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FORECASTING FUTURE MARKET VALUES

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Project No. 3109-209

FORECASTING FUTURE MARKET VALUES OF WATER RIGHTS IN NEW MEXICO

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ABSTRACT

In considering the economic future of the American Southwest, important questions to be addressed are the expected availability of water and the price at which that available water will be provided to the ultimate consumers.

Using several sources, Chapter I illustrates that the Southwest in general, and New Mexico specifically will face what is called an "absolute scarcity" of water before the turn of the century. There are two alternatives with which to resolve this "absolute scarcity" -- (i) using physical means to make more water available to the region under stress, or (ii) setting up a mechanism to resolve scarcity internally taking into consideration important objectives such as efficiency and/or equity. The first alternative has not been researched in depth, but the conclusion drawn is that such an alternative would be either extremely difficult to implement or would alleviate water scarcity only temporarily. The second alternative, the market mechanism, has been shown to be a practical solution, and although somewhat rigid, consistent with the econimist's notion of efficiency.

Taking into consideration barriers to the first alternative and the practicality of the market mechanism in the second, the present and future fears concerning physical limitation of water will be transformed into an increasing awareness relating to the price at which water will become available. The information that could be gathered regarding such a price, would promote

further understanding for: small right holders, planning by large developments, the shift to new ground water sources, and special impact situations.

In Chapter 2, practicality of the market mechanism and rigidities associated with it are analyzed. This chapter discusses the actual process of transferring a right to a specific quantity of water. Several legal impediments to a smooth working market are also discussed. The rigidities of the legal system and lack of flow of public information are translated into monetary terms through transaction costs. These transaction costs and the variables affecting them are analyzed in Chapter 3. It is concluded that most of the transaction costs are indeed related to the lack of public information concerning these costs and can be explained by variables such as the price of a water right and existence of an adjudication decree.

Chapter 4 discusses the theoretical determinants that affect the price of water rights. To do so, a distinction is made between the price of water in one time period (flow) and the price of a given amount of water in perpetuity (stock). Some of the literature relating to demand for water as a flow are elaborated and are further used to project demand for water in perpetuity. These final demands for water in perpetuity are put into a simultaneous system to derive variables having an impact on the price of water in equilibrium. Chapter 5 uses a questionnaire to provide a data base to implement the model presented in Chapter 4. Prices for water rights in the future are forecasted for the Rio Grande Basin of New Mexico. The projected real prices for the Rio Grande in 1990 are about four times that of prices prevailing in 1975.

The adjustments in the present water allocation system are classified into two categories -- technical and institutional. These are analyzed in Chapter 6 along with a summary and conclusions reached in this research.

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CHAPTER 1

INTRODUCTION

In considering the economic future of the American Southwest[1] an important question to be addressed is the future availability of water and the price at which the available water will be provided to the ultimate consumers. Fear of physical limitation has long been a shadow on the horizon for all water-users in New Mexico and the Southwest. With increased sophistication this fear is being translated into an increasing awareness that the scarcity will, in many instances, result in greatly increased prices for water rather than in actual physical limitation upon availability. As with any cost, the expectation of significant increases in the price of water may have important consequences for water use within the region.

The increasing perception of the importance of the price of water generally accompanies the approach of a condition of "absolute scarcity" within a given basin in the state or region. Kneese and Brown (1975) define "absolute scarcity" as a situation in which there is a lesser physical amount of water available than would be consumed (evaporated, transpired or exported) at the commonly existing zero price for the water itself, as distinguished from the positive storage and delivery cost for the commodity. The calendar year in which this condition of "absolute scarcity" is reached will vary with the water basin of the region. The San Juan Basin of New Mexico will serve to illustrate the use of this term and its implication.

Projections made by the State Engineer of New Mexico indicate that future consumptive use of water for planned and proposed projects in the San Juan Basin is 701,000 acre-feet.[2] These projections are reproduced here as Table 1.1. It should be noted that this projection may be conservative in the sense that the entries in Table 1.1 represent water quantities associated with documented plans for development in the Basin. To the extent that future developments within the Basin may exceed current plans these projections will underestimate the requests for use of surface water within the Basin. Regarding water availability, the position adopted by the State Engineer is that New Mexico's entitlement in this Basin is 727,000 acre-feet annually.[4] This high position may be subject to challenge on several grounds.[5]

If the conservative consumption projections made by the State Engineer are combined with the Bureau of Reclamation's estimates of water availability, then it is clear that the year is approaching in which there will exist an excess demand for the surface water of the San Juan Basin of New Mexico.

Until that time water users and managers are principally preoccupied with putting the available water to beneficial use. As long as there exists unappropriated or surplus water in the Basin, then the least cost alternative for water users is to put this surplus water to use thereby avoiding more costly

TABLE 1.1

PRESENT AND PROPOSED DEPLETIONS (SAN JUAN)[3]
(UNITS 1000 ACRE-FEET PER ANNUM)

	1974	Future
Irrigation (present)	83	83
Other (M & I, R & W & Rec., mineral, etc. - present)	13	13
Hammond	8	10
San Juan-Chama	46	110
Navajo Reservoir	24	26
Hogback Expansion	2	10
Utah International Inc. (Four Corners)	25	39
Farmington M & I (increase)	0	5
Navajo Indian Irrigation	0	226
Navajo M & I Contracts		
New Mexico Public Service Co. (San Juan)	5	16
Utah International Inc. (WESCO)	0	35
El Paso Natural Gas Co.	0	28
Other (Gallup)	0	8
Animas-La Plata	0	34
Irrigation	0	(14)
M & I	0	(20)
Mainstream Reservoir		
520x.1125	58	58
	264	701

competitive bargaining attempts to bid previously appropriated water away from existing uses. As the date of full appropriation or absolute scarcity nears, moreover, the perception of water users that price increases for water are in prospect leads to positive pricing for the right to the surface water even in advance of a fully appropriated condition.

The basins of New Mexico and the Southwest in general have reached or are nearing a fully appropriated state. As for the region as a whole, Project Independence (1974) has provided a summary statement for the Upper Colorado which is the single most important basin within the region.

> The Upper Colorado may be the most critical of any of the water regions although projected consumption of 3,402 thousand acre-feet is only 34 percent of firm supply, treaty commitments with Mexico and commitments to users in the Lower Colorado Basin require an additional 59 percent of the available supply, leaving very little water to meet already established allocations such as the export of water to the Rio Grande, Arkansas-White-Red and Missouri River Basins.
>
> Most of the projected water consumption is associated with utilities, synthetics, and shale oil. The Colorado River Basin Act of 1968 prohibits any planning by Federal agencies for inter-basin transfers prior to 1978. The water supply situation will be worse beyond 1985, as shale and synthetic fuel development increases. It is estimated that irrigated crop land in the region will increase from 1.6 million acres to about 2.1 million acres by 2020. When the water requirements for the additional irrigation are estimated and combined with export requirements and water for energy projects, the insufficient water supply could severely limit development and growth in the area.

Though the numbers used in their analysis may be subject to dispute, as the authors themselves point out, there can be little doubt that absolute scarcity of surface waters is in prospect and should already be included within the planning horizon of the region's leaders. This heightened scarcity will be felt more dramatically in some areas than in others as set forth below.

1) California and Arizona (Lower Basin States) have made greater use of the annual runoff in the Colorado Basin than is their entitlement under the 1922 Compact. Obviously there must be curtailment by the Lower Basin as the Upper Basin States complete the process of putting their full share to use.

2) Arizona, which has been systematically mining ground water for years, cannot continue the process indefinitely.

3) If, as some authorities suggest, the reliable annual flow of the Colorado system is significantly less than the 15 m.a.f. annually upon which the 5.8 m.a.f. Upper Basin allotment is based, then the Upper Basin states may share in the chronic problem (Kneese and Brown, 1975);

4) The resolution of Indian water claims may or may not change the pattern of availability, but there is a potential for significant effect upon water right allocations.

The increasing demands have stimulated and will continue to stimulate two types of human response. First, there is the expected clamor for more water for the region. The Texas Water Plan's transfer to the High Plains from the Mississippi was the grandest version of this movement with any chance of success, to which it came very close, but to this date it has failed. On a wider scale, there have been numerous schemes proposed including other inter-basin transfers. Stream flow augmentation, renegotiation of the Colorado River Compact, and increased exploration to discover new, deep aquifers underlying various points within the region are but a few. The current federal moratorium[6] on any discussion of inter-basin transfers, the failure of the Texas Water Plan, and the enormous time and expense associated with interbasin transfers all point to the fact that the possibility of significant interbasin transfers seems unrealistic within any reasonable period for the foreseeable future. Renegotiation of the Colorado River Compact, which requires considerably less in the way of monetary expenditures for physical facilities, would involve so much unraveling of the economic and property rights structures of the states involved as to be impractical on the grounds of time and politics.

This leaves stream flow augmentation and exploration of new, deep water sources. Both of these have some practicality. To the extent that either does occur, there will be some lessening of the stresses on water use in the region. However, any additions from stream augmentation, though valuable, will likely be marginal in the total water picture of the region. The Colorado River Basin pilot project, which began in 1968, is a comprehensive research effort to determine the feasibility of utilizing cloud seeding techniques to increase snowfall over a 1,300 square mile area in the San Juan Mountains of Southern Colorado and to determine the effect on the ecology of the area. Preliminary analysis of the data indicates that a 10 to 20 percent increase in seasonal snowfall may be possible.[7,8]

The extent of the new, deep sources is unknown at this point, though a United States Geological Survey exploration program has recently been initiated.[9] Whatever the outcome, new fields are likely to be nonrenewable with a limited lifespan and consequently not permanent additions to the region's supply. Moreover, it should be noted that development of any new nonrenewable resource raises the question of practicability in the utilization of an exhaustible resource, a question which the states have not adequately handled to date in the case of coal, copper, and other minerals as well as other nonrecharging aquifers.

Thus, to summarize the last few paragraphs, it can be stated with some confidence that although some new sources may arise in the future, they will not be large enough or permanent enough to change the fundamental water scarcity picture. They can only postpone full appropriation.

The implication of this condition of scarcity is clearly illustrated by a comparison of recent prices paid for water rights in each of New Mexico water basins for which full appropriation already exists or is an imminent prospect.[10] Table 1.2 reports the estimates of the Bureau of Reclamation (prepared in cooperation with the State Engineer) of water availability and use in each of these basins.[11] The table also presents an estimate of recent prices paid for water rights in those basins.[12] The Santa Fe River is a subbasin

TABLE 1.2

WATER RESOURCES SUMMARY
SURFACE AND GROUND SUPPLIES AND CURRENT PRICE OF WATER RIGHTS
(THOUSANDS OF ACRE-FEET)

Basin	Estimated Present Depletion[1]			Total Present Depletions[1]	Estimated Present Surplus Surface Supply	Estimated Total Usable Surface Supply[2]	Current Price of Water Right Per Acre Foot
	Surface	Ground					
		Surface-Water Related	Overdraft				
Rio Grande	540.4	168.7	150.0	859.1	-	540.4	
Rio Grande excluding Santa Fe							$250 (1969)
Santa Fe							$3733 (1969)
Pecos River	205.0	175.7	120.0	500.7	-	205.4	$238 (1970)
Upper Colorado	132.0	2.1	0	134.1	537.0[3]	669.0	$72 (1970)
Lower Colorado	35.9	6.4	40.0	82.3	42.1[4]	78.3	$657 (1971)

1 1970 for all uses except irrigation which is 1969.

2 Assumed usable surface supply is considered to represent present surface use plus any present surplus surface supply.

3 Consists of authorized uses such as San Juan-Chama Project, Navajo Indian Irrigation Project, Animas-La Plata Project, Utah International Inc., and various Navajo Reservoir contracts.

4 Not all usable in that about 30 percent will be lost in developing the supply.

of the Rio Grande and consequently is not reported separately in the Bureau of Reclamation publication from which the water use and availability figures are taken. However, this sub-basin has long been fully appropriated and yet has continued to experience growth in water demand with one consequence being the high price for water rights reported in the Table 1.2.

With the prospect of full appropriation in most basins and the increasing economic value of water and water rights that will accompany this occurrence, the importance of the allocative procedures used to apportion water between competing uses becomes clear. There are two basic approaches to this allocative task which might find application in the state and region.

Centralized Mechanism Approach

First, there is a centralized procedure which seeks to determine the optimal allocation of water in a given set of circumstances. In technical terms the allocative problem may be framed as a programming problem with the objective of maximizing the net benefits arising from different allocations. This approach possesses two strong links with current water management practices within the region. In the first place water is generally considered to be a semi-public[13] good and is legally endowed in prior appropriation law with a public interest.[14] In principle the notion that water allocation should be determined according to the rule of maximum social benefit seems compatible with the fundamental public ownership. Furthermore, as much of the surface water of the region is in federal ownership, there is already in place a management organization with experience in making water management decisions, albeit a more restrictive class of decisions than would be required here.

However, there are significant problems associated with this approach. The procedure is obviously directed towards finding the most economically efficient solution. One assumption that must be made is that the goal is empirically concrete. There is no single practical (politically acceptable and empirically quantifiable) procedure that can be used to determine economic efficiency as of yet. Ideally, an exact measure of loss and benefits derived from each scenario of water allocation could be obtained by summing up the losses and benefits accruing to each party or elements of parties sharing the consumptive use of the water. However this is not a practical procedure because of the immense cost involved in implementation as well as the unlikely event of its political acceptance. Moreover, in reality there may not be a single quantifiable economic solution even when the goal is concrete. The concept of economic efficiency could be alternatively interpreted with respect to different geographical divisions such as county, state, region, and finally the nation. It is unlikely that all of the answers obtained are consistent with one another. A variety of answers may come out of even a single procedure for analyzing alternative allocations.

Still, there are methods for obtaining an approximation of this magnitude. Let us for the moment ignore the problem of having a variety of goals and assume that the only goal being considered is the maximization of value added accumulating in the region. Note that value added includes both direct and indirect value added. Procedures are available whereby the initial losses accruing as the consequence of a given scenario of water shortages can be estimated. By applying economic principles, we may also find the indirect losses occurring as the result of each initial change in the scenarios. Even, input-output analysis which is the most practical procedure, does not give a definitive answer nor does it give a unique one.[15] However, it is still possible to find some approximate solution by this procedure. Wollman et al. (1962) projected scenarios and direct economic benifits associated with these scenarios. Then having assumed a relationship between direct and indirect effects, they calculated the second type of effects occurring as the result of initial changes. It seems evident that this procedure was accepted because there did not exist any input-output table for the state of New Mexico or the San Juan Basin at the time the study was done. Each of the above procedures could deal in a normative way with the problem of water scarcity, though they may not necessarily give the same solution. Input-output and Wollman's procedure could prove fruitful if there was an intensive amount of information plus the existence of a single planning office administrating water allocation according to an accepted rule; e.g., maximizing value added. However, it is a fact that water allocation is restricted by institutional arrangements, and on this premise we will turn from the above normative procedures which do not jibe with existing institutional arrangements and concentrate on the alternative of decentralized markets for water rights.[16]

Market Mechanism Approach

Organized markets, such as the markets for common stocks, do not exist in any of the states. It is unlikely that such sophisticated, fluid institutions will ever develop within the region. Nevertheless, there are agents in many basins who "deal" in water rights and facilitate the sale of rights from one user to another. There are institutional procedures for such transfers in many states though some states such as Arizona do not allow transfer of a right from one use to another. This latter posture will be increasingly strained as new uses arise and if maintained may severely inhibit economic improvement as more valuable uses arise. However, for New Mexico and others, transfers are permitted so long as the requesting party can establish that the transfer would not be injurious to other right holders. The legal framework governing the transfer of water rights in New Mexico is presented in the next chapter. Where transfer of rights is possible, the increasing demands will result in an increasing market value for an established water right. The requirement that a transfer not be damaging to another rightholder can often necessitate considerable expense in legal and other fees before such a conclusion is reached. This cost falls within the general category of "transaction cost" within the economic literature. In some cases transaction costs may be more than the market value paid to the supplier of the water right. Chapter 3 will be concerned with quantifying "transaction costs" in New Mexico.

In those states which allow transfers, there is buying and selling of water rights but no formal market institution for facilitating these exchanges. As a consequence, there is little public flow of information on the value of a water right. There are several reasons for this lack of information. First, until full appropriation is achieved in a given basin there is little reason to purchase existing rights when a new appropriation can be made instead. Such has been the case for significant portions of Colorado and Utah. Secondly, there is apparently no requirement that the sales value of a transaction be recorded publicly as is the case with various other characteristics of the transfer. Thirdly, when the water right itself is sold appurtenant to the land, it is difficult to distinguish between the sales value of the land and that of the water right. Fourthly, uncertainty regarding quantification and other characteristics of a right, (e.g., they have different priority dates and thereby different expected claims on water) make water rights a nonhomogeneous commodity and as a result there may not be a common market value for all rights in a given basin.

Yet, a historical series of market values for water rights up through the present, and into the future under various scenarios is important. These projections should be made publicly available for a number of practical reasons apart from their value as a general indicator of the relative scarcity of water and its use for planning purposes.

1) Small rightholder. Many of the existing rightholders in New Mexico and other states are small farmers who have senior rights to small amounts of water. Although in many cases these individuals or families are resistant to change and currently profess an unwillingness to sell their rights, these circumstances for better or for worse may change with changing generations and an evolving environment. In similar cross-cultural bargaining in the past and present, the argument has always been raised that the indigenous culture suffers from a bargaining disadvantage relative to the sophisticated affluence of the corporations and individuals seeking to purchase that right. An adequate historical record as well as projected future values of the rights would assist in analyzing this problem if it could be linked with practical methods of disseminating the information into the numerous, individual bargaining situations.

2) Planning by large developments. Many of the possible developments speculated for the Southwest may be expected to founder over water. Currently the discussions seem to arise in absolutist terms; e.g., discussion of a nuclear power plant's water needs will be cast in terms such as "available or not available" without economic parameters considered. With increased sophistication, the discussions may be expected to take on economic tones, such as "What would be the cost of obtaining rights to 40,000 acre-feet a year?" This changes the character of the discussions, and forecasts of the market value of water rights become important. Any company anticipating

large capital expenditures over a delayed time will do its best to anticipate prices and costs at the projected future time of action. Even though such forecasts can never be made with a great deal of accuracy, two conditions give them credibility. One, they will inevitably influence the expectations of corporate decision makers and thereby their decisions. Two, in the case of significant changes in the magnitude of the variable being forecast, which certainly may occur with water rights prices, forecasting tools may at least successfully identify these changes.

3) Shift to new groundwater sources. As discussed briefly above with the increased market value of surface rights, it becomes economically profitable to develop new, deep sources which have presumably not been previously appropriated. Definition of such basins hydrologically, legally, and economically becomes a large and expensive administrative problem. With the ability to project future water right values, it becomes possible to compare exploration and development costs for new sources, and consequently to make judgments about the extent of such activity and a likely time pattern for it.

4) Special impact situations. A variety of other special situations could be addressed by projection routines ranging from the impact of any large water using public enterprise for which the benefits and costs have been measured in some esoteric fashion, to the consequence of a court decision favoring large scale allocation of water to Indian rightholders, or evaluating the applicability of new water saving technology. There are

also a number of more academic uses of the historical information, including the testing and estimation of various aspects of resource economic theory. Chapter 4 will be devoted to the construction of a forecasting procedure for future values of water rights. Chapter 5 discusses procedures relating to the development of questionnaire methodology to obtain price information, the rate of responses received and presents the historical time series relating to the exogenous variables. The results of the application of the model discussed in Chapter 4 together with the projected prices for 1980, 1985 and 1990 are also presented in Chapter 5.

Finally, in Chapter 6, a summary discussion of the market transfer mechanism will be presented which draws upon the material discussed in the earlier chapters. An assessment will be made as to the future serviceability of the transfer mechanism and improvements that could be made.

FOOTNOTES - CHAPTER 1

[1]The American Southwest is defined to be the Four Corners States of Arizona, Colorado, New Mexico, and Utah.

[2]See the statement given by Steve Reynolds, New Mexico State Engineer, before the Senate Subcommittee on Energy Research and Water Resources. U.S. Congress, Hearing on San Juan-Chama Project, 1975.

[3]This table was reproduced from Table 2 of the statement given by Steve Reynolds before the aforementioned Senate Subcommittee.

[4]Steve E. Reynolds, State Engineer of New Mexico, in a memorandum dated September 24, 1974 and published in the aforementioned Senate Subcommittee Report (p. 123) cites a quotation by Howard A. Brown which says that El Paso and Transwestern have expressed interest in eventually building units which will require approximately 225,000 acre-feet per year.

[5]The Bureau of Reclamation [Reference: Water for Energy in the Upper Colorado River Basin] uses a 5.8 million acre-feet per year figure as the portion of the flow of the Upper Colorado to which the Upper Basin states are entitled. New Mexico's share is thus computed as 11.25% of this figure (approximately 650,000 acre-feet per year) which is substantially less than the estimate of the State Engineer.

[6]See Kneese and Brown (1975).

[7]See statement by Morris Thompson, Commissioner of Indian Affairs before the Senate Subcommittee. U.S. Congress, Hearing on San Juan-Chama Project, 1975.

[8]Since the extraction of water from underground sources and the augmentation of current water supplies would be costly, the present and future decisions concerning these alternatives, must be determined on a cost feasibility basis.

[9]Information gathered through personal conversations with Forest Lyford, Project Director, U.S. Geological Survey concerning underground exploration of aquifers in the San Juan Basin. The project is to be completed by 1980 and as yet there are no preliminary results available.

[10]The Canadian River basin of New Mexico is not fully appropriated nor is it likely to be so for the near future.

[11]Data regarding these quantities was acquired from U.S. Department of Interior, New Mexico Water Resources Assessment for Planning Purposes, 1976, page 91, Table 7.

[12]The "price of water rights" was determined for one acre-foot consumptive use from a compilation of data from the State Engineer's Office in Santa Fe and the water rights questionnaires that were mailed to both the buyer and seller parties. These price comparisons are presented in Table 6.1.

[13]This term refers to the fundamental ownership of the commodity which in law is considered to be owned by the entirety of society which allows private entitlement but only under specified conditions.

[14]One example of this legal endowment is the provision, common to virtually all western water law, that any right to water which is not exercised in a beneficial use for a specified period of time reverts to the public domain.

[15]Howe and Easter (1971) have stated that the impact of changing water availability, either limiting or expanding can be measured in terms of impacts created by "supply push" and "demand push" linkages between agriculture and other sectors. With the outcome being affected by assumptions made relating to stability or change in these linkages.

[16]There obviously is a range of possibilities between these two poles. As an example, a centralized agency may hold all rights to the water but lease the water itself on an annual basis by competitive bidding. There are existing institutional arrangements most notably conservancy districts -- from which such a structure could be fashioned.

CHAPTER 2

THE INSTITUTIONAL SETTING FOR TRANSFERRING WATER RIGHTS

In this chapter the assumption is made that economic tools have enabled us to determine the value of water in different uses and that it has proven desirable to transfer water from one use to another. Although, as indicated earlier, it is possible to devise transfer procedures for shifting water among different uses without transferring the right itself, a strong argument supporting the latter approach is that it is the dominant mechanism currently in use -- at least in those states where transfer is legally permissible at all. Accordingly the objectives of this chapter are a description of the existing legal and institutional structure for transferring water rights and an examination of that structure for barriers to a smooth working of a market directed transfer procedure. Although reference will be made to the circumstances of other states, the emphasis will be upon New Mexico.

