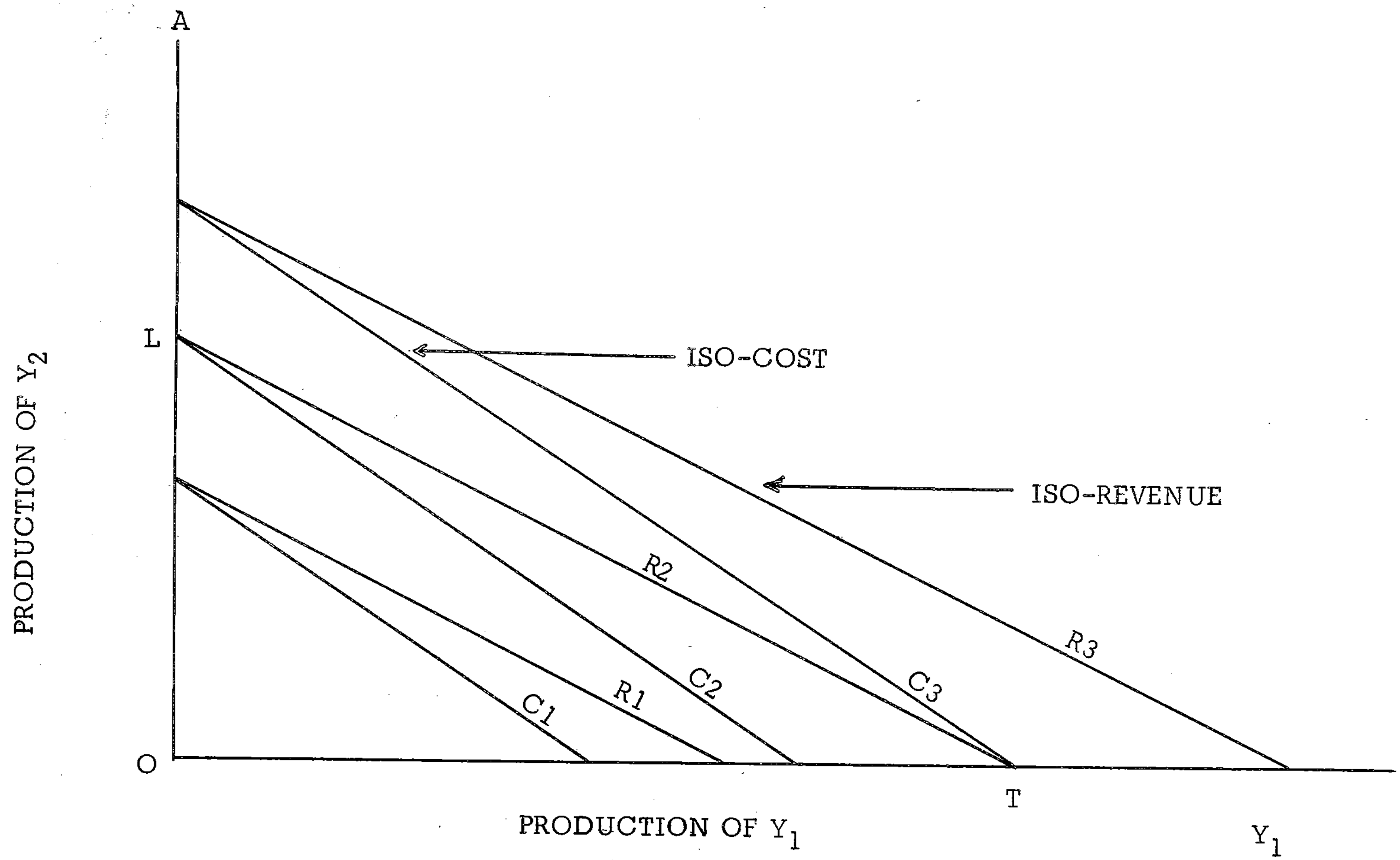

Figure 2. Optimum production combinations of Y_1 and Y_2 enterprises at three levels of resource inputs with constant rate of substitution (hypothetical).

the lowest of the two iso-cost curves. For example, in Figure 2, given the iso-revenue R_2 and iso-costs C_2 and C_3, the optimum level of production is OL given by the intersection of R_2 and C_2.

When the inverse price ratio between two crops is the same as the constant marginal rate of substitutability between these two crops, the farmer is indifferent between producing all of one crop or producing any combination of the two crops.

While the factor-factor and the factor-product relationships are taken as given in this study for 1965[8] and are developed for 1975[9] the product-product relationships provide the basis for analysis of the second objective, i. e. the impact of water rights on farm organization.

In the budgetary analysis, it is assumed that the constant rate of substitution relationships will prevail between the different crops. Analysis of the prices indicate that the inverse price ratios prevailing between the crops are different from the marginal rate of substitution between these crops. It is assumed, however, that the farmer will not put all his land in one crop if his goal is to maximize returns over a long period of time. Growing all of one crop on a parcel of land is found to deplete the soil and a point in time may be reached when this crop will no

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8. They are already determined for a study (including area of above study) under preparation by Dr. Aaron G. Nelson, Professor of Agricultural Economics, University of Arizona.

9. They are developed in a similar manner to 1965.

longer pay. A satisfactory rotation is therefore the practice of a good farmer. Also because uncertainty characterizes agriculture--climatic changes, pest infestation, uncertainty in commodity prices, etc.--and because of the drive for an efficient use of his labor throughout the year, the farmer is believed to adopt crop diversification. Moreover, institutional restrictions and water peak requirements prevent farmers from putting all their land under one crop. Special attention has been given to these restrictions when setting the budgets.

The above framework provides a conceptual basis for dealing with any number of products. When large numbers of products are involved, mathematical (algebraic) procedures may be used in place of geometrical models.

Sources of Data

Data pertaining to the first part of this study were collected primarily from the Salt River Project. The author spent part of the summer of 1963 studying the Project. He visited with Project personnel on the various aspects of the Project. Most of the information was obtained first-hand, directly from Project personnel. Other information was obtained from the Bureau of Reclamation in Phoenix, from publications by some writers interested in the Project[10], from project records and reports, and

10. Arizona Highway Department and others.

from court decisions in cases involving the Project and others. Data pertaining to the second objective and used in the 1965 budgetary analyses were obtained from the Department of Agricultural Economics of the University of Arizona.[11] These data include calendars of operations, costs of production, commodity prices and yields. These data, however, were supplemented by other data from offices of the United States Department of Agriculture in Phoenix.

Yield estimates for 1975 are based on the judgment of specialists in the College of Agriculture of the University of Arizona.[12] These judgments indicate that the yields of all the crops under this study may increase. Associated with these increases in yield are higher levels of fertilizer applications.

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11. Aaron G. Nelson, Costs and Returns for Major Field Crops in Central Arizona by Size of Farm, Arizona Agricultural Experiment Station Bulletin in preparation, 1965.

12. Lyman R. Amburgey, Robert E. Dennis, Aaron G. Nelson and others.

Data available indicate that the per unit costs of labor[13], management and groundwater[14], and farm real estate taxes per acre[15] may increase, relative to other costs, in 1975 while the prices of cotton lint[16] may fall and those of cotton seed[16] may rise, relatively. (Discussion of above per unit costs is given in Chapter III.) Except for these items, it was assumed the same per unit costs, calendars of operations, and commodity prices would prevail in 1975 as in 1965.

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13. U.S.D.A., Agricultural Statistics, U. S. Government Printing Office, Washington, D. C., 1963.

14. Natalie D. White and others, Annual Report on Groundwater in Arizona, Spring 1962 to Spring 1963. U. S. Geological Survey, Phoenix, Arizona, 1962. Also Alan P. Kleinman, The Cost of Pumping Irrigation Water in Central Arizona, Unpublished Ms. Thesis, University of Arizona, Tucson, 1964.

15. U. S. D. A., Farm Real Estate Taxes, Recent Trends and Developments, A. R. S. 43-130, 1960.

16. U. S. D. A., Agricultural Price and Cost Projections for Use in Making Benefit and Cost Analysis of Land and Water Resource Projects, Washington, D. C., 1957.

CHAPTER II

NATURE, ORGANIZATION AND OPERATION OF THE SALT RIVER PROJECT

Organization and Administration

The Salt River Project is a nonprofit organization which incorporates the Salt River Valley Water Users' Association (SRVWUA; hereafter referred to as the Association) and the Salt River Project Agricultural Improvement and Power District (hereafter referred to as the Power District), both of which have identical boundaries. The Power District was formed to secure the rights, privileges, exemptions and immunities granted to public corporations or political sub-divisions for the Association lands. Under a contract between the Association and the Power District all Association properties have been transferred to the Power District. "The Association continued to operate all of the properties as agent of the Power District until 1949 when the contract was amended whereby the Power District took over the project with the Association continuing to operate the irrigation system as agent of the Power District." S.R.P. (1961)[1]

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1. Salt River Project, <u>Major Facts in Brief</u>, 1961, p. 20.

The Salt River Project[2] is divided into 10 reservoir districts. At the general elections the shareholders[3] elect from each of the 10 districts one governor for the Association board of governors, one director for the Power District board of directors and three councilmen. At the same election and in addition to the above electees, a president and a vice president are elected at large for the board of governors and the board of directors. There are always two elections at the same time, one from the Association side and the other from the Power District side. Thus while a board of governors and a board of directors are elected, the two boards have always been composed of the same individuals. For this reason and for simplification the term Board will be used throughout the manuscript when referring to these bodies.

To run for the office of president, vice president, governor, director, or councilman an individual must be an owner of at least one acre of land within the Project and a resident of the Project. "If he should during his term of office cease to be such an owner or resident of such Reservoir District, his office shall thereof become vacant." (Articles of Incorporation of SRVWUA, 1903, p. 11). The elector also must be an owner of land. Each acre of land has one vote. The Association

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2. The word 'project' is used whenever is meant the whole organization.

3. The word 'shareholders' includes those who own one or more acres of land within the Project and who pay the "assessment" directly to the project.

elector has a maximum of 160 votes whereas the Power District elector can cast as many votes as he has acres of land. Companies, corporations, municipalities, and churches have no right to vote. Each shareholder has to vote in person.

Figure 3 shows the general organization of the Project. The Project has one general manager, one treasurer, one project secretary and comptroller. All are appointed by the Board.

Working under the general manager are: one associate general manager for the Project Association, and two associate general managers and three assistant general managers for the Power District. The associate general managers and the assistant general managers are selected by the general manager but are approved and appointed by the Board. Under the associate and assistant general managers for the Project Power District come the different departments of the Project Power District, and under the Associate general manager for the Water Users' Association come the different departments of the Project Water Users' Association.

While no attempt is made to discuss the organization of the Power District, the organization of the Project Water Users' Association is hereafter briefly discussed.

Organization of the Association

There are five departments in the Association, each of which has a different objective and function unique to itself yet all the five departments

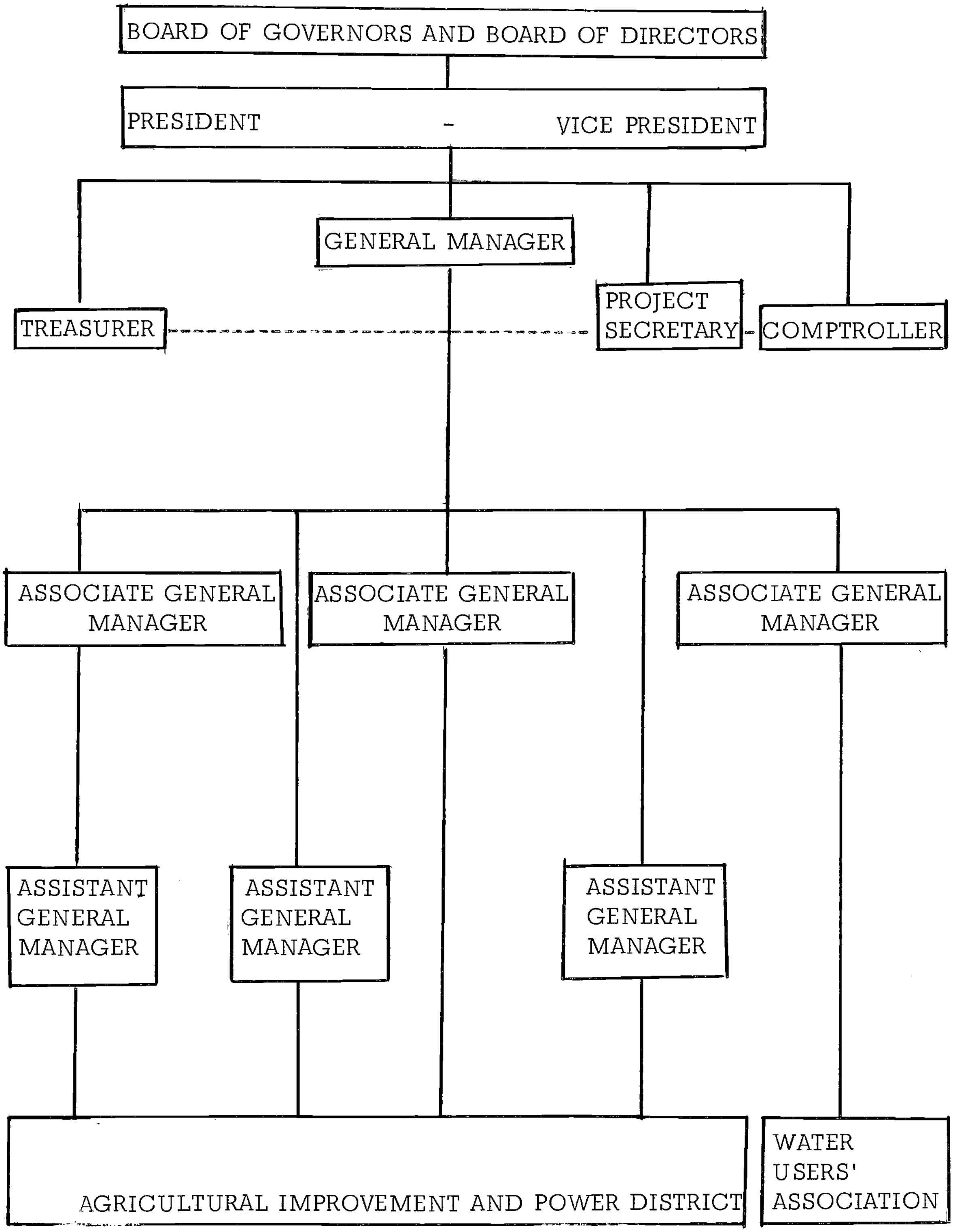

Figure 3. Salt River Project Organization

Source: Reference Manual of Association operation, Salt River Project, 1962 are important key factors and all vital to successful operation. These departments, portrayed in Figure 4, are discussed below.

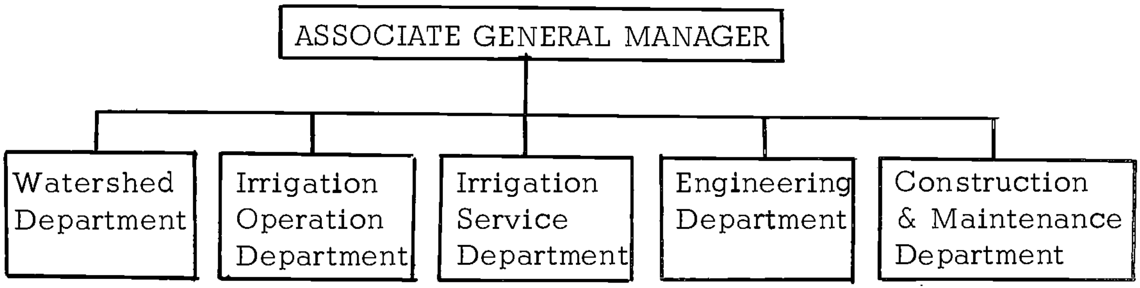

Figure 4. Organization of the Association.

Watershed Department

The objectives of this department are to observe, record, and take necessary action for the protection of the water supply from uses by others not entitled to it, and for the conserving of this water supply for the project storage system. It conducts the annual survey of watershed snow-pack and provides an estimate (forecast) of expected water yield to the river system.

The Watershed Department participates with other agencies in a watershed research program whose goals are the stabilization and increase of natural resources from the watershed area.

Irrigation Operation Department

The Irrigation Operation Department is comprised of transmission and communication division and the water distribution division.

The primary objective of this department is to deliver, with a minimum of loss, the stored and developed water to the land within the project on demand of the shareholders. To achieve this objective it performs the following functions:

1. Receiving and recording water orders from shareholders.

2. Requesting release of water from reservoirs and transmitting it to canal system.

3. Operating deep well pumps.

4. Coordinating dry-ups in project's laterals and canals to accommodate private construction such as installing an underground cable across the lateral.

5. Delivering water to users on request.

6. Completing charge cards and submitting them to machine accounting.

7. Requesting needed construction and maintenance.

8. Maintaining public relations by answering and correcting complaints from users and the general public.

9. Patrolling the project when storms occur and disposing of storm water.

10. Performing studies on work load, water demand and related undertakings. The objective of these studies is to improve the services of water distribution division to the shareholders.

11. Directing tours with foreign visitors over the project.

Irrigation Service Department

The Irrigation Service Department consists of two divisions, the accounting and collection division and the subdivision division (Figure 5). Each of these divisions has a number of sections performing different duties. The accounting and collection division consists of the transfer journal section, the plat and escrow section, bookkeeping section, and customer service section.

