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Economic Implications of Farmer Storage of Surface Irrigation Water in Federal Projects: El Paso County, Texas

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ECONOMIC IMPLICATIONS OF FARMER STORAGE OF SURFACE IRRIGATION WATER IN FEDERAL PROJECTS: EL PASO COUNTY, TEXAS

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ABSTRACT

The Bureau of Reclamation has approved a program for farmer storage of surface irrigation water in Elephant Butte Reservoir, New Mexico. This program would allow individual farmers to store part of their annual surface water allotment in the reservoir subject to evaporation loss to be drawn at a future date upon request. The purpose of this study is to ascertain the economic implications of such a program for farmers in the El Paso County Water Improvement District No. 1.

The economic analysis was based on results from a linear programming model developed for crop production in El Paso County. The model was designed to maximize net farm revenue. Twelve crops were included in the analysis. The effects of soil type and salinity level of irrigation water on crop yields for all twelve crops were estimated. Input requirements by crop and yield level were identified. Input categories included seed, chemical, water, machinery, labor, harvest, other and fixed costs. Irrigation alternatives included both surface and ground sources. In addition, the water saving technology of laser leveling was incorporated into the model.

The model was restricted by acreage of a soil group with a specified level of salinity in the underlying groundwater. Also, the quantity of surface irrigation water available was limited.

This static linear programming model was applied for various surface irrigation water allocations ranging from zero to three acre feet per acre of cropland with groundwater assumed available. This procedure produced a schedule of net farm revenues for alternative

surface irrigation water allocations for use in conjunction with groundwater. The procedure was repeated with groundwater availability limited to zero. These two schedules of net farm revenues were then used (1) to form the basis of two temporal linear programming models which maximized the real value in 1980 dollars of a stream of net farm revenues, and (2) to evaluate a specified annual surface irrigation water use scenario of two acre feet per acre per year.

The temporal models maximized the 1980 real value of net farm revenues. This revenue stream was generated by optimal temporal use of the actual annual surface irrigation water allotments for 1963 to 1980. This optimal use includes the opportunity to store water in Elephant Butte Reservoir subject to evaporation. Results were obtained both with and without groundwater pumping over three surface water use scenarios (actual, optimal temporal and two acre feet per year).

The results of this study indicated that, with the ability to store surface water, temporally optimizing surface water use would have increased the real value of net farm revenue $0.84 per acre per year or 0.4 percent above the real value of net farm returns implied by the actual use rates for the groundwater pumping case. For the no groundwater pumping case, the real value of net farm returns increased by $3.56 per acre per year or 2 percent above the net farm returns indicated by the actual use rates. Also, storing surface water for future use, or accumulation, tends to decrease the year to year variability of net farm revenues. Groundwater pumping is also known to decrease this variability.

The target surface water allocation of the project administrators is three acre feet per year. The optimal temporal solutions tended to be between this three acre feet allocation and the two acre feet allocation as specified in the two acre feet per year scenario. An optimal temporal allotment of three acre feet appears too high while two acre feet appears too low. Without a system of farmer-held surface water storage, optimizing temporal use of surface irrigation water would not be possible. Thus, this water storage opportunity is an important irrigation management tool for individual farmers in the El Paso County Water Improvement District No. 1.

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CHAPTER I

INTRODUCTION

Texas agriculture is heavily dependent upon irrigation. It is estimated that Texas uses 7.1 million acre feet of water annually from its groundwater reserves that are not recharged into those reserves (McNeely and Lacewell). A critical need exists to carefully manage the water resources of Texas, particularly the western section where rainfall is extremely limited.

The El Paso area of Texas is arid and has experienced significant water level declines in the underlying aquifer due to water mining (Texas Water Development Board). Meyer and Gordon show a 10 to 60 foot drop in water levels in the El Paso area during the period 1903 to 1969. Agriculture in the El Paso area has the potential to aid in countering the overdraft problem. More efficient use of surface water and improved usage of surface water allocations among years could decrease agriculture's need for groundwater. Groundwater may only be needed in years when the quantity of surface water is extremely limited.

As reported by Sonnen, Dendy and Lindstrom, the emphasis of President Carter's policy toward water in the western United States was one of seeking to increase conservation of irrigation water rather than development of additional sources. In their search for incentives for further irrigation water conservation by agricultural producers in

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The style and format of this dissertation follows that of the American Journal of Agricultural Economics.

California and Texas, Sonnen, Dendy and Lindstrom found (a) due to their complete dependence on irrigation water, producers currently practice a very high degree of water conservation, (b) recent technological advances (i.e., level-basin irrigation[1]) have resulted in substantial reductions in water use, and (c) possible government incentives for further conservation are likely to result in only meager reductions in water use.

The Sonnen, et al. study found that the El Paso County farmers of Texas would like to experiment with a system in which they would be allowed to store part or all of their annual allotment of Rio Grande River waters in Elephant Butte Reservoir, New Mexico for use upon their request in some future year. Under the current system, any unused water allotment remains in Elephant Butte Reservoir and is reallocated among all users in the following year. While a carry-over storage, or accumulation, program would not, over time, decrease water usage as was the aim of the Carter policy, it could allow farmers to store water for those years when their water allocation was low. This program would help stabilize agricultural output and farmer incomes and reduce some of the risk of farmers in the El Paso area.

The Department of the Interior has recently changed its regulations to allow the El Paso County Water Improvement District No. 1 to begin an accumulation program for its members. The El Paso County Water Improvement District No. 1 is the local agency charged with the proper disposition of Rio Grande River irrigation waters in El Paso County,

[1]See Appendix A.

Texas. Thus, the interviewed farmers mentioned above will be able to participate in this program.

The water use and economic implications of an accumulation program for El Paso County are not known. Issues include impact on actual water use efficiency, cropping patterns, producer profit and equity implications. This study will address these factors.

Study Area

This research will focus on that area in El Paso County, Texas which is contained in the El Paso County Water Improvement District No. 1. This area is roughly the flood plain of the Rio Grande River which lies within the county (Figure 1).

The Rio Grande flood plain is about 12 percent of the county area, or approximately 94,000 acres (U.S. Department of Agriculture, Soil Conservation Service). Of the 49,113 acres of total cropland reported for El Paso County (U.S. Department of Commerce), virtually all were in the Rio Grande flood plain. While 44,801 acres of this cropland were reported harvested, 45,045 acres were reported irrigated (U.S. Department of Commerce). With an annual rainfall of 7.77 inches per year (The Dallas Morning News), irrigation is absolutely necessary for the existence of economically viable crop production in the area.

The primary source of irrigation water to El Paso County farmers is from the Rio Grande River. The correct disposition of Rio Grande River waters, according to international treaty and federal law, is the responsibility of the Rio Grande Compact Commission. In dispatching its duty, the Rio Grande Compact Commission receives the

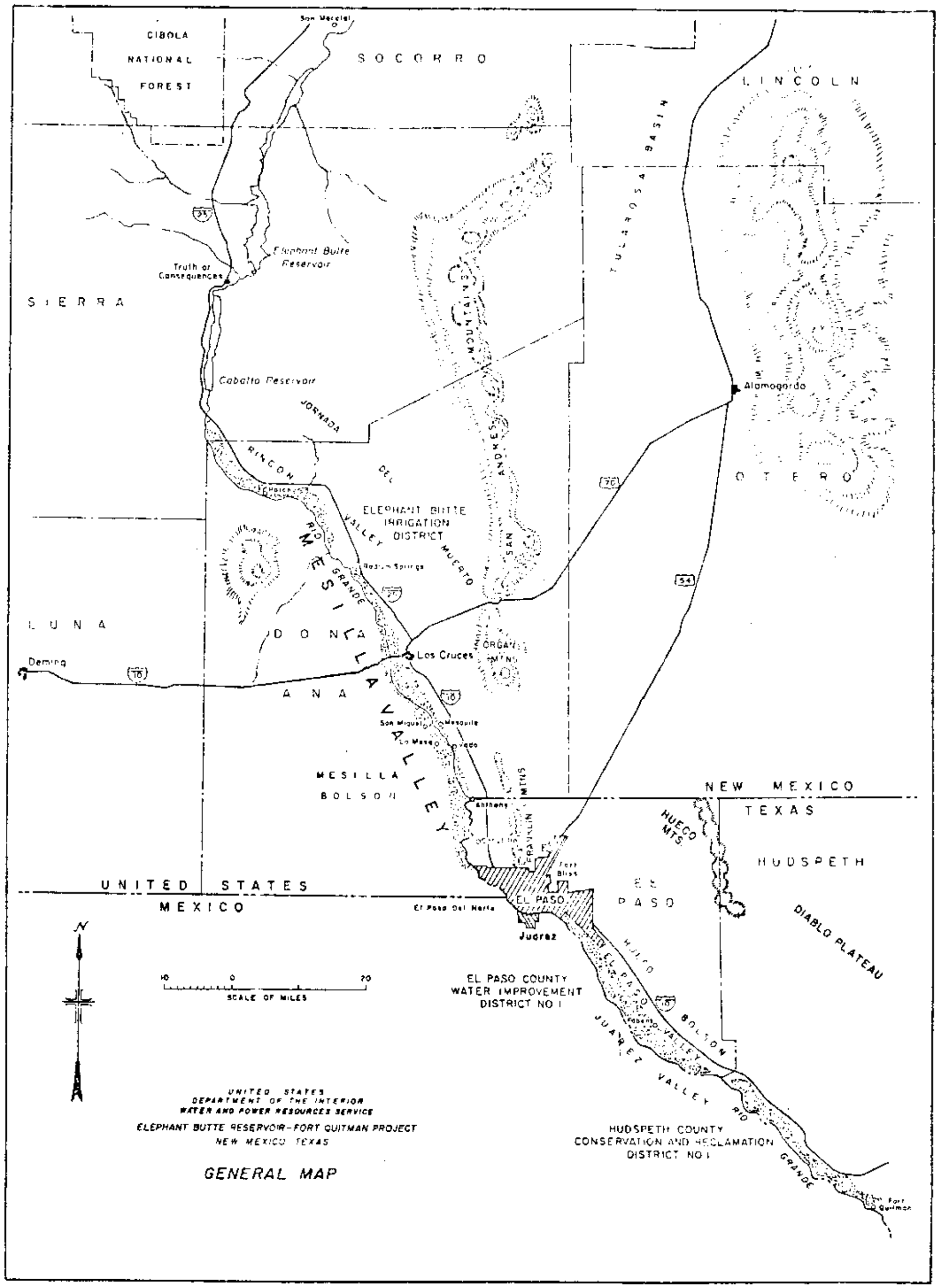

Figure 1. Map of the General Study Area

assistance and cooperation of the Office of the State Engineer of Colorado, the U.S. Bureau of Reclamation, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the United Pueblo Agency. The total irrigation project is called the Rio Grande Project.

Irrigation waters are gathered primarily in Elephant Butte Reservoir, New Mexico (Figure 1), although a number of smaller water storage reservoirs exist in the Rio Grande watershed above Elephant Butte Reservoir in both the states of Colorado and New Mexico. Water released from Elephant Butte for irrigation purposes is subsequently delivered to the user by one of three irrigation districts. The first is the Elephant Butte Irrigation District. This district is composed of all irrigated lands in the state of New Mexico and in the Rio Grande flood plain below Elephant Butte Reservoir and above the Texas state line and the international boundary with Mexico (Figure 1).

The El Paso County Water Improvement District No. 1 oversees water deliveries to farmers in the Rio Grande flood plain of El Paso County, Texas. The Juarez Valley Irrigation District delivers up to 60,000 acre feet annually to agricultural producers in the Juarez Valley of the Republic of Mexico (Figure 1). Although it has no water rights, the Hudspeth County Conservation and Reclamation District No. 1 has contracted for residual water arriving at the Hudspeth County line.

Principal crops grown in the area are cotton, wheat, barley, grain sorghum, alfalfa, pecans and various vegetables. Table 1 gives the historical acreages of these crops. The historical yields of selected crops are given in Table 2.

In years of low allotments of Rio Grande River waters, farmers

Table 1. Planted or Harvested Acres of Selected Crops Grown in El Paso County, 1968 to 1980

	Planted Acres						Harvested Acres			
	Cotton									Pecans[a]
Year	Upland	Pima	Alfalfa	Wheat	Barley	Grain Sorghum	Tomatoes	Lettuce	Onions	1000 lbs.
1980	6,600	17,400	7,300	8,000	b	3,000	b	160	b	2,500
1979	5,400	25,300	10,000	2,000	600	800	b	b	b	3,575
1978	8,300	21,900	10,100	3,400	600	850	b	b	b	2,840
1977	10,100	18,100	13,200	8,100	2,400	b	b	b	b	1,871
1976	6,500	6,200	16,600	19,600	1,900	6,300	b	–	100	2,017
1975	5,300	17,400	16,700	8,500	1,800	3,700	b	100	100	2,057
1974	12,800	21,000	15,300	b	800	1,000	b	100	200	1,400
1973	8,250	19,900	16,700	b	4,100	1,500	b	–	200	2,156
1972	9,800	21,650	15,500	b	2,300	600	b	100	200	1,592
1971	13,100	20,550	10,100	–	700	2,200	100	100	300	818
1970	19,600	15,300	11,100[c]	–	4,500	6,100	100	100	200	830
1969	38,100[d]		9,900[c]	b	2,500	3,200	200	200	300	280
1968	39,400[d]		9,500[c]	b	1,650	4,300	200	200	300	380

Source: Texas Crop and Livestock Reporting Service, 1980a.

[a]Pecans are measured in 1,000's of pounds of production.

[b]One producer.

[c]All hay.

[d]All cotton.

Table 2. Per Acre Yields of Selected Crops Grown in El Paso County, Texas, 1968 to 1979

Year	Cotton Upland (lb.)	Cotton Pima (lb.)	Alfalfa (ton)	Wheat (bu.)	Barley (bu.)	Grain Sorghum (bu.)
1979	596	371	6.1	48.7	52.0	67.9
1978	598	499	6.1	65.3	43.0	50.5
1977	730	772	6.4	62.1	59.3	[a]
1976	675	764	7.1	46.2	75.0	65.4
1975	435	219	6.2	82.4	42.1	33.0
1974	660	373	6.46		81.7	69.5
1973	653	345	6.53		72.6	49.8
1972	742	429	6.45		61.9	38.8
1971	758	467	4.0		50.0	45.3
1970	525	324			62.6	56.0
1969					61.0	67.8
1968					33.0	84.5
Average	637	426	6.15	63.0	57.9	16.3

Source: Texas Crop and Livestock Reporting Service, 1980a.

[a]No yield published for grain sorghum.

pump groundwater to supplement river water to grow these crops. This groundwater varies in salinity from 263 to 24,800 milligrams per liter dissolved solids (Meyer and Gordon). This use of saline groundwater affects yield, management and cultural practices, input usage and costs, soil condition and the quantity of irrigation water required.

Objectives

The overall objective of this study is to evaluate the effects of allocated irrigation water carry-over storage on farmers' crop production decisions in El Paso County, Texas and on agriculture in aggregate for the El Paso County Water Improvement District No. 1. Specific objectives are as follows:

1. To evaluate the individual farmer's position relative to allocated irrigation water carry-over storage. Specific items to be addressed are

    a. level basin irrigation,
    b. use of groundwater,
    c. selling of water, and
    d. identification of limitations.

2. To provide estimates for the district of

    a. production by crop,
    b. input needs by category,
    c. net farm income,
    d. changes in cropping patterns, and
    e. temporal implications on value of irrigation water.

Literature Review

With an average annual rainfall of 7.77 inches (The Dallas Morning News), El Paso County, Texas and the surrounding area are constantly concerned with adequate water supplies for agricultural, urban, industrial and recreational uses. El Paso County, with an international border, a state border and a county border, must view its water problems on four levels: international, national, state and local as shown in Figure 1.

The major aquifer in El Paso County, the Hueco Bolson, extends into Mexico (Figure 1). The Rio Grande River forms the international boundary between El Paso County and the Republic of Mexico. Therefore, the use, quantity and quality of available water supplies whether groundwater or surface water are of international concern and subject to international discussion (Day; Hernandez, 1978).

The Rio Grande flows into El Paso County from the state of New Mexico (Figure 1). The Hueco Bolson also extends into New Mexico. Thus, the impact of water use, quantity and quality on the regional economy are of national (national, in that more than one state is concerned) interest. Regional studies have been conducted by the Center for Business Services, College of Business Administration and Economics, New Mexico State University and the Department of Interior, Water and Power Resources Service, Southwest Regional Office (1980). Rio Grande River water quality has been studied and recorded by Hernandez (1976) for locations from San Marcial, New Mexico to Fort Quitmand, Texas.

The State of Texas is, of course, extremely concerned with the use, quantity and quality of water in El Paso County. McDaniels includes the El Paso area in his bulletin on water use by various crops in different parts of the state of Texas. The El Paso area is included in the Texas Water Plan (Texas Water Development Board). Groundwater supplies for westernmost Texas were surveyed by Gates, White, Stanley and Ackerman.

Groundwater development in the local El Paso area has been examined by Alvarez and Buckner as well as Meyer and Gordon. Alvarez and Buckner attempted to identify fresh groundwater for irrigation purposes. Meyer and Gordon provide a thorough examination of the development of groundwater in the study area for the period 1963 to 1970.

Water conservation is a prime concern in the El Paso area. Lansford, Creel and Seipel evaluated alternative water management systems for the Mesilla Valley, New Mexico (the Rio Grande River Valley in New Mexico adjacent to the valley in Texas, Figure 1) which would reduce return flows to the Rio Grande. Similarly, selected El Paso County farmers were intervived by Sonnen, et al. concerning current and future water conservation practices and incentives to further increase conservation efforts. These farmers indicated they would like to have the option to store part or all of their allocation of Rio Grande River water in Elephant Butte Reservoir, New Mexico, to be used at some future date upon request. This idea of irrigation water carry-over storage is sometimes referred to as "accumulation".

The quality of irrigation water and its effects on plant growth have been studied by several researchers. Shainberg and Oster relate the properties of irrigation water, the soil properties affecting water quality, crop growth and salinity to irrigation management for salt control. Maas and Hoffman discussed crop tolerances to salt. Ayers reviewed the limitations on use of irrigation water as imposed by the quality of the water. Longenecker and Lyerly explained the concepts of salinity and salinity control for farmers, landowners, gardeners and townspeople.

To evaluate the benefits of salinity control on the Red River of Texas and Oklahoma, Laughlin, Lacewell and Moore used a recursive linear program where production parameters were identified for various crops by soil types. The concept of modelling a limited agricultural production area by soil types provides more reliable cropping patterns and average yields. It also provides a guide for studying water accumulation in El Paso County.

The concern for the stochastic nature of water available for agriculture and profits therefrom have inspired various research activities. Lane and Littlechild examined two irrigation water pricing schemes for the Texas High Plains. One was independent of weather. The other scheme considered the effects of weather on the capacities of reservoirs in Louisiana. This water from Louisiana would be transported to the Texas High Plains by canals. This study showed that farm profits would be increased by 10% annually if a weather-dependent pricing scheme was used rather than a nonweather-dependent one. Moore and Armstrong used probabilistic linear programming techniques and Bayesian statistics to assess the value of increased accuracy of water supply forecasts for irrigated agriculture to decision makers. This study found that increased accuracy of water supply forecasts could increase return per acre by $6.25 for Colorado irrigators. Ahmed, van Bavel and Hiler developed a dynamic simulation model of the soil-water-atmosphere-plant system to make optimal irrigation decisions under a stochastic weather regime and limited water supplies. Young and

Bredehoeft developed a simulation model for dealing with conjunctive ground and surface water use in a fifty-mile reach of the North Platte River in eastern Colorado where the surface waters are stochastic in supply.

Randall addresses the question of irrigation water in the southwestern United States. Surface irrigation water supplies are stochastically replenishing over time. Federal law allows only waters actually on hand to be allocated for irrigation. Therefore, the supply of surface irrigation water in each year is fixed at some level. Randall's discussion leads to an examination of the demand and supply relationships of surface water. Randall says there are two demands for water, agricultural and urban. But the flow of the Rio Grande within the Rio Grande Project by law can only be used for satisfying agricultural water demand. Citizens may buy lands which have water rights and obtain Rio Grande water, but only as if they were an agricultural producer. Also, a city's ability to be involved in this manner is limited by law. Howe has provided a much more useful examination of water resource systems. He relates the availability of surface water to probability distributions. In addition, he discusses reservoir inflow and withdrawal. Howe's discussion was used extensively to gain insight and guidance on this study as a whole.

Watson, Nuckton and Howitt examine crop production and water supply characteristics of Kern County, California. This study demonstrates the types of information needed to deal with irrigation water questions in a localized, well-defined agricultural production area. Libbins, et al. developed detailed crop budgets for Dona Ana and Sierra counties of New Mexico. This study provides a detailed review of farming in the Rio Grande Valley just north of El Paso County, Texas. Richardson, et al. looked at farm size in El Paso County. They concluded that strict enforcement of the 160 acre limitation for farms irrigated by federal projects would have adverse economic effects on agriculture in El Paso County.

The importance of the judicious use of irrigation water in the southwestern United States is evidenced by the extensive literature concerning this topic and related issues. The above discussion is only an example of this literature. This literature is used in a variety of ways to ascertain the applicant theory set forth in the next chapter. It is also used to guide the collection of relevant input data in Chapter III. The development of the analytical models in Chapter IV are based on this literature. The analytical models produced results which are given in Chapter V. The results are interpreted by the conclusions, implications and limitations given in Chapter VI.

CHAPTER II

THEORY

The change in the regulation governing the use and storage of individual irrigation water allocations necessitates that agriculture producers of El Paso County re-examine their strategies for allocating resources and selecting cropping patterns. This requires the re-evaluation of resource allocation within a production period and the temporal allocation of a stochastically replenishable resource. The theory underlying these two allocation problems is reviewed in this chapter. Also, examined in this chapter is the theoretical relationship between marginal analysis and linear programming.

Allocation of Variable Resources

The demand for variable resources used in production by a firm can be explained by economic theory. If perfect competition is assumed in the product market[2] and producers are characterized as profit maximizers, the marginal value product (MVP) curve of a resource gives the demand for that resource by the firm (Beattie). Under these assumptions the MVP_x equals the marginal physical product of the resource (X) times the price (P) of the product (Y) or $MVP_x = MPP_x \cdot P_y$. The demand for a resource given that there are no other variable resources used in

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[2]Activities of a single firm have no effect on the market in which its production is sold. Specifically, a change in the amount of resource X employed by the i^{th} firm will not affect the price P of output Y.

production can be given by the MVP curve. The MVP curve is simply a schedule which depicts the quantity of the resource demanded by the firm at various prices for the resource (Figure 2). Since the firm is assumed to be profit motivated, it would use that quantity of X such that the price of the resource, P_X, would just equal the MVP of the resource, or $P_X = MVP_X$.

An MVP curve is not an appropriate estimate as a firm's demand for a resource if the firm utilizes more than one variable resource in its production process. If there are i such variable resources used by the firm, then as the price of one variable resource, say X_1, changes different quantities of complementary or competitive variable resources are demanded. This assumes that the prices of all other variable resources other than X_1 are held constant. As the price of X_1, $P_{x_1^o}$, decreases to $P_{x_1^1}$, increased levels of the other complementary resources, X_2, X_3, ..., X_i, are employed because increased levels of X_1 are being employed. This changes the production relationships and causes the MPP_{x_1} to change, thus shifting the MVP curve for X_1 from $MVP_{x_1^o}$ to $MVP_{x_1^1}$ (Figure 3). Thus, as P_{x_1} changes instead of moving along, $MVP_{x_1^o}$ the firm must search along $MVP_{x_1^1}$ for a position in which the new price, $P_{x_1^1}$, equals the new MVP curve, $MVP_{x_1^1}$. The demand for X_1 in this circumstance then is along some schedule D drawn through points X_1^o, $P_{x_1^o}$ and X_1^1, $P_{x_1^1}$. Now, if the other resources had been substitutes then the shift in the MVP curve would have been to the left with a move along it to the right to find the profit maximizing point. Thus, when dealing with production process involving several variable resources, a price change for one resource can cause adjustments in other variable resources.

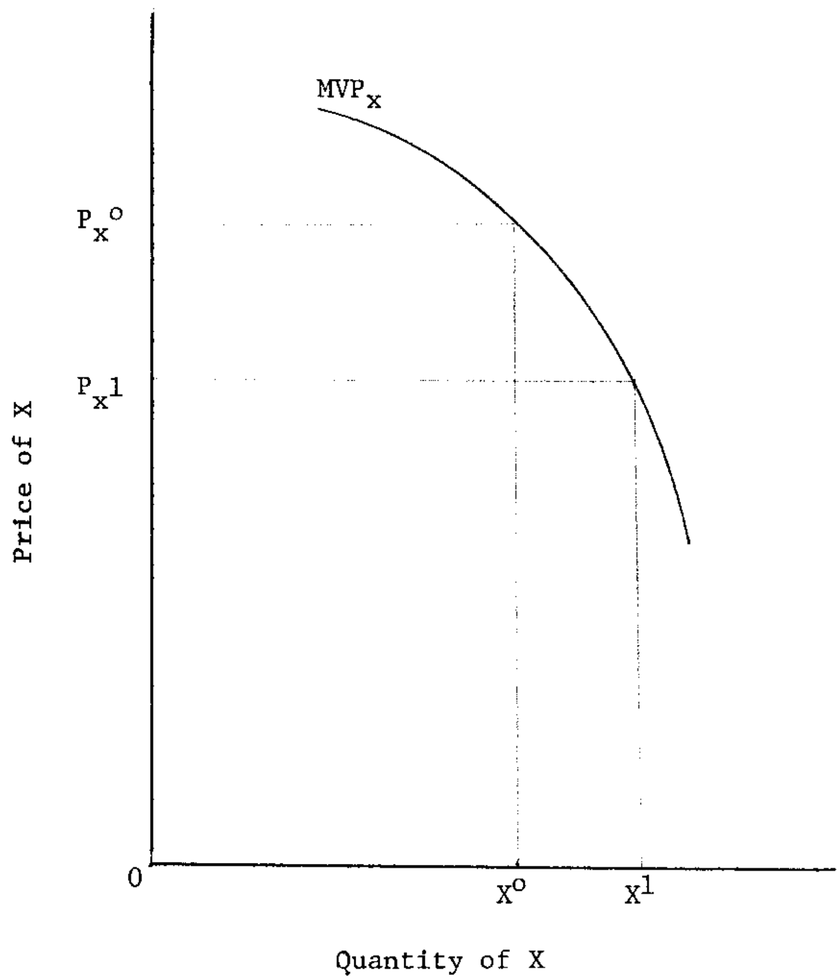

Figure 2. Demand for a Single Variable Resource, X.

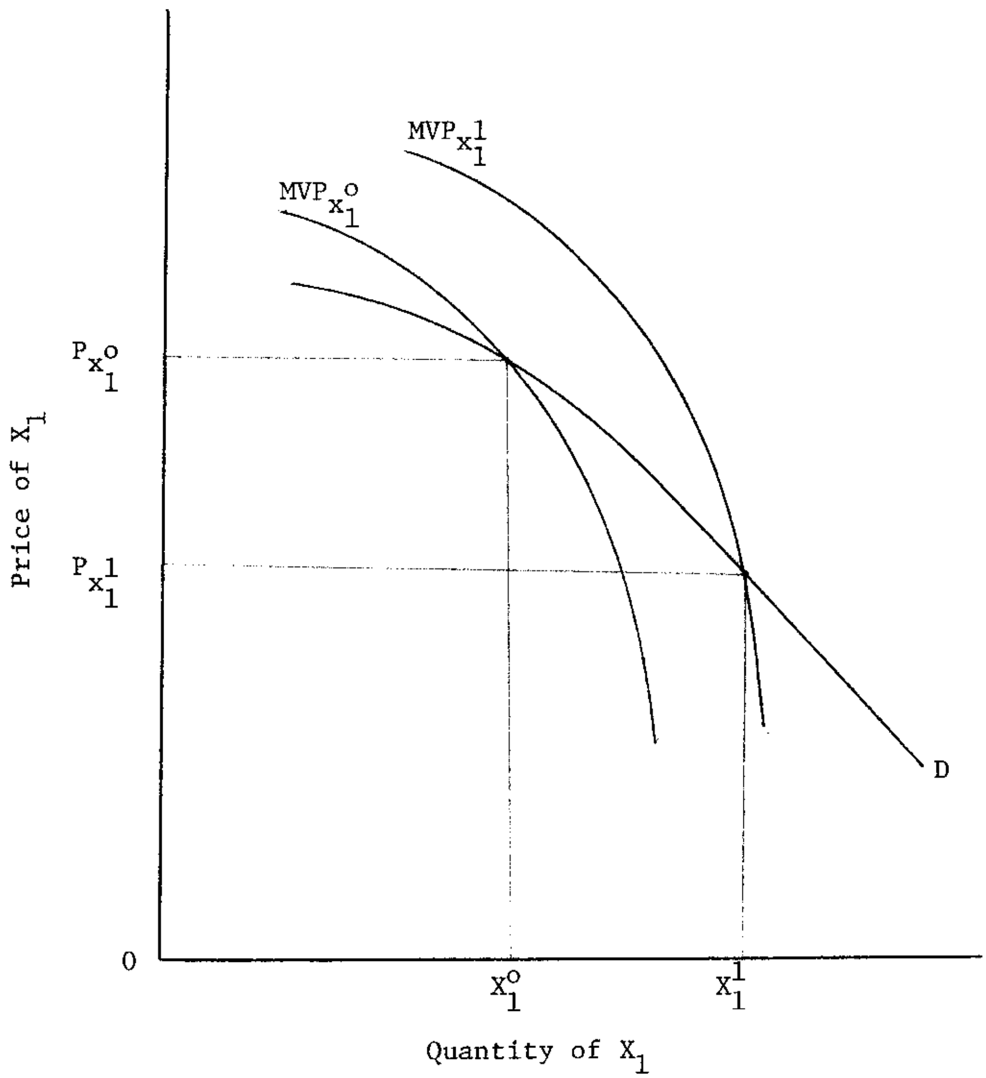

Figure 3. Demand for a Variable Resource, X_1, With Other Complementary Variable Resources Used in Production.

Profit maximizers are interested in the least-cost combinations of producing each possible level of output. If the MPP of resource X_1 relative to its price, P_{x_1}, was greater than the MPP of resource X_2 relative to its price, P_{x_2}, then utilizing more X_1 relative to X_2 would lower the total cost of producing some output level Y_o. Thus, the least cost situation is where $MPP_{x_1}/P_{x_1} = MPP_{x_2}/P_{x_2}$. This condition over various output levels is called the expansion path and can also be given by $MVP_{x_1}/P_{x_1} = MVP_{x_2}/P_{x_2}$ because $MVP_{x_i} = MPP_{x_i} \cdot P_y$. To maximize profits, $MVP_{x_i} = P_{x_i}$ or $MVP_{x_i}/P_{x_i} = 1$. At $MVP_{x_i}/P_{x_i} = 1$, the MPP to resource price ratios of all resources are also equal. Thus, $MVP_{x_i}/P_{x_i} = 1$ gives the least-cost profit maximizing combination of resources and output level. This situation is shown for the two resource case in Figure 4 along with the expansion path and the pseudoscale lines for the two resources where the ratio of the MVP and price of a resource equal one.

Allocation of a Stochastically Replenishable Resource

Short-Run Allocation

A resource such as surface irrigation water in the El Paso County Water Improvement District is stochastic in that the pattern of water allocations to producers is not readily predictable or uniform. Renewable resources, such as timber, groundwater and fish are renewed at a determinable rate. Surface irrigation water is not replenished at a determinable rate, although it is replenished annually at some level.

As a producer approaches a production period, the annual amount of surface water (the stochastically replenishable resource) is fixed

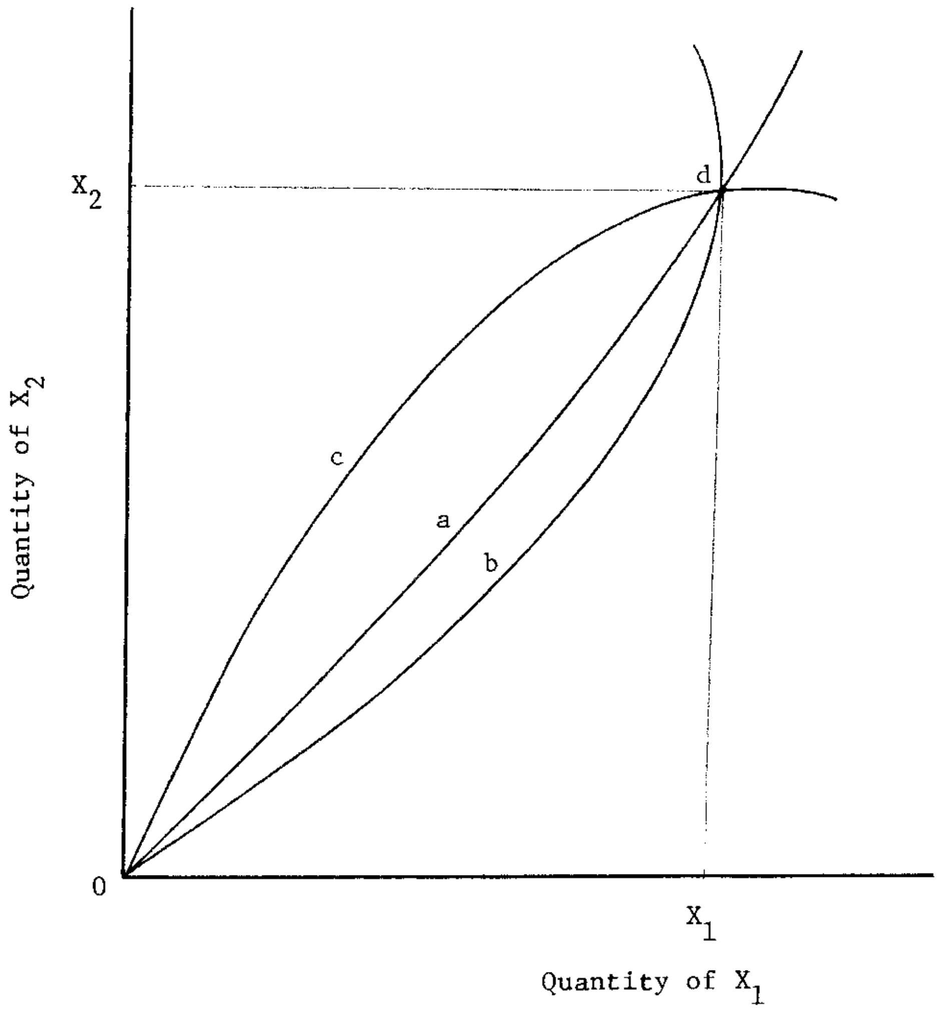

Figure 4. Expansion Path, Pseudoscale Lines and Least Cost, Profit Maximizing Point for the Two Resources, X_1 and X_2, Case.

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[a] Expansion path, $\frac{MPP_{x_1}}{P_{x_1}} = \frac{MPP_{x_2}}{P_{x_2}}$.

[b] Pseudoscale line for X_1, $\frac{MVP_{x_1}}{P_{x_1}} = 1$.

[c] Pseudoscale line for X_2, $\frac{MVP_{x_2}}{P_{x_2}} = 1$.

[d] This point indicates the levels of X_1 and X_2 which yield the profit maximizing level of production.

to him by governmental agencies in keeping with international, national, state and local laws. Thus, to now a producer had to regard his surface water allocation as a fixed resource in any year. He either took his entire allocation in a given year or lost it. Thus, the least cost, profit maximizing combination of resources and output was determined subject to a fixed level of the surface irrigation water resource available and subject to all other variable resources.

Temporal Analysis

The real question of a stochastically replenishable resource is how much of this varying resource flow to use and when to use it. Since irrigation reservoirs are replenished by probablistic physical processes, the availability of surface water can be described by a probability distribution (Howe). A Rippl diagram[3] which employs cumulative inflow and withdrawal curves addresses this idea of a probability distribution of flows rather than a constant rate. The concept of the "storage-yield curves" says that ignoring evaporation losses, there is some uniform withdrawal rate which approaches the mean flow. This uniform withdrawal rate is maintained by storing all excess waters. Along with evaporation and transportation losses, these concepts define the resource dynamics of a surface irrigation water system. These resource dynamics affect the manner in which surface water is temporarily used.

How does one use a resource optimally over time? This depends on the objectives of those managing the resource. To determine an actual

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[3] The Rippl diagram was named after an engineer who first used it in reservoir design in 1882.

optimal temporal use schedule for a resource, a deterministic model may be developed which incorporates these management objectives and resource dynamics. One such model may utilize linear programming.

Marginal Analysis and Linear Programming

Optimal allocation of scarce resources in the production process is the primary concern of production economics. This is done by utilizing the marginal analysis techniques developed above. The application of economic theory is sometimes done by means of linear programming, as it will be done in this study. Linear programming optimizes a linear objective function given a set of constraints or limitations on the resources involved.[4] In doing so, differences from marginal analysis do appear.

Marginal analysis is based on a continuous production function with a decreasing marginal rate of substitution. This production function is defined on the inputs used and, while it expresses the relationship of inputs to outputs, it does not specifically define each activity involved in the production process. Linear programming is based on specifically defined production activities with constant input-output ratios. Linear programming assumes that inputs and outputs are additive and divisible. Marginal analysis maximizes profit subject to the technical constraints of the production function. On the other hand, linear programming maximizes profit subject to the constraints of the specifically defined activities and input levels.

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[4]The degree of scarcity of the resource is numerically specified.

With these differences, how is it that linear programming can be used for marginal analysis? Precisely, can the activities of linear programming define a production function? Each point on a production function has some ratio of inputs to output. Thus, each point could be described by a linear programming activity. But this is not necessary if there are portions of the production function which can be estimated by a linear segment. Any point between the end points of a line segment can be described as a linear combination of the activities specified by the end points. Thus, linear programming can reflect a production function and is, in fact, more readily adaptable to multi-product, multi-resources problems than attempting to estimate a production function.

CHAPTER III

INPUT DATA

The basic technique used to estimate the effects of establishing a water accumulation or storage system for the El Paso County Water Improvement District No. 1 was mathematical programming. A summarization of the steps followed to build the model was as follows:

(a) Estimation of current (1980) irrigated crop yields for each of the study area soil types.

(b) Estimation of reduced irrigated crop yields due to the use of saline groundwater for each of the study area soil types.