The Doctrine of Prior Appropriation

The water rights doctrine followed in the western United States, including New Mexico, is the doctrine of Prior Appropriation. If individual A begins using water in the year 1900 and individual B begins use in 1901, then, according to the Prior Appropriation Doctrine, A has priority over B. In particular, suppose A puts 100 acre-feet of water to beneficial use in 1900 while B puts 100 acre-feet to beneficial use in

1901 and in some subsequent year there is a shortage of water with available water being only 100 acre-feet. In this case, under prior appropriation law, A would take the entire flow of water with nothing going to B.

There are two main deficiencies that economists have found in the prior appropriation system of allocation:[1]

1) If an allocation of water is rigidly determined between A and B, then there is little likelihood that the value of the last acre-foot of water used by A will be the same as that of B. As a consequence the water is not employed in its most productive allocation; and,

2) With all of the risk associated with low flow years loaded on the more junior rights there will be less developmental investment associated with the junior rights than would occur if risks were shared equally.

Both of these deficiencies are substantially mitigated, however, if a market system of rights is permitted in which: 1) water may be moved from one use to another thus tending to equilibrate the value of the last acre-foot in each use, and 2) a structure of prices would tend to equilibrate risk for parties A and B.

Institutional Framework for Transferring Water Rights

The following abbreviated description of the New Mexico transfer procedure is presented. The description begins at the conclusion of an agreement between a current rightholder, party A, (the seller) and a prospective rightholder, party B, (the buyer). The latter is also referred to as the transferee. It should be born in mind that the stated objective of the State Engineer is to prevent changes in ownership, use, or point of diversion which are detrimental to other rightholders.[2] The following procedure is the established method for arriving at an affirmative or negative conclusion with respect to that objective.

An Abbreviated Description[3] of the Procedure for Transferring Water Rights in New Mexico from One Ownership and Use to Another

1) Once an agreement to transfer a water right is concluded, buyer party B must fill out application forms in duplicate with the State Engineer. The application fee for a simple change of ownership is one dollar, while the fee for changing the diversion point or method and purpose of use is five dollars. This fee difference, while minor, reflects the generally greater complexity associated with changing the point of diversion or the type of beneficial use.

2) The application, if more than a simple change of ownership, must be accompanied by surveys, maps, plans and specifications[4] illustrating in detail the change to be made. The maps are of a standard form while the results of surveys, maps, plans and specifications must be notarized before submitting them to the State Engineer. These surveys, maps, plans and specifications can be provided by any registered surveyor or engineer familiar with the admini-

strative requirements of the State Engineer. If the transfer is not a complicated one, maps, plans, and specifications may be provided together in one unit. If the proposed transfer is complicated, they should be provided separately.

3) After examination of all documents for conformity with the statutes and rules and regulations of his office and after any necessary corrections have been made, the State Engineer will declare his acceptance of the application. He then shall prepare a Notice of Publication and send it to the applicant with instructions that it shall be published weekly for three consecutive weeks in a newspaper of general circulation in the pertinent stream system. Except that "the State may refuse to order the publication of notice of any application which, in his opinion, is contrary to the public interest".[5]

4) Any party which deems that the granting of the application will be detrimental to that party's valid and existing right may protest the approval of the application in writing to the State Engineer within 10 days of the final date of publication.

5) If there are no protestants and the State Engineer judges the evidence supporting the application to be conclusive, then he may approve the application.

6) If, however, there are protestants and/or the State Engineer judges the evidence to be inconclusive or the

data insufficient for a proper decision, then he may order a hearing to be held.

7) Upon reaching a decision on any protested application, the State Engineer shall issue a Findings and Order. Appeal may be taken to the District Court within whose jurisdiction the lands lie.[6]

With this descriptive information on the transfer procedure in mind, an examination of the difficulties associated with a market for water rights can be made. Four general difficulties are enumerated.

1) In many basins the amount of water to which a given right is entitled is inadequately defined.

2) There is a general ignorance about water rights and the transfer procedure itself [among rightholders as well as potential rightholders].

3) There is considerable uncertainty attached to individual rights arising not only from variable stream flow but also from the prospect of significant changes in Indian and federal usage. The commodity being traded is clearly nonhomogeneous.

4) Transaction costs associated with transfers may be considerable.

These are general difficulties. New Mexico water laws have significantly reduced some of these problems as will be shown in the next few pages. A number of specific conditions determine the degree of difficulty in establishing some trading in water rights; i.e., the kind of organization responsible for approving water transfers is important, and whether the water basin being considered is an adjudicated basin[7] is also a relevant consideration. In New Mexico, approval of transfers is the responsibility of the State Engineer's Office. In Colorado, decisions concerning transfers must be made in the courts. The New Mexico system seems on balance to make transferability easier than the Colorado system.[8]

A relevant point in considering the flexibility of trading water rights is whether there has been an adjudication decree for the basin being considered. In New Mexico, if there is such a decree, the first difficulty above is partially alleviated since the decree quantifies the water rights. But it persists to the extent that there are few records of whether a right has been abandoned or forfeited.[9,10,11] Under the law of Colorado the difficulty is more troublesome. In Colorado adjudication decrees, "maximum use" is determined rather than the amount which the rightholder is entitled to put to beneficial use.[12] In some basins in New Mexico--the San Juan and Gila are examples --adjudication decrees have been granted; in others they have not.

One other point concerning the flexibility of establishing trading in water rights has significance. According to Colorado water law, the burden of proof for showing that there is not impairment of other water rights and that rights of junior appropriators are protected is borne by the transferee before the appropriate court.[13] In complex cases this proof is costly and the cost to a small transferee is high when compared with the market value of the right being transferred. Thus, the incentive to transfer may be low. In New Mexico, the State

Engineer makes decisions about impairment and protection, and the cost to the transferee may in many cases be less.[14]

In New Mexico, the principal statutes regarding transfer of water are 75-5-21, 75-5-22, and 75-5-23 N.M.S.A. 1953 Comp. (1975 Supp.). In addition to these statutes, there are several important court decisions. Two of these decisions will be discussed in detail. In discussing the cases, some comparison between New Mexico's water rights law and that of other states, particularly Colorado, will be noted.

W.S. Ranch Company (A corporation, protestant-apellant)

vs.

Kaiser Steel Corporation, State Engineer of New Mexico (applicants-appellees), Supreme Court of New Mexico, 70 N.M. 65 439 p. 2d, 714 (1968).

Kaiser Corporation applied for the transfer of water rights which had been purchased from a party having adjudicated water rights in a specific stream. The transfer involved changing the point of diversion and use. The person who had formerly been entitled to this water right had been using it for irrigation. Kaiser wanted to use it for industrial uses and coal washing. The State Engineer, having followed due regulations, approved the transfer. The transfer was also approved by the District Court of Colfax County. The protestant then appealed and the New Mexico Supreme Court held that water rights purchased by Kaiser could be transferred. Essentially, the judgment was based upon fact-finding by the State Engineer that the transfer would not have a detrimental effect on the senior user, W.S. Ranch Company.

There are some unique characteristics of this case, and it is a landmark in distinguishing between Colorado's system and that of New Mexico:

1) In considering the petition to transfer water rights, the State Engineer was required to accept judgment in the adjudication decree about the nature and extent of rights to be transferred. 1953 Comp. § 75-5-22, 75-5-23 (The history of the right is available to the State Engineer as was explained earlier in the text). Under the water law of Colorado the amount of water defined in a decree is a maximum use per one acre of land. The beneficial use established in practice may be different than the maximum use established by decree. Under the Colorado system, then, a water right transfer requires a new determination of the actual amount of water put to beneficial use historically. In New Mexico, the Supreme Court of the state has said in W.S. Ranch Co. that water rights transferred will be the amounts given under an adjudication decree. Therefore, it is easier to set up a system for trading water rights in New Mexico.

2) Where there is an adjudication decree governing water rights in a particular stream, the purchaser of a right who applies for transfer is not required to offer proof of the nature of rights transferred. Also if no one comes forward with an affirmative proof of detrimental effect from the transfer, then the transferee may rely on the adjudication decree and the transfer will be granted. But in the Colorado system, the person who

applies for a transfer bears the burden of proving that there are no detrimental effects to others even when there is a decree.

3) The State Engineer made findings showing that the transfer would not cause detrimental effects on existing water rights established by the adjudication decree. These findings were supported by substantial evidence. Thus, the major technical information is provided by the State Engineer. This is significantly different from Colorado where judgements are made by the court itself.

4) In W.S. Ranch Co. the corporation which purchased water rights decided to change the point of diversion from below the ranch to above the ranch. The Court stated that the water right was limited to the amount which would be available at the former point of diversion. This provision helps in recognizing the amount of water rights susceptible of transfer and makes this right almost like a commodity. Other major points mentioned by the Supreme Court are: the transfer was accepted providing that the right transferred would remain junior as it was before with respect to the senior right of the ranch company and could not be expanded at the expense of other appropriations. The Supreme Court stated that one aspect of the judgement would be to decrease uncertinaty. In short it is clear from this case that transfer is facilitated by the presence of an administrating unit such as the State Engineer and the existence of an adjudication decree.

Attention is now turned to a case which permitted the conversion of rights from stream water rights to underground water rights.

City of Albuquerque vs. Reynolds
71 N.M. 428, 379 p. 2d, 73 (1963).

The City of Albuquerque applied to the State Engineer for permits to appropriate underground waters. According to the State Engineer's opinion, the appropriation of underground water implies appropriation of stream flow in the Rio Grande. In response to the city's application, the State Engineer took the position that approval of appropriation for underground water would be contingent upon retirement of part of the city's Rio Grande entitlement -- enough to offset the adverse hydrological effect of drilling wells. The city then appealed the decision of the State Engineer to Bernalillo District Court. Finally, the case came to the New Mexico Supreme Court. There were several complicating disagreements such as applicability of the 1927 act regarding the satisfaction of municipalities' consumptive use and the aggregating provisions of 1953 Comp. § 75-11-3 for inhabitants of a city. What is of greatest importance, however, is approval of the State Engineer's decision by the Supreme Court concerning the imposition of conditions on the application. The Supreme Court's opinion can be briefly summarized:

Both surface and groundwater are subject to prior appropriation. The State Engineer was allowed to take the progressive position that there is a hydrological connection between these waters which formed the basis for his opinion. It was then ruled that the State Engineer can impose restrictions regarding retirement of the city's Rio Grande entitlement to offset the adverse effects of drilling wells.

Of importance is the fact that transferability of irrigation water (stream appropriation) to the municipality is supported. More than that, there is the possibility of transferring stream flow to underground water rights.

Factors Complicating Transfer of Water Rights

As a result of the statutes and cases cited, New Mexico's water law is a very flexible system within which the goal of transferability might be achieved. However in some basins, there are complicating factors. The San Juan Basin can be used as an example. Two major complexities arise from the existence of Winter's Doctrine rights and the management authority of the Bureau of Reclamation.

A. Water Rights for Indian Reservations

The origin of this modern conflict over Indian water rights is in Winters vs. United States, U.S. Supreme Court, 1908, 207 U.S. 564, 28s, ct. 207, 52 l. e. d. 340. In this case, the Court held that when Indian reservations were established by the U.S. Government as places of settlement for Indians, the intention was to provide sufficient water for Indian agriculture such as irrigation. In other words, the appropriation of enough water for the reservation was appurtenant to the creation of the reservation. Furthermore, the Supreme Court held that it is not necessary to put the water to beneficial use in order to continue having such a right. There is, however, controversy about the date of starting priority. Some experts argue that Indians have prehistoric rights to appropriation of water for the reservation.[15] The interpretation which is most commonly applied indicates that the priority date goes back to the date on which the reservation was created by the U.S. Government.

The complexities of these conflicting arguments do not permit further development of the reasoning and evidence behind them in this narrative. However, their resolution will have significant impact upon the ownership of water rights in many basins of New Mexico and the West generally.

A second important consideration surrounding Indian water rights is the potential for transfer to non-Indian uses. In connection with the Winter's Doctrine, the important point is the purpose of creating Indian reservations. It is argued that reservations were created in order to change the life style of Indians from nomadic life to agricultural and industrial life. With respect to water right transfers, the idea that Indian rights could be transferred outside the reservation would be inconsistent with this original goal of creating agricultural and industrial life styles. However, it can also be argued that Indian social and economic development should not be restricted by the narrowly defined objectives of earlier federal policies. Again, the resolution of this question will have important consequences for the region.

The question also remains, how are reservation water rights to be measured?

In Arizona vs. California, (Supreme Court of the United States, 1963, 373 U.S. 546, 83 Sup. Ct. 1468, 10 L. Ed 572.), the court appointed Water Master, Simon H. Rifkind, indicated that the measure of reservation water rights is the amount of water necessary to irrigate all the practically irrigable lands of the reservation and to provide for related domestic and stock uses. He argued that as long as these Indian water rights are not determined, there is considerable uncertainty for other appropriators.

Based on this theory, Navajo Indians claim the right to all water existing in the San Juan Basin. This was the position taken by Peter McDonald, Chairman of the Navajo Tribal Council, in hearings before the subcommittee on Energy Research and Water Resources of the Senate Committee on Interior and Insular Affairs, June 12, 1975.

McDonald also said that Navajo Plans would require more water than exists in the San Juan basin. These views, if implemented, would profoundly affect existing interstate compacts. McDonald said that if it is just 5% of the Navajo land which is irrigable (implying practicably irrigable), something close to 3 1/2 million acre-feet per year would be required. It is clear that the "practicably irrigable land hypothesis" has some ambiguity. The Vice-Chairman of the Navajo Council said a preliminary study shows that the water need for practically irrigable land is about 2 1/2 million acre-feet annually.

All of these claims are far in excess of the share of New

Mexico in waters of the Upper Colorado River Basin. Moreover, if rights of Indians are defined by the Winter's Doctrine; and if Indian water rights are not dominated by state laws; and if the 1868 priority date (date of reservation creation) is used; then existing interstate compacts would of necessity have to be renegotiated. According to an extreme number given by Mr. McDonald, if one-quarter of the Navajo Reservation is irrigable, the Navajos would have rights to all water existing in both the Upper and Lower Colorado Basins. With this cloud of uncertain ownership hanging over water allocation in the San Juan, no allocative mechanism market -- market directed or otherwise -- can be expected to operate efficiently.

B. Bureau of Reclamation Contracts

Presently, there are two ways open for municipalities, industrial users, and other users located in the San Juan Basin to increase their use of surface water:

(1) They may contract with the U.S. Bureau of Reclamation to obtain water subject to the senior rights discussed earlier.

(2) They may transfer water rights as determined by the 1948 San Juan adjudication decree and subsequent appropriations made through the State Engineer prior to the Bureau of Reclamation Project.

Public Law 87-483 does not allow the Secretary of the Interior to approve long term contracts for water existing in Navajo reservior unless he can certify that there is water available in excess of already established commitments including the Navajo Irrigation Project, San Juan-Chama Project, and prior rights under the 1948 adjudication decree.

However, based upon investigation by the Secretary of the Interior and pursuant to Public Law 90-272 approved in 1968, three new long-term contracts with the following companies were authorized:

	Water Diversion (acre-feet)	Water Depletion (acre-feet)	Proposed Uses
Public Service Co. of New Mexico	20,200	16,200	Thermal-Electric Generation
Southern Union Gas Co.	50	50	Pump Cooling
Utah Construction & Mining Co.	44,000	35,300	Thermal-Electric Generation

The State Engineer of New Mexico has indicated that in the event of a shortage his position regarding Section 11 (a) of Public Law 87-483 would see any deficiency divided among the different parties, including the San Juan-Chama Project and the Navajo Irrigation Project, by means of a pro rata sharing. This interpretation, however, may be the source of conflict in future years.

The principal relevance for the market allocation mechanism of the contracting power granted the Secretary of Interior, however, lies with the large quantity of San Juan water made subject to contract. The rudimentary water rights markets that currently exist in many basins are based on the trading of the in perpetuity rights to water. All of the water which is made subject to Bureau of Reclamation contracts by PL 87-483 is removed from the trading market. In fact since these contracts require remuneration solely for the cost of storage and conveyance, the water itself is not priced at all. What has been created is a two-tiered system in which some water rights may be traded at market value while other water is kept at a zero price for the duration of the contracts. A permanent remedy to the water allocation problem will likely involve elements of both these procedures: 1) contracting by a public agent and 2) market pricing of the water resource itself.

Before concluding this discussion of problems in the San Juan Basin, recent questions concerning Jicarilla Apache water rights should be mentioned. The Jicarilla Apache Reservation was created by an Executive Order dated February 11, 1887, and another dated January 28, 1908. Recently the Jicarillas submitted a plan to appropriate water.[16] This proposed appropriation further complicates the already complex water problems of the San Juan. One of the problems involve the question of the priority date to be assigned the Jicarillas. Another question is their willingness to accept a pro rata basis for sharing water in the event of shortage or their continued stress on the earlier priority of Winter's Doctrine rights.[17] These are open questions; yet, they clearly illustrate the uncertainty surrounding water rights in this basin as well as others in which federal and Indian rights are strongly asserted. The above submitted plan by the Jicarillas may show that all the annual flow of the Navajo River could be put to beneficial use by the Jicarillas. The Jicarilla Apaches have also claimed that the San Juan-Chama diversion was causing damage to fish and wildlife in the Navajo River. It is clear that the entire question of water rights of the Jicarilla Apaches remains to be resolved. Irrespective of the manner in which this question is resolved, the only practicable way for new surface water users in the San Juan basin to obtain water is through the transfer of privately held water rights obtained under the 1948 adjudication decree.

Thus the San Juan basin of New Mexico contains several legal complexities which contribute to uncertainty in the quantum of water attached to any water right. Other special complications exist in other basins such as the Rio Grande. Since the Rio Grande will be used as the case study for projecting the market value of water rights, it is useful to briefly consider the institutional complications in that basin also.

Special complications which exist in the Rio Grande Basin not considered in the above discussion on the San Juan basin are: (i) the absence of an adjudication decree regarding appropriation of water rights, and (ii) the existence of a <u>conservancy district</u> with legislatively delegated special powers with regard to water rights. What advantages are rendered by the existence of an adjudication decree? What practices of the Middle Rio Grande Conservancy District affect water right transfers in the Rio Grande Basin? These are important issues but will be discussed here only briefly.

As for the first question, the advantages of having an adjudication decree in a basin are best understood by citing 75-4-5 N.M.S.A. 1953 Comp. (Supp. 1975) which says:

> Adjudication of rights - decree filed with State Engineer - content of decree - upon the adjudication of the rights to the use of the waters of a stream system, a certified copy of the decree shall be prepared and filed in the office of the State Engineer by the clerk of the court, at the cost of the parties. Such decree shall in every case, declare, as to the water right, adjudged to each party, the priority, amount, periods and place of use, and as to water use for irrigation, except as otherwise provided in this article, the specific tracts of land to which it shall be appurtenant, together with some other conditions as may be necessary to define the right and its priority.

The existence of an adjudication decree reduces the first three difficulties enumerated earlier surrounding the establishment of a functioning water rights market. Therefore, it may reduce the transaction costs associated with the transfer of rights. This hypothesis will be examined in Chapter 3. The existence of a decree delineates the commodity traded more accurately as far as its technical description, time of delivery, location, and in general, the information that is publicly available concerning that right. Viewed in reverse the lack of an adjudication decree in the Rio Grande Basin impedes the establishment of a workable market.[18]

As for the second question above, in order to understand its practical implications existing water rights should be divided in three categories: (i) all surface rights established by the beneficial use of water in New Mexico (Rio Grande application) prior to March 19, 1907,[19] (ii) underground water rights; and (iii) surface water rights established by the beneficial use after March 19, 1907. Regarding (i), in the Manual of Rules and Regulations it is stated that the decisions relating to transfer of these rights must be made by the courts of competent jurisdiction. This is the primary reason that only those surface rights have been transferred which have priorities before 1907 or at least priorities before the creation of the district. Thus questions of allocative control are restricted to the second and third categories enumerated above. Here there is dispute over the issue of jurisdictional authority. The Middle Rio Grande Conservancy District asserts authority over all surface waters within the district put to use subsequent to the creation of the District and underground waters hydrologically linked to those surface waters. The District thus asserts a veto over the transfer of water rights to uses outside of the District, a claim which is not accepted by the State Engineer. As this issue has not been fully tested in the courts and holds promise of extensive litigation, its prospect is a significant cloud over water right transfers within the geographic area of the Conservancy District. One informed source views the problem as an obstacle of sufficient importance as to prevent any significant market transaction in the Middle Rio Grande until the issue is settled. Future events will test this ominous statement.

From this brief discussion of difficulties impeding the smooth working of a market for water rights, it is clear that substantial institutional changes are required before such a market truly approximates the efficient allocative mechanism described in the economic literature and touted by economists generally. Nevertheless it is also true that a rudimentary form of a market for water rights does exist in most basins of the state as will be more fully evidenced in the succeeding chapters.

From an institutional perspective the intriguing question is whether the increasing demand for water within the state and region will lead to increasing use of the market system with consequent pressures for improvement in the institutional arrangements which allow that market to exist or whether public attitudes will turn towards an increase in the centralized regulation of water allocation. The latter theme has been sounded in recent years by several regional leaders who have expressed concern about the inevitable shift of water from agricultural uses occasioned by the increasing value of water rights in the marketplace.

FOOTNOTES - CHAPTER 2

[1]According to Gaffney (1969), prior appropriation, which is similar to "rationing under scarcity," would cause the two economic principles noted to be denied. However, this argument is based upon firm analysis and in Appendix A, it will be shown that if the criterion is utility maximization, prior appropriation without water right transfer would also result in social welfare loss.

[2]See New Mexico Statutes, Ann., 1953, Comp. Sec. § 75-5-23.

[3]This summary is abstracted from the Manual of Rules and Regulations, August 1953 revision, published by the State Engineer, Santa Fe, New Mexico.

[4]In Spencer vs. Bliss (1955) 60 N.M. 16.287 p. 2d 221, the court upheld the decision refusing permission for a transfer by the State Engineer's Office on the grounds that the transferee had not shown that the transfer would not have a detrimental effect on other right holders (see Meyers and Posner, 1971).

[5]Manual of Rules and Regulations, p. 9.

[6]See New Mexico Statues, Ann., 1953, Comp. Sec. § 75-6-1.

[7]The advantages of having an adjudication decree in which a court has legally determined ownership and priority of rights are presented in the latter parts of this chapter.

[8]See Hartman and Seastone, Economic Efficiency and Alternative Institutions, 1969.

[9]Ibid. p. 20, footnote 13, "In New Mexico the Office of the State Engineer is directly involved in the determination of continued beneficial use by the holders of water rights."

[10]In Chapter 3, it is concluded that having a decree reduces the transaction costs significantly.

[11]For a definition of abandonment and forfeiture, see William H. Ellis, "Water Transfer Problems: Law," 1965.

[12]See the next case in this chapter: W.S. Ranch vs. Kaiser Steel Corporation.

[13]Colo. Rev. Stat. 1969, Perm. Supp. § 148-21-20.

[14]Under New Mexico's sytem the burden of proof still rests upon the transferee to present the case to the State Engineer's Office. This burden would be drastically reduced when there is an adjudication decree. This point is elaborated in the legal case noted, W.S. Ranch vs. Kaiser Steel Corp.

[15]See Bloom, "Paramount Rights to Water Use," (1971), and Frank J. Trelease "Indian and Reserved Rights," (1974).