The subdivision division consists of three sections: scheduling section, subdivision irrigation section, and clerical section.

The primary objective of the Irrigation Service Department is to properly administer the water rights of all land within the boundary of the project.

The accounting and collection division provides the proper accounting and collection of all revenues from the delivery and sale of water for both irrigation and municipal domestic purposes. The objectives of the sections of this division are:

1. The transfer journal section is to properly process new shareholder accounts.

2. The plat and escrow section is to properly maintain plats for all sections within the exterior boundary of the project and daily escrow service to various title companies.

3. The bookkeeping section collects and accounts for all revenues received for farm and residential irrigation, and for water delivered to municipalities.

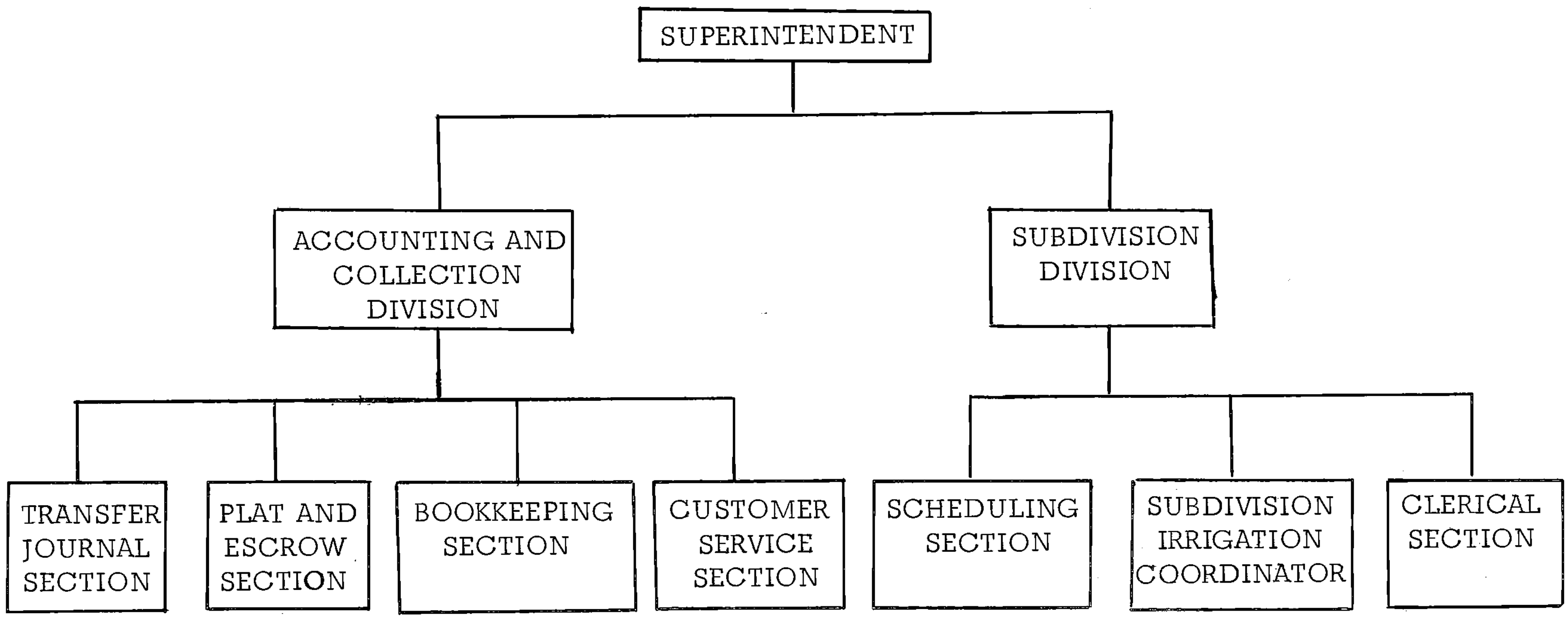

Figure 5. Organization of the Irrigation Service Department

Source: Reference Manual of Association Operation, Salt River Project, 1962.

Page Missing in Original Volume

4. The customer service section processes service complaints and responds to inquiries and requests for service made by shareholders.

The objective of the subdivision division is to serve the urbanized or subdivided residential areas of the project with the most modern efficient type of flood irrigation service. It reports and accounts for all water in the project. Part of the irrigation service functions is to compile data that will aid in increasing the efficiency of deliveries to users and the conservation of water.

Engineering Department

The Engineering Department consists of an administrative body--office coordinator, administrative assistant, irrigation consultant and operation coordinator, and of a technical body--civil engineering division and ground water division. Figure 6 shows the different sections under each division.

The objective of the Engineering Department is to provide the engineering and technical skills in construction, maintenance and research for the irrigation transmission, distribution and groundwater system, to maintain proper efficiency of water delivery to the shareholders of the Project. The Association Engineering Department has the following functions:

1. It provides engineering services for construction and maintenance purposes pertaining to the irrigation transmission,

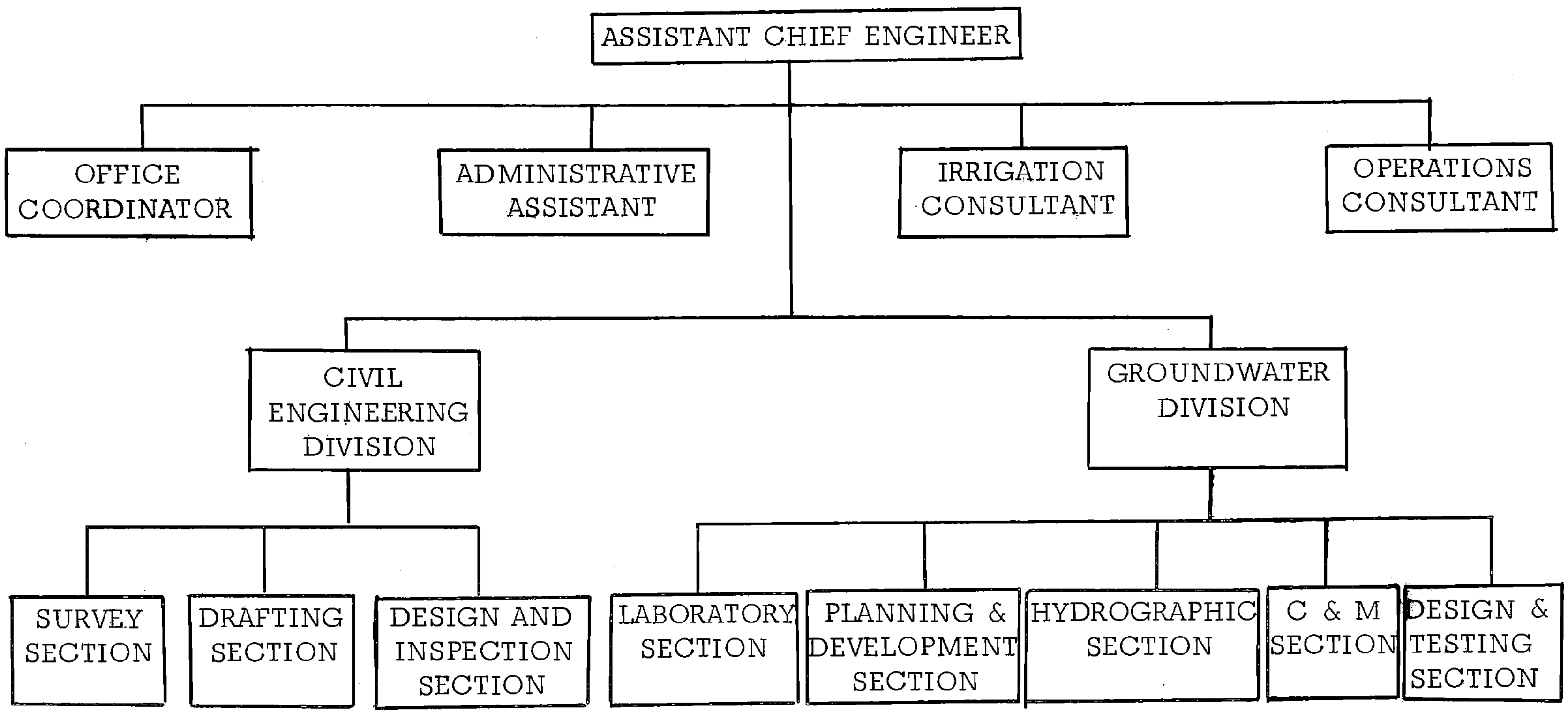

Figure 6. Organization of Engineering Department.

Source: Reference Manual of Association Operation, Salt River Project, 1962.

distribution and division system. This is the responsibility of the civil engineering division.

2. It provides engineering services in hydrography and chemistry pertaining to the operation of the irrigation and electric hydro-generation system. It constructs, maintains and operates facilities pertaining to the ground water production system; operates and maintains sand dredging equipment at Granite Reef Diversion Dam and provides engineering planning and development pertaining to the entire irrigation system. This is the responsibility of the groundwater division.

3. It helps plan and coordinate the irrigation engineering and construction functions and liaison between the Project and municipalities.

4. It provides technical service pertaining to irrigation problems for the engineering department, shareholders and others.

Construction and Maintenance Department

The Construction and Maintenance Department consists of two construction and maintenance headquarters and a field engineer. Under the above two headquarters function the six sections shown in Figure 7.

The objective of the Construction and Maintenance Department is to maintain the irrigation facilities in a condition that will permit economical and efficient operation of the system. It is responsible for providing construction and maintenance pertaining to the irrigation transmission, distribution, and diversion system. It coordinates and plans

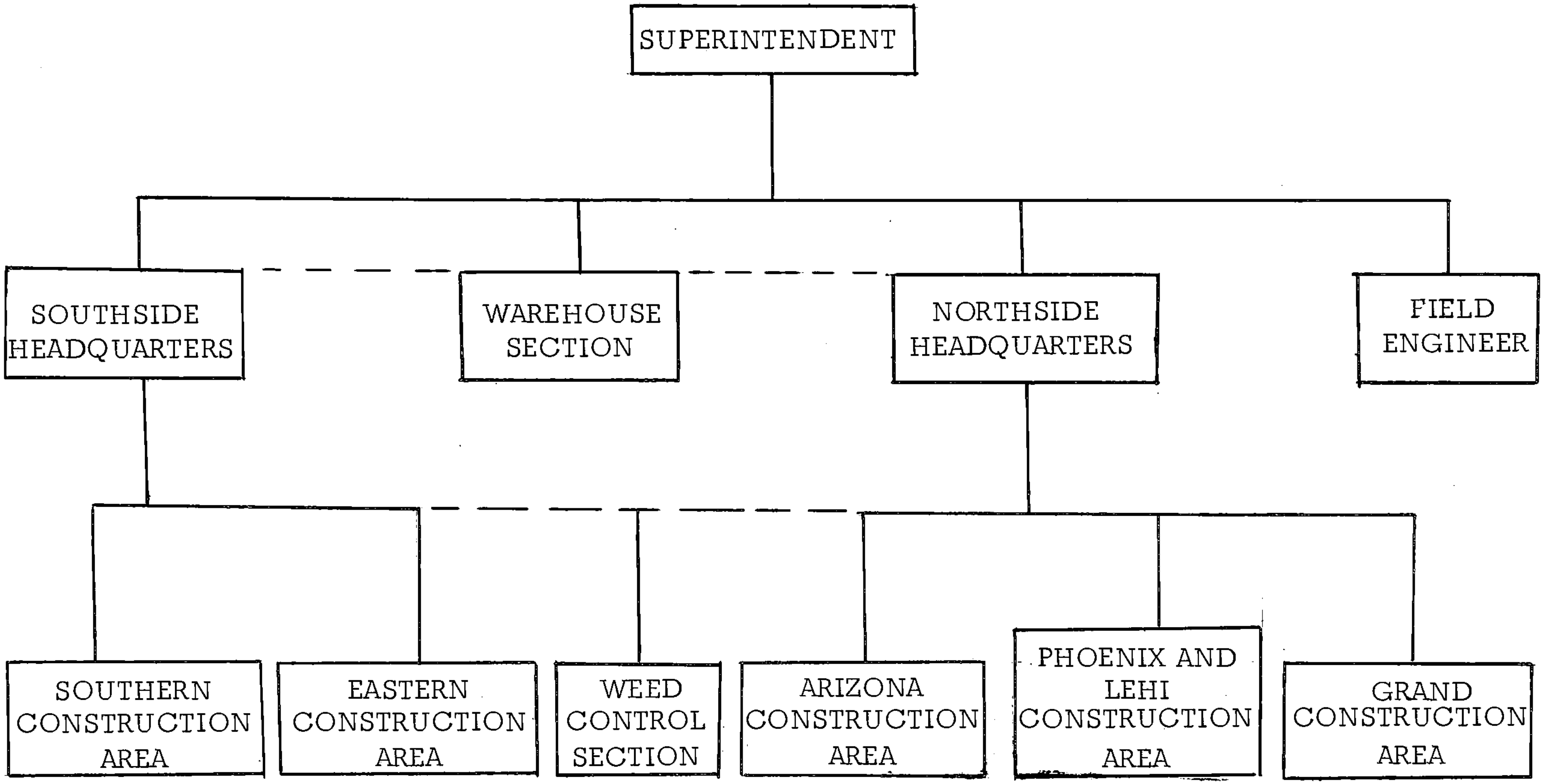

Figure 7. Organization of Construction and Maintenance Department.

Source: Reference Manual of Association Operation, Salt River Project, 1962.

man-power and equipment used by north side and south side headquarters. It also evaluates weed control materials such as herbicides, selective weed killers, and administers the weed control program. It recommends improvements or replacements of existing construction facilities. It also improves existing construction and maintenance methods.

Power Generation

"The future of water supply in the Salt River Valley will depend on continuing the partnership between these essential elements--water and electric power."

"But behind all this success stands the reclamation principle: the development of water resources financed by using money derived from the production and sale of electric energy."[4]

These two quotations from the president of the Project, indicate the importance of power in the availability of water supply at low costs. It was in 1937 when the Project organized the Project Agricultural Improvement and Power District, a political subdivision of the State of Arizona coexistive with the Salt River Valley Water Users' Association. In 1949 the Power District assumed the operation of the electrical and generating systems.

In the early twenties there were two private utility companies serving areas in central Arizona. These private utility companies signed

4. Salt River Project Annual Report, 1958, p. 5.

an agreement with the Salt River Project setting forth the boundaries and outlines for the areas where the project would assume responsibility for supplying power. The agreement was amended several times.[5]

Population of central Arizona increased tremendously beginning in 1945 and pushed new subdivisions into what formerly had been operating farm land. This increased the responsibility of the project in meeting the demand for electric power in its boundaries set by the above-mentioned agreement. In 1940 the Project built its first steam generating unit at Cross-Cut having a generating capacity of 7,500 kw. Because of the continuous increase in population within the Project, the Project continued installing steam electric plants, the latest of which was built in 1961. A summary of the Project power generating plants is given in Table 1.

Energy production increased from 829,539,000 kwh. in 1950 to 2,891,964,000 kwh. in 1962[6]--an increase of over two billion kwh. The Project Power is sold at both wholesale and retail. In 1960 the wholesale distribution amounted to 11 percent while the retail distribution amounted to 89 percent. Revenue received from power sale in 1960 amounted to $38,667,313.00.

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5. W. Brandon Glenn, Historical Documents Pertaining to Power Contracts and Agreements of the Salt River Project, 1961, p. 36.

6. The relationship between the generating capacity given in kw. and the production given in kwh. is that Production (kwh.) = Generating Capacity X No. of hours operated at that capacity.

Table 1. Project Power Generating Plants

Nature of Power	Where Generated	Location	Yr. Cons.	Generating Capacity	No. of Customers
Hydroelectric	Roosevelt Dam	80 mi. from Phoenix	1911	19,247 kw.	
Hydroelectric	Horse Mesa "	65 mi. " "	1927	29,982 kw.	45-1921
Hydroelectric	Mormon Flat	51 mi. " "	1925	6,997 "	
Hydroelectric	Stewart Mt.	41 mi. " "	1930	10,384 "	
Thermal Elec.	Cross Cut	Cross Cut	1940	7,500 "	
Thermal Elec.	Kyrene	Kyrene	1952	30,000 "	8,000-1941
Thermal Elec.	Kyrene	Kyrene	1954	60,000 "	
Thermal Elec.	Agua Fria	Agua Fria	1957	100,000 "	
Thermal Elec.	Agua Fria	Agua Fria	1958	100,000 "	
Thermal Elec.	Agua Fria	Agua Fria	1961	175,000 "	97,975 120,000-1963

From the farmer's point of view the important role that the Project's power system plays is providing low cost water for its shareholders. At the same time power revenue is used in meeting the annual maturity of long term debt and interest. This debt is the result of financing the different storage and power facilities of the Project through borrowing from the Federal Government and through the sale of bonds.

In examining the Project's annual statements of income from irrigation operation one finds a net operating deficit. This deficit is planned each year in the process of budgeting the year's activities. It represents the amount of money which will be available for water cost subsidy from power revenue for that year. In this way benefits from power revenue are passed directly to all water users including residential home owners. Table 2 gives the total operating costs and expenses of water, and the amount of subsidy derived from power for the period 1961-1964. Note that the subsidy accounts for an average of 60 percent of the total operating costs and expenses of water.