(c) Development of input requirements for all crops grown on all soil types for irrigation with either surface water or groundwater and with and without laser land leveling[5] technology.

(d) Formulation of the above data into a linear programming model to determine cropping patterns and optimal resource allocations for a given annual level of surface irrigation water.

(e) Development and application of a companion linear programming model to determine optimal temporal allocation of surface water.

(f) Calculation of net present value of various net revenue streams which are determined by some specified scenario of temporal surface irrigation water use.

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[5]See Appendix A.

Each of the steps above is discussed in greater detail beginning with crop yields and their input requirements. Next, the linear program utilized to allocate resources will be examined in Chapter IV. Also, Chapter IV will deal with temporal surface water use scenarios.

Crop Yields, Soil Types and Salinity

Twelve crops were selected for the study because of their acreage or their potential or historical production. These crops are upland and pima cotton, alfalfa, wheat, barley, grain sorghum, pecans, tomatoes, lettuce, onions and green and red chili. Table 1 presents either the planted or harvested acreage of ten of the above crops. Chili was not given in the county statistics. The predominate crops are upland and pima cotton, alfalfa, wheat, grain sorghum and pecans. Cotton represents about 50 percent of total crop acreage. Barley and vegetables have been historically more important than at present. The vegetable crops -- tomatoes, lettuce, onions, green chili and red chili -- have potential for expansion (Peavy). Chili acreage has been on the increase and Peavy estimates that approximately 700 acres are grown in the county.

Yields may vary according to soil type and salinity of groundwater. Yields for all crops by soil type were first determined. The soils of the study area were obtained from the U.S. Department of Agriculture, Soil Conservation Service (Table 3). Madeland, the Agustin Association and the Bluepoint Association were deleted from consideration because each comprised less than one percent of irrigated land in the study area. The remaining fourteen soils were placed into six separate groups. Soils

Table 3. Soil Types, Percentages of Irrigated Land and Acreages for El Paso County, Texas

Soil Type	Percent of Irrigated Land[a]	Adjusted Percentage of Irrigated Land	Acreage
Glendale loam	1.3		
Glendale silty clay loam	5.4		
Harkey loam	16		
Harkey silty clay loam	22		
Total GH Soil Group	44.7	47.6	22,848
Gila fine sandy loam	3		
Gila loam	4		
Pajarito association, level	1.4[b]		
Total GP Soil Group	8.4	8.9	4,272
Saneli silty clay loam	9		
Anapra silty clay loam	6		
Total SA Soil Group	15	16.0	7,680
Saneli silty clay	3.3		
Tigua silty clay	8.5		
Glendale silty clay	9		
Total ST Soil Group	20.8	22.2	10,656
Vinton fine sandy loam (VN Soil Group)	4	4.3	2,064
Brazito loamy fine sand (BR Soil Group)	1	1.1	528
Made land, gila soil material	0		
Agustin association, undulating	<1		
Bluepoint association, rolling	<1		
Total Percentage	93.9	100.1	
Total Acres			48,048

[a]Reported by the U.S. Department of Agriculture, Soil Conservation Service.

[b]Reported as 1,000 acres. The percentage was calculated dividing this 1,000 acres by 69,010 acres of water right vested land.

with the same or very nearly the same crop yield estimates across all crops were placed in the same group.[6] The groups closely followed the suggestions and comments of area soil and crop experts (McDonald, McMasters, Rives, Bauer, Peavy and Malstrom). Where more than one yield estimate was obtained for a crop on a given soil group, the mean of all estimates for that soil group was used as the group yield. The soil group yields were adjusted by .8 to reflect typical management. Laughlin has also adjusted yields in this manner. The yields developed as representative for the study area are given in Table 4 under salinity level 1.

Since the salinity levelof irrigation water also affects crop yield, the effect of pumping saline groundwater on crops was estimated. Meyer and Gordon give salinity levels of selected wells in the study area. From this information salinity ranges were established. The median of the range was used as the salinity value for the range with the exception that the salinity value for level 1 was set at 450 parts per million dissolved solids. This information is given in Table 5. The number of wells with salinity levels in specified ranges was used to determine the percentage of land with groundwater of a given salinity level. Two groups of wells from Meyer and Gordon were not considered. The first was all wells in New Mexico. The second group was those wells between the gap (El Paso de Norte) and the intersection of F.M. 75 and U.S. 80. These wells are primarily El Paso City water wells in the city area proper.

[6] Yield estimates were made assuming high level management.

Table 4. Yields for Selected Crops by Irrigation Water Salinity Level and Soil Group for El Paso County, Texas

Crop	Salinity Level[a]	Yield Reduction[b]	Soil Group[c] GH	GP	SA	ST	VN	BR
Cotton, Upland (lbs.)	1-4	0	872	836	696	680	592	440
	5	5.8	821	788	656	641	558	414
	6	24.2	661	634	528	515	449	334
Cotton, Pima (lbs.)	1-4	0	540	540	431	431	371	300
	5	5.8	509	509	406	406	349	283
	6	24.2	409	409	327	327	281	227
Alfalfa (tons)	1	0	6.4	6.4	4.8	4.4	4.0	3.6
	2	2.0	6.3	6.3	4.7	4.3	3.9	3.5
	3	14.0	5.5	5.5	4.1	3.8	3.4	3.1
	4	28.3	4.6	4.6	3.4	3.2	2.9	2.6
	5	49.6	3.2	3.2	2.4	2.2	2.0	1.8
Wheat (bus.)	1-4	0	80	72	68	61	56	48
	5	19.6	64	58	55	49	45	39
	6	44.6	44	40	38	34	31	27
Barley (bus.)	1-4	0	80	79	70	72	52	48
	5	4.0	77	76	67	69	50	46
	6	21.3	63	62	55	57	41	38
Grain Sorghum (bus.)	1-3	0	77	69	64	57	51	47
	4	15.4	65	58	54	48	43	40
	5	36.0	49	44	41	36	33	30
Pecan (lbs.)	1-2	0	2000	1750	1250	1100	1500	1300
	3	5.3	1894	1657	1184	1042	1421	1231
	4	16.6	1668	1460	1043	917	1251	1084
	5	33.3	1334	1167	834	734	1001	867
Tomato (tons)	1-2	0	12.0	9.8	11.6	8.4	7.8	6.0
	3	13.0	10.3	8.4	10.0	7.2	6.7	5.2
	4	32.9	8.1	6.6	7.8	5.6	5.2	4.0
Lettuce[d] (ctn[e])	1	0	578	472	558	405	376	289
	2	11.8	510	417	492	357	331	255
	3	34.2	381	311	368	266	247	190
Onion[d] (sack[f])	1	0	740	605	714	518	481	370
	2	17.7	614	502	592	429	399	207
	3	42.7	424	347	409	297	276	212
Chili, green (tons)	1	0	8.0	6.5	7.7	5.6	5.2	4.0
	2	9.7	7.2	5.9	7.0	5.1	4.7	3.6
	3	32.9	5.4	4.4	5.2	3.8	3.5	2.7
Chili, red (tons)	1	0	3500	2860	3378	2450	2275	1750
	2	9.7	3161	2583	3050	2212	2054	1580
	3	32.9	2349	1919	2267	1644	1527	1174

[a]Salinity levels are defined in Table 5. Salinity levels which have the same yields are listed together.

[b]Yield reductions were calculated from information in Ayers.

[c]Soil groups are defined in Table 3.

[d]Yields adjusted for possibility of non-harvest.

[e]50 pound carton.

[f]50 pound sack.

Table 5. Salinity Levels, Ranges and Values and Number and Percentages of Wells for El Paso County, Texas

Salinity Level	Limits: Lower PPM	Limits: Upper PPM	Salinity Level Value PPM	Number of Wells[a]	Percentage of Total Wells
1	0	600	450	10	5.9
2	601	1300	950	48	28.7
3	1301	2000	1650	46	27.5
4	2001	3000	2500	33	19.7
5	3001	4500	3750	22	13.1
6	4501	6000	5250	8	4.7

[a]The number of wells by salinity level was determined from information in Meyer and Gordon.

Based on the El Paso County Soil Survey, all soils in the study area occur randomly throughout (U.S. Department of Agriculture, Soil Conservation Service). Salinity levels increase in the groundwater going from north to the south. With the random occurrence of each soil, each soil group acreage was divided into salinity level acreages based on the percentage of wells in a salinity range. These acreages are given in Table 6.

Using information given in Ayers and based on the salinity level value of Table 5, crop yield reductions for each salinity level were developed. The crop yield reduction and yield by salinity level is shown in Table 4. Pecans are an exception. Ayers did not provide any yield reduction for pecans. Malstrom suggested that the threshold salinity level, the highest level of salinity which does not cause a yield loss, may be about 1250 ppm. He also indicated that a 10 percent yield reduction was likely around 2000 ppm. Malstrom also said that a 40 percent yield reduction probably occurs near 5000 ppm. These were the relationships used to determine the percentage yield reductions for pecans in Table 4. Yields for crops irrigated with project water (surface water) was assumed to be the same as the yield for salinity level 1, Table 4.

While tomatoes and chili are grown under contract, lettuce and onions are not. In some years, even high yielding, excellent quality fields of lettuce and onions are simply plowed under due to lack of demand. Thus, the yields of both lettuce and onions were adjusted by a factor to reflect the possibility of not being harvested. Dona Ana County, New Mexico produces most of the vegetables in the general area. This adjustment factor was determined by dividing the reported harvested

Table 6. Cultivated Acreages by Salinity Level and Soil Group for El Paso County, Texas

Salinity Level[a]	Percentages of Total Acreage	Soil Group[b]					
		GH	GP	SA	ST	VN	BR
1	5.9	1,368	256	460	638	124	32
2	28.7	6,567	1,228	2,207	3,063	593	152
3	27.5	6,293	1,177	2,115	2,935	569	145
4	19.5	4,513	844	1,518	2,106	408	104
5	13.1	3,010	563	1,012	1,404	272	70
6	4.7	1,095	205	368	510	99	25
Total		22,848	4,272	7,680	10,656	2,064	528

[a] Salinity levels are defined in Table 5.

[b] Soil groups are defined in Table 3.

acres of Dona Ana County by the reported planted acres for Dona Ana County for each crop for the years 1976 through 1980 (New Mexico Crop and Livestock Reporting Service). These acreages and adjustment factors are listed in Table 7. Yields for lettuce and onions were adjusted downward by 17.32 percent and 7.45 percent, respectively. The yields of lettuce and onions given in Table 4 represent the results of the adjustment.

The yield of cottonseed, not shown in Table 4, was set at 1.6 pounds per pound of cotton lint. A cottonseed yield of 1.6 pounds per pound of lint (Table 8) appears to be the relationship in Dona Ana County which lies adjacent to El Paso County. No measures of cottonseed production were available for El Paso County.

Input Requirements

Crop input requirements were developed for a base situation. This involved one yield for each crop. These yields were those used by Libbin, et al. with the four exceptions of barley, pecans, lettuce and green chili. The barley yield was that used in 1979 "Texas Crop Budgets" for El Paso County (Extension Economists-Management). The pecan yield was that used by Gorman, Landrum and Hicks in the southern Rio Grande Valley of New Mexico. The lettuce yield was a weighted average of Libbins, et al.'s spring and fall yields.[7] The green chili

[7] Spring was weighted 1/3 and fall 2/3 based on the historical acreages of these crops in Dona Ana County, New Mexico (New Mexico Crop and Livestock Reporting Service). Any single number used in this study relating to lettuce or lettuce production is a weighted average calculated in this manner unless otherwise stated.

Table 7. Planted and Harvested Acres and Percentages of Planted Acres Harvested for Lettuce and Onions, Dona Ana County, New Mexico, 1976 through 1980

Year	Lettuce[a]			Onions		
	Acres		Percent of Planted Acres Harvested	Acres		Percent of Planted Acres Harvested
	Planted	Harvested		Planted	Harvested	
1980	3900	3500	89.74	4000	3900	97.50
1979	4420	3830	86.65	2830	2600	91.87
1978	5700	4650	81.58	3380	2930	86.69
1977	5500	3750	68.18	3500	3200	91.43
1976	4700	4100	87.23	4200	4000	95.24
Average			82.68			92.55

Source: New Mexico Crop and Livestock Reporting Service.

[a]Total spring and fall lettuce.

Table 8. New Mexico State Production of Cottonseed, Cotton Lint and Their Relationship for 1976 through 1980

Year	Cottonseed 1,000 Tons	Cotton Lint 1,000 Bales	Cottonseed Divided by Cotton Lint lb./lb.
1980	43	110.2	1.63
1979	44	111.5	1.64
1978	44	114	1.61
1977	68	173	1.64
1976	29	76.2	1.59

Source: New Mexico Crop and Livestock Reporting Service.

yield was that used by Libbins, et al. except the final harvest of low quantity red chili was converted to a green chili equivalent at the ratio of 5 pounds of green chili to 1 pound of red chili (New Mexico Crop and Livestock Reporting Service).

Input requirements were divided into the eight following areas: (1) seed; (2) chemicals; (3) water; (4) machinery; (5) labor; (6) harvest; (7) other; and (8) fixed. Table 9 presents the base crop enterprise input requirements. Where no barley input requirements were available, the input requirements for wheat were used.

Seed Inputs

The quantities of seed indicated in Table 9 were taken from Libbins, et al., except for barley. The seed requirement for barley was taken from the 1979 "Texas Crop Budgets" (Extension Economists-Management). Seed and seedling costs for alfalfa and pecans are included in amoritized establishment cost under the fixed input section.

Chemical Inputs

Fertilizer requirements were established as a function of expected yields due to soil type or salinity level for upland and pima cotton, wheat, barley and grain sorghum. Constant fertilization rates were assumed for alfalfa and pecans due to the temporal nature of production of these crops. A lack of proper fertilization in one year could affect the yield in some future yield. Tomatoes, lettuce, onion and green and red chili were assumed to be fertilized at constant rates due to the high cost of production. When high levels of returns are required to offset high costs of production, it was assumed a producer

Table 9. Input Requirement for Twelve Selected Crops Grown in El Paso County, Texas

Item	Unit	Upland Cotton	Pima Cotton	Alfalfa	Wheat	Barley	Grain Sorghum
Yield		650	650	8	33	85	71.4
Unit		lb.	lb.	ton	bu.	bu.	bu.
Inputs:							
Seed	lb.	25	25		120	120	9
Chemicals							
Nitrogen	lb.	a	a		b	b	b
Phosphorus	lb.	a	a	80			
Potassium	lb.						
Zinc	gal.						
Insecticide	$	35	20	10	7	7	18
Herbicide	$	18	18		5	5	12
Nematicide	$						
Dust	$						
Water							
Required [c]	ac/ft.	2.5	2.5	6.0	3.0	3.0	2.17
Well [c]		d	d	d	d	d	d
Machinery							
Diesel	gal.	17.72	17.72	.95	7.04	7.04	11.71
Gas	gal.	2.0	2.0	1.8	1.4	1.4	2.0
Oil and Lube	$	5.70	5.70	.31	2.95	2.95	4.48
Repairs	$						
Labor							
Machinery	hr.	6.79	6.79	.38	2.45	2.45	4.73
Irrigation [c,e]	hr.	5.75	5.75	13.80	6.90	6.90	5.06
Hoe [f]							
Harvest							
Custom	$	.074	.080		.36	.35	.336
Wire	lb.			8.75			
Bags	number						
Forklift	hr.						
Diesel	gal.	g	g	h			
Gas	gal.	g	g	h			
Oil and Lube	$	g	g	h			
Repairs	$	g	g	h			
Labor	hr.	g	g	h			
Other							
Crop Insurance	$	20	20				
Laser Leveling	$	45	45		45	45	45
Farm Insurance	$	4.30	4.30	4.30	4.30	4.30	4.30
Land Tax	$	7.83	7.83	7.83	7.83	7.83	7.83
Water District Tax	$	21	21	21	21	21	21
Miscellaneous	$	30	30	30	30	30	30
Interest on Operating Capital (6 mo.)	%	9.203	9.203	9.203	9.203	9.203	9.203
Fixed							
Establishment	$			50.50			
Machinery	$	77.11	77.32	72.00	22.61	22.61	27.69
Well	$	33.51	33.51	33.51	33.51	33.51	33.51

Table 9. (Continued)

Item	Unit	Pecans	Tomatoes	Lettuce	Onions	Green Chili	Red Chili
Yield		2000	12	467	700	8.25	280
Unit		lb.	ton	ctn.	sack	ton	lb.
Inputs:							
Seed	lb.		2	.6	4	5	8
Chemicals							
Nitrogen	lb.	330	63	300	450	300	200
Phosphorus	lb.	110	180	200	250	70	60
Potassium	lb.	60					
Zinc	gal.	3					
Insecticide	$	16.84	15	100	41	9.70	9.70
Herbicide	$		12	6.67	35	19	19
Nematicide	$					30	30
Dust	$			11.67			
Water							
Required[c]	ac/ft.	3.0	2.6	2.6	2.6	2.6	2.6
Well[c]		d	d	d	d	d	d
Machinery							
Diesel	gal.	13.70	20.58	22.32	25.02	23.07	21.57
Gas	gal.	1.8	2.0	2.0	2.0	2.0	2.0
Oil and Lube	$	20.86	6.06	7.26	8.17	7.48	6.97
Repairs	$	32.61	8.11	8.62	9.45	8.31	7.97
Labor							
Machinery	hr.	15.54	8.90	9.30	10.79	9.45	9.07
Irrigation[c,e]	hr.	6.90	5.98	5.98	5.98	5.98	5.98
Hoe		20.21	37.00	160.00	120.00	93.00	93.00
Harvest[f]							
Custom	$	.18	8.75	2.5493	2.33	75.64	.1975
Wire	lb.						
Bags	number				1.15		
Forklift	hr.					.99	.33
Diesel	gal.		h			7.83	2.61
Gas	gal.		h				
Oil and Lube	$		h			.84	.28
Repairs	$		h			1.82	.61
Labor	hr.		h			4.87	1.62
Other							
Crop Insurance	$					40	40
Laser Leveling	$		45	45	45	45	45
Farm Insurance	$	4.30	4.30	4.30	4.30	4.30	4.30
Land Tax	$	7.83	7.83	7.83	7.83	7.83	7.83
Water District Tax	$	21	21	21	21	21	21
Miscellaneous	$	42	30	30	30	30	30
Interest on Operating Capital (6 mo.)	%	9.203	9.203	9.203	9.203	9.203	9.203
Fixed							
Establishment	$	219.53					
Machinery	$	101.14	67.22	53.82	57.92	61.07	51.79
Well	$	33.51	33.51	33.51	33.51	33.51	33.51

[a]See Table 10.

[b]See Table 11.

[c]These requirements increase by 20 percent when leaching is required.

[d]See Table 15.

[e]Does not include labor to operate irrigation well.

[f]All requirements for harvesting operations are on a per harvested unit basis except where indicated.

[g]See Table 16.

[h]See Table 17.

would not risk a yield reduction due to lack of a necessary input such as fertilizer.

The 1979 "Texas Crop Budgets" (Extension Economists-Management) were used to establish the base fertilizer requirements for upland and pima cotton, alfalfa, wheat, barley and grain sorghum. The fertilizer requirements for pecans were taken from Gorman, Landrum and Hicks. For tomatoes, lettuce, onions and green and red chili, the fertilizer requirement was taken from Libbins, et al. The fertilizer requirements at alternative yield levels for upland and pima cotton, wheat, barley and grain sorghum are listed in Tables 10 and 11.

To adjust fertilizer requirements as yield changes, information given by Welch, et al. was used. Welch, et al. report fertilization rates for various yields for various soil fertility levels for grain sorghum, cotton and wheat. The information for wheat was assumed suitable for barley. The soil productivity in the study area appears to have dropped in the last thirty years (McDonald; McMasters). The low fertility level from Welch, et al. was used for fertilizer requirements. But crop yields and total fertilizer applications for the study area exceeded the crop yields and total fertilizer applications given in Welch, et al. Therefore, Welch, et al. was used at a base to adjust those fertilizer requirements for the study area given in the 1979 "Texas Crop Budgets" (Extension Economists-Management).

Welch, et al. suggested a 20 pound application of nitrogen for each 240 pounds of cotton lint yield for the three yield levels reported. Therefore, the fertilizer-yield response was assumed linear. To determine this relationship the nitrogen fertilizer requirement

Table 10. Nitrogen and Phosphorus Requirements for Selected Upland and Pima Cotton Yields for El Paso County, Texas

Upland Cotton			Pima Cotton		
Yield lb/acre	Nitrogen Requirement lb/acre	Phosphorus Requirement lb/acre	Yield lb/acre	Nitrogen Requirement lb/acre	Phosphorus Requirement lb/acre
872	126	63	540	120	60
836	121	61	509	113	57
821	119	60	431	96	48
788	114	57	409	91	46
696	101	51	406	90	45
680	99	50	371	82	41
661	96	48	349	78	39
656	95	48	327	73	37
641	93	47	300	67	34
634	92	46	283	63	32
592	86	43	281	62	31
558	81	41	227	50	25
528	77	39			
515	75	38			
449	65	33			
440	64	32			
414	60	30			
334	48	24			

Note: Nitrogen and phosphorus requirements were developed from Extension Economists-Management and Welch, et al.

Table 11. Nitrogen Requirements for Selected Wheat, Barley and Grain Sorghum Yields for El Paso County, Texas

Wheat		Barley		Grain Sorghum	
Yield bu/acre	Nitrogen Requirement lb/acre	Yield bu/acre	Nitrogen Requirement lb/acre	Yield bu/acre	Nitrogen Requirement lb/acre
80	234	80	188	77	162
72	211	79	186	69	145
68	199	77	181	65	137
64	188	76	179	64	134
61	179	72	169	58	122
58	170	70	164	57	120
56	164	69	161	54	113
55	162	67	155	51	107
49	143	63	143	49	103
48	140	62	140	48	101
45	129	57	125	47	99
44	125	55	116	44	92
40	110	52	103	43	90
39	105	50	94	41	86
38	99	48	85	40	84
34	77	46	76	36	76
31	61	41	60	33	69
27	49	38	56	30	63

Note: Nitrogen and phosphorus requirements were developed from Extension Economists-Management and Welch, et al.

of 100 pounds (Extension Economists-Management) was divided by the expected yield of 690 pounds (Extension Economists-Management) for upland cotton. Likewise, 100 pounds of nitrogen was divided by 450 pounds of cotton lint for pima cotton. This gave a coefficient of 0.14493 pounds of nitrogen for each pound of upland cotton lint and 0.22222 pounds of nitrogen for each pound of pima cotton lint over the range of yields considered. These coefficients were then multiplied by each projected upland or pima cotton yield to determine the correct fertilizer requirement. The same linear relationship holds for phosphorus. The phosphorus rates for cotton (Welch, et al.) and the phosphorus base rate (Extension Economists-Management) were exactly one-half the corresponding nitrogen rates. No potassium requirements were indicated for any crop except pecans.

The situation for wheat and barley was more complex and a summary of the calculations is given in Table 12. Extension Economists-Management gave a 250 pound nitrogen requirement for an 85 bushel wheat yield. Welch, et al. reported an 80 pound requirement at a 50 bushel wheat yield. Welch's 80 pound nitrogen requirement was replaced by a 147 pound requirement. This adjustment was based on pounds of nitrogen per bushel of yield given 250 pounds of nitrogen at an 85 bushel yield. Welch, et al. indicate that 3/4 of the nitrogen required at a 50 bushel yield is required at a 40 bushel yield. Thus, the requirement at a 40 bushel yield was set at 3/4 of 147 pounds or 110 pounds. Likewise, 1/2 of the requirement at a 40 bushel yield is necessary at a 30 bushel yield. Thus, 1/2 of 110 pounds or 55 pounds was used as the nitrogen fertilizer requirement at a 30 bushel wheat

Table 12. A Summary of the Calculations Necessary to Establish Nitrogen Requirements for Wheat and Barley

Crop	Yield (bu)	Welch Nitrogen Requirement[a] (lb)	Extension Nitrogen Requirement[b] (lb)	Adjusted Nitrogen Requirement (lb)	Yield Difference (bu)	Nitrogen Requirement Difference (lb)	Difference Coefficient (lb/bu)
Wheat	30	30		55	30	55	1.8
	40	60		110	10	55	5.5
	50	80		147	10	37	3.7
	85		250		35	103	2.9
Barley	43	30		63	43	63	1.46512
	57	60		125	14	62	4.42857
	71	80		167	14	42	3
	85		250		14	33	2.35714

[a]Welch, et al.

[b]Extension Economists-Management.

yield. Next, the differences between yield levels were calculated. Also, the associated change in the fertilizer requirement was determined. The change in fertilizer requirement was divided by the change in yield to determine a coefficient of change for each yield range. Thus, a coefficient was determined for each range, 0 to 30 bushels, 30 to 40 bushels, 40 to 50 bushels and above 50 bushels. A fertilizer requirement could then be found for a yield by: first, finding the range in which the yield falls; second, subtracting from the yield the low end of the range; third, multiplying this difference by the coefficient of the range; and fourth, adding this number to the fertilizer requirement for the yield at the low end of the range. This procedure was used to determine all the nitrogen fertilizer requirements for wheat. Extension Economists-Management do not have a phosphorus requirement for wheat. Thus, no phosphorus requirement was included.

The same procedure was used for barley except that the relationship of 60 bushels of wheat for 85 bushels of barley was first used to establish barley yield levels comparable to the wheat yields previously used. There was no phosphorus requirement for barley (Extension Economists-Management). Nitrogen fertilizer requirements for wheat and barley are given in Table 11.

The nitrogen fertilizer-yield response given in Welch, et al. for grain sorghum is also linear for the range of relevant yields. The coefficient used in this study was determined by dividing 150 pounds of nitrogen by 71.4 bushels (Extension Economists-Management) giving a coefficient of 2.10084 pounds of nitrogen for each bushel of grain sorghum. This coefficient was multiplied by all projected grain sorghum yields to determine the fertilization rates. At the suggestion of Lindsay, the requirement for phosphorus fertilizer was dropped for grain sorghum. The nitrogen fertilizer requirements for grain sorghum are given in Table 11.

Pecan rosette, a nutritional disorder in pecans caused by zinc deficiency, does occur in the area. Therefore, following Gorman, Landrum and Hicks, three gallons of 5 percent zinc solution per acre per year were required on pecans (Table 9).

The per acre input requirements of insecticide, herbicide, nematicide and dust for lettuce were taken from Libbins, et al. for all crops except pecans. The insecticide requirement for pecans was taken from Gorman, Landrum and Hicks.[8] These pesticide requirements are given in Table 9 and are specified in dollar cost per acre.

Water Inputs

The irrigation water requirement for each crop was calculated by subtracting from each monthly plant water requirement (Texas Board of Water Engineers) the monthly average rainfall. Since rainfall provides only a small portion of the plant water requirement, rainfall efficiency was disregarded. The remaining monthly irrigation requirements were totaled. These plant irrigation requirements are listed in Table 13. These requirements were then adjusted to reflect 80 percent in field irrigation distribution efficiency. Accumulation will require

[8]Gorman, Landrum and Hicks developed pecan budgets for 1979. Inputs specified in dollar terms were inflated to 1980 dollars by use of the annual indexes of prices paid by farmers for production items; interest, taxes and wage rates for 1979 and 1980 (U.S. Department of Agriculture, Statistical Reporting Service, 1981a). The 1979 value was multiplied by the 1980 index of 140 (1977=100) and that result divided by the 1979 index of 125. These adjusted figures were then used for those pecan input requirements specified in dollar terms in this study.

Table 13. Irrigation Requirements in Acre Inches and the Development Thereof for Twelve Selected Crops Grown in El Paso County, Texas

	Cotton										Chili	
	Upland	Pima	Alfalfa	Wheat	Barley	Grain Sorghum	Pecans	Tomatoes	Lettuce	Onions	Green	Red
Plant Irrigation Requirements [a]	28.15	28.15	58.43	33.34	33.34	23.53	35.46	25.39	17.62	17.62	25.39	25.39
Total Irrigation Requirement (80% Efficiency)	35.19	35.19	73.03	41.68	41.68	29.41	44.33	31.74	22.03	22.03	31.74	31.74
Stress Coefficients[b]	.185	.128	-.104	.153	.229	.163						
Total Irrigation Adjusted for Stress	28.67	30.69		35.30	32.14	24.62						
Irrigation Level	30.00	30.00	72.00	36.00	36.00	26.00	36.00	31.2	31.2	31.2	31.2	31.2
Irrigation Level 20% Leaching	36.00	36.00	86.4	43.2	43.2	31.2	43.2	37.44	37.44	37.44	37.44	37.44

[a]Plant irrigation requirements are the annual net of monthly plant requirements (Texas Board of Water Engineers) and the monthly average rainfall (The Dallas Morning News).

[b]Stress coefficients are developed in Table 14.

the use of meters to determine actual water deliveries. With these meters in place, it is felt that 80 percent in field irrigation distribution efficiency can be attained. The total irrigation requirements in Table 13 reflect the irrigation efficiency adjustment.

The irrigation level for pecans was set at 36 acre inches, just above the plant irrigation requirement. This was based on the suggestion by Malstrom of an irrigation level for pecans of 36 to 40 inches. In a survey of farmers by Fifer, it appears that farmers irrigate all vegetables the same amount, 31.2 inches. This would tend to indicate that lettuce and onions are being over watered. But with a high cost vegetable crop, a yield loss due to water stress could be critical in determining profit or loss. Therefore, the irrigation level for vegetables was set at 31.2 acre inches.

For field crops, the problem of allowing water stress in the plant was considered. This problem is not considered in the plant water requirements established by the Texas Board of Water Engineers. To account for this stress, the percentage difference between the typical management weighted average yield developed in this study in Table 14 and the historical county yield (Texas Crop and Livestock Reporting Service, 1980a) in Table 2 were used. These stress coefficients are given in Table 13. The stress coefficient for alfalfa was negative. The total irrigation requirement was, therefore, adjusted to 72 inches and used as the irrigation level for alfalfa. Seventy-two inches was the irrigation level used in Extension Economists-Management data and by Richardson, et al., for alfalfa grown in the El Paso Valley.

Table 14. Weighted and Average Crop Yields and Their Implied Stress Coefficients for Six Selected Crops Grown in El Paso County, Texas

Soil Group[a]	Percent of Area	Cotton Upland	Cotton Pima	Alfalfa	Wheat	Barley	Grain Sorghum
GH	47.6	872	540	6.4	80	80	77
GP	8.9	836	540	6.4	72	79	69
SA	16.0	696	431	4.8	68	70	64
ST	22.2	680	431	4.4	61	72	57
VN	4.3	592	371	4.0	56	52	51
BR	1.1	440	300	3.6	48	48	47
Weighted Average		782	489	5.57	17.9	75.0	68.3
El Paso County Average[b]		637	426	6.15	63.0	57.9	57.2
Percentage Difference (Stress Coefficient)		18.5	12.8	-10.4	15.3	22.9	16.3

[a]Soil groups are defined in Table 3.

[b]Historical El Paso County averages are from Table 2.

Fifer's survey indicates that both upland and pima cotton are irrigated the same. Also, wheat and barley were indicated to be irrigated the same. Therefore, the irrigation levels for upland and pima cotton, wheat and barley and grain sorghum were set at 30, 36 and 26 inches, respectively. These levels are close to the irrigation requirements adjusted for stress in Table 13. They also agree with levels used by Extension Economists-Management, Libbins, et al., and Fifer's survey.

At groundwater salinity levels which caused yield reductions for a given crop (Table 4), the water requirement was increased by 20% to allow for leaching of salts (Runkles). These increased requirements are given in Table 13. Table 9 gives water requirements which have not been adjusted for leaching.

Since irrigation water is supplied by both project water and groundwater, irrigation well input requirements were established. The inputs associated with pumping the various levels of required water (Table 13) are given in Table 15. The input requirements were determined by establishing the characteristics of a typical irrigation well in the study area and then working through the irrigation cost program developed by Kletke, Harris and Mapp. Appendix B contains an irrigation cost input form completed for the typical well. The characteristics were supplied by North unless otherwise indicated. It should be noted that the acres irrigated per well may be less than 100. Tuck estimates 600 irrigation wells are in the study area. Thus, 69,010 water right acres gives an average of 115 acres per well. On the other hand, the assumption of this study of 48,050 acres of land in

Table 15. Irrigation Well Inputs for Various Levels of Water Pumped by a Typical Well in El Paso County, Texas

Water Pumped (in.)	26	30	31.2	36	37.44	43.2	72	86.4
Water Pumped (feet)	2.7	2.5	2.6	3.0	3.12	3.6	6.0	7.2
LP Gas Required (gal.)	41.42	47.80	49.71	57.36	59.65	68.83	114.71	137.65
Oil and Lube ($)	.98	1.10	1.18	1.34	1.39	1.60	2.69	3.22
Repairs ($)	1.10	1.28	1.33	1.53	1.60	1.84	3.06	3.68
Labor (hours)	.45	.52	.54	.62	.65	.75	1.25	1.50

Note: This information was developed from the irrigation levels given in Table 13, the irrigation cost program developed by Kletke, Harris and Mapp and data supplied primarily by North which is given in Appendix B.

current production gives an average of 80 acres per well. Fifer's survey suggested that farmers prefer to have one well per 200 acres. Therefore, for purposes of well cost calculations the acres irrigated per well were set at 100 acres per well.

It was possible to calculate an oil requirement in gallons for irrigation well operation separate from the lubrication requirement. But, this requirement was multiplied by the price of oil and added to lubrication costs to be constant in measurement with other oil and lubrication input requirements. Labor hours were increased by 15 percent to reflect employee benefits.

Machinery Inputs

Input requirements in the machinery section do not consider irrigation or harvesting operations. These operations are reviewed elsewhere. The operations and machinery necessary to grow and produce the crops were assumed to be those specified by Libbins, et al. and by Gorman, Landrum and Hicks for pecans. These specified farming operations and machinery complements may not reflect each individual farmer's operations or machinery complement. However, it is felt that these operations and machinery complements adequately represent farming practices in El Paso County.

The following diesel consumption rates were suggested by Childers:

tractor, 40 hp	- 1.752 gal/hr
tractor, 80 hp	- 3.504 gal/hr
tractor, 125 hp	- 5.474 gal/hr
cotton picker	- 6.5 gal/hr

Since most hay swathers have approximately 80 hp, the consumption rate of an 80 hp tractor of 3.504 gal/hr was used. These consumption rates are generalized from the Nebraska tractor tests and do not assume a

100 percent load. These consumption rates were used to determine all diesel requirements given in Table 9.

The gasoline requirement for upland and pima cotton, alfalfa, wheat, barley and grain sorghum were taken from Extension Economists-Management. The pecan requirement was assumed the same as alfalfa and vegetable requirements were assumed as the same as cotton. These gasoline requirements are given in Table 9.

The oil and lube input requirements were developed by subtracting from the fuel, oil and lubricant costs from Libbins, et al. and for pecans from Gorman, Landrum and Hicks, the cost of the quantities of diesel and gasoline as previously determined. This was done for required machinery operations. In making this calculation the prices of diesel and gasoline used by Libbins, et al. and Gorman, Landrum and Hicks were used. These input requirements in dollars per acre for each crop are given in Table 9.

Repair input requirements for crops were taken from Libbins, et al. and for pecans from Gorman, Landrum and Hicks. This was done by summing the repair input requirements for indicated machinery operations for each crop. These input requirements in dollars per acre are given in Table 9.

Labor Inputs

Machinery labor is all labor required for machinery operations and does not include labor necessary for irrigation, harvest or well operation. The labor requirements, down time (25 percent) and employee benefits (15 percent) were taken from Libbins, et al. Machinery labor for pecans was taken from Gorman, Landrum and Hicks. These labor requirements are given in Table 9.

Irrigation labor was based on two hours of labor being necessary for each acre foot of applied water (Extension Economists-Management). This irrigation labor requirement was increased by 15 percent to account for employee benefits (Libbins, et al.). This irrigation labor requirement was increased by 20 percent when the water requirement was increased to allow for leaching of salts.

Custom hoeing was included for pecans following Gorman, Landrum and Hicks. Custom hoeing was also included for all vegetables (Libbins, et al.).

Harvest Inputs

The input requirements for harvesting for each crop are based on the yield of each crop. Harvest requirements were determined by taking the yield and harvest input requirements from Libbins, et al. and calculating proportional requirements for any given yield from Table 4. The harvest diesel requirement was calculated in the manner described above for the machinery diesel requirement. The harvest gasoline requirement was figured at a consumption rate of 2 gallons per hour for a pickup (Extension Economists-Management) in a like manner to the diesel calculation. Consumption rates were multiplied by time requirements of an activity given in Libbins, et al. Oil and lube, repairs and labor requirements were calculated in the same manner as machinery oil and lube, machinery repairs and labor requirements. The various crop yields and their associated harvest requirements are given in Table 16 for upland and pima cotton and Table 17 for alfalfa and tomatoes. The following harvest input requirements were established on a per unit

Table 16. Yields and Associated Harvest Requirements for Upland and Pima Cotton Grown in El Paso County, Texas

Crop	Yield (lbs. lint)	Diesel (gallons)	Gasoline (gallons)	Oil and Lube ($)	Repairs ($)	Labor (hours)
Cotton, Upland	872	17.79	5.37	9.87	21.61	7.59
	836	17.05	5.14	9.47	20.72	7.28
	821	16.75	5.05	9.30	20.35	7.15
	788	16.08	4.85	8.92	19.53	6.86
	696	14.20	4.28	7.88	17.25	6.06
	680	13.87	4.18	7.70	16.85	5.92
	661	13.48	4.07	7.48	16.38	5.76
	656	13.38	4.04	7.43	16.26	5.71
	641	13.08	3.94	7.26	15.87	5.58
	634	12.93	3.90	7.18	15.71	5.52
	592	12.08	3.64	6.70	14.67	5.15
	558	11.38	3.43	6.32	13.83	4.86
	528	10.77	3.25	5.98	13.09	4.60
	515	10.51	3.17	5.83	12.76	4.48
	449	9.16	2.76	5.08	11.13	3.91
	440	8.98	2.71	4.98	10.91	3.83
	414	8.45	2.55	4.69	10.26	3.60
	334	6.81	2.06	3.78	8.28	2.91
Cotton, Pima	540	11.02	3.32	6.11	13.38	4.70
	509	10.38	3.13	5.76	12.62	4.43
	431	8.79	2.65	4.88	10.68	3.75
	409	8.34	2.52	4.63	10.14	3.56
	406	8.28	2.50	4.60	10.06	3.54
	371	7.57	2.28	4.20	9.20	3.23
	349	7.12	2.15	3.95	8.65	3.04
	327	6.67	2.01	3.70	8.10	2.85
	300	6.12	1.85	3.40	7.44	2.61
	283	5.77	1.74	3.20	7.01	2.46
	281	5.73	1.73	3.18	6.69	2.45
	227	4.63	1.40	2.57	5.63	1.98

Note: Harvest requirements were obtained by multiplying the input to yield ratio determined from Libbins, et al., times the yields from Table 4.