[16]"Reconnaissance Report" Water Resources Inventory; North Half Jicarilla Apache Reservation Irrigation Project," United States Department of Interior, Bureau of Indian Affairs, Albuquerque Area Office, Branch of Land Operation, Senate Subcommittee. In U.S. Congress, Hearing on San Juan-Chama Project, 1975, pp. 163-237.

[17]In this instance the Jicarillas' and Navajo's separate water claims under the Winters' Doctrine may come into direct conflict.

[18]To know how the adjudication is implemented see: New Mexico Statutes, Comp. Sec. Ann., 1953, 75-2-2, 75-4-3, 75-4-4, 75-4-5, 75-4-6, 75-4-7 and especially 75-4-8.

[19]Separating these categories of water rights from the rest are of great concern in the water rights market. Pre-1907 water rights declared by the Federal Court and confirmed by administrative practice could not constitutionally be restricted by the statute and were freely transferable. See Hughes vs. Lincoln Land Co., 27 F. Supp. 972 (Who. 1939).

CHAPTER 3

THE TRANSACTION COSTS ASSOCIATED WITH A WATER RIGHT TRANSFER

The term "transaction costs" as associated with a water right transfer is not a finely interpreted concept as used by economists and its characteristics must be further clarified. One general definition for transaction costs or cost of contracting for any exchange is the following: (Demstez, 1969).

> The cost of contracting can be taken to include the cost of search and negotiation in the market place and cost of insuring that voluntary agreements are honored. The cost of contracting is the value placed by markets on the resources used to make markets work. It is the cost of utilizing voluntary agreements to resolve the problem that arises from competing claims for scarce resources and this cost is measured in the market place.

Even if there were no dispute concerning the above definition, application of it to the transfer of water rights is not a simple task and needs further clarification. Recall the summary discussion of the operational procedures for transferring a right presented in Chapter 2. From that discussion four categories of participants in the transfer may be identified: 1) the buyer of the right, also designated the transferee or party B; 2) the seller of the right, party A; 3) the administrative unit, and/or 4) other individuals such as protestants and witnesses who also are involved in some aspect of the transfer. Some of the cost (private cost) borne by the above groups may have direct effects on the actual performance of the water rights markets while other cost should be treated merely as components of social cost. The costs of the second group, the sellers, are chiefly related to the perfectability of a right. These costs may be drastically affected by the existence or absence of an adjudication decree for the pertinent basin. This cost, however, will not be considered further here since it is a separate, distinct transaction from the transfer itself. Concentration will be on the cost associated with transferring a perfected right.

The costs borne by the buyer, party B, may be broken into the following components:

(a) The cost of providing application forms. There is a formal fee, one dollar for change of ownership, and five dollars for change of diversion point or purpose and method of use. In addition, often an application is completed by professional people such as lawyers, so their charges must be included.

(b) The cost of providing surveys, maps, plans and specifications primarily involves assistance from engineers and to some extent lawyers and administrative personnel. So, the cost associated with these should be calculated as part of the cost borne by party B.

(c) The cost of publication which is entirely borne by party B.

(d) Hearing cost. This component, i.e. legal, engineering, administrative, and miscellaneous, may be borne by party B depending upon the disposition of the case by the State Engineer.

(e) The cost of district court appearance in the event of appeal.

(f) The costs of any appeal beyond the district court level.

(g) The cost of inspection by the State Engineer's Office when the transfer is a complicated one. The portion allocated as cost of inspection for the phase before approving transfer should be counted under this heading.

The costs borne by the administrative system -- the Office of the State Engineer and the Courts -- in terms of manpower and material used to resolve the transfer is difficult to account for and generally does not appear as a market value. Other than the fees and charges listed above, they will not be calculated.

The costs incurred by the other parties to the transfer process are generally of two kinds. First, in the process of resolving the transfer some witnesses may be called to the court. Their time is valuable and often what they receive is different from the market value that would be assigned their services. The difference should be used in calculating an unbiased estimate for the social cost of transfer. Second, protestants may suffer from two categories of cost: (a) they may devote part of their time searching for information, and (b) they may lose the hearing and as a result have to pay the charges determined by the courts. There is also a market valued part of the protestant's costs which involve legal, engineering, and administrative costs.

All costs associated with all actions taken by seller, purchaser, protestant, administration, court officers, in short all persons taking part in the procedures subsequent to the conclusion of an economic agreement between seller and purchaser and prior to the certification of the new ownership for use by final authority, beyond what would have occurred had such an agreement not been reached are in actuality transaction costs. However, for purposes of quantification, only those elements of the above actions to which a dollar value may reasonably be attached will be termed the "quantifiable transaction costs." Yet having made this distinction, it will still be convenient and less cumbersome to revert to the simpler term "transaction costs."

In actually developing this initial estimate of transaction costs, it is even further narrowed by excluding those costs associated with other parties. These are particularly hard to estimate as well as time consuming and so have been excluded in this estimate of transaction costs. The costs to the administrative units are assumed equal to whatever fees are paid by parties A and B, for that specific purpose. Lastly, it should be stated that transaction costs associated with unsuccessful attempts to transfer a right have not been covered in this estimation procedure.

A complete procedure for estimating this narrowed concept of transaction costs would involve a questionnaire such as the following:

Transaction Cost Questionnaire

a) Estimating transaction costs to the buyer party B using questions:

1. Did you use the right for the same purposes (or the same point of diversion) as the previous owner?

___ Yes ___ No

2. Was the application for transfer filed by:

___ an attorney ___ yourself ___ other (please specify)

3. If an attorney did assist in filing the application, what fee was paid?

$___________ ___ not applicable

What services did the attorney render for the fee?

___ not applicable

4. How much was paid to the state engineers office?

$___________

5. What services did the state engineers office perform for the fee?

6. If an attorney was employed, did the attorney's fee include the amount paid to the state engineer's office?

___ Yes ___ No ___ not applicable

7. Did you go to a qualified engineer or surveyor in order to obtain maps, plans, and specifications?

___ Yes ___ No

What fee did you pay for this service?

$__________ ___ not applicable

8. Did the state engineer ask for change, modification, or correction after you submitted your application and maps, plans, etc.?

_____ Yes _____ No

If yes:

a) What was the cost of making those changes?

$___________

b) What changes were made?

9. Did the state engineer give or send you notice for publication of the transfer?

_____ Yes _____ No

10. What was the cost of publishing the transfer in the newspaper?

$___________

11. Were there any protestants to the transfer?

_____ Yes _____ No

If yes, how did you resolve the conflict?

___ responded through the state engineer's office without a formal hearing

___ protestants accepted judgment of hearing held by state engineer

___ decision by the district court

___ decision by c ourt of appeals or supreme court

___ other (please specify)

12. What costs in each of the following areas were involved in answering the protestants?

___ Engineering ___ Legal ___ Witnesses

___ Administrative ___ Other (please specify)

b) Estimating transaction costs to the seller party A, using questions:

1. Who sold the water right?

   ___ yourself ___ an attorney ___ a broker

   ___ other (please specify)

2. If an attorney or broker was used what fee was paid?

   $____________

   What services did they render?

3. Does the attorney's fee include any expenses for other items such as engineering fees, administrative costs, etc.?

   ___ Yes ___ No

   If no, list any other costs involved in selling the water right.

4. Did you have to go through the state engineer's office or other legal processes to prove your ownership of the right?

   ___ Yes ___ No

   If yes, what costs did you incur?

   $______________

5. Was your right decreed before any court?

   ___ Yes ___ No

   If no, answer questions 6-11.

   If yes, skip questions 6-11.

6. Who assisted you in declaring (proving ownership) of the right?

   _____ yourself _____ an attorney ___ other (specify)

7. If an attorney assisted you, what fee was paid?

   $____________

What services did the attorney render for that fee?

8. Did you go to a qualified engineer or surveyor to obtain maps, surveys, and specifications?

_____ Yes _____ No

If yes, what fee did you pay?

$___________

9. After turning in your application, maps, and specifications, did the state engineer ask for a correction, modification, or change?

_____ Yes _____ No

If yes, what were the costs, in each of the following areas of making those changes?

Engineering $________ Legal $___________

Administrative $_____ Witnesses $_________

Other (please specify) $______________

10. Did the state engineer approve your declaration of ownership?

_____ Yes _____ No

If no, did you appeal the decision in district court?

_____ Yes _____ No

11. If you did appeal, what costs were involved in each of the following areas?

Engineering $___________ Legal $_______________

Administrative $________ Witnesses $___________

Other (please specify) $_____________________

If we assume that the costs to the state engineer office, the courts and the administrative parties are all paid by the fees received by these institutions, they have been accounted for and no further calculation is needed.

The remaining part of transaction cost is the market cost incurred by the protestant. This part is hard to estimate, as stated above, and therefore has not been included in the estimation procedure. One should consider those costs (the market costs incurred by the protestant) and the additional administrative costs as social costs however, and as such they should be included in any complete enumeration of the costs.

Practical considerations dictated a considerably abbreviated questionnaire than that presented above. As a result we sent the following type of modified questionnaire to both buyers and sellers. Notice, that based upon our prior information we could say which responses were from sellers and which ones were from buyers. We could also say which rights were decreed and which ones were not.

BUREAU OF BUSINESS AND ECONOMIC RESEARCH
INSTITUTE FOR APPLIED RESEARCH SERVICES
THE UNIVERSITY OF NEW MEXICO □ ALBUQUERQUE, NEW MEXICO 87131
505/277-2216

November 18, 1976

Dear

You were kind enough to complete the questionnaire on water rights that we sent to you sometime ago. Your information has proven valuable to us, and we appreciate greatly your cooperation. Can we test your patience a little longer by asking you to fill in the enclosed postcard and mail it to us. We promise not to make any other demands upon you in the future.

A second important feature of the water rights transfer in New Mexico is the cost of obtaining administrative approval (from the State Engineer or District Court) for the transfer after the purchase agreement has been reached between seller and buyer. There are indications that this expense may be very large in some cases. On the accompanying card, we ask you to estimate the expense that you incurred to obtain approval for the transfer after agreement was reached between buyer and seller. If you can break the expense down into the categories indicated, that would be even more valuable.

Once again, thank you for your cooperation. We look forward to your reply.

Sincerely,

F. Lee Brown

F. Lee Brown
Associate Professor of Economics

The cost of obtaining administrative (and/or) court approval for the water right transfer after agreement was reached between buyer and seller is estimated to be:

Engineering $__________ Witness $__________

Legal $__________ Other (please specify) $__________

Administrative $__________ __________

TOTAL $__________

Was there any opposition to the transfer at any administration or judicial hearing?

______YES ______NO

Another item of transaction cost which cannot be determined from the answers given to the questionnaires but should be included in the determination of transaction cost, as defined above, is the commission cost. The percentage of total sale value allocated to this item varies with the circumstances in which the transaction occurred and its complexity, but it is generally 6.0%. So, for those who were represented by a lawyer or real estate agent (answers received from question 6 in the questionnaire for sellers), 6% was added to the earlier determined transaction cost in order to obtain total transaction costs corresponding to the accepted definition. Thus, from general transaction cost Table 3.1, a new table of costs for seller parties, was derived. These transaction costs, incurred by the seller parties, are shown in Table 3.2.

In order to provide some initial clues concerning the significance of 1) the price of water rights, 2) the existence or non-existence of a hearing, 3) the existence or nonexistence of an adjudication decree; and 4) the quantity of water rights transferred on the total transaction cost, some simple statistical procedures were employed. Table 3.3 presents the transaction costs incurred by the buyer parties after those transfers for which the quantity transferred was unclear were excluded. Using the data presented in Table 3.3 different hypotheses were tested to determine the best combination of variables which could explain variations in transaction cost. In order to do this, total transaction costs were regressed on the following variables: 1) price of water right, 2) number of acre-feet bought, 3) existence or nonexistence of hearing, and 4) existence of a decree for the water rights purchased. The results of the regression are as follows:

Variable	B (coefficient)	T
1	-0.19359	-1.86
2	-0.14617	-0.17
3	-324.85	-0.99
4	-731.31	-2.70
Constant	1109.2	2.99

R-square = 0.4952 No. of observations = 13
SSR = 1304000 DF = 8

The following were significant with 90% probability: price of water right, existence of a decree, and exogenous variable "1" (constant). The results obtained were: (i) the higher the price of a right, the lower is the total transaction cost, (ii) having a decree reduces the total transaction costs. Transaction costs are tabulated in Tables 3.1, 3.2, and 3.3 (some of the statistics estimated from Table 3.3 are presented in Table 3.4).

It should be emphasized again that no sophisticated analysis was performed on this data since the number of observations and quality of the data did not seem to warrant it. However, these results provide useful indicators of the probable effect of certain variables upon transaction cost. Even more they provide interesting questions for additional investigation.

TABLE 3.1

BUYER AND SELLER TRANSACTION COSTS

	Geographic Basin					Variable						Disaggregation of Transaction Costs						Response Received	
File No.	Rio Grande	Gila & San Francisco	San Juan	Roswell & Artesia	Others	Hearing, 1 No Hearing, 0	Change of Use to	Price of Right	Total Transaction Costs	Transaction Costs/Acre-foot Consumptive Use	Number of Acre-feet Transferred	Engineering	Legal	Administration	Advertising	Witness	Others	Buyer, B Seller, S	Year
266				*		0	Irrigation	$ 270	$ 100	$ .18	544.4		50	50				B	73
265				*		0	Irrigation	238	0	0	302.4							B	70
240			*			1	Industrial	72	65	7.80	8.3	65						B	70
262			*			1	Irrigation	43	495	241.50	2.0	400		20			75	B	72
89	*					1	Municipal	900	0	0	7.8							B	63
83	*					1	Industrial	1000	112	75.00	1.5	100		12.5				B	63
80	*					0	Irrigation	3030	1000	758.00	1.3							B	65
130	*					0	Municipal	3733	100	13.33	7.5			100				B	69
95	*					0	Municipal	3333	0	0	7.5							S	70
125	*					0	Irrigation	4667	25	16.00	1.5	5			20			B	71
94	*					0	Municipal	4667	610	†	†	600		10				B	71
133	*					1	Municipal	10909	11500	†	†	8000	3500					B	75
128	*					0	Municipal	250	1500	8.24	182.0	700	500	300				B	
84	*					0	Municipal	214	690	8.88	77.7	130	350	210				S	71
32		*				0	Irrigation	625	16	10.31	1.6				16			B	73
41		*				0	Irrigation	625	5	3.12	1.6			5				B	73
23		*				0	Irrigation	937	36	22.50	1.6	1			35			B	74
13		*				0	Irrigation	3676	42	77.20	0.5	6			36			B	75
28		*				0	Irrigation	1062	640	133.41	4.8		340				300	B	74
82		*				0	Recreation	1491	25	.57	43.5			25				B	

† Not able to be determined.

TABLE 3.2

SELLER TRANSACTION COSTS

File No.	Rio Grande	Gila & San Francisco	San Juan	Roswell & Artesia	Hearing, 1 No Hearing, 0	Change of Use to	Price of Right	Total Transaction Costs	Transaction Costs/Acre-ft. Consump. Use	Number of Acre-feet Transferred	Non-Decreed, 0 Decreed, 1
265				*	0	Irrigation	$ 238	0	0	302.4	0
95	*				0	Municipal	3333	0	0	7.5	0
84	*				0	Municipal	214	690	8.88	77.7	0
28		*			0	Irrigation	1062	640	133.41	4.8	1

TABLE 3.3

BUYER TRANSACTION COSTS

File No.	Rio Grande	Gila & San Francisco	San Juan	Roswell & Artesia	Hearing,1 No Hearing,0	Change of Use to	Price of Right	Total Transaction Costs	Transaction Costs/Acre-ft. Consump. Use	Number of Acre-feet Transferred	Non-Decreed,0 Decreed,1
266				*	0	Irrigation	$ 270	$ 100	$ .18	554.4	1
240			*		1	Industrial	72	65	7.80	8.3	1
262			*		1	Irrigation	43	495	241.50	2.1	1
83	*				1	Industrial	1000	112.5	75.00	1.5	0
88	*				0	Irrigation	3030	1000	758.00	1.3	0
130	*				0	Municipal	3733	100	13.33	7.5	0
125	*				0	Irrigation	4667	25	16.00	1.5	0
128	*				0	Municipal	250	1500	8.24	182.0	0
32		*				Irrigation	625	16	10.31	1.6	1
41		*			0	Irrigation	625	5	3.12	1.6	1
23		*			0	Irrigation	938	36	22.50	1.6	1
13		*			0	Irrigation	3676	42	77.20	0.5	1
82		*			0	Recreation	1491	25	0.57	43.46	1

TABLE 3.4

ESTIMATED STATISTICS OF THE TRANSACTION COSTS FOR ALL THE BASINS COMBINED

Average	Transaction	Costs/acre-foot			consumptive	use	$ 4.36
Minimum	"	"	"	"	"	"	.18
Maximum	"	"	"	"	"	"	758.00

The average of all of the transaction costs for each transaction were obtained from all the observations irrespective of their quantities. This value was found to be: $95.05

CHAPTER 4

MODEL CONSTRUCTION

Introduction

The primary objective of this chapter is the development of an econometric model forecasting the equilibrium price of water rights. However, before constructing the model, a distinction must be drawn between the value of entitlement to a given amount of water in one time period, e.g. a year, and the value of entitlement to the same amount of water each year in perpetuity. The market value of entitlement to one acre-foot of water in one time period is identified by the term "price of one acre-foot of water" and the value of entitlement to one acre-foot of water each year in perpetuity is identified by the term "the price of a right to one acre-foot of water."

This distinction is critical both for reasons of economic theory and practicality. The commodity, water, is itself sold to end users as in municipal water systems. The principal means, however, for transferring water from one category of use (e.g. agriculture) to another category (e.g. industrial) is not through exchange of the commodity itself but through the exchange of the <u>right</u> to consume that commodity. Thus actual market observations are generated by the trading of rights. Yet the value attached to these rights stems from the use that will be made of the water itself. Presumably the demand for the water is in accord with conventional economic theory which posits certain relationships determining the demand for any factor -- in this case water -- used in production.

As additional clarification of the difference between the water right and the water itself, use may be made of the stock-flow concept in which the right becomes the stock variable from which annual values flow through the exercise of the right. The market value of the right (stock) then is the discounted value of the future values of the water itself (flow).

Having sharply drawn the distinction between water and water rights, demand relationships for the latter in each category of use will be constructed in two steps. First a demand relationship for water in each major category -- irrigation, municipal, and industry -- will be distilled from the existing theoretical and empirical literature. Second, the demand for water rights will be derived from these sector demands for water according to the present value formulation implicit in the stock-flow conceptualization. As this derivation is somewhat obscure to other than technically trained economists, further clarifying discussion will be devoted to it. But first let us complete a general summary discussion of the econometric framework.

Water rights, like common stock, are sold in an exchange market. Barring the addition of new appropriations or the deletion of abandoned or forfeited rights, a reduction in the stock of rights in one sector of use must be accompanied by an increase in the stock of rights held in another sector.

Thus a complete description of the market for water rights will include demand relationships for water rights in each sector of use accompanied by a balancing equation which reflects this exchange characteristic of this market.

There are two theoretically equivalent methods for setting up a simultaneous equations representation for the water rights market. The first makes use directly of the demands for water rights theoretically determined accordingly to the procedure briefly outlined above. In this case the balancing equation is expressed by the fact that in market equilibrium the quantity demanded (and held at the equilibrium price) must sum to the constant stock (subject to any additions and subtractions as indicated above) of existing rights. A second formulation would convert the demand relationships into excess demand functions which explicitly introduce the stock of rights held in a given sector at the beginning of a time period. In this case the balancing equation is expressed as a sum of changes in sector holdings which must sum to zero. Empirically there may be advantages to the second approach since the changes in sector holdings can be measured more easily (and probably more accurately) than the total level of the sector holdings. However, the sector holdings still appear in the relationships. Thus the question of superiority in form becomes a statistical one, but the principal interest in this model is with the price variable and the reduced form equation for this variable is the same in each formulation. On these grounds the choice of form is essentially arbitrary. The decision here is in favor of the "total demand" formulation.

Attention is now focused upon the demand for water in the various sectors of use. Since the thrust of this research is directed toward the operation of water rights markets and possible future values for water rights, no original investigation has been undertaken aimed at enhancing the explanations of demand in any sector. Instead the available literature -- theoretical and empirical -- has been surveyed and the form of demand relationships in each sector extracted as well as the independent variables that other investigators have found appropriate. Stated in more technical terms, the maintained hypothesis will be constructed from relationships appearing in the literature rather than from original research. However, the form of these relationships as well as the independent variables will be modified for reasons of data availability and problems in model construction. With these introductory remarks completed, let us turn to each of the principal water using sectors and focus upon the demand for water in each.

The Demand for Water in Irrigation

There is not a single accepted approach to the estimation of demand for water in the irrigation sector. However, there have been two methodologies employed: (i) estimation through an optimization routine, and (ii) estimation based upon a theoretical model of a firm operating in the agricultural sector.

The first approach has been used in many research efforts. Kelso et al. (1973) have used this approach to estimate the demand for water in the irrigation sector in Arizona. Through this approach Gisser (1970) has been able to estimate a demand for water in irrigation for the Pecos Basin of New Mexico. The technique most commonly used in estimating these demands is linear programming, with a given objective imposed by the researcher. Demands derived through this approach will predict what the demand should be if the unit modeled behaves according to the model assumptions. If, of course, behavior differs from that assumed, then the observed demands will differ from those predicted.

In the second approach, Bain et al (1966) developed the theoretical basis for a downward sloping demand function. Their research was based upon the premise that every farm manager seeks to maximize the net value of average products, and as a consequence a downward sloping demand function would be determined. The only variable used in this procedure was the price of water, but the authors were aware of the limitations of this assumption in the analysis. In other cases, when there are additional variables affecting the demand for water, i.e., price of land for dry farming, dry pasture, residential uses, etc., they suggest their inclusion. According to their analysis there are three types of decisions which create a downward sloping demand for water in the irrigation sector:

1) If the crop, which is the most profitable for a given acreage, remains so after raising the price of water, then the ultimate response expected is a decrease in water use per acre.

2) If when the price of water increases the same crop does not remain the most profitable alternative and irrigators shift to another crop, this crop will likely use a lesser amount of water per acre of land than the former crop thereby yielding a higher net value per acre-foot of water used.

Both of these responses are practicable if there were not institutional restrictions preventing economic gain to the irrigator from reduced water usage. Unfortunately, in the state of New Mexico, as is common throughout the West, extra water saved cannot be sold in the market place. In fact, a reduction in water use per acre would mean the loss of rights to the additional water.

3) The rising price of water creates an incentive to reduce water used for marginal irrigations lands.

These theoretical arguments give support to the possibility of strong effects of price changes upon the quantity demanded. There are also other variables which may affect the quality demanded. To list a few:

a. The price of land has been indicated but not stressed. This price has an impact in the vicinity of cities and should be included in any demand estimation. Also, the price of land for non-irrigation uses such as dry farming or pasture should be included as a determining factor. Note that it is of importance not to use land price observations which include the capitalized value of any water rights attached to it. Hereafter the term "price of land" will be used restrictively to identify the market value of land which has no water rights appurtenant to it or from which the value of the rights has been deducted.

b. The migration of populations from rural areas to urban areas is another factor which affects the demand for water in the irrigation sector. This could be explained in part by the differences between family income in the farming and non-farming sectors. There does not seem to be any single variable which can fully capture this effect, but one possibility is the difference between per capita income in agriculture and other sectors.

c. The demand for water in the irrigation sector depends upon total production in irrigated agriculture.

d. Significant technological change in the irrigation sector may have a great impact on the demand for water. At the present time in New Mexico, there is little incentive for private right holders to change from the ditch to the sprinkler system since this change in technology would have higher capital costs (Halderman and Frost, 1968).