Table 2. Total Operating Costs and Expenses Charged to Irrigation Water in the Salt River Project and the Subsidy Derived from Power in the Period 1961-1964.

Year	Total Operating Costs and Expenses	Subsidy Derived from Power	Percentage of Subsidy to Total Costs
1961	$ 9,596,000	$5,700,000	59.39%
1962	8,445,898	4,875,181	57.72
1963	8,657,653	5,175,491	59.77
1964	10,419,974	6,646,147	63.78
Average	9,279,881	5,599,204	60.34

Source: Salt River Project Annual Reports from 1961-1964.

The Water Supply

There are two sources of water supply in the Project, the surface water supply and the underground water supply.

The Surface Water Supply

The surface water supply comes primarily from the watershed area. This area constitutes an entire drainage area of 8,300,000 acres, located in the mountainous areas of central Arizona. Figure 8 shows the State of Arizona, watershed area, principal stream and storage dams. Of the entire drainage area 7,500,000 acres are above the dams and out of this only 2,500,000 acres are covered by snow in the winter season. Elevations range from 1,325 feet above sea level to more than 11,000 feet. Above elevation 4,000 feet, snowfall prevails during winter. Precipitation increases generally with elevation. In the lower areas precipitation is in the order of nine inches while at points in the high mountain area, precipitation falling upon the area above the dams is 20 inches, equivalent to about 12,000,000 acre feet of water. Of this amount, 2.08 inches or 1,241,800 acre feet is accounted for annually by measurement at stream gauging stations. The difference (17.92") or 10,758,200 acre feet of water represent the amount of potential water supply which is used or lost on watershed areas above reservoirs.[7] Factors which contribute to the disposition of precipitation in watershed areas above dams and to resulting low stream flow are:

1. The interception, use and transpiration of water by natural vegetation.

2. Evaporation from wet ground and snow.

3. Evaporation from stream channels and,

4. Diversion for agricultural and other upstream benefits.

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7. George W. Barr and others, Recovering Rainfall; More Water for Irrigation, 1957.

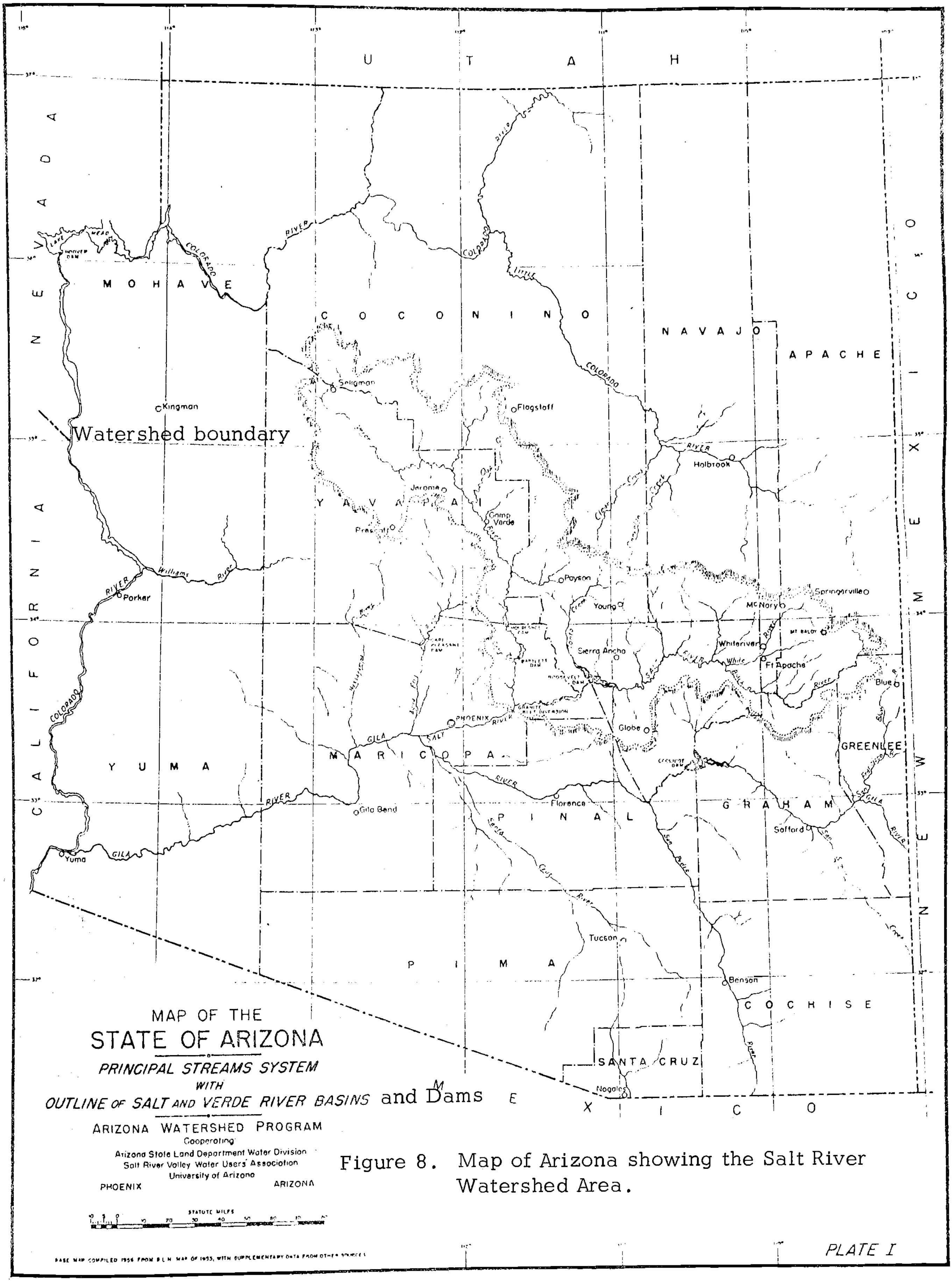

Figure 8. Map of Arizona showing the Salt River Watershed Area.

Rivers

Water from the watershed area is carried by three rivers; the Salt River, the Tonto River, and the Verde River. The Salt River and the Tonto River flow into the Salt reservoir system (see below). These two rivers are referred to hereafter as the Salt System. The Verde on the other hand flows into Horseshoe and Bartlett Dams.

Normal flow

The normal flow of the rivers varies from river to river, from year to year, and within the year. Table 3 gives the flow of the two systems by months from 1956 to 1962. The table shows that the total amount carried by the Salt System in any one year was greater than that carried by the Verde River. The overall amount of water carried by both rivers also varies from month to month within the year and from year to year.

The average annual flow of the two rivers for the period 1956 to 1962 was 788,500 acre feet (see Table 3). Note that normal flow in winter and spring months is more than three quarters of the annual normal flow of the two rivers. However, more than 40 percent of the total stream flow is received during the winter months.

The storage system and the stored water

Water carried by the three rivers is stored in six reservoirs, four on the Salt River and two on the Verde River. One diversion dam, Granite Reef Diversion Dam, is located on the Salt River just below its confluence

Table 3. Normal Flow of the Salt (including Tonto) and Verde Rivers by Months for the Period 1956-1962 (in 1,000 acre feet of Water)

Year & River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
1956													
Salt	15.4	26.8	47.7	39.8	23.4	7.2	9.3	12.4	6.5	9.0	10.0	15.0	222.5
Verde	15.4	14.0	12.6	11.0	7.2	5.2	12.6	11.6	5.9	11.2	13.1	17.4	137.2
Total	30.8	40.8	60.3	50.8	30.6	12.4	21.9	24.0	12.4	20.2	23.1	32.4	359.7
1957													
Salt	107.1	76.6	54.2	38.9	32.5	19.7	12.2	68.8	21.3	5.7	7.8	8.4	453.2
Verde	83.0	124.3	36.2	10.4	12.4	10.4	11.9	19.8	8.1	9.7	12.5	14.2	352.9
Total	190.1	200.9	90.4	49.3	44.9	31.1	24.1	88.6	29.4	15.4	20.3	22.6	806.1
1958													
Salt	12.5	50.0	241.6	250.4	114.4	24.8	9.3	20.4	42.2	16.6	27.4	16.4	826.0
Verde	14.3	50.0	165.3	70.3	9.6	7.7	4.6	15.6	36.0	12.8	57.9	16.6	460.7
Total	26.8	100.0	406.9	320.7	124.0	32.5	13.9	36.0	78.2	29.4	85.3	33.0	1286.7
1959													
Salt	12.2	13.5	16.0	15.4	8.2	4.7	1.6	97.0	14.3	44.0	14.9	13.8	255.6
Verde	13.9	21.0	20.3	10.1	8.2	5.6	14.0	33.6	7.8	16.5	14.5	14.7	182.2
Total	26.1	34.5	36.3	25.5	16.4	10.3	15.6	130.6	22.1	61.5	29.4	28.5	436.8
1960													
Salt	219.8	70.2	214.5	102.4	43.5	17.6	8.5	11.6	8.8	56.9	86.9	227.1	1067.8
Verde	52.8	23.7	115.2	14.6	9.5	6.5	5.5	10.7	14.1	39.3	18.7	84.1	394.7
Total	272.6	93.9	329.7	117.0	53.0	24.1	14.0	22.3	22.9	96.2	105.6	311.2	1462.5
1961													
Salt	12.2	11.5	23.1	34.3	12.5	6.6	8.7	19.8	19.5	16.0	12.6	11.9	188.7
Verde	13.8	12.5	14.2	24.5	7.5	5.1	8.2	16.5	20.2	13.8	13.6	14.2	164.1
Total	25.0	24.0	37.3	58.8	19.0	11.7	16.9	36.3	39.7	29.8	26.2	26.1	352.8
1962													
Salt	75.8	134.2	133.8	246.4	74.4	18.9	11.9	9.8	14.7	9.2	16.9	38.1	784.1

Table 3 (continued). Normal Flow of the Salt (including Tonto) and Verde Rivers by Months for the Period 1956-1962 (in 1,000 acre feet of Water)

Year & River	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	YEAR
1962 (continued)													
Verde	20.6	95.0	78.9	50.0	7.2	5.5	5.5	7.8	16.6	9.9	13.1	18.2	328.3
Total	96.4	229.2	212.7	296.4	81.6	24.4	17.4	17.6	31.3	19.1	30.0	56.3	1112.4
Average Annual of 1956-62	87.1	93.5	151.5	117.8	48.5	22.3	21.3	67.8	32.6	36.6	42.7	66.8	788.5
% of Total	11.0	11.9	19.2	14.9	6.2	2.8	2.7	8.6	4.1	4.6	5.4	8.6	100.0

Source: Geological Survey Department and the Salt River Project, Phoenix, Arizona with the Verde. This dam has limited storage capacity, its primary function being to divert water released for agricultural use from the six dams into the Project north and south canals. A summary of selected information related to the storage system is given in Table 4.

Table 4. Characteristics of Storage Dams on the Salt and Verde Rivers.

River and Dam	Location (Distance From Phoenix in Miles)	Ht. in Ft.	Length in Feet	Water Holding Capacity in Ac. Feet	Year Built	Hydro-electric Generating Capacity
SALT RIVER						
Roosevelt	80	280	723	1,381,580	1905-11	Yes
Horse Mesa	65	300	660	245,138	1924-27	Yes
Mormon Flat	51	224	380	57,852	1923-25	Yes
Stewart Mountain	41	207	1,260	69,765	1928-30	Yes
VERDE RIVER						
Horse Shoe	58	60	1,500	142,830	1944-46	None
Bartlett	46	283	800	179,548	1936-39	None
At the Conflux of Salt and Verde Rivers						
Granite Reef Diversion Dam	32	29	1,000	Divert water	1906-08	None

Source: Salt River Project, Major Facts in Brief, 1961.

The reservoir system has a combined storage capacity of 2,009,400 acre feet. Water stored varies from month to month and from year to year depending on precipitation and use of water. However, the storage system receives the bulk of its water during winter and spring months (December through May). Figure 9 shows the combined reservoir capacity and water stored for the period 1910-1962.

A study of the period 1952-1956 illustrates the value of the storage system. Precipitation in 1952 was substantial. The two rivers had a combined flow of 1,881,435 acre feet. The months starting January up to May of that year brought a total runoff of approximately 1,680,000 acre feet. This runoff raised the amount of water stored from 400,000 acre feet at the beginning of January being carried over from the previous year to 1,720,000 acre feet in May of 1952.

There was very little precipitation in the period 1953 to 1956. The total flow of the rivers during this period (4 years) was 1,982,240 acre feet, only slightly above the flow for the year 1952. The carry-over in the reservoirs for the years 1953, 1954, 1955, 1956 and 1957 was 1,360,000; 970,000; 850,000; 640,000; and 200,000 acre feet, respectively. Had it not been for the storage facilities which make use of the good years to replenish the dry years, the dry period of 1953-1956 would have been disastrous for many farmers.

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The interworking of the storage system

The procedure adopted in operating the storage system is to lower the Verde system to a predetermined quantity to make certain of sufficient storage capacity for any spring runoff. Having done that, water is then demanded from Stewart Mountain Dam on the Salt System. This dam is the lowest dam on the Salt Reservoir System. As water is released from this dam, it passes through hydroelectric generating equipment and electricity is developed. In the meantime water is being released from the dam above to replenish the water released from the reservoir below, and as it does so electricity is generated. This process goes through all four hydroelectric plants on the Salt System to keep the three downstream reservoirs at maximum operating level.

The Underground Water Supply

Project pumps

Underground water is the other source of water supply in the Project. Pumping of water started first as a result of the high water table problem in the western part of the Project prior to and during the First World War. Water was then pumped into the river. At that time the Project entered into a contract for 99 years with the Roosevelt Irrigation District (RID) to pump water within the Project boundaries (now amended). But in the late 1920's and the 1930's, the Project faced draught and underground water was badly needed to supplement stored water. The Project began drilling wells to supplement surface water and by 1962 the Project had 246 pumps. These pumps contributed each year 500,000 acre feet of underground water. They are fairly evenly distributed all over the Project and are installed near the canals to discharge the pumped water into the Project canal system. The average pump size is 250 hp. The summer months are the months of heavy pumping. Table 5 shows the amount of water in acre feet that was pumped in each month of 1959. The amount of pumped water varies inversely with the amount of runoff and stored water in the dams.

Because of heavy pumping, the water table continued to drop annually.[8] The drop in water table varies from one area to the other. The annual report on ground water in Arizona, spring 1962 to spring 1963, shows that the decline in water in the Project area ranged between 20 feet to 40 feet for the 5-year period 1958-1963. An average annual decline of six feet is believed to be the rule. This continuous decline in water table has a direct effect on costs of pumping due to the increase in lift. Also because of the above fact the Project drills annually about six replacement wells.

Interworking between stored and pumped water

Pumping during the heavy flow of rivers in winter and spring months is less than during the summer months. In summer months because

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8. Natalie White and others, Annual Report on Groundwater in Arizona, Spring, 1962-Spring 1963, U. S. Geological Survey.

Table 5. The Project Pumping by Months in 1959. (Quantities in acre feet.)

Month	North Side A	South Side B	Total A/B
January	13,364	14,081	27,445
February	8,943	13,869	22,812
March	22,010	30,808	52,818
April	19,462	29,526	48,988
May	19,640	30,588	50,228
June	22,463	28,133	50,596
July	22,974	29,748	52,722
August	17,158	26,926	44,084
September	19,527	28,168	47,695
October	12,022	21,645	33,667
November	7,034	6,428	13,462
December	4,865	10,026	14,891
Total	189,462	269,946	459,408

Source: Salt River Hydrographic Section.

of the great demand for water by crops and because the flow of the rivers is less than that of winter and spring, heavy pumping takes place. During the summer months pumps work continuously for 24 hours per day. Table 6 gives the total acre feet of water produced for Project use from surface water and from groundwater sources and the relative percentages of these two sources to the total for the period 1955-1963. Figure 10 indicates that while the total acre feet of water produced for Project use is fairly constant the surface water supply and the groundwater supply are inversely proportional to each other.

Table 6. Acre Feet of Water Produced for Project Use from the Two Sources of Water and the Percentage of Groundwater to the Overall Total for the Period 1955-1963.

Year	Surface Water	Groundwater	Total	Percentage of total water Surface water	Groundwater
1955	600,007	467,619	1,067,626	56.2	43.8
1956	634,779	517,469	1,152,248	55.1	44.9
1957	528,417	461,461	989,878	53.4	46.6
1958	591,729	432,106	1,023,835	57.8	42.2
1959[a]	552,142	462,090	1,014,232	54.4	45.6
1960	719,892	352,747	1,072,639	67.1	32.9
1961	553,544	497,205	1,050,749	52.7	47.3
1962	727,404	403,521	1,130,925	64.3	35.7
1963	692,153	403,874	1,096,027	63.2	36.8
Total	5,600,067	3,998,092	9,598,159		
Average	622,230	444,322	1,066,552	58.3	41.7

Source: Salt River Project Annual Reports for the period 1955-1963.

a. Note that the figures given here and in Table 5 for 1959 are not the same, The figures were taken from different sources.