Table 17. Yields and Associated Harvest Requirements for Alfalfa and Tomatoes Grown in El Paso County, Texas

Crop	Yield (tons)	Diesel (gallons	Oil and Lube ($)	Repairs ($)	Labor (hours)
Alfalfa	6.4	8.41	11.54	5.58	3.36
	6.3	8.28	11.36	5.50	3.31
	5.5	7.23	9.92	4.80	2.89
	4.8	6.31	8.66	4.19	2.52
	4.7	6.17	8.48	4.10	2.46
	4.6	6.04	8.30	4.01	2.42
	4.4	5.78	7.94	3.84	2.31
	4.3	5.65	7.76	3.75	2.26
	4.1	5.39	7.40	3.58	2.15
	4.0	5.26	7.22	3.49	2.10
	3.9	5.12	7.03	3.40	2.05
	3.8	4.99	6.85	3.32	2.00
	3.6	4.73	6.49	3.14	1.89
	3.5	4.60	6.31	3.05	1.84
	3.4	4.47	6.13	2.97	1.79
	3.2	4.20	5.77	2.79	1.68
	3.1	4.07	5.59	2.70	1.63
	2.9	3.81	5.23	2.53	1.52
	2.6	3.42	4.69	2.27	1.37
	2.4	3.15	4.33	2.09	1.26
	2.2	2.89	3.97	1.92	1.16
	2.0	2.63	3.61	1.75	1.05
	1.8	2.36	3.25	1.57	0.95
Tomatoes	11.6	16.01	3.63	3.61	11.45
	10.3	14.21	3.23	4.98	10.16
	10.0	13.80	3.13	4.83	9.87
	9.8	13.52	3.07	4.74	9.67
	8.4	11.59	2.63	4.06	8.29
	8.1	11.18	2.54	3.92	7.99
	7.8	10.76	2.44	3.77	7.70
	7.2	9.94	2.26	3.48	7.10
	6.7	9.25	2.10	3.24	6.61
	6.6	9.11	2.07	3.19	6.51
	6.0	8.28	1.88	2.90	5.92
	5.6	7.73	1.75	2.71	5.53
	5.2	7.18	1.63	2.51	5.13
	4.0	5.52	1.25	1.93	3.95

Note: Harvest requirements were obtained by multiplying the input to yield ratio determined from Libbins, et al., times the yields from Table 4.

harvest basis:

Upland cotton - custom ginning;
Pima cotton - custom ginning;
Alfalfa - baling wire;
Wheat - custom harvest;
Barley - custom harvest;
Grain sorghum - custom harvest;
Pecans - custom harvest;
Tomatoes - custom harvest;
Lettuce - custom harvest;
Onion - custom harvest and field bags;
Green chili - custom harvest, fork lift rental, diesel, oil and lube, repairs and labor;
Red chili - custom harvest, fork lift rental, diesel, oil and lube, repairs and labor.

Other Inputs

There are a variety of other inputs which do not fit into any category. As Libbins, et al. suggest, a crop insurance input was included of $20.00 per acre for all cotton and $40.00 per acre for all chili.

Fifer's survey indicated that farmers were receiving a 20 to 30 percent savings in labor, fertilizer and water from the laser leveling input. The median of 25 percent was chosen to reflect these savings due to laser leveling. Laser leveling was allowed for all crops except alfalfa and pecans which may or may not have been laser-leveled during establishment. Laser leveling was also restricted from two soil groups, ST and BR. The ST group is made up of tight clays with very slow permeability. Laser leveling would tend to drown out plants. The BR group is a sand with very rapid permeability. The advantage of laser leveling of uniform watering may be circumvented by rapid uptake of water near the turnout. The laser leveling input is a custom applied input and is given in Table 9 at its rate of $45.00 per acre

(Libbins, et al.).

Three inputs were common to all crops at the same rate. The first was farm insurance. A generalization of $4.30 per acre was taken from Libbins, et al. and Gorman, Landrum and Hicks. The second input was land taxes which were set at $7.83 per acre. This is the tax rate for an unidentified producer selected by an El Paso County, Central Appraisal District employee as an example of the tax level. The third input was the water district tax of $21.00 per acre.

Following Libbins, et al. a $30.00 per acre cost was included to cover miscellaneous overhead items such as the farm share of the telephone, other utilities, buildings and accounting fees. For pecans, the expenditure items from Gorman, Landrum and Hicks of pruning, shaping and budding, repair and maintenance of ditches and roads, legal and accounting and miscellaneous were combined to create an analogous cost input. The costs of pruning, shaping and budding were averaged for the 14 years of full mature production yielding $19.00 per year. This cost, when added to the other expenditures mentioned above, totaled $37.41 per acre for pecans.

The interest rate on operating capital was taken to be one half of the yearly interest rate on credit lines established by farmers in the study area. This was done to reflect that money borrowed to plant and tend a crop is payed back at harvest time, generally six months after planting. According to Richardson, credit lines are usually established in March or April. Richardson also said that credit lines for 1980 are being extended at one percent above the current prime lending rate. Thus, to calculate an interest rate for operating capital, the quoted prime interest rate was taken from the Wednesday edition of The Wall Street Journal for eight consecutive Wednesdays beginning with March 11th and ending with April 29th. These quoted rates and any median values are listed in Table 18. Adding one percent to the average prime rate from Table 18 of 17.40625 percent gives 18.40625 percent as the interest rate on a farmer's line of credit. Adjusting this rate to the six month borrowing period, yields an annual effective rate of 9.203 percent.

Fixed Inputs

Three fixed inputs were identified -- establishment, machinery and irrigation well. The fixed establishment inputs for alfalfa and pecans had to be calculated. Libbins, et al.'s total cost from the alfalfa establishment budget was amortized over a five-year alfalfa production period (Lindsay). Likewise, net establishment costs from Gorman, Landrum and Hicks for the first eleven years of pecan orchard life were brought to constant dollars of the eleventh year and then totaled. This total was then amortized over the fourteen years of mature production (Gorman, Landrum and Hicks). The rate used for inflating or amortization was $7^3/_8$ percent which is the discount rate set for federal agencies in formulating and evaluating plans for water and related land resources for the period October 1, 1980 through September 30, 1981 (U.S. Water Resources Council).

The fixed machinery input was calculated by adding the machinery depreciation to the interest on equipment inventory from Libbins, et al. and for pecans from Gorman, Landrum and Hicks.

Fixed well inputs were determined by summing fixed costs per well from the irrigation cost program (Kletke, Harris and Mapp). This sum

Table 18. The Wednesday Quoted Prime Interest Rate for March 11, 1981 through April 29, 1981

Date	Quoted Prime Interest Rate	Median Value Used for Calculation
March 11	18	18
March 18	17.5	17.5
March 25	17 to 17.5	17.25
April 1	17 to 17.5	17.25
April 8	17	17
April 15	17 to 17.5	17.25
April 22	17.5	17.5
April 29	17.5	17.5
Average		17.40625

Source: The Wall Street Journal, Wednesday issues, March 11, 1981 through April 29, 1981.

was then multiplied by the total number of wells in the study, 600 (Tuck). The result was then divided by the cropland acreage assumed in this study, 48,050 acres. This procedure gave a fixed well input of $33.51 and this value was applied to each acre for all crops. The input values in all categories discussed are presented in Table 9.

CHAPTER IV

ANALYTICAL MODEL

To determine the impact of a water carry-over storage option, two linear programming models were built. The first linear program was built to model crop production in the El Paso County Water Improvement District No. 1. This linear program maximized returns to land, management, risk and profit. This model was run parametrically over all possible surface water allocations (zero to three acre feet of water per vested water right acre). The resultant schedule of surface water allocations and net returns (objective function values) were used to build a second linear programming model. The second model maximized net returns over the eighteen years 1963 through 1980 subject to the real interest rate (time value of money), the annual evaporation from Elephant Butte Reservoir for those years and the actual surface water allocations available to El Paso County farmers for those years.

An additional surface water use scenario was developed. This scenario assumed that water users would set a limit, two acre feet, on surface water use. Any amount of an allocation greater than two acre feet would be stored for future use. In years of allocations below two acre feet, the difference between the allocation and two acre feet would be made up from stored water, if possible. This scenario also depleted stored water used in a given year by only the evaporation for the first six months of that year.

The Static Linear Programming Model

The model used to estimate optimum allocation of irrigation water within a year had to include many factors. The most important being the alternative crop production activities.

Model Activities

Crop activities were developed for each crop for each of six soil groups, for each of six salinity levels of groundwater, for either project water or groundwater, and for laser leveling and no laser leveling. Thus, the following number of activities were developed for the model:

cotton, upland - 120;
cotton, pima - 120;
alfalfa - 66;
wheat - 120;
barley - 120;
grain sorghum - 110;
pecans - 66;
tomatoes - 100;
lettuce - 90;
onions - 90;
chili, green - 90; and
chili, red - 90; or,
total - 1182.

These activities were developed from the yields given in Table 4 and the input requirements given in Table 9. A simplified structure of this static linear programming model is given in Table 19.

Table 19. A Simplified Structure of the Static Linear Programming Model

Item	Crop Production: Surface water	Crop Production: Ground-water	Input Purchases	Crop Sales	Harvest Costs	Well Costs	Crop Acreages	Surface Water Required	Two Acre Feet Available	Third Acre Foot Available	Ground-water Used	RHS
Objective Function			-a	b	-c	-a				8		= 0
Yield Transfer	d	d		-1								= 0
Input Transfer	e	e	-1									= 0
Harvest Costs				f	-1							
Land by Soil Group by Salinity Level	1	1										≤ g
Crop Account	1	1					-1					= 0
Surface Water Required	h							-1				= 0
Surface Water Available								-1	1	1		= 0
Two Acre Feet Available									1			≤ i
Third Acre Foot Available										1		≤ j
Groundwater Required		k									-1	= 0
Well Costs		1				-1						= 0

[a]Input prices.

[b]Crop prices.

[c]Harvest Costs.

[d]Yield coefficients.

[e]Input-yield coefficients.

[f]Harvest cost-yield coefficients.

[g]Level of land available.

[h]Surface water-yield coefficients.

[i]Level of taxed surface water available.

[j]Level of purchased surface water available.

[k]Groundwater-yield coefficients.

[l]Well costs-yield coefficients.

The linear programming model contains 1182 production activities and 100 buy, sell or transfer activities. The linear programming model contained 154 rows. Forty-six rows were restrictions while the remaining 104 were accounting or transfer rows and the objective function. A reduced matrix for this model is given in Appendix C. Appendix C also contains an explanation of the column and row names used.

The acreage restrictions for the soil groups were taken from Table 6. The surface water restriction, for the first two acre feet allocated per acre, was 96,100 acre feet. If the allocation was less than two acre feet per acre, this restriction was decreased to reflect the lower allocation. For the third acre foot allocated per acre, the restriction was 48,050 acre feet at a three acre foot allotment. For a two or less acre foot allocation, this restriction was zero. When the allocation was between two and three acre feet, this restriction was linearly adjusted between zero and 48,050 acre feet. The per acre water district tax is $21.00. This allows the farmer to use up to 2 acre feet of water if it is allocated. An additional acre foot can be allocated and is currently being priced at $8.00 per acre foot. Thus, for surface water input requirements in Table 9, there is a charge of $8.00 per acre foot for any water requirement over 2.0 acre feet. The following crops were limited to no more than the following acres:

Alfalfa	-	8,517 acres;
Pecan	-	5,200 acres;
Tomatoes	-	100 acres;
Lettuce	-	200 acres;
Onions	-	200 acres; and
All chili	-	700 acres.

A minimum acreage was established for alfalfa and pecans which was 6,083 acres and 4,800 acres, respectively. The limits on alfalfa were determined by adding and subtracting one-sixth of the reported 1980 alfalfa acreage for El Paso County from Table 1. One-sixth was used because of the six year cycle assumed in alfalfa production from establishment to re-establishment. Malstrom estimated that there are 5,000 acres of pecans in El Paso County. The limits on pecan acreage were determined by adding and subtracting one twenty-fifth of this acreage. One twenty-fifth was used because of the twenty-five year cycle between establishment and re-establishment (Gorman, Landrum and Hicks). The limits on vegetables were set at levels suggested by Peavy.

The input items relating to irrigation labor, fertilizer and water were not changed when laser leveling was employed as compared to non-laser leveled land. Rather for each of these inputs a coefficient was adjusted in the linear program to reduce the quantity of each by 25 percent. This was done to facilitate the possibility of changing the percentage of this savings due to laser leveling as more is learned about this technology.

Operating capital needs were determined by summing the dollar value of all input requirements except the third acre foot of surface irrigation water, all harvest inputs except baling wire, the constant inputs (farm insurance, land tax and water district tax) and the fixed inputs. The cost associated with the third acre foot of surface water is assessed in December after the water has been used. Therefore, no interest was charged. Harvest costs can immediately be offset by sale of the crop. Thus, no interest was charged. Baling wire is sometimes purchased in quantity, months before it is used. This is the reason baling wire was charged the operating capital interest rate. Land and water district taxes are assessed at the end of the year, thus no interest was charged. Since farm insurance was included with these taxes in the linear programming model, it was not charged interest. The fixed inputs -- establishments, fixed machinery and fixed well -- were not charged interest because they reflect non-cash expenditures (depreciation) and an interest charge on an investment; no current cash outlays are necessary.

Prices

In building the model, an attempt was made to include as many of the output and input prices in the objective function as possible. This was done to generalize the model so that price could easily be changed parametrically. Output prices were determined by converting the reported prices for each crop for 1976 to 1980 to equivalent prices in 1980 dollars and then taking an average. The 1980 index value, I_{1980}, was divided by the index value of, say, 1976, I_{1976}. This ratio was then multiplied by 1976 reported price, P_{1976}, yielding the 1976 price in 1980 dollars, $\hat{P}_{1976}$,

$$\hat{P}_{1976} = P_{1976}(I_{1980}/I_{1976})$$

This procedure attempts to answer the question, what price would have been observed if 1976 had occurred with a 1980 price structure?

To convert the reported prices to 1980 dollars the following prices received indexes (U.S. Department of Agriculture, Statistical Reporting Service, 1980) were used for the indicated crops:

cotton - upland cotton;
oil bearing crops - cottonseed;
feed and hay - alfalfa;
food grains - wheat;
feed grains - barley and grain sorghum;
fruit - pecans; and,
vegetable - tomatoes, lettuce, onion, green chili and red chili.

These indexes, the reported prices and the results of the above procedures are given in Table 20. New Mexico State prices were used for upland cotton, cottonseed, wheat, barley, grain sorghum, pecans, lettuce, onions, green chili and red chili (New Mexico Crop and Livestock Reporting Service). El Paso County lies closer to all of

Table 20. Crop Indexes, Crop Prices and the Same Crop Prices in 1980 Dollars for Eleven Crops Grown in El Paso County, Texas for 1976 through 1980

Item	Unit	Years					Five Year Average
		1980	1979	1978	1977	1976	
Cotton Index	%	317	258	245	270	265	
Upland Cotton Price	$/lb	.80	.685	.62	.53	.70	
Upland Cotton (1980 $'s)	$/lb	.80	.84	.80	.62	.84	.78
Oil Bearing Crops Index	%	247	249	226	243	205	
Cottonseed Price	$/ton	123	115	125	66	102	
Cottonseed Price (1980 $'s)	$/ton	123	114.08	136.62	67.00	122.90	112.74
Feed and Hay Index	%	240	207	184	181	218	
Alfalfa Price	$/ton	79.50	69.00	64.00	57.50	63.50	
Alfalfa Price (1980 $'s)	$/ton	79.50	80.00	83.48	76.24	69.91	77.83
Food Grain Index	%	257	229	191	156	201	
Wheat Price	$/bu	4.24	3.42	2.60	2.15	3.53	
Wheat Price (1980 $'s)	$/bu	4.24	3.84	3.50	3.54	4.51	3.93
Feed Grain Index	%	235	204	181	174	214	
Barley Price	$/bu	2.55	2.40	1.95	1.65	2.17	
Barley Price (1980 $'s)	$/bu	2.55	2.76	2.53	2.23	2.38	2.49
Grain Sorghum Price	$/bu	3.81	2.49	2.22	1.88	2.02	
Grain Sorghum Price (1980 $'s)	$/bu	3.81	28.7	2.88	2.54	2.22	2.86
Fruit Index	%	207	235	226	163	132	
Pecan Price	$/lb	.85	.69	.75	.81	1.00	
Pecan Price (1980 $'s)	$/lb	.85	.61	.69	1.03	1.57	.95
Vegetable Index	%	198	194	188	176	161	
Tomato Price	$/ton	82.50	140.00	75	75	75	
Tomato Price (1980 $'s)	$/ton	82.50	142.89	78.99	84.38	92.24	96.20
Lettuce Price	$/ctn	4.42	4.44	5.18	4.26	6.39	
Lettuce Price (1980 $'s)	$/ctn	4.42	4.53	5.46	4.79	7.86	5.41
Onion Price	$/sack	4.60	5.55	4.27	3.85	2.80	
Onion Price (1980 $'s)	$/sack	4.60	5.66	4.50	4.33	3.44	4.51
Green Chili Price	$/ton	228.00	245.90	232.98	218.82	a	
Green Chili Price (1980 $'s)	$/ton	228.00	250.97	245.37	246.17	a	242.63
Red Chili Price	$/lb	.421	.3945	.37	.3655	.394	
Red Chili Price (1980 $'s)	$/lb	.421	.4026	.3897	.4112	.4845	.4218

Note: Price indexas are from U.S. Department of Agriculture, Statistical Reporting Service, 1980. Prices are New Mexico State prices reported by the New Mexico Crop and Livestock Reporting Service.

[a] The green chili price was not available for 1976.

the State of New Mexico geographically and climatically than to most of the State of Texas. Therefore, New Mexico State prices seemed much more appropriate. For several crops, a large portion of the New Mexico state production is from Dona Ana County. Fishburn indicated that although little data are available for tomatoes grown in New Mexico, most production does occur in Dona Ana County. Pedde and Farias provided the per unit value of tomatoes from the crop production reports for Elephant Butte Irrigation District, New Mexico for 1976 through 1980. The Elephant Butte Irrigation District is comprised of most or all of the farmland in Dona Ana County. Thus prices for the Elephant Butte District are as relevant as Dona Ana County prices.

The pima cotton price was not established by the procedure outlined above. It was noted that the relative price difference between upland and pima has been changing (Table 21). According to Cross this may be due to a decrease in demand. Some thread manufacturers may be switching to synthetics. The cotton index used above for upland cotton is based on the national cotton price. This national price is weighted by production. Over 95 percent of national cotton production is upland cotton. Therefore, the cotton index can be considered as a good index of upland cotton prices. But, since the price relationship between upland and pima cotton has been changing, the cotton index is inappropriate for adjusting the pima cotton price.

Table 21. Upland and Pima Cotton Prices and the Upland Price as a Percentage of the Pima Price for 1976 to 1980

Year	Upland Cotton Price	Pima Cotton Price	Upland as a Percent of Pima
	¢/lb.		
1980	.80	1.11	.72
1979	.685	1.00	.685
1978	.62	.941	.659
1977	.53	.876	.605
1976	.70	1.17	.598

Note: Upland cotton prices are New Mexico state prices reported by the New Mexico Crop and Livestock Reporting Service. Pima cotton prices are Texas state prices reported by the Texas Crop and Livestock Reporting Service, 1980b.

Cross has indicated that most of the 1981 pima cotton contracts were priced at the quotes given by the U.S. Department of Agriculture, Agricultural Marketing Service, Cotton Division (1981b). Cross suggested establishing a weighted price based on these quotes by grade. The weights were the percentage of 1980 El Paso area production by grades reported by the U.S. Department of Agriculture, Agricultural Marketing Service, Cotton Division (1981a). This information is given in Table 22. This weighted average price was $1.0376 per pound of lint. This price was used for the pima cotton selling price throughout this study.

All input prices were established by using current 1980 or 1981 prices. On April 30, 1981, Fabens Delinting Plant was quoting most varieties of upland cottonseed at $960 per ton or $0.48 per pound, pima cottonseed at $600 per ton or $0.30 per pound, wheat seed at $22 per cwt or $0.22 per pound, barley seed at $18 per cwt or $0.18 per pound and grain sorghum seed at $60 per cwt or $0.60 per pound. Also, on the same day, Agricultural Products and Seed Company of Mesquite, New Mexico were quoting tomato seed at $10 per pound, onion seed at $16-$18 per pound, lettuce seed at $35 per pound and green and red chili seed at $12 per pound.

Fertilizer prices are those quoted by the Fabens Delinting Plant for April 30, 1981. Liquid nitrogen (anhydrous ammonia) was quoted at $240 per ton or $0.12 per pound. Superphosphate was quoted at $250 per ton or $0.125 per pound. Potash (60 percent K_2O) was quoted at $160 per ton or $0.08 per pound.

Table 22. March 1981 Pima Cotton Prices and Percentages of 1980 Pima Cotton Production by Grades

Grade	March 1981 Pima Cotton Price $/lb.	Percentage of 1980 Production El Paso[a]
1	1.0810	
2	1.0760	1
3	1.0710	36
4	1.0610	46
5	.9331	14
6	.7978	2
7	.6666	1
8	.6021	b
9	.5808	b

Source: U.S. Department of Agriculture, Agricultural Marketing Service, Cotton Division, 1981a and 1981b.

[a]Includes eastern Arizona, New Mexico and Texas.

[b]Less than 0.5 percent, therefore taken as zero.

Agricultural Products and Seed Company quoted zinc solution at $5.00 per gallon on April 30, 1981. Dust for lettuce was priced at $11.67 per acre (Libbins, et al.). This dust price is a composite of the spring and fall lettuce requirements.

LP gas for use in irrigation was quoted May 1, 1981 by Ikard and Newsom of Fabens at $0.69 per gallon. The price of farm diesel used was the price quoted by Transmountain Oil Company on May 1, 1981 of $1.063 per gallon. Transmountain Oil Company also quoted farm gasoline at $1.242 per gallon.

The price of labor was set at the minimum wage of $3.60 due to the abundance of semi-skilled and unskilled labor in the area. This price for labor was used for all four types of labor -- well, machinery, irrigation and harvest.

Custom harvest or ginning prices were obtained from Libbins, et al. and Gorman, Landrum and Hicks. These prices are given in Table 9. The Meyers Company was quoting baling wire at $35.50 for a 100 pound roll when 11 to 100 rolls were purchased or $0.355 per pound. Field bags for onion harvest were priced at $0.10 each (Libbins, et al.). Forklifts for chili harvest rent for $10 per hour (Libbins, et al.).

Custom laser leveling costs $45 per acre (Libbins, et al.). The total price per acre of the constant inputs was $32.83. The individual prices per acre of these inputs are given in Table 9.

A total price for all fixed well inputs was determined for all 600 irrigation wells in El Paso County. This total price, $1,610,200.00, was calculated by multiplying the fixed well inputs for the typical irrigation well times 600 wells.

This provides a discussion of the static linear programming model. This model was first solved with no limits on any crops. Then acreage limits were imposed. Adjustments were made to the coefficients of upland and pima cotton and pecan yields in the sell upland cotton lint, sell pima cotton lint, sell upland cototnseed, sell pima cottonseed and sell pecans activities. This was done so that the average yield indicated by the model for upland and pima cotton and pecans would be closer to the average historic yield (Table 2). Total cotton acreage was then restricted to a level of 28,000 acres which is close to the study area historical average acreage of total cotton (Table 1).

The quantity of surface water was parametrically adjusted from zero to three feet per acre under two assumptions. First, no groundwater was available and, second, groundwater was available. These two parametric runs constitute a catalog of all model solutions for any level of surface water allocation with or without groundwater supplementation.

The Temporal Linear Programming Model

With the series of solutions from the static model, a temporal linear programming model was built. This model maximized temporal net returns by choosing optimum temporal uses of annual water allocations and an optimum carry-over storage scenario.

The static linear program produced a schedule of 83 surface water allocations and maximized net returns for the case when no groundwater was available. This schedule included a zero water allocation with a zero net return. The rest of the schedule ranged from 1.059 to 3.0 acre feet of surface water allocated per vested acre. Without groundwater, surface water allocation of less than 1.059 acre feet per vested acre would not provide enough total water to sustain established pecan orchards and alfalfa fields. When groundwater pumping is allowed, pecan orchards and alfalfa fields can be sustained by pumping wells. Therefore, when pumping was allowed, solutions were generated for 78 surface water allocations from zero to three acre feet. A simplified structure of this temporal linear programming model is given in Table 23.

The actual water allocations granted to the El Paso County Water Improvement District No. 1 from Elephant Butte Reservoir for 1963 through 1980 were used as the temporal pattern of water allocations. Table 24 gives total surface water allotments from 1951 through 1980. As late as 1962 allotments of more than three acre feet were given. An allotment of more than three acre feet is still a possibility under federal law. The board of directors of the El Paso County Water Improvement District No. 1 decided to restrict the district to no more than a three acre feet allotment (Fifer). Therefore, no water allocations over three acre feet were

Table 23. A Simplified Structure of the Temporal Linear Programming Model

	Net Revenue Production						Revenue Transfer			Water Used			Water Saved				Sell Stored Water	RHS
	1963 Surface Water Use[a]		1964 .... Surface Water Use		1980 Surface Water Use		1963	1964...	...1980	1963	1964...	...1980	1963	1964...	...1979	1980		
	0...3 ac. ft.		0...3 ac. ft.		0...3 ac. ft.													
Objective Function							1	1	1								b	
Revenue Transfer:																		
1963	c	c					-d											=0
1964			c	c				-d										=0
⋮																		
1980					c	c			-d									=0
Individual Solution Requirement:																		
1963	1	1																=1
1964			1	1														=1
⋮																		
1980					1	1												=1
Water Required																		
1963	e	e								-1								=0
1964			e	e							-1							=0
⋮																		
1980					e	e						-1						=0
Water Available																		
1963										1			1					=f
1964											1		-g	1				=f
⋮																		
1980												1			-g	1		=f
Stored Water Transfer																1	-1	=0

[a] Water use includes 78 alternatives ranging from 0 to 3 acre feet of water per acre.
[b] Stored water price parameters.
[c] Revenue-water use coefficients.
[d] 1980 real dollars coefficients.
[e] Water use coefficients.
[f] Level of water availability.
[g] Evaporation of saved water coefficients.

Table 24. Total Water Allocation for the El Paso County Water Improvement District No. 1 in Acre Feet Per Vested Acre and the Annual Evaporation Rate for Elephant Butte Reservoir, New Mexico, 1951 to 1980

Year	Total Allotment (acre feet)	Annual Evaporation (% of project water)
1951	1.75	41.889
1952	.21	25.522
1953	1.90	25.404
1954	.50	33.233
1955	.42	28.022
1956	.39	33.079
1957	1.17	21.665
1958	4.00	11.139
1959	3.50	15.398
1960	3.25	16.327
1961	2.45	20.548
1962	3.25	18.056
1963	2.00	24.756
1964	.33	30.363
1965	1.85	22.187
1966	2.50	17.297
1967	1.50	22.250
1968	2.00	21.005
1969	3.00	16.588
1970	3.00	17.894
1971	2.00	24.519
1972	.67	21.304
1973	3.00	13.994
1974	3.00	14.189
1975	3.00	14.889
1976	3.00	14.851
1977	1.25	21.428
1978	.75	21.359
1979	3.00	13.591
1980	3.00	12.189

Note: Water allotments were provided by Fifer. Annual evaporation rates were calculated from data provided by the Rio Grande Compact Commission. The calculation of evaporation rates is given in Appendix D.

considered. This is the reason that the temporal analysis begins in 1963, the first year after the last allocation of greater than three acre feet.

These allocation-net returns activities were named by a seven character code. The first character was always A. The next four indicated the level of the surface water allocation. The last two indicated the year. A000063 reads, the activity of no surface water allocation in 1963. A256677 reads, the activity of a 2.566 acre foot allocation in 1977.

The objective function maximized the real value in 1980 dollars of net returns over the time period. The allocation-net return activities did not have an objective function value. Instead, a transfer activity, designated OBJ63 through OBJ80,[9] was used to inflate the net returns associated with the water use level chosen to 1980 dollars. All solutions given in the schedules of allocation-net returns were in 1980 dollars (no inflation). But, this still does not account for the real interest rate (time value of money).

To establish the real rate of interest in El Paso County, the inflation rate was subtracted from the agricultural lending rate. A real rate of interest established in this manner includes an agricultural lending risk component. Thus, the real interest rate determined herein does include this element.

The inflation rate was determined by adjusting the monthly

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[9] The two digits on the end of the names indicate the year.

percentage change in the consumer price index (Council of Economic Advisors) to a yearly basis. This inflation rate was subtracted from the mean of the prime interest rates reported for each month (Council of Economic Advisors). This was done for the period February 1980 through January 1981. The monthly differences were then averaged. All this information is given in Table 25. One percent was then added to this twelve month average. This was done to reflect that the agricultural lending rate in El Paso County is one percent above the prime interest rate. The rate used as the real interest rate for El Paso County was 4.94933 percent. In the temporal linear programming model all net returns were converted to 1980 dollars when transferred to the objective function by a coefficient expressing this percentage.

Each year has a water used activity identified by WATUS plus 63 through 80 which specifies the year. Likewise, there is a water saving activity, identified by WATSV plus 63 through 80 which specifies the year. Water can be used in a given year to generate net returns or some or all of the water can be transferred to the next year for use. The transferred water must suffer the full evaporation loss for the next year. The evaporation rates are given in Table 24. Their calculation is explained in Appendix D. If water was saved in the last year, 1981, it was sold through an activity named SELL80 at $8.26 per acre foot. This price is the shadow price for surface irrigation water from the static model at a three acre foot allocation.

Table 25. The Annual Inflation Rate by Month, the Monthly Prime Interest Rate and the Estimated Monthly Real Interest Rate for February, 1980 through January 1981

Month	Year	Monthly Increase in Consumer Price Index	Annual Inflation Rate	Monthly Prime Rate	Mean Monthly Prime Rate	Estimate of Monthly Real Interest Rate
		---percent---				
February	1980	1.3	16.765	15.25-16.75	16	-0.765
March	1980	1.3	16.765	16.75-19.50	18.125	1.36
April	1980	.9	11.135	19.5	19.5	8.365
May	1980	.9	11.135	18.5-14	16.25	5.115
June	1980	1.0	12.683	14-12	13	0.317
July	1980	.1	1.207	12-11	11.5	9.843
August	1980	.8	10.034	11-11.50	11.25	1.216
September	1980	1.0	12.683	11.50-13	12.25	-0.433
October	1980	1.0	12.683	13.50-14.50	14	1.317
November	1980	1.1	14.029	14.50-17.75	16.125	2.096
December	1980	1.0	12.683	17.75-21.50	19.625	6.942
January	1981	.7	8.731	21.50-20	20.75	12.019
Average						3.94933

Note: The monthly increase in the consumer price index and the monthly prime interest rate were reported by the Council of Economic Advisors.

There were two groups of constraints and two groups of accounting rows in the model. The first group of constraints was surface water available in a given year. These rows restricted the amount of new surface water available in a year and accounted for any water saved from the previous year or stored for the next year. These rows were named WATAV plus 63 through 80 to specify the year.

The second group of constraints was to require the model to choose one activity from each year for the solution. This was done by requiring each allocation-net returns activity to include an input of one unit. Each year was restricted to equal one unit. These rows were named by an S plus 63 through 80, to specify the year.

The first groups of accounting rows account for water used by the allocation-net returns activities. They are named WAT plus 63 through 80 to reflect the year. The second group of accounting rows account for net returns produced in each year. They are identified by REV plus 63 through 80 to indicate the year.

This temporal model, optimized with and without the option of groundwater pumping, defined two optimum scenarios of surface water use over the time period. These scenarios define the limits on the range of possible temporal surface water use scenarios which maximize net returns.

CHAPTER V

RESULTS

An accumulation policy for federal irrigation water allowing farmers to allocate water among years is of interest to El Paso County farmers (Sonnen, et al.). This chapter reports the results of an accumulation policy for farmers in El Paso County with emphasis on cropping patterns and economic implications. The first objective was to establish a base of comparison and consider alternative model solutions for El Paso County.

Static Model

The static model was applied under several alternative scenarios. The early solutions were used to further refine the model to better represent average crop yields in the study area as well as define the limits of this model.

Model Refinement

The initial model solution included no crop acreage restrictions and included a cost for fixed machinery and well inputs. The entire 48,050 acres of available cropland was allocated to lettuce production. While a three acre foot allotment was specified, lettuce uses only 2.6 acre feet per acre. Thus, not all of the available surface water was used. The model was then solved without the fixed machinery and well inputs. The only difference was, as expected, an increase in the objective function (net farm revenue) from $39,290,055.62 to

$43,426,314.62. These results are given in Table 26. This acreage of vegetables is certainly unrealistic and would exceed both facilities and demand.

To more appropriately represent the study area situation, the crop acreage restrictions for vegetables, pecans and alfalfa as given in the previous chapter were imposed. Crop acreages were distributed in a much more realistic manner, although 35,967 acres were allocated to upland cotton. The model was then solved without the fixed machinery and well inputs. Again, the only effect was that the objective function value increased from $7,226,356.04 to $12,604,648.73 (Table 26). Based on the results of these first four solutions of the model, crop acreage restrictions were imposed for all subsequent model applications while a cost for fixed machinery and well inputs was not included.

In refining the model, the first four applications were made with pecan yields reduced by 50 percent as compared to yields developed from secondary sources. The purpose was to approximate historical production with the pecan acreage restriction. As Table 27, solution 1 indicates, even with this adjustment the total production of pecans in the model was greater than the historical high (Table 1).

Similarly, the upland cotton yield of 782 pounds of lint per acre was greater than the El Paso County historical yield of 637 pounds per acre. Therefore, an adjustment of .83333 was included for the yields of upland cotton lint and seed and the model was solved again. The result is solution II and shows a decrease in the objective function from $12.60 million to $10.44 million and a switch of 35,967 acres from upland cotton to pima cotton. The pima cotton yield was 478 pounds of

Table 26. Selected Static Model Results With and Without a Fixed Machinery and Well Input Cost and With and Without Crop Acreage Restrictions

		No Crop Acreage Restrictions		Crop Acreage Restrictions	
	Units	Fixed Machinery and Well Input Costs Included	No Fixed Machinery and Well Input Costs Included	Fixed Machinery and Well Input Costs Included	No Fixed Machinery and Well Input Costs Included
Net Farm Revenue	Million $	39,230,055.62	43,426,314.62	7,226,356.04	12,604,648.73
Upland Cotton	Acres			35,967	35,967
Pima Cotton	Acres				
Alfalfa	Acres			6,083	6,083
Wheat	Acres				
Barley	Acres				
Grain Sorghum	Acres				
Pecans	Acres			4,800	4,800
Tomatoes	Acres			100	100
Lettuce	Acres	48,050	48,050	200	200
Onions	Acres			200	200
Green Chili	Acres			700	700
Red Chili	Acres				
Surface Water Used	Acre Feet	124,930	124,930	143,935.5	143,935.5

Table 27. Selected Static Model Results for Various Solutions with Yield Adjustments for Upland Cotton, Pima Cotton and Pecans

Item	Unit	Solutions Leading to Final Model I	II	III	IV [a]
Upland Cotton Adjustment[b]			.83333	.83333	.83333
Pima Cotton Adjustment[b]				.90909	.90909
Pecan Adjustment[b]		.5	.5	.5	.5
Model Results:					
Net Farm Revenue	Million $	12.6	104.4	8.9	7.34
Upland Cotton	Acres	35,967		23,246	17,344[c]
Pima Cotton	Acres		35,967	12,721	10,656[c]
Alfalfa	Acres	6,083	6,083	6,083	8,517
Wheat	Acres				2,940
Barley	Acres				
Grain Sorghum	Acres				
Pecans	Acres	4,800	4,800	4,800	4,800
Surface Water Used	Acre Feet	143,935.5	143,935.5	143,935.5	144,150
Model Yield:					
Upland Cotton	lb/acre	782		686	693
Pima Cotton	lb/acre		478	383	392
Pecan	lbs.	4,800,000	4,800,000	4,800,000	3,200,000
County Yield:					
Upland Cotton	lb/acre	637	637	637	637
Pima Cotton	lb/acre	426	426	426	426
Pecan[d]	lbs.	3,575,000	3,575,000	3,575,000	3,575,000

[a]Basic model used for analysis with yield adjustments.

[b]These adjustments are the factors by which yields were decreased. The actual coefficients used in the model are the reciprocals of these adjustments due to model mechanics.

[c]Total cotton acreage restricted to 28,000 acres.

[d]Highest ever total yield of pecans for El Paso County. County yields are from Table 2.

lint per acre while the historical El Paso County yield was 426 pounds per acre. Thus, pima cotton lint and seed yield were adjusted by .90909 and the model was again solved, giving solution III in Table 27. The objective function value decreased further from $10.44 million to $8.98 million with 23,246 acres shifted back into upland cotton production leaving 12,721 acres in pima cotton production. This resulted in a 686 pound per acre yield for upland cotton and a 383 pound per acre yield for pima cotton.

While these cotton yields are near the study area average, 35,967 acres in cotton production is more than has been observed in recent years (Table 1). Thus, total cotton acreage was restricted to 28,000 acres. Also, at this time the adjustment on pecans was lowered from .5 to .33333. The model was again solved giving solution IV of Table 27. The objective function again declined in value from $8.98 million to $7.34 million. Upland cotton acreage decreased to 17,344 acres and pima cotton acreage decreased to 10,656 acres. Alfalfa acreage increased from 6,083 acres to 8,517 acres. A total of 2,940 acres of wheat were produced and all available surface water was used. The yield of upland and pima cotton increased to 693 and 392, respectively. The total production of pecans decreased to 3,200,000 pounds which is within the range of observed production.