The above economic variables affect demand for water in the irrigation sector. There are also several substitute goods, e.g. fertilizers, whose prices may affect the use of water. In addition, other noneconomic classes of variables which affect the demand for water exist. Generally these can be divided into two classes:

1) Environmental variables -- these variables explain the pattern of water use per acre or interbasin differences in water use per acre within the state of New Mexico.

a. Soil characteristics

b. Land characteristics

c. Climate

To illustrate their importance, let us assume a situation in which there is still some unappropriated water rights available. As a result, when the price of water was zero, in the years when appropriations of new water rights were easy to obtain, these environmental variables could explain differences among basins in the amount of water required -- and administratively allowed -- for irrigating a given tract of land. In order to satisfy environmental differences between different tracts of lands in different parts of the state, different quantities of water have been allocated to a given tract of land. As a consequence, the conclusion reached is that variation in the amount of water rights appropriated to one acre of land can be used as a single valued transformation of the impact of these variables. This data can be obtained from the state engineer's office.

2) Technical variables -- these variables include quality of water and changing technology as was explained earlier.

Finding observations relating to water quality and its impact on the demand for water is difficult; therefore, they have not been included in this model. To summarize, the following variables have been included as determinants of the demand for water in the irrigation sector.

a. Price of water

b. Price of land

c. Level of production in the agriculture sector

d. Differences in per capita income between agriculture and non-agricultural sector, and,

e. Amount of water allocated to one acre of land.

A linear demand for water in the irrigation sector is expressed below:

$$d_{Ir,t} = \gamma_1 + \gamma_2 P_t + \gamma_3 P_{L,t} + \gamma_4 Y_{o,t} + \gamma_5 Z_{Io,t} + \gamma_6 A_t + \varepsilon_t \tag{4.1}$$

and ε_t is normally distributed with $E(\varepsilon_t \cdot \varepsilon_t') = \sigma^2$, $t = 1, \ldots, n$.

The variables are defined as follows:

P_t = Price of one acre-foot of water in agriculture for year t;

$P_{L,t}$ = Price of one acre of land;

$Y_{o,t}$ = Level of output for the agriculture sector in year t;

$Z_{Io,t}$ = Differences between per capita income in agriculture and other sectors;

A_t = Water allocated to one acre of land for one year (consumptive);

ε_t = Error term for year t; and

$d_{Ir,t}$ = Quantity of water demanded in year t.

The inverse of the above demand function is:

$$P_t = \frac{d_{Ir,t}}{\gamma_2} - \frac{\gamma_1}{\gamma_2} - \frac{\gamma_3}{\gamma_2} P_{L,t} - \frac{\gamma_4}{\gamma_2} Y_{o,t} - \frac{\gamma_5}{\gamma_2} Z_{Io,t} - \frac{\gamma_6}{\gamma_2} A_t - \frac{\varepsilon_t}{\gamma_2} \quad (4.2)$$

Demand for Water in the Municipal Sector

Per capita demand for water in the municipal sector has been subject to more quantitative measurement and statistical analysis than in any other sector. In one instance, sixty-three variables have been included in the estimation of this demand relation (Saunders, 1969).

Though the number of variables hypothetically affecting the demand for water in the municipal sector are abundant, only a few of them have been shown to have significant impact throughout different studies. Where possible all of these variables will be included in this model. Note that commonly only part of the demand for water in the municipal sector is exclusive of demands for the other sectors.

The price of water has been shown to have a significant effect in several studies (Young, 1973; Bain, 1966; Howe, 1967; etc.). However, Berry and Bonem (1974) claim that price is not a significant factor in determining per capita demand for water in the municipal sector for New Mexico. This study will not attempt to compare and criticize each model. However, since a number of studies have found price to be significant as a potential determinant, it should be hypothetically included and tested in the demand for this sector.

Per capita income is another important factor considered in virtually all research as a potential determinant and usually has been found empirically to be significant. Research by Berry and Bonem (1974) concludes that per capita income is a significant one. There are several variables that have been used as a proxy for the income variable in different studies. Family income has been used interchangeably with these to show the significance of income. A proxy that can be used is the value or size of the house. In this context, per capita income will be used as a factor determining demand for municipal water in the past, present, and future. Two environmental variables having an impact on demand for water are temperatures and precipitation. Most often only one of these two variables has been included in empirical work. Summer average temperatures have been used as a proxy for determining the effect of environmental variables.

Another important determinant is the per capita housing space for one individual. This variable has been measured by different researchers in different ways. For example, Turnovsky (1969) uses the following index:

$$h_{(i)} = \frac{\text{Average number of rooms per dwelling unit in town i}}{\text{Median number of occupants per dwelling unit in town i}}$$

Other researchers, i.e., Bain et al. (1966) use density of population as a proxy for this variable. Obtaining the former index is difficult as it is often unavailable. The second index is available for the past and present and will therefore be used in this study.

The form of function assumed to explain per capita demand for water in the residential sector has not been definitely established, but most often a linear function has been used. In conclusion, the determinants of per capita demand for water in this sector included in this model are price, per capita income, temperature and density of population.

It is said, generally, that demand for water in the municipal sector should be broken down into domestic, commercial, public, and industrial aspects. Such a detailed analysis is time consuming and expensive. In this research demand for water in the municipal sector includes domestic, commercial, and public aspects, but industrial demand has been treated as a separate sector. In addition, for the basins studied, data exists only on the aggregate level, and it is not possible to obtain the estimated per capita demand based upon present information. So the models presented should be aggregated over all the population residing in a specific municipality.

A linear per capita demand for water in the municipalities sector is given by:

$$\frac{d_{M_t}}{N_t} = \gamma_1 + \gamma_2 P_t + \gamma_3 \frac{Y_t}{N_t} + \gamma_4 \overline{s}_t + \gamma_5 d_{Pt} + \xi_t \quad (4.3)$$

The associated aggregate demand in the municipal sector is:

$$d_{M_t} = \gamma_1 N_t + \gamma_2 N_t P_t + \gamma_3 Y_t + \gamma_4 N_t \overline{s}_t + \gamma_5 N_t d_{Pt} + N_t + \xi_t \quad (4.4)$$

The variables are defined as follows:

$\frac{d_{M_t}}{N_t}$ = per capita water demand in year t

P_t = price of an acre-foot of water in year t (lease value)

$\frac{Y_t}{N_t}$ = per capita personal income in year t

$\bar{s}_t$ = average summer temperature in year t

d_{Pt} = density of population in one year

ξ_t = error term for year t

N_t = population for year t

Y_t = personal income for year t

The assumption again is that ξ_t is normally distributed and $E(\xi_t \xi_t') = \sigma^2$.*

Equation (4.4) can be inverted into the following:

$$P_t = \frac{dM_t}{\gamma_2 N_t} - \frac{\gamma_1}{\gamma_2} - \frac{\gamma_3 Y_t}{\gamma_2 N_t} - \frac{\gamma_4 \bar{s}_t}{\gamma_2} - \frac{\gamma_5}{\gamma_2} dP_t - \frac{\xi_t}{\gamma_2} \quad (4.5)$$

Demand for Water in the Industrial Sector

Any single equation treatment of the industrial sector inevitably aggregates a number of widely disparate water demand relationships. Given the simple nature of this first simultaneous representation of a water rights "market" and the lack of available data on industrial subsectors within any one basin, this cost must be paid.

The formulation that will be used here stems from recent work by Jacob de Rooy (1974). According to de Rooy, the

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*The assumption that the variance parameter for this disturbance term is the same as that appearing in 4.1 is rather stringent. However, given the purpose of this initial simultaneous representation, a more robust assumption would be superfluous.

principal determinants of the demand for water in the industrial sector are: the price of water, changes in output, technological improvements, and employment. His work was at the plant level and involved a log linear form. In order to conform to the linear form of the remainder of the simultaneous equations representation and to the aggregate nature of the available information, his relationships are strongly modified to produce

$$g_{wt} = \alpha_o + \alpha_1 P_t + \alpha_2 I_t + \tau_t \qquad (4.6)$$

where g_{wt} = intake water demanded at time t

P_t = price of an acre-foot of water at time t

I_t = employment in mining and manufacturing at time t.

These particular variables are used largely because of data availability.

The Demand for Water Rights

As discussed at the beginning of this chapter entitlement to one acre-foot of water in one year must be distinguished from entitlement to one acre-foot of water -- the water right -- in perpetuity. Having introduced relationships denoting the demand for the water itself, we must now transform these relationships into the demand for water rights.

According to conventional economic theory the value of one acre-foot of a water right should be the capitalized value of the expected prices for an acre-foot of water each year in perpetuity. Practical interpretation of this theoretical statement is difficult but is of great importance with respect to the prevailing institutional arrangements of prior appropriation. In particular since priority dates are assigned to each water right, the actual amount of water to which any given right is entitled in any future year is subject to significant uncertainty. The entitlement of a water right will be affected in the first place by the result of a variation in the source, as with fluctuations in the stream flow or changes in New Mexico's entitlement to a share of the Colorado River, the Rio Grande, and the Gila. There is also uncertainty in determining the amount of water being consumed by senior users, and as a result, variations in the return flow to the stream. So, when representing a market for water rights, this problem of uncertainty along with differences among basins can cause difficulty. The rights which have earlier priorities may not have the same value as the rights with later priorities. In general, rights which are located in a water scarce area have higher value than the rights which are located in an area with less scarcity, other things being equal.

In reality we can say that we have a heterogenous type of commodity in the market for water rights. As is common in empirical research, simplifications must be devised which may affect the accuracy of the representation. There are two ways for dealing with these problems: (i) limit analysis to a given basin in which all rights are transferable both physically and legally to any point in the basin, and (ii) treat the expected value of a right as being the same as the face value of the right. A more elaborate investigation of this latter assumption would involve a look at the historical exercise of a given right, determination of the distribution of its actual entitlement, and estimation of its expected value.

Once the expected value of the availability of entitlement to a given right is known, then conceptually a market for the water rights that have different priorities but are in the transferable location can be more readily modeled. This implies that all of the rights which have the same expected value, for a given location, are the same. In other words, we can account for the effects of seniority dates and other uncertainties by replacing the face value of the right with its expected value. However, in this study, the simpler procedure will be used in which the face value is accepted as the expected value.

We now turn to the problem of transforming the demand for water into the demand for water rights. Let the demand for water in any sector, e.g., the irrigation sector at time t be graphically shown as in Figure 4.1.

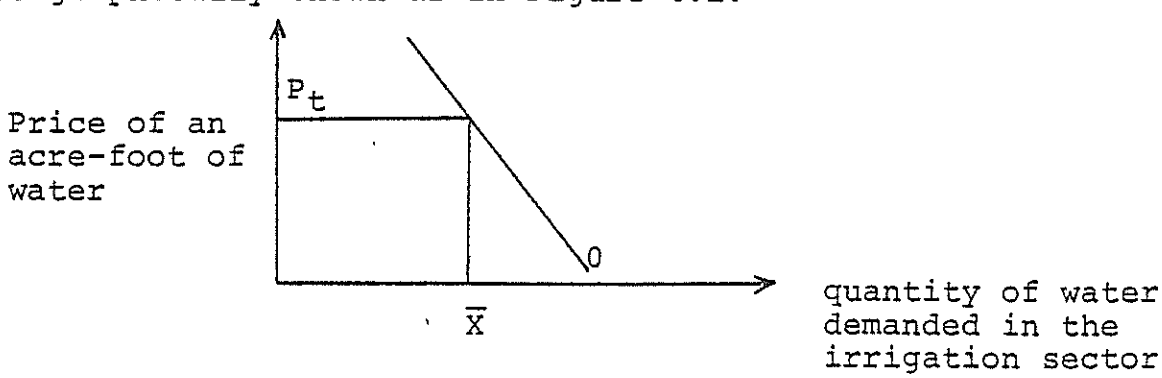


Figure 4.1 Demand for Water in the Irrigation Sector

Let us take an arbitrary quantity such as $\bar{X}$. The price associated with this quantity $\bar{X}$ is P_t at time t. Similarly there will be a price associated with $\bar{X}$ for each time period into the future. Then, by choosing an appropriate rate of interest, r, the price of a water right to the amount $\bar{X}$ would be capitalized value of these prices. The price of this water right could be found by formula 4.7.

$$P_{w,o} = P_o + \frac{P_1}{1+r} + \cdot \cdot \cdot + \frac{P_t}{(1+r)^t} \cdot \cdot \cdot + \frac{P_n}{(1+r)^n} + \cdot \cdot \cdot \quad (4.7)$$

where $P_{w,o}$ is the value of the water right at time 0. We can take any other arbitrary acre-feet on the demand for water in that sector and construct the curve which shows demand for water rights in the same sector. The derived demand for water rights in the sector is then illustrated in Figure 4.2.

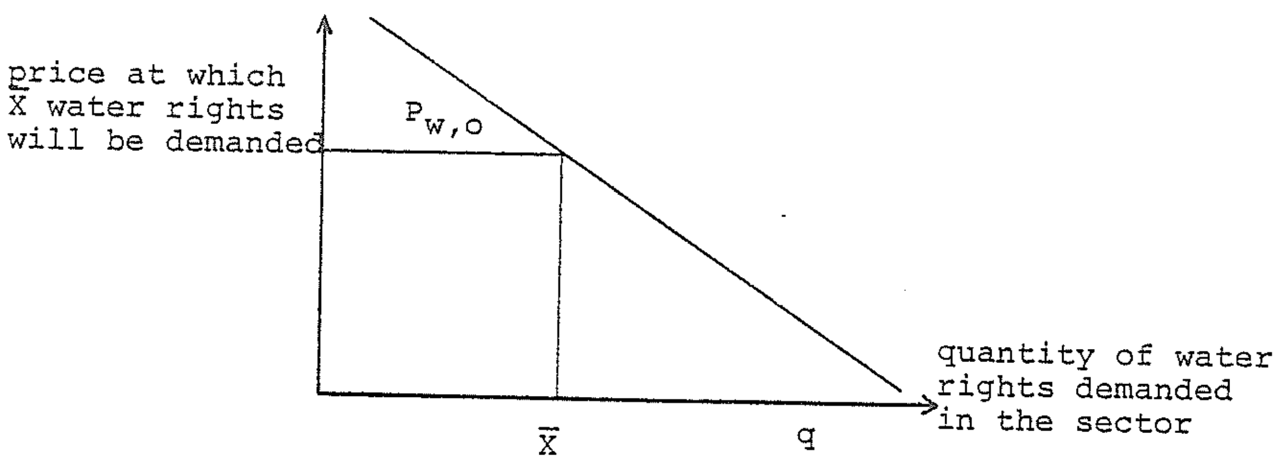


Figure 4.2 Demand for Water Rights in the Irrigation Sector

Two points are worth noting. First, the demand for water rights in any time period depends upon all values affecting the price of water in each ensuing time period in the future.

Second, if the form of demand is linear for each time period, demand for water rights should also be linear.

Using the irrigation sector as an example, we can now construct the algebraic demand relationship for water rights. Taking the expected value of 4.1 and then inserting its inverse (as in 4.2) into expression 4.7 we obtain

$$P_{w,o} = \sum_{t=0}^{\infty} \frac{P_t}{(1+r)^t} = \frac{1}{\gamma_2} \sum_{t=0}^{\infty} \frac{E(d_{Ir,t})}{(1+r)^t} - \frac{\gamma_1}{\gamma_2} \sum_{t=0}^{\infty} \frac{1}{(1+r)^t} - \frac{\gamma_3}{\gamma_2} \sum_{t=0}^{\infty} \frac{E(P_{L,t})}{(1+r)^t} - \frac{\gamma_4}{\gamma_2} \sum_{t=0}^{\infty} \frac{E(Y_{o,t})}{(1+r)^t} - \frac{\gamma_5}{\gamma_2} \sum_{t=0}^{\infty} \frac{E(Z_{Io,t})}{(1+r)^t} - \frac{\gamma_6}{\gamma_2} \sum_{t=0}^{\infty} \frac{E(A_t)}{(1+r)^t} \qquad (4.8)$$

This equation then indicates the dependence of the water right value upon future values of the determinants of the demand for water, or more accurately, the dependence should be upon the perceived values of these variables by market participants. Unfortunately no data exists on these perceived values. Moreover, the adequacy of a simultaneous formulation such as developed here is insufficiently tested at this time to justify the more elaborate investigation that would be required to make use of form (4.8) directly. Instead, using the first and third series in (4.8) as examples, we can introduce simplifying assumptions which will in turn simplify (4.8). Specifically we assume that $E(d_{Ir,t}) = \bar{d}_{Ir}$ for some given value of water demanded, and we assume a constant growth rate of $1 + \alpha (\alpha < r)$ for the price of land. The latter assumption then reduces to $P_{L,t} = (1 + \alpha)^t P_{L,o}$. With these simplifications we can close the first and third series in (4.8) as follows:

$$\frac{1}{\gamma_2} \sum_{t=0}^{\infty} \frac{\bar{d}_{Ir}}{(1+r)^t} = \frac{1+r}{r\gamma_2} \bar{d}_{Ir} = C_1 \bar{d}_{Ir} \qquad (4.9) \quad \text{and}$$

$$\frac{\gamma_3}{\gamma_2} \sum_{t=0}^{\infty} \frac{P_{L,t}}{(1+r)^t} = \frac{\gamma_3}{\gamma_2} \sum_{t=0}^{\infty} \frac{(1+\alpha)^t P_{L,o}}{(1+r)^2} = \frac{\gamma_3 (r-\alpha)}{\gamma_2 (1+r)} P_{L,o} = C_2 P_{L,o} \qquad (4.10)$$

Consequently (4.8) by this procedure can be reduced to a transformant which takes specific values for d_{Ir} and the remaining variables and uniquely determines $P_{w,o}$. If d^w_{Ir} then is the quantity of water rights demanded by the irrigation sector, we now have

$$E(d^w_{Ir}) = g(P_{w,o}\ P_{L,o}\ Y_{o,o}\ Z_{Io,o},\ A_o) \qquad (4.11)$$

where g is a linear relation.

From (4.11) and analogous results for the municipal and industrial sectors, we can proceed to assemble the simultaneous equations model. The remaining addition is the balancing equation that requires that the stock of water rights within any fully-appropriated basin be fixed. Finally, eliminating those exogenous variables for which data is not available we have the following set of equations:

Demand for water rights in the irrigation sector:

$$Y_{t,1} = \beta_{4,1} Y_{t,4} + \gamma_{1,1} Z_{t,1} + \gamma_{2,1} Z_{t,2} + \gamma_{3,1} + e_{t,1} \qquad (4.12)$$

Demand for water rights in the municipal sector:

$$Y_{t,2} = \beta_{4,2}Z_{t,5}Y_{t,4} + \gamma_{4,2}Z_{t,4} + \gamma_{5,2}Z_{t,5} + \gamma_{6,2}Z_{t,6} + \gamma_{7,2} + e_{t,2} \quad (4.13)$$

Demand for water rights in the industrial sector:

$$Y_{t,3} = \beta_{4,3} Y_{t,4} + \gamma_{8,3} Z_{t,8} + \gamma_{9,3} + e_{t,3} \quad (4.14)$$

Balancing equation:

$Y_{t,1} + Y_{t,2} + Y_{t,3} = A$ = total water rights available to three aforementioned sectors (4.15)

Where the variables are defined as follows:

$Y_{t,1}$ = the amount of water rights (acre-foot consumptive use) that the agriculture demands at time t

$Y_{t,2}$ = the amount of water rights that the municipal sector demands at time t

$Y_{t,3}$ = the amount of water rights that the industrial sector (mining and manufacturing) demands at time t

$Y_{t,4}$ = the price of a right to one acre-foot of water in perpetuity

$Z_{t,1}$ = the price of one acre of land at time t

$Z_{t,2}$ = the value of output in the agriculture sector at time t

$Z_{t,4}$ = personal income at time t

$Z_{t,5}$ = population at time t

$Z_{t,6}$ = population squared as a proxy for density of population at time t

$Z_{t,7}$ = the number of employees in mining and manufacturing

$Z_{t,3} = Z_{t,7} = Z_{t,9} = 1$ to estimate intercepts for each sector.

β's are the coefficients for the endogenous variables and γ's are the coefficients for the exogenous variables.

$e_{t,1}$, $e_{t,2}$, and $e_{t,3}$ are disturbance terms which (for simplicity) are assumed to be normally distributed. Population appears in the right hand side of 4.13 as a factor multiplying each variable due to the aggregate nature of the demand relation. The reduced form equation for the price variable alone is then given by:

$$Y_{t,4} = -\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}} Z_{t,1} - \frac{\gamma_{2,1}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}} Z_{t,2}$$

$$- \frac{\gamma_{4,2}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}} Z_{t,4} - \frac{\gamma_{5,2}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}} Z_{t,5}$$

$$- \frac{\gamma_{6,2}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}} Z_{t,6} - \frac{\gamma_{8,3}Z_{t,8}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}}$$

$$+ \frac{A - \gamma_{3,1} - \gamma_{7,2} - \gamma_{9,3}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}} - \frac{e_{t,1} + e_{t,2} + e_{t,3}}{\beta_{4,1} + \beta_{4,2}Z_{t,5} + \beta_{4,3}} \quad (4.16)$$

The above equilibrium price may be estimated (with general linear tools) only for the special cases shown below:*

I $\beta_{4,2} = 0$ (the price is not significant in the municipal sector)

II $\beta_{4,1} + \beta_{4,3} = 0$ (this condition requires that either: [i] price is significant in both irrigation and industrial sectors, or [ii] $\beta_{4,1}$ and $\beta_{4,3}$ are of equal value with opposite signs).

*For a more general treatment, see Appendix B.

Four estimates will be presented for the first case only:

1) estimation using a monetary price relation for the Rio Grande Basin excluding Santa Fe, where all the variables used are in monetary forms;

2) estimation using a real price relation for the Rio Grande Basin excluding Santa Fe, where all the variables used are in real values;

3) estimation using a monetary price relation, for Planning District III only, and;

4) estimation using a real price relation for Planning District III only;

Since the principal concern is with forecasting the real value of the price variable, only (2) and (4) will be used for forecasting purposes.

CHAPTER 5

DATA CONSTRUCTION AND EMPIRICAL RESULTS

As was explained in the introductory chapter, there has not been any systematic historical data compiled which is specifically related to the price of water rights. Therefore, in order to provide such data and also to implement the proposed model in Chapter 4 some additional information should be provided in coordination with the price information. Accordingly, two types of questionnaires were devised -- the seller and the buyer. The records of those involved in transfer as well as a change of use of water rights were obtained from the public register at the office of the State Engineer. The intent was to include all of those transfers that occurred in the major basins of New Mexico -- The Rio Grande, Gila-San Francisco, San Juan, Pecos and Artesia. The information gathered indicated that we had a very limited number of observations and consequently extra care should be devoted to formulating the questionnaires, asking only for the necessary data and facilitating as many responses as possible.