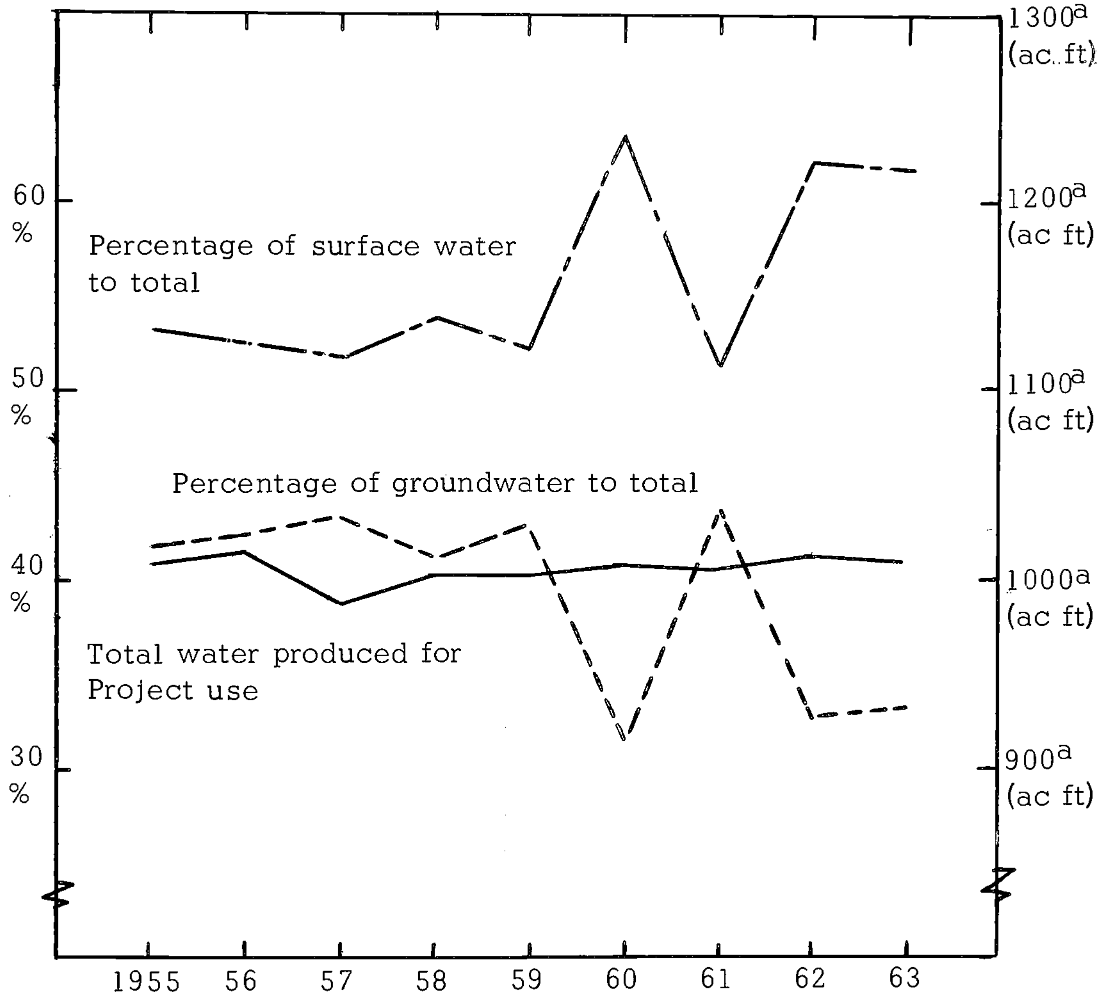

Figure 10. The trends of total acre feet of water produced for Project use and the percentages of surface water and groundwater to total in the period 1955-1963.

a. Figures are in thousands of acre feet of water.

Private pumps

Some farmers in the Project have their own private pumps to supplement Project water. The number of these wells is believed to be more than 400.[9] Since 1956 no records have been kept for private wells in the Project. The average annual amount of water recorded in the period 1946-1956 was about 220,000 acre feet. There was little fluctuation from year to year. Current data regarding private wells are lacking and an economic study including these private wells may be justifiable when studies of this area are made.

Water Agreements With Others Having Rights to Water

The Salt River Project has entered into a number of agreements with irrigation districts and other parties who have established rights to water in the Salt River Valley. Some of these rights pertain to surface water, and others pertain to groundwater.

The Roosevelt Conservation District

The Salt River Project entered into an agreement in 1924 with the Roosevelt Water Conservation District, amended in 1939, whereby the latter would have a perpetual right to 5.6 percent of all water diverted at Granite Reef Diversion Dam, in return for providing cement lining for

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9. No one seems to know exactly the number of private wells in the Project. Above estimate is to the best knowledge of the Project personnel.

portions of South Canal below Granite Reef Diversion Dam to reduce seepage loss of water. The 5.6 percent represents the amount of water saved by such lining. The average annual water received under the above agreement during the period 1955-1963 was 35,000 acre feet. The Roosevelt Water Conservation District obtains this water by pumping it from South Canal into its own canal system.

The Salt River Indians

When the normal flow rights were considered by Judge Kent in 1910, the Salt River Indians were adjudged to be the earliest settlers of the Salt River Valley and were given priority rights over all normal flow rights. This normal flow right amounts to 700 miners' inches[10] of water continuous flow (i. e., 35 acre feet per day), measured at the lateral ditch or ditches to Land of the Salt River Indian Reservation at their point of diversion from the Arizona Canal.

In addition to this normal flow right, the Indians obtained a right to 20 percent of water stored in Bartlett and Horseshoe Dams (both considered one reservoir in this respect, and have a total capacity of 322,378 acre feet) in return for contributing 20 percent of the total costs of building Bartlett Dam. However, their share of stored water in the two dams is limited to a maximum of 60,000 acre feet in any one year.

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10. Edward Kent, Chief Justice, Original No. 4564 Decree, March 10, 1910, Third Judicial District, Phoenix, Arizona, p. 18.

Phelps Dodge Copper Company at Morenci

The Phelps Dodge Copper Company at Morenci needs a constant and adequate supply of water for its mines. The company therefore entered into an agreement with the Salt River Project in 1944 whereby it would build Horseshoe Dam on the Verde River at no cost to the Project and in return would receive a total production of 250,000 acre feet. Phelps Dodge Copper Company then had to divert this water by pumps from the Black River, a tributary of the Salt River into its system. Under this agreement, Phelps Dodge Company is limited to 40 acre feet of water per day or 14,000 acre feet in any calendar year. As of June 22, 1962, 67,836 acre feet of water had been diverted leaving a balance of 183,164 acre feet under the agreement. Unless extended, this agreement will terminate at the time when the above company has diverted all of the 250,000 acre feet.

The City of Phoenix Domestic Water Contract

Under the Phoenix domestic water contract with the Salt River Project, the City of Phoenix has to pay all current and future assessments on Project land which the city serves with domestic and yard water. In return the city is given the normal flow and reservoir water allotted to this land for use only within the Project boundaries.

The amount of water received by the city under this contract varies from year to year depending on the number of acres for which the assessment is paid. In 1960, 1961, and 1962, the City of Phoenix received under the above contract 56,924; 68,020; and 74,175 acre feet of water respectively.[11] These amounts account for 50 percent, 64.3 percent and 65.4 percent respectively, of the total acre feet used by the city domestic water system. The Project water is delivered to the city at its plant on the Verde and its Squaw Peak plant on Arizona canal.

<u>The City of Phoenix "Water-Gates" Contract</u>

Because of the ruling that Salt River Project water cannot be used outside the Project boundaries, in 1949 the City of Phoenix entered into a contract with the Salt River Project whereby the former would install gates on the spillway of Horseshoe Dam and in return receive not more than 25,000 acre feet of water per year. This amount of water, however, would be available to the city only after Bartlett Dam was full and Horseshoe Dam was full to its spillway crest. The installation of these gates increased the storage capacity of Horseshoe Dam by 75,000 acre feet, bringing its capacity to 142,830 acre feet.

The water received under this contract is used for areas outside the Project boundaries.

<u>Buckeye Irrigation District</u>

Buckeye Irrigation District, located southwest of Phoenix, had surface flow rights to water in the Gila and Salt Rivers, but due to the

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11. Salt River Project, <u>Annual Report</u>, 1960, 1961 and 1962.

heavy pumping by the Salt River Project the groundwater was lowered and the surface flow disappeared. Buckeye Irrigation District then brought suit against the Project, in 1930. The Project lost the suit and the final agreement was that the Project should provide Buckeye Irrigation District with 1.1 percent of the water diverted at Granite Reef Diversion Dam. The average annual water received for the period 1955-1963 was 6,844 acre feet.

Roosevelt Irrigation District

In 1924, the Salt River Project entered into a contract with the Roosevelt Irrigation District located west of the Salt River Project whereby the Roosevelt Irrigation District would pump out of the southwestern portion of the Project land an amount not less than 70,000 acre feet per year.

Farmers in the Salt River Project at that time were facing a problem of water-logging and increased alkalinity (sodium chloride) on the surface of the soil caused by the then rising water table.

Over time the Salt River Project began to depend more and more on groundwater to supplement the surface water. The water table continued to decline and the water-logging problem vanished. The pumping by Roosevelt Irrigation District within the Project land under the above contract therefore no longer related to a drainage problem. Instead it was depleting the underground water supply to the Project. In 1950, the Project entered into a new contract with Roosevelt Irrigation District which limited pumping by the latter to not more than 155,000 acre feet in any one year or a maximum of 725,000 acre feet in any five-year consecutive period.

Peninsula and Horowitz

Peninsula and Horowitz are located west of the Salt River Project. Peninsula and Horowitz had surface flow right to water in Gila and Salt Rivers, but due to the heavy pumping by the Project and by Roosevelt Irrigation District, the surface flow decreased and a suit was brought against the Project. The Project lost the suit, and an agreement was filed in 1930 whereby the Project would install three wells to supply two acre feet annually for an area of 1,650 acres.

Water Rights Within Project

Land of the Salt River Project was classified by Judge Kent in what is known as the "Kent Decree"[12] into three classes of land--A, B, and C. Class A land includes all land which has been under use with cultivation by irrigation continuously year by year from various dates of reclamation to the year 1903; 1903 being the year when the first dam in the storage system underwent construction.

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12. Edward Kent, Chief Justice, Original No. 4564 Decree, March 10, 1910, Third Judicial District, Phoenix, Arizona.

Class B land is that land which had been under cultivation when the flow of the rivers was over and above the flow necessary for the cultivation of land in Class A and to which application of water stopped prior to 1903 because of lack of storage facilities. Class C land includes that land other than A and B.

Only Class A land has a normal flow right. There is no normal flow right to Class B or C land. However all three classes of land have rights to stored and developed and to pumped water under certain considerations.

<u>Normal Flow Water Right</u>

"Normal flow water" is that water carried by the rivers and which is not restricted by impounding. Farmers having a right to this water must use it at the time it flows (technically, within the following eight days). Otherwise they lose their right to it.

Rights of each parcel of Class A land, within the Project, to normal flow were established by Judge Kent in 1910. Judge Kent established the date of appropriation by each individual land owner, and the right to normal flow of each parcel of land. The water rights established were from 1869 to 1909. Among these normal flow water rights, there is priority in right. The 1869 land has the first right, then the 1870, and so on up to 1909 land. The necessary amount set by Kent for the beneficial use was 48 miners' inches constant flow to the quarter section, measured and delivered to the high point of the quarter section every eight days. This right covers an area of 148,753 acres of the Project, total of 240,000 acres. The maximum amount of normal flow under such a standard necessary for the irrigation of all Class A land is 45,325 miners' inches. When the flow of the river is less than the maximum amount, the amount available will be distributed among the parcels of land, according to their relative dates of priority. Kent (1910). The distribution of this water may range from five acre feet for the 1869 land to zero acre feet for 1909 land.

But do all farmers take their full share in the normal flow water? The answer is no. This is because as mentioned earlier, most of the natural flow from the watershed (70 percent) comes in the period December-April. During this period with a typical rotation, the total farm water need approximated 30 percent[13] of the annual total. The assessment water supplied to farmers during this period (under the assessment water right discussed below) approximates 37 percent of the annual total. Farmers tend to use assessment water because it is less costly. Another reason may be that application of normal flow right water every eight days may turn out to be more expensive due to irrigation labor than applying water from other sources. Water from other sources is not applied as often as the normal flow. It has been calculated that the average water received under

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13. Based on total acres grown under the rotation.

this right is one-half acre foot.[14] Farmers having earlier water right may receive up to one acre foot.[14]

The normal flow right given by such appropriation is strictly not a right to the water itself but a right to the use of water. The right to appropriate is a right that belongs to the land owner but the water appropriated is appropriated for the land and becomes appurtenant to the land, and not to the owner.

Water Rights to Stored and Developed Water

Stored and developed water represents that water carried by the rivers over and above that taken by the farmers under the normal flow right. This water is then stored in the dams and given to farmers under assessment water right and excess water right.

By the agreement entered between the Project and the United States, Project members, whether owners of land in Class A, B, or C, are entitled to the benefits of stored water. Such members have equal rights to stored water. This right covers the entire area of 240,000 acres of the Project. Each farmer has to pay an annual assessment levied by the board of governors of the Project. On payment of his assessment, each farmer gets "assessment water". This water has been two acre feet per acre. Also in case of any excess in stored water over and above the

14. Estimates made by Dr. M. M. Kelso, Agricultural Economics Department, University of Arizona.

"assessment water", each farmer gets an equal portion of that water on paying a certain water rate. "Excess water" has been one acre foot.

Water Rights to Pumped Water

Pumped water represents that water pumped by the Project for those farmers having a pump water right.

In 1929, the Project offered pumped water rights for sale. All owners of parcels of land within the Project were entitled to purchase a pump water right for $5.00 an acre foot per acre. Again in 1948, due to extended drought and scarcity of water, a program was advanced to develop additional underground water. Each land owner had the right to acquire this pump water right upon payment of assessment of $14.00 per acre for each acre foot. The pump water right purchased in any or both periods allows the farmer to buy pump water if and when needed, up to a maximum of two acre feet per acre, the upper limit that could be acquired by any farm.

All above water rights adhere to the land. They are not transferable nor purchasable without the land to which they pertain and to which they are attached.

Canal System

Water derived from the various water rights moves to individual parcels of land through a system of canals. The canal system starts at

Granite Reef Diversion Dam. There are two major canals leading from this dam, one is located on the north of the river and is called Arizona Canal and the other to the south of the river and is called South Canal. These canals in turn supply water for five additional canals.

The Arizona Canal (canal number 1), provides water to Grand Canal (canal number 2), through the so-called Cross-cut canal. On the south of the river, the South Canal (canal number 3), provides water for Eastern canal (number 4), the Consolidated canal (number 5), Tempe canal (number 6), and Western canal (number 7).

The capacity of each canal depends on the number of laterals it serves and on its length. The total length of these canals and laterals is about 1,282 miles.

The Project is obliged to deliver water to the highest corner of the quarter section (160 acres) and to collect the drainage water at the low point of the quarter section. No water is lost and the canal system is a perfectly woven network. Most of these canals and laterals are open ditches.

In the canals and laterals there are delivery gates installed in the structures. A structure consists of walls and bottom made of concrete that is reinforced with steel bars. The purpose of the structure is to raise the water level high enough to make a proper delivery. The laterals are numbered. Numbering runs from upstream to downstream of the canal. Each gate is also numbered. The numbering starts at the head of the lateral.

Every gate in the Project is indicated by its specific number, its lateral number and canal number. For example, 2 - 15 - 13 means canal 2, lateral 15 and gate 13. This procedure makes work in the field easier when locating a farm or a gate.

The Project is trying to tile the laterals with tile pipes. This is done to improve irrigation facilities and to eliminate hazardous situations for children and animals, to improve roads and locations, to minimize loss due to evaporation and seepage and minimize operation difficulties and lessen moss and vegetation growth.

The tiling program is helped by the rehabilitation and betterment program, a law that has been passed by the United States Congress to provide loans to irrigation districts established under the reclamation act of 1902, in order to improve irrigation facilities and conserve irrigation water. It is worth noting that this program has enabled the Project to improve its canals and laterals. Of a total of 1,144 miles of laterals and ditches, as of 1963, 351 miles had been improved by pipe and slip form, open or closed.[15] Also, of 138 miles of major canals, 44 miles had been lined as of this date.

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15. Slip form is another term given to open ditches lined with cement.

Water Transmission and Distribution

Water for irrigation is released from the dams only at the request of the water user. The ordering of the release of water is done only by the superintendent of water transmission.

In each of the five field offices there is a watermaster, a chief clerk and "zanjeros".[16] The chief clerk receives the orders and requests of the water users. He checks the water user's water credit. If the water user has credit then he is notified about the time he will receive his water. The watermaster compiles all water orders in his area, previously received by his office and which are scheduled for the next day. He deducts from his water requirement the water that he can get from the pumps located in his area. He then figures the amount he needs from the storage system after allowing for carriage and other losses. The overall loss is about 30 percent of all water diverted from the storage system. The watermaster sends his water order to the superintendent of transmission.

The superintendent of transmission combines the orders received from the five field office divisions and computes the water needed from the reservoirs. The time factor is always considered when scheduling the release and distribution of irrigation water.

When the water ordered from the dams is diverted into the canal system the zanjero or water distributor measures his ordered water. He

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16. A zanjero is a Spanish word meaning a ditch rider or a water distributor.

makes telephone calls to the users who ordered the water for that day, telling them when their water will be in their gates. He then opens the lateral gates and measures the right amount of water in the desired gate.

Each zanjero has a car equipped with a radio-phone. He can be contacted at all times through a field dispatching office or through the main office. This type of field communication facilitates field operations and results in efficient services.

