Rural to urban water transfers in Arizona : an economic analysis

RURAL TO URBAN WATER TRANSFERS IN ARIZONA: AN ECONOMIC ANALYSIS

by

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ABSTRACT

Arizona cities and urban developers in Arizona have been purchasing irrigated agricultural lands in recent years to obtain the lands' appurtenant water rights in order to meet the increased urban water demands. The objective of the study was to determine whether or not farmers who sold their land and water rights benefitted from the transactions based on a comparison of the price received with the value of the land and water rights in agricultural production. Results showed that the minimum price that a farmer could have accepted was a fraction of what the urban buyers paid.

Included in the study was the effects of government commodity programs on the value of water in irrigated agriculture. The study concluded that for Arizona cotton growers, federal price support programs increased the returns to water significantly, which, in turn, increased the value of water to the Arizona cotton farmer. Price supports, therefore, kept the farmer's minimum price for land and water rights higher than had there not been price supports.

Chapter 1

Introduction

The major metropolitan areas of Arizona are experiencing population growths at phenomenal rates. City officials are seeking additional water supplies to meet the increasing urban water demands. Additional water supplies are perceived as an essential ingredient to the sustenance of future growth in Arizona metropolitan areas.

Because agriculture in Arizona consumes the vast majority of water resources in the state, cities have looked to this sector for additional supplies of water. The Groundwater Management Act of 1980 mandates that irrigated land must be purchased in order to obtain grandfathered irrigation rights (defined on page 33). Arizona law also requires purchase of irrigated land to obtain surface water rights that have been used in irrigation. Agricultural properties can be an attractive means of increasing municipal water supplies because vast supplies of water are applied in agriculture and because purchases of irrigated land can be less costly than other alternatives for acquiring additional water for urban use. Consequently, city officials have begun purchasing agricultural lands for the sole purpose of obtaining water rights.

How do the buyers and sellers negotiate a price for the land and water rights? How much is the city willing to pay for the water, and how much is the farmer willing to accept? This study will investigate the latter question. It will determine the value of water to the Arizona farmer and the minimum acceptable price an Arizona farmer could require from a buyer for the farmer's land and water rights.

Method of Analysis

One way to estimate the minimum value of the water to the farmer is to determine what the water is worth in agricultural production. A grower would most likely accept no less than the capitalized value of this amount from the buyer.

To find what the water is worth to a grower in agricultural production requires knowledge of all costs of production, both fixed and variable. By using a technique referred to as the residual method a determination of the value of water in crop production can be made. An explanation of this method will be discussed in later chapters.

Scope of Analysis

The value of water in agricultural production fluctuates from year to year due to a variety of factors such as prices received, yields, pumping costs, etc. Bush (1984) found that the water's worth in agricultural production in Arizona varied widely depending on the crop planted. Since cotton is the major crop grown in Arizona, this thesis will focus on water's value in cotton production.

Objectives

The primary objective of this study is to estimate the value of water in crop production in order to determine the minimum price an Arizona farmer could accept when negotiating a land/water transaction with urban buyers. Information on water values would also be useful to state and local policymakers who are confronted with complex decisions about water supply management and allocation. Agricultural water users must make important decisions about current and future management of their water allocations. Farmers need to be able to compare the value of water in agricultural uses with its value in other uses. Such information will enable them to make sound long-term production and investment decisions, and to bargain more efficiently with potential buyers if they decide to sell land and appurtenant water rights.

Another objective is to determine water values in Arizona cotton production with and without the implementation of Upland Cotton programs. Many studies have estimated water values in crop production without taking into account the governmental commodity programs.

Policymakers and cotton growers could benefit from information on the impacts of government programs on water's value in Arizona agriculture.

Chapter two is a review of the literature pertaining to water transfers and values of water in alternative uses. It covers the background of water transfers and water market development around the western United States, and the economics of a water purchase. It describes various methods of estimating water values and the range of these values in irrigated agriculture.

Chapter three details rural to urban water transfers in the state of Arizona. It will concentrate on the legal and economic setting of water transfers.

Chapter four focuses on the value of water in irrigated cotton with and without government programs from 1983 to 1987.

Chapter five analyzes a few of the recent water transfers in Arizona by comparing the values of water on a whole farm basis, to prices paid by urban officials. It will determine whether or not farmers are capturing gains from selling.

Chapter six concludes the thesis by discussing the policy implications of water transfers from rural to urban areas. The chapter will examine efficiency losses from keeping water in agriculture, and societal losses in rural areas due to a decline in agricultural production.

Chapter 2

Literature Review

Many natural resource economists have argued that market development is necessary to allocate resources efficiently. In a competitive market environment (defined later) price signals guide people to use a resource efficiently. Water is one natural resource that could potentially be reallocated through the market process. It was initially allocated as a free good, part of a pool of publicly owned resources offered to early settlers of the West.

Urban populations in the Southwest are growing rapidly, because of the region's attractive climate. Rapid urban growth has caused municipal officials to seek additional sources of water to meet the increasing demands of the growing population. One means of obtaining water to support urban growth involves water transfers from agriculture to higher valued domestic and industrial water uses. Agriculture consumes up to 92 per cent of all water used in the West (Gibbons, 1986). When farmers are willing and legally permitted to sell water rights to city users, a water market may evolve.

Economic Theory of Production

A review of economic theory is necessary to gain a better understanding of the word "value." The following section explains various concepts relating to "value."

Returns to a variable input, water in this case, refer to the effects on output of changes in one input with other inputs held constant. Economists express the relationship between the quantity of an input applied and the quantity of output produced in the form of a production function. A production function is a schedule (or table) showing the maximum amount of an output that can be produced from any specified set of inputs. Since the relationship between the quantity of output and a single input (water) is necessary for this study, a Total Product (TP) function is required. The TP function requires that all inputs are held constant except for one. This restricted production function is shown in Figure 1.

Figure 1 shows a hypothetical TP curve for total crop yield (product) as a function of water quantity. As water is applied, output increases until a maximum is reached. Additional water inhibits production and output begins to fall. The increase in output due to an additional unit of input, all other inputs held constant, is referred to as the marginal product (MP) of the input, in this case, water.

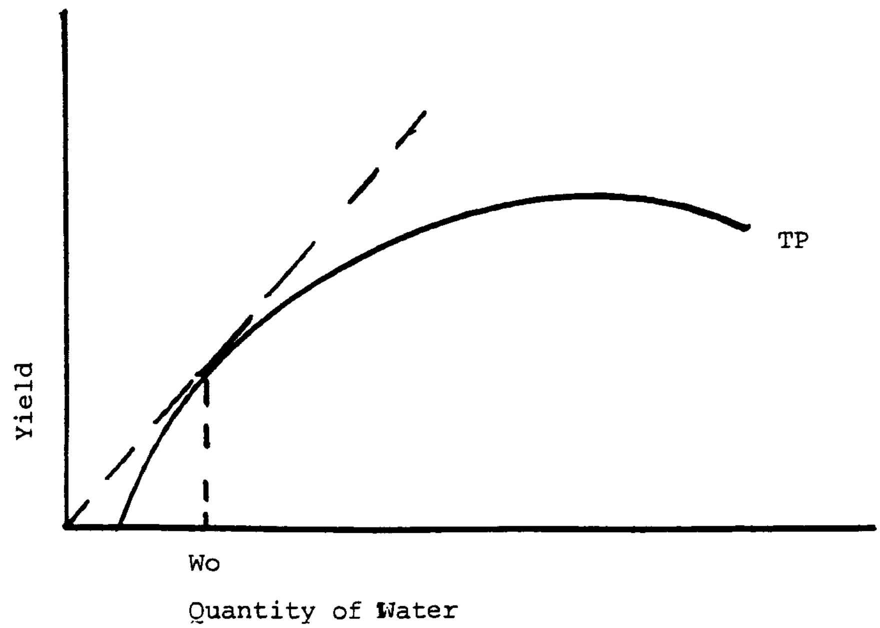

Figure 1. Total Product Curve (Hypothetical).

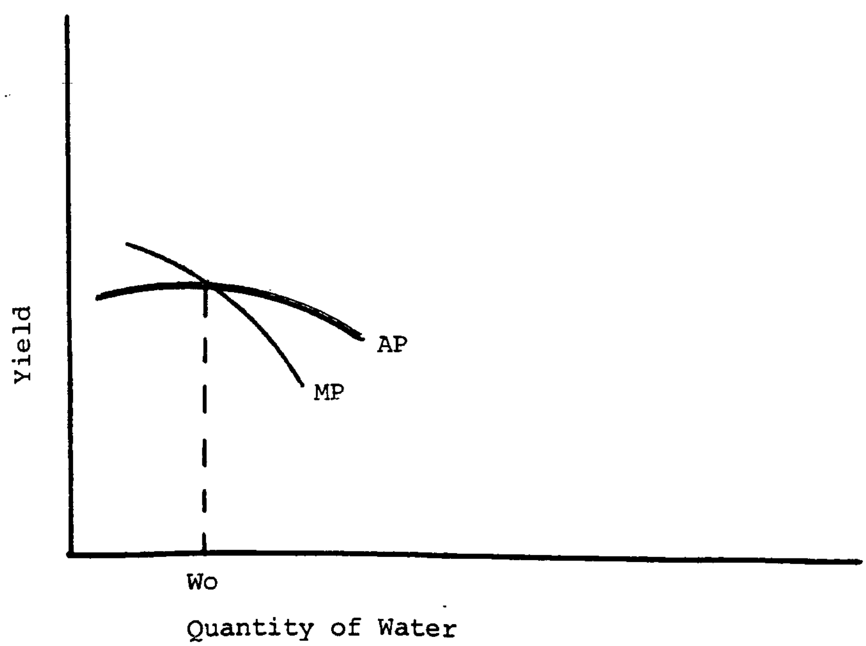

Figure 2. Marginal and Average Product Curve (Hypothetical).

The TP curve illustrates the law of diminishing marginal productivity: as each additional unit of a variable input is added, the incremental increase in yields becomes less, to the point where yields cease to increase and begin to decrease as additional units of water are applied.

The average product (AP) of water is defined as the total product per unit of water. Graphically, for any amount of water, the AP equals the slope of the line drawn from the origin of Figure 1 to any point on the TP curve. When the slope of the AP of water is at its maximum, the AP of water equals the MP of water. The relationship between the AP of water and the MP of water is as follows:

1.) So long as the AP of water is rising, the MP of water is greater than the AP of water.
2.) So long as the AP of water is falling, the MP of water is less than the AP of water.
3.) The MP of water equals the AP of water atthe maximum of the AP curve. (See Figure 2).

When the price of the product is multiplied by the MP of water, the result is the marginal value product (MVP) of water, or the value of the additional product resulting from the addition of one unit of water. When the price of the product is multiplied by the average product of water, the result is the average value product (AVP) of water, or the total value product per unit of water.

Values of Water in Various Uses

Values of water differ depending on the use of the resource. Information on the value of water and rights to water is useful for both public and private decision-making. A farmer could use this information when deciding whether to sell water rights or to continue using them for irrigation. A city could use this information when negotiating a land/water purchase from a farmer. While little material has been published on valuing water rights, alternative methods have been used in the valuation of water.

Saliba and Bush (1987) examined prices generated within active water markets in six western states. They evaluated these observable prices as measures of water's value. They found that market prices will not usually provide an accurate measure of water value because of the characteristics of water markets, such as external effects of market activity, public goods characteristics of water, imperfect competition, plus the legal, economic, and hydrologic uncertainties. In most areas of the West, water has either not been a marketable resource or has been exchanged in imperfect market settings so that prices are often not an appropriate measure of water values. Consequently, various non-market valuation methods have been used.

Agriculture

There are a number of methods used to determine the value of water in irrigated agriculture. One technique is referred to as the residual method. This approach finds the gross revenue of a given crop by multiplying yield by its price. All costs of production except water costs are subtracted from gross revenue. The remainder constitutes the maximum amount that a farmer could pay for water and cover his costs.

This procedure is methodologically correct if several conditions are satisfied. All inputs aside from water must be priced at their value marginal products, so that input prices are equated to returns at the margin. This is a well known condition for competitive equilibrium. Finally, total value of a crop can be divided into shares, such that each input is paid according to its marginal productivity and the total value of the crop is completely exhausted. Young and Gray (1985) note that these conditions for residual computation of water values are met as long as the requirements of the competitive model are satisfied.

Bush (1984) used the residual method to show the value of water in relation to various crops grown by Central Arizona farmers. He found that the cost of water to Arizona farmers could approach $100 per acre foot before they would forego cotton production. An acre foot is the amount of water that will cover an acre of land to the depth of one foot, or about 326,000 gallons. Because Bush used Hathorn's budgets, the marginal value product of water equals the average value product of water in his study. Hathorn's data is on a per acre basis, meaning that any additional uses of an input results in average increases or decreases in the total value of the product. (In all further references to Hathorn's Budgets I will use "average value product" to avoid any confusion with "marginal value product). Using Hathorn's formula (Arizona Field Crop Budgets, 1984), the typical pumping costs for water were approximately $43 per acre foot. Bush therefore concluded that a typical Central Arizona farmer could pay more than twice as much for irrigation water in the short run without having to change production processes.

Holding the costs of all other variable factors of production constant, the short run production rule for the use of irrigation water (using Hathorn's data) is that if a farmer pays less than the average value product of water on his crop, then the additional revenue over variable costs helps cover the fixed costs of the operation (Bush and Martin, 1986). If he had to pay more than the average value product of water in the short run, then variable costs of production would not be covered. In this case the farmer would be better-off not producing the crop.

Another method used to estimate water values involves crop water production function analyses and farm crop budget analyses. A crop water production function can be developed and used to show the relationship between production inputs and outputs. Holding all other inputs constant, the marginal physical product of water for each unit of water used on crops can be calculated. Multiplying the marginal physical product by the crop price gives the marginal value of each unit of water (not equal to the average value product). The changes in yields associated with each succeeding unit of water (the marginal physical product) can be identified by data collected from controlled experiments which would hold all input levels constant except water. From these data the dollar value of the yield associated with each succeeding unit of water could be identified.

Ayer and Hoyt (1981) used the crop water production function method to estimate the marginal value of irrigation water on various crops grown in the western states. Their estimates of the value of water to the average Arizona cotton grower ranged from $36 per acre foot (AF) to $54/AF (1980 dollars) depending on the crop price.

Many factors influence the value of water in irrigated agriculture. Crop prices are very important in the valuation. Any method used to determine irrigation water values will use crop prices as a basis for calculation. Also important are the acquisition costs of water. Acquisition costs are those costs incurred to pump water from the groundwater table or divert and convey surface water to the field that is to be irrigated. These costs are a function of depth to lift, electricity rates, and the efficiency of the irrigation system. Water values are dependent on many non-water input costs. These include management and land rents. Various federal government programs influence all of these variables. Government policies often keep prices at artificially high levels. They subsidize input costs by way of lower electricity rates and tax incentives for farmers. These many variables make it difficult to accurately determine the value of irrigation water.

Water values vary with geographic location and the crops for which the water is used. Using some of the techniques mentioned above, researchers have shown that irrigation water is worth no more than $15 per acre foot in the Upper Colorado River Basin but as much as $45 per acre foot in the Ogallala groundwater region in the High Plains (Campbell, 1986). Researchers have found that specific values for irrigation water vary significantly. In 1981, water used to grow sorghum in Arizona was worth less than $15 (1980 dollars) per acre foot (Ayer and Hoyt, 1981). Conversely, water used to grow sorghum in Texas was worth up to $113 per acre foot (Hoyt, 1982). Water to irrigate potatoes in the state of Washington valued at about $300 per acre foot, but for potatoes grown in Idaho, water has been worth up to $700 per acre foot (Ayer, 1983). Study of specialty crop production, such as dry onions grown in the Salt River Valley in Arizona, indicated water values up to $990 per acre foot (Martin and Snyder, 1979).

Bush (1984) estimated that the value of water to irrigate cotton in Maricopa, Pima, and Pinal Counties to be $98, $114, and $95 per acre foot, respectively. Over the last ten years these values have fluctuated from a high of $224.69 per acre foot in 1976 to a low of $60 per acre foot in 1982.

Municipal and Industrial

The value of the marginal product of water in all applications, however, is not equal among agricultural, municipal and industrial uses. Recent estimates show that the value of the marginal product of water for municipal and industrial use to be as much as eleven times larger than the corresponding value of marginal product of water in agriculture (Krutilla, Bowes, and Sherman, 1983). Residents in Colorado suburbs were willing-to-pay up to $300 per acre foot to irrigate their lawns and gardens, and water to carry pulverized coal through a slurry-coal pipeline was worth more than $1600 per acre foot when compared to the next cheapest transportation alternative (Campbell, 1986). Water is currently used to cool electric generating plants at a cost of $5 per acre foot. The next best alternative, dry-cooling systems, would cost almost $1300 per acre foot to cool the comparable unit of electricity produced by water cooling (Gibbons, 1986).