In order to implement the second objective, encouraging the response, a letter was enclosed with the questionnaire that included the following points: (i) identifying the sponsors of the project; (ii) identifying the source of the names and addresses of the buyers and sellers; (iii) assuring the buyers and sellers that there was no affiliation between the University of New Mexico and any private company dealing in water rights; (iv) stating that individual responses would be kept completely confidential; (v) explaining the project, its objective and its significance to the seller and the buyer parties; and (vi) establishing a direct connection by phone or mail between the buyer and sellers and the investigators so that if they had any questions relating to the project or the questionnaire they would feel free to communicate. Copies of the buyer's questionnaire, the seller's questionnaire, and the accompanying letter are presented on pages 85-90. In order to encourage a higher rate of response the questionnaire was constructed to fold into a self-addressed post paid mailing envelope. As is stated above, in order to obtain the highest rate of price information response, a decision was made to include only those questions that either were directly related to price or pertinent to the data gathering process.

The essential purpose of the two different sets of questions is to obtain an equilibrium price either from the buyer or the seller parties. At the top of each questionnaire, confidentiality was reemphasized, and it was requested that each response be as accurate as possible. At the end of the questionnaire, it was reinterated that questions concerning the questionnaire itself or the project were encouraged.

BUREAU OF BUSINESS AND ECONOMIC RESEARCH
INSTITUTE FOR APPLIED RESEARCH SERVICES
THE UNIVERSITY OF NEW MEXICO □ ALBUQUERQUE, NEW MEXICO 87131
505/277-2216

October 11, 1976

Dear Sir/Madam:

The Department of Economics at the University of New Mexico, in cooperation with the Bureau of Business and Economic Research, is engaged in research on water rights in the State of New Mexico supported by the New Mexico Water Resources Institute.

The State Engineer's office has provided your name as one who has been party to a water rights transfer in New Mexico. Since you are the only source of price information on these rights, we ask for your cooperation in completing and returning the enclosed questionnaire.

We have no affiliation with any company dealing in water rights and will keep both your name and your reply completely confidential. The summary report will not reveal the response of any party and will be available to the public.

Present and future developments in New Mexico -- particularly energy and minerals related industries -- are placing increasing demands on the state's water resources. These increased demands may lead to higher prices for privately held water rights in the State. We intend to develop a forecast of these prices which should be of considerable value to all citizens of the State. If you would like a copy of the summary report, please check the appropriate box on the questionnaire.

If you have any questions about the survey or the project, please telephone my research associate, Rahman, at 505/277-5937, or write me at the above address. Additionally, we would be happy to schedule an appointment with you at your convenience to further discuss any aspect of the survey or the project itself. Thank you for your time and attention to this matter of great importance to all New Mexico residents.

Sincerely,

F. Lee Brown

F. Lee Brown
Associate Professor of Economics

P. S. For those parties who have been both purchasers and sellers of water rights, two questionnaires have been enclosed. In this case each transaction should be reported separately.

SELLER'S QUESTIONNAIRE

All individual responses will be kept confidential. Please answer all questions as accurately as possible, giving your best recollection. If any answer requires further explanation, please feel to do so on this form. USE ONE FORM FOR EACH TRANSACTION.

1. Did you sell the water rights that were transferred?

   ____ Yes (If yes, please answer the following questions and then return the questionnaire.)

   ____ No (If no, please return the questionnaire.)

2. What was the amount of water rights sold (in acre-feet per year)?

   ________ acre-feet ____ don't know

3. If the right sold was an irrigation right, did you also sell the land that had been irrigated?

   ____ Yes If yes, how much land did you sell? _______ acres ____ don't know

   ____ No

   ____ Not applicable

4. Why did you decide to sell the water right?

   ____ Unable to farm any longer

   ____ Entered an occupation other than irrigation farming

   ____ Sold the land and did not need the water right any longer

   ____ Other (please specify) ________________________________

   ____

5. What was the gross payment received for the water right and any land if sold jointly? Do not exclude any associated costs such as legal fees, real estate commissions, etc. Please approximate the answer to your best recollection even if you do not remember it exactly. $ ______________

   Can you separate this sum into payment for land and payment for water right?
   Land payment $ ______________ Water right payment $ ______________
   ____ No
   ____ Not applicable

6. Who represented you in selling?

   ____ Myself

   ____ An attorney

   ____ A real estate agent

   ____ Other (please specify) ________________________________

   ____

7. Did you have a hearing before the state engineer? ____ Yes ____ No

8. If for some reason the transfer had not been approved (or was not approved), would you have (or have you):

   ____ Used the water right as before

   ____ Looked for another buyer

   ____ Other (please explain) ____

   ____

9. Who purchased your water right? ________________________________

   Were there other buyers who wished to purchase your right? ____ Yes ____ No

   If yes, why did you sell the right to that particular buyer? ______________

   ____

Check this box if you would like to receive a free copy of the summary report when completed. /_/

REMARKS OR COMMENTS:

BUYER'S QUESTIONNAIRE

All individual responses will be kept confidential. Please answer all questions as accurately as possible, giving your best recollection. If any answer requires further explanation please feel free to do so on this form. USE ONE FORM FOR EACH TRANSACTION.

1. Did you buy these rights that were transferred?

    ____ Yes (If yes, please answer the following questions and then return the questionnaire.)

    ____ No (If no, please return the questionnaire.)

2. What was the amount of water right bought (in acre-feet per year)?

    __________ acre-feet ____ don't know

3. If the right purchased was an irrigation right, did you also purchase the land that had been irrigated?

    ____ Yes If yes, how much land did you buy? ________ acres ____ don't know

    ____ No

    ____ Not applicable

4. Why did you purchase the water right?

5. What was the gross payment (in dollars) you paid to the seller for the water right (and land, if purchased jointly)? Please approximate the answer to your best recollection even if you do not remember it exactly? $__________

    Can you separate this sum into payment for land and payment for water rights?
    Land payment $__________ Water right payment $__________

6. Who represented you in BUYing?

    ____ Myself

    ____ An attorney

    ____ A real estate agent

    ____ Other (please specify) ______________________________

    ____

7. Did you have a hearing before the state engineer?

    ____ Yes

    ____ No

8. If for some reason the transfer had not been permitted,(or was not), would you have (or have you):

____ Continued your activity without additional water

____ Ceased or not begun your activity

____ Other (please specify) ______________________________

____

9. From whom did you pruchase the right? ______________________

Were there other sellers from whom you could have purchased water rights?

____ Yes If yes, why did you buy the right from the above party? ________

____

____ No

Check this box if you would like to receive a free copy of the summary report when completed. ☐

REMARKS OR COMMENTS:

SECOND FOLD: Please fold here and staple or tape so that address below appears on outside for return mailing of questionnaire.

Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY MAIL
FIRST CLASS PERMIT No. 677, ALBUQUERQUE, NEW MEXICO

BUREAU OF BUSINESS & ECONOMIC RESEARCH
c/o RAHMAN
INSTITUTE FOR APPLIED RESEARCH SERVICES
THE UNIVERSITY OF NEW MEXICO
ALBUQUERQUE, NEW MEXICO 87131

FIRST FOLD: Fold here so that address above appears on outside.

Logic and Shortcomings of the Questions Asked of the Seller Parties

From the records existing in the office of the State Engineer, it was only possible to determine that there had been a change of ownership from party A to party B. Interest, however, was solely in those transactions involving monetary payment. Those responses that had no money involved in transferring water rights would assist in determining what percentage of the total involved in a transfer were interested in responding to such a questionnaire. Based upon this consideration, question 1 was formulated as follows:

Did you sell the water rights that were transferred?

_____ yes

_____ no

If the answer to this question was "yes," that implied that monetary consideration was a factor and the sellers were to continue answering the other questions. If the answer was "no," they were asked to return the questionnaire.

Question #2 is related to the quantity of water rights sold. In most of the cases the actual quantity of water right sold could be obtained from the records existing in the office of the State Engineer. We included this question for two primary reasons: (i) what the perceived quantity of water sold was, and (ii) as a source of information when State Engineer Office records were deficient. Therefore, the following question was devised:

What was the amount of water rights sold (in acre-feet per year)?

__________ acre-feet   _________ don't know

The importance of gathering information on the quantity of water sold was that: (i) price is often unspecified, rather total gross (or net) sale value is specified for each transaction and by knowing the quantity sold we can obtain accurate pricing information; (ii) even though we did not need to project the demand for water rights in each sector, this information could be used in any supply or demand analysis and estimation; and (iii) in order to determine what the average transaction cost per acre foot of water right, one needs to know the quantity sold.

This question was, in several cases misunderstood. There are some ambiguities in determining the definition of a well accepted unit for each transaction. There are generally three units used in order to illustrate quantity sold. One, the quantity of a water right is often stated in terms of amount of land bought instead of the actual amount of a water right in acre-feet (consumed or diverted). Two, the quantity of water right diverted is another way of stating the amount of water used. However, in our model this was transformed into quantity of water consumed using the conversion tables provided by New Mexico State University. Three, the quantity of water rights consumed or depleted is another way of categorizing water use. This is the number which will be used directly in extracting the price information for the model and on rare occasions the answer was stated in those terms. Finally, some respondents interpreted the question asked as the quantity of water rights allocated to an acre of land. As far as applying the number toward the price estimation, the actual consumptive use of water rights from the office of the State Engineer was used. Of course, in a number of cases the figures from the State Engineer's Office were not in terms of quantity depleted and so the necessary conversions were made.

Concerning questions three it was perceived that since the value of water rights in the irrigation sector was less than the value of water rights in other sectors, transfer most generally occurred from irrigation. Therefore, this question brought to light several points: (i) it would tell whether the right sold was irrigated land or not, if land and water rights were sold together, and how much land was included in a joint transaction. The question was phrased as follows:

> If the right sold was an irrigation right, did you also sell the land that had been irrigated?
>
> _____ yes _____ no _____ not applicable

An answer of "yes" or "no" indicated that the rights sold were irrigation rights. Specifically, a "yes" answer implies that irrigated land and water rights were sold jointly, and a "no" answer implies that the right sold was a previously irrigated right sold separately from the land irrigated. A "not applicable" response implies that the right sold was not used previously for the purpose of irrigation.

Question four was intended to find out what the idiosyncratic reasons were for selling a water right. Based upon some previous communications with those who sold their water rights, some of the specific reasons for sale had been determined such as: unable to farm any longer, entered an occupation other than irrigation farming, or sold the land and did not need the water right any longer. Another answer option for this question was saying that the reason for selling a water right was different from the above reasons, and respondents could check "other" and explain the particular reason or reasons. This question was phrased in the following way:

Why did you decide to sell the water right?

_____ unable to farm any longer

_____ entered an occupation other than irrigation farming

_____ sold the land and did not need the water right any longer

_____ other (please specify) ______________________

Question number five was probably the most important for direct use in the project. It was intended for use in obtaining the overall market equilibrium price in the transaction. This was the main reason for asking the prospective transferee <u>not</u> to exclude the cost associated with the transaction from the sales value. As is understood from question three, there are two ways of selling a water right -- jointly with the land or selling the right separately. The first part of the question was set up for the purpose of determining the total gross sale value. With the answers received from question number three, it was possible to determine whether the land and water were sold jointly or not. A "yes" answer to question number three implied that the land and water rights were sold jointly. Whereas, "no" and "not applicable" to question number three implied that there was not a joint sale. The sellers were then asked to separate the amounts received for land and water rights. If the "no" answer was checked, it implied the sale was joint, but that the seller could not separate the two prices. In order to extract price information, one needs to know the price of land transferred, and the resulting balance is the price assigned to the water right. Unfortunately, there is not any standard historical price of land available to use as a comparison. The other option, choosing "not applicable," implied that the sale of a water right was separate. Notice that if the seller did not mark any of the second set of answers for question number five and also did not answer "yes" to question three, these gross values were used as the sale value for the water right. Even though this question was carefully phrased some sellers answered in a different manner than what was prescribed -- the price of water rights allocated to one acre of land, or the price of one acre-foot of diversion water right. These answers were then converted to a price for one acre foot of consumptive water right using the converting factors produced by the State Engineer Office for each location.

Questions six and seven were generally intended to solicit information regarding transaction costs as they are explained in Chapter 3. Furthermore answers to question six would help in devising criteria for determining perfectability of the market.

Question eight looks for options available for unsuccessful sales. Even though the question is eliciting a response from those who have already sold their water rights, the answers received would be considered responses from those who have not been able to sell their water rights successfully. The question is stated this way:

> If for some reason the transfer had not been approved (or was not approved) would you have (or have you):
>
> ______ used the water as before
>
> ______ looked for another buyer
>
> ______ other (please specify) ______________________________

As explained, answers received from this question and from question four were devised to analyze the existing idiosyncracies in the market place as it is related to either withholding or retaining the sale of water rights.

The first part of question nine is intended to qualify the sale more accurately. The records obtained from the State Engineer's Office are organized by file number and consequently there is the possibility of having more than one file related to a sale. Therefore, by asking to whom specifically the right was sold and correlating this information with the number of acre-feet in question number two, any confusion resulting from a number of sales by the same person is hopefully countermanded. The second part of the question is intended to determine whether the calculated price is the equilibrium price of water rights in the market or not. If the sellers marked "no," the answer implies that the market was in equilibrium. If the sellers marked "yes," and also answered "Why did you sell the right to that particular buyer?" by explaining that he offered the highest price or most reasonable price, then this answer could be used as an equilibrium price. On the contrary, if the answer is "yes" but the seller decided to sell to a specific person under an equal price bidding situation then this questionnaire could not be used as an observation for determining the price of water rights in equilibrium.

Discussion and Critique of Questions Asked of Buyers

As far as the substance of the questionnaires is concerned, both the seller and buyer questionnaires were intended to elicit the same information. In order to avoid repetition, it can be noted that the only difference between questions one, two, three, five, six, seven and nine in the seller's questionnaire and the buyer's questionnaire is that the seller's questionnaire is addressed to sellers and the buyer's to buyers; i.e., in question number five -- for the seller the gross payment was required, and in the buyer questionnaire the amount of gross payment was required. In advertently in the buyer's questionnaire "no" and "not applicable" were omitted for question five, but that information could be ascertained from the first part of question five together with the response to question number three. Based upon the implied decision behind the answers to question five in the seller's questionnaire, and similar answer in the buyer's questionnaire, the following criteria was set up.

Those responses which had answers to the first parts of question five for both sellers and buyers were classified as complete responses. Of course, some of these responses were not usable for implementation of the model. These latter responses are the ones which answered "yes" to question number three, or they answered the first part of question five and marked or wrote "no" to the second part. Those responses should be checked for the criteria set up for the second part of question nine.

Findings Obtained from Survey

After the first mailing, the responses received were not sufficient to construct a time series of price information for the Rio Grande Basin which was the basin chosen for the model. A second registered mailing to those addresses which were confirmed by the first mailing and those who did not answer our first questionnaire was undertaken. There was also a special letter included with the new questionnaires sent in the second mailing. After sending out the registered mailing a complete time series dating back to 1962 for the price of water rights had not been obtained; so, the records in the State Engineer's Office were scrutinized to find new observations, especially for those years where no observations existed. A registered questionnaire was sent to these in particular since based upon the questionnaires received from the first mailing, the rate of response will be higher when the questionnaire is mailed registered. These findings are expressed in the following Tables: 5.1, 5.2, 5.3, and 5.4.

Since the files in the office of the State Engineer do not distinguish between the Santa Fe basin and other parts of the Rio Grande basin, it is difficult to disaggregate the observations obtained. So, in order to obtain the rate of response both the information related to the Santa Fe market, and the Rio Grande, excluding Santa Fe, were considered. However, the Santa Fe market is physically distinct from other parts of the Rio Grande, and consequently usable price information for the model implementation was divided into the Santa Fe and the Rio Grande, excluding Santa Fe.

The questionnaires mailed to buyer and seller parties, in the San Juan, Pecos and Artesia basins were combined for determining the rate of response. But, the usable price information was divided into the San Juan basin and the Pecos/ Artesia basins. The reason for combining the observations relating to the Pecos and Artesia basin is based on the assumption that these two markets are similar in price increase over time and geographically indistinguishable, and information was inadequate to analyze them separately.

The data related to price should have been extracted from the questionnaires; however, there were some uncertainties which

TABLE 5.1

RESPONSES RECEIVED FROM
RIO GRANDE RIVER BASIN

	Qualification of Questionnaires	Total Number of Questionnaires Mailed			Questionnaires with Insufficient Addresses			Questionnaires Received by Addressee		
	Quantities	Total	Seller	Buyer	Total	Seller	Buyer	Total	Seller	Buyer
#1	Total number of questionnaires mailed	109	62	47	23	14	9	86	48	38
#2	Total number of responses received	46	23	23	-	-	-	46	23	23
#3	Incomplete responses received	18	10	8	-	-	-	18	10	8
#4	Complete responses received	28	13	15	-	-	-	28	13	15
#5	Usable	21	10	11	-	-	-	21	10	11
#6	Usable but not complete	3	1	2	-	-	-	3	1	2
#7	Land and water rights priced jointly	4	2	2	-	-	-	4	2	2
#8	Percentage of response $\frac{\text{ques. \#2}}{\text{ques. \#1}} \times 100$	42.2%	37.0%	48.9%	-	-	-	53.5%	47.9%	60.5%
#9	Percentage of usable response $\frac{\text{ques. \#5}}{\text{ques. \#1}} \times 100$	19.3%	16.1%	23.4%	-	-	-	24.4%	20.8%	28.9%

TABLE 5.2

RESPONSES RECEIVED FROM
GILA-SAN FRANCISCO RIVER BASINS

	Qualification of Questionnaires	Total Number of Questionnaires Mailed			Questionnaires with Insufficient Addresses			Questionnaires Received by Addressee		
	Quantities	Total	Seller	Buyer	Total	Seller	Buyer	Total	Seller	Buyer
#1	Total number of questionnaires mailed	87	51	36	16	12	4	71	39	32
#2	Total number of responses received	50	25	25	–	–	–	50	25	25
#3	Incomplete responses received	18	10	8	–	–	–	18	10	8
#4	Complete responses received	32	15	17	–	–	–	32	15	17
#5	Usable	26	13	13	–	–	–	26	13	13
#6	Usable but not complete	0	0	0	–	–	–	0	0	0
#7	Land and water rights priced jointly	6	2	4	–	–	–	6	2	4
#8	Percentage of response $\frac{\text{ques. \#2}}{\text{ques. \#1}} \times 100$	57.5%	49.0%	69.4%	–	–	–	70.4%	64.1%	78.1%
#9	Percentage of usable response $\frac{\text{ques. \#5}}{\text{ques. \#1}} \times 100$	29.9%	25.5%	36.1%	–	–	–	36.6%	33.3%	40.6%

TABLE 5.3

RESPONSES RECEIVED FROM
ALL REMAINING RIVER BASINS

	Qualification of Questionnaires	Total Number of Questionnaires Mailed			Questionnaires with Insufficient Addresses			Questionnaires Received By Addressee		
	Quantities	Total	Seller	Buyer	Total	Seller	Buyer	Total	Seller	Buyer
#1	Total number of questionnaires mailed	124	51	73	31	10	21	93	41	52
#2	Total number of responses received	65	28	37	-	-	-	65	28	37
#3	Incomplete responses received	36	20	16	-	-	-	36	20	16
#4	Complete responses received	29	8	21	-	-	-	29	8	21
#5	Usable	10	2	8	-	-	-	10	2	8
#6	Usable but not complete	0	0	0	-	-	-	0	0	0
#7	Land and water rights priced jointly	19	6	13	-	-	-	19	6	13
#8	Percentage of response $\frac{\text{ques. \#2}}{\text{ques. \#1}} \times 100$	52.4%	54.9%	50.7%	-	-	-	69.9%	68.3%	71.2%
#9	Percentage of usable response $\frac{\text{ques. \#5}}{\text{ques. \#1}} \times 100$	6.3%	3.9%	11.0%	-	-	-	10.8%	4.9%	15.4%

TABLE 5.4

RESPONSES RECEIVED FROM
ALL THE MAJOR RIVER BASINS COMBINED
(NEW MEXICO)

	Qualification of Questionnaires	Total Number of Questionnaires Mailed			Questionnaires with Insufficient Addresses			Questionnaires Received By Addressee		
	Quantities	Total	Seller	Buyer	Total	Seller	Buyer	Total	Seller	Buyer
#1	Total number of questionnaires mailed	320	164	156	70	36	34	250	128	122
#2	Total number of responses received	161	76	85	-	-	-	161	76	85
#3	Incomplete responses received	72	40	32	-	-	-	72	40	32
#4	Complete responses received	89	36	53	-	-	-	89	36	53
#5	Usable	57	25	32	-	-	-	57	25	32
#6	Usable but not complete	3	1	2	-	-	-	3	1	2
#7	Land and water rights priced jointly	29	10	19	-	-	-	29	10	19
#8	Percentage of response $\frac{\text{ques. \#2}}{\text{ques. \#1}} \times 100$	50.3%	46.3%	54.5%	-	-	-	64.4%	59.4%	69.7%
#9	Percentage of usable response $\frac{\text{ques. \#5}}{\text{ques. \#1}} \times 100$	17.8%	15.2%	20.5%	-	-	-	22.8%	19.5%	26,2%

are enumerated in the following discussion. One, the quantities of water rights transferred could not be determined from the State Engineer's Office records, nor from the information given by the respondents. Two, the gross value of the sale or purchase associated with water rights transferred was not completely specified, and three, there were some inconsistencies among the answers given to specific questions on the questionnaire. Since it was imperative that we utilize all of the price information available, a decision was made to classify the information into three categories as follows: Class A prices, those which could be extracted with complete certainty; Class B prices, those which could be extracted with a lesser amount of certainty; and Class C prices, which could be extracted with the least amount of certainty. We decided to drop price Class C and use only Class A and B observations for time series analysis, except for one year in the Santa Fe table, in which the questionable price (having least certainty) was confirmed by Class A type of answer (having complete certainty).

The price information obtained (Tables 5.5 through 5.9) was then plotted on three figures for the three markets - the Rio Grande excluding Santa Fe (Figure 5.1), the Santa Fe (Figure 5.2), and the Gila (Figure 5.3). The San Juan and the Pecos/Artesia market observations were not plotted because of an insufficient number of responses able to show the nature of trend in prices. The following procedure was used to plot each figure. A "circle" was made around the numbers associated with Class A

TABLE 5.5

HISTORICAL PRICES USED FOR TIME SERIES ANALYSIS
(RIO GRANDE EXCLUDING SANTA FE)

Year	Current Price
1962	$ 267.00*
1962	285.00
1963	214.00*
1964	214.00*
1965	267.00*
1966	214.28
1968	214.28*
1969	250.00
1971	335.00
1971	214.28
1971	214.28
1972	280.00
1973	500.00
1974	492.00
1975	532.00
1976	786.16

Source: Except those identified by an asterisk, the above historical price values were extracted from the results of the questionnaires. Those identified by an asterisk were extracted from the sale contracts in the State Engineer Office.

TABLE 5.6

HISTORICAL PRICES USED FOR TIME SERIES ANALYSIS
(SANTA FE)

Year	Current Price
1963	$ 900.00
1963	1000.00
1965	3030.00
1969	3733.00
1970	3333.00
1971	4667.00
1971	4667.00
1972	11429.00
1975	10909.00

Source: The above historical price values were extracted from the results of the questionnaires.