This final adjusted model (solution IV) was selected for use in the analysis. To examine the option in which pumping groundwater was not allowed, the model was modified. The price of the LP gas required for the operation of an irrigation well was increased from $0.69 per gallon to $999,999.0 per gallon. This change effectively eliminated groundwater pumping.

To provide base solutions, the quantity of surface water available annually was parametrically increased from zero to three feet per acre with the groundwater pumping option included and from 1.05927 to three feet per acre for the no groundwater pumping option. At least 50,898 acre feet of surface water are required to sustain established alfalfa fields and pecan orchards. This is equivalent to a surface water allocation of 1.05927 feet per acre. Allocations of surface water below 1.05927 feet per acre were not considered when groundwater pumping was not permitted.

Economic Implications

Tables 28 and 29 give the net farm revenues generated for alternative surface water allocations. Table 28 gives the results where groundwater pumping is included, while Table 29 gives the results in the absence of groundwater pumping. These data are plotted in Figure 5. With groundwater pumping included, net farm revenues range from 4.719 million dollars at no surface water allocation to 7.336 million dollars at a three acre foot per acre surface water allocation. Without groundwater pumping, net farm revenues range from 1.132 million dollars at a 1.15927 acre foot per acre surface water allocation to 7.331 million dollars at a three acre foot surface water allocation. As can be seen, groundwater pumping is not that important in terms of net farm returns at surface water allocations above about 2.25 feet per acre. On the other hand, at surface water allocations below 2.25 feet per acre, pumping groundwater is extremely important in maintaining net farm returns.

Table 28. Irrigation Water Use and Economic Implications for Alternative Surface Water Allocations with Groundwater Pumping

Total Water Applied feet/acre	Surface Water Allocation feet/acre	Total Surface Water acre feet	Shadow Price of Surface Water $/acre foot	Total Groundwater acre feet	Groundwater per Acre feet/acre	Net Farm Revenues million $
2.77831	0	0	90.37	133,497.7	2.77831	4.719
2.78310	.00812	390	87.32	133,337.7	2.77498	4.754
2.78788	.01623	780	85.05	133,177.7	2.77165	4.789
2.79362	.02597	1248	78.47	132,985.7	2.76765	4.828
2.79362	.02597	1248	57.32	132,985.7	2.76765	4.828
2.79974	.03107	1493	57.32	133,034.7	2.76867	4.842
2.82204	.04965	2385.5	53.50	133,213.2	2.77239	4.893
2.83483	.06031	2898	47.76	133,315.7	2.77452	4.920
2.83808	.06356	3054	45.63	133,315.7	2.77452	4.928
2.83808	.06829	3281.5	40.94	133,088.2	2.76979	4.938
2.84079	.07100	3411.5	39.14	133,088.2	2.76979	4.943
2.85577	.08598	4131.5	37.48	133,088.2	2.76979	4.972
2.86395	.09416	4524.5	35.85	133,088.2	2.76979	4.986
2.86825	.09775	4697	34.44	133,122.7	2.79050	4.992
2.88074	.10816	5197	32.36	133,222.7	2.77258	5.010
2.87214	.15113	7262	32.36	130,744.7	2.72101	5.077
2.84943	.26477	12722	31.88	124,192.7	2.58466	5.253
2.84431	.27757	13337	31.81	123,331.7	2.56674	5.273
2.84701	.28027	13467	31.67	123,331.7	2.56674	5.277
2.82708	.34471	16563.5	30.71	119,278.1	2.48237	5.375
2.82926	.34725	16685.3	29.04	119,260.7	2.48201	5.379
2.86847	.36424	17501.7	29.04	120,328.3	2.50423	5.402
2.87946	.36900	17730.5	29.04	120,627.5	2.51046	5.409
2.87946	.36900	17730.5	27.74	120,627.5	2.51046	5.409
2.95813	.46078	22140.5	27.74	119,997.5	2.49735	5.531
3.00632	.51701	24842.5	27.39	119,611.5	2.48931	5.606
3.00633	.56349	27075.5	26.92	117,378.5	2.44284	5.668
2.99783	.58825	28265.5	26.92	115,780.5	2.40958	5.700
2.97049	.66801	32098	24.07	110,634	2.30248	5.803
2.96219	.70947	34090	22.48	108,243	2.25272	5.851
2.93153	.86281	41458	21.12	99,402	2.06872	6.016
2.92604	.86904	41757.2	21.12	98,838.8	2.05700	6.023
2.90281	.89536	43022	20.09	96,458	2.00745	6.049
2.90281	.91539	43984.5	20.09	95,495.5	1.98742	6.069
2.90281	.95930	46094.5	19.39	93,385.5	1.94351	6.111
2.92604	.97866	47024.5	19.39	93,571.5	1.94738	6.129
2.94102	.99114	47624.5	19.39	93,691.5	1.94988	6.141
2.94901	.99780	47944.5	18.10	93,755.5	1.95121	6.147

Table 28. Continued

Total Water Applied per Acre feet/acre	Surface Water Allocation feet/acre	Total Surface Water acre feet	Shadow Price of Surface Water $/acre foot	Total Groundwater acre feet	Groundwater per Acre feet/acre	Net Farm Revenues million $
2.97973	1.02340	49174.5	18.10	94,001.5	1.95633	6.169
3.03667	1.07085	51454.5	18.10	94,457.5	1.96582	6.210
3.06851	1.09739	52729.5	16.60	94,712.5	1.97112	6.234
3.06851	1.09765	52742.3	16.60	94,699.7	1.97086	6.234
3.06852	1.09835	52775.5	16.60	94,666.5	1.97017	6.234
3.06851	1.09855	52785.5	16.28	94,656.5	1.96996	6.234
3.06851	1.18807	57087	16.27	90,355	1.88044	6.304
3.06851	1.20453	57921	16.27	89,521	1.86308	6.318
3.06851	1.23740	59457	16.26	87,985	1.83111	6.343
3.06851	1.26133	60607	16.26	86,835	1.80718	6.362
3.06852	1.27861	61437	16.26	86,005	1.78991	6.375
3.06851	1.28901	61937	16.26	85,505	1.77950	6.383
3.07892	1.29942	62437	16.26	85,505	1.77950	6.392
3.06851	1.33261	64032	16.26	83,410	1.73590	6.417
3.06850	1.49197	71689.5	16.26	75,752.5	1.57653	6.542
3.06851	1.64468	79027	16.26	68,415	1.42383	6.661
3.06852	1.75426	84292	16.26	63,150	1.31426	6.747
3.06851	1.75701	84424.5	16.26	63,017.5	1.31150	6.749
3.06851	1.75946	84542	16.26	62,900	1.30905	6.751
3.06851	1.83100	87979.5	16.26	59,462.5	1.23751	6.807
3.06851	1.84827	88809.5	16.26	58,632.5	1.22024	6.820
3.06851	1.85868	89309.5	16.26	58,132.5	1.20983	6.829
3.06852	1.86706	89712	16.26	57,730	1.20146	6.835
3.06851	1.93100	92784.5	16.26	54,657.5	1.13751	6.885
3.06851	1.93823	93132	16.26	54,310	1.13028	6.891
3.06851	2.00000	96100	8.27	51,342	1.06851	6.939
3.06851	2.09062	100454.5	8.27	46,987.5	0.97789	6.975
3.06851	2.10798	101288.5	8.27	46,153.5	0.96053	6.982
3.06851	2.13995	102824.5	8.26	44,617.4	0.92856	6.995
3.06851	2.18537	105007	8.26	42,435	0.88314	7.013
3.06851	2.20930	106157	8.26	41,285	0.85921	7.022
3.06851	2.24999	108112	8.26	39,330	0.81852	7.038
3.06851	2.25722	108459.5	8.26	38,982.5	0.81129	7.041
3.06851	2.40993	115797	8.26	31,645	0.65858	7.102
3.06851	2.43386	116947	8.26	30,495	0.63465	7.111
3.06851	2.48407	119359.5	8.26	28,082.5	0.58444	7.131
3.06851	2.81851	135429.5	8.26	12,012.5	0.25000	7.264
3.06851	2.82574	135777	8.26	11,665	0.24277	7.267
3.06851	2.89619	138162	8.26	8,280	0.17232	7.295
3.06851	2.92491	140542	8.26	6,900	0.14360	7.306
3.06852	2.97374	142888	8.26	4,554	0.09478	7.326
3.06851	3.00000	144150	8.26	3,292	0.06851	7.336

Table 29. Irrigation Water Use and Economic Implications for Alternative Surface Water Allocations in the Absence of Groundwater Pumping

Surface Water Allocation feet/acre	Total Surface Water acre feet	Shadow Price of Surface Water $/acre foot	Net Farm Revenue million $
1.05927	50,898	544.49	1.132
1.06739	51,288	485.26	1.344
1.07550	51,678	395.34	1.533
1.10391	53,043	326.34	2.078
1.10797	53,238	99.99	2.137
1.11453	53,553	99.99	2.168
1.14184	54,866	99.99	2.299
1.14965	55,241	99.99	2.337
1.15745	55,616	99.99	2.374
1.16135	55,803	99.99	2.393
1.18348	56,866	99.99	2.500
1.19967	57,644	99.99	2.577
1.21079	58,179	99.99	2.631
1.21860	58,554	99.99	2.668
1.22640	58,929	99.99	2.706
1.22699	58,957	99.99	2.709
1.23479	59,332	99.99	2.746
1.24260	59,707	99.99	2.784
1.37586	66,110	99.99	3.424
1.40317	67,422	99.99	3.555
1.41098	67,797	99.99	3.592
1.41371	67,929	99.99	3.606
1.41761	68,116	99.99	3.624
1.41878	68,172	99.99	3.630
1.42990	68,707	99.99	3.683
1.49331	71,754	99.99	3.988
1.52063	73,066	99.99	4.119
1.52843	73,441	99.99	4.157
1.53604	73,807	99.99	4.193
1.54603	74,287	99.99	4.241
1.59395	76,589	99.99	4.472
1.63988	78,796	99.99	4.692
1.65927	79,728	99.99	4.785
1.66317	79,915	99.99	4.804
1.67281	80,379	99.99	4.850
1.69478	81,434	82.56	4.956
1.69868	81,622	74.01	4.971
1.69888	81,631	74.01	4.972
1.71273	82,297	74.01	5.021
1.72600	82,934	71.35	5.069
1.73380	83,309	69.47	5.095
1.74005	83,609	69.47	5.116
1.74161	83,684	59.54	5.121

Table 29. Continued

Surface Water Allocation feet/acre	Total Surface Water acre feet	Shadow Price of Surface Water $/acre foot	Net Farm Revenue million $
1.75940	84,539	59.54	5.172
1.84482	88,644	59.54	5.417
1.92668	92,577	59.54	5.651
1.95282	93,833	53.93	5.726
1.95417	93,898	51.94	5.729
1.96250	94,298	51.94	5.750
1.97290	94,798	51.94	5.776
1.97811	95,048	51.94	5.789
2.00000	96,100	43.94	5.844
2.03258	97,666	43.94	5.912
2.04091	98,066	43.94	5.930
2.06900	99,416	43.94	5.989
2.07733	99,816	43.94	6.007
2.08773	100,316	43.94	6.029
2.09293	100,566	43.94	6.040
2.15095	103,353	43.94	6.162
2.18737	105,103	43.94	6.239
2.19777	105,603	43.94	6.261
2.20298	105,853	43.94	6.272
2.22993	107,148	43.94	6.329
2.26635	108,898	43.94	6.406
2.27675	109,398	43.94	6.428
2.28196	109,648	43.94	6.439
2.28258	109,678	43.94	6.440
2.29132	110,098	42.65	6.459
2.32452	111,693	42.65	6.527
2.48388	119,351	42.65	6.853
2.56614	123,303	39.76	7.022
2.57236	123,602	39.76	7.034
2.57334	123,649	39.76	7.036
2.57561	123,758	32.94	2.040
2.57831	123,888	23.81	7.044
2.58102	124,018	15,72	7.047
2.71226	130,324	15.72	7.146
2.75009	132,142	15.72	7.175
2.88495	138,622	9.79	7.277
2.88870	138,802	9.79	7.279
2.94901	141,700	9.79	7.307
3.00000	144,150	9.79	7.331

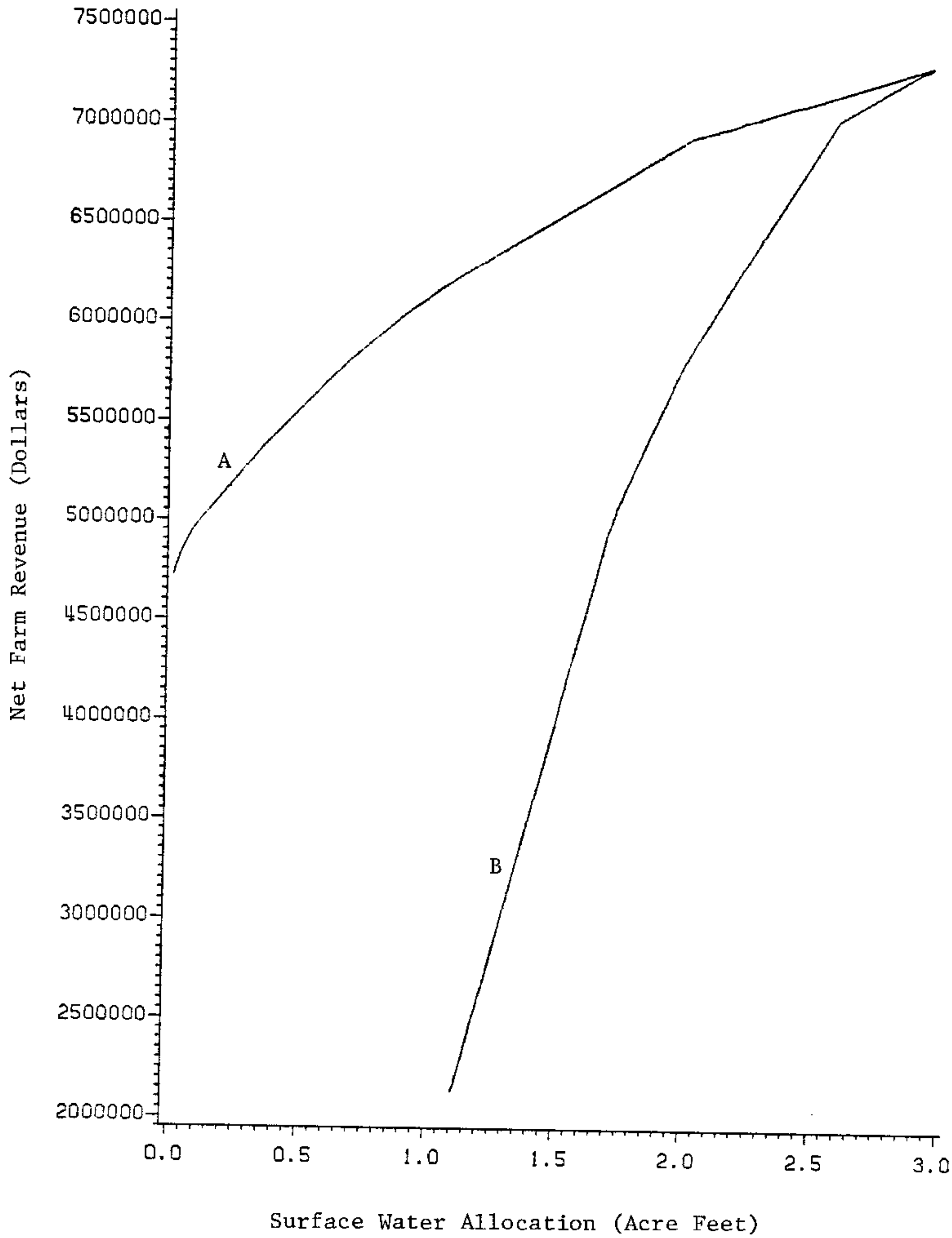

Figure 5. Net Farm Revenue as a Function of Surface Water Allocation With (A) and Without (B) Groundwater Pumping

Tables 28 and 29 also give the value of an additional acres foot of surface water at each specified allocation level (i.e., the marginal value product of irrigation water). This information is displayed in Figure 6. For the groundwater pumping option, this value ranges from $90.37 per acre foot where no surface water is allocated down to $8.26 per acre foot at a three foot surface water allocation. For the no pumping option, the value drops from $544.49 per acre foot at 1.05927 foot allocation to $9.79 at a three foot surface water allocation. This is almost as low as the $8.26 value when groundwater pumping is allowed. These values of an additional foot of water establish the economically justifiable maximum price which could be paid for an additional unit of irrigation water.

As the surface water allocation increases, the use of groundwater generally decreases. This is depicted graphically in Figure 7 and numerically in Table 28. The total water applied per acre is also given in Table 28. It ranges from 2.78 feet, or 2 feet and 9.34 inches to a high of 3.08 feet or 3 feet and 0.95 inches. This information is displayed in Figure 8.

There are two abrupt decreases in total water applied as surface water is increased. These drops come about because surface water is replacing saline groundwater. Twenty percent more water is pumped from saline groundwater sources for salt leaching than is required from surface water sources. Thus, total groundwater used is dropping faster than total surface water applied is rising. At a surface water allocation of 1.09737 acre feet, total water applied levels off to 3.06851 acre feet. It appears that the 3 acre feet allocation set as the

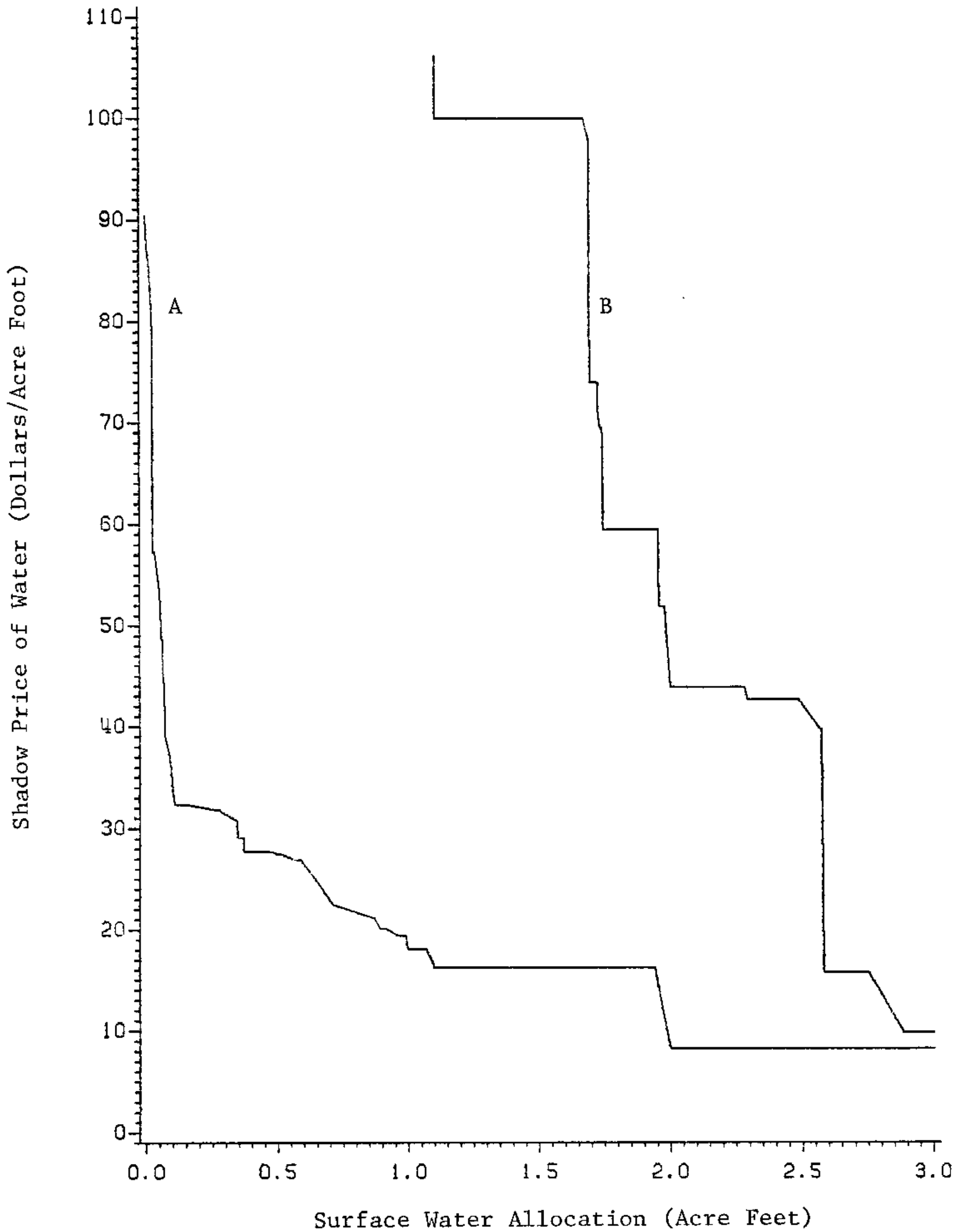

Figure 6. Value of an Additional Acre Foot of Surface Water at Alternative Surface Water Allocations With (A) and Without (B) Groundwater Pumping

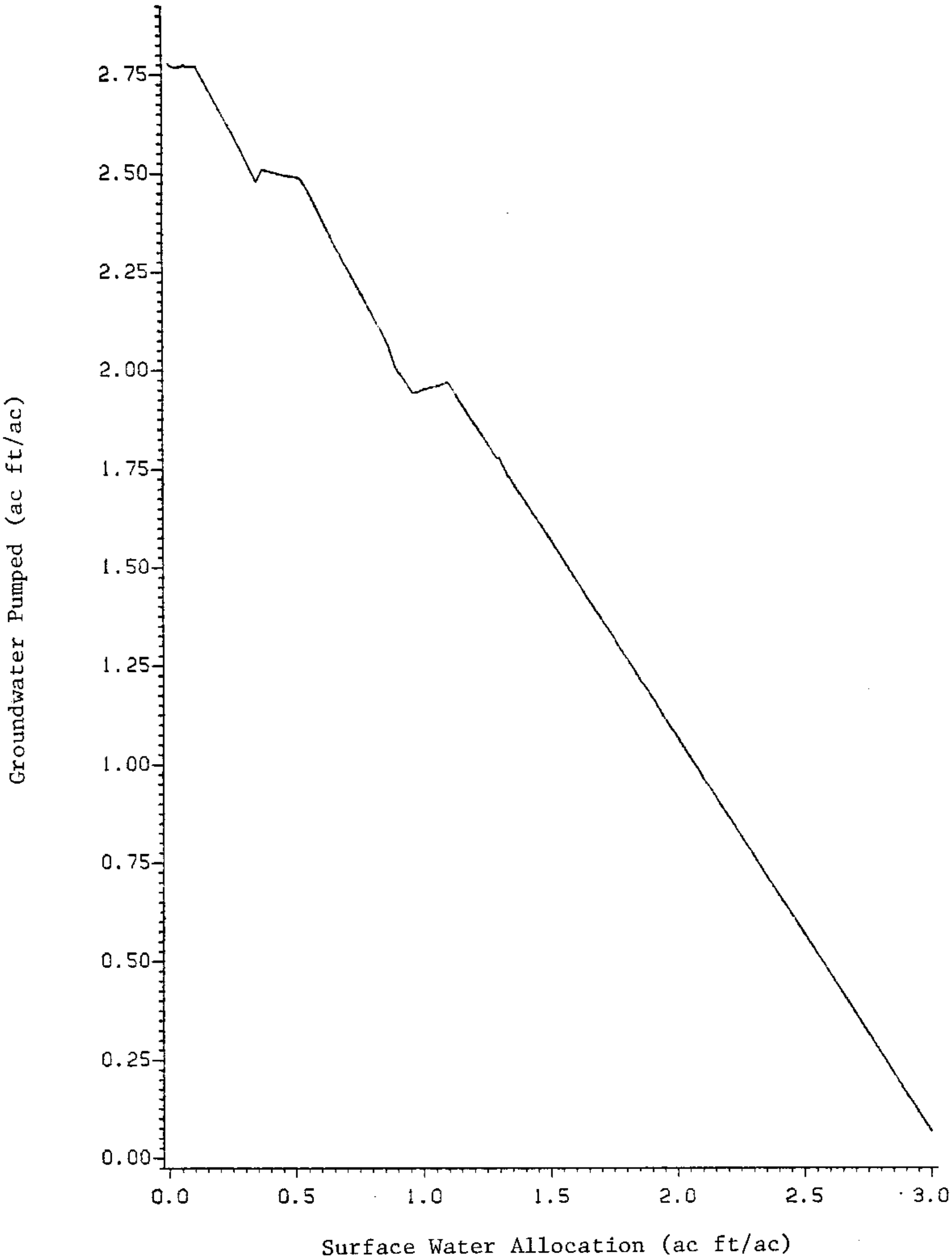

Figure 7. Groundwater Pumped Per Acre at Alternative Surface Water Allocation Levels

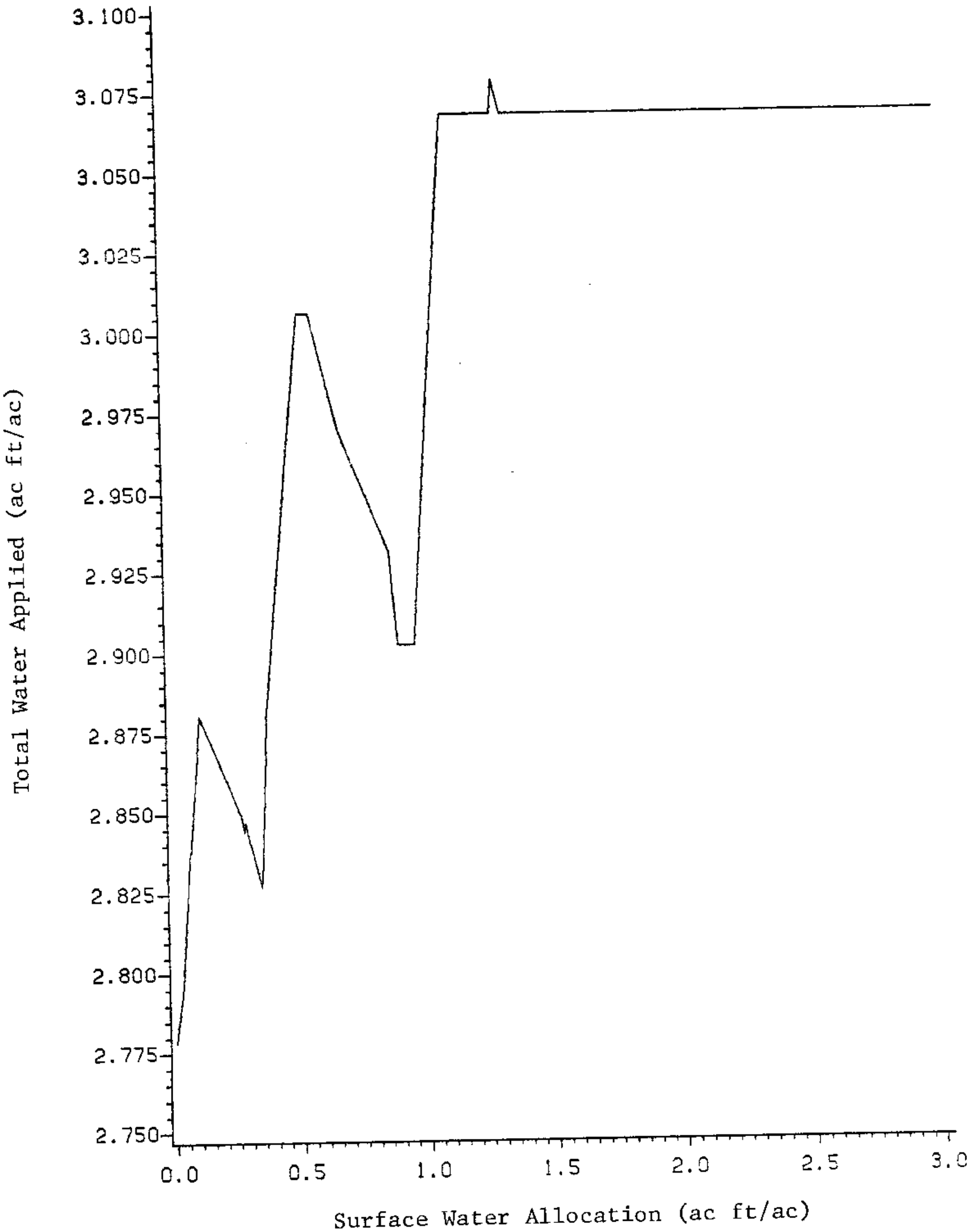

Figure 8. Total Ground and Surface Irrigation Water Applied Per Acre at Alternative Surface Water Allocation Levels

appropriate allocation by Rio Grande Project planners is very close to the optimal requirement for maximum profit. As the surface water allocation rises, the total water applied per acre varies and then stabilizes at 3.06851 acre feet.

Cropping Patterns

The cropping pattern for zero surface water when groundwater pumping is allowed is the following:

Upland cotton	-	17312 acres;
Pima cotton	-	10688 acres;
Alfalfa	-	6083 acres;
Wheat	-	708 acres;
Barley	-	0 acres;
Grain sorghum	-	0 acres;
Pecans	-	4800 acres;
Tomatoes	-	100 acres;
Lettuce	-	200 acres;
Onions	-	200 acres;
Green chili	-	700 acres; and
Red chili	-	0 acres.

Barley, grain sorghum and red chili did not enter the solution. Wheat, barley and grain sorghum actually compete for the same acreage. These crops are viewed as substitutes for each other. When land is allocated for the production of grain, the one crop of these three with the highest profit is planted. Thus, the acreages given in the results for wheat could have easily been barley or grain sorghum.

As the surface water allocation increases only upland and pima cotton, alfalfa and wheat acreage change. These changes are given in Table 30. At a surface water allocation of three feet per acre these four crops had the following acreages:

Upland cotton	-	17,344 acres;
Pima cotton	-	10,656 acres;
Alfalfa	-	8,517 acres; and
Wheat	-	2,940 acres.

Table 30. Crop Production Acreages for Upland and Pima Cotton, Alfalfa and Wheat by Selected Surface Water Allocation with the Pumping of Groundwater Allowed

Surface Water Allocation feet/acre	Cotton		Alfalfa	Wheat
	Upland	Pima		
	acres			
0	17,312	10,688	6,083	780
.00812	17,312	10,688	6,083	980
.01623	17,312	10,688	6,083	1,180
.02597	17,312	10,688	6,083	1,420
.03107	17,312	10,688	6,083	1,518
.04965	17,312	10,688	6,083	1,875
.06031	17,107	10,893	6,083	2,080
.08598	17,107	10,893	6,083	2,320
.09416	17,107	10,893	6,083	2,451
.09775	17,107	10,893	6,083	2,520
.10816	17,107	10,893	6,083	2,720
.27757	17,312	10,688	6,083	2,720
.34471	17,875	10,125	6,083	2,720
.34725	17,875	10,125	6,083	2,778
.36424	17,875	10,125	6,397	2,778
.36900	17,875	10,125	6,485	2,778
.46078	17,875	10,125	7,745	1,518
.51701	17,875	10,125	8,517	746
.56349	17,237	10,763	8,517	746
.70947	17,569	10,431	8,517	746
.86904	17,657	10,343	8,517	658
.89536	18,029	9,971	8,517	286
.91539	18,414	9,586	8,517	286
.95930	19,258	8,742	8,517	286
.97886	19,258	8,742	8,517	658
.99114	19,258	8,742	8,517	898
.99780	19,258	8,742	8,517	1,026
1.02340	18,766	9,234	8,517	1,518
1.07085	17,854	10,146	8,517	2,430
1.09739	17,344	10,656	8,517	2,940
3.00000	17,344	10,656	8,517	2,940

The model solutions for crop acreages when groundwater pumping is not allowed is a completely different situation. The results are given in Table 31. At a surface water allocation of 1.05927 feet per acre, only 6083 acres of alfalfa and 4800 acres of pecans were in the solution. The 4800 acres of pecans were constant throughout all solutions. Vegetable crops came into the solution as soon as there was irrigation water available beyond the alfalfa and pecan requirements. Vegetable acres across all surface water allocations of 1.11 acre feet/acre or more were as follows:

Lettuce - 200 acres;
Onions - 200 acres;
Green chili - 700 acres; and
Tomatoes - 100 acres.

As the allocations of surface water were increased, upland cotton, wheat and finally pima cotton successively entered the solutions (Table 31). At a three foot surface water allocation, upland and pima cotton, alfalfa and wheat had the following acreages:

Upland cotton - 18,441.33;
Pima cotton - 9,558.67;
Alfalfa - 8,517; and
Wheat - 1,842.67.

It should be noted from Table 31 that as the surface water allocation is increased, vegetable crops were first added to the solution, then upland cotton. Only above a surface water allocation of 2.32452 feet per acre do pima cotton and wheat enter the solution and alfalfa acreage increase over its lower limit.

Laser Leveling

Laser leveling was shown to be unimportant when groundwater pumping is allowed. Only a maximum of 640 acres leveled and only at surface

Table 31. Crop Production Acreages for Upland and Pima Cotton, Alfalfa, Wheat, Tomatoes, Lettuce, Onions and Green Chili at Alternative Surface Water Allocations Without the Pumping of Groundwater

Surface Water Allocation feet/acre	Cotton		Alfalfa	Wheat	Tomatoes	Lettuce	Onions	Green Chili
	Upland	Pima						
	acres							
1.05927			6,083					
1.06739			6,083			200		
1.07550			6,083			200	200	
1.10391			6,083			200	200	700
1.10797			6,083		100	200	200	700
1.11453	168		6,083		100	200	200	700
1.14184	868		6,083		100	200	200	700
1.14965	1,068		6,083		100	200	200	700
1.15745	1,268		6,083		100	200	200	700
1.16135	1,368		6,083		100	200	200	700
1.18348	1,935		6,083		100	200	200	700
1.19967	2,350		6,083		100	200	200	700
1.21079	2,635		6,083		100	200	200	700
1.21860	2,835		6,083		100	200	200	700
1.22640	3,035		6,083		100	200	200	700
1.22699	3,050		6,083		100	200	200	700
1.23479	3,250		6,083		100	200	200	700
1.24260	3,450		6,083		100	200	200	700
1.37586	6,865		6,083		100	200	200	700
1.40317	7,565		6,083		100	200	200	700
1.41098	7,765		6,083		100	200	200	700
1.41371	7,835		6,083		100	200	200	700
1.41761	7,935		6,083		100	200	200	700
1.41878	7,965		6,083		100	200	200	700
1.42990	8,250		6,083		100	200	200	700
1.49331	9,875		6,083		100	200	200	700
1.52063	10,575		6,083		100	200	200	700
1.52843	10,775		6,083		100	200	200	700
1.53604	10,970		6,083		100	200	200	700
1.54603	11,226		6,083		100	200	200	700
1.59395	12,454		6,083		100	200	200	700
1.63988	13,631		6,083		100	200	200	700
1.65927	14,128		6,083		100	200	200	700
1.66317	14,228		6,083		100	200	200	700
1.67281	14,475		6,083		100	200	200	700
1.69478	15,038		6,083		100	200	200	700
1.69868	15,138		6,083		100	200	200	700

Table 31. Continued

Surface Water Allocation feet/acre	Cotton		Alfalfa	Wheat	Tomatoes	Lettuce	Onions	Green Chili
	Upland	Pima						
	acres							
1.69888	15,143		6,083		100	200	200	700
1.71273	15,498		6,083		100	200	200	700
1.72600	15,838		6,083		100	200	200	700
1.73380	16,038		6,083		100	200	200	700
1.74005	16,198		6,083		100	200	200	700
1.74161	16,238		6,083		100	200	200	700
1.96250	16,398		6,083		100	200	200	700
1.97290	16,598		6,083		100	200	200	700
1.97811	16,698		6,083		100	200	200	700
2.00000	17,118.8		6,083		100	200	200	700
2.03258	17,745		6,083		100	200	200	700
2.04091	17,905		6,083		100	200	200	700
2.06900	18,445		6,083		100	200	200	700
2.07733	18,605		6,083		100	200	200	700
2.08773	18,805		6,083		100	200	200	700
2.09293	18,905		6,083		100	200	200	700
2.15095	20,020		6,083		100	200	200	700
2.18737	20,720		6,083		100	200	200	700
2.19777	20,920		6,083		100	200	200	700
2.20298	21,020		6,083		100	200	200	700
2.22993	21,538		6,083		100	200	200	700
2.26635	22,238		6,083		100	200	200	700
2.27675	22,438		6,083		100	200	200	700
2.28196	22,538		6,083		100	200	200	700
2.28258	22,550		6,083		100	200	200	700
2.29132	22,718		6,083		100	200	200	700
2.32452	22,718	638	6,083		100	200	200	700
2.48388	22,718	3,701	6,083		100	200	200	700
2.56614	22,718	5,282	6,083		100	200	200	700
2.71226	21,667	6,333	7,134		100	200	200	700
2.75009	21,364	6,636	7,437		100	200	200	700
2.88495	20,284	7,716	8,517		100	200	200	700
2.88870	20,224	7,776	8,517	60	100	200	200	700
2.94901	19,258	8,742	8,517	1,027	100	200	200	700
3.00000	18,441.33	9,558.67	8,517	1,842.67	100	200	200	700

water allocations below .28027 feet per acre. The crops that justified laser leveling were lettuce, onions and green chili. This information is given in Table 32.

Laser leveling was much more important in the absence of groundwater pumping. In addition to lettuce, onions and green chili, tomatoes and upland cotton were also leveled. The vegetables were leveled first and then upland cotton. The acreages immediately go to the limit for vegetables. Upland cotton acreage laser leveled increases to 17,438 acres at a surface water allocation of 1.74161 feet per acre with the total acres leveled at a maximum of 18,638 acres. At surface water allocations above 1.95282 feet per acre, only vegetables are leveled, and above 2.58102 feet per acre no acres are laser leveled. These results are also given in Table 32.

Temporal Model

The temporal model was run with and without groundwater pumping. The temporal model selected the temporal water usage of available surface water allocations under a situation of perfect knowledge across all years. The model maximized the real value in 1980 dollars of net revenue brought forward to 1980 by the real interest rate.