Recreation

A technique used by Daubert and Young (1981) was derived from the contingent valuation method. This method relies on asking individuals to identify their willingness-to-pay for specific levels of a non-market good. Daubert and Young's objective was to estimate a total willingness-to-pay function for instream flows on the basis of one's income. This willingness-to-pay function is analogous to indifference curves with the slope measuring the marginal rate of substitution between income and instream flow levels. The slope represents a marginal benefit function which is equivalent to a Hicksian compensated demand function. This makes it possible to determine the marginal value of a non-marketed resource, or a resource that has been exchanged in imperfect market settings, such as water. The results of Daubert and Young's study showed that the marginal value of water flow for fishing was as high as $20/AF in the summer months, with the annual average of

$12/AF. The marginal value of irrigation water in the same area was $15/AF during the summer monthes, and $7/AF annually. Their results suggested that water managers could switch some reservoir filling (for future crop irrigation) from fall to spring and increase the social benefits from recreational water use in the fall. Recreation benefits could increase in the fall if the water was not stored, without decreasing next year's crop output.

The contingent valuation method approach encounters various problems. Responses to survey questions may be biased because of the participants degree of interest in the survey. The biases may be informational, meaning that the respondent does not have sufficient information to respond, or hypothetical, meaning that the respondent might not take the survey seriously because of its hypothetical nature (Just, Hueth, and Schmitz, 1982).

Another method of valuing non-marketed goods includes the travel cost method (TCM). The TCM is used primarily for recreational facilities. It uses variable expenditures (primarily travel costs) as a proxy for a non-existent market price. Applying this technique to estimate water values would be very difficult, if not impossible, because the method is applicable to specific recreation sites, and it is difficult to evaluate specific components of a site (Just, Hueth, and Schmitz, 1982).

Economics of Water Market Development

As shown above, the marginal value of water in irrigated agriculture is generally much less than its marginal value in municipal,industrial, and recreational uses. The differences create incentives for transactions to occur between municipal/industrial users and agricultural users because both sectors can gain from a transfer. The economic conditions necessary for the development of a water market are emerging. How and why market transfers take place, using economic reasoning, is discussed next.

Economic efficiency in a water market is concerned with maximizing the net value of goods and services produced through water use. Flexibility of water among uses and locations is the important key in achieving net total value (MacDonnell and Howe, 1986). This flexibility is essential because of the ever changing demands and values of water users. If competitive water rights markets could develop to facilitate exchanges of water rights, efficiency gains could result. For a water market to provide efficient allocation, use, and supply of water resources, the following criteria must be met:

1.) No individual or firm can affect market prices. Buyers and sellers jointly determine market prices through simultaneous exchanges.

2.) All market individuals must have access to complete information on legal and hydrologic characteristics of water rights, and the costs of alternative means of obtaining water.

3.) Any water allocation system designed for allocative efficiency should be well-defined, enforced, transferable, and confront users with full costs of their actions (Trelease, 1965).

The direction of water rights transfers is from lower valued seller uses toward higher valued buyer uses. Economically efficient water use requires that the marginal value product of water in each use should not differ by more than the cost of physically transporting the water among uses and locations. Martin (1986) showed how this would work hypothetically. Assuming only two uses of water in an economy, agricultural and municipal and industrial (M + I), he showed how the downward sloping demand curves would differ among uses (Figure 3). Demand curves show the maximum amount that people would pay for alternative quantities of water. M + I users value water in small increments much higher than agricultural users because small increments of water are necessary for daily activities such as drinking, cooking, and bathing. Due to the inelastic nature of urban water demand, urban consumers' willingness-to-pay decreases faster than a farmers' willingness-to-pay. Thus, the M + I demand curve is steeper in slope than the agricultural demand curve. If the current use was represented by W_o (the initial allocation), the value of an additional unit of water would be "a" for M + I uses, and "b" for agricultural uses. Under this scenario M + I could pay a maximum of "a" for additional water, agriculture could

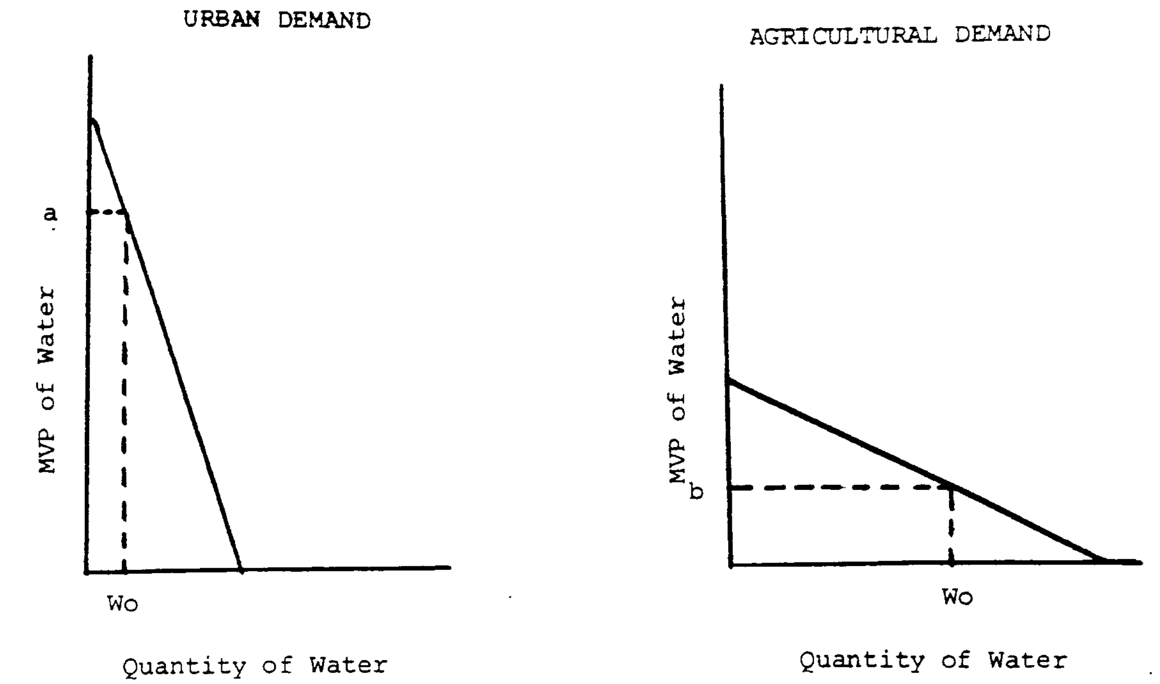

Figure 3. Municipal and Agricultural Demand Curves for Water with Initial Water Allocation (Hypothetical).

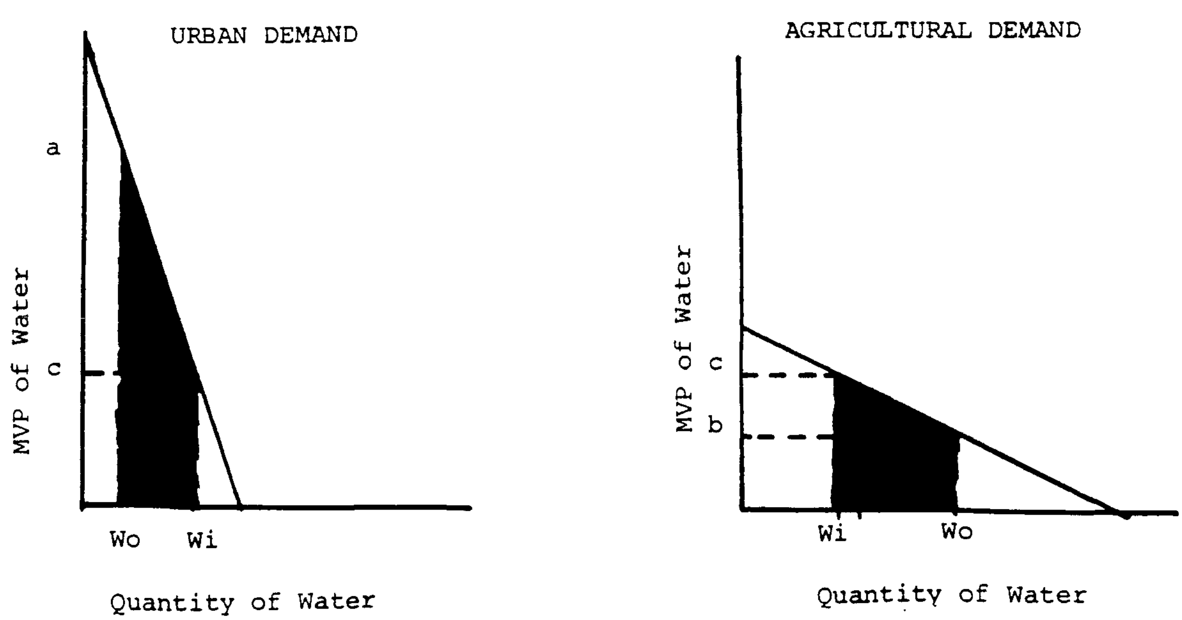

Figure 4. Municipal and Agricultural Demand Curves for Water with Water Reallocation (Hypothetical).

accept a minimum of "b" for additional water, and if a transfer of water took place, both sectors would benefit. These transfers would take place until the marginal value products of water in each sector were equal (Figure 4). The quantity of water taken out of irrigated agriculture and put into the M + I sector would be W_oW_i. Consequently each sector would have a different amount of water for its respective uses, but the marginal values of the water would approach equivalency, thus creating a more efficient allocation of water.

So, what are the reasons behind why so few transactions have taken place between agricultural and M + I interests? A number of obstacles may prevent these transfers from occurring. One is the lack of transfer systems (pipelines, canals) to transport water from location to location. This can play a large role in discouraging transfers. Another obstacle is the characteristics of water itself. Water flows, seeps, evaporates, and transpires. Its mobility presents problems in identification and measurement, creating difficulty in establishing exclusive property rights (Young, 1986). Its uncertainty in supply creates high variability both in time and quality, which also adds to the difficulty in establishing property rights.

Another obstacle that may discourage transfers is farmer expectation of large future increases in water right values. Some farmers may hold on to their water rights in hopes that M + I demand will increase, which, in turn, would lead to higher prices offered (Gardner and Miller, 1983). Even if the value of water in irrigation is less than the current price offered by non-irrigation water buyers, some farmers may justify holding out by anticipating that price increases for their water will be greater than their opportunity costs.

The obstacles that have been presented are just a few that may discourage water transfer from occuring. A further obstacle, the legal setting, is probably the most complex and for this reason it is treated separately in the following section.

Legal Setting for Water Transfers

In order for water to be a marketable commodity, it must somehow be given property status, referred to as a water right. The allocation of property rights in water resources follows the pattern set for other resources. Since water is a renewable resource producing a flow of benefits, what is allocated is its use, the right to take and use it over a period of time (Trelease, 1979).

There is a variety of water law pertaining to water rights in the western states. The doctrine of prior appropriation is most prevalent, but is implemented in various ways in the western states. In California, surface water is governed by appropriations doctrine and the doctrine of riparian rights. The doctrine of riparian rights states that rights to use water reside with the owners of land adjacent to a watercourse. In New Mexico the appropriation doctrine applies to both surface and groundwater. In New Mexico and Colorado water is severable from land but in Arizona irrigation water rights are only severable under certain conditions.

Under the appropriation doctrine the water right is a usufructory right: a right to use, but not ownership (Howe, Schurmeier, and Shaw, 1986). Two main types of ownership rights have evolved under the appropriation doctrine: priority rights and proportional rights. A proportional rights system divides available water among owners according to a set of percentages determined by the number of rights owned. Priority rights are for those who were first to stake a claim for water rights, more commonly referred to as "first in time, first in right." These people are considered senior right holders. The claims of senior rights holders are honored in full before the junior rights holders may stake a claim. Having these seniority rights can make a substantial impact on the valuation of water rights.

One of the legal bases of prior appropriation is water must be put to beneficial use to qualify for a water right. What constitutes beneficial use changes with time and may even be uncertain at a point in time. This uncertainty can reduce the values of rights in the market (Howe, Schurmeier, and Shaw, 1986). The most basic definition of beneficial use is that the use of the water must be domestic, mining, agricultural, manufacturing, or power related. These uses continue today, but the changing needs of our society are generating new uses for water and must be included in the definition. For example, Montana, North Dakota, and Colorado have revised their water laws to expand the concept of beneficial use to include recreation and environmental protection (Trelease, 1979).

Reclamation law has its impacts on water transfers. The Bureau of Reclamation supplies over 25% of the water used for irrigated agriculture in the western states (Trelease, 1979). Federal law does not restrict transfers, but the Bureau of Reclamation repayment contracts require the consent of the Bureau to any transfer of water rights. Officials of the Bureau have generally opposed transfers because they feel that the irrigators are obtaining windfall profits from federally subsidized water and that these transfers will jeopardize a project's repayment. The National Water Commission, however, recommended a Congressional declaration of policy permitting transfer of Reclamation rights. If all the construction costs haven't been paid, the new or old owner should either pay a lump sum of the outstanding costs or the new owner should assume the contractual repayment obligation (Trelease, 1979).

One other legal consequence to be considered is third party effects. Water transfers from agricultural land to cities have a negative economic impact on rural areas. In addition to the economic losses of those impacted by the transfer, a rural area could undergo a "drastic disintegration of the social and political fabric" (Nunn, et.al.,1986). Rural to urban water transfers have potentially significant redistributive effects. Since transfers tend to be from poorer rural communities to wealthier urban communities, this redistribution magnifies existing inequalities in the distribution of wealth (Nunn, et.al., 1986).

Compensation for third party impacts can be a problem confronting water transfers. Third party effects of transfers can include diminished instream flows, declining water quality, and area of origin economic impacts. If the flow of a stream is reduced by a water transfer from upstream, a downstream user may be impaired by not having access to the resource.

> Water trades should not be fostered unless the complexity of achieving fairness is fully addressed and until the investigative and approval process is substantially improved for protection of non-beneficiaries. There is yet no assurance that this type of water trade can be entered into without substantial uncertainty and jeopardy for parties other than the buyer and the seller.
>
> Hildebrand, 1986.

If these externalities can be overcome so that third party effects are minimal or at least compensated for, then water markets and transfers may become more common.

Rural to Urban Water Transfers Around The West

Initially, western water transfers were regional development projects. In the first decades of the twentieth century several large interbasin transfers were implemented, the Central Valley Project in California and the Colorado-Big Thompson Project for instance. Other large projects were discussed, but were never started. These included a proposal by the North American Water and Power Alliance to bring water from Alaska and Canada to the arid Southwest, and a project that would have transferred water from the lower Mississippi River to the Rio Grande Valley in west Texas and eastern New Mexico (Nunn and Ingram, 1986).

Sunbelt cities are on the receiving end of most of the transfers. Since water supplies in the area of many southwestern cities are fully appropriated, the demand for new urban water supplies must be met by sources outside the local environment.

In many states cities can obtain rights to irrigation water by purchasing agricultural lands. The earliest example of this type of transfer is Los Angeles' acquisition of water rights on the Owens River in 1905. In 1948, the city of Tucson began contemplating irrigated land purchases in the Avra Valley and in 1971 began doing so.

Various water markets have developed in the western states over the last couple of decades. An overview of some of the more important transactions will demonstrate the range of prices that have been negotiated. All prices have been adjusted, using the Gross National Product deflator, to 1986 dollar values and all are reported in 1986 dollars. The prices reported in this chapter are for water rights, perpetual rights to use water, and so are not directly comparable to annual values for water in alternative uses.

In northeastern Colorado, water markets developed with the completion of the Central-Big Thompson Project in the late 1950's. The price for rights to this water initially started at $95/AF in the early 1960's. Through the 1960's and 1970's, prices climbed rapidly, $550/AF by 1967, $1,000/AF by 1974, and over $3,500/AF by 1980. Prices then declined to about $1,000/AF in 1985 (Howe, Schurmeier, and Shaw, 1982).

Another project, known as the Windy Gap Project, has allowed the town of Estes Park to sell water rights from the Project to the Central Weld County Water District for

$510/AF and to the city of Broomfield for $415/AF (Hill, 1985).

In southeastern Colorado, the cities of Pueblo and Colorado Springs purchased water stock from the Twin Lakes Reservoir and Canal Company for $2,400/AF in the early 1970's. The city of Aurora acquired 2,500 shares of Twin Lakes stocks in 1973 for $2675/AF. Because of Aurora's rapid expansion in the 1980's, the city has acquired over 16,000 acre feet of water rights from various water and ditch companies for $2,500 to $3,500 per acre foot (Kemper, 1987). In 1986 Colorado Springs acquired 17,500 acre feet of direct flow and storage rights from three different water companies at $1,600/AF.