TABLE 5.7

HISTORICAL PRICES USED FOR TIME SERIES ANALYSIS (GILA AND SAN FRANCISCO)

Year	Current Price
1968	$ 1250.00
1971	843.75
1971	470.58
1973	625.00
1973	625.00
1973	937.50
1973	937.50
1973	625.00
1973	1818.18
1974	919.11
1974	1062.50
1974	937.50
1974	937.50
1974	1250.00
1974	1312.50
1975	1491.00
1975	937.50
1975	1250.00
1975	1250.00
1976	2379.00
1976	1562.00

Source: The above historical price values were extracted from the results of the questionnaires.

TABLE 5.8

HISTORICAL PRICES USED FOR TIME SERIES ANALYSIS
(ROSWELL AND ARTESIA)

Year	Current Prices
1970	$ 238.00
1973	270.00
1974	445.00
1976	628.00

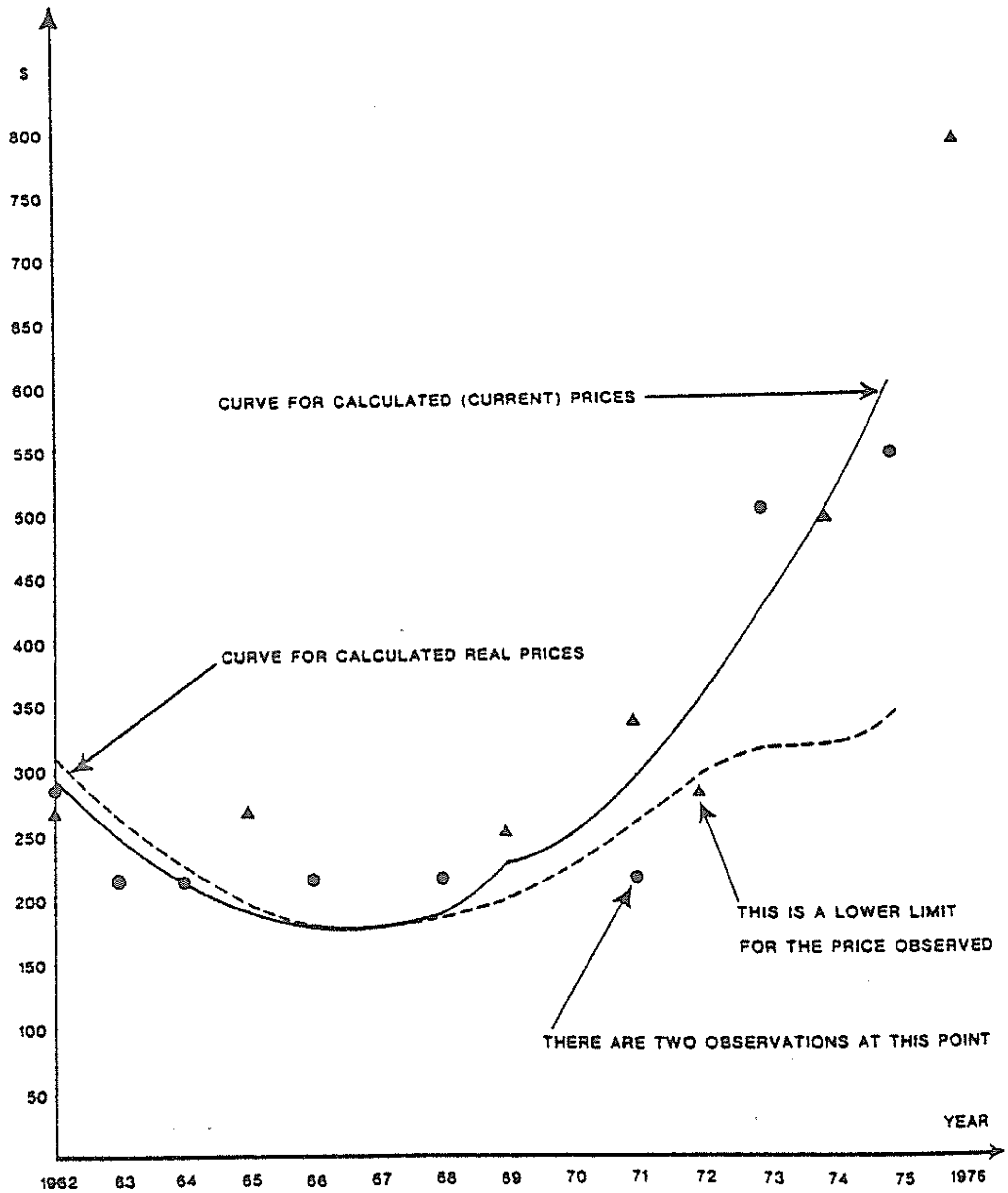
Source: The above historical price values were extracted from the results of the questionnaires.

TABLE 5.9

HISTORICAL PRICES USED FOR TIME SERIES ANALYSIS
(SAN JUAN BASIN)

Year	Current Prices
1967	$ 274.00
1970	72.00
1972	137.00
1972	43.00
1972	171.00

Source: The above historical price values were extracted from the results of the questionnaires.



● SHOWS CLASS A TYPE OF PRICE OBSERVATION

▲ SHOWS CLASS B TYPE OF PRICE OBSERVATION

FIGURE 5.1
PRICE OF WATER RIGHTS
(RIO GRANDE EXCLUDING
SANTA FE - PLANNING DISTRICT III)

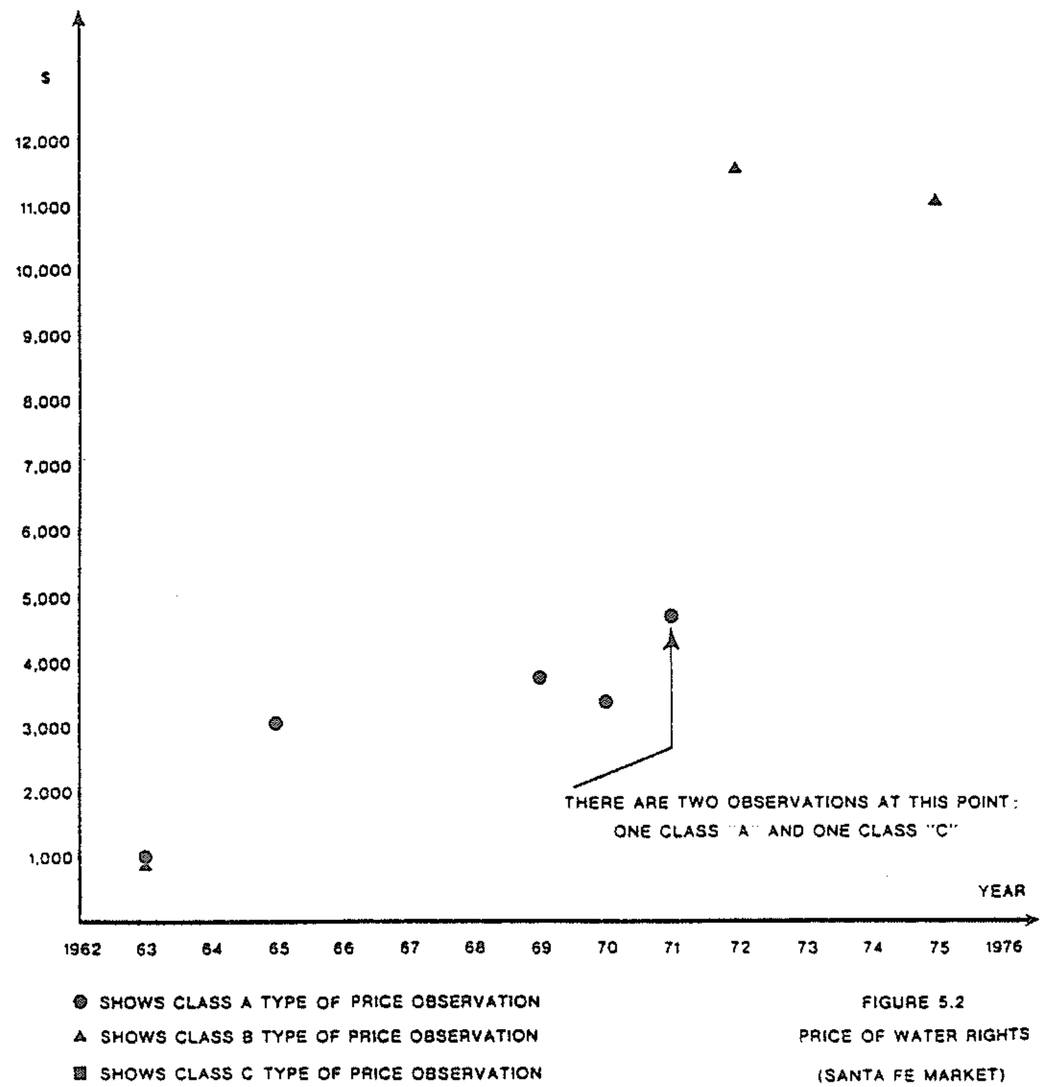


FIGURE 5.2
PRICE OF WATER RIGHTS
(SANTA FE MARKET)

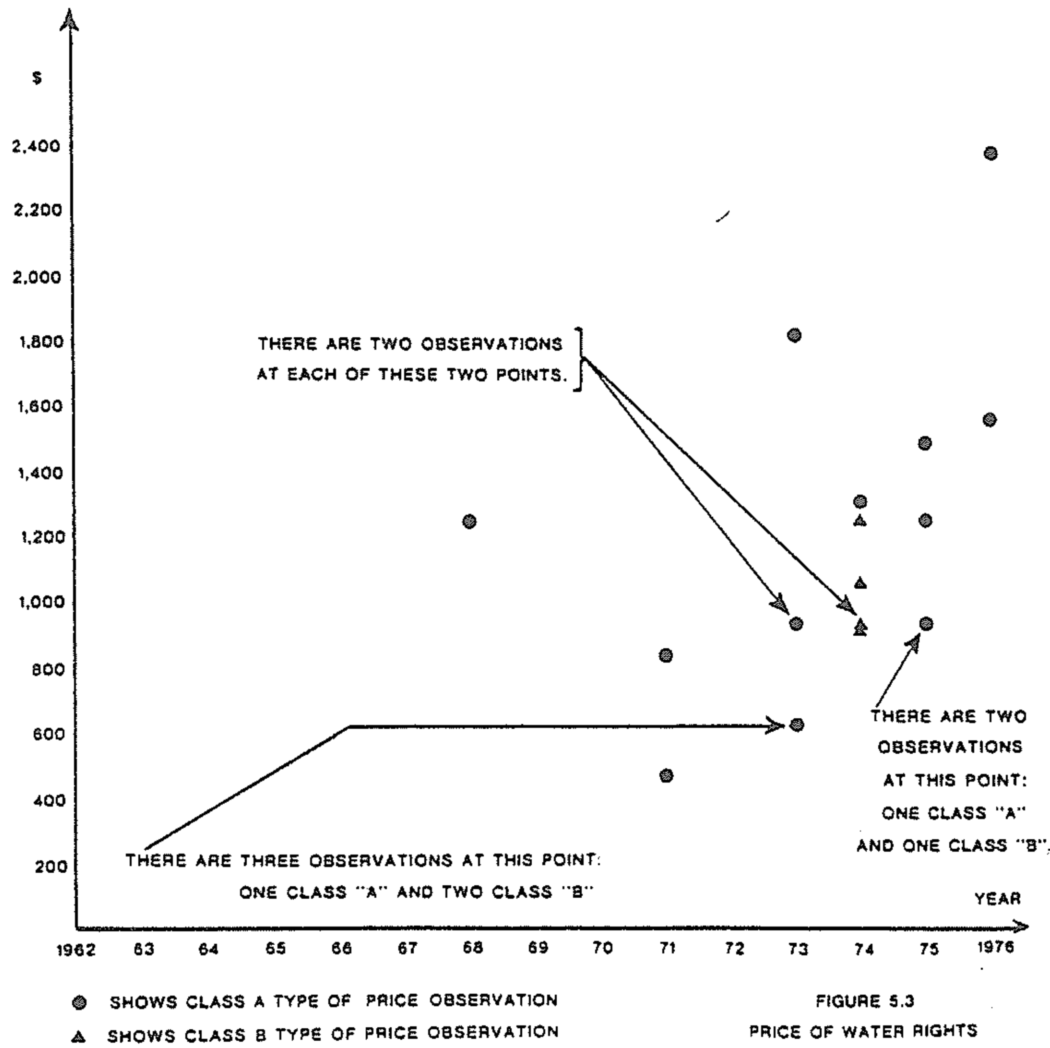


FIGURE 5.3
PRICE OF WATER RIGHTS
(GILA & SAN FRANCISCO MARKET)

type of price information. A "triangle" was made around the numbers associated with B type of price information, and a "square" was made around the numbers associated with Class C type of price information.

There are two shortcomings in using these observed prices as the basis for economic analysis. First, some observations of the intervening years are missing. Second, for quite a few of the years there is only one observation available and a fitted trend curve for the price will more closely approximate the nature of the relation between price and time than taking each price as an independent observation. Consequently, time series trends were found for all the basins under consideration. Hypotheses generally fitted were: (i) price = a+b (time), (ii) price = a+b (time) + c(time)^2, (iii) price = $Ae^{a(\text{time})}$, (iv) price = $Ae^{a(\text{time}) + b(\text{time})^2}$. No No weighing procedure was used for adjusting the data except in the case of Gila Basin where there was more than one observation for each year, and these observations showed drastic price changes related to the quantity of the water right transacted. So, all the variables used in the calculation of the time trend in this basin were divided by the square root of the quantities transferred.

Information obtained as the result of these time series are presented in the following Tables 5.10 through 5.14. The time series with the best fit was found for the Rio Grande excluding Santa Fe and used as the calculated price of water

TABLE 5.10

RIO GRANDE EXCLUDING SANTA FE
THE RESULTS OF THE TIME SERIES ANALYSIS, FOR THE HIGHEST R^2

Variables	B	T
X2-TIME	-64.78	-4.6292
X3-TIM2	+ 5.8709	6.5510
Constant	354.34	7.9059
R-square = 0.8797	SSR = 48500	DF = 13

Appropriate curve is price = a + b(time) + c)time)^2

With 90% probability X2, X3, and the constant are significant and should be used for obtaining the calculated price of water rights.

TABLE 5.11

SANTA FE COUNTY BASIN
THE RESULTS OF THE TIME SERIES ANALYSIS, FOR THE HIGHEST R^2

Variables	B	T
X3-TIME	0.23707	1.7534
X4-TIM2	-0.28193×10^{-2}	-0.31211
Constant	6.5489	15.13
R-square = 0.8661	SSR = 0.8432	DF = 6

Appropriate curve is Log P = constant + a(time) + b(time)^2

TABLE 5.12

ROSWELL AND ARTESIA
THE RESULTS OF THE TIME SERIES ANALYSIS, FOR THE HIGHEST R^2

Variables	B	T
X4-TIME	-6.3526	-0.78763×10^{-1}
X5-TIM2	12.583	1.1226
Constant	222.44	1.7826
R-square = 0.9534	SSR = 4524	DF = 1

Appropriate curve is price = constant + a(time) + $b(\text{time})^2$

TABLE 5.13

SAN JUAN BASIN
THE RESULTS OF THE TIME SERIES ANALYSIS, FOR THE HIGHEST R^2

Variables	B	T
X4-TIME	-1.0564	-1.0369
X5-TIM2	0.12219	0.8741
Constant	6.5474	4.6461
R-square = 0.4837	SSR = 1.099	DF = 2

Appropriate curve is Log P = constant + a(time) + $b(\text{time})^2$

TABLE 5.14

GILA AND SAN FRANCISCO MARKET
THE RESULTS OF THE TIME SERIES ANALYSIS, FOR THE HIGHEST R^2

A. Adjusted

Variables	B	T
X3-TIME	-423.82	-2.6485
X4-TIM2	49.263	3.4045
Constant	1625.9	3.6763
R-square = 0.5023	SSR = 0.1967×10^7	DF = 18

Appropriate curve is price = constant + a(time) + b(time)^2

B. Unadjusted

Variables	B	T
X1-INSQ	7.5334	8.6433
X4-ADJT	-0.27754	-1.0416
X5-ADJ2	0.29696×10^{-1}	1.3241
Constant	-0.64840×10^{-1}	-0.71659
R-square = 0.9936	SSR = 0.7172	DF = 17

Appropriate curve is Log A = constant + a(INSQ) + b(ADJT) + c(ADJ2)

where:

$$A = \text{adjusted price of water rights} = \frac{\text{observed price}}{\text{square of the quantity transferred}}$$

$$INSQ = \frac{1}{\text{square of the quantity transferred}}$$

$$ADJT = \frac{\text{time}}{\text{square of the quantity transferred}}$$

$$ADJ2 = \frac{(\text{time})^2}{\text{square of the quantity transferred}}$$

rights. These current prices are presented in the first column of the following Table 5.15. Then the current prices were divided by the wholesale price index to obtain the real price of water rights. The real prices calculated were used in implementing the model.

Historical and Projected Values of the Exogenous Variables

There are six (6) exogenous variables remaining in our revised model which is explained on page 81. These exogenous variables are: the total value of crops produced in the agricultural sector; the price of one acre of marginal irrigated land; population; population squared (instead of density of population); personal income; and the number of laborers in mining and manufacturing (or employment in the industrial sector). Historical values can be stated in two ways -- current values and real values.

The historical monetary current values of total crops produced in the agricultural sector for each county were obtained from "New Mexico Agricultural Statistics" provided by the New Mexico Department of Agriculture in cooperation with the United States Department of Agriculture. This data was compiled for the years 1963 to 1975. The total value of crops produced in the agricultural sector was also available for New Mexico as a whole, for 1962. However, it was not disaggregated for the counties forming the state. In order to obtain corresponding numbers for the counties under consideration, it was assumed that the ratio of agricultural

TABLE 5.15

CALCULATED PRICE OF WATER RIGHTS
PLANNING DISTRICT III
RIO GRANDE EXCLUDING SANTA FE

Year	Current Price of Water Rights	Real Price of Water Rights (67 = 100)
1962	$ 295.43	$ 311.63
1963	248.26	262.71
1964	212.83	224.74
1965	189.15	195.80
1966	177.20	177.56
1967	177.00	177.00
1968	188.54	183.94
1969	211.82	198.89
1970	246.84	223.59
1971	293.61	257.78
1972	352.12	295.65
1973	422.37	313.56
1974	504.36	315.03
1975	598.09	341.96

output for a given county and the state in 1962 was the same in 1963, the year for which we had disaggregated data.

The price of marginal irrigated land which was proposed for our model implementation is the price of that type of land which if released from crop production would be used for other purposes such as dry farming, industrial sites, residential lots, mobile home sites, and so on. Such a recorded price does not exist for New Mexico, so a decision was made to theoretically construct such data. Although time consuming and expensive, it was imperative to estimate the best usable number for this exogenous variable in the project. Consequently, the following procedure was used in order to obtain the price of one acre of land. Valencia County contains some marginal lands already converted from agriculture to other uses and can therefore be used to estimate the price of land in the Rio Grande excluding the Santa Fe basin. This county has at least two advantages relative to any other county in the Rio Grande. First, there have been instances where the lands irrigated in this county have been converted to nonagricultural uses, and second, the county maintains a low degree of urbanization. However, its potential for urbanization is much greater than that of other parts of the Rio Grande basin. Having chosen Valencia County as the exemplary county, the price of those lands in this county, located in the Middle Rio Grande Conservancy District, should be determined because they are potentially available for both agricultural as well as nonagricultural uses. Therefore, sale contracts existing in the office of the Valencia County Clerk were examined and eight observations were picked for each year from 1962 to 1975. Those sale contracts which involved parcels greater than 50 acres were excluded. An average price for each year was calculated from these arbitrary observations. Prices for land and water taken from the clerk's records were very difficult to separate in some cases and a certain bias was incorporated into the calculations as a result. Due to the limitation of time and funds available, these were the best numbers obtainable. The reason for including the price of marginal land in our estimation was that this variable is discussed in the theory presented in the previous chapter, and it has also been verified by the responses received to question 4 of the seller questionnaire.

Estimated population data exists for New Mexico counties up to and including 1974 in the "New Mexico Statistical Abstracts." In addition, an estimate of the population of New Mexico counties and metropolitan areas exists in "Current Population Reports Federal-State Cooperative Program for Population Estimates," for 1975. These two publications were the sources for determining the population of New Mexico counties in our project.

Personal income data for each county was obtained from a publication of the Bureau of Economic Analysis called "Employment, Income, Farm . . . ."

"Employment in the Industrial Sector" consists of a combined number of laborers in the manufacturing and mining sectors, which were obtained from the above BEA publication. Note that the numbers of laborers in manufacturing and/or mining are missing for some of the years under consideration. To fill these missing years, either the value of the closest year was assumed for the missing year, or if two consecutive published data were drastically different and there were some missing years, then the increment was proportioned with respect to the increment in the associated years.

Digression to Determine Geographic Boundaries of the Markets and their Associated Historical Exogenous Variables

Having obtained the historical current values of the exogenous variables for the counties, it was necessary to construct an aggregation in order to obtain historical data for the markets under consideration. As was discussed, the model presented on page 81 is implementable only for the Rio Grande basin, due mainly to the lack of sufficient historical data for other basins. This basin was also chosen because it is the largest in the state and therefore the most significant. In other research (Lansford, 1973), the geographic boundaries of the Rio Grande basin were determined by including ten (10) counties. In accordance with this designation, the geographic boundaries of the Rio Grande basin are - Bernalillo, Sandoval, Dona Ana, Rio Arriba, Santa Fe, Sierra, Socorro, Taos, and Valencia. According to Jim Williams and other administrative authorities of the Rio Grande river basin at the State Engineer Office, the market existing in Santa Fe is separate from the market or markets for the rest of the basin due to the physical impossibility of transferring water rights from the rest of the Rio Grande to Santa Fe without creating detrimental effects for some intervening users.

Other parts of the Rio Grande, because of their proximity to one another, do not have any difficulty in transferring water rights from one location to another except in the legal expenses involved. In short, a market devised for the nine counties <u>outside</u> Santa Fe County is feasible.*

Therefore, the aggregate for the four exogenous variables -- total value of crops produced, population, personal income, and employment in the industrial sector -- was calculated for the nine remaining counties. The price of land (as explained on page 118) was used as the representative price of land for this market.

By examining the returned questionnaires it was determined that almost all of the responses were from three counties -- Bernalillo, Sandoval, and Valencia. These three counties comprise almost all of Planning District III, the most populated planning district in the state. It was therefore imperative that we set up a market containing these three counties. Hence, the following two markets will be analyzed by the model presented on page 81.

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*There are some legal difficulties in transferring water rights from one division of the Rio Grande Conservancy District to another (there are three). This legal difficulty could be resolved if the transfer is approved by the corresponding boards.

1) The nine counties market -- comprising the Rio Grande basin excluding Santa Fe County.

2) The three counties market -- covering only Bernalillo, Sandoval, and Valencia counties.

The second market is more of an artificial market, and historically calculated prices of water rights for this market are the same as those for the nine counties market. In order to obtain the value of the exogenous variables for the three county market, the same process was employed as in determining the exogenous variables for the nine counties.

The historical current values of the exogenous variables along with calculated prices of water rights for the two markets established are presented in the following Tables 5.16 and 5.17.

In order to obtain the historical real values of the total crops produced in the agriculture sector, the current values derived earlier were divided by an agricultural price index provided for the nation (Table 5.18). Whereas, to obtain the real price of land, the current monetary prices already discussed were divided by the wholesale price index for the nation. The wholesale price index was used because land is one of the factors of production, and so this index seems the most appropriate.