Annual Surface Water Use

The optimal usage rates and the actual surface water allocations are given in Table 33. It should be noted here that the surface water usage for the no groundwater pumping scenario for 1964 and 1978 are below 1.05927 feet per acre. This is the allocation necessary to maintain alfalfa fields and pecan orchards. There is not 1.05927 feet

Table 32. Crop Acreages Laser Leveled at Alternative Surface Water Allocations With and Without Groundwater Pumping

Surface Water Allocations	Acres Laser Leveled				
	Onions	Lettuce	Green Chili	Tomatoes	Upland Cotton
Pumping					
.00812	200				
.01623	200	200			
.02597	200	200	240		
.06356	200	200			
.07100	200				
.28027					
No Pumping					
1.06739		200			
1.07550	200	200			
1.10391	200	200	700		
1.10797	200	200	700	100	
1.11453	200	200	700	100	168
1.14184	200	200	700	100	868
1.14965	200	200	700	100	1,068
1.15745	200	200	700	100	1,268
1.16135	200	200	700	100	1,368
1.18348	200	200	700	100	1,935
1.19967	200	200	700	100	2,350
1.21079	200	200	700	100	2,635
1.21860	200	200	700	100	2,835
1.22640	200	200	700	100	3,035
1.22699	200	200	700	100	3,050
1.23479	200	200	700	100	3,250
1.24260	200	200	700	100	3,450
1.37586	200	200	700	100	6,865
1.40317	200	200	700	100	7,565
1.41098	100	200	700	100	7,765
1.41371	200	200	700	100	7,835
1.41761	200	200	700	100	7,935
1.41878	200	200	700	100	7,965
1.42990	200	200	700	100	8,250
1.49331	200	200	700	100	9,875
1.52063	200	200	700	100	10,575
1.52843	200	200	700	100	10,775
1.53604	200	200	700	100	10,970
1.54603	200	200	700	100	11,226
1.59395	200	200	700	100	12,454
1.63988	200	200	700	100	13,631
1.65927	200	200	700	100	14,128
1.66317	200	200	700	100	14,228

Table 32. Continued

Surface Water Allocations	Acres Laser Leveled				
	Onions	Lettuce	Green Chili	Tomatoes	Upland Cotton
1.67281	200	200	700	100	14,475
1.69478	200	200	700	100	15,038
1.69868	200	200	700	100	15,138
1.69888	200	200	700	100	15,143
1.71273	200	200	700	100	15,498
1.72600	200	200	700	100	15,838
1.73380	200	200	700	100	16,038
1.74005	200	200	700	100	16,198
1.74161	200	200	700	100	17,438
1.75940	200	200	700	100	14,870
1.84482	200	200	700	100	8,303
1.92668	200	200	700	100	2,010
1.95282	200	200	700	100	
1.95417	200	200	700		
2.57236	200	200	240		
2.57334	200	200	168		
2.57561	200	200			
2.57831	200				
2.58102					

Table 33. Actual Surface Water Allocations, Optimal Temporal Surface Water Usage Rates With and Without Groundwater Pumping and the Two Acre Feet Usage Rates, 1963 to 1980

Year	Actual Surface Water Allocation ac ft/acre	Optimal Temporal Surface Water Usage Rates: Groundwater Pumping ac ft/acre	Optimal Temporal Surface Water Usage Rates: No Groundwater Pumping ac ft/acre	Two Acre Feet Per Acre ac ft/acre
1963	2	1.51461	2	2
1964	.33	.66801	.33	.33
1965	1.85	1.85	1.85	1.85
1966	2.5	2	2	2
1967	1.5	1.88875	1.88875	1.93229
1968	2	2	2	2
1969	3	3	2.57831	2
1970	3	2	2.57831	2
1971	2	2	2	2
1972	.67	1.26401	1.12615	1.95148
1973	3	3	2.58102	2
1974	3	3	2.58102	2
1975	3	2.58241	2.57831	2
1976	3	2	2.57561	2
1977	1.25	2	2	2
1978	.75	.99780	.99290	2
1979	3	3	3	2
1980	3	3	3	2
Available for Transfer to 1981				2.27122
Total	38.85	37.76559	37.66038	36.33499
Evaporation Feet		1.08441	1.18962	2.51501
%		2.79	3.06	6.47

Note: All entries measure surface water use only. The two acre feet per acre option is the same whether or not groundwater pumping is allowed. Its method of calculation is given in Appendix E.

per acre available total for both the years of 1963 and 1964. For the model to solve, it was necessary to allow the surface water usage for 1964 to be below 1.05927 feet per acre. This resulted in the 1978 surface water usage falling just below the 1.05927 alfalfa and pecan maintenance level. Thus, the production and acreage for alfalfa and pecans for 1965 and 1979 may not be as realistic as estimates for other years.

Also given in Table 33 is a usage scheme whereby a maximum of two acre feet of surface water is used per acre and the rest stored for future use. This is a practical surface water usage scheme which will, most likely, be contemplated by farmers. The adaptation of the Rippl diagram, described in Chapter II, in Figure 9 demonstrates how water would be needed for use in short surface water allocation years and be available for storage in long surface water allocation years. The area below the two acre feet per year line is needed from storage to provide two acre feet per year. The area above the two acre feet per year line is available for storage. Evaporation has not been taken into account.

The calculation of this surface water usage scenario is explained in Appendix E. Table 33 also contains the total surface water used over the time period, the total evaporation from stored water and the percentage loss to evaporation for each of the three scenarios. As can be seen, while the two acre feet per acre scenario provides a much more consistent supply of water, the associated evaporation loss is at least twice as high as either of the other scenarios. The groundwater pumping scenario indicates losses to evaporation of almost as much water as the

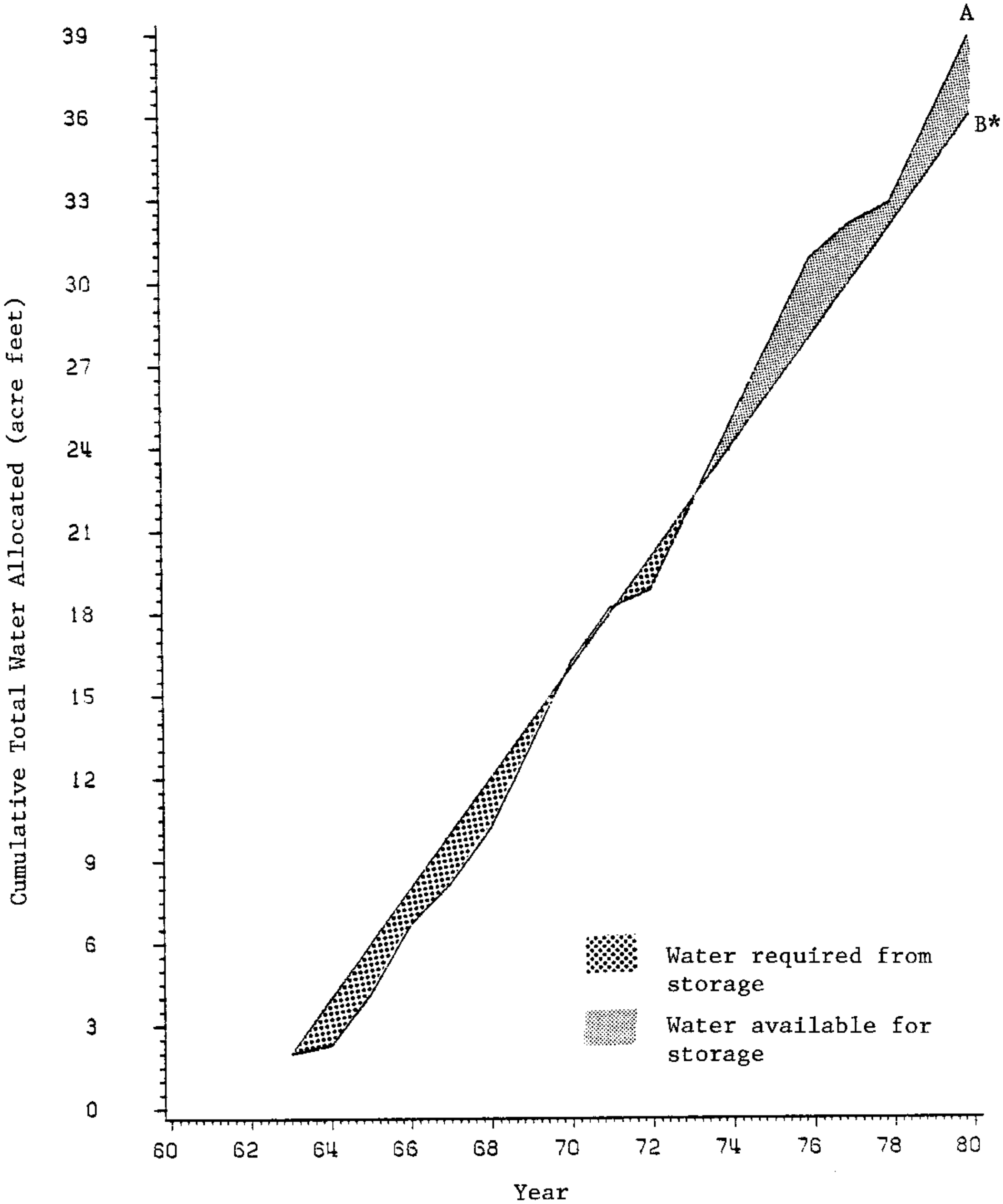

Figure 9. Cumulative Total Water Allocated (A) by Year and the Cumulative Total Water for Two Acre Feet Per Year (B) by Year.

* Does not take into account evaporation of stored water.

no groundwater pumping scenario. It should be noted only the two acre feet per acre scenario had stored water in 1980 for 1981 use. Each of these three scenarios is depicted graphically against the actual surface water allocation for 1963 through 1980 in Figures 10, 11 and 12. Each figure demonstrates when water would be required from storage and available for storage.

Crop Production

Crop production was very consistent, as expected, for surface water use of the two acre feet and the optimal temporal surface water allocation with groundwater pumping. Both these scenarios showed the same production of the following crops for all years:

Barley	- 0 bushels;
Grain sorghum	- 0 bushels;
Pecans	- 3,200,000 pounds;
Tomatoes	- 1160 tons;
Lettuce	- 111,600 50-lb. cartons;
Onions	- 142,800 50-lb. sacks;
Green chili	- 5390 tons; and
Red chili	- 0 pounds.

Upland and pima cotton lint and seed, alfalfa and wheat production varied only for the years 1964 and 1978, for the optimal temporal surface water use scenario and for the year 1964 for the two acre feet per acre surface water allocation scenario. The production levels for these crops are given in Table 34. The crop production results of the no groundwater pumping scenario were more varied and are given in Table 35. Pima cotton and wheat are not always produced and the production of pecans and vegetables varies. There is no production of barley, grain sorghum or red chili.

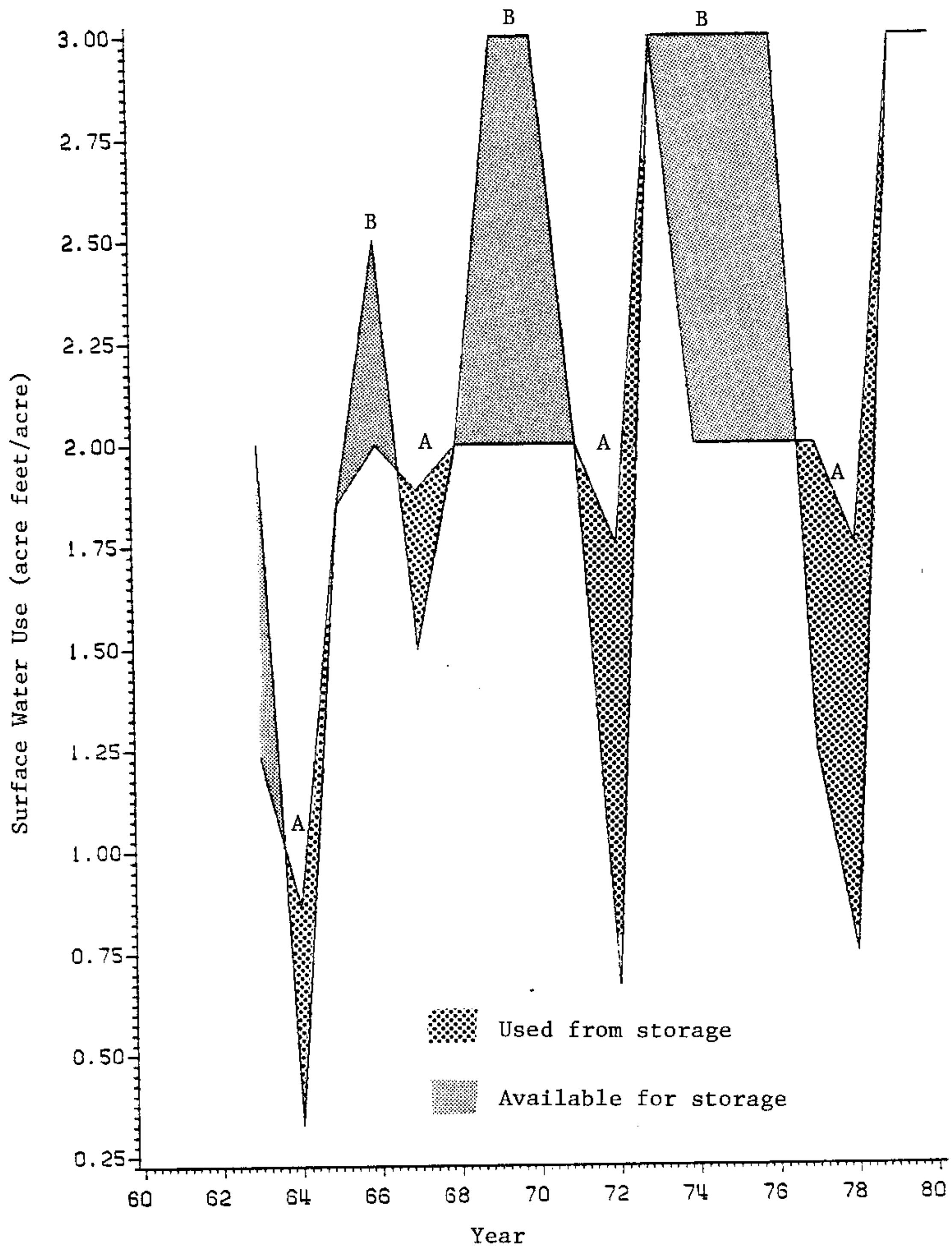

Figure 10. Optimal Temporal Surface Water Use With Groundwater Pumping (A) Against the Actual Pattern of Water Allocations (B)

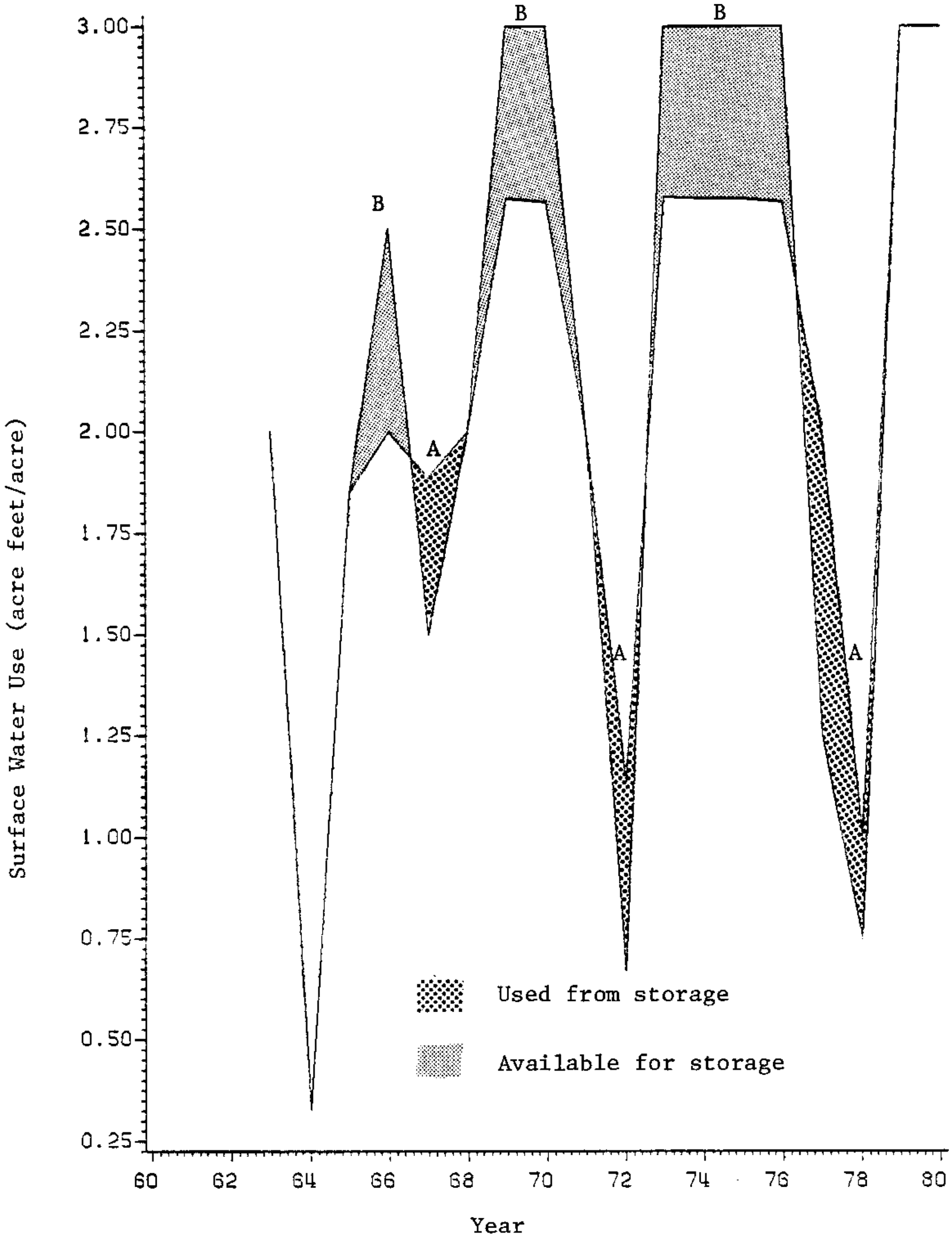

Figure 11. Optimal Temporal Surface Water Use Without Groundwater Pumping (A) Against the Actual Pattern of Water Allocations (B).

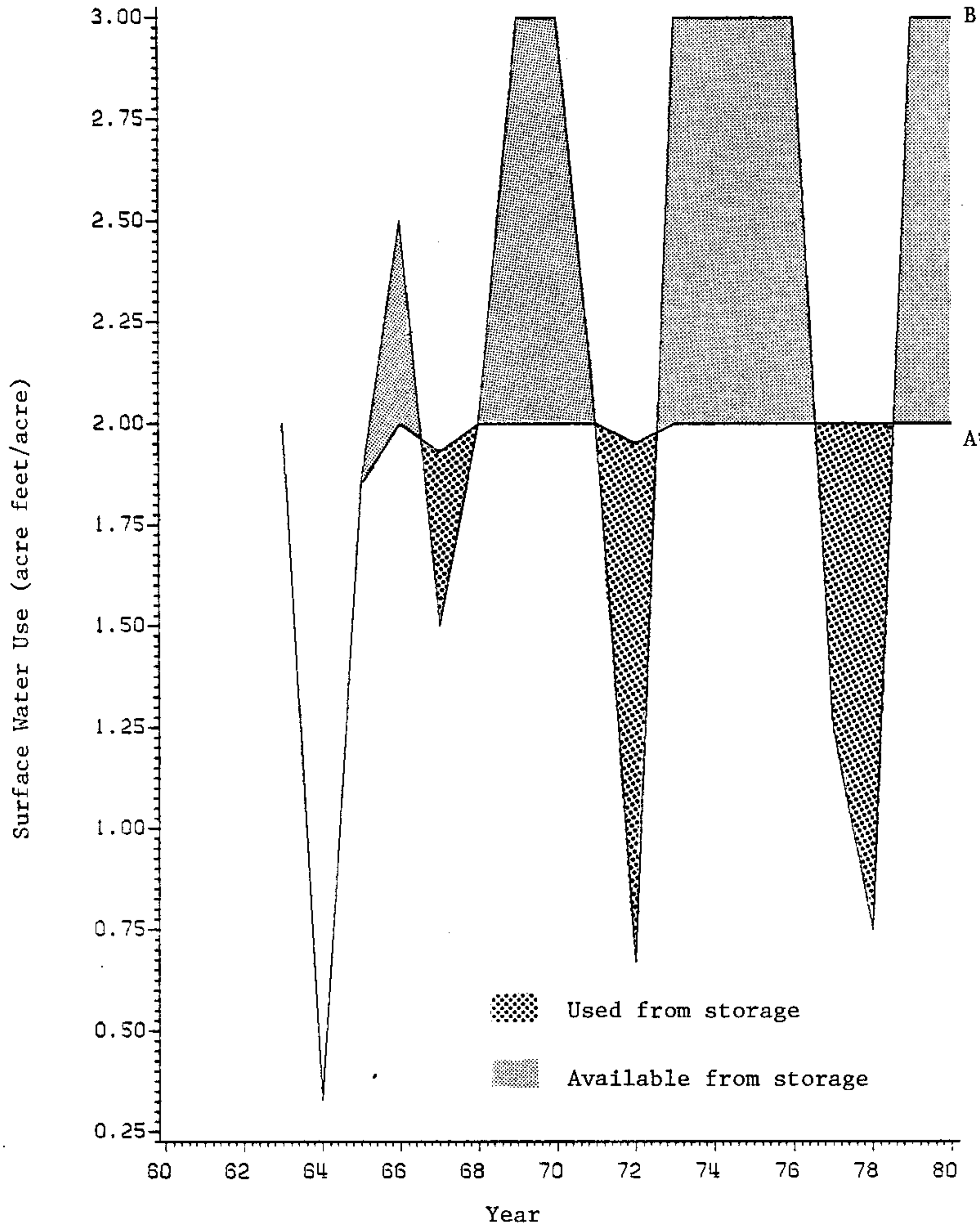

Figure 12. The Two Acre Feet Per Acre Surface Water Use Scenario (A) Against the Actual Pattern of Water Allocations (B).

* Groundwater pumping does not affect the decision of how much surface water is used.

Table 34. Crop Production Levels for Upland and Pima Cotton, Alfalfa and Wheat for the Optimal Temporal Surface Water Allocation With Groundwater Pumping and Two Acre Feet Per Acre Scenarios, 1963-1980

	Upland Cotton		Pima Cotton			
	Lint lb.	Seed lb.	Lint lb.	Seed lb.	Alfalfa ton	Wheat bu.
Optimal Temporal Allocation	12,084,107	19,334,571	4,175,215	6,680,343	54,509	199,920
Except: 1964	11,713,100	18,868,960	4,417,402	7,067,843	53,617	50,728
1978	13,194,227	21,110,763	3,425,275	5,480,439	54,509	69,768
Two Acre Feet Per Acre	12,084,107	19,334,571	4,175,215	6,680,343	54,509	199,920
Except: 1964	12,473,984	19,958,375	4,213,429	6,741,486	37,339	184,960

Table 35. Crop Production Levels for Twelve Selected Crops for the Optimal Temporal Surface Water Allocation Without Groundwater Pumping Scenario

Year	Upland Cotton Lint (lb.)	Upland Cotton Seed (lb.)	Pima Cotton Lint (lb.)	Pima Cotton Seed (lb.)	Alfalfa (ton)	Wheat (bu.)	Pecans (lb.)	Tomatoes (ton)	Lettuce (carton)[a]	Onions (sack)[b]	Green Chili (ton)
1963	12,310,477	19,696,764			38,931		3,200,000	1,160	111,600	164,200	5,390
1964	2,235,791	3,477,265			7,377		606,336	220	21,146	31,116	1,021
1965	11,799,613	18,879,381			38,931		3,200,000	1,160	111,600	164,200	5,390
1966	12,310,477	19,696,764			38,931		3,200,000	1,160	111,600	164,200	5,390
1967	11,799,613	18,879,381			38,931		3,200,000	1,160	111,600	164,200	5,390
1968	12,310,477	19,696,764			38,931		3,200,000	1,160	111,600	164,200	5,390
1969	15,558,013	24,892,821	2,069,584	3,311,334	38,931		3,200,000	1,160	111,600	164,200	5,390
1970	15,558,013	24,892,821	2,069,584	3,311,334	38,931		3,200,000	1,160	111,600	164,200	5,390
1971	12,310,477	19,696,764			38,931		3,200,000	1,160	111,600	164,200	5,390
1972	7,629,748	12,207,597			25,173		2,069,152	750	72,162	106,173	3,485
1973	15,558,013	24,892,821	2,069,584	3,311,334	38,931		3,200,000	1,160	111,600	164,200	5,390
1974	15,558,013	24,892,821	2,069,584	3,311,334	38,931		3,200,000	1,160	111,600	164,200	5,390
1975	15,558,013	24,892,821	2,069,584	3,311,334	38,931		3,200,000	1,160	111,600	164,200	5,390
1976	15,558,013	24,892,821	2,069,584	3,331,334	38,931		3,200,000	1,160	111,600	164,200	5,390
1977	12,310,447	19,696,764			38,931		3,200,000	1,160	111,600	164,200	5,390
1978	6,727,077	10,763,324			22,195		1,824,352	661	63,624	93,612	3,073
1979	12,720,560	20,352,896	3,745,259	5,992,415	54,509	125,301	3,200,000	1,160	111,600	164,200	5,390
1980	12,720,560	20,352,896	3,745,259	5,992,415	54,509	125,301	3,200,000	1,160	111,600	164,200	5,390

[a] 50 pound cartons.

[b] 50 pound sacks.

Cropping Patterns

Cropping patterns naturally followed closely the production patterns for the alternative surface water usage scenarios. For the optimal temporal surface water allocation with groundwater pumping and two acre feet per acre surface water scenarios, the following acreages of these crops were indicated by the model results for all years:

Barley	- 0 acres;
Grain sorghum	- 0 acres;
Pecans	- 4800 acres;
Tomatoes	- 100 acres;
Lettuce	- 200 acres;
Onions	- 200 acres;
Green chili	- 700 acres; and
Red chili	- 0 acres.

Upland and pima cotton, alfalfa and wheat acreage change only for 1964 and 1978 for the optimal temporal surface water allocation and only in 1964 for the two acre feet per acre scenario (Table 36). The optimal temporal surface water allocation without groundwater pumping scenario results reflect much more variation than the results of the other scenarios (Table 37). Cropping pattern results based on no groundwater pumping do not always include acreages for pima cotton and wheat and never include acreages for barley, grain sorghum and red chili.

Input Requirements

The level of input requirements for a 2 or 3 foot surface water allocation per year per acre with groundwater pumping and for a 2, 2.57831 and 3 foot surface water allocation without groundwater pumping are presented in Table 38. These surface water allocations were chosen because of their more frequent occurrence over time in the alternative scenarios.

Table 36. Crop Acreages for Upland and Pima Cotton, Alfalfa and Wheat for the Optimal Temporal Surface Water Allocation With Groundwater Pumping and the Two Acre Feet Per Acre Scenarios (1963-1980)

	Cotton			
	Upland acres	Pima acres	Alfalfa acres	Wheat acres
Optimal Temporal Allocation Pumping	17,344	10,656	8,517	2,940
Except: 1964	17,237	10,763	8,517	746
1978	19,258	8,742	8,517	1,026
Two Acre Feet Per Acre	17,344	10,656	8,517	2,940
Except: 1964	17,776	10,224	6,083	2,720

Table 37. Crop Acreages for Twelve Selected Crops for the Optimal Temporal Surface Water Allocation Without Groundwater Pumping Scenario, 1963 to 1980

Year	Upland Cotton	Pima Cotton	Alfalfa	Wheat	Pecans	Tomatoes	Lettuce	Onions	Green Chili
	acres								
1963	17,118.8		6,083		4,800	100	200	200	700
1964	3,076.78		1,156.61		909.5	18.95	37.9	37.9	132.64
1965	16,238		6,083		4,800	100	200	200	700
1966	17,118.8		6,083		4,800	100	200	200	700
1967	16,238		6,083		4,800	100	200	200	700
1968	17,118.8		6,083		4,800	100	200	200	700
1969	22,718	5,282	6,083		4,800	100	200	200	700
1970	22,718	5,282	6,083		4,800	100	200	200	700
1971	17,118,8		6,083		4,800	100	200	200	700
1972	10,499.65		3,933.33		3,103.73	64.66	129.32	129.32	452.63
1973	22,718	5,282	6,083		4,800	100	200	200	700
1974	22,718	5,282	6,083		4,800	100	200	200	700
1975	22,718	5,282	6,083		4,800	100	200	200	700
1976	22,718	5,282	6,083		4,800	100	200	200	700
1977	17,118.8		6,083		4,800	100	200	200	700
1978	9,257.45		3,467.98		2,736.53	57.01	114.02	114.02	399.08
1979	18,441.33	9,558.67	8,517	1,842.67	4,800	100	200	200	700
1980	18,441.33	9,558.67	8,517	1,842.67	4,800	100	200	200	700

Table 38. Input Requirement Levels for Selected Surface Water Allocations With and Without Groundwater Pumping

Item	Unit	Surface Water Allocation				
		Groundwater Pumping		No Groundwater Pumping		
		2 ac ft/ac	3 ac ft/ac	2 ac ft/ac	2.57831 ac ft/ac	3 ac ft/ac
Upland Cottonseed	lb.	433,600	433,600	427,970	567,950	461,033
Pima Cottonseed	lb.	266,400	266,400		132,050	238,967
Wheat Seed	lb.	352,800	352,800			221,120
Tomato Seed	lb.	200	200	200	200	200
Lettuce Seed	lb.	120	120	120	120	120
Onion Seed	lb.	800	800	800	800	800
Green Chili Seed	lb.	3,500	3,500	3,500	3,500	3,500
Nitrogen Fertilizer	lb.	5,655,180	5,655,180	3,995,249	5,135,340	5,442,297
Phosphorus Fertilizer	lb.	2,880,040	2,880,040	2,156,805	2,718,150	2,883,332
Potassium Fertilizer	lb.	288,000	288,000	288,000	288,000	288,000
Zinc Solution	gal.	14,400	14,400	14,400	14,400	14,400
Insecticide	$	1,043,232	1,043,232	777,310	1,078,922	1,052,011
Herbicide	$	541,534	541,534	330,972	526,834	536,047
Nematicide	$	21,000	21,000	21,000	21,000	21,000
Dust	acre	200	200	200	200	200
Surface Water	ac. ft.	96,100	144,150	96,100	123,888	144,150
Groundwater	ac. ft.	51,342	3,292			
LP Gas	gal.	981,648	62,943			
Diesel	gal.	1,086,235	1,086,235	761,815	1,080,567	1,084,447
Gasoline	gal.	204,004	204,004	147,195	206,919	204,256
Oil and Lubrication	$	616,070	594,839	446,838	578,759	594,148
Repairs	$	910,215	885,637	682,563	906,941	887,931
Labor	hr.	835,450	825,460	578,938	770,472	817,054
Custom Hoeing	$	221,808	221,808	221,808	221,808	221,808
Custom Upland Cotton Ginning	$	894,224	894,224	910,975	1,151,293	941,321
Custom Pima Cotton Ginning	$	334,017	334,017			299,621
Custom Wheat Harvest	$	71,971	71,971			45,108
Custom Pecan Harvest	$	576,000	576,000	576,000	576,000	576,000
Custom Tomato Harvest	$	10,150	10,150	10,150	10,150	10,150
Custom Lettuce Harvest	$	284,502	284,502	284,502	284,502	284,502
Custom Onion Harvest	$	332,724	332,724	332,724	332,724	332,724
Custom Green Chili Harvest	$	407,700	407,700	407,700	407,700	407,700
Baling Wire	lb.	476,952	476,952	340,648	340,648	476,952
Field Bags	bag	164,220	164,220	164,220	164,220	164,220
Forklift Services	hr.	647	647	647	647	647
Crop Insurance	$	588,000	588,000	370,376	588,000	588,000
Laser Leveling	acre			1,100	200	

Table 38. Continued

Item	Unit	Surface Water Allocation				
		Groundwater Pumping		No Groundwater Pumping		
		2 ac ft/ac	3 ac ft/ac	2 ac ft/ac	2.57831 ac ft/ac	3 ac ft/ac
Constant Inputs	$	1,577,482	1,577,482	1,577,482	1,577,482	1,577,482
Miscellaneous	$	1,421,310	1,421,310	933,654	1,260,090	1,388,390
Interest on Operating Capital	$	919,620	853,756	594,509	794,791	837,133
Establishment-Alfalfa and Pecans	$	1,483,853	1,483,853	1,360,936	1,360,936	1,483,852

Economic Implications

With more efficient use of surface water supplies, the recharge of groundwater in the study area will decrease. As time passes, limits on groundwater pumping can be expected. Not knowing what these limits may be, this study used the two extreme limits to develop economic implications. These two extremes are no restrictions at all on groundwater pumping and an absolute restriction against any groundwater pumping. With each of these limits imposed the economic implications of accumulation of surface irrigation water for future use was examined.

As a basis of comparison, the actual surface water allocations for 1963 to 1980 (Table 33) were used to determine the annual net farm revenue for 1963 to 1980. This was done for both cases -- groundwater pumping (Table 39) and no groundwater pumping (Table 40). For each actual surface water allocation, the appropriate net farm revenue was determined from the schedule of net farm revenues by surface water allocation given in Table 28 for groundwater pumping and in Table 29 for no groundwater pumping. These annual net farm revenues were then adjusted to 1980 dollars by the real interest rate developed in Chapter IV (Tables 39 and 40).

The results of the temporal linear programming model were an optimal temporal scenario of net farm revenues and their 1980 real values for 1963 to 1980 for both the groundwater pumping (Table 39) and no groundwater pumping options (Table 40). The two acre feet per acre usage scheme (Table 33) was also evaluated in the same manner as earlier described for the actual surface water allocation. The net farm revenue and 1980 real value scenarios developed in this manner are also included in Table 39 for the groundwater pumping case and Table 40 for the no groundwater pumping case.

Assume that there is no limit on groundwater pumping. The results in Table 39 indicate that both the optimal temporal and the two acre feet per acre scenarios would have generated more total net revenues than the actual allocation did. Also, the net farm revenue streams of the optimal temporal and two acre feet per acre scenarios have less variation than the net farm revenue stream of the actual allocation. The optimal temporal scenario provided $0.84 per acre per year in 1980 dollars above the returns of the actual allocation. The two acre feet per acre scenario provided only about as half as big an increase or $0.44 per acre per year in 1980 dollars. But the two acre foot per acre scenario produced the most stable stream of net farm revenues as indicated by the coefficients of variation in Table 39.

Now assume that absolutely no groundwater pumping is allowed. The results in Table 40 indicate that the optimal temporal scenario would have generated more total net revenues than the actual allocation did. But the two acre feet per acre scenario would have not generated as much total net revenue as the actual allocation. The optimal temporal scenario would have added $3.56 per acre per year in 1980 dollars to total net revenues. The two acre feet per acre scenario would have decreased net farm revenue per acre per year by $2.50 in 1980 dollars below the net revenues of the actual allocation. But, again, the two acre feet per acre scenario had the most stable flow of net farm revenues. The optimal temporal scenario also had less variability than the net farm revenue stream of the actual allocation.

Table 39. Annual Net Farm Revenue and 1980 Real Values for the Actual Surface Water Allocation and the Optimal Temporal and Two Acre Feet Per Acre Scenarios Both with Groundwater Pumping, 1963 to 1980

	Net Farm Revenue			1980 Real Value[a]		
	Actual Allocation	Optimal Temporal Scenario	Two Acre Feet Per Acre Scenario	Actual Allocation	Optimal Temporal Scenario	Two Acre Feet Per Acre Scenario
Year:						
1963	6,939,006	6,559,682	6,939,006	15,774,356	14,912,042	15,774,356
1964	5,357,712	5,802,723	5,357,712	11,605,239	12,569,169	11,605,239
1965	6,821,782	6,821,782	6,821,782	14,079,683	14,079,683	14,079,683
1966	7,137,553	6,939,006	6,939,006	14,036,691	13,646,229	13,646,229
1967	6,548,262	6,852,067	6,886,090	12,270,486	12,839,770	12,903,526
1968	6,939,006	6,939,006	6,939,006	12,389,487	12,389,487	12,389,487
1969	7,336,102	7,336,102	6,939,006	12,480,780	12,480,780	11,805,208
1970	7,336,102	6,939,006	6,939,006	11,892,196	11,248,483	11,248,483
1971	6,939,006	6,939,006	6,939,006	10,718,013	10,718,013	10,718,013
1972	5,800,990	6,363,829	6,901,089	8,537,672	9,366,037	10,156,755
1973	7,336,102	7,336,102	6,939,006	10,287,813	10,287,813	9,730,922
1974	7,336,102	7,336,102	6,939,006	9,802,647	9,802,647	9,272,040
1975	7,336,102	7,170,280	6,939,006	9,340,362	9,129,236	8,834,777
1976	7,336,102	6,939,006	6,939,006	8,899,878	9,418,136	8,418,136
1977	6,352,882	6,939,006	6,939,006	7,343,613	8,021,143	8,021,143
1978	5,894,451	6,146,925	6,939,006	6,492,362	6,770,446	7,642,872
1979	7,336,102	7,336,102	6,939,006	7,699,190	7,699,190	7,282,440
1980	7,336,102	7,336,102	6,939,006	7,336,102	7,336,102	6,939,006
Value of Water Stored			901,431			901,431
Total	123,419,446	124,031,834	124,014,188	190,986,570	191,714,409	191,369,768
Coefficient of Variation	9.0704	6.3105	5.4251			
Difference from Actual Allocation:						
Total		612,368	594,722		727,839	383,198
Percentage		.5	.5		.4	.2
Per Acre		12.74	12.38		15.15	7.97
Per Acre Per Year		.71	.69		.84	.44

[a] 4.94933 percent was used as the real rate of interest.