Water markets in the state of Nevada have developed in the Truckee River Basin in the northwestern part of the state. Much of the activity has involved the Sierra Pacific Power Company. Sierra Pacific began purchasing irrigation rights in the mid-1940's and acquired additional rights until 1979. Prices ranged in real dollars from $35/AF in 1946 to $160/AF in the mid 1960's.

Some groundwater rights in Nevada have sold for large sums of money in the Reno or Sparks areas where development pressures are strong. Prices have ranged between $4,000 and $10,000/AF (Holt, 1985). Surface water rights transactions, however, have been appraised from $875 to $2016/AF (Test, 1985). Large consolidated blocks of surface water brought the higher prices.

The Gila-San Francisco Basin of southwestern New Mexico has experienced market activity since the mid 1960's. Silver City, a city of 20,000 people, located just outside of the basin, has been acquiring water rights periodically. In 1981 the city purchased 43 acre feet of water rights for $3,000/AF. In 1984 they purchased another 131 acre feet at a cost of $2,900/AF. These rights were developed from two groundwater wellfields in the Gila-San Francisco Basin.

These are just a few of the many water right transactions that are taking place in the western states. As water markets become more developed, rural to urban transfers are becoming more common. Many transactions are taking place in the state of Arizona in addition to the Tucson-Avra Valley transfers. The following chapters will be devoted to Arizona transfers specifically.

CHAPTER 3

THE SETTING FOR ARIZONA WATER TRANSFERS

Water rights transfers are becoming increasingly common in Arizona because of the state's rapidly growing population. Before 1980 the Arizona laws applicable to water transfers were not adequate to meet the growing needs of the state. There have been numerous court cases pertaining to the transportation of water from location to location. This chapter will examine the water transfer laws in Arizona and explain why water transfers are important to Arizona.

Legal Setting

Background

The basis for use of the doctrine of prior appropriation for surface waters in Arizona was established by the passage of the Howell Code in 1864 (Water Works Association, 1985). It provided that all surface water was public, and therefore, subject to appropriation and beneficial use.

Since then, the adjudication of surface rights has been accomplished by four judicial decrees. The Salt and Verde River systems were adjudicated under the Kent Decree of 1910. This decree laid the foundation for future adjudications by establishing basic definitions of terms used in the adjudication process. The Benson-Allison Decree of 1917 awarded rights to certain landowners to beneficially use water from the Salt, Agua Fria, and Gila Rivers. The Little Colorado River was adjudicated the following year by the Norveil Decree, and the Gila River system in eastern Arizona was adjudicated under the Gila River Decree of 1935. These four decrees served as the framework for all adjudicating proceedings for surface water rights.

Presently the state is conducting two adjudications to determine the rights of water users in the Little Colorado River and the Gila River watersheds. These proceedings are being conducted under the General Adjudication of Water Rights statute that was passed by the Arizona State Legislature in 1979. All water rights, including those of the federal government and the Indian reservations, will be determined (Arizona Water Information Center, 1986).

Groundwater rights in Arizona were subject to the doctrine of prior appropriation until 1980 when Arizona adopted the Groundwater Management Act. The Act requires that a permit system be used to allocate groundwater resources in the Active Management Areas of the state.

Before 1980 agricultural interests were given priority by the courts over cities and mining interests (Doyle, 1983). This was achieved by a rule that pumpers could not transport water off overlying land if there were any third party injuries. This ruling was confirmed in 1953 in the court case Bristor v. Cheatham. Bristor had pumped water for irrigation for more than 35 years. Cheatham dried up Bristor's wells by sinking his own wells and transporting water to irrigate land three miles away. The Supreme Court of Arizona adopted the doctrine of reasonable use which meant that the overlying landowner had proprietary interest in water beneath the land. This meant that Cheatham was not allowed to transport water off of the land because of the adverse effects on the common supply of water beneath the land.

In 1968 the farmers in Avra Valley took the city of Tucson to court in Jarvis v. State Land Dept. (better known as Jarvis I) because Tucson was going to pump 30,000 acre feet of water per year out of the valley and transport it to the metropolitan area. The court issued an injunction preventing Tucson from doing so. The primacy of agricultural interests prevailed (Doyle, 1983). In Jarvis II, however, the court relaxed its earlier stand and allowed Tucson to deliver water to Tucson provided the city purchased and retired irrigated land. The city was allowed to withdraw the amount of water equal to the "annual historical maximum use" (106 Ariz. 506, 479 P.2d 169 (1970)). In Jarvis III, the court ruled that in the Jarvis

II ruling, "use" meant "consumptive use." In other words, Tucson could withdraw only the amount historically consumed in irrigation and not the total amount historically applied to the land (113 Ariz. 230, 550 P.2d 227).

A third case that brought about changes in the state groundwater laws was Farmers Investment Co. (FICO) v. Bettwy, (1976). This case dealt with the transportation of groundwater from wells to the company's mills. FICO asked the courts to enjoin Anamax Corporation from pumping from Anamax wells and transporting the water to its mills four miles away. The city of Tucson intervened, claiming FICO and Anamax were polluting the water that Tucson depended upon for domestic use. Anamax counterclaimed against Tucson using the same reasoning that FICO had used against them, that the city should be enjoined from pumping water for transportation away from the area.

The Arizona Supreme Court enjoined both Anamax and the city of Tucson. The decision sent enough shock wave through the economic and political leadership of the state and prompted a comprehensive re-examination of Arizona's archaic groundwater laws (Pontius, 1981). The court's ruling threatened to destroy the mining industry near Tucson and the city's ability to meet growing urban water demands. This case, along with federal pressure to control groundwater overdraft as a condition for CAP funding, led to the 1980 Arizona Groundwater Management Act.

The Groundwater Management Act of 1980

The Act established a new set of rules regarding the transportation of groundwater. It established the Arizona Department of Water Resources and four Active Management Area's (AMA's). These AMA's were created because groundwater problems were not uniform statewide. Each AMA is under the direction of the Department of Water Resources (DWR). The DWR's purpose is to manage water rights as defined by the Act and to administer water conservation and supply augmentation programs to help eliminate groundwater overdraft in Arizona by the year 2025.

The Act achieved three main goals. It created a centrally-controlled administrative mechanism, the DWR, for regulating water use in the state. It established an agenda for statewide groundwater management, and it set up a system for defining and quantifying groundwater rights.

All groundwater pumping taking place at the time of the Act's passage could be continued in existing uses by filing for a Grandfathered (GF) Right. Three kinds of GF rights were established by the Act. The first was an irrigation GF right which allowed continued irrigation of acreage that had an irrigation history (January 1, 1975 - January 1, 1980). The maximum quantity of the right was formulated using three factors: the water duty per acre, the number of GF acres, and the number of water duty acres.

The water duty is a measure of reasonable water use per acre. The number of GF irrigation acres equals the number of acres that were irrigated at any time between January, 1975 and January, 1980. The number of water duty acres is the maximum number of GF irrigated acres that were irrigated during any one of those years. Due to crop rotation practices, the number of water duty acres may be significantly less than the total number of grandfathered irrigation acres.

Grandfather irrigation rights are appurtenant to the land for which the right is granted. The full amount of the right is transferred with the sale of the land. The water that comes with the right must be used for irrigation purposes and on the land for which the right is granted. However, the right may be converted to a non-irrigated use. Then the right is a Type I non-irrigation right.

A Type I non-irrigation right allows withdrawal of water from farmland retired from irrigation after January, 1965. This water must be used for non-irrigation uses. The right is also appurtenant to the land where the right originated. The full amount of the right is conveyed with the sale of the land. Each right is granted three acre feet per acre of irrigated land or the historical maximum amount consumptively used on that land for crop production, whichever is less.

The remaining GF right is a Type II non-irrigation right which allows the continuation of established groundwater pumping for non-irrigation uses. The quantity of water assigned to Type II rights equals the maximum amount used for non-irrigation purposes in any one of the five years before January 1980. Type II rights are not appurtenant to a particular parcel of land and may be transferred. The entire right, however, must be conveyed. These rights do not involve agricultural-urban transfers and therefore, will not be discussed further in this thesis.

Other Types of Water Rights

Arizona law recognizes other rights to use water in addition to groundwater rights. These include Central Arizona Project (CAP) water delivery contracts, appropriative surface water rights, and sewage effluent. CAP water is available by contract through the Central Arizona Water Conservancy District and the Bureau of Reclamation. Water users may not sell or transfer CAP water among themselves, although contracts for agricultural CAP water may be converted to M + I contracts at the rate of one acre foot per acre (Bureau of Reclamation, 1983).

Before 1962, surface water rights were not transferable to locations other than those specified in the original setting of the right. In 1962 this legal constraint was removed and surface water rights became transferable to new locations, as long as the rights of other appropriators were not impaired (Kelso, Martin, and Mack,1973).

The rights to effluent are currently in litigation. The courts decided that the effluent is neither surface water nor groundwater, and therefore, is not subject to the Act's regulations (A. Tumbling T Ranches v. City of Phoenix et.al., 1983). The verdict is still out on how effluent will be administered.

Economic Setting For Water Transfers in Arizona

Population Trends

The state of Arizona is experiencing one of the fastest rates of growth in the United States. While the U.S. population increased by 11% in the 1970s, Arizona's population boomed by 53%. It has grown by 15% since 1980, and is projected to grow another 15% by 1990 (Arizona Economic Profile, 1985).

To accommodate this inflow of people, Phoenix and Tucson have expanded their incorporated areas by as much as 40% since 1975 (Arizona Statistical Review, 1985). Much of this expansion has occurred by displacing agricultural land uses. In 1971, the Salt River Project (SRP), located in Maricopa County contained agricultural land of 146,004 acres. These acres amounted to over 61% of the total acreage in the SRP. In 1985, the number of agricultural acres in the SRP dropped to 81,911 or approximately 35% of the SRP acreage (Arizona Farmer and Stockman, 1986).

As Phoenix and surrounding communities grow, apartments, condominiums, houses, and shopping centers are built on land previously farmed. Incoming residents are for the most part employed by non-agricultural industries. Non-agricultural industries have increased employment numbers by 75% statewide since 1975. Construction and service industries have led the surge by employing up to 155% more people than in 1975 (Arizona Statistical Review, 1985). Agricultural employment, on the other hand, has not increased since 1975. There were 15,000 farm employees in 1985, the same number as in 1975 (USDA Agricultural Statistics, 1975-85).

The Decline of the Agricultural Economy

Some farmers are interested in selling their irrigated lands because they are facing increasing debt loads. Real net incomes for Arizona farmers since 1973 have been highly unstable. In 1982, real net farm income plummeted (Ayer, 1986), and has since rebounded only slightly. The real price of cotton has shown considerable variation over time, but in general has been declining since 1975 (Arizona Agricultural Statistics, 1980, 1985). The rise in energy prices, in addition to deeper pumping lifts in some areas, has caused groundwater irrigation costs to increase. Low commodity prices plus increased production costs have forced many Arizona farmers to abandon agricultural production. These forces will continue to exert pressure to limit plantings of many crops in Arizona.

The main crop that will experience this decline in production will be cotton. Cotton is Arizona's number one cash crop. It represents almost 40% of all cash receipts for crops grown in Arizona (Arizona Agricultural Statistics, 1985). Those cotton growers in Maricopa, Pinal, Pima, and La Paz Counties (where 80% of the state population is centered according to the Arizona Statistical Review, 1986) produce more than 3/4 of all cotton grown in Arizona.

Cotton does not represent the most economically marginal crop that Arizona farmers grow. The most marginal crops, those with the lowest marginal value product of water (sorghum, wheat, etc.), would be taken out of production first. When cities buy agricultural land for the lands' water rights, however, they buy the whole farm, and not just the marginal cropland. Since cotton is the crop devoted to a majority of the farm acres in Arizona, it is reasonable to assume that cotton acreages will decline the most.

The following chapter will analyze the value of water on cotton grown in the major cotton producing areas of Arizona to demonstrate the impacts of governmental programs on Arizona cotton growers.

Chapter 4

Values of Water on Cotton

Water's value in irrigated cotton production in Arizona has declined over the last ten years due to the general decrease in cotton prices. Water's average value product in cotton production was as high as $224 per acre foot in 1976 in Pima County, but has been declining ever since (Hathorn Budgets, 1975-1985).

Average water values are calculated using the residual method. First the cash receipts are found for cotton and cottonseed. These are calculated by multiplying the yields per acre by the price of the lint and seed, respectively. Then, if the cotton grower participates in the cotton program, all payments from participation are added to the cash receipts to find the total cash payment to the cotton farmer. Returns to water are found by taking the total cash receipts and subtracting all variable costs of production except water. This residual amount is then divided by the amount of water used per acre. This figure represents the short run average value product (SRAVP) of water on that cotton crop. The SRAVP of water is the maximum amount per acre foot a farmer could pay for water and still be able to cover all variable costs of production.

Fixed costs of cotton production are not considered because they can not be entirely allocated to cotton production, assuming the cotton farmer has other crops on the farm.

Government programs affect farm receipts for cotton production and so the SRAVP of water on cotton differs depending on whether or not a grower participates in a government program. The following analysis of the 1986 Upland Cotton Program demonstrates these differences. The different SRAVPs of water in cotton production for other recent years (1983-1985, 1987) in which the programs were incorporated, are in Appendices E through H.

The 1986 Upland Cotton Program

Description

The 1986 Upland Cotton Program had various features, some similar to its predecessor, others entirely new. The Program featured the deficiency payment which was based on the difference between the target price and the larger of the average U.S. cotton price, or the loan rate. This deficiency payment was subject to the $50,000 per producer payment limit.

The Program also had a market enhancement payment which was based on the difference between the $.55/lb loan rate and the $.44/lb. loan repayment rate. The market enhancement payment was not subject to the $50,000 payment limit.

The permitted acreage in the 1986 Program was 75% of base acreage. Base acreage was the average number of acres planted to cotton over a specified time period. The permitted acreage was defined as the maximum a program participant could plant to upland cotton in 1986.

The Acreage Conservation Reserve (ACR) required that 33 1/3 of the planted acreage be taken out of production and devoted to conservation uses. However, ACR acreages could be reduced and planted to certain non-program/conserving use (NP/CU) crops (any crop except rice, cotton, wheat, feed grain, or soybeans).

The reduction in ACR acreages were termed "free acres" and were the difference between the unadjusted ACR acreages and the adjusted ACR acreages. The free acres could be planted to any NP/CU crop. Esablished alfalfa was assumed to be planted to free and NP/CU acres in this analysis.

The Analysis

The analysis of the 1986 cotton program's impacts on the average value of water in cotton production will cover four cotton producing areas in Arizona; Pima, Pinal, Maricopa, and La Paz Counties. The analysis will, arbitrarily, use cotton bases of 200 acres and 1,000 acres to demonstrate the effect of the $50,000 deficiency payment limit on varying farm sizes. The analysis will also demonstrate the effect of forming partnerships on the 1,000 base acre farm, comparing this size base operated by five partners and this size base operated by a sole proprietor. Pinal County will be used as an example in this comparison.

Because cotton prices were very low in 1986, the most that non-participating cotton growers could pay for water and still cover variable costs of production was $35/AF (Pinal County) (See Table 1). La Paz County farmers were hurt the most because of the low prices. They could only pay $10/AF to irrigate their cotton and still cover other variable costs of production.

Table 1. Short Run Average Value Products of Water on Upland Cotton[a], 1986 Upland Cotton Program. Sole Proprietorship.

	No Part.	Full Part.	"50-92"
County			
	200 Base Acres		
	$/AF	$/AF	$/AF
Maricopa	29.48	101.00	148.16
Pinal	35.51	110.21	163.37
Pima	22.48	108.61	162.36
LaPaz	10.10	114.11	182.70
	1,000 Base Acres		
Maricopa	29.48	59.87	71.47
Pinal	35.51	69.80	82.56
Pima	22.48	62.86	81.09
LaPaz	10.10	52.77	68.10

[a]Lint price = .40/lb. Seed price = $85/ton. Likely yields
Source: Hathorn's Field Crop Budgets, 1986.

If cotton growers fully participated in the 1986 Upland Program, the average value products of water on cotton increased dramatically. La Paz County growers with the 200 acre base experienced the highest percentage increase in water values. They could pay $114/AF for irrigation water and still cover variable costs of production. This amounted to over a tenfold difference had these growers not participated. Pima County growers could afford $109/AF (a 383% increase over non-participation), Maricopa cotton growers could afford $101/AF (a 243% increase over non-participation), and Pinal cotton growers could afford $110/AF (a 210% increase over non-participation) for irrigation water and still cover variable costs of production.

The sole proprietor with the 1,000 acre base that fully participated did not experience as dramatic an increase in water values because of the $50,000 limit on the deficiency payment, but the increases over non-participation were still evident. Pinal County growers' average value products of water on cotton were almost $70/AF, twice as much as had they not participated. Pima and Maricopa County growers could pay $62/AF (a 180% increase over non-participation) and $60/AF (a 103% increase over non-participation), respectively, for irrigation water and still cover variable costs of production. La Paz County growers experienced the highest percentage increase in the average value product of water on cotton , a 422% increase over non-participating La Paz County growers.