In order to obtain real personal income, current monetary personal incomes were divided by the consumer price index for the nation. Note that the abovementioned price indices use

TABLE 5.16

RIO GRANDE RIVER BASIN EXCLUDING SANTA FE COUNTY
(CURRENT VALUES)

Year	Calculated Price	Value of Output in Agriculture	Price of Land	Population	$(Population)^2$	Personal Income	Labor in Mining & Manufacturing
1962	$295.429	$30,347,409	$1022	464,300	$215574 x 10^6$	$ 954,700,000	10,740
1963	248.260	31,818,850	1453	479,100	$229537 x 10^6$	1,020,574,300	11,326
1964	212.832	28,305,500	901	494,000	$244036 x 10^6$	1,086,448,600	11,939
1965	189.147	27,713,300	1299	502,400	$252406 x 10^6$	1,152,700,000	11,277
1966	177.203	26,906,200	1838	505,700	$255732 x 10^6$	1,215,200,000	11,886
1967	177.000	32,109,050	2287	506,600	$256643 x 10^6$	1,298,300,000	11,438
1968	188.540	30,089,300	2333	506,600	$256643 x 10^6$	1,389,000,000	11,576
1969	211.822	28,074,600	1429	515,600	$265843 x 10^6$	1,509,000,000	12,755
1970	246.844	27,784,700	2630	519,600	$269984 x 10^6$	1,668,700,000	13,401
1971	293.610	30,787,700	1392	536,900	$288262 x 10^6$	1,839,300,000	14,377
1972	352.117	30,432,400	2691	551,100	$303711 x 10^6$	2,063,800,000	17,347
1973	422.366	42,016,400	3173	571,000	$326041 x 10^6$	2,286,600,000	18,636
1974	504.356	50,251,500	2968	585,300	$342576 x 10^6$	2,519,000,000	19,801
1975	598.089	41,667,800	3471	595,300	$354382 x 10^6$	2,770,900,000	19,190

TABLE 5.17

BERNALILLO, SANDOVAL AND VALENCIA COUNTIES
(CURRENT VALUES)

Year	Calculated Price	Value of Output in Agriculture	Price of Land	Population	$(\text{Population})^2$	Personal Income	Labor in Mining & Manufacturing
1962	$ 295.429	$ 2,405,657	$1022	334,200	111690×10^6	$ 721,800,000	9141
1963	248.260	2,522,300	1453	346,700	120201×10^6	766,551,600	9625
1964	212.832	2,553,500	901	358,500	128522×10^6	811,303,200	9747
1965	189.147	3,147,800	1299	360,700	130104×10^6	856,100,000	9219
1966	177.203	3,311,400	1838	362,500	131406×10^6	903,600,000	9559
1967	177.000	3,609,200	2287	364,600	132933×10^6	968,700,000	9332
1968	188.540	3,802,900	2333	365,100	133298×10^6	1,035,600,000	9187
1969	211.822	4,570,400	1429	372,100	138458×10^6	1,132,700,000	10216
1970	246.844	3,867,600	2630	374,800	140475×10^6	1,256,300,000	10873
1971	293.610	4,621,200	1392	389,300	151544×10^6	1,391,100,000	11881
1972	352.117	3,761,300	2691	400,800	160640×10^6	1,587,500,000	14297
1973	422.366	5,448,000	3173	418,200	174891×10^6	1,751,500,000	15642
1974	504.356	6,148,100	2968	428,200	183355×10^6	1,931,100,000	16845
1975	598.089	5,156,200	3471	433,800	188182×10^6	2,124,210,000	16223

TABLE 5.18

PRICE INDICES

Year	Agricultural Price Index	Consumer Price Index	Wholesale Price Index
1962	98	90.6	94.8
1963	96	91.7	94.5
1964	94.6	92.9	94.7
1965	98.7	94.5	96.6
1966	105.9	97.2	99.8
1967	100	100	100
1968	102.5	104.2	102.5
1969	108.8	109.8	106.5
1970	111.0	116.3	110.4
1971	112.9	121.3	113.9
1972	125	125.3	119.1
1973	176.3	133.1	134.7
1974	187.7	147.7	160.1
1975	186.7	161.2	174.9
1976		170.5	182.9

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Business Statistics*, 20:41, 45, and 46, 1975.

the year 1967 as the base year. The reason for using national price indices was the lack of appropriate calculated price indices for New Mexico. Real values used for the nine counties market and the three counties market for the exogenous variables along with the real prices of water rights are presented in Tables 5.19 and 5.20. Having obtained the historical values of variables in terms of current and real dollars, the projected values could be ascertained.

Projected Values of the Exogenous Variables

The projected values of all exogenous variables except price of land were obtained from the economic component of the "Southwest Trends and Perspectives Project." This component was devised by Mark Evans and its substance was also the material used in Evans' doctoral dissertation (1977). The model used for the economic component analysis is a multiregional input-output model of the Four Corners states, which interacts with a cohort-survival model. The purpose of the economic component is to forecast the economic and demographic implications of alternative national and regional scenarios.

Projected values of the above exogenous variables would vary, depending upon the type of the scenario under consideration. The numbers provided under scenario A appeared to be closer to reality than any other scenario set up in the economic component. Therefore, the data used in the analysis were extracted from scenario A. Note that the monetary

TABLE 5.19

RIO GRANDE RIVER BASIN EXCLUDING SANTA FE COUNTY
(REAL VALUES)

Year	Calculated Price	Value of Output in Agriculture	Price of Land	Population	$(\text{Population})^2$	Personal Income	Labor in Mining & Manufacturing
1962	$ 311.634	$30,966,700	$1078.06	464,300	215574×10^6	$1,053,750,000	10,740
1963	262.709	33,144,600	1537.57	479,100	229537×10^6	1,112,940,000	11,326
1964	224.743	29,921,200	951.43	494,000	244036×10^6	1,169,480,000	11,939
1965	195.804	28,078,300	1344.72	502,400	252406×10^6	1,219,790,000	11,277
1966	177.558	25,407,200	1841.68	505,700	255732×10^6	1,250,210,000	11,686
1967	177.000	32,109,100	2287.00	506,600	256643×10^6	1,298,300,000	11,438
1968	183.941	29,355,400	2276.10	506,600	256643×10^6	1,333,010,000	11,576
1969	198.894	25,803,900	1341.78	515,600	265843×10^6	1,374,320,000	12,755
1970	223.581	25,031,200	2382.25	519,600	269984×10^6	1,434,820,000	13,401
1971	257.770	27,269,900	1222.12	536,900	288262×10^6	1,516,320,000	14,377
1972	295.648	24,345,900	2259.45	551,100	303711×10^6	1,647,010,000	17,347
1973	313.56	23,832,300	2355.61	571,000	326041×10^6	1,717,960,000	18,636
1974	315.02	26,772,200	1853.84	585,300	342576×10^6	1,705,480,000	19,801
1975	341.96	22,318,000	1984.56	595,300	354382×10^6	1,718,920,000	19,190

TABLE 5.20

BERNALILLO, SANDOVAL AND VALENCIA COUNTIES
(REAL VALUES)

Year	Calculated Price	Value of Output of Agriculture	Price of Land	Population	$(Population)^2$	Personal Income	Labor in Mining & Manufacturing
1962	$ 311.634	$2,454,750	$1078.06	334,200	111690×10^6	$ 796,689,000	9,141
1963	262.709	2,627,400	1537.57	346,700	120201×10^6	835,934,000	9,625
1964	224.743	2,699,260	951.43	358,500	128522×10^6	873,308,000	9,747
1965	195.804	3,189,260	1344.72	360,700	130104×10^6	905,926,000	9,219
1966	177.558	3,126,910	1841.68	362,500	131406×10^6	929,629,000	9,559
1967	177.000	3,609,200	2287.00	364,600	132933×10^6	968,700,000	9,332
1968	183.941	3,710,150	2276.10	305,100	133298×10^6	993,858,000	9,187
1969	198.894	4,200,730	1341.78	372,100	138458×10^6	1,031,600,000	10,216
1970	223.591	3,484,320	2382.25	374,800	140475×10^6	1,080,220,000	10,873
1971	257.779	4,093,180	1222.12	389,300	151554×10^6	1,150,950,000	11,881
1972	295.648	3,009,040	2259.45	400,800	160640×10^6	1,266,960,000	14,297
1973	313.560	3,090,190	2355.61	418,200	174891×10^6	1,315,930,000	15,642
1974	315.025	3,275,490	1853.84	428,200	183355×10^6	1,307,450,000	16,845
1975	341.960	2,761,760	1984.56	433,800	188182×10^6	1,317,750,000	16,228

values projected by the aforementioned economic component are in terms of 1971 dollars. The base year for the real dollars used in the research is 1967. In order to obtain the real values, the projections provided by the economic component were converted to 1967 dollars. Another point, which is worth noting is the fact that projections provided by the economic components are for the planning districts rather than counties. To disaggregate these projections into projections for the counties, it was assumed that the ratio of the value of variables for a given county to the value of corresponding variables for the planning district will be the same as it was in 1974 (Table 5.21). For the sake of clarification, the agricultural sector is the summation of sectors 3, 4, and 5 in the economic component. The economic component does not provide any projection for the price of land in the future. The average rate of increase in the real price of land was about 7% from 1970 to 1975, and it was assumed that the real price of marginal land would compound at 7% yearly (Table 5.22).

The projected values of the exogenous variables are presented in the following Tables 5.23 and 5.24.

Model Implementation and the Results

As was already discussed, the two markets -- the nine county market, and the three county market -- are considered the same in so far as application of the model presented on page 81 is concerned. In order to find projected prices of

TABLE 5.21

FORMULAS FOR CONVERTING PROJECTED VALUES FROM PLANNING DISTRICTS INTO PROJECTIONS FOR THE RIO GRANDE MARKET

Value of output in agriculture for the Rio Grande	36% II + 67% III + 100% III
Population in the Rio Grande	38% II + 98.5% III + 100% VII
Personal Income in the Rio Grande	37% II + 99% III + 100% VII
Labor in Manufacturing & Mining	40% II + 100% III + 100% VII

TABLE 5.22

PROJECTED PRICE OF LAND AT 7% ANNUAL INCREASE

1980	$ 2778
1985	3889
1990	5445
1995	7623
2000	10672

TABLE 5.23

BERNALILLO, SANDOVAL AND VALENCIA COUNTIES
(Projections 1967 = 100)

Year	Value of Output in Agriculture	Price of Land	Population	$(Population)^2$	Personal Income	Labor in Mining & Manufacturing
1980	$ 3,939,885	$2778	445,023	198,045,470,000	$15,447,288.00	19,526
1985	3,920,301	3889	473,095	223,818,880,000	16,908,213.00	19,103
1990	4,049,672	5445	518,701	269,050,730,000	20,248,453.00	21,966

TABLE 5.24

RIO GRANDE EXCLUDING SANTA FE COUNTY
(PROJECTIONS 1967 = 100)

Year	Value of Output in Agriculture	Price of Land	Population	$(Population)^2$	Personal Income	Labor in Mining & Manufacturing
1980	$104,933,570	$2778	619,103	383,288,520,000	$20,526,954.00	23,950
1985	110,242,690	3889	659,493	434,931,020,000	22,568,026.00	23,605
1990	116,760,850	5445	714,899	511,080,580,000	26,584,891.00	26,387

water rights in the future, one should first measure the historical significance of price determinants. To estimate the relation between price of water rights and the exogenous variables, two types of variables should be analyzed -- current values (monetary), and real values.

A regression was run between the historical current prices of water rights and the historical current values of the exogenous variables. A regression was also run between the historical real prices of water rights and the historical real values of the exogenous variables. The results of the historical price regression in current values and real values for the two markets are presented in the following Tables 5.25, 5.26, 5.27, and 5.28.

Since the projected values are in terms of real dollars, we can only use the computer runs associated with historical real values. With 90% probability, the following variables were significant for determining the price of water rights for the nine counties market: PRL1, the price of one acre of marginal land; POP1, population; PIP2, population squared; PE11, personal income; LMM1, employment of labor in mining and manufacturing; and a constant. Variables significant for determining the price of water rights for the three county market were: VOA1, value of output in agriculture; PRL1; POP1; PIP2, PE11 (all defined above); and a constant.

As presented at the end of the preceding chapter, Case I and Case II are special cases -- only Case I is implemented

TABLE 5.25

REGRESSION FOR
RIO GRANDE EXCLUDING SANTA FE
(CURRENT VALUES)

Variables	B	T
X2-VOA1	-0.19790×10^{-5}	-1.8827
X3-PRL1	-0.13501×10^{-1}	-1.9892
X4-POP1	-0.43562×10^{-1}	-13.379
X5-PIP2	0.40774×10^{-4}	12.052
X6-PE11	0.15142×10^{-6}	3.7343
X7-LMM1	0.14304×10^{-1}	3.4620
Constant	11.514	13.824
R-square = 0.9965	SSR = 0.7903×10^{-3}	DF = 7

TABLE 5.26

REGRESSION FOR
RIO GRANDE EXCLUDING SANTA FE
(REAL VALUES)

Variables	B	T
X2-VOA1	-0.61427×10^{-6}	-0.28591
X3-PRL1	-0.24786×10^{-1}	-2.1677
X4-POP1	-30.377	-5.1102
X5-PIP2	0.26038×10^{-1}	4.8092
X6-PE11	0.39239×10^{-6}	2.7235
X7-LMM1	16.160	2.1456
Constant	8266.1	5.2937
R-square = 0.9624	SSF = 1676	DF = 7

With 90% probability X3, X4, X5, X6, X7, and the constant are significant and are used for projections of prices of water rights.

TABLE 5.27

REGRESSION FOR
BERNALILLO, SANDOVAL AND VALENCIA (CURRENT VALUES)

Variables	B	T
X2-VOA1	$-0.21193x10^{-4}$	-4.0995
X3-PRL1	$-0.22611x10^{-1}$	-4.1439
X4-POP1	$-0.45693x10^{-1}$	-16.595
X5-PIP2	$0.58717x10^{-4}$	15.015
X6-PE11	$0.28966x10^{-6}$	7.8307
X7-LMM1	$0.86803x10^{-2}$	2.1439
Constant	8.8000	16.992
R-square = 0.9976	SSR = $0.5296x10^{-3}$	DF = 7

TABLE 5.28

REGRESSION FOR
BERNALILLO, SANDOVAL AND VALENCIA (REAL VALUES)

Variables	B	T
X2-VOA1	$-0.32264x10^{-4}$	-2.3593
X3-PRL1	$-0.38986x10^{-1}$	-3.7291
X4-POP1	-30.981	-5.0131
X5-PIP2	$0.35952x10^{-1}$	4.5494
X6-PE11	$0.68050x10^{-6}$	4.2398
X7-LMM1	6.2377	0.64007
Constant	6179.0	5.2926
R-square = 0.9752	SSR = 1108.	DF = 7

With 90% of probability X2, X3, X4, X5, X6, and the constant are significant and are used for projections of price of water rights.

and discussed at this time.* Case I ($B_{4,2} = 0$) is one special case of a general formula developed in Appendix B. However, in order to have a more accurate approximation we need more historical time series data.

There is a problem that arises because the coefficient of value of output in agriculture is negative. This result is contrary to the fact that $\gamma_{2,1}$ should be positive. There could be several justifications for this type of result:

(1) The data compiled are inaccurate, especially the real value of output in agriculture and the indices used in calculating the real values.

(2) The theory does not fully explain the demand function. One possibility in this regard is that when output in the agricultural sector increases, there will be more water saving technologies and practices available and consequently the quantity of water right demanded in the agricultural sector will decrease. Our model does not include any type of variable to explain these factors.

(3) Forecasting should be based upon determination of idiosyncracies existing in the market rather than conventional theories because there is no formal competitive market to begin with.

The only short-cut available is to say that the projected price can be forecasted under two scenarios: (1) that

*The reason for dropping Case II of application was drastic divergencies between calculated price of water rights and observed prices.

scenario that includes the negative impact of the real value of the output in the agriculture sector, and (2) that scenario that does not include the negative impact of the real value of the output in the agricultural sector. These projected prices, stated in terms of 1967 dollars, for each scenario are presented in the following Tables 5.29, 5.30, and 5.31.

The projections in Table 5.29 show significant price increases for water rights in the Rio Grande. In fairness to any user of these projections we should stress once again the basis for this projection and some principal weaknesses of it.

In essence we have successfully established a correlation among the estimated historical equilibrium price of water rights and a number of other variables which are indicators of the demand for water in the Basin. That correlation is the basis for the projection. However, this projection should not be given without also emphasizing several weaknesses. First, if the warning expressed at the end of Chapter Two concerning the prospect for extensive litigation in the Middle Rio Grande is realized, then market activity in water rights may effectively cease and the projection accordingly would become moot.

Secondly in the last few years the San Juan-Chama diversion water has arrived in the Rio Grande providing something of a glut on the market. Since the historical period on which the correlation is established largely preceeded this addition to the surface water supply of the Basin, it is possible that the correlation will be destroyed by this new addition. Without more data than we had available it is impossible to forecast the effect of additions to supply.

There are other more technical caveats attached to the use of this projection which have been explicitly stated or are implicit in the methodology used and consequently do not need to be restated here. No particular reliance should ever be placed on a single forecast value and presumably any user will accept this projection in that spirit. As an indicator of the direction and magnitude in which market values for water will move in the Rio Grande and other basins of New Mexico in the future, however, we assert that the projection is a reasonable one.

TABLE 5.29

PROJECTED PRICES FOR
RIO GRANDE EXCLUDING SANTA FE MARKET

The following is the projected real price of water rights in terms of 1967 dollars. The index for inflating these prices should be the wholesale price index (1967 = 100)

Year	Price of Water Rights
1980	$ 563.31
1985	728.03
1990	1191.75

The following is the projected real price of water rights in terms of 1967 dollars. The index for inflating these prices should be the wholesale price index (1967 = 100).

TABLE 5.30

PROJECTED PRICES FOR
BERNALILLO, SANDOVAL, AND VALENCIA MARKET
(negative impact of agriculture is included)

Year	Price of Water Rights
1980	$ 535.15
1985	670.04
1990	1093.64

TABLE 5.31

PROJECTED PRICES FOR
BERNALILLO, SANDOVAL, AND VALENCIA MARKET
(negative impact of agriculture is omitted)

Year	Price of Water Rights
1980	$ 678.66
1985	812.85
1990	1241.16

CHAPTER 6

SUMMARY

The prospect of a fully appropriated condition throughout the Southwest has been avoided for many years by many of the region's leaders by placing a reliance on speculative schemes for augmentation of the region's water resources. In particular the Texas Water Plan which proposed large scale diversions of waters of the Mississippi River to the high plains of Texas and New Mexico is an example of a scheme which has received large scale public investment but has consistently fallen short of final approval. Even grander notions to divert water from the northern areas of the continent into the semi-arid areas of the Southwest have been proposed at one time or another. Locally within the region there have, of course, been many examples of interbasin transfers in which augmentation of one basin's surface water flows have been achieved by reducing the available water in a contiguous basin. Although elaborate benefit-cost studies have commonly accompanied the approval of these interbasin diversions, in the final analysis their approval has always been a political matter rather than an economic one.[1]

Although some additions to the usable water supplies of the region may be developed either through stream flow augmentation or exploration and development of deep groundwater, the recent conflict between President Carter and some elements of

Congress may portend the end of any large scale schemes for further diversions of water into the region or even any sizable shifts of water from one basin to another within the region. Thus for practical purposes it would seem that the region must accept the limited nature of its water supplies and should move strongly to adapt itself to that condition.

In accepting the limited nature of the region's water supplies, however, we must avoid acceptance of the corollary that limited water places an absolute limit on development within the region. Any rigid, immutable barriers within the region created by limited water are more a construction of man than they are a matter of physical reality. In particular it is the institutions of man which prevent in the state of Arizona and elsewhere the transfer of water from agricultural uses readily into other, more highly valued, uses. Also it is social insistence on artificially low prices for municipal water that creates the apparent rigid barriers to residential or other development in many of the urban areas of the region.[2] Instead of promoting rigid constraints upon water use patterns within the region, political effort should be directed toward increasing the flexibility and allowance for modification of current water use practices on the part of all water users within the region. Generally speaking there is considerable opportunity for such modification if the region's institutions would simply permit and encourage it. As an exmple, in planning new electrical generation facilities in the San Juan portion of the Colorado River that lies in New Mexico, utilities have available several options regarding the use of cooling water even though the New Mexico State Engineer has projected a fully appropriated condition for the San Juan Basin without the addition of any new generating facilities.[3] First, technological adjustment could be made in the cooling process with dramatic savings in cooling water required. Second, existing privately held water rights in the basin could be purchased. With approval of the appropriate authorities this water could then be transferred into industrial use from its current predominant use in agriculture. Third, cooling water may be drawn from deep groundwater stocks as opposed to the reliance that has been placed on surface water supplies up to the present. These and other options which could be developed illustrate the range of possibilities available if and when flexible conditions surround water use within the region.

One general institution which contributes to this flexibility is the existence, where permitted, of an economic market for water rights. Such a market, if it works properly, provides a signal to all water users in the form of the price that a water right may command in the market place. This price simultaneously measures the availability of water and the competing demands for its use. With the information provided by the price signal water users, current and prospective, can make more informed and intelligent decisions regarding the water use options that are available to them. In addition, as the price of the water rights increases there is a strong incentive to become more conserving in the use of water. In this study we have investigated the market for water rights in the state of New Mexico and the prices being paid for those rights. Table 6.1 lists representative values for each of five water basin areas in the state of New Mexico as taken from data presented earlier. If the data in Table 6.1 is accompanied by additional information regarding the scarcity of water in each of those basins the usefulness of the price signal is clearly revealed. The lowest reported values paid for water rights are in the San Juan Basin. Although proposals exist which if completed would fully utilize the surface waters of that basin, those proposals have not yet put all the surface supply to beneficial use, and there is considerable doubt whether some of the projects will ever be completed. Thus there is currently water in that basin which is not being put to beneficial use. At the other extreme, the highest prices for water rights have been paid in the Santa Fe area which is a subbasin in which water has been an extremely scarce commodity for some period of time. The relative prices of water rights, then, in the different basins do

TABLE 6.1

PRICE COMPARISONS OF ONE ACRE-FOOT OF CONSUMPTIVE WATER RIGHT OVER TIME OF FIVE MAJOR RIVER BASINS IN NEW MEXICO

Basin	Price of Right ($)	Year
San Juan	72	1970
	171	1972
Roswell/Artesia	238	1970
	628	1976
Rio Grande	250	1969
(excluding Santa Fe)	532	1975
Gila	657	1971
	1,610	1976
Santa Fe	3,733	1969
	10,909	1975

provide a good indicator of the demand for water in those basins and the supply of that water, even though the market for these water rights is extremely rudimentary when compared to more sophisticated markets which exist for other commodities.