Table 40. Annual Net Farm Revenue and 1980 Real Values for the Actual Surface Water Allocation and the Optimal Temporal and Two Acre Feet Per Acre Scenarios Both Without Groundwater Pumping, 1963 to 1980

	Net Farm Revenue			1980 Real Value[a]		
	Actual Allocation	Optimal Temporal Scenario	Two Acre Feet Per Acre Scenario	Actual Allocation	Optimal Temporal Scenario	Two Acre Feet Per Acre Scenario
Year:						
1963	5,843,575	5,843,575	5,843,575	13,284,127	13,284,127	13,284,127
1964	970,410	970,410	970,410	2,101,986	2,101,986	2,101,986
1965	5,431,539	5,431,539	5,431,539	11,210,317	11,210,317	11,210,317
1966	6,886,339	5,843,575	5,843,575	13,542,654	11,491,957	11,491,957
1967	4,366,846	5,542,397	5,666,948	8,182,831	10,385,644	10,619,032
1968	5,843,575	5,843,575	5,843,575	10,433,612	10,433,612	10,433,612
1969	7,331,068	7,044,258	5,843,575	12,472,216	11,984,271	9,941,570
1970	7,331,068	7,044,258	5,843,575	11,884,036	11,419,102	9,472,734
1971	5,843,575	5,843,575	5,843,575	9,026,007	9,026,007	9,026,007
1972	1,940,820	3,311,574	5,721,859	2,856,424	4,873,879	8,421,210
1973	7,331,068	7,047,354	5,843,575	10,280,753	9,882,886	8,194,761
1974	7,331,068	7,047,354	5,843,575	9,795,921	9,416,817	7,808,303
1975	7,331,068	7,044,258	5,843,575	9,333,952	8,968,785	7,440,069
1976	7,331,068	7,039,976	5,843,575	8,893,771	8,540,629	7,089,201
1977	3,639,038	5,843,575	5,843,575	4,206,546	6,754,880	6,754,800
1978	2,183,423	2,919,784	5,843,575	2,404,901	3,215,936	6,436,325
1979	7,331,068	7,331,068	5,843,575	7,693,907	7,693,907	6,132,793
1980	7,331,068	7,331,068	5,843,575	7,331,068	7,331,068	5,843,575
Value of Water Stored			1,068,403			1,058,403
Total	101,597,684	104,323,173	100,669,209	154,935,029	158,015,809	152,770,782
Coefficient of Variation	37.8672	30.1783	20.6666			
Difference from Actual Allocation:						
Total		2,725,489	-928,475		3,080,780	-2,164,247
Percentage		2.7	-.9		2.0	-1.4
Per Acre		56.72	-19.32		64.12	-45.04
Per Acre Per Year		3.15	-1.07		3.56	-2.50

[a] 4.94933 was used as the real rate of interest.

With the results in Tables 39 and 40, the range of economic implications of accumulation for the El Paso County Water Improvement District No. 1 has been identified. This range is defined in the knowledge dimension by the optimal temporal (perfect knowledge) and the two acre feet per acre (no future knowledge) scenarios. This range is also defined on the conjunctive groundwater use dimension by the results in Table 39 (no limit) and in Table 40 (no groundwater).

CHAPTER VI

CONCLUSIONS, IMPLICATIONS AND LIMITATIONS

The purpose of this study was to identify the impacts on El Paso County farmers and the El Paso County Water Improvement District No. 1 of allowing individual El Paso County water users to hold part of their surface water allocation in account in Elephant Butte Reservoir for future call subject to evaporation losses. In identifying these impacts, the economic theories concerning the allocation of variable resources, marginal analysis and linear programming were employed.

The procedure was to first develop a static linear programming model. This static model was comprised of 1182 crop production activities. Production activities were developed for twelve crops on six different soil groups where irrigation was from groundwater with one of six different salinity levels or surface water and either laser land leveling or no laser land leveling. The inputs for these activities came from six input groups -- seed, chemicals, water, machinery, labor, harvest, other and fixed. The model also contained about 100 buy, sell or transfer activities. The model contained 154 rows with constraints on the acreages of soil classes by salinity of underlying groundwater and on the surface water available.

The model was solved for each level of surface irrigation water in which the basic solution changed considering conjunctive use of groundwater. Groundwater pumping was then disallowed and the model was again solved for all levels of surface irrigation water for which the basic solution changed. This resulted in two schedules of solutions for all possible surface water allocations up to three acre feet per acre with and without groundwater pumping.

These schedules were used to build temporal linear programming models to optimize the use of surface irrigation water allocation over the period 1963 to 1980 both with and without groundwater pumping. The models were developed to maximize the real value of net farm returns subject to the actual surface water allocation made in each year and the actual evaporation of stored water in Elephant Butte Reservoir. The results produced two optimal temporal scenarios of surface irrigation water use over the last 18 years, i.e., one considering groundwater pumping and one not including any groundwater pumping. For comparison purposes, four other temporal water use scenarios were included, e.g., the use each year of the actual surface water allocation with and without groundwater pumping and a scenario in which two acre feet are used each year with the surplus stored for years of less than two acre feet allotments with and without groundwater pumping. These scenarios provide the basis for this analysis.

Conclusions

The results of the static model indicate the following conclusions:

1. Red chili is not as profitable as green chili.
2. If vegetables are limited in acreage, upland cotton can successfully compete for more acres than it has historically.
3. Vegetable crops could produce a much higher return per acre than general field crops or pecans.

4. Total groundwater and surface water needed to sustain net farm revenue above $4.719 million range from 2.79 to 3.07 acre feet per acre.
5. Below an annual surface water allocation of 2.25 acre feet per acre, groundwater is extremely important in maintaining net farm revenues.
6. When groundwater is pumped the cropping pattern of the district is relatively constant across alternative surface water allocations.
7. When groundwater is not pumped, the district cropping pattern varies widely in response to surface water allocations.
8. Barley and grain sorghum are less profitable than other field or grain crops based on crop prices used in this analysis.
9. Laser leveling is economically justified initially on high value crops such as vegetables.
10. Laser leveling economic potential is much more important when total available irrigation water is limited.
11. Under the current circumstance of conjunctive groundwater and surface water use, laser leveling does not contribute to net farm revenues on a district wide basis.

The results of the temporal model and the water use scenarios indicate the following conclusions:

1. The optimal temporal allocation of surface water in conjunction with groundwater pumping is the most efficient in terms of evaporation loss.
2. The two acre feet per acre annual surface water use scenario

is the least efficient in terms of evaporation loss.

3. Only relatively minor improvements can be made in net farm revenues by optimal conjunctive groundwater and surface water usage or by stabilizing water usage if unlimited groundwater withdrawals can be made.
4. The two acre feet per acre surface water use rate provides the most consistent and stable flow of net farm returns.
5. When groundwater is pumped, crop production and acreages change very little over time.
6. By not permitting groundwater pumping, crop production and acreages and net farm revenues vary dramatically over time.
7. Not permitting groundwater pumping also increases the variability of the levels of required inputs.
8. Temporally optimizing surface water allocation use increases net farm revenue.
9. The optimal temporal scenario for no groundwater pumping increases net farm revenues more than the optimal temporal scenario allowing groundwater pumping.

Implications

The above conclusions suggest the following implications:

1. Some increase in vegetable production could increase farm net returns but it is also likely to increase risk faced by producers.
2. Upland cotton acreage could be profitable beyond its current level at the expense of pima cotton acreage and/or an

increase in total cotton acreage.

3. Conjunctive use of ground and surface irrigation water stabilizes net farm revenue, cropping patterns, crop production and input usage. The limits of the aquifer and implications of long term pumping need to be clearly identified.
4. Laser leveling is not necessary to produce maximum net farm revenues for the district, assuming water is not limiting; i.e., unlimited groundwater pumping.
5. Surface irrigation water storage by farmers will add little to net farm revenue as long as large supplies of groundwater exist, but it will help stabilize net farm revenue.
6. Without perfect knowledge of the future, farmers may increase total net farm revenue and stabilize their incomes by adopting a policy of using only two acre feet of surface water per year and storing any remainder with supplementary groundwater pumping.
7. Temporally optimizing surface water use can increase net farm revenues.
8. Temporally optimizing surface water use seems to be much more important when groundwater pumping is not allowed. That is, if groundwater shortages develop in the future, optimizing surface water use by use of accumulation will be extremely important.

Limitations

The model indicates that vegetables are highly profitable activities. The model cannot take into account the fact that lettuce producers are trying to match a ten-day to two-week lull in the lettuce market. Production areas elsewhere in the nation leave this gap. On the other hand, chili and tomato producers operate under contracts which guarantee a market for their production.

Vegetables are very expensive to produce. Only one out of three or four years do producers usually make a profit. Thus, vegetable producers must be able to finance several bad years in order to receive the profits of a good year. Therefore, vegetable activities in reality may not be nearly as attractive as they appear to the model, and do represent substantial risk faced by the producer.

Laser leveling is new to the study area. Accurate data on input reduction associated with laser leveling has not yet been gathered. There may be yield and quality increases from laser leveling which have not been quantified at this time. As more knowledge is gained about laser leveling and its effects on crops and crop production, laser leveling may well become a necessary operation for profitable crop production in El Paso County. This could be particularly true with groundwater limitations.

The temporal model which optimized water usage over time had perfect knowledge of surface water allocation and evaporation rates. Since the future is unknown, the two acre feet per acre scenario with its more stable flow of net farm revenues may be more realistic. The storage decision is made regardless of any future surface water allocations or evaporation rates.

The level of future surface water allocation is, of course, an unknown. Echlin has done a tree ring study for the Rio Grande above San Marcial, New Mexico. One might conclude from this study that rainfall and consequently the flow of the Rio Grande may be generally increasing and above average for the next forty years. If this turns out to be the case, stored water may simply evaporate in storage, never being needed.

Water in the Southwest is a very precious resource. The city of El Paso is constantly involved in searching for new sources of water as its demands for water continue to grow. The Republic of Mexico does not receive near enough Rio Grande water under treaty to irrigate all of its potential agricultural acreage (U.S. Department of the Interior, Water and Power Resources Service, Southwest Regional Office, 1980). Hudspeth County farmers are now farming with residual Rio Grande River flows and drainage flows from El Paso County as their only sources of surface irrigation water. The quality of groundwater is extremely poor in Hudspeth County (Alvarez and Buckner). Thus, accumulation and its associated water saving technologies (e.g., laser leveling) will tend to not only decrease or eliminate residual and drainage flows, but to further decrease groundwater availability through reduced recharge. In years of low surface water allocations when the El Paso County farmers have plenty of water from their individual stored accounts, the city of El Paso, the Republic of Mexico, Hudspeth County producers and Elephant Butte District producers without stored water may have the necessary incentive to push for, and possibly succeed in, changing the state, federal and international laws which govern the water of the Rio Grande. In this case, those who have more water, the El Paso County farmers, would lose water to those who have less, everyone else. This and other institutional factors make water issues in the region most complex.

Any analytical model like the one developed in this study cannot make subjective judgments. Marketing techniques and strategies with their associated risks and possibilities cannot be included. The model works on knowledge and data and, therefore, does not include any consideration of uncertainty of the future. The model is also apolitical and does not account for the political ramifications of the results. But, despite these shortcomings, the model does efficiently and effectively evaluate the information provided it. This provides a basis for evaluating a policy such as impact of water accumulation in Elephant Butte Reservoir.

REFERENCES

Agricultural Products and Seed Company. Personal communication. Mesquite, New Mexico, April 30, 1981.

Ahmed, J., C. H. M. van Bavel and E. A. Hiler. "Optimization of Crop Irrigation Strategy under a Stochastic Weather Regime: A Simulation Study." Water Resources Research 12(1976): 1241-1247.

Alvarez, H. J., and A. W. Buckner. Ground-Water Development in the El Paso Region, Texas with Emphasis on the Lower El Paso Valley. Report 246, Austin, Texas. Texas Department of Water Resources, June 1980.

American Ground Water Consultants, Inc. "Evaluation of the Albuquerque Plan to Store Its San Juan-Chama Water in Elephant Butte Reservoir." Albuquerque, New Mexico.

Ayers, R. "Water Quality: Use Limitations Related to Irrigation Water Quality." Mimeograph. Cooperative Extension Service, University of California.

Bauer, W. Personal communication. Soil Conservation Service District Office, Pecos, Texas, April 1981.

Beattie, B. R. "Lecture Notes and Selected Readings for Production Economics Theory." Mimeograph. Department of Agricultural Economics, Texas A&M University.

Beltran, A. Personal communication. Farm Bureau Insurance, El Paso, Texas, April 21, 1981.

Childers, Roy. Personal communication. Department of Agricultural Engineering, Texas A&M University, College Station, Texas, April 28, 1981.

Council of Economic Advisors. "Economic Indicators." Prepared for the Joint Economic Committee. Washington, D.C.: U.S. Government Printing Office, February 1981.

Cross, Henry. Personal communication. Cotton Division, Agricultural Marketing Service, U.S. Department of Agriculture, Memphis, Tennessee, May 1981.

Dallas Morning News, The. Texas Almanac and State Industrial Guide, 1980-81, Fred Pass (ed.). Dallas, Texas: A. H. Belo Corporation, 1979.

Day, J. C. "International Aquifer Management: The Hueco Bolson on the Rio Grande River." Nat. Resources Journal 18(1978): 163-180.

Echlin, Douglas. Personal communication. Biologist, International Boundry and Water Commission, El Paso, Texas, July 27, 1981.

El Paso County, Central Appraisal District. Personal communication. El Paso, Texas, April 20, 1981.

Erie, L. J., and A. R. Dedrick. Level-Basin Irrigation: A Method for Conserving Water and Labor. Farmers' Bulletin No. 2261, U.S. Department of Agriculture. Washington, D.C.: U.S. Government Printing Office, April 1979.

Extension Economists-Management. "Texas Crop Budgets." Texas Agricultural Extension Service, Texas A&M University System, College Station, Texas, MP-1027, 1979.

Fabens Delinting Plant. Personal communication. Fabens, Texas, April 30, 1981.

Farias, Dan. Personal communication. Rio Grande Project, Bureau of Reclamation, U.S. Department of the Interior, El Paso, Texas, June 1981.

Fiffer, E. Personal communication. General Manager, El Paso County Water Improvement District #1, El Paso, Texas, from July 1980 to October 1981.

Fishburn, M. Personal communication. Agricultural Statistician, New Mexico Department of Agriculture, Las Cruces, New Mexico, May 14, 1981.

Gates, J. S., D. E. White, W. D. Stanley, and H. D. Ackerman. Availability of Fresh and Slightly Saline Ground Water in the Basins of Westernmost Texas. Report 256, Austin, Texas. Texas Department of Water Resources, September 1980.

Gorman, W. D., D. F. Landrum, and S. D. Hicks. Pecan Orchard Costs and Returns for 40 and 320 Acres, Southern Rio Grande Valley, New Mexico, 1979. Research Report 413. Las Cruces, New Mexico: Agricultural Experiment Station, New Mexico State University, May 1980.

Hernandez, J. W. Rio Grande Water Quality Base Line Study 1974-75 for the Rio Grande Canals, and Associated Drains from San Marcial, New Mexico to Fort Quitman, Texas. WWRI Report No. 064, Las Cruces, New Mexico. New Mexico Water Resources Research Institute, New Mexico State University, June 1976.

______________. "Interrelationship of Ground and Surface Water Quality in the El Paso-Juarez and Mesilla Valleys." Nat. Resources Journal 18(1978): 1-9.

Hinz, W. W., and A. D. Holderman. "Laser Beam Land Leveling Costs and Benefits." Q114, Cooperative Extension Service, University of Arizona, November 1978.

Howe, C. W. Natural Resource Economics. New York: John Wiley and Sons, 1979.

Ikard and Newsom of Fabens. Personal communication. Fabens, Texas, May 1, 1981.

Kletke, D. D., T. R. Harris, and H. P. Mapp, Jr. Irrigation Cost Program Users Reference Manual. Research Rep. P-770, Stillwater: Oklahoma State University, 1978.

Lane, M. N., and S. C. Littlechild. "Water-Dependent Pricing for Water Resources in the Texas High Plains." Water Resources Research 12(1976): 599-605.

Lansford, R. R., B. J. Creel, and C. E. Seipel. Demonstration of Irrigation Return Flow Water Quality Control in the Mesilla Valley, New Mexico. WRRI Report No. 120, Las Cruces, New Mexico. New Mexico Water Resources Research Institute, May 1980.

Laughlin, D. H. "The Agricultural Benefits of Salinity Control on the Red River of Texas and Oklahoma." Ph.D. Thesis, Texas A&M University, College Station, Texas, 1980.

Laughlin, D. H., R. D. Lacewell, and D. S. Moore. The Agricultural Benefits of Salinity Control on the Red River of Texas and Oklahoma. Technical Report No. 112, College Station, Texas. Texas Water Resources Institute, Texas A&M University, December 1980.

Libbins, J. D., J. J. Dillon, Jr., M. L. Jones, L. J. Porter, D. C. Nelson, R. R. Lansford, P. Gutierrez, N. R. Gollehon, J. Vargas, and R. F. Lamb. "Costs and Returns for Producing Selected Irrigated Crops on Farms with Above-Average Management in the Lower Rio Grande Valley, Dona Ana and Sierra Counties, 1980." Forthcoming Research Report, Agricultural Experiment Station, New Mexico State University.

Lindsey, K. E. Personal communication. Area Extension Agronomist, Ft. Stockton, Texas, April 1981.

Longenecker, D. E., and P. J. Lyerly. Control of Soluble Salts in Farming and Gardening. Bulletin B-876, College Station, Texas. Texas Agricultural Experiment Station, June 1974.

Maas, E. V., and G. J. Hoffman. "Crop Salt Tolerance -- Current Assessment." J. Irrig. and Drainage Div. 103(1977): 115-124.

Malstrom, H. L. Personal communication. Pecan Researcher, Texas A&M University Agricultural Research Center, El Paso, Texas, April and June 1981.

McDaniels, L. L. Consumptive Use of Water by Major Crops in Texas. Bulletin 6019. Austin, Texas. Texas Board of Water Engineers, November 1960.

McDonald, J. W. Personal communication. Soil Conservation Service, El Paso, Texas, April 1, 1981.

McMasters, G. A. Personal communication. Soil Conservation Service, El Paso, Texas, April 1981.

McNeely, J. G., and R. D. Lacewell. Water Resources Uses and Issues in Texas. Report B-1189, College Station, Texas. Texas Agricultural Experiment Station, August 1978.

Meyer, W. R., and J. D. Gordon. Development of Ground Water in the El Paso District, Texas, 1963-70. Report 153, Austin, Texas. Texas Water Development Board, August 1972.

Meyers Company. Personal communication. El Paso, Texas, May 1, 1981.

Moore, J. L., and J. M. Armstrong. "The Use of Linear Programming Techniques for Estimating the Benefits from Increased Accuracy of Water Supply Forecasts." Water Resources Research 12(1976): 629-639.

New Mexico Crop and Livestock Reporting Service. New Mexico Agricultural Statistics. U.S. Department of Agriculture, Las Cruces, New Mexico, 1976-1980.

New Mexico State University, Center for Business Services, College of Business Administration and Economics. Inventory of the Economic, Sociocultural and Socioeconomic Resources in the Rio Grande Valley from Elephant Butte Reservoir, New Mexico to Fort Quitman, Texas. Las Cruces, New Mexico, July 1976.

North, C. L. Personal communication. Cole Drilling and Pump Co., El Paso, Texas, April 1981.

Peavy, W. S. Personal communication. Area Extension Vegetable Specialist, El Paso, Texas, April 1981.

Pedde, K. R. Personal communication. Project Superintendent, Rio Grande Project, Bureau of Reclamation, U.S. Department of the Interior, El Paso, Texas, June 5, 1981.

Randall, A. Resource Economics. Columbus, Ohio: Gard Publishing, Inc., 1981.

Richardson, J. W. Personal communication. Department of Agricultural Economics, College Station, Texas, May and August 1981.

Richardson, J. W., T. P. Zacharias, G. D. Condra, and D. D. Stebbins. "Economic Analysis of Alternative Farm Sizes in El Paso County, Texas." Departmental Technical Report No. 79-1. Department of Agricultural Economics, Texas Agricultural Experiment Station, Texas A&M University, College Station, Texas, 1979.

Riley, B. Personal communication. Chief Engineer, Rio Grande Compact Commission, El Paso, Texas, from July 1980 to July 1981.

Rio Grande Compact Commission. Report of the Rio Grande Compact Commission. Annual Report, El Paso, Texas, 1950-1980.

Rives, J. Personal communication. Soil Conservation Service District Office, Pecos, Texas, April 1981.

Runkles, J. R. Personal communication. Director of the Texas Water Resources Institute, College Station, Texas, April 23, 1981.

Shainberg, I., and J. D. Oster. Quality of Irrigation Water. Pub. No. 2, Ottowa, Canada. International Irrigation Information Center, 1978.

Sonnen, M. B., B. Dendy, and K. P. Lindstrom. Incentives for Agricultural Water Conservation. Washington, D.C.: Office of Water Research and Technology, U.S. Department of the Interior, July 1980.

Texas Crop and Livestock Reporting Service. Texas County Statistics. U.S. Department of Agriculture, Austin, Texas, 1968-1980a.

__________. Texas Cotton Statistics. U.S. Department of Agriculture, Austin, Texas, 1976-1980b.

Texas Water Development Board. Continuing Water Resources Planning and Development for Texas. Draft of Phase I, Austin, Texas, May 1977.

Transmountain Oil Company. Personal communication. Cantutillo, Texas, May 1, 1981.

Tuck, Comer. Personal communication. Texas Department of Water Resources, Austin, Texas, May 6, 1981.

U.S. Department of Agriculture, Agricultural Marketing Service, Cotton Division. Quality of Cotton Classed Under Smith-Doxey Act, Western States. Vol. 22, No. 28, Memphis, Tennessee, February 3, 1981a.

__________. Long Staple Cotton Review. Vol. 20, No. 8, Memphis, Tennessee, March 1981b.

U.S. Department of Agriculture, Soil Conservation Service. Soil Survey, El Paso County, Texas. Washington, D.C., November 1971.

U.S. Department of Agriculture, Statistical Reporting Service. Agricultural Prices, Annual Summary. Washington, D.C., 1976-1980.

__________. Agricultural Prices. Washington, D.C., May 1981.

U.S. Department of Commerce. 1974 Census of Agriculture, State and County Data. Washington, D.C., 1977.

U.S. Department of the Interior, Water and Power Resources Service, Southwest Regional Office. Elephant Butte Reservoir -- Fort Quitman Project, New Mexico - Texas (Rio Grande Regional Environmental Project). Amarillo, Texas. Preliminary Draft, Special Report, July 1980.

__________. Personal communication with Leroy Buettner, Jim Morrison, Fred Landefelt, Larry Walkoviak, Rufus Pepper, and Bill Seth. Amarillo, Texas, May, June and July 1981.

U.S. Water Resources Council. "Discount Rate Set at 7 3/8 Percent." Federal Register. 45(1980): 70167.

Wall Street Journal, The. March 11, 18, and 25, and April 1, 8, 15, 22, and 29, 1981. New York, New York, Dow Jones and Company.

Watson, W. D., C. F. Nuckton, and R. E. Howitt. "Crop Production and Water Supply Characteristics of Kern County." Giannini Foundation Bulletin No. 1895, University of California, Berkeley, April 1980.

Welch, C. D., C. Gray, K. E. Lindsay, W. B. Gass, and L. B. Fenn. Fact Sheet - Field and Forage Crop Fertilization in the Trans Pecos and Edwards Plateau. Rep. L-1506, College Station, Texas. Texas Agricultural Extension Service, 1979.

Young, R. A., and J. D. Bredehoeft. "Digital Computer Simulation for Solving Management Problems of Conjunctive Groundwater and Surface Water Systems." Water Resources Research 8(1972): 533-556.

APPENDIX A

Laser Leveling and Level-Basin Irrigation

Laser Leveling and Level-Basin Irrigation

Laser leveling is a term used to describe a land leveling activity which utilizes a laser beam. Laser leveling has been used and is increasingly being used to bring irrigated acreages in the southwest United States under level-basin irrigation. Level-basin irrigation is the rapid turnout of irrigation water onto an extremely level field with no escape for tailwater. The field becomes uniformly watered with greater irrigation efficiency. Greater efficiency is obtained by reduced atmospheric evaporation and no losses to tailwater.

Laser leveling is used to gain the necessary accuracy in land leveling required to utilize level-basin irrigation. The term "laser leveling" is loosely used to imply that level-basin irrigation practices are followed subsequent to actual performance of the laser leveling procedure. In this study, the term laser leveling is also used to indicate level-basin irrigation.

The following is a list of the advantages and requirements of level-basin irrigation and was adapted from Eric and Dedrick:

Level-Basin Advantages

- Less Water Required
  - High application efficiencies
  - Natural even leaching of salts
  - No guess work in applying correct amount of water
  - Large stream reduces irrigation time thus evaporation and waste
  - All rainfall contained for plant growth and leaching
  - Even water distribution; no extra water for high spots
- Less Labor Required
  - Time of set controlled by clocks
  - Fewer outlets
  - No tailwater
  - Large streams reduce irrigation time hence labor requirements

- Charge of sets predetermined--no continual attention
- Little time to open and close valves
- No erosion

Increased Yield

- Natural even leaching of salts
- Precise correct water application
- Maintains fertilizer in root zone
- Light applications possible--frost control and fertilizer application
- Even germination in furrows
- All rainfall contained for plant growth and leaching
- No erosion of soil or crops
- Even water distribution improved plant environment and even growth

Management

- Reduces water table build-up--minimizes drainage requirements
- Maintains fertilizer in root zone--not leached to groundwater
- Precise water application
- Light applications possible for vegetables
- Used for flat bed and furrow
- Corner flood may not require a supply along one side of field--reduce waste area, costs and maintenance
- 40 acre fields--large machinery
- No erosion

Reduced Inputs

- Maintains fertilizer in root zone
- Even germination in furrow crops--greater germination percent, no replant or spot replant

Level-Basin Requirements

Level-Basin Requirements

- Precision leveling required
- More soil movement required--top soil must be deep
- Soil movement depends on topography--may limit field size
- Large stream requires elaborate erosion prevention at outlet
- Secondary ditches are usually required
- Temporary dikes may be required in front of turnouts

Management Requirements

- Correct water applications
- Benched level-basin fields--dike breakage if too much water
- Emergency drainage may be necessary to protect from over irrigation

It is clear to see from this list of advantages and requirements that level-basin irrigation is an advanced managerial practice. Also, the exactness of land leveling is of critical importance. Laser leveling offers this accuracy.

The laser leveling technique utilizes a command post from which emanates a laser beam set at a prescribed level or grade. This command post rotates so that the beam cuts a 1000 foot circle in a level plane. A receiver is mounted on a scraper and automatically operates the scraper and automatically operates the scraper's hydrolic controls. The accuracy of such a procedure has been within plus or minus .05 feet.

Fifer estimates that 80 percent of the farmland in El Paso County could be laser leveled. Laser leveling is very common in Dona Ana County, New Mexico and was routinely included by Libbins, et al. in their crop budgets. More information concerning laser leveling is contained in Hinz and Halderman. An excellent review of level-basin irrigation is given in Eric and Dedrick.

APPENDIX B

Costs and Characteristics of a Typical Irrigation Well in El Paso County, Texas

DDK 477
Surface Default
Data

Mailing Address ______________________

Irrigation Cost Input Form

Default System (5) ________

Identification Typical Well
El Paso Valley

THE FARM			
Acres irrigated	155.0	(1)	100[a]
Acre inches/acre/year	20.0	(2)	varies
Average inches applied per set	3.0	(3)	7[b]
Gallons/minute produced by the well	850.0	(4)	1800
Pressure/square inch at the final opening	5.0	(5)	0
THE WELL			
Depth of well	480.0	(6)	150
Depth to water (average drawdown)	360.0	(7)	80
Development cost per foot for well	25.50	(8)	35
THE PUMP			
Depth setting of column pipe	400.0	(9)	100
Line number from column, pipe, shaft array	6.0	(10)	9
Number of bowls (0 for it to be computed by program)	0.0	(11)	2
Pump efficiency	0.75	(12)	.7
THE ENGINE			
Fuel type (1=LP, 2=NG, 3=diesel, 4=electric)	2.0	(13)	1
Engine type (1=auto, 2=light ind., 3=inter. ind., 4=electric)	2.0	(14)	3
Engine line number (if 0 the program will determine)	0.0	(15)	5
Altitude above sea level	3100.0	(16)	4000
Maximum average daily temperature	90.0	(17)	100
Are there accessories? (generator, air cleaner, heat exchanger)(0=no, 1=yes)	1.0	(18)	1
Are a fan and radiator used? (0=no, 1=yes)	0.0	(19)	0
Type of drive (0=direct, 1=right angle, 2=Vee-belt, 3=flat belt)	1.0	(20)	1

PARAMETERS

Interest rate	.09	(21)	.19[c]	Fuel cost/gal, MCF, or KWH	1.40	(31)	.69[g]
Insurance rate	0.005	(22)	.0175[d]	Cost/gal of lubricant	5.00	(32)	3.53[h]
Labor cost/hour	3.00	(23)	3.60[e]	Cost of above ground valves	25.75	(33)	0
Property tax rate	0.01	(24)	.0102474[f]	Cost of below ground valves	30.10	(34)	0
Tax assessment ratio	0.2	(25)	1.0[f]	Electric engine life	50,000.00	(35)	0
Well tax per gallon	0.0	(26)	0.0[f]	Automotive engine life	20,000.00	(36)	0
Well life	20.0	(27)	15	Light ind. engine life	30,000.00	(37)	0
Bowl life	8.0	(28)	5	Inter. ind. engine life	40,000.00	(38)	10 years
Column life	16.0	(29)	10	PSI/1000 ft. allowed in pipe	15.00	(39)	0
Gearhead life	15.0	(30)	10	53			

Source: North, unless otherwise noted.

[a] Tuck
[b] Fifer
[c] See other inputs, Chapter III.
[d] Beltran
[e] Minimum Wage
[f] El Paso County, Central Appraisal District
[g] Ikard and Newsom of Fabens
[h] Transmountain Oil Company

APPENDIX C

Static Linear Programming Model Column and Row Names and Abbreviated Matrix

The static linear programming model contains 1182 production activities and 100 buy, sell or transfer activities. The production activities were designated by a 7 or 8 character code. The first 3 characters identified the crop. The twelve crop codes follow:

CTU - Cotton, Upland;
CTP - Cotton, Pima;
ALF - Alfalfa;
WHE - Wheat;
BAR - Barley;
GSH - Grain Sorghum;
PCN - Pecans;
TOM - Tomatoes;
LET - Lettuce;
ONI - Onions;
CHG - Chili, Green; and,
CHR - Chili, Red.

The fourth and fifth characters indicated the soil group upon which crop is to be grown. These groups are GH, GP, SA, ST, VN and BR and are identified in Table 3. The sixth character is either R or G. R indicates that the irrigation water used is project water and G indicates groundwater. The seventh character is a number between 1 and 6 and indicates the salinity level of groundwater underlying the land regardless of the source of irrigation water. The six salinity levels are the same as those defined in Table 5. If there is an eighth character, it will be an L indicating that laser leveling his been employed.

The name CHGVNG1 translates to green chili on land of soil group VN utilizing groundwater of salinity level 1. TOMGPR4L means tomatoes grown on laser leveled land of soil group GP with underlying groundwater of salinity level 4 but irrigated with project water. The production activities are read crop, soil group, water source, groundwater salinity level, laser leveling.

The buy and sell activities were named by attempting to include as much of the common name as possible. But, transfer and accounting activities were not necessarily named in this manner. The following is a list of all the buy, sell, transfer and accounting activities:

SEEDCTUP - Buy upland cottonseed;
SEEDCTPI - Buy pima cottonseed;
SEEDWHEA - Buy wheat seed;
SEEDBARL - Buy barley seed;
SEEDGRAI - Buy grain sorghum seed;
SEEDTOMA - Buy tomato seed;
SEEDLETT - Buy lettuce seed;
SEEDONIO - Buy onion seed;
SEEDGREE - Buy green chili seed;
SEEDREDC - Buy red chili seed;
NITROGEN - Buy nitrogen fertilizer;
NITREG - Total nitrogen fertilizer required on non-laser leveled land;
NITLL - Total nitrogen fertilizer required on laser leveled land;
PHOSPHOR - Buy phosphorus fertilizer;

PHOREG - Total phosphorus fertilizer required on non-laser leveled land;

PHOLL - Total phosphorus fertilizer required on laser leveled land;

POTASSIU - Buy potassium fertilizer;

ZINC - Buy zinc solution;

INSECTIC - Buy insecticide;

HERBICID - Buy herbicide;

NEMATICI - Buy nematicide;

DUST - Buy dust;

WATERSUR - Total surface water required on non-laser leveled land;

WATERSLL - Total surface water required on laser leveled land;

WATER2FT - Total surface water required of the first two feet of water allocated;

WATER3RD - Buy surface water required above two acre feet per acre, not to exceed one acre foot per acre;

WATERTOT - Total surface water required;

WATERGR - Total groundwater required on non-laser leveled land;

WATERGLL - Total groundwater required on laser leveled land;

WATERGRO - Total groundwater required;

LPWELL - Total LP gas required for well operation on non-laser leveled land;

LPWELLLL - Total LP gas required for well operation on laser leveled land;

LPGAS - Buy LP gas;

DISOTHER - Total machinery diesel required;

DISHARVE - Total harvest diesel required;

DIESEL - Buy diesel;

GASOTHER - Total machinery gasoline required;

GASHARVE - Total harvest gasoline required;

GASOLINE - Buy gasoline;

OLWELL - Total oil and lubrication required for well operation on non-laser leveled land;

OLWELLLL - Total oil and lubrication required for well operation on laser leveled land;

OLWELLT - Total oil and lubrication required for well operation;

OLOTHER - Total machinery oil and lubrication required;

OLHARVES - Total harvest oil and lubrication required;

OILLUBE - Buy oil and lubrication;

OLIOC - Total machinery and well oil and lubrication;

REPWELL - Total repairs required for well operation on non-laser leveled land;

REPWELLL - Total repairs required for well operation on laser leveled land;

REPWELLT - Total repairs required for well operation;

REPOTHER - Total machinery repairs required;

REPHARVE - Total harvest repairs required;

REPAIRS - Buy repairs;

REPIOC - Total machinery and well repairs;

LABORIRR - Total irrigation labor required on non-laser leveled land;

LABORIRL - Total irrigation labor required on laser leveled land;

LABORIRT - Total irrigation labor;

LABORWEL - Total well operation labor required on non-laser leveled land;

LABORWLL - Total well operation labor required on laser leveled land;

LABORWLT - Total well operation labor;

LABORHAR - Total harvest labor;

LABOROTH - Total machinery labor;

LABORIOC - Total machinery, irrigation and well labor;

LABOR - Buy labor;

HOECUSTO - Buy custom hoeing service;

CUSHRCTU - Buy custom ginning for upland cotton;

CUSHRCTP - Buy custom ginning for pima cotton;

CUSHRWHE - Buy custom wheat harvest;

CUSHRBAR - Buy custom barley harvest;

CUSHRGRA - Buy custom grain sorghum harvest;

CUSHRPCN - Buy custom pecan harvest;

CUSHRTOM - Buy custom tomato harvest;

CUSHRLET - Buy custom lettuce harvest;

CUSHRONI - Buy custom onion harvest;

CUSHRCHG - Buy custom green chili harvest;

CUSHRCHR - Buy custom red chili harvest;

BALEWIRE - Buy baling wire;

FIELDBAG - Buy field bags for onion harvest;

FORKLIFT - Buy forklift services;

CROPINSU - Buy crop insurance;

LASERLEV - Buy laser leveling;

FIXEDCOS - Buy constant inputs: farm insurance, land tax, water district tax;

OTHEREXP - Buy miscellaneous inputs;

INONOPCP - Buy interest on operation capital;

ESTABLIS - Buy establishment inputs for alfalfa and pecans;

FIXMACHC - Buy fixed machinery inputs;

FIXWELLC - Buy fixed well inputs;
ACREGREE - Total acres of green chili;
ACREREDC - Total acres of red chili;
COTTON - Sell upland cottonlint;
PIMA - Sell pima cottonlint;
COTTONSE - Sell pima cottonseed;
COTTONSU - Sell upland cottonseed;
ALFALFA - Sell alfalfa;
WHEAT - Sell wheat;
BARLEY - Sell barley;
GRAINSOR - Sell grain sorghum;
PECAN - Sell pecans;
TOMATO - Sell tomatoes;
LETTUCE - Sell lettuce;
ONION - Sell onions
GREENCHI - Sell green chili;
REDCHILI - Sell red chili;
ACREUPLA - Total acres of upland cotton; and
ACREPIMA - Total acres of pima cotton.

Buy and sell activities also total the commodities bought or sold.

The linear programming model contained 154 rows. Forty-six rows were restrictions while the remaining were 104 accounting or transfer rows and the objective function. The objective function was designated OBJ. The rows which total crop yields are named by Y plus the crop code with the additions of CTSD, pima cottonseed, and CTSDU, upland cottonseed. The rows which accumulate crop production to be custom harvested or ginned are named by CUS plus the crop codes. Alfalfa is not custom harvested. The rows which accumulate the planting seed required for each crop are given by S plus the crop code. Since alfalfa and pecans are established by means other than planting at the beginning of the yearly production cycle, they have no seed requirement as such. There are 36 acreage restrictions which limit the acreage of a given soil group with underlying groundwater of a given salinity level. Thus, these restrictions are named by four characters. The two characters are one of the above six soil group designations. The third character is G for groundwater and the fourth is salinity level 1 through 6.

The remaining rows are defined as follows:

N - Totals nitrogen required on non-laser leveled land;
NL - Totals nitrogen required on laser leveled land;
NT - Totals all nitrogen required;
PH - Totals phosphorus required on non-laser leveled land;
PHL - Totals all phosphorus required on laser leveled land;
PHT - Totals all phosphorus required;
PO - Totals all potassium required;
Z - Totals all zinc solution required;
IN - Totals all insecticide required;
HR - Totals all herbicide required;
NEM - Totals all nematicide required;
DUST - Totals all dust required;
WRQ - Totals surface water required on non-laser leveled land;
WRQL - Totals surface water required on laser leveled land;

WRQ2	- Restricts the amount of surface water available up to 2 acre feet per acre;
WRQ3	- Restricts the additional amount of surface water which can be purchased to 1 acre foot per acre;
WRQAVL	- Totals all surface water available;
WRQT	- Restricts total surface water required to total surface water available;
WRQG	- Totals groundwater required on non-laser leveled land;
WRQGL	- Totals groundwater required on laser leveled land;
WRQGT	- Totals groundwater required;
LP	- Totals LP gas required for well operations on non-laser leveled land;
LPL	- Totals LP gas required for well operations on laser leveled land;
LPT	- Totals all LP gas required;
DH	- Totals diesel required during harvesting operations;
DO	- Totals machinery diesel required;
DT	- Totals all diesel required;
GH	- Totals gasoline required during harvesting operations;
GO	- Totals machinery gasoline required;
GT	- Totals all gasoline required;
OLH	- Totals oil and lubrication required for harvesting operations;
OLO	- Totals machinery oil and lubrication required;
OLW	- Totals oil and lubrication required for well operation on non-laser leveled land;

OLWL - Totals oil and lubrication required for well operation on laser leveled land;

OLWT - Totals all oil and lubrication required for well operations;

OLTIOC - Totals machinery and well oil and lubrication required;

OLT - Totals all oil and lubrication required;

RH - Totals repairs required for harvest operations;

RO - Totals machinery repairs required;

RW - Totals repairs required for well operation on non-laser leveled land;

RWL - Totals repairs required for well operation on laser leveled land;

RWT - Totals all repairs required for well operation;

RTIOC - Totals machinery and well repairs required;

RT - Totals all repairs required;

LI - Totals labor required for irrigation on non-laser leveled land;

LIL - Totals labor required for irrigation on laser leveled land;

LIT - Totals all irrigation labor;

LH - Totals labor required for harvesting operations;

LO - Totals machinery labor required;

LW - Totals labor required for well operation on non-laser leveled land;

LWL - Totals labor required for well operation on laser leveled land;

LWT - Totals all labor required for well operation;

LTIOC - Totals machinery, irrigation and well labor required;

LT - Totals all labor required;

HOE - Totals all custom hoeing required;

WIRE - Totals all baling wire required.