If the 1,000 acre base cotton farm was operated by five partners, the total cash receipts increased by almost 27%. This meant an increase in the average value product of water on cotton of $50/AF over the fully participating sole proprietor (from $69/AF to $119/AF) (See Table 2). Forming partnerships helped avoid the deficiency payment limitation because each partner could receive up to the $50,000 limit.

Table 2. Short Run Average Value Products of Water on Upland Cotton[a], 1986 Upland Cotton Program. Five Partnersin Pinal County (1,000 Base Acres).

	NoPart.	Full Part.	"50-92"
	$/AF	$/AF	$/AF
Sole Proprietor	35.51	69.80	82.56
Five Partners	35.51	119.24	181.45

[a]Lint price = .40/lb. Seed price = $85/ton. Likely yields
Source: Hathorn's Field Crop Budgets, 1986.

The "50-92" option had the most dramatic impact on average value products of water on cotton. Pinal County growers with the 200 acre base could afford $163/AF for irrigation water (a 360% increase over non-participation) and still cover variable costs of production. Maricopa

County growers could pay $148/AF (a 403% increase over non-participation) and Pima County growers could pay $162/AF (a 622% increase over non-participation) and still cover variable costs of production. Again, La Paz County growers benefitted the most from this option. They could afford $182/AF for irrigation water, a seventeen-fold increase over non-participation.

The $50,000 limit on the deficiency payment showed its impact on the 1,000 acre base operated by a sole-proprietor. Pinal County growers could only afford $82/AF (a 132% increase over non-participation) for irrigation water and still cover variable costs of production. Pima and Maricopa County growers could pay $81/AF (a 261% increase over non-participation) and $71/AF (a 142% increase over non-participation), respectively, for their irrigation water and still cover variable costs of production. The La Paz County farmer could afford only $68/AF for irrigation water, but this still represented a 574% increase over the non-participating La Paz County cotton grower.

If the 1,000 base acre farm was operated by five partners, who participated in the "50-92" option, gross receipts increased by more than 28% over the sole proprietorship who participated in the "50-92" option. This meant an increase in the average value product of water on cotton of 120% (from $82/AF to $181/AF). Again, partnerships proved to be beneficial in avoiding the $50,000 deficiency payment limit.

Despite the supplemental government payments that many cotton growers receive, there is still pressure to retire irrigated land from cotton production because of urban encroachment and urban farmland/ water purchases. The larger cities of the state are willing to pay large sums of money to cotton growers for their land and the accompanying water rights.

Other pressures that farmers face are variations in government programs. The uncertainties that arise because of these variations force farmers to consider retiring from cotton production. In 1983, the PIK Program was very beneficial to many Arizona cotton farmers. The average value product of water on Upland Cotton to the small base acre farmer was as high as $206/AF (See Appendix E). They could not base future expectations on these values, however, because the PIK option was discontinued the following year. The 1984 and 1985 Upland Cotton programs were similar to each other, but vastly different from the 1983 program. In these two years, the highest average value product of water on cotton was $149/AF (See Appendix F). In 1986 and 1987, the Upland Cotton program offered the new 50-92 option. This option increased the average value product of water on cotton to $222/AF in 1987 (See Appendix H). These year to year variations may increase the pressures to retire from farming because of the variability in income associated with the uncertainties of changing governmental programs.

The next chapter will review the latest transactions that have taken place in Arizona dealing with rural land purchases by urban officials and developers who are seeking additional water rights. An analysis of these purchases will follow. It will address the questions of how much farmers are receiving for their land and water in comparison to the value of these resources in agricultural use.

Chapter 5

Economic Analysis of Arizona Land/Water Purchases

In the previous chapter returns to water on cotton were examined to demonstrate the effects of the Upland Cotton program. In this chapter the value of a water right on a whole farm basis will be determined by capitalizing the average value product of water on each crop grown on the farm. Capitalized values of water rights will be compared with the prices paid by urban buyers to determine whether Arizona farmers who have sold their farms to urban buyers are receiving more for their land and water than what they are worth to the farmer in agriculture.

Various Water Transfers in Arizona

The quest for additional water supplies by some Arizona cities began many years ago. As early as 1940, the city of Tucson considered developing water rights in the Avra Valley, fifteen miles west of the city (Saliba, Bush and Martin, 1987). Tucson began purchasing and retiring farmland from the valley in 1971 to obtain the rights to the water appurtenant to the parcels of land. Since then the city has acquired over 16,000 acres involving 32 separate transactions (See Appendix A). By owning the land, Tucson had rights to nearly 50,000 acre feet of groundwater annually from the valley (transferable water rights average 3 acre feet per acre of irrigated land in the Tucson Active Management Area).

This water purchase plan has cost the city more than $22.8 million (all costs and prices reported in 1986 dollars). Prices paid for the land have ranged from just under $1,200 to over $3,400 per acre. The price of the water rights, therefore, has ranged from $400/AF to over $1,100/AF, assuming that the land and its improvements have no value once the rights have been converted to city use. The price represents the amount paid for rights to use an acre foot of water each year (not the amount paid per acre foot per year). The prices reported throughout chapter 5 will be reported in this manner.

A second example of an Arizona community acquiring farmland for the conversion of irrigation rights to Type I nonirrigation rights involves the city of Mesa. In 1985, Mesa made 14 purchases of farmland in Pinal County (See Appendix B). This acquisition of over 11,000 acres in the area between Eloy and Coolidge cost the city just under $30 million. The per acre costs to the city ranged from $2,500 to $3,300, the average cost equalling more than $2,900 per acre. Mesa is allowed to transfer 2.7 acre feet of water per acre of land, and therefore, obtained rights to 30,000 acre feet of water per year at a cost of $1,000 per acre foot.

Though not yet officially approved, Mesa plans to exchange water with Tucson by pulling 30,000 acre feet per year out of the Central Arizona Project (CAP) and then pumping an equivalent amount out of the Pinal County farmland and back into the CAP aqueduct further down canal from Mesa. Tucson could then have 30,000 acre feet of Pinal County groundwater. Mesa's other alternative is to pipe the groundwater 40 miles north to its borders (Saliba, Bush and Martin, 1987).

Groundwater is not the only source cities are investigating to obtain additional water rights. In 1984, the city of Scottsdale purchased the Planet Ranch, an 8,400 acre ranch and alfalfa farm on the Bill Williams River in western Arizona at a cost of $11.6 million (Saliba, Bush, and Martin, 1987). With this acquisition came appropriative rights to 13,500 acre feet of surface water per year. This water is to be used for future municipal growth. Additional costs for improving the ranch facilities and for operating losses due to continued farming (Scottsdale must continue farming to keep the water in a beneficial use.) amount to an estimated $4.5 million. The total cost of acquiring Planet Ranch and maintaining its water rights in beneficial use, was around $16 million. The rights to 13,500 acre feet of water cost just under $1,200 per acre foot.

In 1985, two other "water ranches" were purchased to support urban growth in the Phoenix metropolitan area. The Lincoln Ranch, which is upstream from the Planet Ranch, was purchased by Vector Enterprises, and the Crowder-Weiser Ranch, located near Vicksburg in La Paz County, was purchased by American Continental. Collectively, these ranches will supply over 55,000 acre feet of water per year. The use of this water is yet to be determined. Real estate development in Tucson and Phoenix are the most likely uses (Saliba, Bush, and Martin, 1987).

In 1986, the city of Phoenix purchased over 13,000 acres of irrigated farmland near the unincorporated communities of Salome and Wenden in the McMullen Valley in La Paz County (Water Market Update, 1987). For $33 million the city obtained rights to 30,000 acre feet annually to be used to support urban growth (See Appendix C). The means to transport these water supplies has yet to be determined. Phoenix may be able to hook up with the CAP canal, which is only 12 miles from the valley at its closest point. The Central Arizona Water Conservancy District (CAWCD) is the agency responsible for the operation and maintenance of the canal. It has not given permission to Phoenix to transport water in the canal because no formal policy has been formulated concerning this alternative. The other alternative is for Phoenix to construct their own conveyance system from the McMullen Valley to the city's perimeter, approximately 100 miles.

Analysis of Water Transfers

The previous chapter estimated the short run average value product of water on cotton in four cotton producing areas in Arizona. The short run average value products of water estimated in Chapter 4 included payments received through federal cotton programs. This short run average value product of water on cotton, however, does not give the whole-farm picture of the value of water in irrigated agriculture. To determine the actual value of irrigation water one must consider the other crops that farmers typically produce in addition to cotton. This analysis will determine the short run and long run average value product of water in irrigation on a whole farm basis.

Short Run Whole Farm Average Value Product

To determine the short run average value product of water in agricultural production, all variable costs of production, except variable water costs, must be subtracted from gross farm receipts obtained from the market and government programs. Dividing this return by the number of acre feet per year that the irrigation right allows (assumed to equal the maximum quantity of water applied to crops on a representative farms by a typical farmer during the years of the study) represents the short run average value product (SRAVP) of water in crop production. This SRAVP represents the maximum amount a farmer could pay for irrigation water and be able to cover all other variable costs, given a particular crop mix.

In implementing the 1980 Arizona Groundwater Management Act, irrigation groundwater rights were determined to be the maximum quantity of water a farmer within an Active Management Area applied to his crops in any of the five years preceding January 1, 1980 (Arizona Revised Statute, 45-465). Actual water application rates for each year of crop production are not appropriate to use, because a farmer could have applied less than the total quantity of his irrigation water right. Using the actual quantity of water applied each year for a given crop mix (not the maximum quantity allowed) would over estimate the value of the water because the returns to water would be divided by a less than maximum quantity of water.

Long Run Whole Farm Average Value Product

To determine the long run average value product of water in agriculture, the long run returns to the farm must be calculated. The calculation involves subtracting all fixed costs, except interest on land, and interest and depreciation on wells, from the short run returns to the water. The residual is the return to the land and water resource base of the farm. The long run average value product (LRAVP) of water is then determined by dividing these long run returns by the quantity of the water right associated with the farm (as was done for calculating the SRAVP). (A detailed explanation of the calculation of the LRAVP of water on the farm is shown in Appendix D). This LRAVP of water represents the amount a farmer could afford to pay for land and water and cover all other costs of production, both variable and fixed.

This long run average value product of water will be compared to prices paid by metropolitan buyers to determine whether or not the sellers/farmers received prices that fully compensated them for the agricultural returns foregone in selling their land and water rights.

The LRAVP of water in irrigated agriculture is only one of many factors that farmers would consider when deciding whether or not to accept an offer for their farms. The LRAVP of the farmers' water represents the lowest price they could rationally accept. The farmers would not necessarily accept this price because of the other factors under consideration, such as speculation regarding higher future land and water values. These factors will be discussed at the end of this chapter.

Scope of Analysis

The analysis will concentrate on the recent land/water purchases in Pinal County by the city of Mesa in 1985, the McMullen Valley in La Paz County by the city of Phoenix in 1986, and the Avra Valley by the city of Tucson in 1984. Also analyzed will be the acquisitions of Planet Ranch by the city of Scottsdale in 1984 and the Lincoln Ranch by Vector Enterprises in 1985.

Method of Analysis

The technique used for comparison is referred to as capitalization. This is a process by which the present value of a stream of annual benefits is estimated. In this case, the annual benefits of holding an irrigation right are equal to the long run average value product of water on a representative farm and the value of the right in irrigation use is the capitalized value of these annual benefits. The formula used to find the market value of an irrigation right is based on a financial tool known as the present value of a uniform series of payments (an annuity). This is the equivalent of capitalizing annual benefits over a certain time period and discount rate.

The formula used is:

$$Vo = A \{[1-(1+i)^{-n}]/i\} = A\ [USPVi,n]$$

where A is the annual benefit from water use (the long run average value product of water) in each period, in this case, one year. USPV refers to the Uniform Series Present Value for the specified discount rate (i) and planning horizon (n).

For example, if the farmer's crops are expected to generate revenue such that the LRAVP of water is $100/AF, then by discounting this amount by 4%, with a five year planning horizon, the value of the water in irrigated crop production is $445/AF ($100*4.452) (See Table 3). This is the present value of future returns attributable to water that a grower will receive if continuing with crop production over that five year period.

Table 3. Uniform Series Present Value.
Present Value = A(USPVi,n).

n	4%	8%	12%
5	4.452	3.993	3.605
10	8.111	6.710	5.650
15	11.118	8.559	6.811

i = Discount Rate.
n = Time Horizon in Years.

The important variables determining the present value of an annuity are the farmer's time horizon and the discount rate. At high discount rates, the length of the time horizon has little effect on present values. At low discount rates, however, the length of the planning horizon has a significant impact on present value. For example, an annuity of $1,000, discounted annually at 12% for five years, would be worth only $3605 today. The present value of this annuity would be $6811 if discounted over fifteen years at that same rate. At 4%, however, the present value of the annuity would be worth $4452 discounted five years, and $11,118 discounted fifteen years. Over a lengthy time horizon, the present value of an annuity is significantly affected by a low discount rate.

The farmer has to determine a minimum acceptable price for his land and water rights. The minimum price a grower/seller should be willing-to-accept will be no less than what the water is worth to the grower in irrigated agriculture, its capitalized LRAVP in this analysis. The analysis will not suggest the capitalized LRAVP of water is the price that the farmer would actually accept, but only the minimum price based on the value of water in agricultural production. The farmer may decline to sell at this price if he speculates that the value of his water rights will increase in the future. Because most of the recent land/water purchases analyzed in this study were in remote areas in Arizona, however, urban encroachment pressures would not increase the minimum acceptance price.

Some studies have determined the value of water in irrigation based on the profit maximizing level of water use (Kelso, Martin, and Mack, 1973; Martin and Snyder, 1979). Since the data used in this study originates from typical water application rates in each county, rather than profit maximizing use, this analysis will be based on what the representative farmer would typically apply. This implies that the LRAVP of water in irrigation may not be the maximum possible value, but the representative value for Arizona farms in the areas studied.

The analysis will investigate irrigation water values by looking at time horizons of five years, ten years, and fifteen years with interest rates of 4%, 8%, and 12%. The low rate reflects the approximate inflation rate from 1984 to 1986, the years that most of the land/water purchases within the state occurred. The high rate is the approximate short term loan rate for agricultural lenders (Agricultural Statistics, 1985).

The analysis will also consider different scenarios with respect to high, medium, and low yields for each crop. The medium yield is equivalent to Hathorn's "likely" yields, with a 10% differential in the high and low yield scenarios.

A farmer will base his decision on whether to sell or continue in agricultural production on a variety of economic and personal factors. Personal considerations would include quality of life, health, age and retirement plans. Economic considerations would include how profitable crop production has been and is expected to be compared to how lucrative offers are for a farmer's land and water rights.

Since each farmer has a unique set of considerations, this analysis will not suggest what the typical farmer should or should not have done when negotiating with the urban buyers. Rather the analysis will show the capitalized values of water rights applied in agriculture under 9 separate scenarios (3 time horizons, 3 discount rates) and determine whether or not the farmer would have received more for his land and water rights, had he sold, than what the land and water rights were worth in agriculture, as measured by the capitalized LRAVP. The farmer would not base his decision to sell solely on these minimum acceptance prices. Therefore, these minimum acceptance prices are not a decision rule on whether or not to sell.

One point that is very important here, is that the buyers of irrigated acreage within an Active Management Area will receive only the "consumptive" use of water that the typical farmer historically applied, not the total amount the farmer has historically applied. This means that the amount of water that the buyer receives is not equal to the quantity of water the farmer is giving up. For example, the consumptive use of Pinal County irrigation has been approximately 2.7 acre feet per acre. The Pinal County farmers, on the other hand, are applying 4.3 acre feet per acre when irrigating. The price that the city of Mesa pays for water has been based on the amount they are able to transfer (2.7 acre feet per acre). The LRAVP of the water to the Pinal County farmer, however, is based on the amount he actually uses (4.3 acre feet per acre). To allow comparison of prices paid by the cities and received by the farmers on a per acre-foot basis, one has to take the amount that the buyer pays per acre-foot of transferable water rights, and multiply that by the ratio of how much the buyer can transfer to how much the farmer actually applies. This adjusted price can then be compared to the LRAVP of water in crop production.

For example, suppose the buyer paid $3,000 per acre for land and was allowed to transfer 3 acre feet of water per acre. This is equivalent to the buyer paying $1,000 per acre foot for water rights. The seller, however, applied 5 acre feet of water per acre of cropland, and therefore, is relinquishing the rights to 5 acre feet per acre. The seller is essentially receiving only $600 per acre foot of water that he is giving up ($1,000 * 3 / 5).