CHAPTER III

EFFECT OF WATER RIGHTS ON OPTIMUM FARM ORGANIZATION

This section pertains to the second primary objective of this study; determining the impact of water rights on the cropping system. For this analysis, a typical medium-sized commercial farm of 360 acres is considered. Data available indicate that 280 acres, or 78 percent of the total farm area, are in crops.[1] The other 80 acres are composed of fallow, idle land, farmstead, ditches and roads.

Water Situations

The budget analysis of the 360-acre farm is made on the basis of four different water situations. These include all the various water source combinations which farms have in the Salt River Project. The four water situations, together with the maximum acre feet of water which a 360-acre farm can obtain from each are given in Table 7.

Each of these water situations differs from the other in one respect. All of them have equal rights to assessment water and to excess water. Water allotments from these rights have been two acre feet of

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1. This is based on field survey data provided by Dr. A. G. Nelson, Agricultural Economics Department, University of Arizona, and on analysis of the crop reports compiled by the Salt River Project.

Table 7. Four Water Right Situations and Estimated Maximum Acre Feet of Water Which a 360-Acre Farm can Obtain from Each, Salt River Project.

Water Situation I		Water Situation II		Water Situation III		Water Situation IV	
Right	Acre Feet	Right	Acre Feet	Right	Acre Feet	Right	Acre Feet
Assessment	720	Assessment	720	Assessment	720	Assessment	720
Excess	360	Excess	360	Excess	360	Excess	360
Normal Flow (Early)	360	Normal Flow (Late)	180	---	---	---	---
Project Pump	720	Project Pump	720	Project Pump	720	---	---
---	---	---	---	---	---	Private Pump	up to 720
Total	2100		1960		1800		1800

assessment and one acre foot of excess water. It is assumed that these water allotments will continue to apply in both 1965 and 1975. Water situation I has an early normal flow right estimated to provide one acre foot per acre available at all times when it could be used.[2] Water situation II has a late normal flow right estimated at one-half acre foot per acre.[2] Water situations I, II, and III include Project pump water rights

2. There is no official record on this part. These estimates were obtained from Dr. M. M. Kelso, Professor of Agricultural Economics, University of Arizona.

up to two acre feet per acre. Water situation IV, on the other hand, has a private pump instead of a Project pump right.

The potential water available for water situations I, II, and III is 2,100, 1,960, and 1,800 acre feet respectively. Water situation IV has a total of 1,080 acre feet available from the Project stored and developed water, and an estimated 720 acre feet from private pumps. The 720 acre feet of water may not be the maximum which can be pumped in some circumstances, but it is taken as the limit for this analysis.

Cropping Pattern

There are four crops considered in this study; cotton, alfalfa, sorghum and barley, which constitute the major field crops in the Salt River Project. These crops occupy over 80 percent of total harvested acreage.[3]

The approach followed in this study is:

1. To examine each of the above crops individually to determine its relative profitability on a per-acre basis.
2. To allocate these crops to the different water situations in order to choose a cropping system that will maximize net returns.

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3. Salt River Project, Crop Reports. Salt River Project, Phoenix, Arizona, from 1957 to 1962.

In each water situation, consideration is given to following a sound rotation that will maintain a constant level of productivity in both periods 1965 and 1975. Following a sound rotation is important in reducing or eliminating pests and disease infestation, in maintaining soil fertility and in facilitating an efficient farm organization. Therefore a sound rotation serves as a limiting factor restricting the expansion of the most profitable crops, thereby preventing them from occupying all the cropland.

In the 1965 budgets, the cotton acreage is limited to 112 acres because of the acreage control program. To conform to a sound rotation, alfalfa hay acreage is fixed at 56 acres and grain acreage at 112 acres.

Alfalfa typically remains in the rotation for three years, during which six cuttings are taken each year. If alfalfa hay acreage is increased to more than 56 acres, the acreage of cotton, sorghum or barley must then be decreased by that much. The farmer is assumed to be rational in his farm decision-making, and, since cotton is the most profitable crop, to maximize his profits he will not substitute alfalfa for cotton.

The acreage of sorghum or barley (single or double-cropped) varies from one budget to another within the limit of 112 acres and varies from one water situation to another depending on their relative profitability with each water right type.

The 1975 cropping pattern is the same as in 1965, and for similar reasons. Note that this does not mean that the optimum cropping systems shall be the same in both periods.

Yields and Associated Inputs of Materials

The yield estimates used in this study were obtained as discussed earlier in the section pertaining to sources of data. These yields are given in Table 8.

Table 8. Yield Estimates per Acre for the Major Field Crops in the Salt River Project for 1965 and 1975 Periods.

Crop	Yield		
	Unit	1965	1975
Cotton Lint	Lb.	1150	1400
Cotton Seed	Lb.	1775	2161
Alfalfa Hay	Ton	6.5	8.0
Sorghum	Lb.	4100	5500
Barley	Lb.	3470	4000
Sorghum after Barley	Lb.	3400	4000

The inputs of materials associated with the above yields are given in Table 9. Note that while seed rates, water requirements, insecticides and defoliants were kept constant in both periods, fertilizer application was anticipated by specialists in the College of Agriculture to increase in 1975.

Commodity Prices and Expenses

The sources of commodity prices and per-unit costs and expenses are as discussed in the section on sources of data.

Commodity Prices

The 1965 cotton prices are based on 1964 support payments. Alfalfa hay is assumed to be sold at the average price available during the past five years. Prices for the other crops are similarly determined. In 1975 only cotton and cottonseed prices are anticipated to be different from 1965. Long-term predictions[4] made by the United States Department of Agriculture indicate that prices of cotton lint may fall from $.315 per pound in 1965 to $.25 per pound in 1975. Prices of cottonseed, however, may increase from $48 per ton to $67 per ton in the above period. Other commodity prices used in both periods are as follows:

Alfalfa Hay	@	$25.00 per ton
Sorghum	@	$2.32 per cwt.
Barley	@	$2.17 per cwt.

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4. U.S.D.A., Agricultural Price and Cost Projections for Use in Making Benefit and Cost Analyses of Land and Water Resource Projects, Washington, D. C., Sept. 1957, p. 18.

Table 9. Summary of Materials Used Per Acre in 1965 and 1975 for Producing Crop Enterprise

	Cotton	Alfalfa incl. estab. stand[a]	Barley	Sorghum	Barley Sorghum Double-Cropped	Cotton	Alfalfa[a]	Barley	Sorghum	Barley Sorghum Double-Cropped
			1965					1975		
Nitrogen (lb)	120	2	64	72	136	150	2	80	80	160
P_2O_5 (lb)	30	43	24	20	44	30	64	25	25	50
Seed (lb)	22	20	100	10	110	22	20	100	10	110
Water (acre feet)	5	6.5	2.50	2.75	5.25	5	6.5	2.5	2.75	5.25
Dalapon[b] (lb)	6	--	--	--	--	6	--	--	--	--
4-2 Emulsion[c] (qts)	15	--	--	--	--	15	--	--	--	--
Defoliant (gal) ($NaClO_3$)	2	--	--	--	--	2	--	--	--	--

a. Include 1/3 establishing and maintaining alfalfa stand.

b. Dalapon is a herbicide - it includes stickers.

c. Includes four pounds per gallon of toxaphene and two pounds per gallon of D.D.T.

Expenses

Cost per unit of input in 1965 and 1975

The costs per unit of input used in this study in 1965 and 1975 are given in Table 10.

Table 10. Estimated Input Costs per Unit in 1965 and 1975, Salt River Project.

Input	Unit	1965	1975
		dollars	dollars
Labor			
Tractor Driver and general	hour	1.35	1.50
Temporary and irrigators	hour	1.05	1.15
Fuel and Oil			
Gasoline	gallon	.23	same
Diesel	gallon	.19	same
Gas used in trucks	gallon	.30	same
Material			
Nitrogen Fertilizer	Lb.	.116	same
Phosphate Fertilizer	Lb.	.106	same
Cotton seeds	100 lbs.	15.00	same
Alfalfa seeds	100 lbs.	15.00	same
Sorghum	100 lbs.	21.00	same
Barley	100 lbs.	4.30	same
Dalapon	lbs.	1.15	same
4-2 Emulsion	quart	1.16	same
Defoliant (sodium chlorate)	gallon	1.10	same
Assessment water	2 ac. ft./acre	4.00	same
Excess water	acre feet	3.00	same
Normal flow water	acre feet	3.00	same
Project Pump Water	acre feet	7.50	same
Private Pump water	acre feet	7.00	9.00

Source: Dr. Aaron G. Nelson, Department of Agricultural Economics, University of Arizona.

Labor estimates used in the analysis include all labor even though the work may be done by the operator and members of his family. Labor wage rates are estimated at the level paid hired labor and include housing and perquisites when provided. Analysis of wage indexes from 1955 to 1963 indicates that wage rates increase over time relatively more than per-unit costs of other inputs.[5] By calculating the relative changes in wage rate (wages paid in any particular year divided by total prices paid by farmers in the same year), the results obtained indicate that there may be a relative increase of 10 percent in wage rates in 1975. Labor wages of 1965 were therefore increased by 10 percent in arriving at 1975 labor wages. Supervision of labor was estimated to be 20 percent of farm labor cost in both periods.

Water rates per acre foot prevailing in 1964 were anticipated by Project personnel to continue unchanged for the coming ten years.

There are no data available for private pumps within the Project. Therefore data for comparable private pumps in the West Pinal and Queen Creek areas[6] were used in estimating water costs for private wells within the Project. The variable costs include power, attendance, lubrication, and motor and pump repairs. Because there were different power rates

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5. U.S.D.A., Agricultural Statistics, 1963, Table 685, p. 477.

6. Alan P. Kleinman, "Cost of Pumping Water in Central Arizona," unpublished M.S. thesis, University of Arizona, Tucson, 1964.

prevailing in the Salt River Project and the West Pinal and Queen Creek areas, the power cost for private pumps within the project was estimated to be the same relative to lift as for Project pumps.

Reports on groundwater in Arizona indicate that the water table in the Project area is declining at an average annual rate of six feet.[7] Assuming the water table continues to decline at this rate, the lift will increase 60 feet by 1975 to 343 feet. The water cost per acre foot per foot of lift for private pumps within the Project in 1975 was estimated in the same way as for 1965.

It is to be noted that the estimated water costs for private pumps in 1965 and 1975 do not include the overhead fixed costs of management, deepening wells, depreciation, interest on investment, or taxes on pump, well and motor.

Variable costs of production in 1965

Using the above per-unit costs, calendars of operations for production of the four crops were developed. The results are summarized in Table 11. This table gives the variable costs for each operation. The costs include fuel and oil; repair and maintenance; farm labor and custom work; materials such as seeds, fertilizers and insecticides and miscellaneous items such as auto and pickup variable costs, and insurance.

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7. Natalie D. White and others, <u>Annual Report on Groundwater in Arizona, Spring 1962 to Spring 1963</u>, U.S. Geological Survey, Phoenix, Arizona, 1963.

Repair and maintenance for each operation include both the repair and maintenance of the tractor and the equipment. Where the farmer did not own the machine, custom work was assumed.

Table 11. Estimated Variable Costs per Acre, Other Than Water, and Interest on Variable Costs for Specified Crops in the Salt River Project, 1965.

Crop and Operation	Fuel and Oil	Repair and Mainte-nance	Labor and Custom Work	Ma-terial	Misc.	Total
		Dollars				
Cotton						
Cut stalks	.28	.33	.54			1.15
Disk (2 x)	.34	.64	.54			1.52
Subsoil	.40	.73	.61			1.74
Plow	.74	1.05	.96			2.75
Float (75% or 25%)	.26	.23	.30			.79
Land plane (custom)			.75			.75
Furrow out	.25	.16	.34			.75
Fertilize	.09	.12	.27	10.14		10.62
Prepare ends	.08	.08	.12			.28
Irrigate			10.51			10.51
Mulch seed bed	.10	.07	.30			.47
Plant	.12	.22	.34	3.30		3.98
Drag off	.10	.07	.30			.47
Cultivate and/or Fertilize	1.08	2.52	3.66	6.96		14.22
Chemical weed control			5.00	6.90		11.90
Thin and weed (custom)			9.45			9.45
Spray (custom)			7.60	18.44		26.04
Defoliate (custom)			1.90	2.20		4.10
Pick	1.84	10.30	7.00			19.14
Scrap			13.80			13.80
Haul	.34	1.20	1.35			2.89
Supervision @ 20% Labor			5.43			5.43

Table 11. (continued)

Crop and Operation	Fuel and Oil	Repair and Mainte- nance	Labor and Custom Work	Ma- terial	Misc.	Total
		Dollars				
Cotton (cont.)						
Auto and Pickup					3.05	3.05
Miscellaneous					6.70	6.70
Ginning			46.00			46.00
Total	6.02	17.72	117.07	47.94	9.75	198.50
Alfalfa						
Establish Stand						
Disk (2 x)	.34	.64	.54			1.52
Plow	.74	1.05	.96			2.75
Float twice, 75%[a]	.51	.34	.59			1.44
Land plane, 25%[a]	(custom)		1.25			1.25
Build border	.23	.17	.34			.74
Fertilize	.09	.12	.34	5.85		6.40
Irrigate			3.17			3.17
Mulch seed bed	.10	.07	.34			.51
Plant	.15	.35	.34	9.00		9.84
Total	2.16	2.74	7.87	14.85		27.62
1/3 of Total	.72	.91	2.62	4.95		9.21
Hay Crop						
Irrigate			12.62			12.62
Fertilize	.04	.12	.14	2.77		3.07
Cut (6 times)	.96	2.10	3.24			6.30
Rake (6 times)	.96	1.80	3.24			5.94
Bale and Roadside			34.13			34.13
Supervision @ 20% Labor			4.29			4.29
Auto and Pickup					1.96	1.96
Miscellaneous					1.85	1.85
Total[b]	7.90	4.02	60.28	2.86	3.81	79.27

a. The farmer land planes once every four years and floats the other three years.

b. Includes 1/3 of establishing and maintaining the alfalfa stand.

Table 11. (continued)

Crop and Operation	Fuel and Oil	Repair and Mainte-nance	Labor and Custom Work	Ma-terial	Misc.	Total
		Dollars				
Barley						
Disk (2 x)	.47	.75	.65			1.87
Float, 75%[c]	.26	.17	.30			.73
Land Plane, 25%			.75			.75
Build border	.12	.08	.16			.36
Prepare ends	--	--	--	--	--	--
Fertilize	.09	.12	.27	9.97		10.45
Irrigate			5.26			5.26
Mulch seed bed	.10	.08	.34			.52
Plant	.15	.35	.34	4.30		5.14
Cultivate and/or Fertilize	--	--	--	--	--	--
Combine			6.00			6.00
Haul			3.30			3.30
Supervision @ 20% Labor			1.46			1.46
Auto and Pickup					.95	.95
Miscellaneous					2.10	2.10
Total	1.19	1.55	18.83	14.27	3.05	38.89
Sorghum (single crop)						
Cut stalks	.28	.33	.54			1.15
Disk (2 x)	.34	.64	.54			1.52
Plow	.74	1.05	.96			2.75
Float, 75%	.26	.17	.30			.73
Land Plane, 25%			.75			.75
Furrow out	.25	.16	.34			.75
Prepare ends	.16	.06	.09			.21
Irrigate			5.78			5.78
Mulch seed bed	.10	.07	.30			.47
Plant	.12	.22	.34	2.10		2.78

c. *Ibid*.

Table 11. (continued)

Crop and Operation	Fuel and Oil	Repair and Mainte- nance	Labor and Custom Work	Ma- terial	Misc.	Total
		Dollars				
Sorghum (single crop) cont.						
Cultivate and/or Fertilize	.36	.84	1.50	10.47		13.17
Combine			6.00			6.00
Haul			4.10			4.10
Supervision @ 20% Labor			2.13			2.13
Auto and Pickup					1.18	1.18
Miscellaneous					2.00	2.00
Total	2.51	3.54	23.67	12.57	3.18	45.47
Sorghum after Barley						
Disk	.47	.75	.65			1.87
Float, 75%	.26	.17	.30			.73
Land plane, 25%			.75			.75
Furrow out	.25	.16	.34			.75
Build border	--	--	--			--
Prepare ends	.06	.06	.09			.21
Fertilize	--	--	--			--
Irrigate			5.75			5.78
Mulch seed bed	.10	.07	.30			.47
Plant	.12	.22	.34	2.10		2.78
Cultivate and/or Fertilize	.36	.84	1.50	10.47		13.17
Combine			6.00			6.00
Haul			2.00			2.00
Supervision @ 20% Labor			2.13			2.13
Auto and Pickup					1.18	1.18
Miscellaneous					2.00	2.00
Total	1.62	2.27	20.18	12.57	3.18	39.82

Table 11. (continued)

Crop and Operation	Fuel and Oil	Repair and Maintenance	Labor and Custom Work	Material	Misc.	Total
		Dollars				
Barley-Sorghum double-cropped[d]						
Total	2.91	3.82	39.01	26.84	6.23	78.71

d. This includes estimated variable costs for barley and sorghum after barley.

Source: Dr. Aaron G. Nelson, Department of Agricultural Economics, University of Arizona.