BAGS - Totals field bags required for onion harvest;

FORKL - Totals forklift services required.

IC - Totals all crop insurance required;

LL - Totals all acres laser leveled;

FC - Totals all constant inputs required;

OE - Totals all miscellaneous inputs required;

IOC - Totals all operating costs to be charged interest;

EST - Totals all establishment inputs required;

FMC - Totals all fixed machinery inputs required;

FWC - Accounts for all fixed well inputs;

ACTV - Totals all acres of upland cotton;

ACTP - Totals all acres of pima cotton;

AALF - Restricts the number of acres which can grow alfalfa;

AWHE - Totals all acres of wheat;

ABAR - Totals all acres of barley;

AGSH - Totals all acres of grain sorghum;

APCN - Restricts the number of acres which can grow pecans;

ATOM - Restricts the number of acres which can grow tomatoes;

ALET - Restricts the number of acres which can grow lettuce;

AONI - Restricts the number of acres which can grow onions;

ACHG - Totals all acres of green chili;

ACHR - Totals all acres of red chili;

CHILITOT - Restricts the acreages of all chili either green or red;

AALF2 - Requires a minimum number of acres of alfalfa to be grown;

APCN2 - Requires a minimum number of acres of pecans to be grown; and

TOTALCOT - Totals upland and pima cotton acreage.

The model was abbreviated by deleting all laser leveling activities and all activities for salinity levels 2 through 6. The resultant linear programming matrix in computer output form follows:

	CTUGHR1	CTUGPR1	CTUSAR1	CTUSTR1	CTUVNR1	CTUBRR1	CTUGHG1	CTUGPG1	1....1
YCTU	872.00000	836.00000	696.00000	680.00000	592.00000	440.00000	872.00000	836.00000	YCTU
YCTSDU	1395.2000	1337.6000	1113.6000	1088.0000	947.20000	704.00000	1395.2000	1337.6000	YCTSDU
SCTU	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	SCTU
GHG1	1.00000	.	.	.	.	.	1.00000	.	GHG1
GPG1	.	1.00000	.	.	.	.	.	1.00000	GPG1
SAG1	.	.	1.00000	.	.	.	.	.	SAG1
STG1	.	.	.	1.00000	.	.	.	.	STG1
VNG1	.	.	.	.	1.00000	.	.	.	VNG1
BRG1	.	.	.	.	.	1.00000	.	.	BRG1
N	126.00000	121.00000	101.00000	99.00000	86.00000	64.00000	126.00000	121.00000	N
PH	63.00000	61.00000	51.00000	50.00000	43.00000	32.00000	63.00000	61.00000	PH
IN	35.00000	35.00000	35.00000	35.00000	35.00000	35.00000	35.00000	35.00000	IN
HR	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	HR
DH	17.79000	17.05000	14.20000	13.87000	12.08000	8.98000	17.79000	17.05000	DH
DO	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	DO
GH	5.37000	5.14000	4.28000	4.18000	3.64000	2.71000	5.37000	5.14000	GH
GD	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GD
LP	.	.	.	.	.	.	47.80000	47.80000	LP
DLH	9.87000	9.47000	7.88000	7.70000	6.70000	4.98000	9.87000	9.47000	DLH
DLO	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	DLO
DLW	.	.	.	.	.	.	1.10000	1.10000	DLW
RH	21.61000	20.72000	17.25000	16.85000	14.67000	10.91000	21.61000	20.72000	RH
RO	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	RO
RW	.	.	.	.	.	.	1.28000	1.28000	RW
LI	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	LI
LH	7.59000	7.28000	6.06000	5.92000	5.15000	3.83000	7.59000	7.28000	LH
LO	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	LO
LW	.	.	.	.	.	.	.52000	.52000	LW
WRQ	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	.	.	WRQ
WRQG	.	.	.	.	.	.	2.50000	2.50000	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
DE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	DE
FMC	77.11000	77.11000	77.11000	77.11000	77.11000	77.11000	77.11000	77.11000	FMC
IC	20.00000	20.00000	20.00000	20.00000	20.80000	20.00000	20.00000	20.00000	IC
ACTU	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	ACTU

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	CTUSAG1	CTUSTG1	CTUVNG1	CTUBRG1	CTPGHR1	CTPGPR1	CTPSAR1	CTPSTR1	2....1
YCTU	696.00000	680.00000	592.00000	440.00000	.	.	.	.	YCTU
YCTP	.	.	.	.	540.00000	540.00000	431.00000	431.00000	YCTP
YCTSD	.	.	.	.	864.00000	864.00000	689.60000	689.60000	YCTSD
YCTSDU	1113.6000	1088.0000	947.20000	704.00000	.	.	.	.	YCTSDU
SCTU	25.00000	25.00000	25.00000	25.00000	.	.	.	.	SCTU
SCTP	.	.	.	.	25.00000	25.00000	25.00000	25.00000	SCTP
GHG1	.	.	.	.	1.00000	.	.	.	GHG1
GPG1	.	.	.	.	.	1.00000	.	.	GPG1
SAG1	1.00000	.	.	.	.	.	1.00000	.	SAG1
STG1	.	1.00000	.	.	.	.	.	1.00000	STG1
VNG1	.	.	1.00000	.	.	.	.	.	VNG1
BRG1	.	.	.	1.00000	.	.	.	.	BRG1
N	101.00000	99.00000	86.00000	64.00000	120.00000	120.00000	96.00000	96.00000	N
PH	51.00000	50.00000	43.00000	32.00000	60.00000	60.00000	48.00000	48.00000	PH
IN	35.00000	35.00000	35.00000	35.00000	20.00000	20.00000	20.00000	20.00000	IN
HR	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	HR
DH	14.20000	13.87000	12.08000	8.98000	11.02000	11.02000	8.79000	8.79000	DH
DO	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	DO
GH	4.28000	4.18000	3.64000	2.71000	3.32000	3.32000	2.65000	2.65000	GH
GD	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GD
LP	47.80000	47.80000	47.80000	47.80000	.	.	.	.	LP
DLH	7.88000	7.70000	6.70000	4.98000	6.11000	6.11000	4.88000	4.88000	DLH
DLO	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	DLO
DLW	1.10000	1.10000	1.10000	1.10000	.	.	.	.	DLW
RH	17.25000	16.85000	14.67000	10.91000	13.38000	13.38000	10.68000	10.68000	RH
RO	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	RO
RW	1.28000	1.28000	1.28000	1.28000	.	.	.	.	RW
LI	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	LI
LH	6.06000	5.92000	5.15000	3.83000	4.70000	4.70000	3.75000	3.75000	LH
LO	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	LO
LW	.52000	.52000	.52000	.52000	.	.	.	.	LW
WRQ	.	.	.	.	2.50000	2.50000	2.50000	2.50000	WRQ
WROG	2.50000	2.50000	2.50000	2.50000	.	.	.	.	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
DE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	DE
FMC	77.11000	77.11000	77.11000	77.11000	77.32000	77.32000	77.32000	77.32000	FMC
IC	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	IC
ACTU	1.00000	1.00000	1.00000	1.00000	.	.	.	.	ACTU
ACTP	.	.	.	.	1.00000	1.00000	1.00000	1.00000	ACTP

	CTPVNR1	CTPBRR1	CTPGHG1	CTPGPG1	CTPSAG1	CTPSTG1	CTPVNG1	CTPBRG1	3....1
YCTP	371.00000	300.00000	540.00000	540.00000	431.00000	431.00000	371.00000	300.00000	YCTP
YCTSD	593.60000	480.00000	864.00000	864.00000	689.60000	689.60000	593.60000	480.00000	YCTSD
SCTP	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	25.00000	SCTP
GHG1	.	.	1.00000	.	.	.	.	.	GHG1
GPG1	.	.	.	1.00000	.	.	.	.	GPG1
SAG1	.	.	.	.	1.00000	.	.	.	SAG1
STG1	.	.	.	.	.	1.00000	.	.	STG1
VNG1	1.00000	.	.	.	.	.	1.00000	.	VNG1
BRG1	.	1.00000	.	.	.	.	.	1.00000	BRG1
N	82.00000	67.00000	120.00000	120.00000	96.00000	96.00000	82.00000	67.00000	N
PH	41.00000	34.00000	60.00000	60.00000	48.00000	48.00000	41.00000	34.00000	PH
IN	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	IN
HR	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	HR
DH	7.57000	6.12000	11.02000	11.02000	8.79000	8.79000	7.57000	6.12000	DH
DO	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	17.72000	DO
GH	2.28000	1.85000	3.32000	3.32000	2.65000	2.65000	2.28000	1.85000	GH
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	.	.	47.80000	47.80000	47.80000	47.80000	47.80000	47.80000	LP
DLH	4.20000	3.40000	6.11000	6.11000	4.88000	4.88000	4.20000	3.40000	DLH
DLO	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	5.70000	DLO
DLW	.	.	1.10000	1.10000	1.10000	1.10000	1.10000	1.10000	DLW
RH	9.20000	7.44000	13.38000	13.38000	10.68000	10.68000	9.20000	7.44000	RH
RO	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	6.56000	RO
RW	.	.	1.28000	1.28000	1.28000	1.28000	1.28000	1.28000	RW
LI	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	5.75000	LI
LH	3.23000	2.61000	4.70000	4.70000	3.75000	3.75000	3.23000	2.61000	LH
LO	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	6.79000	LO
LW	.	.	.52000	.52000	.52000	.52000	.52000	.52000	LW
WRQ	2.50000	2.50000	.	.	.	.	.	.	WRQ
WRQG	.	.	2.50000	2.50000	2.50000	2.50000	2.50000	2.50000	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FMC	77.32000	77.32000	77.32000	77.32000	77.32000	77.32000	77.32000	77.32000	FMC
IC	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	20.00000	IC
ACTP	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	ACTP

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	ALFGHR1	ALFGPR1	ALFSAR1	ALFSTR1	ALFVNR1	ALFBRR1	ALFGHG1	ALFGPG1	4....I
YALF	6.40000	6.40000	4.80000	4.40000	4.00000	3.60000	6.40000	6.40000	YALF
GHG1	1.00000	.	.	.	.	.	1.00000	.	GHG1
GPG1	.	1.00000	.	.	.	.	.	1.00000	GPG1
SAG1	.	.	1.00000	.	.	.	.	.	SAG1
STG1	.	.	.	1.00000	.	.	.	.	STG1
VNG1	.	.	.	.	1.00000	.	.	.	VNG1
BRG1	.	.	.	.	.	1.00000	.	.	BRG1
PH	80.00000	80.00000	80.00000	80.00000	80.00000	80.00000	80.00000	80.00000	PH
IN	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	10.00000	IN
DH	8.41000	8.41000	6.31000	5.78000	5.26000	4.73000	8.41000	8.41000	DH
DO	.95000	.95000	.95000	.95000	.95000	.95000	.95000	.95000	DO
GO	1.80000	1.80000	1.80000	1.80000	1.80000	1.80000	1.80000	1.80000	GO
LP	.	.	.	.	.	.	114.71000	114.71000	LP
OLH	11.54000	11.54000	8.66000	7.94000	7.22000	6.49000	11.54000	11.54000	OLH
OLO	.31000	.31000	.31000	.31000	.31000	.31000	.31000	.31000	OLO
OLW	.	.	.	.	.	.	2.69000	2.69000	OLW
RH	5.58000	5.58000	4.19000	3.84000	3.49000	3.14000	5.58000	5.58000	RH
RO	.28000	.28000	.28000	.28000	.28000	.28000	.28000	.28000	RO
RW	.	.	.	.	.	.	3.06000	3.06000	RW
LI	13.80000	13.80000	13.80000	13.80000	13.80000	13.80000	13.80000	13.80000	LI
LH	3.36000	3.36000	2.52000	2.31000	2.10000	1.89000	3.36000	3.36000	LH
LO	.38000	.38000	.38000	.38000	.38000	.38000	.38000	.38000	LO
LW	.	.	.	.	.	.	1.25000	1.25000	LW
WRO	6.00000	6.00000	6.00000	6.00000	6.00000	6.00000	.	.	WRQ
WROG	.	.	.	.	.	.	6.00000	6.00000	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
EST	50.50000	50.50000	50.50000	50.50000	50.50000	50.50000	50.50000	50.50000	EST
FMC	72.00000	72.00000	72.00000	72.00000	72.00000	72.00000	72.00000	72.00000	FMC
AALF	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	AALF
AALF2	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	AALF2

	ALFSAG1	ALFSIG1	ALFVNG1	ALFBRG1	WHEGHR1	WHEGPR1	WHESAR1	WHESTR1	5....1
YALF	4.80000	4.40000	4.00000	3.60000	.	.	.	.	YALF
YWHE	.	.	.	.	80.00000	72.00000	68.00000	61.00000	YWHE
SWHE	.	.	.	.	120.00000	120.00000	120.00000	120.00000	SWHE
GHG1	.	.	.	.	1.00000	.	.	.	GHG1
GPG1	.	.	.	.	.	1.00000	.	.	GPG1
SAG1	1.00000	.	.	.	.	.	1.00000	.	SAG1
STG1	.	1.00000	.	.	.	.	.	1.00000	STG1
VNG1	.	.	1.00000	.	.	.	.	.	VNG1
BRG1	.	.	.	1.00000	.	.	.	.	BRG1
N	.	.	.	.	234.00000	211.00000	199.00000	179.00000	N
PH	80.00000	80.00000	80.00000	80.00000	.	.	.	.	PH
IN	10.00000	10.00000	10.00000	10.00000	7.00000	7.00000	7.00000	7.00000	IN
HR	.	.	.	.	5.00000	5.00000	5.00000	5.00000	HR
DH	6.31000	5.78000	5.26000	4.73000	.	.	.	.	DH
DO	.95000	.95000	.95000	.95000	7.04000	7.04000	7.04000	7.04000	DO
GO	1.80000	1.80000	1.80000	1.80000	1.40000	1.40000	1.40000	1.40000	GO
LP	114.71000	114.71000	114.71000	114.71000	.	.	.	.	LP
DLH	8.66000	7.94000	7.22000	6.49000	.	.	.	.	DLH
DLO	.31000	.31000	.31000	.31000	2.29000	2.29000	2.29000	2.29000	DLO
DLW	2.69000	2.69000	2.69000	2.69000	.	.	.	.	DLW
RH	4.19000	3.84000	3.49000	3.14000	.	.	.	.	RH
RO	.28000	.28000	.28000	.28000	2.95000	2.95000	2.95000	2.95000	RO
RW	3.06000	3.06000	3.06000	3.06000	.	.	.	.	RW
LI	13.80000	13.80000	13.80000	13.80000	6.90000	6.90000	6.90000	6.90000	LI
LH	2.52000	2.31000	2.10000	1.89000	.	.	.	.	LH
LO	.38000	.38000	.38000	.38000	2.45000	2.45000	2.45000	2.45000	LO
LW	1.25000	1.25000	1.25000	1.25000	.	.	.	.	LW
WRQ	.	.	.	.	3.00000	3.00000	3.00000	3.00000	WRQ
WRQG	6.00000	6.00000	6.00000	6.00000	.	.	.	.	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
DE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	DE
EST	50.50000	50.50000	50.50000	50.50000	.	.	.	.	EST
FMC	72.00000	72.00000	72.00000	72.00000	22.61000	22.61000	22.61000	22.61000	FMC
AALF	1.00000	1.00000	1.00000	1.00000	.	.	.	.	AALF
AWHE	.	.	.	.	1.00000	1.00000	1.00000	1.00000	AWHE
AALF2	1.00000	1.00000	1.00000	1.00000	.	.	.	.	AALF2

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	WHEVNR1	WHEBRR1	WHEGHG1	WHEGPG1	WHESAG1	WHESTG1	WHEVNG1	WHEBRG1	6....1
YWHE	56.00000	48.00000	80.00000	72.00000	68.00000	61.00000	56.00000	48.00000	YWHE
SWHE	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	SWHE
GHG1	.	.	1.00000	.	.	.	.	.	GHG1
GPG1	.	.	.	1.00000	.	.	.	.	GPG1
SAG1	.	.	.	.	1.00000	.	.	.	SAG1
STG1	.	.	.	.	.	1.00000	.	.	STG1
VNG1	1.00000	.	.	.	.	.	1.00000	.	VNG1
BRG1	.	1.00000	.	.	.	.	.	1.00000	BRG1
N	164.00000	140.00000	234.00000	211.00000	199.00000	179.00000	164.00000	140.00000	N
IN	7.00000	7.00000	7.00000	7.00000	7.00000	7.00000	7.00000	7.00000	IN
HR	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	HR
DO	7.04000	7.04000	7.04000	7.04000	7.04000	7.04000	7.04000	7.04000	DO
GO	1.40000	1.40000	1.40000	1.40000	1.40000	1.40000	1.40000	1.40000	GO
LP	.	.	57.36000	57.36000	57.36000	57.36000	57.36000	57.36000	LP
OLO	2.29000	2.29000	2.29000	2.29000	2.29000	2.29000	2.29000	2.29000	OLO
OLW	.	.	1.34000	1.34000	1.34000	1.34000	1.34000	1.34000	OLW
RO	2.95000	2.95000	2.95000	2.95000	2.95000	2.95000	2.95000	2.95000	RO
RW	.	.	1.53000	1.53000	1.53000	1.53000	1.53000	1.53000	RW
LI	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	LI
LO	2.45000	2.45000	2.45000	2.45000	2.45000	2.45000	2.45000	2.45000	LO
LW	.	.	.62000	.62000	.62000	.62000	.62000	.62000	LW
WRQ	3.00000	3.00000	.	.	.	.	.	.	WRQ
WRQG	.	.	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FMC	22.61000	22.61000	22.61000	22.61000	22.61000	22.61000	22.61000	22.61000	FMC
AWHE	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	AWHE

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	BARGHR1	BARGPR1	BARSAR1	BARSTR1	BARVNR1	BARBRR1	BARGHG1	BARGPG1	7....1
YBAR	80.00000	79.00000	70.00000	72.00000	52.00000	48.00000	80.00000	79.00000	YBAR
SBAR	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	SBAR
GHG1	1.00000	.	.	.	.	.	1.00000	.	GHG1
GPG1	.	1.00000	.	.	.	.	.	1.00000	GPG1
SAG1	.	.	1.00000	.	.	.	.	.	SAG1
STG1	.	.	.	1.00000	.	.	.	.	STG1
VNG1	.	.	.	.	1.00000	.	.	.	VNG1
BRG1	.	.	.	.	.	1.00000	.	.	BRG1
N	188.00000	186.00000	164.00000	169.00000	103.00000	85.00000	188.00000	186.00000	N
IN	7.00000	7.00000	7.00000	7.00000	7.00000	7.00000	7.00000	7.00000	IN
HR	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	HR
DO	7.04000	7.04000	7.04000	7.04000	7.04000	7.04000	7.04000	7.04000	DO
GO	1.40000	1.40000	1.40000	1.40000	1.40000	1.40000	1.40000	1.40000	GO
LP	.	.	.	.	.	.	57.36000	57.36000	LP
OLO	2.29000	2.29000	2.29000	2.29000	2.29000	2.29000	2.29000	2.29000	OLO
OLW	.	.	.	.	.	.	1.34000	1.34000	OLW
RO	2.95000	2.95000	2.95000	2.95000	2.95000	2.95000	2.95000	2.95000	RO
RW	.	.	.	.	.	.	1.53000	1.53000	RW
LI	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	LI
LO	2.45000	2.45000	2.45000	2.45000	2.45000	2.45000	2.45000	2.45000	LO
LW	.	.	.	.	.	.	.62000	.62000	LW
WRQ	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	.	.	WRQ
WRQG	.	.	.	.	.	.	3.00000	3.00000	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
DE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	DE
FMC	22.61000	22.61000	22.61000	22.61000	22.61000	22.61000	22.61000	22.61000	FMC
ABAR	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	ABAR

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	BARSAGI	BARSTGI	BARVNGI	BARBRGI	GSHGHRI	GSHGPRI	GSHSARI	GSHSTRI	8....1
YBAR	70.00000	72.00000	52.00000	48.00000	.	.	.	.	YBAR
YGSH	.	.	.	.	77.00000	69.00000	64.00000	57.00000	YGSH
SBAR	120.00000	120.00000	120.00000	120.00000	.	.	.	.	SBAR
SGSH	.	.	.	.	9.00000	9.00000	9.00000	9.00000	SGSH
GHGI	.	.	.	.	1.00000	.	.	.	GHGI
GPGI	.	.	.	.	.	1.00000	.	.	GPGI
SAGI	1.00000	.	.	.	.	.	1.00000	.	SAGI
STGI	.	1.00000	.	.	.	.	.	1.00000	STGI
VNGI	.	.	1.00000	.	.	.	.	.	VNGI
BRGI	.	.	.	1.00000	.	.	.	.	BRGI
N	164.00300	169.00000	103.00000	85.00000	162.00000	145.00000	134.00000	120.00000	N
IN	7.00000	7.00000	7.00000	7.00000	18.00000	18.00000	18.00000	18.00000	IN
HR	5.00000	5.00000	5.00000	5.00000	12.00000	12.00000	12.00000	12.00000	HR
DO	7.04000	7.04000	7.04000	7.04000	11.71000	11.71000	11.71000	11.71000	DO
GO	1.40000	1.40000	1.40000	1.40000	2.00000	2.00000	2.00000	2.00000	GO
LP	57.36000	57.36000	57.36000	57.36000	.	.	.	.	LP
OLO	2.29000	2.29000	2.29000	2.29000	3.76000	3.76000	3.76000	3.76000	OLO
OLW	1.34000	1.34000	1.34000	1.34000	.	.	.	.	OLW
RO	2.95000	2.95000	2.95000	2.95000	4.48000	4.48000	4.48000	4.48000	RO
RW	1.53000	1.53000	1.53000	1.53000	.	.	.	.	RW
LI	6.90000	6.90000	6.90000	6.90000	4.98000	4.98000	4.98000	4.98000	LI
LO	2.45000	2.45000	2.45000	2.45000	4.73000	4.73000	4.73000	4.73000	LO
LW	.62000	.62000	.62000	.62000	.	.	.	.	LW
WRO	.	.	.	.	2.17000	2.17000	2.17000	2.17000	WRO
WROG	3.00000	3.00000	3.00000	3.00000	.	.	.	.	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FMC	22.61000	22.61000	22.61000	22.61000	27.69000	27.69000	27.69000	27.69000	FMC
ABAR	1.00000	1.00000	1.00000	1.00000	.	.	.	.	ABAR
AGSH	.	.	.	.	1.00000	1.00000	1.00000	1.00000	AGSH

	GSHVNR1	GSHBRR1	GSHGHG1	GSHGPG1	GSHSAG1	GSHSTG1	GSHVNG1	GSHBRG1	9....1
YGSH	51.00000	47.00000	77.00000	69.00000	64.00000	57.00000	51.00000	47.00000	YGSH
SGSH	9.00000	9.00000	9.00000	9.00000	9.00000	9.00000	9.00000	9.00000	SGSH
GHG1	.	.	1.00000	.	.	.	.	.	GHG1
GPG1	.	.	.	1.00000	.	.	.	.	GPG1
SAG1	.	.	.	.	1.00000	.	.	.	SAG1
STG1	.	.	.	.	.	1.00000	.	.	STG1
VNG1	1.00000	.	.	.	.	.	1.00000	.	VNG1
BRG1	.	1.00000	.	.	.	.	.	1.00000	BRG1
N	107.00000	99.00000	162.00000	145.00000	134.00000	120.00000	107.00000	99.00000	N
IN	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	18.00000	IN
HR	12.00000	12.00000	12.00000	12.00000	12.00000	12.00000	12.00000	12.00000	HR
DO	11.71000	11.71000	11.71000	11.71000	11.71000	11.71000	11.71000	11.71000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	.	.	41.42000	41.42000	41.42000	41.42000	41.42000	41.42000	LP
OLO	3.76000	3.76000	3.76000	3.76000	3.76000	3.76000	3.76000	3.76000	OLO
OLW	.	.	.98000	.98000	.98000	.98000	.98000	.98000	OLW
RO	4.48000	4.48000	4.48000	4.48000	4.48000	4.48000	4.48000	4.48000	RO
RW	.	.	1.10000	1.10000	1.10000	1.10000	1.10000	1.10000	RW
LI	4.98000	4.98000	4.98000	4.98000	4.98000	4.98000	4.98000	4.98000	LI
LO	4.73000	4.73000	4.73000	4.73000	4.73000	4.73000	4.73000	4.73000	LO
LW	.	.	.45000	.45000	.45000	.45000	.45000	.45000	LW
WRQ	2.17000	2.17000	.	.	.	.	.	.	WRQ
WRQG	.	.	2.17000	2.17000	2.17000	2.17000	2.17000	2.17000	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
DE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	DE
FMC	27.69000	27.69000	27.69000	27.69000	27.69000	27.69000	27.69000	27.69000	FMC
AGSH	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	AGSH

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	PCNGHR1	PCNGPR1	PCNSAR1	PCNSTR1	PCNVNR1	PCNBRR1	PCNGHG1	PCNGPG1	10....1
YPCN	2000.0000	1750.0000	1250.0000	1100.0000	1500.0000	1300.0000	2000.0000	1750.0000	YPCN
GHG1	1.00000	.	.	.	.	.	1.00000	.	GHG1
GPG1	.	1.00000	.	.	.	.	.	1.00000	GPG1
SAG1	.	.	1.00000	.	.	.	.	.	SAG1
STG1	.	.	.	1.00000	.	.	.	.	STG1
VNG1	.	.	.	.	1.00000	.	.	.	VNG1
BRG1	.	.	.	.	.	1.00000	.	.	BRG1
N	330.00000	330.00000	330.00000	330.00000	330.00000	330.00000	330.00000	330.00000	N
PH	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	PH
PO	60.00000	60.00000	60.00000	60.00000	60.00000	60.00000	60.00000	60.00000	PO
Z	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	Z
IN	16.84000	16.84000	16.84000	16.84000	16.84000	16.84000	16.84000	16.84000	IN
DO	13.70000	13.70000	13.70000	13.70000	13.70000	13.70000	13.70000	13.70000	DO
GO	1.80000	1.80000	1.80000	1.80000	1.80000	1.80000	1.80000	1.80000	GO
LP	.	.	.	.	.	.	57.36000	57.36000	LP
OLO	20.86000	20.86000	20.86000	20.86000	20.86000	20.86000	20.86000	20.86000	OLO
OLW	.	.	.	.	.	.	1.34000	1.34000	OLW
RO	32.61000	32.61000	32.61000	32.61000	32.61000	32.61000	32.61000	32.61000	RO
RW	.	.	.	.	.	.	1.53000	1.53000	RW
LI	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	6.90000	LI
LO	15.54000	15.54000	15.54000	15.54000	15.54000	15.54000	15.54000	15.54000	LO
LW	.	.	.	.	.	.	.62000	.62000	LW
HOE	20.21000	20.21000	20.21000	20.21000	20.21000	20.21000	20.21000	20.21000	HOE
WRO	3.00000	3.00000	3.00000	3.00000	3.00000	3.00000	.	.	WRO
WROG	.	.	.	.	.	.	3.00000	3.00000	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	42.00000	42.00000	42.00000	42.00000	42.00000	42.00000	42.00000	42.00000	OE
EST	219.53000	219.53000	219.53000	219.53000	219.53000	219.53000	219.53000	219.53000	EST
FMC	101.14000	101.14000	101.14000	101.14000	101.14000	101.14000	101.14000	101.14000	FMC
APCN	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	APCN
APCN2	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	APCN2

	PCNSAG1	PCNSTG1	PCNVNG1	PCNBRG1	TOMGHR1	TOMGPR1	TOMSAR1	TONSTR1	11....1
YPCN	1250.0000	1100.0000	1500.0000	1300.0000	.	.	.	.	YPCN
YTOM	.	.	.	.	12.00000	.	11.60000	8.40000	YTOM
STOM	.	.	.	.	2.00000	2.00000	2.00000	2.00000	STOM
GHG1	.	.	.	.	1.00000	.	.	.	GHG1
SAG1	1.00000	.	.	.	.	.	1.00000	.	SAG1
STG1	.	1.00000	.	.	.	.	.	1.00000	STG1
VNG1	.	.	1.00000	.	.	.	.	.	VNG1
BRG1	.	.	.	1.00000	.	.	.	.	BRG1
N	330.00000	330.00000	330.00000	330.00000	63.00000	63.00000	63.00000	63.00000	N
PH	100.00000	100.00000	100.00000	100.00000	180.00000	180.00000	180.00000	180.00000	PH
PO	60.00000	60.00000	60.00000	60.00000	.	.	.	.	PO
Z	3.00000	3.00000	3.00000	3.00000	.	.	.	.	Z
IN	16.84000	16.84000	16.84000	16.84000	15.00000	15.00000	15.00000	15.00000	IN
HR	.	.	.	.	12.00000	12.00000	12.00000	12.00000	HR
DH	.	.	.	.	16.56000	13.52000	16.01000	11.59000	DH
DO	13.70000	13.70000	13.70000	13.70000	20.58000	20.58000	20.58000	20.58000	DO
GO	1.80000	1.80000	1.80000	1.80000	2.00000	2.00000	2.00000	2.00000	GO
LP	57.36000	57.36000	57.36000	57.36000	.	.	.	.	LP
OLH	.	.	.	.	3.76000	3.07000	3.63000	2.63000	OLH
OLO	20.86000	20.86000	20.86000	20.86000	6.06000	6.06000	6.06000	6.06000	OLO
OLW	1.34000	1.34000	1.34000	1.34000	.	.	.	.	OLW
RH	.	.	.	.	5.80000	4.74000	5.61000	4.06000	RH
RO	32.61000	32.61000	32.61000	32.61000	8.11000	8.11000	8.11000	8.11000	RO
RW	1.53000	1.53000	1.53000	1.53000	.	.	.	.	RW
LI	6.90000	6.90000	6.90000	6.90000	5.98000	5.98000	5.98000	5.98000	LI
LH	.	.	.	.	11.84000	9.67000	11.45000	8.29000	LH
LO	15.54000	15.54000	15.54000	15.54000	8.90000	8.90000	8.90000	8.90000	LO
LW	.62000	.62000	.62000	.62000	.	.	.	.	LW
HOE	20.21000	20.21000	20.21000	20.21000	37.00000	37.00000	37.00000	37.00000	HOE
WRO	.	.	.	.	2.60000	2.60000	2.60000	2.60000	WRO
WROG	3.00000	3.00000	3.00000	3.00000	.	.	.	.	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	42.00000	42.00000	42.00000	42.00000	30.00000	30.00000	30.00000	30.00000	OE
EST	219.53000	219.53000	219.53000	219.53000	.	.	.	.	EST
FMC	101.14000	101.14000	101.14000	101.14000	67.22000	67.22000	67.22000	67.22000	FMC
APCN	1.00000	1.00000	1.00000	1.00000	.	.	.	.	APCN
ATOM	.	.	.	.	1.00000	1.00000	1.00000	1.00000	ATOM
APCN2	1.00000	1.00000	1.00000	1.00000	.	.	.	.	APCN2

	TCMVNR1	TOMBRR1	TOMGHG1	TOMGPG1	TOMSAG1	TOMSTG1	TOMVNG1	TOMBRG1	12....1
YTOM	7.80000	6.00000	12.00000	9.80000	11.60000	8.40000	7.80000	.	YTOM
STOM	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	STOM
GHG1	.	.	1.00000	.	.	.	.	.	GHG1
GPG1	.	.	.	1.00000	.	.	.	.	GPG1
SAG1	.	.	.	.	1.00000	.	.	.	SAG1
STG1	.	.	.	.	.	1.00000	.	.	STG1
VNG1	1.00000	.	.	.	.	.	1.00000	.	VNG1
BRG1	.	1.00000	.	.	.	.	.	.	BRG1
N	63.00000	63.00000	63.00000	63.00000	63.00000	63.00000	63.00000	63.00000	N
PH	180.00000	180.00000	180.00000	180.00000	180.00000	180.00000	180.00000	180.00000	PH
IN	15.00000	15.00000	15.00000	15.00000	15.00000	15.00000	15.00000	15.00000	IN
HR	12.00000	12.00000	12.00000	12.00000	12.00000	12.00000	12.00000	12.00000	HR
DH	10.76000	8.28000	16.56000	13.52000	16.01000	11.59000	10.76000	8.28000	DH
DO	20.58000	20.58000	20.58000	20.58000	20.58000	20.58000	20.58000	20.58000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	.	.	49.71000	49.71000	49.71000	49.71000	49.71000	49.71000	LP
OLH	2.44000	1.88000	3.76000	3.07000	3.63000	2.63000	2.44000	1.88000	OLH
OLO	6.06000	6.06000	6.06000	6.06000	6.06000	6.06000	6.06000	6.06000	OLO
OLW	.	.	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	OLW
RH	3.77000	2.90000	5.80000	4.74000	5.61000	4.06000	3.77000	2.90000	RH
RO	8.11000	8.11000	8.11000	8.11000	8.11000	8.11000	8.11000	8.11000	RO
RW	.	.	1.33000	1.33000	1.33000	1.33000	1.33000	1.33000	RW
LI	5.58000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	LI
LH	7.70000	5.92000	11.84000	9.67000	11.45000	8.29000	7.70000	5.92000	LH
LO	8.90000	8.90000	8.90000	8.90000	8.90000	8.90000	8.90000	8.90000	LO
LW	.	.	.54000	.54000	.54000	.54000	.54000	.54000	LW
HOE	37.00000	37.00000	37.00000	37.00000	37.00000	37.00000	37.00000	37.00000	HOE
WRQ	2.60000	2.60000	.	.	.	.	.	.	WRQ
WROG	.	.	2.60000	2.60000	2.60000	2.60000	2.60000	2.60000	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FMC	67.22000	67.22000	67.22000	67.22000	67.22000	67.22000	67.22000	67.22000	FMC
ATOM	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	ATOM

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	LETGHR1	LETGPR1	LETSAR1	LETSTR1	LETVNR1	LETBRR1	LETGHG1	LETGPG1	13....1
YLET	578.00000	472.00000	558.00000	405.00000	376.00000	289.00000	578.00000	472.00000	YLET
SLET	.60000	.60000	.60000	.60000	.60000	.60000	.60000	.60000	SLET
GHG1	1.00000	.	.	.	.	.	1.00000	.	GHG1
GPG1	.	1.00000	.	.	.	.	.	1.00000	GPG1
SAG1	.	.	1.00000	.	.	.	.	.	SAG1
STG1	.	.	.	1.00000	.	.	.	.	STG1
VNG1	.	.	.	.	1.00000	.	.	.	VNG1
BRG1	.	.	.	.	.	1.00000	.	.	BRG1
N	300.00000	300.00000	300.00000	300.00000	300.00000	300.00000	300.00000	300.00000	N
PH	200.00000	200.00000	200.00000	200.00000	200.00000	200.00000	200.00000	200.00000	PH
IN	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	IN
HR	6.67000	6.67000	6.67000	6.67000	6.67000	6.67000	6.67000	6.67000	HR
DUST	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	DUST
DO	22.32000	22.32000	22.32000	22.32000	22.32000	22.32000	22.32000	22.32000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	.	.	.	.	.	.	49.71000	49.71000	LP
OLD	7.26000	7.26000	7.26000	7.26000	7.26000	7.26000	7.26000	7.26000	OLD
OLW	.	.	.	.	.	.	1.18000	1.18000	OLW
RO	8.62000	8.62000	8.62000	8.62000	8.62000	8.62000	8.62000	8.62000	RO
RW	.	.	.	.	.	.	1.33000	1.33000	RW
LI	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	LI
LO	9.30000	9.30000	9.30000	9.30000	9.30000	9.30000	9.30000	9.30000	LO
LW	.	.	.	.	.	.	.54000	.54000	LW
HOE	160.00000	160.00000	160.00000	160.00000	160.00000	160.00000	160.00000	160.00000	HOE
WRQ	2.60000	2.60000	2.60000	2.60000	2.60000	2.60000	.	.	WRQ
WROG	.	.	.	.	.	.	2.60000	2.60000	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FMC	53.82000	53.82000	53.82000	53.82000	53.82000	53.82000	53.82000	53.82000	FMC
ALET	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	ALET