The quantity of transferable water averages 2.7 acre feet per acre in the Pinal AMA. The Pima AMA averages 3 acre feet per acre. These amounts are based on historical "consumptive" uses, and are established by law to determine transferable quantities in each AMA. For areas outside of an Active Management Area, rights to pump groundwater are not clearly defined or quantified. Pumping appears to be limited only by the provision that other water users are not impaired.

Since nearly 82% of the farmers in Arizona participate in cotton programs annually (See Table 4), only water values for participating cotton growers will be analyzed. The wheat program will not be considered because of its erratic participation rates (See Table 5) and because only a small proportion (13.5 %, Arizona Agricultural Statistics, 1985) of cropland in Arizona is devoted to wheat.

Table 4. Cotton Program Participation Rates For Arizona Cotton Farmers, 1983-1986.

YEAR	RATE
1983	0.96
1984	0.69
1985	0.79
1986	0.84
AVERAGE	0.82

Source: ASCS, 1986.

Table 5. Wheat Program Participation Rates For Arizona Farmers, 1983-1986.

YEAR	RATE
1983	0.61
1984	0.21
1985	0.39
1986	0.37

Source: ASCS, 1986.

Following is a list of assumptions pertinent to this analysis of recent land/water purchases in Arizona.

1.) Each representative farm is planted to cotton,wheat, and alfalfa. The crop mix varies depending on conservation requirements of the cotton programs.
2.) Only the LRAVP of water for farmers who participated in the cotton program will be analyzed (their values were consistently the highest).
3.) The number of acre feet per irrigation right is assumed to equal the maximum amount applied by the farmer in any one year used in the analysis.
4.) There will be high, medium, and low yield scenarios.
5.) This comparison of agricultural water values with market prices is based on returns to agriculture in selected years preceding the transaction.

Purchases within an Active Management Area are treated differently than purchases outside of an Active Management Area in this analysis, because purchases of irrigated land outside of an Active Managment Area for the purpose of transferring water are not regulated by the Arizona Groundwater Management Act. The analyses are different because the quantification of water rights are determined within an Active Management Area, whereas they are not specifically determined outside an Active Management Area.

Purchases Within an Active Management Area

Avra Valley Purchases (1984)

The analysis of these purchases will use data on the LRAVP of water from the years 1983 and 1984 to determine the minimum acceptance price a grower could have considered from the buyer. Because the 1983 PIK Program was very unusual, farmers' expectations changed. Therefore, these two years were the only years that a Pima County farmer could use to obtain a reliable estimate of the value of water in agricultural production.

Representative Farm Characteristics

The average size farm sold to the city of Tucson in 1984 was 550 acres (See Table 6). The typical farmer planted 42% of his irrigated acres to cotton, 22% to grains (wheat will be used), and 8% to alfalfa. The remaining 28% was kept fallow because of the conservation requirements of governmental programs. The average water use for these three crops was 3.7 acre feet per acre (See Table 7).

In 1984 the city of Tucson paid an average of $2594 per acre for Avra Valley farmland with prices ranging from $1,957 to $3,433 per acre. Because Tucson can transfer only three acre feet of water per acre of land (historical "consumptive" use), as established by law, the city paid an average of $865 per acre foot of water received. The price that the farmer received per acre foot, however, was less because the typical grower applied 3.7 acre feet of water per acre of cropland. In other words, he relinquished the rights to apply 3.7 acre feet of water per acre of irrigated land. Therefore, the typical farmer in Avra Valley received an average of $701/AF for his water rights($865 * 3.0 / 3.7). The following analysis will use Hathorn's data on the Avra Valley farmer, specifically.

Table 6. Avra Valley Purchases by the City of Tucson, 1984.

	ACRES	AF	BUYER $/AC PAID	BUYER $/AF PAID	FARMER $/AF REC
	633	1899	2911.00	970.00	786.00
	273	819	3433.00	1144.00	928.00
	1005	3015	2357.00	786.00	637.00
	184	552	1957.00	652.00	529.00
	300	900	2106.00	702.00	569.00
	772	2316	2319.00	773.00	627.00
	608	1824	2510.00	837.00	679.00
	620	1860	3159.00	1053.00	854.00
AVERAGES	550	1650	2594.00	865.00	701.00

All prices reported in 1986 dollars.
Tucson receives 3.0 acre feet per acre purchased.
Farmers historically applied 3.7 acre feet per acre.
Source: Hathorn's Field Crop Budgets, 1983-1984.

Table 7. Average Water Use Per Acre (AF). Variable Crop Mix of Cotton, Wheat, and Alfalfa.

COUNTY	1983	1984	1985	1986	1987
PIMA	3.77	3.73	3.72	3.98	3.83
PINAL	4.31	4.29	4.26	4.79	4.80
LA PAZ	5.00	5.09	4.92	5.35	5.06

Source: Hathorn's Field Crop Budgets, 1983-1986.

Avra Valley Analysis

In the short run, an Avra Valley grower experiencing high yields from his farmland could afford $121/AF for water in 1983 and 1984 and be able to cover other variable costs of production. In the long run, however, this grower could only pay $78/AF for water and still be able to cover all costs of production, both variable and fixed (See Table 8).

Table 8. Avra Valley Short Run and Long Run Average Value Products of Water, 1983-1984. ($/AF/Year)

	1983 PIK OPTION		
	YIELDS		
	LOW	MEDIUM	HIGH
SRAVP	85.21	100.15	115.08
LRAVP	43.27	58.20	73.13
	1984 PARTICIPATION		
	YIELDS		
	LOW	MEDIUM	HIGH
SRAVP	90.97	108.34	126.91
LRAVP	46.38	63.76	82.30
Averages			
SRAVP	88.09	104.25	121.00
LRAVP	44.83	60.98	77.72

Only the farmer with the 15 year planning horizon who discounted by 4% would not benefit from selling to the city of Tucson (See Table 9). The present value of the typical Avra Valley grower's LRAVP of water was $864/AF of water right, $163/AF greater than what Tucson offered. All other time horizon/ discount rate scenarios proved selling beneficial to the Avra Valley farmer. An Avra Valley farmer with a five year planning horizon, a 12% discount rate, and high yields, could have accepted as low as $280/AF and improved his financial position by selling. Tucson's offer was more than 2.5 times the capitalized value of water this farmer could have generated from continued crop production.

Table 9. Avra Valley Farmer's Minimum Acceptance Prices . Sole Proprietorship or Partnership. ($/AF of water right)

LRAVP * USPVi,n
i = Discount Rate.
n = Time Horizon in Years.

n	4%	8%	12%
High Yield			
5	346.00	310.00	280.00
10	630.00	522.00	439.00
15	864.00	665.00	529.00
"Likely" Yield			
5	271.00	243.00	220.00
10	495.00	409.00	345.00
15	678.00	522.00	415.00
Low Yield			
5	200.00	179.00	162.00
10	364.00	301.00	253.00
15	498.00	384.00	305.00

The Avra Valley grower with lower yielding cropland would presumably be even more eager to sell than the grower with high yielding cropland. The low yielding cropland owner could not pay any more than $45/AF for irrigation water and cover all variable and fixed costs of crop production. The present value of this grower's water in crop production discounted by 4% over 15 years was only $498/AF (the greatest value in the low yielding scenario). Tucson's offer was 40% higher than what this farmer could generate through continued crop production.

Whether the farms were organized as sole proprietorships or partnerships for the purpose of the Upland Cotton Program, made no difference in the value of water in crop production. The cotton acreages were too small for the $50,000 limit of the farm programs to be of any consequence.

Pinal County Purchases (1985)

The analysis of these purchases will use the LRAVP of water in agricultural production from the years 1983 to 1985 to determine the minimum acceptance price for the representative Pinal County growers. The Pinal County growers had an additional year to re-evaluate the worth of their water rights in agriculture due to the 1983 PIK Program.

Representative Farm Characteristics

The average size farm sold to the city of Mesa in 1985 was 800 acres (See Table 10). The typical cotton grower in that area planted 42% of his irrigated acres to cotton, 30% to wheat, and 6% to alfalfa. The remaining 22%

was left fallow due to cotton program conservation requirements. The average water application rate to the three crops was 4.31 acre feet per acre.

Table 10. Pinal County Purchases by Mesa, 1985.

	ACRES	AF	BUYER PAID/ACRE	BUYER PAID /AF	FARMER REC'D/AF
	307	828	2967.00	1099.00	690.00
	883	2385	2738.00	1014.00	637.00
	1404	3792	2506.00	928.00	583.00
	566	1527	2754.00	1019.00	640.00
	650	1755	2749.00	1017.00	639.00
	571	1542	2876.00	1065.00	669.00
	131	353	2741.00	1014.00	637.00
	568	1533	2759.00	1022.00	642.00
	1282	3462	2344.00	868.00	545.00
	1427	3852	2830.00	1048.00	658.00
	1090	2944	2808.00	1040.00	653.00
	1514	4089	3032.00	1123.00	705.00
	478	1290	2530.00	937.00	588.00
	267	720	2603.00	964.00	605.00
AVERAGES	800	2160	2731.00	1011.00	635.00

Mesa Receives 2.7 acre feet per acre purchased.
Farmer historically applied 4.3 acre feet per acre.
All prices reported in 1986 dollars per acre foot of water right.

The city of Mesa paid an average of $2,731 per acre for Pinal County farmland in 1985, with prices ranging from $2,344 to $3,032 per acre. Because the quantity of transportable water averaged 2.7 acre feet per grandfathered irrigation acre (historical "consumptive" use), as established by law in the Arizona Groundwater Code, Mesa paid the equivalent of $1,011/AF of water. Pinal County farmers, however, applied 4.3 acre feet of water on each acre of farmland. This means the farmer received only $635 for each acre foor of water he relinquished by selling ($1,011 * 2.7 / 4.3). The following analysis relies on data from Hathorn's Pinal County Field Crop Budgets (1983-1985), concentrating on the Eloy area data.

Pinal County Analysis

As a sole proprietor, the high yielding Pinal County crop land owner in the Eloy area could pay $105/AF for water in the short run and cover all variable costs of production (See Table 11). In the long run, however, the average value product of water in agricultural production for the sole proprietor was only $68/AF.

If this sole proprietor had a 15 year planning horizon and discounted the LRAVP of water in crop production by 4%, the present value of the water would be $761/AF (See Table 12). This is $126/AF more than what the city of Mesa offered. This farmer would not improve his financial position by selling. However, under the remaining time horizon/discount rate scenarios, selling the farm to Mesa would be beneficial. If the sole proprietor had a five year planning horizon and discounted by 12%, he could accept as low as $247/AF. Mesa's offer was more than 2.5 times greater than this value.

Table 11. Pinal County Short Run and Long Run Average Value Products of Water, 1983-1985 ($/AF/Year)

	Sole Proprietor			Partnership		
	Yields			Yields[1]		
	1983 PIK OPTION			1983 PIK OPTION		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
SRAVP	73.38	86.61	99.84	73.38	86.61	99.84
LRAVP	37.97	51.20	64.44	37.97	51.20	64.44
	1984 PARTICIPATION			1984 PARTICIPATION		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
SRAVP	73.20	89.61	106.02	82.36	98.68	115.01
LRAVP	35.77	52.18	68.59	44.93	61.26	77.58
	1985 PARTICIPATION			1985 PARTICIPATION		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
SRAVP	79.31	94.38	109.44	93.41	111.20	128.99
LRAVP	42.19	57.25	72.32	56.29	74.08	91.87
Averages						
SRAVP	75.30	90.20	105.10	83.05	98.83	114.61
LRAVP	38.64	53.54	68.45	46.40	62.18	77.96

1. Values are identical with sole proprietorship because $50,000 deficiency payment limit is not reached.

Pinal County farmers who owned cropland that did not produce high yields would improve their financial positions by accepting Mesa's offer because the capitalized value of water left in agriculture was considerably lower. The owner of low yielding farm land could accept $139/AF (12% discount rate, five year planning horizon) and improve his financial position by selling to Mesa.

If the Pinal County farm was operated by three partners, the average value product of water increased by $10/AF (high yield) in both the short run and the long run (The value of water is higher because each partner can receive up to $50,000 on a deficiency payment). Only two of the nine high yielding, time horizon/discount rate scenarios reveal that selling to the city of Mesa would not improve a Pinal County farmer's financial position. With a time horizon of 15 years, and discount rates of 8% and 4%, the capitalized values of the LRAVP of water in crop production were $667/AF and $867/AF, respectively (See Table 12). These values were $32/AF and $232/AF, respectively, more than what Mesa offered.

If the farmland produced "likely" yields for the partners, the LRAVP of water was $62/AF. Capitalizing this by the 4% discount rate over a 15 year planning horizon, revealed that accepting Mesa's offer would not have been beneficial. The present value of continuing in agricultural

Table 12. Pinal County Farmer's Minimum Acceptance Prices. ($/AF of water right)

LRAVP * USPVi,n
i = Discount Rate.
n = Time Horizon in Years.

	Sole Proprietorship			Partnership		
	High Yield			High Yield		
n	4%	8%	12%	4%	8%	12%
5	305.00	273.00	247.00	347.00	311.00	281.00
10	555.00	459.00	387.00	632.00	523.00	440.00
15	761.00	586.00	466.00	867.00	667.00	531.00
	"Likely" Yield			"Likely" Yield		
n						
5	238.00	214.00	193.00	277.00	248.00	224.00
10	434.00	359.00	303.00	504.00	417.00	351.00
15	595.00	458.00	365.00	691.00	532.00	424.00
	Low Yield			Low Yield		
n						
5	172.00	154.00	139.00	207.00	185.00	167.00
10	313.00	259.00	218.00	376.00	311.00	262.00
15	430.00	331.00	263.00	516.00	397.00	316.00

production would have been $691/AF, $55/AF greater than Mesa's offer. Any other time horizon/discount rate scenario proved selling to Mesa beneficial to the partnership.

Purchases Outside of an Active Management Area

Purchases of irrigated land outside an Active Management Area for the purpose of transferring water are not regulated by the Arizona Groundwater Code. For analytical purposes, the amount of water that the buyer receives is assumed to equal that amount the sellers used historically in irrigated crop production. It must be understood, however, that some of the growers may have had rights to more water than the amount they used in agriculture. In addition, the quantity of water rights the buyer will actually be able to transfer will not be known until the buyer successfully completes sever and transfer proceedings with the Arizona Department of Water Resources to obtain permission to transfer the water. Sever and transfer proceedings have not yet been initiated for any of the land/water purchases described here. Assumptions about transferable quantities are therefore based on the buyer's projections made at the time of purchase.

Phoenix/McMullen Valley Purchases

In 1986 the city of Phoenix purchased over 13,000 acres of irrigated cropland in the McMullen Valley of La Paz

County for $30,000,000. Phoenix paid the equivalent of $1,000/AF for rights to 30,000 AF annually.

McMullen Valley Farm Characteristics

The typical seller in the McMullen Valley irrigated 575 acres of farmland. 50% of the typical farm was planted to cotton, 30% to wheat, and the remaining 20% fallow to meet conservation requirements of cotton programs. The average water use for these crops amounted to just under 5 AF per acre (Montgomery, 1986).

This analysis will investigate the value of water to the farmer using data from 1983 to 1986. Hathorn's Yuma County Field Crop Budgets were used for the years 1983 and 1984 because La Paz County was not formed until 1984. Hathorn's La Paz County Field Crop Budgets, specific to the McMullen Valley, were used for 1985 and 1986.

McMullen Valley Analysis

The sole proprietor who owned high yielding cropland could afford $69/AF for irrigation water in the short run and still cover other variable costs of production (See Table 13). In the long run, however, the sole proprietor could only afford $46/AF and cover all other costs of production.

The highest capitalized value of this LRAVP of water was $515/AF (4% discount rate, 15 year planning horizon) (See Table 14). Phoenix' offer was almost twice this amount.