The cost estimates given in Table 11 represent the variable costs (other than water costs and interest on variable costs) incurred in the growing season. The variable costs of producing alfalfa hay represent one-third of the costs of establishing an alfalfa stand (alfalfa remains in soil for three years) and the costs of maintaining the alfalfa stand to give six cuttings per year.

Table 12 gives the variable costs for producing the selected crops with each type of water (assessment, excess, etc.). (Note that the figures given with each water source assume that all the water is from that given source.) Total variable costs also include interest charged at annual rate of six percent for the approximate period the funds were used in producing the crop.

Note that the reason for including water costs and interest on variable costs in Table 12 instead of Table 11 was for the sake of simplifying the accounts in these tables.

Variable costs of production in 1975

Variable production costs for 1975 were set up in a similar manner to those for 1965. Calendars of operations for the selected crops are summarized in Tables 13 and 14. Table 13 gives the variable costs, other than water and interest on variable operating capital. Table 14 gives a summary of the total variable costs including water and interest charged at the annual rate of six percent for the approximate period the funds were used in producing the crop.

Although the same calendars of operations were used in both periods, the variable costs in 1975 were greater than those in 1965. This increase in costs is attributed to higher per-unit costs of labor and groundwater, to higher levels of fertilizer application and to higher harvesting costs associated with the high yields.

The summaries given in Tables 12 and 14 are used later, with other data, to derive estimated returns over variable costs for each crop with each water source. These estimates in turn, are used in the budget analysis.

Table 12. Estimated Variable Costs of Production per Acre for Each Crop with Each Water Source, the Salt River Project, 1965.

Item	Cotton Per Acre	Alfalfa Hay Per Acre	Barley Per Acre	Sorghum Per Acre	Sorghum after Barley Per Acre	Barley Sorghum Double-Cropped
			Dollars			
Variable Costs other than Water and Interest on Variable Costs	198.50	79.37	38.89	45.47	39.82	78.71
Water Cost with						
Assessment @ $2.00	10.00	13.00	5.00	5.50	5.50	10.50
Excess @ 3.00	15.00	19.50	7.50	8.25	8.25	15.75
Normal Flow @ 3.00	15.00	19.50	7.50	8.25	8.25	15.75
Project Pump @ 7.50	37.50	48.75	18.75	20.63	20.63	39.38
Private Pump @ 7.00	35.00	45.50	17.50	19.25	19.25	36.75
Interest on Variable Costs at 6% with:						
Assessment	4.17	.92	.88	1.02	.91	1.78
Excess	4.27	.99	.93	1.07	.96	1.89
Normal Flow	4.27	.99	.93	1.07	.96	1.89
Project Pump	4.72	1.28	1.15	1.32	1.21	2.36
Private Pump	4.67	1.25	1.13	1.29	1.18	2.31
Total Variable Costs with						
Assessment	212.67	93.29	44.77	51.99	46.23	90.99
Excess	217.77	99.86	47.32	54.79	49.03	96.35
Normal Flow	217.77	99.86	47.32	54.79	49.03	96.35
Project Pump	240.72	129.40	58.79	67.42	61.66	120.45
Private Pump	238.17	126.11	57.52	66.01	60.25	117.77

Table 13. Estimated Variable Costs per Acre, Other Than Water and Interest on Variable Costs for Specified Crops in the Salt River Project, 1975.

Crop and Operation	Fuel and Oil	Repair and Mainte- nance	Labor and Custom Work	Ma- terial	Misc.	Total
		Dollars				
Cotton						
Cut stalks	.28	.33	.59			1.20
Disk (2 x)	.34	.64	.59			1.57
Subsoil	.40	.73	.67			1.80
Plow	.74	1.05	1.06			2.85
Float (25% or 75%)	.26	.23	.33			.82
Land plane			.75			.75
Furrow out	.25	.16	.37			.78
Fertilize	.09	.12	.31	10.14		10.66
Prepare ends	.08	.08	.13			.29
Irrigate			11.56			11.56
Mulch seed bed	.10	.07	.33			.50
Plant	.12	.22	.37	3.30		4.01
Drag off	.10	.07	.33			.50
Cultivate and/or Fertilize	1.08	2.52	4.03	10.44		18.07
Chemical weed control			5.00	6.90		11.90
Thin and weed			9.45			9.45
Spray			7.60	18.44		26.04
Defoliate			1.90	2.20		4.10
Pick	2.24	12.54	10.24			25.02
Scrap			13.80			13.80
Haul	.41	1.46	1.81			3.68
Supervision @ 20% Labor			6.54			6.54
Ginning			56.00			56.00
Auto and Pickup					3.05	3.05
Miscellaneous					6.70	6.70
Total	6.49	20.22	133.76	51.42	9.75	221.64

Table 13. (continued)

Crop and Operation	Fuel and Oil	Repair and Mainte-nance	Labor and Custom Work	Ma-terial	Misc.	Total
		Dollars				
Alfalfa Hay						
Established Stand						
Disk (2 x)	.34	.64	.59			1.57
Plow	.74	1.05	1.06			2.85
Float twice (75%)	.51	.34	.65			1.50
Land plane twice (custom)			1.25			1.25
Build border	.23	.17	.37			.77
Fertilizer	.09	.12	.37	8.53		9.11
Irrigate			3.49			3.49
Mulch seed bed	.10	.07	.37			.54
Plant	.15	.35	.37	9.00		9.87
Total	2.16	2.74	8.52	17.53		30.95
1/3 of Total	.72	.91	2.84	5.84		10.32
Hay Crop						
Irrigate			13.88			13.88
Fertilize	.04	.12	.15	4.10		4.41
Cut and Rake (6 x)	2.29	4.80	8.77			15.86
Bale and roadside			37.54			37.54
Supervision @ 20% Labor			5.04			5.04
Auto and Pickup					1.96	1.96
Miscellaneous					1.85	1.85
Total[a]	3.05	5.83	68.22	9.94	3.81	90.86
Barley						
Disk	.47	.75	.72			1.94
Plow	.74	1.05	1.06			2.85
Float	.26	.17	.33			.76
Land plane			.75			.75
Build border	.12	.08	.18			.38
Fertilize	.09	.12	.30	11.93		12.44
Irrigate			5.79			5.79

a. Includes 1/3 of costs of establishing and costs of maintaining the alfalfa stand.

Table 13. (continued)

Crop and Operation	Fuel and Oil	Repair and Mainte-nance	Labor and Custom Work	Ma-terial	Misc.	Total
		Dollars				
Barley (cont.)						
Mulch seed bed	.10	.08	.37			.55
Plant	.15	.35	.37	4.30		5.17
Combine			6.91			6.91
Haul			3.80			3.80
Supervision @ 20% Labor			1.61			1.61
Auto and Pickup					.95	.95
Miscellaneous					2.10	2.10
Total	1.93	2.60	22.19	16.23	3.05	46.00
Single Crop Sorghum						
Cut stalks	.28	.33	.59			1.20
Disk (2 x)	.34	.64	.59			1.57
Plow	.74	1.05	1.06			2.85
Float (75%)	.26	.17	.33			.76
Land plane			.75			.75
Furrow out	.25	.16	.37			.78
Prepare ends	.06	.06	.10			.22
Irrigate			6.36			6.36
Mulch seed bed	.10	.07	.33			.50
Plant	.12	.22	.37	2.10		2.81
Cultivate and/or Fertilize	.36	.84	1.65	11.93		14.78
Combine			8.05			8.05
Haul			5.50			5.50
Supervision @ 20% Labor			2.34			2.34
Auto and Pickup					1.18	1.18
Miscellaneous					2.00	2.00
Total	2.51	3.54	28.39	14.03	3.18	51.65
Sorghum after Barley						
Disk	.47	.75	.72			1.94
Float (75%)	.26	.17	.33			.76

Table 13. (continued)

Crop and Operation	Fuel and Oil	Repair and Mainte-nance	Labor and Custom Work	Ma-terial	Misc.	Total
		Dollars				
Sorghum after Barley (cont.)						
Land plane			.75			.75
Furrow out	.25	.16	.37			.78
Prepare ends	.06	.06	.10			.22
Irrigate			6.36			6.36
Mulch seed bed	.10	.07	.33			.50
Plant	.12	.22	.37	2.10		2.81
Cultivate and/or Fertilize	.36	.84	1.65	11.93		14.78
Combine			7.05			7.05
Haul			2.35			2.35
Supervision @ 20% Labor			2.34			2.34
Auto and Pickup					1.18	1.18
Miscellaneous					2.00	2.00
Total	1.62	2.27	22.72	14.03	3.18	43.82
Barley Sorghum Double Cropped						
Disk	.94	1.50	1.44			3.88
Plow	.74	1.05	1.06			2.85
Float (75%)	.52	.34	.66			1.52
Land plane			1.50			1.50
Furrow out	.25	.16	.37			.78
Build border	.12	.08	.18			.38
Prepare ends	.06	.06	.10			.22
Fertilize	.09	.12	.30	11.93		12.44
Irrigate			12.15			12.15
Mulch seed bed	.20	.15	.70			1.05
Plant	.27	.57	.74	6.40		7.98
Cultivate and/or Fertilize	.36	.84	1.65	11.93		14.78
Combine			13.96			13.96
Haul			6.15			6.15

Table 13. (continued)

Crop and Operation	Fuel and Oil	Repair and Mainte-nance	Labor and Custom Work	Ma-terial	Misc.	Total
		Dollars				
Barley Sorghum Double Cropped (cont.)						
Supervision @ 20% Labor			3.95			3.95
Auto and Pickup					2.13	2.13
Miscellaneous					4.10	4.10
Total	3.55	4.87	44.91	30.26	6.23	89.82

Table 14. Estimated Variable Costs of Production per Acre for Each Crop with Each Water Source, the Salt River Project, 1975.

Item	Cotton Per Acre	Alfalfa Hay Per Acre	Barley Per Acre	Sorghum Per Acre	Sorghum after Barley Per Acre	Barley Sorghum Double-Cropped
			Dollars			
Variable Costs other than Water and Interest on Variable Costs	221.64	90.86	46.00	51.65	43.82	89.82
Water Costs with						
Assessment @ $2.00	10.00	13.00	5.00	5.50	5.50	10.50
Excess @ 3.00	15.00	19.50	7.50	8.25	8.25	15.75
Normal Flow @ 3.00	15.00	19.50	7.50	8.25	8.25	15.75
Project Pump @ 7.50	37.50	48.75	18.75	20.63	20.63	39.38
Private Pump @ 9.00	45.00	58.50	22.50	24.75	24.75	47.25
Interest on Variable Costs at 6% with:						
Assessment	4.63	1.04	1.02	1.14	.99	2.00
Excess	4.73	1.10	1.07	1.20	1.04	2.11
Normal Flow	4.73	1.10	1.07	1.20	1.04	2.11
Project Pump	5.18	1.40	1.30	1.44	1.29	2.58
Private Pump	5.33	1.50	1.37	1.53	1.37	2.74
Total Variable Costs with						
Assessment	236.27	104.90	52.02	58.29	50.31	102.32
Excess	241.37	111.46	54.57	61.10	53.11	107.68
Normal Flow	241.37	111.46	54.57	61.10	53.11	107.68
Project Pump	264.32	141.01	66.04	73.72	65.74	131.78
Private Pump	271.97	150.85	69.87	77.93	69.94	139.81

Overhead Costs

Overhead costs are classified in this study into cash and non-cash overhead costs. The cash overhead costs are those which the farmer has to pay currently. They include insurance on machinery and equipment and on improvements other than houses (any house costs are included in wage costs); taxes; accounting and legal costs; and miscellaneous items such as telephone, bookkeeping charges and subscriptions. Note that six percent interest on cash overhead cost was included in total overhead costs. Overhead non-cash costs include depreciation, interest on investment, and management. These items however may not always be non-cash, for example, the case of a farmer making annual payments of interest on credit used in purchasing machinery and equipment. These overhead costs include non-cash costs other than returns to land. In the analysis, the return to land is shown as the residual over and above all other costs.

The estimated cash and non-cash overhead costs with the four water situations in 1965 are given in Table 15. Note that for water situation IV cash and non-cash overhead costs include those involved in water situations I, II, and III and in addition taxes, interest, and depreciation on the privately owned well, pump, and motor.

Taxes were estimated from annual assessments of personal property and real estate and the average total tax rate of school districts in the area. The assessed value of personal property was estimated to be

Table 15. Estimated Cash and Non-cash Overhead Costs per Farm with the Four Water Situations in the Salt River Project, 1965 and 1975.

Item	Situation I, II & III 1965	Situation I, II & III 1975	Situation IV 1965	Situation IV 1975
	Dollars			
Cash Overhead Costs				
Insurance				
machinery and equipment	280	280	280	280
improvements other than houses	131	131	131	131
Taxes				
personal property	487	487	487	487
real estate	1,836	2,441	1,836	2,441
well, pump, and motor			239	290
Accounting and Legal	182	182	182	182
Miscellaneous (telephone, bookkeeping charges, etc.)	196	196	196	196
Interest on overhead cash costs	187	223	201	240
Subtotal	3,299	3,940	3,552	4,227
Non-cash Overhead Costs				
Depreciation				
machinery and equipment	5,202	5,202	5,202	5,202
improvements other than houses	266	266	266	266
cement ditches including irrigation equipment, e. g., head gates, etc.	1,476	1,476	1,476	1,476
pump, well, and motor			802	972
Management	5,085	5,593	5,085	5,593
Interest on Investment @ 6%				
machinery and equipment and improvements	1,894	1,894	1,894	1,894
well, pump, and motor			465	564
Subtotal	13,923	14,431	15,190	15,967
Total	17,222	18,371	18,742	20,194

20 percent of the average life value of machinery, equipment and well, pump and motor. The assessed value of real estate was estimated to be five percent[8] of the value of real estate in the district estimated at $1,200[9] per acre. Tax rate was estimated to be $8.50 per $100 of assessed value.

Interest on investment was estimated at six percent of the average life value of machinery, equipment and well, pump and motor.

Estimated cash and non-cash overhead costs for 1975 are given in Table 15. Note that except for taxes per acre of farm real estate, management, and depreciation, interest and taxes on well, pump and motor, the same cost levels of overhead items in 1965 were assumed in 1975.

Analysis of taxes per acre of farm real estate indicates an increase in real estate taxes over time relative to other prices paid by farmers. By taking the indexes of farm real estate taxes per acre and dividing them by the indexes of all prices paid by farmers for the period 1955-1965[10], the results obtained indicate that there may be an increase of 33 percent in taxes per acre in 1975. Taxes of farm real estate paid in 1965 were therefore adjusted accordingly.

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8. Five percent is the average assessment rate for real estate.

9. Land value estimated by appraisors in Maricopa County ranged from $1,000 to $1,400.

10. U.S.D.A., Agricultural Statistics, 1963, p. 477.

Because of lack of data available for management costs over time, the level of management costs was assumed to increase in the same proportion as wage rates.

As the water table continues to decline, additional capital investment is required periodically in one or more of three components[11]: deepening of wells, adding column and bowls, and enlarging the power unit. The related overhead costs of depreciation, interest on investment and taxes, per-acre foot of water per foot of lift were therefore adjusted to the increased lift of 343 feet in 1975.

Returns over Variable Costs

Using the income and cost estimates presented above, one turns now to calculate the returns over variable costs. A summary of gross returns, variable costs and returns over variable costs for 1965 and 1975 are given in Table 16.

Table 17 shows the ranking of these crops with each water source in both periods according to their highest returns over variable costs. Note that there is no change in 1965 in the pattern of ranking of crops in all water sources. However in 1975, sorghum production becomes more profitable with groundwater than barley-sorghum double cropped.

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11. Alan P. Kleinman, unpublished thesis, "The Cost of Pumping Irrigation Water in Central Arizona," University of Arizona, Tucson, 1964.

Table 16. Gross Returns, Variable Costs, and Returns over Variable Costs per Acre for Specified Crops with Each Water Source in the Salt River Project, 1965 and 1975.

Item	Cotton	Alfalfa Hay	Barley	Sorghum	Sorghum after Barley	Barley Sorghum Double-Cropped
		1965				
Gross Returns	404.85[a]	170.00	75.30	95.12	78.88	154.16
Total Variable Costs with:						
Assessment	212.67	93.29	44.77	51.99	46.23	90.99
Excess	217.77	99.86	47.32	54.79	49.03	96.35
Normal Flow	217.77	99.86	47.32	54.79	49.03	96.35
Project Pump	240.72	129.40	58.79	67.42	61.66	120.45
Private Pump	238.17	126.11	57.52	66.01	60.25	117.77
Returns over Variable costs with:						
Assessment	192.18	76.71	30.53	43.13	32.65	63.17
Excess	187.08	70.14	27.98	40.33	29.85	57.81
Normal Flow	187.08	70.14	27.98	40.33	29.85	57.81
Project Pump	164.13	40.60	16.51	27.70	17.22	33.71
Private Pump	166.68	43.89	17.78	29.11	18.63	36.39
		1975				
Gross Returns	422.39[b]	200.00	86.80	127.60	92.80	179.60
Total Variable Costs with:						
Assessment	236.27	104.90	52.02	58.29	50.31	102.32
Excess	241.37	111.46	54.57	61.10	53.11	107.68
Normal Flow	241.37	111.46	54.57	61.10	53.11	107.68
Project Pump	264.32	141.01	66.04	73.72	65.74	131.78
Private Pump	271.97	150.85	69.87	77.93	69.94	139.81
Returns over Variable costs with:						
Assessment	186.12	95.10	34.78	69.31	42.49	77.28
Excess	181.02	88.54	32.23	66.50	39.69	71.92
Normal Flow	181.02	88.54	32.23	66.50	39.69	71.92
Project Pump	158.07	58.99	20.76	53.88	27.06	47.82
Private Pump	150.42	49.15	16.93	49.67	22.86	39.79

a. Include 1,150 lb. of lint at $.315 and 1,775 lbs. of cottonseed at $48.00 per ton.

b. Includes 1,400 lb. of lint at $.25 and 2,161 lbs. of cottonseed at $67.00 per ton.