Effort was also made to establish a correlation between the price of water rights and various factors determining the demand for those rights in the Rio Grande Basin. Based on historical data in that basin, a strong correlation was found between the price of a water right and the following five variables: 1) the price of land, 2) population, 3) population squared, 4) personal income, and 5) labor employed in mining and manufacturing. Based on this correlation as well as projections of the correlated variables to the year 1990, water right prices were projected to rise in real terms to over $1200 by 1990. However, several qualifications were made to that projection. The first and most serious qualification is that the correlation was established for an historical time period in which available water supply in the Rio Grande had remained essentially constant. Beginning in the middle 1970s however additional water from the San Juan-Chama diversion project was diverted into the Rio Grande Basin. At this time much of that water is going unused. This increase in the supply of water may disturb the past relationship that has existed between the correlated variables and the price of water rights so that the price of rights in the Rio Grande Basin may possibly remain constant or even fall before resuming its upper trend. In general the permanence of the correlation rests upon a maintenance of the underlying structure that has existed with respect to water in the Rio Grande Basin for some time. One instance of this structure is the set of rules promulgated by the New Mexico State Engineer concerning withdrawl of water from the deep aquifers lying under the Rio Grande. Were those rules to be changed to allow increased extraction of water from that aquifer there would presumably be a dampening effect on the otherwise rising prices of water rights in the Rio Grande Basin. The point to be emphasized here however is that historically a correlation has existed between the price of a water right and indicators which reflect the level of development within the basin. Despite the rudimentary nature of the market for water rights, the price paid for water rights has provided a reasonably accurate signal for the relative scarcity of water in the basin.

Obstacles Reducing the Flexibility of the Water Transfer Process

In addition to the rigid barrier to water transfers provided by outright legal prohibition of such transfers as occurs in Arizona, there are numerous other obstacles which reduce the efficiency of the market transfer procedure in the region. Let us briefly review a few of these obstacles. First, overriding the entire water picture in the Southwest, of course, is the uncertain ownership status of the water, vis-á-vis the Winter's rights of the Indian tribes and the federal reserve rights. With such a large legal cloud hanging over the entire transfer procedure it is doubtful that a water rights market will ever function smoothly within the region because of the inhibition to large capital investments created by the tenuous nature of the ownership to the water right itself. Second, the large number of institutions having a hand in deciding water questions within a given basin provides a fertile setting for disputes of all kinds regarding the transfer of a right from one use to another. Third, the lack of a centralized, or even organized, flow of information on the value of water rights perpetuates a condition in which prices paid may fluctuate widely from one transaction to another simply because the parties in one transaction are not fully informed of the "going" market values for the rights being transferred. A small but useful step designed to correct this deficiency would be to require that each purchaser of a water right provide the price paid for the right as information submitted to the administrating authority who in each jurisdiction ultimately must approve the transfer. Information relating to the transfer is gathered as a matter of routine but generally speaking the price of the water right is not included in it. Fourth, there may be large "transaction costs" associated with the transfer of a right from one owner or use to another. Specifically, engineering and legal costs associated with a contested transfer may be considerable. In this study a survey was conducted of individuals who had transferred rights in an effort to determine the expenses incurred in the transfer process. The values obtained ranged from a low of $.18 in transaction costs per acre-foot of consumptive use in the right transferred to a high of $758 for the same unit. Although the existing law of prior appropriation and the administrative procedures that have been established to implement that law will never allow the elimination of engineering and legal costs associated with the transfer of a water right there are steps which can be taken which hold promise for significantly reducing the costs involved. In particular it was found that the presence of an adjudication decree in a given basin significantly reduced the transaction costs associated with the transfer of a right within that basin. Although the adjudication decree represents a significant monetary investment in its own right, it seems useful as a capital investment designed to improve the efficiency of the water rights transfer process as well as for other well understood reasons. Finally, the basic rule governing beneficial use of water provides substantial disincentive to the effective functioning of the water right market and the price signals that it provides. Namely under current rules there is no reason for a farmer to engage in water conserving practices and thereby reduce his water consumption since he cannot profit by such reduction. Were the rules changed to allow that farmer to sell the rights to any water he was able to conserve, substantial incentive would be created in agriculture and other uses which would promote conservation as the price of the right increased. These and other obstacles prevent an efficient and smooth working of the market for water rights. Actions to eliminate or reduce these impediments will aid in increasing the flexibility allowed by the regional water institutions and thereby assist the region in adapting to the increasingly tight water situation.

This brief summary discussion should not conclude however without some comment on the general acceptability of the water right market as a procedure for evolving change in the water use within the region for there are two fundamental circumstances which raise serious questions concerning the future useability of the market mechanism for evolving change in water use practices. The first, to which some allusion was made above, is simply the large number of institutions, agencies, and offices that already have a stake in water management within the region. The large number of institutions may preclude a decentralized market approach for managing water in the region. The second circumstance is perhaps even more fundamental in that it relates to the basic societal attitude towards water. There is a general perception that water is unlike other commodities in that it is a vital necessity to life itself and as a consequence should not be treated in the same manner as automobiles, wheat and other commodities sold in the marketplace. If that view should be considered dominant, then any expanded use of the water right transfer procedure which is analogous to the trading of other commodities is destined to fail. The basic alternative is to accept this public attitude towards water and construct a centralized institution to which over time all water rights would be transferred either through outright purchase or standard public condemnation procedures. This centralized agency would then be empowered to lease the water itself on a year by year basis or for a contracted period of time to all water users within its jurisdiction. This procedure would eliminate the private holding of water rights in its entirety with a continuing obligation on the part of any water user to prove beneficial use to the centralized agency. At a local level precursors to this centralized water management organization exist in the form of the conservancy districts and are well rooted in the agricultural traditions of the region. This solution, of course also has its inefficiencies and philosophical opponents.

Regardless of whether the centralized allocation system, an evolving decentralized market system or some intermediate mechanism between the two is developed, the overriding need within the region--to restate it once again-- is for increased flexibility as water consumption inexorably approaches its physical limit. It is easier to take steps now to begin the slow evolution towards this increased flexibility than it will be to wait until a rigid, humanly constructed barrier is reached.

FOOTNOTES - CHAPTER 6

[1]"Patterns of Politics in Water Resource Development: A Case Study of New Mexico's Role in the Colorado River Basin Bill", Helen M. Ingram, Division of Government Research, Institute for Social Research and Development, The University of New Mexico, December 1969.

[2]The urban areas of Tucson, Denver, and Santa Fe are experiencing painful battles over water prices and the extension of water service to new customers.

[3]From the testimony of Steve E. Reynolds, New Mexico State Engineer, "Statement on the Operation of the San Juan-Chama Project and the Related Impacts in the San Juan River Basin" presented to the Subcommittee on Energy Research and Water Resources of the Senate Committee on Interior and Insular Affairs, June 12, 1975.

APPENDIX A[1]

INCORPORATING IMPERFECTATION INTO THE RESOURCE ALLOCATION MODELS

This paper demonstrates that as far as utility maximization is concerned the lack of transfer causes economic inefficiency.

Let us assume that there are four major water users competing for consumption of water existing in the San Juan Basin of New Mexico:

(1) Irrigation

(2) Industry

(3) Energy

(4) Recreation

Many feasibility studies have shown that there is not a possibility of transferring water from outside the basin at the present time since there are many legal, political, and economic obstacles involved in transferring water from outside the basin; so, one can assume that the water existing in the basin is an upper limit by $\bar{w}$.

Other than the above physical water scarcity, there is one legal constraint which causes this scarcity to be more detrimental to the welfare of the people living in the basin. There is a special way of allocating water among different uses -- called prior appropriation. Water, generally speaking, is allocated based upon historical usage of water. Therefore, water given to each sector is confined by this legal constraint. As a result, there is an upper limit for usage of water by each sector or $w_i \leq \bar{w}_i$ where w_i shows water consumed by the i^{th} sector and $\bar{w}_i$ denotes water allocated to sector i based upon historical records. This allocation would cause a welfare loss as will be shown later on.

Only by elminating water allocation based upon historical consumption and allowing transfer, can we obtain maximum utility.

CONSTRAINTS:

1. Production function constraint $x_i = f_i(L_i, w_i)$ $i = 1, 2, 3, 4$ where x_i denotes production of the i^{th} sector, w_i denotes water consumed in the production of the i^{th} sector.

II. Balance of payments constraint.

This constraint is similar to the budget line constraint usually assumed for one consumer. This constraint can be shown as follows:

$$\sum_{i=1}^{n} P_{x_i} x_i = \sum_{i=1}^{n} P_{x_i} c_i \qquad i = 1, 2, 3, 4$$

where P_{x_i} denotes price of i^{th} product. c_i shows the amount of i^{th} product consumed by inhabitants of the San Juan area.

III. Labor Constraint.

$$\sum_{i=1}^{n} L_i - \bar{L} \qquad i = 1, 2, 3, 4$$

IV. Water Constraint.

$$\sum_{i=1}^{n} w_i \leq \overline{w} \quad i = 1, 2, 3, 4$$

V. Lower Limit Constraint

$$x_i \geq 0, \; L_i \geq 0, \; w_i \geq 0$$

And the objective function is maximizing utility of consuming c_is. For the sake of simplicity, it is assumed that all the individuals have the same kind of utility, and that utility is homothetic, therefore, our Pareto optimization is:

$$\text{Max } u(c_i)$$

$$\text{s.t } x_i = f_i(L_i, w_i) \qquad \text{(I)}$$

$$\sum_{i=1}^{4} P_{x_i} x_i = \sum_{i=1}^{4} P_{x_i} c_i \qquad \text{(II)}$$

$$\sum_{i=1}^{4} L_i \leq \overline{L} \qquad \text{(III)}$$

$$\sum_{i=1}^{4} w_i \leq \overline{w} \qquad \text{(IV)}$$

$$x_i \geq 0, \; L_i \geq 0, \; w_i \geq 0 \qquad \text{(V)}$$

To solve this maximization we should set up a Lagrangian in which we have associated a multiplier for each constraint.

$$L = u(c_i) + \lambda_i f_i(L_i, w_i) + \mu\left(\sum_{i=1}^{4} P_{x_i} c_i - \sum_{i=1}^{4} P_{x_i} x_i\right) - \beta\left(\sum_{i=1}^{4} L_i - \overline{L}\right)$$
$$- \gamma\left(\sum_{i=1}^{4} w_i - \overline{w}\right) + \delta_i x_i + \delta_2 L_i + \delta_3 w_i$$

Necessary and sufficient conditions for the i^{th} sector are:

$$\frac{\partial L}{\partial c_i} = \frac{\partial u}{\partial c_i} - \mu P_{x_i} \leq 0 \; ; \; (\frac{\partial u}{\partial c_i} - \mu P_{x_i}) c_i = 0$$

$$\text{and } \mu(\sum_{i=1}^{4} P_{x_i} x_i - \sum_{i=1}^{4} P_{x_i} c_i) = 0$$

$$\frac{\partial L}{\partial L_i} = \lambda_i \frac{\partial f_i}{\partial L_i} - \beta + \delta_2 \leq 0 \; ; \; (\lambda_i \frac{\partial f_i}{\partial L_i} - \beta + \delta_2) L_i = 0$$

$$\text{and } \beta(\Sigma L_i - \overline{L}) = 0$$

$$\frac{\partial L}{\partial w_i} = \lambda_i \frac{\partial L_i}{\partial w_i} - \gamma + \delta_3 \leq 0 \; ; \; (\lambda_i \frac{\partial L_i}{\partial w_i} - \gamma + \delta_3) w_i = 0$$

$$\text{and } \gamma(\sum_{i=1}^{4} w_i - \overline{w}) = 0$$

From solving the above system of equations, we obtain L_i^*, w_i^*, x_i's and maximum level of utility $v(P_{x_i}, P_1, P_w, \sum_{i=1}^{4} P_{x_i} x_i)$.

Remark: It is assumed that since the relative magnitude of San Juan activities to the nation is very low, we can assume that P_{x_i}'s are given from outside. This probably would not be the case for recreation, but for the sake of simplicity it is assumed that all of the P_{x_i}'s are given from outside.

Having the above information, we try to obtain wage rate P_1 and price of water P_w

$$P_w = P_{x_i} \frac{\partial L}{\partial w_i} \qquad i = 1, 2, 3, 4$$

$$P_l = P_{x_i} \frac{\partial L}{\partial L_i} \qquad i = 1, 2, 3, 4$$

Thus, we obtain the optimal level of consumption as being:

$$c_i(P_{x_i}, P_l, P_w, \sum_{i=1}^{4} P_{x_i} x_i)$$

This consumption level is equal to its associated magnitude of compensated demand:

$$c_i^*(P_{x_i}, P_l, P_w, v(P_{x_i}, P_l, P_w, \sum_{i=1}^{4} P_{x_i} x_i)) = c_i(P_{x_i}, P_l, P_w, \sum_{i=1}^{4} P_{x_i} x_i)$$

From c_i^* we obtain expenditure function for the i^{th} sector

$$m(P_{x_i}, P_l, P_w, v(P_{x_i}, P_l, P_w, \sum_{i=1}^{4} P_{x_i} x_i)) = P_{x_i} c_i^*$$

m determines the magnitude of expenditure necessary to obtain v level of utility for the inhabitants of the San Juan area.

INCORPORATING LEGAL WATER ALLOCATION CONSTRAINT:

This constraint would cause each sector to have an upper limits from the available water in the basin. Constraints I, II, III, and V do not change, and the constraint IV becomes:

$$w_i \leq \bar{w}_i$$

Thus, our new optimization problem is:

$$\text{Max } u(c_i)$$

$$\text{s.t. } x_i = f_i(L_i, w_i) \qquad \text{(I)}$$

$$\sum_{i=1}^{4} P_{x_i} x_i = \sum_{i=1}^{4} P_{x_i} c_i \qquad \text{(II)}$$

$$\sum_{i=1}^{4} L_i \leq \overline{L} \qquad \text{(III)}$$

$$w_i \leq \overline{w}_i \qquad \text{(IV)}$$

and $x_i \geq 0$, $L_i \geq 0$, $w_i \geq 0$

To solve this maximization again we should set up a Lagrangian as follows:

$$L = u(c_i) + \lambda_i' f_i(L_i, w_i) + \mu' \left(\sum_{i=1}^{4} P_{x_i} c_i - \sum_{i=1}^{4} P_{x_i} x_i \right) - \beta' \left(\sum_{i=1}^{4} L_i - \overline{L} \right)$$

$$- \gamma'(w_i - \overline{w}_i) + \delta_i' x_i + \delta_2' L_i + \delta_3' w_i$$

Necessary and sufficient conditions are:

$$\frac{\partial L}{\partial c_i} = \frac{\partial u}{\partial c_i} - \mu' P_{x_i} \leq 0 \; ; \; \left(\frac{\partial u}{\partial c_i} - \mu' P_{x_i}\right) c_i = 0$$

$$\text{and } \mu' \left(\sum_{i=1}^{4} P_{x_i} x_i - \sum_{i=1}^{4} P_{x_i} c_i \right) = 0$$

$$\frac{\partial L}{\partial L_i} = \lambda_i' \frac{\partial f_i}{\partial L_i} - \beta' + \delta_2' ; \; \left(\lambda_i' \frac{\partial f_i}{\partial L_i} - \beta' + \delta_2'\right) L_i = 0$$

$$\text{and } \beta' \left(\sum_{i=1}^{4} L_i - \overline{L} \right) = 0$$

$$\frac{\partial L}{\partial w_i} = \lambda_i' \frac{\partial f_i}{\partial w_i} - \gamma' + \delta_3' ; \quad (\lambda_i \frac{\partial f_i}{\partial w_i} - \gamma' + \delta_3')w_i = 0$$

and $\gamma' \ (w_i - \overline{w}) = 0$

After solving the above system of equations we can obtain the new level of L_i''s, w_i''s, x_i''s, and also the new level of utility v'.

Having obtained the above equilibrium values, we can obtain P_1', P_w', P_{w_2}', P_{w_3}', P_{w_4}' and consequently the indirect level of utility associated with those values which is v'. Ordinarily, v' is less than v, and we are concerned with social welfare loss. First, we can obtain the minimum level of expenditure necessary to reach this level of utility v' which is referred to as m'.

$$m'(P_{x_i}, P_1', P_w', v'(P_{x_i}, P_1', P_w'. \sum_{i=1}^{4} P_{x_i} x_i')) = P_{x_i} c_i'^*$$

$(m-m')$ is measuring the welfare loss as the result of water law regulations. It is the summation of $\varepsilon v + cv$, where εv = equivalent variation, and cv = compensation variation.*

(1) The equivalent variation (εv) for going from m' to

$$m''(P_{x_i}, P_1, P_w, v'(P_{x_i}, P_1, P_w, \sum_{i=1}^{4} P_{x_i} x_i')$$

is $\varepsilon v = m' - m''$

(2) and then compensated variation for going from m to m'' is

$c \cdot v = m' - m$

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*For definition of εv and cv see Kärl Maler (1975).

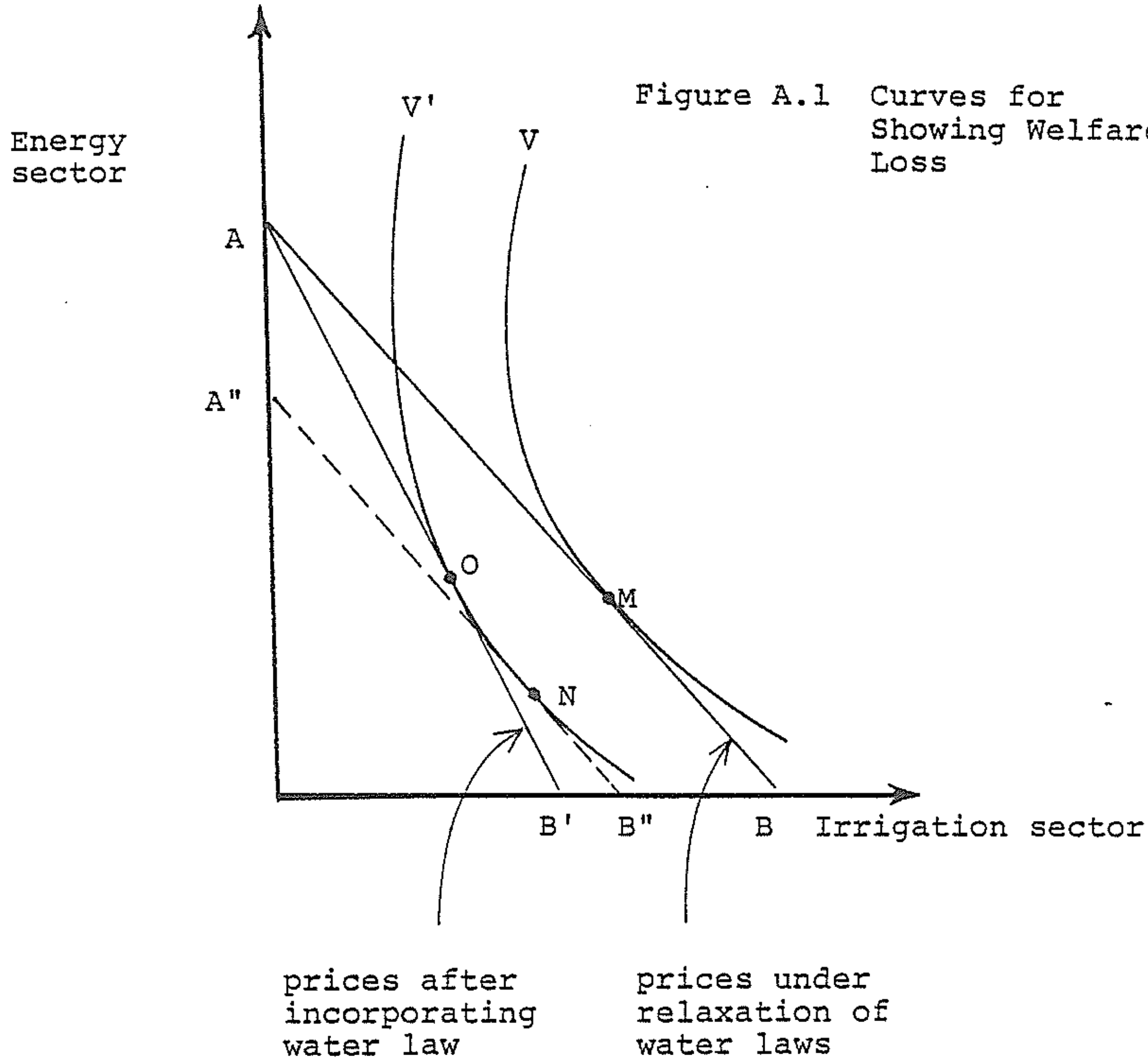

Figure A.1 Curves for Showing Welfare Loss

To show this problem graphically, let us say that whether under relaxation of water laws or under restriction of water laws, prices of water for industry and recreation would not change, but when we have water law constraint the price of water for energy would go up relative to the price of water for irrigation. So we have the above Figure A.1.

The actual circumstances under water law constraint is 0; whereas, if we relax this rigidity and let water be transferred from low value uses to higher value uses, then we obtain M.

We see that there-are two losses involved: (1) from M to N and (2) from N to 0.

from M to N is εv and

from N to 0 is $c \cdot v$

CONCLUSION:

Total welfare loss is related to institutional arrangements, and in order to obtain maximum welfare, we should let market forces determine water allocation.

FOOTNOTE - APPENDIX A

[1]The materials presented in this appendix were written as a term paper for a seminar course which was taught in the fall of 1975 by Professor Kärl Mäler while he was a visiting professor at the University of New Mexico. The materials presented in this paper are independent from the rest of the dissertation, but the significant conclusion made out of this paper is that rigid allocation of the resources would cause social welfare loss.

APPENDIX B

ESTIMATING PRICE OF WATER RIGHTS

Limit for a convergent series such as $\sum_{n=0}^{\infty} az^n$ is: $\frac{a}{1-z}$ or

$$\sum_{n=0}^{\infty} az^n = \frac{a}{1-z} \quad \text{where } -1 < z < 1$$

special case:

$$\frac{1}{1-z} = \sum_{n=0}^{\infty} (z)^k$$

apply this to the first seven terms of the formula developed for $y_{t,4}$ in Chapter 4.

For the first term, $\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,2} + z_{t,5} \quad \beta_{4,3}} z_{t,1}$. the part in the bracket can be calculated in the following way:

$$\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3} + \beta_{4,2}\, z_{t,5}} = \frac{\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3}}}{1- - \frac{\beta_{4,2}}{\beta_{4,1} + \beta_{4,3}} z_{t,5}}$$

$$= \sum_{k=0}^{\infty} \left(\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3}}\right) \left(- \frac{\beta_{4,2}}{\beta_{4,1} + \beta_{4,3}} z_{t,5}\right)^k$$

the above is true under the assumption that

$$- \frac{\beta_{4,2}}{\beta_{4,1} + \beta_{4,3}} z_{t,5} < 1$$

An approximate of the above can be determined, and it becomes more accurate when k gets larger and larger.

for k=0 we have

$$\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3} + \beta_{4,2} Z_{t,5}} = \frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3}}$$

or the first term in the equation for $y_{t,4}$ becomes:

$$\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3}} \quad Z_{t,1}$$

If we assume k = 0 for all other terms having $Z_{t,5}$ in the denominator, the equation becomes like assuming $\beta_{4,2} = 0$ as it was assumed in Chapter 4.

for k = 1, we have

$$\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3} + \beta_{4,2} Z_{t,5}} \doteq \left(\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3}}\right) + \left(\frac{\gamma_{1,1}}{\beta_{4,1} + \beta_{4,3}}\right) \left(- \frac{\beta_{4,2}}{\beta_{4,1} + \beta_{4,3}} \quad Z_{t,5}\right)$$

generalizing this for all the terms would involve estimating 14 coefficients and since we have only 14 years of observations at the most, this is impossible. However, theoretically this process of increasing k should be continued until we get sufficient approximation for the above terms.

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