Table 13. McMullen Valley Short Run and Long Run Average Value Products of Water, 1983- 1986. ($/AF/Year)

	Sole Proprietorship			Partnership		
	Yields			Yields		
	1983 PARTICIPATION			1983 PARTICIPATION[1]		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
SRAVP	51.55	62.51	73.09	51.55	62.51	73.09
LRAVP	26.06	37.02	47.60	26.06	37.02	47.60
	1984 PARTICIPATION			1984 PARTICIPATION[1]		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
SRAVP	48.54	61.32	74.09	48.54	61.32	74.09
LRAVP	26.69	39.46	52.23	26.69	39.46	52.23
	1985 PARTICIPATION			1985 PARTICIPATION		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
SRAVP	46.83	59.44	72.05	56.78	70.90	85.08
LRAVP	24.93	37.54	50.15	35.04	49.08	63.21
	1986 50-92 PART.			1986 50-92 PART.		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
SRAVP	34.50	45.64	56.77	48.92	61.65	74.38
LRAVP	13.06	24.20	35.33	27.48	40.21	52.94
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
Average						
SRAVP	45.36	57.23	69.00	51.45	64.10	76.66
LRAVP	22.69	34.56	46.33	28.82	41.44	54.00

1. Values are identical with sole proprietorship because $50,000 deficiency payment limit was not reached.

Table 14. McMullen Valley Farmer's Minimum Acceptance Prices. ($/AF of water right)

Sole Proprietorship				Partnership		
		High Yield			High Yield	
	4%	8%	12%	4%	8%	12%
n						
5	206.00	185.00	167.00	240.00	216.00	195.00
10	376.00	311.00	262.00	438.00	362.00	305.00
15	515.00	397.00	316.00	600.00	462.00	368.00
		"Likely" Yield			"Likely" Yield	
n						
5	154.00	138.00	125.00	184.00	165.00	149.00
10	280.00	232.00	195.00	336.00	278.00	234.00
15	384.00	296.00	235.00	461.00	355.00	282.00
		Low Yield			Low Yield	
n						
5	101.00	91.00	82.00	128.00	115.00	104.00
10	184.00	152.00	128.00	234.00	193.00	163.00
15	252.00	194.00	155.00	320.00	247.00	196.00

With lower yielding farmland, the sole proprietor may be more eager to sell because of the lower capitalized values of water. A sole proprietor who had low yielding farmland could accept as low as $104/AF (12% discount rate, 5 year planning horizon) and improve his financial position by selling. Phoenix' offer was close to 10 times this amount. It is no wonder that a group of McMullen Valley farmers asked the city of Phoenix to consider buying their farms for water rights. What Phoenix paid was far more than what the farmer could expect in returns to water through continued agricultural production.

Forming partnerships to avoid the $50,000 deficiency payment limit in the cotton program increased the average value product of water by no more than $8/AF in any yield scenario. The capitalized value of this water, at best, would only be $600/AF (4% discount rate, 15 year planning horizon). This amount was still 40% lower than Phoenix' offer of $1,000/AF.

Water Ranches

Various "water ranches" have been purchased by urban officials and land developers since 1984. All of these ranches are located outside of any Active Management Area. As noted earlier, the actual volumes of water available for transfer from irrigated lands located outside of Active Management Areas are uncertain and so the prices paid on a per acre foot basis reported here are only approximate.

Planet Ranch Analysis

The Planet Ranch was purchased by the city of Scottsdale in 1984. Previous to this transaction 1400 acres of irrigated cropland were planted to alfalfa (Dueker, 1987). The alfalfa growers held appropriative rights to 13,500 acre feet of surface water annually, equivalent to over 9.6 acre feet per acre of cropland. Since the city of Scottsdale plans on exporting only 6 acre feet per acre annually, the city is planting an additional 850 acres of alfalfa to satisfy the beneficial use requirement (discussed on page 23) for their 13,500 acre feet surface water right (2250 acres * 6AF/Acre) (Dueker,1987). Scottsdale paid $859 per acre foot to the sellers for the rights to 13,500 acre feet annually. The following analysis will determine whether the sellers made a good decision by accepting Scottsdale's offer of $859/AF.

Data were compiled from Hathorn's Yuma County Field Crop Budgets because La Paz County was not formed at the time of the purchase. Producers of alfalfa do not receive payments from government programs, and therefore, the gross receipts from production are from market receipts. The years 1982-1984 were used to derive an approximate value of water in alfalfa production. The analysis will compare the long run average value product of this water to the price that the city of Scottsdale paid to the seller.

If the Planet Ranch owner had high yielding alfalfa fields, the owner could afford almost $93/AF for irrigation water and cover all other variable costs of production (See Table 15). In order to cover variable fixed costs of production, the owner could afford no more than $80/AF and break even.

Table 15. Planet Ranch Short Run and Long Run Average Value Products of Water on Alfalfa 1982-1984. ($/AF/Year)

	Yields		
1982	LOW	MEDIUM	HIGH
SRAVP	71.47	81.25	91.04
LRAVP	58.33	68.12	77.91
1983	LOW	MEDIUM	HIGH
SRAVP	69.00	78.21	87.43
LRAVP	56.66	65.87	75.09
1984	LOW	MEDIUM	HIGH
SRAVP	78.76	89.12	99.49
LRAVP	66.24	76.61	86.97
AVERAGE AVPs (1982-1984)	LOW	MEDIUM	HIGH
SRAVP	73.08	82.86	92.65
LRAVP	60.41	70.20	79.99

If the owner capitalized this long run average value product of water by 4% over a 15 year planning horizon (the largest USPV multiplier in all scenarios), the present value of continuing alfalfa production would be $889/AF (See Table 16). This is the only time horizon/discount rate scenario that valued water in continued alfalfa production higher than Scottsdale's offer. All other high yielding scenarios indicate that selling to Scottsdale improved the financial position of the Planet Ranch owner.

Table 16. Planet Ranch Owner's Minimum Acceptance Prices. ($/AF of water right)

LRAVP * USPVi,n
i = Discount Rate.
n = Time Horizon in Years.

n	4%	8%	12%
		High Yield	
5	356.00	319.00	288.00
10	649.00	537.00	452.00
15	889.00	685.00	545.00
		"Likely" Yield	
5	313.00	280.00	253.00
10	569.00	471.00	397.00
15	780.00	601.00	478.00
		Low Yield	
5	269.00	241.00	218.00
10	490.00	405.00	341.00
15	672.00	517.00	411.00

All lower yielding scenarios revealed that the value of water in alfalfa production was considerably lower than Scottsdale's offer. If the Planet Ranch had low yielding farmland, the owner could have accepted $218/AF (12% discount rate, 5 year planning horizon) and benefit from selling. Scottsdale's offer was almost four times larger than this capitalized value in continued alfalfa production.

Lincoln Ranch Analysis

The Lincoln Ranch analysis is similar to the Planet Ranch analysis. This ranch, located just upstream from the Planet Ranch, also holds appropriative surface water rights and uses surface water on its acreages devoted entirely to alfalfa. Vector Enterprise paid approximately $1,000/AF for rights to nearly 5000 acre feet per year (Michealis, 1985).

For this analysis data were compiled from the years 1982-1985. Hathorn's Yuma County Field Crop Budgets were used for the years 1982-1984 (before La Paz County was formed) and his La Paz County Field Crop Budget was used for 1985. The estimate of the long run average value product of water on alfalfa will be compared to the price paid by Vector Enterprise to determine whether or not it was rational for the owner to have sold the land and appurtenant water rights for $1,000/AF.

With high yields the owner could afford $71/AF for irrigation water and cover all variable costs of production (See Table 17). In the long run, however, he could afford no more than $58/AF for water and break even.

The highest capitalized value of the nine high yielding, time horizon/discount rate scenarios was $645/AF (See Table 18). Vector Enterprise offered $355/AF more than what the high yielding owner could receive from continued alfalfa production. If the ranch had low yielding farmland, the owner could have accepted $138/AF (12% discount rate , 5 year planning horizon) and improve his financial position. Vector's offer was over seven times greater than the low yielding land owner's value of water in alfalfa production.

Table 17. Lincoln Ranch Short Run and Long Run Average Value Products of Water on Alfalfa. ($/AF/Year). 1982-1985.

	1982		
		Yields	
	LOW	MEDIUM	HIGH
SRAVP	45.35	55.14	64.92
LRAVP	31.62	41.41	51.19
	1983		
	LOW	MEDIUM	HIGH
SRAVP	47.16	56.37	65.58
LRAVP	34.22	43.43	52.64
	1984		
	LOW	MEDIUM	HIGH
SRAVP	55.96	66.33	76.69
LRAVP	42.85	53.21	63.57
	1985		
	LOW	MEDIUM	HIGH
SRAVP	57.05	67.41	77.77
LRAVP	44.06	54.42	64.78
	AVERAGE AVPs		
	LOW	MEDIUM	HIGH
SRAVP	51.38	61.31	71.24
LRAVP	38.19	48.12	58.05

Table 18. Lincoln Ranch Owner's Minimum Acceptance Prices. ($/AF of water right).

LRAVP * USPVi,n
i = Discount Rate.
n = Time Horizon in Years.

n	4%	8%	12%
	High Yield		
5	258.00	232.00	209.00
10	471.00	390.00	328.00
15	645.00	497.00	395.00
	"Likely" Yield		
5	214.00	192.00	173.00
10	390.00	323.00	272.00
15	535.00	412.00	328.00
	Low Yield		
5	170.00	152.00	138.00
10	310.00	256.00	216.00
15	425.00	327.00	260.00

Crowder-Weiser Ranch

The Crowder-Weiser Ranch, located 10 miles west of Salome in La Paz County, was purchased by American Continental, an urban developer, in 1985. The ranch was purchased to meet future development needs in the Tucson and Phoenix metropolitan areas.

The sale involved deeded land, state agricultural leases, and state grazing leases, but no allocation of the total dollar amount of the purchase for each type of land was made. Since the ranch is outside of any Active Management Area, the quantity of water available for transport is not clear in state water law and , unlike the other purchases outside of AMAs, no specific quantity of transferable water has been projected by the buyer. Because of these uncertainties, no economic analysis of this purchase is provided.

Other Decision-Making Criteria

The LRAVP of water in irrigated agriculture is only one of many factors that farmers would consider when deciding whether or not to accept an offer for their farms. Farmers face many uncertainties in agricultural production. Variability in government programs is one source of uncertainty. How much future government programs will assist the farmer is uncertain. Additionally, costs of water, labor, and other inputs needed for continued agricultural production are uncertain. Yield and output price variations due to weather and market conditions are other sources of uncertainty. Such uncertainties have to be considered by the farmer. A farmer must consider the tradeoff between certain payment for land and water from selling today and the risk of uncertainty with respect to continued agricultural production.

Other considerations include the age and changing lifestyle of the owner. A grower near retirement age would have an incentive to accept offers for his land and water from urban interests and retire in comfort. A younger farmer may want to change his career or the location of his farming operation. The chance to sell at prices that exceed likely returns in agricultural production could provide the opportunity this young grower needed.

A final consideration involves the speculative value of water. As urban water demands increase, the prices that urban buyers are willing to pay are likely to increase. Farmers may consider holding on to their land and water rights, speculating that offers from urban buyers will increase in the future. Farmers may hold out for prices exceeding the average value product of water in agriculture because they observe that urban buyers are currently willing to pay more than what water is worth in irrigation and because they expect that urban interests and willingness to pay will increase over time.

Many factors influence the decision-making of the farmer. While determining the value of water in agriculture is one method of analyzing agricultural-to-urban water transactions, it does not include all of these other factors than can influence farmers decisions to sell land and water rights.

Summary

The prices paid by cities for agricultural water rights have been shown to be many times greater than the capitalized value of water in agricultural production in specific areas of Arizona. Even with the support of goverment programs the capitalized value of the water to the farmer is often less in irrigated agriculture than what non-agricultural water interests are willing to pay for water rights. Consequently, the rural to urban transfers analyzed in this study have taken place and more are likely to be negotiated in the near future.

The final chapter deals with policy implications pertaining to rural-urban water transfers in Arizona. It will discuss the advantages and disadvantages of these transfers from a public policy perspective.

Chapter 6

Transfers: Research Implications and Policy Considerations

Research Implications

The results of the analysis in the previous chapter indicate that the Arizona farmers who have sold their land and water rights to urban buyers are receiving prices that often greatly exceed the value of the water in irrigated agriculture. In other words, these farmers/sellers appear to be capturing a portion of the gains generated by water transfers from lower valued agricultural uses to higher valued non-agricultural uses. If returns above and beyond those possible through continued farming can be made by selling, why haven't more farmers sold their land and water rights to urban buyers?

It must be noted that a large number of farmers are interested in selling to urban water buyers. City officials and other urban interests report that they receive more indications of interest in selling from farmers than they could possibly investigate. Because agriculture accounts for such a large proportion of Arizona water use, cities need to obtain only a small proportion of the water currently used in agriculture in order to satisfy projected urban water demands. Therefore, all farmers interested in selling at prices recently paid by urban interests may not find buyers at those prices.

Arizona farmers who have declined offers for land and water from urban interests could be holding out for higher prices due to speculative influences. They could be anticipating future increases in water values. As the urban population grows, the demand for water may increase and prices offered for water rights may increase.

A related factor that may encourage some farmers to not sell is the location of their farms. If farms are located near the urban fringe, the farmers realize that the value of both their lands and their water rights will increase. They speculate that urban developers will pay a premium price for their lands as cities expand in the future. These influences keep some Arizona farmers from selling at this time.

How have the land/water transactions that have already taken place affected Arizona? What are the costs and benefits of these rural-to-urban water transfers to society? The transfer of water from rural areas to municipal areas must deal with efficiency and equity considerations. Efficiency losses result when water remains in lower valued uses when it could be put to higher valued uses and generate higher net returns. Equity concerns involve the effects of water transfers on third parties, the environment, and the area of origin, in this case, rural areas. The rest of the chapter will discuss some of these considerations and suggest how policy influences these efficiency and equity considerations.

Efficiency Considerations

Water markets are useful tools for the efficient allocation of water resources. A well developed water market will guide individuals to make conservation and allocation decisions that increase the economic benefits that society derives from its water resources.

A market reallocation of water is efficient if the gainers from a reallocation would be able to fully compensate the losers and still be better off themselves (Kaldor, Hicks, 1939). This definition of efficiency requires that all benefits from a water reallocation exceed all costs. There has been concern that if the water is used in agriculture when it could be used in higher valued uses, there would be efficiency losses. One objective for the market process is that the market functions efficiently.

Efficiency implies that the water is allocated first to those users who are willing to pay the most for the resource until their demands are satisfied. Then the next increments of water would be allocated to those users who are willing to pay the next highest for the resource, and so on, until all water is used or all demands are satisfied.

This description of the market process, however, has assumed fixed water supplies. A competitive market could also ensure that an efficient quantity of water is provided. Efficiency requires that another unit of water be supplied if the cost of supplying it is less than the benefits generated by supplying it. The optimal supply of water, then, is where the marginal cost of supplying an additional unit of water equals the marginal value of the additional unit. A market price is established when quantity supplied equals quantity demanded. Market prices guide producers to supply water as long as the marginal cost of supplying the water is less than or equal to the marginal value of the water to the consumer. If water becomes more valuable to water users they will bid up prices for water, thus signaling producers to supply more water. The market process should reallocate water, hypothetically, so that net returns to water are maximized.

There can be strong economic incentives for transferring water out of rural areas and into metropolitan areas. The primary reason is that urban water users place a higher value on the first increments of water available to them than the farmer would place on that same quantity made available for agriculture. The urban user requires water for basic everyday needs, such as bathing, drinking, and cooking, and this relatively small increment of water is extremely valuable to the urban user. As long as the urban population is willing to pay more for water than what it is worth to the farmer in irrigated agriculture, the potential for water market development is strong.

There won't always be strong incentives for transfers, however. As urban water users receive quantities of water that satisfy their highest valued uses, the marginal value of additional increments of water decreases. As the quantity of water available to urban areas increases, marginal values of water in urban uses decrease, and eventually become equal to the marginal value of water in agriculture. At this point there would be no further incentives for rural to urban water transfers.

Impediments to Market Development

The development of efficient markets can be hampered by market imperfections. Many characteristics of water contribute to market imperfections, which result in the market's failure to allocate water efficiently.

Nonexclusivity

Exclusive property rights in water, necessary for an efficient market system, are difficult to establish and enforce because of water's mobility (water flows, seeps, evaporates, and transpires). Exclusivity implies that the sale of the water must not impair the rights of others, and terms under which the water may be transferred must be specified (Posner, 1987). Exclusive and protected rights provide individuals with secure expectations when making water transfer and investment decisions. Without secure expectations, there is little incentive to make investments to use water more efficiently.

Externalities

Other problems that may cause a market to fail to efficiently allocate water are externalities. An externality occurs when an activity performed by one decision maker has spillover effects on the activities of other decision makers. For example, if the law allowed groundwater to be transferred out of a basin, the rights of other pumpers may be impaired. When a farmer pumps water from an underground aquifer, he may lower the water table for other pumpers that share the same aquifer. A water aquifer does not stop at an owner's property line. When water transfer decisions involve externalities, the costs to the third party may not be reflected in the market price. If the losses to the third party outweigh the benefits of the transfer, there is inefficiency in the market.

Public Goods

Uses of water which have public good characteristics (nonexcludability and nonrivalry) often cannot be efficiently allocated through the market process.

Nonexcludability refers to the inability to limit benefits of water use only to those who pay for them. An example of this is the aesthetic value of water in a scenic lake or stream located in a national forest. The nonexcludability characteristic means that a price cannot be charged to those who benefit by viewing the lake. Nonexcludability is a problem for the market, because markets allocate goods by excluding those who will not pay the going price.

Nonrivalry is a characteristic of benefits from water use that can be enjoyed by more than one individual simultaneously. By excluding individuals from the benefits of nonrival goods, the total value that these water uses could generate would be reduced. An example of a non-rival good may be the same lake or stream in the national forest used for swimming and fishing. Such water uses cannot be efficiently allocated through the market process because it is not desirable to exclude individuals who benefit from the water use at zero cost to others.