Table 17. Ranking of Crops Relative to their Returns over Variable Costs per Acre with Each Water Source in the Salt River Project, 1965 and 1975

Rank	All Water Sources 1965	Water Sources 1975: Assessment Excess Normal Flow	Water Sources 1975: Project Pump and Private Pump
1	Cotton	Cotton	Cotton
2	Alfalfa hay	Alfalfa hay	Alfalfa hay
3	Barley sorghum	Barley sorghum	Sorghum
4	Sorghum	Sorghum	Barley sorghum
5	Sorghum after barley	Sorghum after barley	Sorghum after barley
6	Barley	Barley	Barley

Budget Analysis for Water Situations in 1965 and 1975

Having now discussed the basic income and cost data pertaining to crop production and the relative profitability of individual crops in the Salt River Project we turn to a budget analysis of the effect of water rights on farm organization. Budgets were developed for each of the four water situations in 1965 and in 1975. For reasons discussed earlier, the cropping system of each budget includes 112 acres of cotton and 56 acres of alfalfa hay. The acreages of barley-sorghum double crop, sorghum and barley were permitted to vary within an aggregate limit of 112 acres.

Budgets for Water Situations in 1965

For the 1965 period three budgets were developed for each water situation to determine which would maximize returns over variable costs for each water situation. The budget developed by organizing crops and acres with the various water sources on the basis of per acre relative profitability was found to maximize returns for each of the water situations.

A summary of these budgets for 1965 is given in Tables 18 and 19. Note that in all budgets 112 acres of cotton and 24.62 acres of alfalfa hay were irrigated with assessment water; 31.38 acres of alfalfa hay and 29.71 acres of barley sorghum double crop (referred to hereafter as barley-sorghum) were irrigated with excess water. The remaining grain acreage and utilization of normal flow and groundwater are discussed below for each water situation.

Budget for water situation I

With water situation I note that the normal flow water and the project pump water was used for 68.57 acres and 13.72 acres of barley-sorghum respectively. The cropping system therefore consisted of 112 acres of cotton, 56 acres of alfalfa hay and 112 acres of barley-sorghum. Note in this budget while the amount of assessment water was twice as much as the excess water or the normal flow water the returns from cotton and alfalfa hay were six times as much as returns from alfalfa hay and

Table 18. Cropping Systems and Returns Over Variable Costs for Water Situations I and II in 1965

Water Source	Water Situation I Cotton	Water Situation I Alfalfa Hay	Water Situation I Barley-Sorghum[a]	Water Situation II Cotton	Water Situation II Alfalfa Hay	Water Situation II Barley-Sorghum[a]
Assessment (720 ac. ft.[b])						
Water used (ac. ft.)	560	160		560	160	
Acres in crops	112	24.62		112	24.62	
Net returns per acre $[c]	192.18	76.71		192.18	76.71	
Total net returns $	21,524	1,889		21,524	1,889	
Excess (360 ac. ft.[b])						
Water used (ac. ft.)		204	156		204	156
Acres in crops		31.38	29.71		31.38	29.71
Net returns per acre $[c]		70.14	57.81		70.14	57.81
Total net returns		2,201	1,717		2,201	1,717
Normal flow (360 ac. ft.[b] for water situation I and 180 acre feet for water situation II						
Water used			360			180
Acres in crops			68.57			34.29
Net returns per acre[c] $			57.81			57.81
Total net returns $			3,964			1,983
Project pump (up to 720 ac. ft.[b]						
Water used			72			252
Acres in crops			13.72			48
Net returns per acre[c] $			33.71			33.71
Total net returns $			463			1,618
Total net returns for each enterprise $	21,524	4,090	6,144	21,524	4,090	5,318
Total net returns for all enterprises $		31,758			30,932	

a. Barley sorghum double-cropped. b. Figures in parentheses represent total amount of water under that water situation. c. Net returns refers to returns over variable costs.

Table 19. Cropping Systems and Returns Over Variable Costs for Water Situations III and IV in 1965

Water Source	Water Situation III Cotton	Water Situation III Alfalfa Hay	Water Situation III Barley-Sorghum[a]	Water Situation IV Cotton	Water Situation IV Alfalfa Hay	Water Situation IV Barley-Sorghum[a]
Assessment (720 ac. ft.[b])						
Water used (ac. ft.)	560	160		560	160	
Acres in crops	112	24.62		112	24.62	
Net returns per acre $[c]	192.18	76.71		192.18	76.71	
Total net returns $	21,524	1,889		21,524	1,889	
Excess (360 ac. ft.[b])						
Water used (ac. ft.)		204	156		204	156
Acres in crops		31.38	29.71		31.38	29.71
Net returns per acre $[c]		70.14	57.81		70.14	57.81
Total net returns $		2,201	1,717		2,201	1,717
Project pump (up to 720 ac. ft.[b]) / Private pump (up to 720 ac. ft.)						
Water used			432			432
Acres in crops			82.29			82.29
Net returns per acre[c] $			33.71			36.39
Total net returns $			2,774			2,995
Total net returns for each enterprise $	21,524	4,090	4,491	21,524	4,090	4,712
Total net returns for all enterprises		30,105			30,326	

a. Barley sorghum double-cropped.

b. Figures in parentheses represent total amount of water under that water source.

c. Net returns refer to returns over variable costs.

barley-sorghum with excess water and also six times as much as returns from barley-sorghum. Returns over variable costs from barley-sorghum with normal flow water were $46 higher than returns from alfalfa hay and barley-sorghum with excess water. While alfalfa hay yields more returns over variable costs per acre with excess or normal flow water than barley-sorghum, the amount of water required to irrigate alfalfa hay would irrigate more acres of barley-sorghum. Therefore the reduction in acres of alfalfa hay resulted in more returns for barley-sorghum irrigated with normal flow water. The total return over variable costs for water situation I was $31,758.

Budget for water situation II

With water situation II note that water from normal flow and project pump was used for 34.29 acres and 48 acres of barley-sorghum respectively. The cropping system consists of 112 acres of cotton, 56 acres of alfalfa hay and 112 acres of barley-sorghum. Note that while the acres of barley-sorghum with normal flow water were one-half less than those in water situation I, the acres with project pump water were more by the reduction in acres from barley-sorghum with normal flow water in water situation II. The total returns over variable costs for water situation II were $30,932.

Budget for water situation III

With water situation III note that no normal flow water was available. Therefore water from project pump was used to irrigate 82.29 acres of barley-sorghum. The cropping system consists of 112 acres of cotton, 56 acres of alfalfa hay and 112 acres of barley-sorghum.

Note that while surface water was used for the highest return crops, project pump water was used for the next most profitable crop, barley-sorghum. The returns over variable costs for water situation III were $30,105.

Budget for water situation IV

Water situation IV, like water situation III, has no normal flow water and depends on groundwater to supplement surface water. With this water situation, note that cotton and alfalfa hay were irrigated with the surface water while the groundwater was used for 82.29 acres of barley-sorghum the same as water situation III. The cropping system of water situation IV consists of 112 acres of cotton, 56 acres of alfalfa hay and 112 acres of barley-sorghum. The returns over variable costs were $30,326.

Discussion

The analysis of the effect of water rights on the cropping system and related returns over variable costs for all water situations indicates that for the 1965 period a cropping system with 112 acres of cotton, 56 acres of alfalfa hay and 112 acres of barley-sorghum was optimum for all water situations. The procedure followed in deriving the above budgets resulted in a farm organization with higher returns than any other procedure examined. However, in budgets of water situations in 1975 we shall see that this procedure does not always result in highest returns over variable costs.

Returns over variable costs in the 1965 budgets presented above were highest for water situation I; water situation II ranked second followed by IV and then by III. This ranking is merely due to differences in water costs among the various water sources and the amount of water available and used under each. The acreages of crops in each water situation, the gross returns and the associated variable costs other than water were the same for all water situations. Therefore, the primary factor that contributed in the above array was water costs.

Whether the above arrangement will prevail when farm overhead costs are considered will be revealed following the discussion of the budgets for water situations in 1975.

Budgets for Water Situations in 1975

The budgets for four water situations in 1975 are summarized in Tables 20, 21, 22 and 23. It will be noted that two budgets are presented for each water situation whereas for 1965 only one was given. Budget 1 for each water situation was developed on the same basis as those for

1965, i.e., within the limitations of the cropping system, the acreage of the most profitable crop on a per acre basis was first increased to the maximum, then the second most profitable crop was brought in, and so forth until the entire crop acreage of the farm was utilized. However, with the yields, prices, and costs used in 1975 budgets, this approach did not give maximum returns over variable costs for the farm as a whole. Therefore, a second budget for each water situation was included. In these budgets the entire cropland acreage in the farm is utilized but more of the acreage is used for sorghum as a single crop. The result is that less groundwater is used since sorghum uses less water than barley-sorghum double-cropped. Returns over variable costs per acre foot of surface water, as well as per acre with groundwater, are higher with sorghum than with barley-sorghum with the result that farm returns are higher with budget 2 than with budget 1.

Budgets for water situation I

With water situation I budget 1 includes 112 acres of cotton and 24.62 acres of alfalfa hay irrigated with assessment water; 31.38 acres of alfalfa hay and 29.71 acres of barley-sorghum irrigated with excess water; 68.57 acres of barley-sorghum irrigated with normal flow water and 13.72 acres of sorghum irrigated with project pump water (Table 20). The cropping system developed under budget 1 was 112 acres of cotton, 56 acres of alfalfa hay, 98.29 acres of barley-sorghum and 13,72 acres of sorghum.

Table 20. Cropping Systems and Returns over Variable Costs for Water Situation I in 1975.

Water Source	Budget 1				Budget 2			
	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum
Assessment (720 ac. ft.)								
Water used (ac. ft.)	560	160			560	160		
Acres in crops	112	24.62			112	24.62		
Net returns per acre $	186.12	95.10			186.12	95.10		
Total net returns $	20,845	2,342			20,845	2,342		
Excess (360 ac. ft.)								
Water used (ac. ft.)		204	156			204	156	
Acres in crops		31.38	29.71			31.38	29.71	
Net returns per acre $		88.54	71.92			88.54	71.92	
Total net returns $		2,778	2,137			2,778	2,137	
Normal flow (360 ac. ft.)								
Water used (ac. ft.)			360				279	79.75
Acres in crops			68.57				53.29	29.00
Net returns per acre $			71.92				71.92	66.50
Total net returns $			4,932				3,833	1,928
Project pump (up to 720 ac. ft.)								
Water used (ac. ft.)				72				
Acres in crops				13.72				
Net returns per acre $				53.88				
Total net returns $				739				
Total net returns for each enterprise	20,845	5,120	7,069	739	20,845	5,120	5,970	1,928
Total net returns for all enterprises		33,773				33,863		

Table 21. Cropping Systems and Returns over Variable Costs for Water Situation II in 1975.

Water Source	Budget 1				Budget 2			
	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum
Assessment (720 ac. ft.)								
Water used (ac. ft.)	560	160			560	160		
Acres in crops	112	24.62			112	24.62		
Net returns per acre $	186.12	95.10			186.12	95.10		
Total net returns	20,845	2,342			20,845	2,342		
Excess (360 ac. ft.)								
Water used (ac. ft.)		204	156			204		156
Acres in crops		31.38	29.71			31.38		56.72
Net returns per acre $		88.54	71.92			88.54		66.50
Total net returns $		2,778	2,137			2,778		3,772
Normal flow (180 ac. ft.)								
Water used (ac. ft.)			180				57.75	121.77
Acres in crops			34.29				11.00	44.28
Net returns per acre $			71.92				71.92	66.50
Total net returns $			2,466				791	2,945
Project pump (up to 720 ac. ft.)								
Water used (ac. ft.)				132				
Acres in crops				48.00				
Net returns per acre $				53.88				
Total net returns $				2,586				
Total net returns for each enterprise $	20,845	5,120	4,603	2,586	20,845	5,120	791	6,717
Total net returns for all enterprises			33,154				33,473	

Table 22. Cropping Systems and Returns over Variable Costs for Water Situation III in 1975.

Water Source	Budget 1				Budget 2			
	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum
Assessment (720 ac. ft.)								
Water used (ac. ft.)	560	160			560	160		
Acres in crops	112	24.62			112	24.62		
Net returns per acre $	186.12	95.10			186.12	95.10		
Total net returns $	20,845	2,342			20,845	2,342		
Excess (360 acre ft.)								
Water used (ac. ft.)		204	156			204		156
Acres in crops		31.38	29.71			31.38		56.72
Net returns per acre $		88.54	71.92			88.54		66.50
Total net returns $		2,778	2,137			2,778		3,772
Project pump (up to 720 ac. ft.)								
Water used (ac. ft.)				226.30				152
Acres in crops				82.29				55.28
Net returns per acre $				53.88				53.88
Total net returns $				4,434				2,979
Total net returns for each enterprise $	20,845	5,120	2,137	4,434	20,845	5,120		6,751
Total net returns for all enterprises $			32,536				32,716	

Table 23. Cropping Systems and Returns over Variable Costs for Water Situation IV in 1975.

Water Source	Budget 1				Budget 2			
	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum	Cotton	Alfalfa Hay	Barley Sorghum	Sorghum
Assessment (720 ac. ft.)								
Water used (ac. ft.)	560	160			560	160		
Acres in crops	112	24.62			112	24.62		
Net returns per acre $	186.12	95.10			186.12	95.10		
Total net returns $	20,845	2,342			20,845	2,342		
Excess (360 ac. ft.)								
Water used (ac. ft.)		204	156			204		156
Acres in crops		31.38	29.71			31.38		56.72
Net returns per acre $		88.54	71.92			88.54		66.50
Total net returns $		2,778	2,137			2,778		3.772
Private pump (up to 720 ac. ft.)								
Water used (ac. ft.)				226.30				152
Acres in crops				82.29				55.28
Net returns per acre $				49.67				49.67
Total net returns $				4,087				2,746
Total net returns for each enterprise $	20,845	5,120	2,137	4,087	20,845	5,120		6,518
Total net returns for all enterprises $			32,189				32,483	

In budget 2 the acreage of cotton and of alfalfa hay irrigated with the lowest cost water were the same as in budget 1. The remaining acreages and crops were organized so that 29.71 acres of barley-sorghum were irrigated with excess water, and 53.29 acres of barley-sorghum and 29 acres of sorghum were irrigated with normal flow water. Note that in this setting of crops and their respective acreages, all surface water was utilized and all the cropland acreage was irrigated. The cropping system developed under this budget was 112 acres of cotton, 56 acres of alfalfa hay, 83 acres of barley-sorghum and 29 acres of sorghum.

Comparing the two budgets, note that while the returns from cotton, alfalfa and barley-sorghum with assessment and excess water were the same in the two budgets, the returns from barley-sorghum and sorghum with normal flow water were $829 higher in budget 2 than returns from barley-sorghum with the same water source in budget 1, but while in budget 2 all the cropland acres were irrigated with surface water, in budget 1, 13.72 acres were put under the highest profitable crop with pump water--sorghum, with the result that returns over variable costs were $90 less than in budget 2. Therefore, the cropping system of budget 2 catered to optimum farm organization for water situation I. Moreover, it is to be noted that the cropping system in budget 2 utilized a smaller amount of water than that of budget 1.

Budgets for water situation II

With water situation II note that in budget 1 the acreages of cotton, alfalfa hay and barley-sorghum irrigated with assessment and excess water were the same as in budget 1 of water situation I; water from normal flow and project pump were used for 34.29 acres of barley-sorghum and 48 acres of sorghum respectively. The cropping system developed by this procedure is 112 acres of cotton, 56 acres of alfalfa hay, 66 acres of barley-sorghum and 48 acres of sorghum.

In budget 2 the acreages of cotton, and of alfalfa hay were irrigated with the lowest cost water, the same as in budget 1. The remaining excess water was used for 56.72 acres of sorghum, and the normal flow water was used for 44.28 acres of sorghum and 11 acres of barley-sorghum. Note that in this budget all surface water was utilized, and all the cropped land was irrigated, and no project pump water was used. The cropping system in budget 2 was 112 acres cotton, 56 acres alfalfa hay, 11 acres barley-sorghum and 101 acres of sorghum.

While returns from cotton and alfalfa hay were the same in budgets 1 and 2, returns from sorghum with excess water in budget 2 were $1,635 higher than returns in budget 1 from barley-sorghum with the same amount of excess water. With the normal flow water the returns from sorghum and barley-sorghum were $1,270 higher than returns from barley-sorghum in budget 1. The total increase in returns from crops with surface water in budget 2 over that in budget 1 was $2,905. But note that while in budget 2 all the cropped land was irrigated with the surface water, only 64 acres were irrigated in budget 1 with a reduction of 48 acres. However, when these 48 acres were put under the highest profitable crop with project pump water--sorghum, they yielded a return of $2,586 which is $319 less than the increase obtained by allocating the surface water such that all the cropped land was irrigated. The cropping system system developed under budget 2, therefore is more profitable than for budget 1 in water situation II.