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	LETSAG1	LETSTG1	LETVNG1	LETBRG1	ONIGHR1	ONIGPR1	ONISAR1	ONISTR1	14....1
YLET	558.00000	405.00000	376.00000	289.00000	.	.	.	.	YLET
YONI	.	.	.	.	740.00000	605.00000	714.00000	518.00000	YONI
SLET	.60000	.60000	.60000	.60000	.	.	.	.	SLET
SONI	.	.	.	.	4.00000	4.00000	4.00000	4.00000	SONI
GHG1	.	.	.	.	1.00000	.	.	.	GHG1
GPG1	.	.	.	.	.	1.00000	.	.	GPG1
SAG1	1.00000	.	.	.	.	.	1.00000	.	SAG1
STG1	.	1.00000	.	.	.	.	.	1.00000	STG1
VNG1	.	.	1.00000	.	.	.	.	.	VNG1
BRG1	.	.	.	1.00000	.	.	.	.	BRG1
N	300.00000	300.00000	300.00000	300.00000	450.00000	450.00000	450.00000	450.00000	N
PH	200.00000	200.00000	200.00000	200.00000	250.00000	250.00000	250.00000	250.00000	PH
IN	100.00000	100.00000	100.00000	100.00000	41.00000	41.00000	41.00000	41.00000	IN
HR	6.67000	6.67000	6.67000	6.67000	35.00000	35.00000	35.00000	35.00000	HR
DUST	1.00000	1.00000	1.00000	1.00000	.	.	.	.	DUST
DO	22.32000	22.32000	22.32000	22.32000	25.02000	25.02000	25.02000	25.02000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	49.71000	49.71000	49.71000	49.71000	.	.	.	.	LP
OLO	7.26000	7.26000	7.26000	7.26000	8.17000	8.17000	8.17000	8.17000	OLO
OLW	1.18000	1.18000	1.18000	1.18000	.	.	.	.	OLW
RO	8.62000	8.62000	8.62000	8.62000	9.45000	9.45000	9.45000	9.45000	RO
RW	1.33000	1.33000	1.33000	1.33000	.	.	.	.	RW
LI	5.98000	5.98000	5.98000	5.98000	5.28000	5.28000	5.28000	5.28000	LI
LO	9.30000	9.30000	9.30000	9.30000	10.79000	10.79000	10.79000	10.79000	LO
LW	.54000	.54000	.54000	.54000	.	.	.	.	LW
HOE	160.00000	160.00000	160.00000	160.00000	120.00000	120.00000	120.00000	120.00000	HOE
WRQ	.	.	.	.	2.60000	2.60000	2.60000	2.60000	WRQ
WROG	2.60000	2.60000	2.60000	2.60000	.	.	.	.	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FMC	53.82000	53.82000	53.82000	53.82000	57.92000	57.92000	57.92000	57.92000	FMC
ALET	1.00000	1.00000	1.00000	1.00000	.	.	.	.	ALET
AONI	.	.	.	.	1.00000	1.00000	1.00000	1.00000	AONI

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	ONIVNRI	ONIBRRI	ONIGHGI	ONIGPGI	ONISAGI	ONISTGI	ONIVNGI	ONIBRGI	15....1
YONI	481.00000	370.00000	740.00000	605.00000	714.00000	518.00000	481.00000	370.00000	YONI
SONI	4.00000	4.00000	4.00000	4.00000	4.00000	4.00000	4.00000	4.00000	SONI
GHGI	.	.	1.00000	.	.	.	.	.	GHGI
GPGI	.	.	.	1.00000	.	.	.	.	GPGI
SAGI	.	.	.	.	1.00000	.	.	.	SAGI
STGI	.	.	.	.	.	1.00000	.	.	STGI
VNGI	1.00000	.	.	.	.	.	1.00000	.	VNGI
BRGI	.	1.00000	.	.	.	.	.	1.00000	BRGI
N	450.00000	450.00000	450.00000	450.00000	450.00000	450.00000	450.00000	450.00000	N
PH	250.00000	250.00000	250.00000	250.00000	250.00000	250.00000	250.00000	250.00000	PH
IN	41.00000	41.00000	41.00000	41.00000	41.00000	41.00000	41.00000	41.00000	IN
HR	35.00000	35.00000	35.00000	35.00000	35.00000	35.00000	35.00000	35.00000	HR
DO	25.02000	25.02000	25.02000	25.02000	25.02000	25.02000	25.02000	25.02000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	.	.	49.71000	49.71000	49.71000	49.71000	49.71000	49.71000	LP
DLO	8.17000	8.17000	8.17000	8.17000	8.17000	8.17000	8.17000	8.17000	DLO
DLW	.	.	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	DLW
RO	9.45000	9.45000	9.45000	9.45000	9.45000	9.45000	9.45000	9.45000	RO
RW	.	.	1.33000	1.33000	1.33000	1.33000	1.33000	1.33000	RW
LI	5.28000	5.28000	5.28000	5.28000	5.28000	5.28000	5.28000	5.28000	LI
LO	10.79000	10.79000	10.79000	10.79000	10.79000	10.79000	10.79000	10.79000	LO
LW	.	.	.54000	.54000	.54000	.54000	.54000	.54000	LW
HOE	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	120.00000	HOE
WRQ	2.60000	2.60000	.	.	.	.	.	.	WRQ
WRQG	.	.	2.60000	2.60000	2.60000	2.60000	2.60000	2.60000	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
DE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	DE
FMC	57.52000	57.92000	57.92000	57.92000	57.92000	57.92000	57.92000	57.92000	FMC
AONI	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	AONI

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	CHGGHR1	CHGGPR1	CHGSAR1	CHGSTR1	CHGVNR1	CHGBRR1	CHGGHG1	CHGGPG1	16....1
YCHG	8.00000	6.50000	7.70000	5.60000	5.20000	4.00000	8.00000	6.50000	YCHG
SCHG	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	5.00000	SCHG
GHG1	1.00000	.	.	.	.	.	1.00000	.	GHG1
GPG1	.	1.00000	.	.	.	.	.	1.00000	GPG1
SAG1	.	.	1.00000	.	.	.	.	.	SAG1
STG1	.	.	.	1.00000	.	.	.	.	STG1
VNG1	.	.	.	.	1.00000	.	.	.	VNG1
BRG1	.	.	.	.	.	1.00000	.	.	BRG1
N	300.00000	300.00000	300.00000	300.00000	300.00000	300.00000	300.00000	300.00000	N
PH	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	70.00000	PH
IN	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	IN
HR	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	HR
NEM	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	NEM
DO	23.07000	23.07000	23.07000	23.07000	23.07000	23.07000	23.07000	23.07000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	.	.	.	.	.	.	49.71000	49.71000	LP
OLO	7.48000	7.48000	7.48000	7.48000	7.48000	7.48000	7.48000	7.48000	OLO
OLW	.	.	.	.	.	.	1.18000	1.18000	OLW
RO	8.31000	8.31000	8.31000	8.31000	8.31000	8.31000	8.31000	8.31000	RO
RW	.	.	.	.	.	.	1.33000	1.33000	RW
LI	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	LI
LO	9.45000	9.45000	9.45000	9.45000	9.45000	9.45000	9.45000	9.45000	LO
LW	.	.	.	.	.	.	.54000	.54000	LW
HOE	93.00000	93.00000	93.00000	93.00000	93.00000	93.00000	93.00000	93.00000	HOE
WRQ	2.60000	2.60000	2.60000	2.60000	2.60000	2.60000	.	.	WRQ
WROG	.	.	.	.	.	.	2.60000	2.60000	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FNC	61.07000	61.07000	61.07000	61.07000	61.07000	61.07000	61.07000	61.07000	FNC
IC	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	IC
ACHG	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	ACHG

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	CHGSAGI	CHGSTGI	CHGVNGI	CHGBRGI	CHRGHRI	CHRGPRI	CHRSARI	CHRSTRI	17....1
YCHG	7.70000	.	.	4.00000	.	.	.	.	YCHG
YCHR	.	.	.	.	3500.0000	2860.0000	3378.0000	2450.0000	YCHR
SCHG	5.00000	5.00000	5.00000	5.00000	.	.	.	.	SCHG
SCHR	.	.	.	.	8.00000	8.00000	8.00000	8.00000	SCHR
GHGI	.	.	.	.	1.00000	.	.	.	GHGI
GPGI	.	.	.	.	.	1.00000	.	.	GPGI
SAGI	1.00000	.	.	.	.	.	1.00000	.	SAGI
STGI	.	1.00000	.	.	.	.	.	1.00000	STGI
VNGI	.	.	1.00000	.	.	.	.	.	VNGI
BRGI	.	.	.	1.00000	.	.	.	.	BRGI
N	300.00000	300.00000	300.00000	300.00000	200.00000	200.00000	200.00000	200.00000	N
PH	70.00000	70.00000	70.00000	70.00000	60.00000	60.00000	60.00000	60.00000	PH
IN	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	IN
HR	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	HR
NEM	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	NEM
DO	23.07000	23.07000	23.07000	23.07000	21.57000	21.57000	21.57000	21.57000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	49.71000	49.71000	49.71000	49.71000	.	.	.	.	LP
OLO	7.48000	7.48000	7.48000	7.48000	6.97000	6.97000	6.97000	6.97000	OLO
OLW	1.18000	1.18000	1.18000	1.18000	.	.	.	.	OLW
RO	8.31000	8.31000	8.31000	8.31000	7.97000	7.97000	7.97000	7.97000	RO
RW	1.33000	1.33000	1.33000	1.33000	.	.	.	.	RW
LI	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	LI
LO	9.45000	9.45000	9.45000	9.45000	9.07000	9.07000	9.07000	9.07000	LO
LW	.54000	.54000	.54000	.54000	.	.	.	.	LW
HOE	93.00000	.	.	93.00000	93.00000	93.00000	93.00000	93.00000	HOE
WRQ	.	.	.	.	2.60000	2.60000	2.60000	2.60000	WRQ
WRQG	2.60000	2.60000	2.60000	2.60000	.	.	.	.	WRQG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
DE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	DE
FMC	61.07000	61.07000	61.07000	61.07000	51.79000	51.79000	51.79000	51.79000	FMC
IC	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	IC
ACHG	1.00000	1.00000	1.00000	1.00000	.	.	.	.	ACHG
ACHR	.	.	.	.	1.00000	1.00000	1.00000	1.00000	ACHR

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	CHRVNR1	CHRBRR1	CHRGHG1	CHRGPG1	CHRSAG1	CHRSTG1	CHRVNG1	CHRBRG1	18....1
YCHR	2275.0000	1750.0000	3500.0000	2860.0000	3378.0000	2450.0000	2275.0000	1750.0000	YCHR
SCHR	8.00000	8.00000	8.00000	8.00000	8.00000	8.00000	8.00000	8.00000	SCHR
GHG1	.	.	1.00000	.	.	.	.	.	GHG1
GPG1	.	.	.	1.00000	.	.	.	.	GPG1
SAG1	.	.	.	.	1.00000	.	.	.	SAG1
STG1	.	.	.	.	.	1.00000	.	.	STG1
VNG1	1.00000	.	.	.	.	.	1.00000	.	VNG1
BRG1	.	1.00000	.	.	.	.	.	1.00000	BRG1
N	200.00000	200.00000	200.00000	200.00000	200.00000	200.00000	200.00000	200.00000	N
PH	60.00000	60.00000	60.00000	60.00000	60.00000	60.00000	60.00000	60.00000	PH
IN	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	9.70000	IN
HR	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	19.00000	HR
NEM	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	NEM
DO	21.57000	21.57000	21.57000	21.57000	21.57000	21.57000	21.57000	21.57000	DO
GO	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	2.00000	GO
LP	.	.	49.71000	49.71000	49.71000	49.71000	49.71000	49.71000	LP
OLO	6.97000	6.97000	6.97000	6.97000	6.97000	6.97000	6.97000	6.97000	OLO
OLW	.	.	1.18000	1.18000	1.18000	1.18000	1.18000	1.18000	OLW
RO	7.97000	7.97000	7.97000	7.97000	7.97000	7.97000	7.97000	7.97000	RO
RW	.	.	1.33000	1.33000	1.33000	1.33000	1.33000	1.33000	RW
LI	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	5.98000	LI
LO	9.07000	9.07000	9.07000	9.07000	9.07000	9.07000	9.07000	9.07000	LO
LW	.	.	.54000	.54000	.54000	.54000	.54000	.54000	LW
HOE	93.00000	93.00000	93.00000	93.00000	93.00000	93.00000	93.00000	93.00000	HOE
WRQ	2.60000	2.60000	.	.	.	.	.	.	WRQ
WROG	.	.	2.60000	2.60000	2.60000	2.60000	2.60000	2.60000	WROG
FC	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	FC
OE	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	30.00000	OE
FMC	51.79000	51.79000	51.79000	51.79000	51.79000	51.79000	51.79000	51.79000	FMC
IC	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	40.00000	IC
ACHR	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	ACHR

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	SEEDCTUP	SEEDCTPI	SEEDWHEA	SEEDBARL	SEEDGRAI	SEEDTOMA	SEEDLETT	SEEDONIO	19....1
OBJ	.48000-	.30000-	.22000-	.18000-	.60000-	18.00000-	35.00000-	17.00000-	OBJ
SCTU	1.00000-	.	.	.	.	.	.	.	SCTU
SCTP	.	1.00000-	.	.	.	.	.	.	SCTP
SWHE	.	.	1.00000-	.	.	.	.	.	SWHE
SBAR	.	.	.	1.00000-	.	.	.	.	SBAR
SGSH	.	.	.	.	1.00000-	.	.	.	SGSH
STOM	.	.	.	.	.	1.00000-	.	.	STOM
SLET	.	.	.	.	.	.	1.00000-	.	SLET
SONI	.	.	.	.	.	.	.	1.00000-	SONI
IOC	.48000	.30000	.22000	.18000	.60000	18.00000	35.00000	17.00000	IOC

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	SEEDGREE	SEEDREDC	NITROGEN	NITREG	NITLL	PHOSPHOR	PHOREG	PHOLL	20....1
OBJ	12.00000-	12.00000-	.12000-	.	.	.12500-	.	.	OBJ
SCHG	1.00000-	.	.	.	.	.	.	.	SCHG
SCHR	.	1.00000-	.	.	.	.	.	.	SCHR
N	.	.	.	1.00000-	.	.	.	.	N
NL	.	.	.	.	1.33333-	.	.	.	NL
NT	.	.	1.00000-	1.00000	1.00000	.	.	.	NT
PH	.	.	.	.	.	.	1.00000-	.	PH
PHL	.	.	.	.	.	.	.	1.33333-	PHL
PHT	.	.	.	.	.	1.00000-	1.00000	1.00000	PHT
IOC	12.00000	12.00000	.12000	.	.	.12500	.	.	IOC

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	POTASSIU	ZINC	INSECTIC	HERBICID	NEMATICI	DUST	BALEWIRE	CROPINSU	21....1
OBJ	.08000-	5.00000-	1.00000-	1.00000-	1.00000-	11.67000-	.35500-	1.00000-	OBJ
PO	1.00000-	.	.	.	.	.	.	.	PO
Z	.	1.00000-	.	.	.	.	.	.	Z
IN	.	.	1.00000-	.	.	.	.	.	IN
HR	.	.	.	1.00000-	.	.	.	.	HR
NEM	.	.	.	.	1.00000-	.	.	.	NEM
DUST	.	.	.	.	.	1.00000-	.	.	DUST
WIRE	.	.	.	.	.	.	1.00000-	.	WIRE
IC	.	.	.	.	.	.	.	1.00000-	IC
IDC	.08000	5.00000	1.00000	1.00000	1.00000	11.67000	.35500	1.00000	IDC

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	OTHEREXP	HOECUSTO	LABORIRR	LABORIRL	LABORIRT	LABORWEL	LABORWLL	LABORWLT	22....1
OBJ	1.00000-	1.00000-	.	.	.	.	.	.	OBJ
LTIDC	.	.	.	.	1.00000	.	.	1.00000	LTIDC
LI	.	.	1.00000-	.	.	.	.	.	LI
LIL	.	.	.	1.33333-	.	.	.	.	LIL
LIT	.	.	1.00000	1.00000	1.00000-	.	.	.	LIT
LW	.	.	.	.	.	1.00000-	.	.	LW
LWL	.	.	.	.	.	.	1.33333-	.	LWL
LWT	.	.	.	.	.	1.00000	1.00000	1.00000-	LWT
HOE	.	1.00000-	.	.	.	.	.	.	HOE
OE	1.00000-	.	.	.	.	.	.	.	OE
IDC	1.00000	1.00000	.	.	.	.	.	.	IDC

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	LABORHAR	LABOROTH	LABORIOC	LABOR	DESOTHER	DESHARVE	DESIEL	GASOTHER	23....1
OBJ	.	.	.	3.60000-	.	.	1.06300-	.	OBJ
DH	.	.	.	.	.	1.00000-	.	.	DH
DO	.	.	.	.	1.00000-	.	.	.	DO
DT	.	.	.	.	1.00000	1.00000	1.00000-	.	DT
GO	.	.	.	.	.	.	.	1.00000-	GO
GT	.	.	.	.	.	.	.	1.00000	GT
LTIOC	.	1.00000	1.00000-	.	.	.	.	.	LTIOC
LH	1.00000-	.	.	.	.	.	.	.	LH
LO	.	1.00000-	.	.	.	.	.	.	LO
LT	1.00000	.	1.00000	1.00000-	.	.	.	.	LT
IOC	.	.	3.60000	.	1.06300	.	.	1.24200	IOC

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	GASHARVE	GASOLINE	LPWELL	LPWELLLL	LPGAS	OLWELL	OLWELLLL	OLWELLT	24....1
OBJ	.	1.24200-	.	.	999999.00-	.	.	.	OBJ
GH	1.00000-	.	.	.	.	.	.	.	GH
GT	1.00000	1.00000-	.	.	.	.	.	.	GT
LP	.	.	1.00000-	.	.	.	.	.	LP
LPL	.	.	.	1.33333-	.	.	.	.	LPL
LPT	.	.	1.00000	1.00000	1.00000-	.	.	.	LPT
OLW	.	.	.	.	.	1.00000-	.	.	OLW
OLWL	.	.	.	.	.	.	1.33333-	.	OLWL
OLWT	.	.	.	.	.	1.00000	1.00000	1.00000-	OLWT
OLTIOC	.	.	.	.	.	.	.	1.00000	OLTIOC
IOC	.	.	.	.	.69000	.	.	.	IOC

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	OLOTHER	OLHARVES	OILLUBE	OLIOC	REPWELL	REPWELLL	REPWELLT	REPOTHER	25....1
OBJ	.	.	1.00000-	.	.	.	.	.	OBJ
OLH	.	1.00000-	.	.	.	.	.	.	OLH
OLO	1.00000-	.	.	.	.	.	.	.	OLO
OLTIOC	1.00000	.	.	1.00000-	.	.	.	.	OLTIOC
OLT	.	1.00000	1.00000-	1.00000	.	.	.	.	OLT
RO	.	.	.	.	.	.	.	1.00000-	RO
RW	.	.	.	.	1.00000-	.	.	.	RW
RWL	.	.	.	.	.	1.33333-	.	.	RWL
RWT	.	.	.	.	1.00000	1.00000	1.00000-	.	RWT
RTIOC	.	.	.	.	.	.	1.00000	1.00000	RTIOC
IOC	.	.	.	1.00000	.	.	.	.	IOC

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	REPHARVE	REPAIRS	REPIOC	WATERSUR	WATERSLL	WATER2FT	WATER3RD	WATERTOT	26....1
OBJ	.	1.00000-	.	.	.	.	8.00000-	.	OBJ
RH	1.00000-	.	.	.	.	.	.	.	RH
RT	1.C0000	1.00000-	1.00000	.	.	.	.	.	RT
RTIOC	.	.	1.00000-	.	.	.	.	.	RTIOC
WRQ	.	.	.	1.00000-	.	.	.	.	WRQ
WRQL	.	.	.	.	1.33333-	.	.	.	WRQL
WRQ2	.	.	.	.	.	1.00000	.	.	WRQ2
WRQ3	.	.	.	.	.	.	1.00000	.	WRQ3
IOC	.	.	1.00000	.	.	.	.	.	IOC
WRQT	.	.	.	1.00000	1.00000	.	.	1.00000-	WRQT
WRQAVL	.	.	.	.	.	1.00000	1.00000	1.00000-	WRQAVL

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	WATERGR	WATERGLL	WATERGRO	LASERLEV	INONOPCP	CUSHRCTU	CUSHRCTP	CUSHRWHE	27....1
OBJ	.	.	.	45.00000-	.09203-	.07400-	.08000-	.36000-	OBJ
CUSCTU	.	.	.	.	.	1.00000-	.	.	CUSCTU
CUSCTP	.	.	.	.	.	.	1.00000-	.	CUSCTP
CUSWHE	.	.	.	.	.	.	.	1.00000-	CUSWHE
WROG	1.00000-	.	.	.	.	.	.	.	WROG
WROGL	.	1.33333-	.	.	.	.	.	.	WROGL
WROGT	1.00000	1.00000	1.00000-	.	.	.	.	.	WROGT
IOC	.	.	.	45.00000	1.00000-	.	.	.	IOC
LL	.	.	.	1.00000-	.	.	.	.	LL

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	CUSHRBAR	CUSHRGRA	CUSHRPCN	CUSHRTOM	CUSHRLET	CUSHRONI	CUSHRCHG	CUSHRCHR	28....1
OBJ	.35000-	.33600-	.18000-	8.75000-	2.54930-	2.33000-	75.64000-	.19750-	OBJ
CUSBAR	1.00000-	.	.	.	.	.	.	.	CUSBAR
CUSGRA	.	1.00000-	.	.	.	.	.	.	CUSGRA
CUSPCN	.	.	1.00000-	.	.	.	.	.	CUSPCN
CUSTOM	.	.	.	1.00000-	.	.	.	.	CUSTOM
CUSLET	.	.	.	.	1.00000-	.	.	.	CUSLET
CUSONI	.	.	.	.	.	1.00000-	.	.	CUSONI
CUSCHG	.	.	.	.	.	.	1.00000-	.	CUSCHG
CUSCHR	.	.	.	.	.	.	.	1.00000-	CUSCHR

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	FIXEDCOS	FIXMACHC	FIXWELLC	ESTABLIS	ACREGREE	ACREREDC	COTTON	PIMA	29....1
OBJ	32.83000-	1.00000-	1610208.0-	1.00000-	.	.	.78000	1.03760	OBJ
YCTU	.	.	.	.	.	.	1.20000-	.	YCTU
YCTP	.	.	.	.	.	.	.	1.10000-	YCTP
CUSCTU	.	.	.	.	.	.	1.00000	.	CUSCTU
CUSCTP	.	.	.	.	.	.	.	1.00000	CUSCTP
FC	1.00000-	.	.	.	.	.	.	.	FC
FWC	.	.	1.00000	.	.	.	.	.	FWC
EST	.	.	.	1.00000-	.	.	.	.	EST
FMC	.	1.00000-	.	.	.	.	.	.	FMC
ACHG	.	.	.	.	1.00000-	.	.	.	ACHG
ACHR	.	.	.	.	.	1.00000-	.	.	ACHR
CHILITOT	.	.	.	.	1.00000	1.00000	.	.	CHILITOT

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	COTTONSE	COTTONSU	ALFALFA	WHEAT	BARLEY	GRAINSOR	PECAN	TOMATO	30....1
OBJ	.05637	.05637	77.83000	3.93000	2.49000	2.86000	.95000	96.20000	OBJ
YCTSD	1.10000-	.	.	.	.	.	.	.	YCTSD
YCTSDU	.	1.20000-	.	.	.	.	.	.	YCTSDU
YALF	.	.	1.00000-	.	.	.	.	.	YALF
YWHE	.	.	.	1.00000-	.	.	.	.	YWHE
YBAR	.	.	.	.	1.00000-	.	.	.	YBAR
YGSH	.	.	.	.	.	1.00000-	.	.	YGSH
YPCN	.	.	.	.	.	.	3.00000-	.	YPCN
YTOM	.	.	.	.	.	.	.	1.00000-	YTOM
CUSWHE	.	.	.	1.00000	.	.	.	.	CUSWHE
CUSBAR	.	.	.	.	1.00000	.	.	.	CUSBAR
CUSGRA	.	.	.	.	.	1.00000	.	.	CUSGRA
CUSPCN	.	.	.	.	.	.	1.00000	.	CUSPCN
CUSTOM	.	.	.	.	.	.	.	1.00000	CUSTOM
WIRE	.	.	8.75000	.	.	.	.	.	WIRE

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31....1

	LETTUCE	ONION	FEILDBAG	GREENCHI	REDCHILI	FORKLIFT	ACREUPLA	ACREPIMA	
OBJ	5.41000	4.51000	.10000-	242.63000	.42180	10.00000-	.	.	OBJ
YLET	1.00000-	.	.	.	.	.	.	.	YLET
YONI	.	1.00000-	.	.	.	.	.	.	YONI
YCHG	.	.	.	1.00000-	.	.	.	.	YCHG
YCHR	.	.	.	.	1.00000-	.	.	.	YCHR
CUSLET	1.00000	.	.	.	.	.	.	.	CUSLET
CUSONI	.	1.00000	.	.	.	.	.	.	CUSONI
CUSCHG	.	.	.	1.00000	.	.	.	.	CUSCHG
CUSCHR	.	.	.	.	1.00000	.	.	.	CUSCHR
DH	.	.	.	.94900	.00093	.	.	.	DH
DLH	.	.	.	.10180	.00010	.	.	.	DLH
RH	.	.	.	.22060	.00022	.	.	.	RH
LH	.	.	.	.59030	.00058	.	.	.	LH
ACTU	.	.	.	.	.	.	1.00000-	.	ACTU
ACTP	.	.	.	.	.	.	.	1.00000-	ACTP
BAGS	.	1.15000	1.00000-	.	.	.	.	.	BAGS
FORKL	.	.	.	.12000	.00012	1.00000-	.	.	FORKL
TOTALCOT	.	.	.	.	.	.	1.00000	1.00000	TOTALCOT

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	P01	CHWATER	
GHGI	1368.0000	.	GHG1
GPGI	256.00000	.	GPG1
SAGI	460.00000	.	SAG1
STGI	638.00000	.	STG1
VNGI	124.00000	.	VNG1
BRGI	32.00000	.	BRG1
WRQ2	.	20.00000	WRQ2
FWC	1.00000	.	FWC
AALF	8517.0000	.	AALF
APCN	5200.0000	.	APCN
ATOM	100.00000	.	ATOM
ALET	200.00000	.	ALET
AONI	200.00000	.	ACNI
AALF2	6083.0000	.	AALF2
APCN2	4800.0000	.	APCN2
CHILITOT	700.00000	.	CHILITOT
TOTALCOT	28000.000	.	TOTALCOT

APPENDIX D

Evaporation from Elephant Butte

Reservoir, New Mexico

Evaporation from Elephant Butte Reservoir

After consultation with the staff members of the U.S. Department of the Interior, Water and Power Resources Service, Southwest Regional Office and Bill Riley, Chief Engineer, Rio Grande Compact Commission, the following procedure was developed to calculate evaporation from Elephant Butte Reservoir. This procedure was based on the suggestions and comments of these above-mentioned experts and any state, federal, compact or treaty law or regulation which might apply.

Percentage evaporation loss was calculated monthly from January 1951 to December 1980. The calculation procedure begins with the monthly pan evaporation in inches reported for Elephant Butte Dam in the annual Rio Grande Compact Commission Report. Riley said that, for Rio Grande Compact Commission purposes, 70 percent of pan evaporation is used as actual lake surface evaporation. Therefore, the monthly pan evaporation figures were multiplied by .7 to obtain actual lake surface evaporation. Monthly rainfall totals in inches were also reported in the Rio Grande Compact Commission Report. The monthly rainfall total was subtracted from the monthly actual lake surface evaporation to give the monthly actual net lake surface evaporation in inches. The procedure to this point is different than that used by American Ground Water Consultants, Inc. (AGWC) in a study done for the Jicarilla Indian Tribe in a lawsuit against the city of Albuquerque, New Mexico. AGWC subtracted rainfall from pan evaporation first, then multiplied by .7 to obtain actual lake surface evaporation. This, of course, diminishes the impact of rainfall on countering actual lake surface evaporation, rainfall being reduced by 30 percent. Thus, evaporation rates were over-estimated. Higher evaporation rates helped support the Indians' lawsuit. The AGWC method was not used. Instead, the technically correct procedure initially described in this appendix was developed with Riley's guidance.

The Rio Grande Compact Commission Report also reported either monthly lake levels in feet above sea level or lake capacities in acre feet for Elephant Butte Reservoir.[10] Monthly lake levels were reported for 1951 and 1959 through 1975. Monthly lake capacities were reported for 1952 through 1958. Transmountain water was introduced into Elephant Butte in 1976. This water under legal agreements is registered as a reduction in lake evaporation with the amount determined by the increase in lake surface area attributable to the transmountain water. Therefore, the monthly lake capacities for 1976 through 1980 were reduced by the monthly capacities of transmountain water. This monthly lake capacity was then used for calculation purposes.

Any container may be measured for the volume of the liquid

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[10] Lake levels and lake capacities are actually reported as of the last day of the month. The end of the month figure and the end of the previous month figure were averaged to obtain the monthly figures for either lake level or lake capacity.

contained. This capacity has a relationship to the height of the liquid in the container. The level of the liquid in the container, depending on the shape of the container, determines some given liquid surface area. For an irrigation water storage reservoir like Elephant Butte, this means that the lake level is exactly related to lake capacity and lake area due to the physical structure of the lake. Periodically the U.S. Department of the Interior, Water and Power Resources Service, Southwest Regional Office redefines these relationships for Elephant Butte Reservoir. In 1980, they developed a new set of elevation-area and elevation-capacity tables for Elephant Butte. By knowing one of the three -- lake level, lake area or lake capacity -- the other two may be determined from the tables. From these tables monthly lake levels, lake areas and lake capacities were determined from either the monthly lake levels or monthly lake capacities reported by the Rio Grande Compact Commission.

The monthly actual net surface evaporation in inches was multiplied by the monthly lake area in acres. The result divided by twelve converts the evaporation to acre feet. This monthly total acre feet of evaporation was divided by the monthly lake capacity yielding the monthly percentage loss due to evaporation. These monthly evaporation rates are listed in Table 41.

In December of 1960, no pan evaporation was reported. The total lake evaporation in acres calculated by Riley in some earlier work was used.

Table 41. Monthly and Annual Percentage Evaporation Rates for Elephant Butte Reservoir 1951 through 1980

Month	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
January	1.004	1.777	.851	.951	.562	1.126	1.793	.336	.522	.274	.246	.411	.580	1.058	1.159
February	1.098	2.708	.656	1.776	1.348	.908	1.670	.600	.676	.802	1.003	1.129	.765	1.107	1.392
March	1.859	5.223	1.348	2.444	2.344	2.425	2.834	.488	1.329	1.552	1.728	1.368	1.748	2.738	2.375
April	2.950	4.182	2.523	3.747	4.053	3.272	4.164	1.509	1.570	2.223	2.764	2.303	2.696	3.794	3.578
May	3.452	3.586	3.423	4.236	4.147	4.622	4.190	1.731	2.445	2.507	3.602	3.209	3.365	5.008	3.739
June	6.295	2.782	4.001	6.039	5.075	4.518	3.780	1.991	2.390	2.348	3.146	3.292	4.264	5.680	3.362
July	6.136	2.012	3.173	6.449	3.245	3.560	2.357	1.648	2.272	1.786	3.093	1.719	3.773	3.238	2.500
August	7.026	2.170	3.393	5.187	2.658	3.642	.481	1.495	.913	2.208	2.191	3.239	3.144	4.387	2.146
September	9.794	1.813	4.090	3.399	3.692	5.660	1.560	.501	2.190	2.068	1.835	.883	2.532	2.114	1.736
October	7.025	1.537	2.654	2.105	2.113	5.335	.384	.385	1.193	1.012	2.375	1.287	2.600	3.320	1.656
November	3.480	.836	1.834	1.941	1.909	2.708	.401	.555	.723	.987	.089	.828	1.477	2.102	.992
December	2.517	.383	.919	1.251	1.182	1.582	.435	.491	.359	-.115	.632	.009	1.083	.962	.121
Annual	41.889	25.522	25.404	33.233	28.022	33.079	21.665	11.139	15.398	16.327	20.548	18.056	24.756	30.363	22.187

Month	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
January	.172	.881	.462	.727	.468	.724	.906	.345	.472	.310	.476	.296	.414	.453	.276
February	.632	1.099	.774	.935	.451	1.129	1.221	.151	.658	.591	.739	.897	.838	.948	.484
March	1.360	2.341	1.222	1.407	1.093	1.901	2.262	1.239	1.227	1.281	1.381	1.499	1.738	1.838	1.166
April	1.990	3.338	2.495	2.340	2.009	2.305	3.295	1.880	1.764	2.101	1.688	1.853	3.341	2.181	1.299
May	2.621	4.033	3.505	2.381	2.339	3.518	3.612	1.884	2.165	2.502	1.860	3.145	2.979	1.861	1.741
June	2.509	3.436	4.224	2.921	2.620	4.267	2.926	2.193	2.667	2.879	2.542	3.249	2.927	1.757	2.178
July	2.631	3.778	2.995	1.822	2.350	4.297	3.810	1.531	1.913	1.752	1.878	3.015	3.299	1.633	1.999
August	1.743	1.415	2.092	2.270	2.316	2.976	2.037	1.415	1.924	1.903	2.299	2.198	3.208	1.170	1.319
September	1.626	1.386	2.269	.915	2.473	3.784	2.297	1.556	1.165	.261	1.120	2.486	2.680	.612	.685
October	1.565	2.056	1.885	1.174	1.356	1.589	.038	1.235	.275	1.299	1.010	2.073	1.993	1.128	.946
November	1.189	.869	.712	.779	1.333	1.036	.546	.962	.693	.753	.481	1.830	-.282	.599	.446
December	.768	.178	.629	.292	.709	.159	.678	.567	.246	.336	.466	1.287	.560	.317	.366
Annual	17.297	22.250	21.005	16.588	17.894	24.519	21.304	13.994	14.417	14.889	14.851	21.428	21.359	13.591	12.189

The annual evaporation rate was determined from the monthly evaporation. Since evaporation is a continual process, the monthly rates must be compounded into the annual rate. The monthly evaporation rates were first divided by 100 and then subtracted from one. These monthly factors of water remaining were then multiplied together for each year. This result was subtracted from one and multiplied by 100 giving the annual evaporation rate in percent (Table 41).

APPENDIX E

The Two Acre Feet Per Acre

Water Use Scenario

The Two Acre Feet Per Acre Water Use Scenario

Farmers in El Paso County do not have perfect knowledge of future surface water allocations. They, therefore, cannot optimally allocate their future surface water allocations by means of a temporal linear programming as was used in this study. Thus, the two acre feet per acre water use scenario was developed as an example of a probable water use scheme which farmers may implement.

Under this scheme a farmer would use no more than two acre feet of surface water in any year. When surface water allocations were above two acre feet per acre, the excess over two acre feet would be stored for future use. Table 42 gives the annual surface water allocation and the portion of that allocation saved for future use. Table 42 also gives the cumulative total of water saved. Water stored for a whole year is charged the total evaporation for the year. Stored water used within a year was only charged evaporation for the first six months of the year.

In development of this water use scenario, it was possible to determine evaporation rates which includes the effects of the additional (stored) water in the reservoir. These revised evaporation rates are given in Table 43 for applicable months. They were determined by adding to actual lake capacity the hypothetical stored water. This yielded a new capacity which from the elevation-capacity tables for Elephant Butte Reservoir produced a new lake level. Then the new lake level was used to read a new lake area from the

Table 42. Development of the Two Acre Feet Per Acre Surface Water Use Scenario for the Years 1963 through 1980

Year	Surface Water Allocation	Water Saved from Allocation	Total Water Used	Water Charged Full Year Evaporation	Water Charged 1/2 Year Evaporation	Water Available to be Called	Saved Water Called	Water Used
	acre feet per acre							
1963	2.00							2.00
1964	.33							.33
1965	1.85							1.85
1966	2.50	.50	.50					2.00
1967	1.50		.50		.50	.50	.43229	1.93229
1968	2.00		.50					2.00
1969	3.00	1.00	1.50					2.00
1970	3.00	1.00	2.50	1.00		1.00		2.00
1971	2.00		2.50	1.83044		1.83044		2.00
1972	.67		2.50		1.45207	1.45207	1.28148	1.95148
1973	3.00	1.00	3.50					2.00
1974	3.00	1.00	4.50	1.00		1.00		2.00
1975	3.00	1.00	5.50	1.86276		1.86276		2.00
1976	3.00	1.00	6.50	2.60291		2.60291		2.00
1977	1.25		6.50	2.51402	.75	3.26402	.75	2.00
1978	.75		6.50	.77722	1.25	2.02722	1.25	2.00
1979	3.00	1.00	7.50	.51318		.51318		2.00
1980	3.00	1.00	8.50	1.44486		1.44486		2.00
1981				2.27122		2.27122		

Table 43. Revised Evaporation Rates for Elephant Butte Reservoir for the Two Acre Feet Per Acre Water Use Scenario

Month	Year										
	1967	1970	1971	1972	1974	1975	1976	1977	1978	1979	1980
	percent										
January	.845	.451	.641	.805	.463	.287	.450	.239	.334	.419	.270
February	1.055	.436	1.014	1.117	.648	.550	.703	.727	.719	.920	.475
March	2.273	1.054	1.679	2.071	1.204	1.190	1.311	1.232	1.511	1.783	1.143
April	3.211	1.930	2.016	2.881	1.732	1.935	1.582	1.528	2.799	2.117	1.274
May	3.762	2.248	3.123	3.064	2.113	2.316	1.729	2.563	2.620	1.802	1.710
June	3.190	2.514	3.659	2.414	2.595	2.687	2.332	2.627	2.572	1.733	2.149
July		2.194	3.365		1.841	1.648	1.668	2.296	3.079	1.618	1.972
August		2.191	2.408		1.806	1.780	1.946	1.607	2.986	1.159	1.303
September		2.221	2.620		1.089	.245	.945	1.822	2.501	.606	.677
October		1.232	1.245		.258	1.221	.854	1.530	1.870	1.120	.935
November		1.266	.844		.652	.713	.406	1.349	-.263	.593	.441
December		.665	.129		.235	.321	.394	.976	.519	.315	.362

elevation-area tables for Elephant Butte. The appropriate monthly net actual lake surface evaporation from Appendix D was multiplied by this new lake area. The result was divided by twelve to convert it to acre feet. This new total evaporation was then divided by the new capacity and multiplied by 100 to produce the percentage loss due to evaporation. This percentage evaporation loss was divided by 100 and subtracted from one to give the factor of water remaining. This factor was multiplied by the hypothetical stored water to give the hypothetical stored water for the next month. This stored water for the next month was added to the actual lake capacity for the next month to yield the new capacity for the next month. Then the whole procedure was repeated for each month as necessary. As water was stored it was added in January to hypothetical stored water. As water was used it was subtracted from the July hypothetical stored water.

Table 42 also gives the water available on January 1st of each year which is in storage and available to be called. The stored water which is called for delivery is also given. Finally, the water used is given which is two acre feet in years with allocations at or above two acre feet. Water used is the water allocation plus the saved water called for years with allocations below two acre feet.