Risk and Uncertainty

The efficiency of a competitive market assumes accurate information is available on quality and availability of the good being traded. Since water is a renewable resource, its supply is variable in time, space, and quality. Specification of property rights for a commodity in uncertain supply is complicated and presents problems for a market system. The stochastic element of water supply increases the uncertainties associated with buying water rights since the yield of the right will vary from year to year depending on streamflow and the competing claims of other right holders.

Risks may be redistributed if some water users are willing to pay more than others to protect themselves against a water shortage. A market could distribute the risks of water shortages between those willing to bear some risks if they are compensated for doing so, and those willing to pay to protect themselves from supply uncertainty. Water buyers need some assurance that they will receive the quantity and quality of water that they expected to receive when they made the purchase or that they can accommodate the risks of uncertain supplies. Changing or ambiguous state and federal water policies do not necessarily provide legal assurances upon which potential buyers can form expectations about the security and reliability of water rights they are considering for purchase.

Imperfect Competiton

Concentration of market power in a water market can lead to an inefficient allocation of water. A large water supplier may be able to influence water prices by undercutting smaller suppliers' prices and eventually decreasing the number of suppliers in the market. Large water providers may be able to undercut competitors' prices because water supply costs typically decrease as the quantity of water provided by a supplier increases. Market power may be concentrated not only on the supply side of the market, but also on the demand side. In some areas of the West there are only a few large cities or industries that buy water rights and these entities can have considerable influence over the level of water market activity and over market prices. Markets in which a few large buyers or sellers influence market prices are characterized as imperfectly competitive. Public policy can promote an imperfectly competitive water market by allowing only one water company to serve an area. Control over local water resources may influence market outcomes if the water company participates in a market transfer.

Legal Barriers to Efficient Water Allocations

Arizona water policies can create barriers to efficient water allocation through regulations that provide little incentive for conserving water and transferring conserved water to higher value uses. One current law that creates impediments associated with transfers involves tying agricultural water rights to agricultural land. This is referred to as the appurtenancy doctrine. Among the various southwestern states, Arizona follows the strictest interpretation of this doctrine (Saliba and Bush, 1987). The doctrine states that appropriative surface water rights may only be acquired by purchasing the land to which the rights are appurtenant (Salt River Users' Association v. Kavocovich, 1966). This requirement applies also to irrigation groundwater rights recognized under the 1980 Groundwater Management Act (Arizona Revised Statutes, 1980).

Because of the Act, a farmer can not sell water and continue to irrigate the same land to which the water right was appurtenant. There is little incentive for the farmer to develop new water conservation techniques or shift to crops that require less water. Such policies impede water market development, preventing farmers from selling water they don't need.

A solution to this problem may be to allow irrigation water rights, in whole or in part, to be severed and transferred separately from irrigated land. This would enable farmers to sell the portion of their water rights that they would be able to conserve by investing in water conservation techniques, such as drip irrigation, or by shifting to less water intensive crops so that their fields can remain in production. Such policy changes could enhance water market development and efficient reallocation of water.

In order for adoption of water conserving technologies to be attractive to farmers, the cost of installing and using water conservation measures has to be less than production cost savings involved in using less water and the benefits received from leasing or selling conserved water. Otherwise, the conservation investment would not be economically rational.

Another related issue that provides the farmer with little incentive to conserve water or shift to less water-intensive crops is also taken from the Kavocovich case. The decision did not allow farmers to line ditches and transfer the "saved" water to irrigate adjacent land, apply it to non-irrigation uses on his property, or sell it to another user. Adherence to this policy creates disincentives for water conservation. A change in water policy that would allow farmers to use conserved water as they see fit would reward water conserving efforts. Such a policy could provide incentive for water market transactions by allowing the water right holder to lease or sell conserved water.

Impacts on Arizona Metropolitan Areas

As mentioned in chapter three, Arizona's economy as a whole is becoming less dependent on agriculture and more dependent on the manufacturing and service industries as evidenced by the state's fast growing population in the metropolitan areas (Arizona Economic Profile, 1985). This has forced urban officials to seek additional water supplies to meet the growing demands of cities' populations. However, vast supplies of this resource are applied in a sector of the economy that is on the decline in Arizona, agriculture. Through the marketing process, water rights from agricultural areas that have low marginal values of water in crop production can be transferred to metropolitan users that collectively have high marginal values for water. These transfers would continue until the marginal values of water in each sector are approximately equal, net of transfer costs. Equal marginal values of water in Arizona across alternative uses, net of transfer costs, would imply an efficient allocation of water resources within Arizona.

Purchasing agricultural land and water rights is not the only alternative for meeting municipal water needs. Other alternatives include conservation, developing new supplies, and limiting growth. The cities of Phoenix and Tucson currently have active conservation programs. They are relying on many strategies to meet future water demands. Many Arizona cities, however, have chosen agricultural land purchases as an attractive option.

Changing policies stemming from the Kavocovich case concerning the appurtenancy doctrine and the "use it or lose it " aspect of the appropriations doctrine would permit a more efficient allocation of water throughout the state, because the farmers would have more incentive to invest in water conserving techniques, and then sell or lease conserved water to individuals or entities that place a higher value on the water. Efficiency, however, is not the only issue involved in a water transfer. Policymakers must consider equity issues to ensure that third party costs imposed by transfers are accounted for in the transfer approval process.

Equity Considerations

Impacts on Agricultural Areas

Individually, Arizona farmers who sell their farms to urban buyers benefit from rural to urban water transfers, but rural economies and communities can suffer from the transfers' effects. Selling land and water rights can be an attractive alternative for the farmer who is experiencing financial difficulties year after year. The lucrative offers from urban buyers could provide the incentive for the farmer either to retire from agricultural production with a positive bank or to buy other irrigable land in new areas with lower land prices and continue farming, as some Arizona farmers have done. The water market allows the financially distressed farmer to avoid bankruptcy and foreclosure on his property.

Water transfers can have negative impacts on rural residents and communities. Losses to the area include current and future incomes directly or indirectly associated with the curtailment of agriculture. Certain "backward linked" industries such as farm equipment and chemical suppliers along with certain "forward linked" industries, such as livestock processing and meat packing facilities will find demand for their services reduced with consequent reductions in their net incomes (MacDonnell, et al., 1985). Individuals who were employed by these industries may become unemployed because of the decreased demand for their services, resulting in income losses for these individuals.

All of these negative impacts affect the rural community as a whole. Due to losses in incomes, there may be a decline in local spending and subsequent business activity. Because state law exempts from taxation land owned by municipalities, a water transfer out of a rural area would reduce the total assessed valuation of the area, which leads to reduced tax revenues collected from the area (Water Resources Study, 1986). The local government would lose property tax revenues. The school district would lose bonding capacity, which is based on the total assessed valuation of a school district.

Area of origin concerns must be recognized by state policymakers. Both efficiency and equity considerations require that those individuals planning transfers must take into account all of the direct and indirect costs associated with a transfer. Requiring that some type of compensation be paid to injured parties would be one way to ensure that water buyers and sellers account for the external costs of water transfers.

Area of origin concerns are receiving more attention by policy makers. Recent Arizona legislative activity has dealt with the impacts of agricultural to urban water transfers on rural areas. Legislation passed in 1986 permits in lieu of property tax payments by cities purchasing and retiring farmland (Az. Revised Statutes, 1986). Numerous bills were introduced in 1987 dealing with area of origin concerns. One bill requested that no transfers of irrigation rights be allowed until a study of the impacts funded by the legislature is complete. Saliba and Bush (1987) state that area of origin concerns have not yet constrained market transfers in Arizona but have the potential to do so.

Environmental Impacts

Environmental impacts must be taken into consideration when water transfers are proposed. The abandonment of agricultural land leaves former crop-producing fields barren and open to noxious weed infestation. This could have deleterious effects on neighboring farms because the noxious weeds (those weeds that have been considered a nuisance to agriculture by the state such as, tumbleweed or morning glory) may encroach other fields that are still agriculturally productive. Insect infestations are also common to unmanaged fields. The increase of insects would also have deleterious side-effects on neighboring fields. The Arizona legislature passed legislation in 1987 that requires a city to maintain in a nuisance-free state municipal property which is not located in or contiguous to its municipal boundaries (House Bill 2257, 1987). This legislation increases the costs to municipal buyers of maintaining property purchased to acquire water rights, but has alleviated some of the environmental problems associated with to water transfers.

Farm Program Considerations

Many sources of irrigation water have been federally subsidized allowing the farmers not to bear the full costs of conveyance projects. Additionally, farm programs have supported the prices of agricultural commodities at artificially high levels. This has caused the value of resources used in agricultural production, including water, to be higher than if there were no federal subsidies. If these subsidies were non-existent, farmers would be forced to curtail agricultural production at the margin, not because of lucrative offers from city officials, but because of financial burdens due to low commodity prices and higher production costs. Urban water buyers, on the other hand, would be able to negotiate lower prices for agricultural farmland because these agricultural properties would not be as valuable.

Policymakers must consider the interests of taxpayers paying for agricultural programs. Taxpayers pay both for providing subsidized irrigation water and for crop price support programs. Farmers capture gains from selling their irrigated land and appurtenant water rights. Policymakers must consider a balance between benefits of agricultural support programs, the costs borne by the taxpayer, and the subsidized gains to farmers--both while they remain in irrigated agriculture and when they sell land and water rights.

Policy makers will increasingly be required to account for a wide range of public interest concerns when drafting water transfer policy. Policies must avoid the "over regulation" of transfers so that potential efficiency gains facilitated by market transactions are not impaired. On the other hand, policies must not "under regulate" water transfers so that the significant external impacts of transfers are ignored.

Conclusion

This thesis has demonstrated the existence of a water market system in Arizona. It has concentrated on the supply side of the market by analyzing the prices farmers have negotiated with urban officials in transfers that have already taken place within the state. The thesis indicates that farmers have negotiated prices for these sales in excess of what the water is worth to them in agricultural production. The research also analyzes the degree to which net returns to water in irrigation (as estimated using the residual method) are dependent on government programs. The thesis concludes with an overview of the impacts of water transfers on different sectors of Arizona's economy, discussing market imperfections which have hampered water markets and suggesting some changes in state water policy that might alleviate impediments to water market development.

Appendix A. Avra Valley Farmland Purchases of Perpetual Water Rights.

YEAR	ACRES	$/ACRE	AF	$/AF
1971	307	1302	921	434
1972	1428	1308	4284	436
1972	660	1197	1980	399
1975	303	1395	909	465
1975	371	1728	1113	576
1975	437	1578	1311	526
1975	296	2184	888	728
1976	92	1581	276	527
1976	152	1434	456	478
1976	261	1218	783	406
1976	628	1599	1884	533
1976	453	1887	1359	629
1976	470	1770	1410	590
1976	469	1776	1407	592
1976	263	1944	789	648
1976	1287	1740	3861	580
1976	1540	1677	4620	559
1976	159	1656	477	552
1977	811	1890	2433	630
1979	140	2004	420	668
1979	221	2184	663	728
1984	633	2910	1899	970
1984	273	3432	819	1144
1984	1005	2358	3015	786
1984	184	1956	552	652
1984	300	2106	900	702
1984	772	2319	2316	773
1984	608	2511	1824	837
1984	620	3159	1860	1053
1986	1112	1800	3336	600
1986	240	2334	720	778
1986	80	2001	240	667
TOTALS	16575	1998	49725	666

All prices reported in 1986 dollars based on Gross National Product price deflator.

Transportable quantity of 3.0 acre feet of water with each grandfathered irrigation acre purchased.

Appendix B. Pinal County Farmland Purchases of Perpetual Water Rights in 1985.

PURCHASE	ACRES	$/ACRE	AF	$/AF
#1	307	2967	828	1099
#2	883	2738	2385	1014
#3	1404	2506	3792	928
#4	566	2751	1527	1019
#5	650	2746	1755	1017
#6	571	2876	1542	1065
#7	131	2738	354	1014
#8	568	2759	1533	1022
#9	1282	2344	3462	868
#10	1427	2830	3852	1048
#11	1090	2805	2943	1039
#12	1514	3032	4089	1123
#13	478	2530	1290	937
#14	267	2600	720	963
TOTALS	11138	2730	30072	1011

All prices reported in 1986 dollars based on Gross National Product price deflator.

Transportable quantity of 2.7 acre feet of water with each grandfathered irrigation acre purchased.

Appendix C. McMullen Valley Farmland Purchases by City of Phoenix, 1986.

PURCHASE	IRRIGATED ACRES
1	314
2	1097
3	1605
4	444
5	917
6	97
7	209
8	292
9	334
10	1320
11	615
12	615
13	1175
14	72
15	40
16	1511
17	51
18	397
19	297
20	376
21	1244
22	148
23	46
Total acres.	13216

Source City of Phoenix, Water Resource Study. December, 1986.

Dollar amount paid per acre or acre foot not available. Total amount of $30,000,000 (1986 dollars) paid for right to 30,000 AF annually.

Appendix D

Calculation of Average Value Products of Water

The calculation of the average value product of water on a farm involves a number of steps and requires many assumptions to be made. An 800 acre farm from Pinal County will be used as a model to demonstrate how the various calculations were made (See Table 19). An explanation of the various assumptions will be made during the calculation. An 800 acre farm represents the average size farm sold to Mesa in 1985. All data are from Hathorn's Field Crop Budgets (1985).

Short Run Average Value Product

The short run average value product must be calculated before the long run average value product. The SRAVP of water is determined by subtracting all variable costs of production, except variable water costs, from total gross receipts. ROTOC represents the returns over total operating costs, except variable water costs. Dividing the ROTOC by the amount of water that was applied to the crops represents the short run average value product of water on the farm on a per acre-foot basis.

Long Run Average Value Product

Fixed costs are not calculated as straight forward as the variable costs, and therefore, an explanation of each item is required.

The management cost calculation is assumed to be 8% of total variable costs according to Hathorn's Budget.

The machinery costs are found by using a machinery complement of a representative farm (See Tables 20 and 21). First, the necessary machinery for the various crop operations is determined. Then, the total number of hours in a year that each piece of machinery is used is calculated. If the total number of hours exceeds 220 hours in one month (the assumed maximum hours used per month) then, either 2 of that piece of machinery are needed, or a substitute could be made if the piece of machinery was not operation specific, such as a tractor. For example, in December, the 100 Horsepower tractor is required 349 hours. It is assumed that the 80 horsepower tractor could take care of the extra hours that the 100 horsepower tractor could not cover.

Next in the calculation of fixed machinery costs is the annual cost of each piece of machinery based on the number of hours each is used. It is assumed that most machinery is not brand new and, therefore, machinery prices from Hathorn's Farm Machinery Costs from 1978 were arbitrarily used. Total annual costs were calculated by adding annual depreciation, interest, and THI (taxes, housing, and insurance) of each piece of machinery. This figure represents the fixed machine costs for any given year.

Farm maintenance costs were $14 for each acre planted to cotton, alfalfa, and wheat. The remaining maintenance costs (for idle acres) were $21 per acre (Ayer and Wade, 1986).

Land taxes amounted to $7.14 per acre of farmland. Well taxes and insurance were based on costs for each well needed. Electric wells with a 620 foot lift were assumed. In this example, the total water applied to the crops was 2755 acre feet. The typical well, however, pumped only 635 acre feet annually. Therefore, five wells were necessary to meet the demands of the irrigator. The well taxes and insurance are, therefore, 5 times the cost of each of these two items.

Total fixed costs, then, are calculated by adding all fixed costs together. The total fixed costs are subtracted from the short run returns to water (the ROTOC). The residual is the net returns to water in the long run. This residual number is then divided by the total amount of water applied to the crops. This number represents the long run average value product of water on that particular farm on a per acre-foot basis.

Table 19. Calculation of SRAVP and LRAVP of Water.