Budgets for water situation III

With water situation III note that in budget 1 cotton, alfalfa hay and barley-sorghum irrigated with assessment and excess water are the same as in budget 1 of the previous water situations. With project pump water sorghum is the highest profitable crop after cotton and alfalfa and 82.29 acres were included. The cropping system developed under budget 1 was 112 acres of cotton, 56 acres of alfalfa hay, 29.71 acres of barley-sorghum and 82.29 acres of sorghum.

In budget 2 of water situation III the acreages of cotton and alfalfa hay were irrigated with the lowest cost water (Table 22). The balance of the excess water was used to irrigate 56.72 acres of sorghum. The remaining 55.28 unirrigated acres were used for sorghum and were irrigated with project pump water. The cropping system for budget 2 was 112 acres of cotton, 56 acres of alfalfa hay and 112 acres of sorghum.

On comparing the two above budgets note that while in budget 1 some barley-sorghum was grown, in budget 2 all the grain acreage was put under sorghum. The returns over variable costs from cotton and alfalfa hay were the same in both budgets, but the returns from sorghum with excess water in budget 2, were $1,635 higher than the returns from barley-sorghum in budget 1 irrigated with the same amount of excess water. Growing only 29.71 acres of barley-sorghum with excess water would leave 27 acres (56.72-29.71) unirrigated relative to the acres irrigated with excess water in budget 2. However, when these 27 acres were planted with sorghum and irrigated with project pump water they yield a return $180 less than the increase in return obtained in budget 2 as discussed above. Therefore, the cropping system developed for budget 2 is more profitable than that for budget 1 with water situation III.

Budgets for water situation IV

The reader may realize that water situation III and IV have many things in common. Both water situations have equal rights to surface water, have no rights to normal flow water and both depend on groundwater to supplement surface water. The only difference between them is that water situation III has access to project pump water through its project pump right while water situation IV has a private well and pump. Since the relative profitability in both water situations with each water source is the same, then the same budgets developed for water situation III and the related discussion will be applicable to water situation IV as is evident from Tables 22 and 23. For this reason no further discussion of water situation IV is given here.

Comparison of Cropping Systems in 1965 and 1975

On comparing the cropping systems developed for periods 1965 and 1975 it is to be noted that while the optimum cropping system for each water situation in 1965 was the same, the cropping systems in 1975 were different in water situation I, II, and III and IV. This means that while the water rights had no effect on the cropping system in 1965 they did affect farm organization in 1975. This was caused by a change in the relative profitability of sorghum in 1975. With the yields, prices and costs used in the budgets sorghum was more profitable relative to other crops in 1975 than in 1965. This was due to increase in returns over variable costs brought about primarily by increase in yields in 1975 (see Table 14). This change also caused sorghum returns per acre foot of water to increase relative to other crops. Thus, in the 1975 period greater returns over variable costs were realized from sorghum with surface water than by using the limited surface water to produce barley-sorghum and producing sorghum on the remaining acreage with groundwater.

It is to be noted that the farm organizations in 1975 utilized less groundwater than the farm organization in 1965 since it grew more sorghum than barley-sorghum. Under these circumstances the farmer in

1975 would not need to worry so much about the continuous declining water table and increasing groundwater costs since they would not depend on groundwater to the extent that they do in 1965.

Returns to and Indicated Value of Land in 1965 and 1975

From the returns over variable costs obtained in the above budgets (Table 18 through 23), cash and non-cash overhead costs other than returns to land were deducted. The residual thus obtained constitutes the returns to land (Table 24). Cash and non-cash overhead costs used above were taken from Table 15 of the text.

Once returns to land have been estimated, an indicated value may be computed for the land by capitalization. Capitalization is the process by which value is derived from annual returns.[12] It requires two factors: an estimate of annual net returns and a capitalization rate.[13] The annual returns to land estimated above for each water situation in the two periods were divided by 360, the total acres of the farm, in order to get the annual returns to land per acre. The capitalization rate expresses the relationship between an annual return and the value of the property. A capitalization rate of 5 percent was used in this study and was chosen as a representative of the opportunity return which might be realized from the capital

12. Net returns here means returns over and above all costs other than returns to real estate.

13. William G. Murray, Farm Appraisal and Valuation, Iowa State, Ames, 1961, p. 238.

invested in land. Therefore the indicated value is an indicated 'opportunity value' of the land.

The capitalization rate however may vary from one water situation to the other depending among other factors on the degree of risk involved in each case. The reader may recognize that water situation II does not get a constant one-half acre foot of normal flow water year after year but that this amount represents an average over a period of time, whereas with water situation I the normal flow is somewhat more dependable. Therefore, the risk involved in the two situations is not the same and hence the capitalization rate in water situation II perhaps should be somewhat higher than in situation I due to the greater risk involved.

Assuming that the project will be able to continue supplying assessment, excess and groundwater at the present level and that the farmer with a private well and pump is concerned about a declining water table and all related items, then the risk involved in water situation IV is greater than the risk involved in water situation III, ceteris paribus, and therefore the capitalization rate of water situation IV perhaps should be higher than that of water situation III. But because of the lack of information as to the relative magnitude of the risks involved only one capitalization rate was used in this study, with the recognition that the indicated value estimated may vary.

On comparing the indicated value of land in each water situation, note that these values vary from one water situation to the other and from

Table 24. Returns Over Variable Costs, Cash and Non-cash Overhead Costs, Returns to Land and the Indicated Value of Land with the Four Water Situations, the Salt River Project, 1965 and 1975

Item	Water Situation I		Water Situation II		Water Situation III		Water Situation IV	
	1965	1975	1965	1975	1965	1975	1965	1975
	Dollars							
Returns over variable costs	31,758	33,863	30,932	33,473	30,105	32,716	30,326	32,483
Overhead cash costs	3,299	3,940	3,299	3,940	3,299	3,940	3,552	4,227
Balance	28,459	29,923	27,633	29,533	26,806	28,776	26,774	28,256
Overhead non-cash costs[a]	13,923	14,431	13,923	14,431	13,923	14,431	15,190	15,967
Returns to real estate	14,536	15,492	13,710	15,102	12,883	14,345	11,584	12,289
Returns to land per acre	40	43	38	42	36	40	32	34
Indicated value of land per acre capitalized at 5%	800	860	760	840	720	800	640	680

a. Other than returns to land.

period to period. The variation within a period was because the returns to land obtained in each water situation were different. Note with reference to Table 24 that the overhead costs were the same in water situations I, II and III and higher in water situation IV by the amount of overhead costs of the private well, pump and motor (see Table 15). Since the returns over variable costs for the first three water situations varied and since these situations have the same overhead costs, then the returns to land were highest for situation I, followed in order by II and then III. However when water situation IV is compared with the former three, the higher level of overhead costs results in ranking it last with respect to returns to land. The relative indicated value of land therefore is highest for water situation I followed by water situation II then III and last IV. However it is to be recognized that although water situation IV has a comparatively low indicated value to land, the presence of a private well and pump in the above situation may make the actual value higher than the estimated indicated value. The capital investment in the well and pump which was deducted in the form of depreciation in arriving at returns to land, may be paid by the purchaser of the real estate over and above the indicated value derived by capitalization.

It is to be noted however the above indicated value of land is not absolute and may vary more or less with any individual farm. The estimated value given above does not include income associated with houses, location and other intangible features.

From the above discussion note that while the water rights had no effect on the cropping system in 1965 their effect on land value resulted in different indicated values of land in the four water situations. With respect to 1975 it is to be noted that water rights affected both cropping systems and land values.

The indicated value of land in the two periods showed an increase in the indicated value of land in 1975 relative to 1965.

CHAPTER IV

SUMMARY AND CONCLUSIONS

This study pertains to the Salt River Project in central Arizona, a non-profit organization which provides irrigation water for farms within its boundaries.

Water is the primary limiting factor in agricultural production in this area. Crop production is dependent upon irrigation since precipitation averages only about eight inches annually.

The objective of this study is twofold: to examine the organization and operation of the Salt River Project and to analyze the effect of water rights on farm organization and value. Only limited work has been done heretofore in these areas. Treatment of the first objective is primarily descriptive, based largely upon first-hand knowledge gained in personal study and observation of the Project. In analysis of the second objective budgets were constructed as of 1965 and 1975 for a medium sized 360 acre farm, assuming various representative water situations to show the effect of water rights upon the cropping system and upon indicated land values assuming the goal of management to be maximization of income. Data for the budget analysis were primarily from A. G. Nelson, major porfessor, Department of Agricultural Economics, and judgment of other departments in the College of Agriculture, University of Arizona, supplemented by information from the United States Department of Agriculture.

The budgets were based upon estimated yields, prices and costs expected to be realized during 1965 and 1975. The yields, prices and costs used in the budgets were estimated at approximately the level prevailing in the area in the 1965 period. In the 1975 period, yields and fertilizer application were increased to account for anticipated increased adoption of presently known technology. Cotton lint prices were anticipated to fall while cotton seed prices to rise, and wages, management and real estate taxes were expected to increase relative to 1965.

The Salt River Project is comprised of the Salt River Valley Water Users' Association and the Salt River Project Agricultural Improvement and Power District. While the Association and Power District are separate legal entities each with its own board of directors, the two boards have always been one and the same, elected by the shareholders in the Project. The Project is administered by a general manager who is responsible for both the irrigation and power phases. Two associate general managers and three assistant general managers assist in carrying out functions of the Power District, while one associate general manager assists on the Water Users' Association side.

The Project obtains its water from a series of dams on the rivers in the watershed located east and north of the Project and from wells located within the Project. To carry out functions involved in supplying water to its users, the Salt River Project Water Users' Association is divided into five departments: watershed, irrigation operation, irrigation service, engineering and construction and maintenance. The watershed department observes, records and takes necessary action for the protection of water supply from uses by others not entitled to it, and for conserving this water supply for the project storage system, and provides annual forecasts of the expected water yield. The irrigation operation department delivers with a minimum of loss the stored and developed water to the land within the Project on demand of the shareholders. The irrigation service department properly administers the water rights of all land within the boundary of the Project. The engineering department provides the engineering and technical skills in construction, maintenance and research for the irrigation transmission, distribution and groundwater system, to maintain proper efficiency of water delivery to the shareholders of the Project. The construction and maintenance department maintains the irrigation facilities in a condition that will permit economical and efficient operation of the system.

Electric power distributed by the Project is obtained from hydroelectric plants on four of the six storage dams in the watershed and six thermal-electric plants within the Project. The power phase of the Project's operation provides a substantial subsidy for irrigation and domestic water.

The water made available by the Salt River Project to its shareholders is allotted among the farms according to water rights as established in 1910 by the Kent decree. Water rights are now of three types: Class A rights, Class B and C, and pump rights. Class A rights include the normal flow rights which represent rights to that water carried by rivers and which is not restricted by impounding. These rights cover an area 148,753 acres comprising the land which was under continuous irrigation year after year from 1869 to 1909. The 1869 land has first priority in rights followed in order by 1870 and so on to 1909. Normal flow rights should be used within the following eight days, otherwise they are lost. Land with Class A rights also has equal rights to stored and developed water along with other land in the Project. Class B and C rights pertain to the water stored and developed over and above that taken by farmers having Class A rights. They include assessment and excess water the benefits of which are equally distributed among all acres in the Project.

The pump rights represent rights to pumped water made available by the Project to those farmers who purchased a pump right at the time they were offered for sale. All water rights adhere to the land; they cannot be bought or sold. In addition, many of the farms in the Project have private wells.

Within this framework, water rights of farms in the Project may be classified into four groups referred to in this study as "water situations" according to the source of the water the farms receive. These are as follows:

Water Situation I	Water Situation II	Water Situation III	Water Situation IV
Assessment	Assessment	Assessment	Assessment
Excess	Excess	Excess	Excess
Normal Flow (early right)	Normal Flow (late right)	-	-
Project Pump	Project Pump	Project Pump	-
-	-	-	Private Pump

Four major field crops typical of the area were included in the budgets: cotton, alfalfa hay, barley and sorghum. Barley-sorghum double-cropped was also included, making a total of five enterprises. Returns over variable costs per acre were calculated for each crop. The ranking of the crop enterprises in terms of returns over variable costs for each of the four water situation in 1965 and 1975 is as follows:

		Water Sources 1975	
Rank	All Water Sources 1965	Assessment, Excess and Normal Flow	Project Pump and Private Pump
1	Cotton	Cotton	Cotton
2	Alfalfa Hay	Alfalfa Hay	Alfalfa Hay
3	Barley Sorghum	Barley Sorghum	Sorghum
4	Sorghum	Sorghum	Barley Sorghum
5	Sorghum after Barley	Sorghum after Barley	Sorghum after Barley
6	Barley	Barley	Barley

Note that while the relative profitability of crops was the same in all water sources in 1965, in 1975 the relative profitability of these crops with surface water sources was different from the groundwater source.

In preparing budgets for the farm, the first approach was to allocate acreage to the most profitable crop up to the limit of governmental acreage allotment or rotational restrictions, then to the crop which ranked second in profitability and so on until the entire cropland acreage was utilized. This budget procedure gave the highest farm returns over variable costs for the 1965 period. However, in the 1975 period, higher farm returns over variable costs were obtained when the entire cropland acreage in the farm was utilized, but more of the acreage was used for sorghum as a single crop. This was due to the change in the relative profitability of sorghum in 1975. With the yields, prices and costs used in the budgets, sorghum was more profitable relative to other crops in 1975 than in 1965. This change also caused sorghum returns per acre foot of water to increase relative to other crops. Thus, in the 1975 period, greater returns over variable costs were realized from sorghum with surface water than by using the limited surface water to produce barley-sorghum and producing sorghum on the remaining acreage with groundwater.

The cropping systems which gave the highest returns over variable costs are as follows:

Crop	1965, All Water Situations (Acres)	1975 Water Situations (Acres) I	II	III	IV
Cotton	112	112	112	112	112
Alfalfa Hay	56	56	56	56	56
Barley Sorghum	112	83	11	-	-
Sorghum	-	29	101	112	112

Overhead cash and non-cash costs other than returns to land were deducted from returns over variable costs to obtain returns to land for each of the water situations in 1965 and 1975. Returns to land were then capitalized to obtain an indicated value of land with each of the water situations in the two periods. A capitalization rate of 5 percent was used, estimated to be the rate which might be earned on capital invested in the farm if it were placed in non-farm investments. Thus, no recognition was given to location, home value and the like in the estimated values. The analysis indicates, however, that water rights have an effect on the capitalized value of land in the Project.

Comparison of the indicated values shows that these values vary from one water situation to another in the two periods and from period to period. They were highest for water situation I followed in order by water situation II, then water situation III and last IV.

The conclusion indicated by this study is that under current conditions water rights probably have no effect on the cropping system but probably do affect land values. Looking to the future, water rights may affect both cropping systems and the value of land. Moreover, with the levels of prices, yields and costs used in 1965 and 1975 the analysis indicates capitalized values of land would increase over the coming decade.

LITERATURE CITED

Barr, George W., ed. Recovering Rainfall. University of Arizona, Tucson, 1956.

Glenn, Brandow W. Historical Documents Pertaining to Power Contracts and Agreements of The Salt River Project. Salt River Project, Phoenix, Arizona, 1961.

Heady, Earl O. Economics of Agricultural Production and Resource Use. Prentice-Hall Inc., Englewood Cliffs, New Jersey, 1961.

Kent, Edward, Chief Justice. Original No. 4564 Decree March 10, 1910. Third Judicial District, Phoenix, Arizona, 1910.

Kleinman, Alan P. "The Cost of Pumping Irrigation Water in Central Arizona." Unpublished Master's thesis, University of Arizona, Tucson, 1964.

Leftwich, Richard H. The Price System And Resource Allocation. Holt, Rinehart and Winston, New York, 1960.

Menzie, Elmer L. "Arizona Farm Income Leads Nation." Progressive Agriculture in Arizona. Vol. XVI, No. 2, University of Arizona, Tucson, March-April, 1964.

Nelson, Aaron G. "Costs And Returns For Major Field Crops In Central Arizona By Size Of Farm." Arizona Agricultural Experimental Station Technical Bulletin in preparation, University of Arizona, Tucson.

Salt River Project. Major Facts In Brief. Phoenix, Arizona, 1961.

_________. Articles of Incorporation of Salt River Valley Water Users' Association. Phoenix, Arizona.

_________. Annual Reports. 1959 through 1963.

_________. Crop Reports. 1957 through 1962, Phoenix, Arizona.

Shadegg, Stephen C. The Phoenix Story, An Adventure In Reclamation. Phoenix, Arizona, 1958.

U. S. Department of Agriculture. Agricultural Price and Cost Projections For Use in Making Benefit and Cost Analyses of Land and Water Resource Projects. Washington, D. C., September, 1957.

_________. Agricultural Statistics. U. S. Government Printing Office, Washington, D. C., 1963.

_________. Farm Real Estate Taxes, Recent Trends and Developments. ARS. 43-130, August, 1960.

U. S. Department of Commerce, Bureau of the Census. U. S. Census of Agriculture, Arizona Counties. 1959.

White, Natalie D., R. S. Stulik and others. Annual Report on Ground Water In Arizona, Spring 1962 to Spring 1963. U. S. Geological Survey, Bulletin No. 15, Phoenix, Arizona, 1963.