COTTON PROGRAM 1985 PINAL COUNTY
ACRES 800 SRAVP + LRAVP FULL PART. ONE OWNER
LIKELY YIELDS

CROPS	COTTON	ALFALFA	WHEAT	TOTAL
ACRES	336	48	262	646
VARIABLE COSTS				
TOT GROSS/ACRE				
TOT GROSS RTNS	348368	29232	73452	451052
VC W/O WATER	137280	12557	36962	186799
VC W/WATER	204456	24502	67783	296741
RTNS/ACRE				
ROTOC	211088	16675	36491	264254
FIXED COSTS				
MGMT SERVICE 8%	16356	1960	5423	23739
MACHINE COSTS				53822
FARM MAINT/ACRE	14	14	14	
TOT MAINTAIN	4704	672	3666	12279
LAND TAX (7.14/ACRE)				5712
WELL TAX + INS				8390
TOTAL FC				103942
NET RTNS TO LAND AND WATER				160312
WATER USED (AF)				2800
NUMBER OF WELLS =				5
SRAVP	94.38			
LRAVP	57.25			

LINT PRICE (LB)	0.65
SEED PRICE (TON	100.00
DEF. RATE =	0.198
MKT.ENHANC. RAT	0.00
LINT YIELD/ACRE	1200
BASE ACRES =	480
BASE ACRES =	480
COT TVC/ACRE	608.50
WATER COST/ACRE	199.93
COTTON AF/ACRE	5.0
WHT PRICE/TON =	110.00
WHT YIELD/ACRE	2.6
WHT TVC/ACRE =	258.85
PART. LEVEL =	0.00
WHT WATER/ACRE	117.70
WHEAT AF/ACRE	3.0
PERMITTED ACRES	0.7
ACR FACTOR =	0.2857
ACR 100 FUL =	96
ACR 1000 FUL =	96
DEF LIMIT =	50000
FRCAST DEF 100	50000
FRCST DEF 1000	50000
FREE ACRES 1000	70
TARGET PRICE =	0.81
PAID DIVERSION	0.10
PAID DIVRSN RAT	0.30
MAX DP 100 =	79834
MAX PADP 100 =	17280
MAX DP 1000 =	79834
MAX PADP 1000 =	17280
RELF FAC 100 =	0.515
RELF FAC 1000 =	0.515
ALFALFA PRICE =	87.00
ALFALFA YIELD =	7.0
ALFALFA ACRES =	48
ALFALFA TVC/ACR	510.45
ALF WATER COST	248.84
ALFALFA WATER =	6.25
WHEAT ACRES =	262
TOTAL PLANTED =	646
FALLOW ACRES =	154

ASSUMPTIONS:
MGMT SERVICE = 8% OF VARIABLE COSTS
FIXED COSTS ON ELECTRIC WELLS
620 FT LIFT
PUMPS 635 AF ANNUALLY

Table 20. Annual Hours of Equipment Usage.

PINAL COUNTY 800 ACRE FARM

POWER EQMNT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
TRACTOR 70HP	72	8	94	266	87	89	132	0	4	7	168	194	1121
TRACTOR 80HP	0	0	0	0	0	0	0	0	2	99	131	53	285
TRACTOR 100HP	381	48	80	92	5	86	12	7	18	12	49	349	1139
1/2 TON TRUK	122	122	122	122	122	122	122	122	122	122	122	122	1464
COMBINE 190	0	0	0	0	27	27	0	0	0	0	0	0	54
COTTON PICKER	0	0	0	0	0	0	0	0	0	240	293	107	640
IMPLEMENTS													
BORDER DISK 6	0	2	0	0	0	2	0	0	2	0	0	0	6
CULTIPKER 13FT	0	0	0	0	0	0	0	0	0	2	2	0	0
LANDPLANE	137	0	0	0	0	0	0	0	7	0	0	0	144
LISTER 5 BTM	48	48	0	0	0	0	0	0	0	0	25	25	146
PLOW 5-16	160	0	0	0	0	0	0	0	0	0	0	0	160
OFFSET DISK	36	0	0	12	5	48	12	3	3	12	24	228	383
MULCHER 4	0	0	80	80	0	0	0	0	0	0	0	0	160
CULTIVATOR 4	0	0	0	160	87	87	120	0	0	0	0	0	454
HARROW 3 SECTN	0	0	34	34	0	0	0	0	0	0	0	0	68
RENOVATOR	0	0	0	0	0	0	0	0	0	1	0	0	1
V-RIPPER 5	0	0	0	0	0	0	0	4	4	0	0	0	8
GRAIN DRILL	24	0	0	0	0	0	0	0	2	3	0	24	53
PLANTER 4 ROW	0	0	60	60	0	0	0	0	0	0	0	0	120
MODULE BUILD	0	0	0	0	0	0	0	0	0	96	131	53	280
ROOD 3 ROW	0	0	0	0	0	0	0	0	0	0	160	160	320
SCRAPPER 10FT	0	0	0	0	0	0	0	0	1	0	0	0	1
FERT BRDCSTER	40	0	0	0	0	0	0	0	1	4	8	8	61
STALK CUTR	0	0	0	0	0	38	0	0	0	0	0	96	134
ROWBUCK 10FT	8	6	0	12	0	0	12	0	0	0	0	2	40

Table 21. Annual Equipment Costs.

PINAL COUNTY 800 ACRE FARM

EQUIPMENT NAME	NEW COST	DEPR.	INT.	THI	TOTAL
TRACTOR 70HP	16238	1021	1118	447	2586
TRACTOR 80HP	19797	725	1181	472	2378
TRACTOR 100HP	24542	1560	1696	678	3934
1/2 TON TRUK	7450	2753	471	373	3597
COMBINES 190	58153	2256	3295	1677	7228
COTTON PICKERS	117520	9270	7624	3882	20776
IMPLEMENTS					
BORDER DISK 6	907	35	51	19	105
CULTIPKER 13FT	1838	71	104	39	214
LANDPLANE	4992	244	290	108	642
LISTER 5 BTM	2496	124	145	54	323
PLOW 5-16	5751	307	339	126	772
OFFSET DISK	6490	670	445	166	1281
MULCHER 4	3458	184	204	76	464
CULTIVATOR 4	5446	386	340	126	852
HARROW 3 SECTN	621	24	35	13	72
RENOVATOR	2718	106	154	57	317
V-RIPPER 5	1336	52	76	28	156
GRAIN DRILL	4612	179	261	97	537
PLANTER 4 ROW	3432	261	218	81	560
MODULE BUILD	24627	959	1390	518	2867
ROOD 3 ROW	14144	1520	979	365	2864
SCRAPPER 10FT	1638	64	93	35	192
FERT BRDCSTER	3767	165	216	80	461
STALK CUTR	3952	219	235	87	541
ROWBUCK 10FT	879	34	50	19	103
TOTAL ANNUAL FIXED COSTS					53822

Appendix E. Average ValueProductsof Water on Upland Cotton[a], 1983 Upland Cotton (PIK) Program.

Options:	No Part.	20/0/0	20/5/0	20/0/30[b]
County				
		200 Base Acres		
Maricopa	85.16	123.58	127.52	187.07
Pinal	93.07	132.66	136.66	197.69
Pima	88.72	133.80	138.08	206.13
LaPaz[c]				
		1000 Base Acres		
Maricopa	85.16	103.27	104.03	173.58
Pinal	93.07	113.00	113.84	185.53
Pima	88.72	117.20	118.39	200.24
LaPaz[c]				

[a]Lint price = .67/lb. Seed price = $85/ton. Likely yields.
[b]PIK Option.
[c]LaPaz County not formed yet.
Source: Hathorn's Field Crop Budgets, 1983.

Appendix F. Average Value Products of Water on Upland Cotton[a], 1984 Upland Cotton Program.

	No Participation	Participation
County		
	200 Base Acres	
Maricopa	89.91	113.91
Pinal	89.24	112.34
Pima	115.16	143.45
LaPaz	114.57	148.95
	1000 Base Acres	
Maricopa	89.91	102.90
Pinal	89.24	103.52
Pima	115.16	135.57
La Paz	114.57	132.43

[a]Lint price = .70/lb. Seed Price = $120/ton.
Source: Hathorn's Field Crop Budgets, 1984.

Appendix G. Average Value Products of Water on Upland Cotton[a], 1985 Upland Cotton Program.

County	No Participation	Participation
	200 Base Acres	
Maricopa	76.75	120.14
Pinal	95.89	143.61
Pima	90.22	142.38
LaPaz	82.50	145.60
	1000 Base Acres	
Maricopa	76.75	89.74
Pinal	95.89	110.17
Pima	90.22	110.63
LaPaz	82.50	99.67

[a]Lint price = .65/lb. Seed price = $100/ton.
Source: Hathorn's Field Crop Budgets, 1985.

Appendix H. Average Value Products of Water on Upland Cotton[a], 1987 Upland Cotton Program[b].

County	No Part.	Full Part.	"50-92"
		200 Base Acres	
Maricopa	70.93	123.66	175.24
Pinal	83.01	136.17	189.34
Pima	71.34	138.15	194.27
LaPaz	70.39	147.07	222.09
		1000 Base Acres	
Maricopa	70.93	82.53	94.13
Pinal	83.01	95.77	108.53
Pima	71.34	89.57	107.80
LaPaz	70.39	95.77	108.53

[a]Lint Price = .59/lb. Seed price = $85/ton.
[b]Projected.
Source: Hathorn's Field Crop Budgets, 1986.

SELECTED BIBLIOGRAPHY

A. Tumbling T. Ranches v. City of Phoenix, et. al. February 28, 1983. Superior Court of the State of Arizona in and for the County of Maricopa. Docket No. C473318.

Agricultural Statistics, 1985, United States Department of Agriculture, United States Government Printing Office. Washington D.C., 1985.

Arizona Farmer Stockman. "Maricopa County Farmland Selling to Speculators." October, 1986.

Arizona Water Information Center, University of Arizona, Tucson, Arizona, 1986.

Ayer, Harry W. "Arizona Agriculture and Forces of Change." Extension Report No. 8624. Cooperative Extension Service and the Department of Agricultural Economics, College of Agriculture, University of Arizona, Tucson, Arizona. 1986.

Ayer, Harry W. and Paul G. Hoyt, "Crop-Water Production Functions: Economic Implications for Arizona." Technical Bulletin no. 242, Agricultural Experiment Station, College of Agriculture, University of Arizona, Tucson. Natural Resource Economics Division, Experimental Research Service, U.S. Department of Agriculture, September, 1981.

Ayer, Harry W., Mark B. Lynham, Paul G. Hoyt, and T.S. Longley, "Crop-Water Production Functions: Economic Implications for Potatoes and Dry Beans Grown in Idaho," Economic Research Service Staff Report no. AGES-830302 (Washington D.C., U.S. Department of Agriculture, March 1983).

Ayer, Harry W. and James C. Wade, "The 1986 Upland Cotton Program and Profits for Arizona Producers (With Profit-Computation Worksheets)" Extension Report No. 12, Department of Agricultural Economics, College of Agriculture, University of Arizona, Tucson, Arizona. 1986.

Brantner, Ron, et.al., Arizona Agricultural Statistics. Arizona Crop and Livestock Reporting Service. Phoenix, Az. 1984.

Bureau of Reclamation, "Subcontract Among the United States, the Central Arizona Water Conservancy District, and the Providing for Central Arizona Project Water Service." Phoenix, Arizona, 1983.

Bush, David B. and William E. Martin, "Potential Costs and Benefits to Arizona Agriculture of the Central Arizona Project, Technical Bulletin no. 254, Arizona Agricultural Experiment Station, College of Agriculture,University of Arizona, Tucson, January, 1986.

Bush, David. "Costs and Returns to Irrigation Under the Central Arizona Project: Alternative Futures for Agriculture." Unpublished masters thesis, University of Arizona, Tucson, Arizona. December, 1984.

Campbell, Gregg A. "Assessing the Value of Water," Water Values and Markets: Emerging Management Tools. published by Freshwater Foundation. 1986.

Daubert, John T. and Robert A. Young. 1981. "Recreational Demands for Maintaining Instream Flows: A Contingent Valuation Approach." American Journal of Agricultural Economics. 63:666-676. (November).

Doyle, Mary, "The Transportation Provisions of Arizona's Groundwater Management Act: A Proposed Definition of Compensable Injury." Arizona Law Review. Volume 25: 655-670. 1983.

Gardner, R.L. and T. A. Miller. "Price Behavior in the Water Market of Northeastern Colorado." Water Resources Bulletin, Vol. 19, No. 4:557-562, 1983.

Gibbons, Diana C., "The Economic Value of Water," Resources for the Future, Inc., Washington, D.C., 1986.

Hathorn, Scott. Arizona Field Crop Budgets. Cooperative Extension Service, University of Arizona, Tucson, Arizona. 1975-1984.

Hick, J.R., "The Foundations of Welfare Economics." The Economic Journal Vol. 49, No. 196, December, 1939, p. 696-712.

Hildebrand, Alex, South Delta Water Agency, a critique of Assembly Office of Research, reported by Susan Schmidt Sudman, Western Water, March/April, 1986.

Hill, Dale, city manager, Estes Park, Colorado. Personal conversation, 1985.

Holt, Tim. engineer, Nevada Public Service Commission, Carson City, Nevada. Personal conversation, 1985.

Howe, Charles W., D. Schurmeier, and W. Shaw. 1982. Innovations in Water Management: An Ex Post Analysis of the Colorado-Big Thompson Project and the NCWCD. Unpublished Manuscript, Dept. of Economics, University of Colorado, Boulder, Colorado.

Howe, Charles W., Dennis R. Schurmeier, and W. Douglass Shaw, Jr., "Innovative Approaches to Water Allocation: The Potential for Water Markets," Water Resources Research. 22(1) 439-445, 1986.

Hoyt, Paul G., "Crop Water Production Functions and Economic Implication for the Texas High Plains Region," Economic Research Service, Staff Report no. AGES-820405 (Washington, D.C., U.S. Department of Agriculture, April, 1982.

Just, Richard E., Hueth L., Schmitz, Andrew. Applied Welfare Economic and Public Policy. Prentice-Hall, Inc.1982.

Kaldor, N. "Welfare Propositions of Economics and Interpersonal Comparisons of Utility." The Economic Journal Vol. 49, No. 195, September, 1939, p. 549-52.

Kelso, M.M., W.E. Martin and L.E.Mack. Water Supplies and Economic Growth in an Arid Environment. University of Arizona Press, Tucson, 1973.

Kemper, Doug. project engineer, utilities department, Aurora, Colorado. Personal conversation, 1987.

Krutilla, John V., Michael D. Bowes, and Paul Sherman, 1983. "Watershed Management for Joint Production of Water and Timber: A Provisional Assessment." Water Resources Bulletin. 19(3): 403-414.

MacDonnell, Lawrence J. and Charles W. Howe, "Area-of-Origin Protection in Transbasin Water Diversions: An Evaluation of Alternative Approaches", Water Marketing: Opportunities and Challenges of a New Era, presented by the University of Denver College of Law, Natural Resources Program, and Watershed West, September, 1986.

Martin, William E., "The Economics of Water Transfers: When do Markets Develop?", Department of Agricultural Economics, the University of Arizona, 1986.

Martin, William E. and Gary B. Snyder, "Valuation of Water and Forage from the Salt-Verde Basin of Arizona," Report to the U.S. Forest Service (September, 1979).

Michaelis, Dee and Steve Webb. Water to Sustain Growth. The Arizona Republic. p.pC1-C2. Sunday, June 30, 1985. Phoenix, Arizona.

Montgomery, James M. Consulting Engineers, Inc. City of Phoenix, Water Resources Study, McMullen Valley. Phoenix, Arizona. December, 1986.

Nunn, Susan Christopher and Helen M. Ingram, "Consequencing Water Decisions: Internalizing Social and Political Externalities in Water Markets", Departments of Hydrology and Natural Resources and Political Science, the University of Arizona, 1986.

Nunn, Susan Christopher, Helen Ingram, Robyn Grimes, and Susanna Eden, "Learning the Limits: Water Management in the Colorado River Basin", a paper presented at the Western Social Science Meetings, Reno, Nevada. April 21-25, 1986.

Office of Economic Planning and Development. "Arizona, 1985 Economic Profile." Phoenix, Az.

Pontius, Dale E. "Groundwater Management in Arizona: A New Set of Rules." Arizona Bar Journal. October, 1980.

Saliba B. Colby and David Bush, Water Markets in Theory and Practice: Market TRansfers, Water Values, and Public Policy University of Arizona, Tucson, Arizona. March, 1987.

Saliba, B. Colby, David B. Bush, and William E. Martin, Water Marketing in the Southwest--Can Market Prices Be Used to Evaluate Supply Augmentation Projects? U.S. Forest Service Rocky Mountain Experiment Station, General Technical Report, 1987.

Test, Louis, private attorney, Reno, Nevada. Personal conversation, 1985.

Trelease, Frank J., "Policies for Water Law: Property Rights, Economic Forces, and Public Regulations". Natural Resources Journal. 5(1965): 1-48.

Trelease, Frank J., Water Law: Cases and Materials, 3rd Edition. West Publishing Co., 1979.

Valley National Bank of Arizona, "Arizona Statistical Review, 1985." Economic Planning Division. Phoenix, Arizona.

Water Market Update, published by Western Network. January, 1987.

Weatherford, G.D. and S.J. Shupe. "Reallocating Water in the West." American Water Works Association Journal, October, 1985.

Young, Robert A., "Why Are There So Few Transactions Between Water Users?" Department of Agricultural and Natural Resource Economics, Colorado State University, 1986.

Young, Robert A. and S. Lee Gray, "Input-Output Models, Economic Surplus, and the Evaluation of State or Regional Water Plans." Water Resources Research, Vol. 21, No. 12, pp. 1819-1823. December, 1985.