HIGH PLAINS-OGALLALA AQUIFER STUDY

LEA COUNTY, NEW MEXICO*

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David P. Hale and Carl Slingerland of the New Mexico Interstate Stream Commission served as coordinators, under the direction of S. E. Reynolds, for all phases of the project.

Although the research team is solely and totally responsible for statements and conclusions in this report, many people helped in the formulation of the analysis. They included representatives from the High Plains Associates: Camp, Dresser, and McKee (Harvey O. Banks, Jean Williams, and Joe D. Harris); Arthur D. Little, Inc. (Richard Feeley, David Land, Russell Fries, and Rufus Perkins); and Black and Veatch (Charles L. Banning and Carl A. Vansant).

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ABSTRACT

New Mexico participated with five High Plains states and the High Plains Associates in the Six-State High Plains-Ogallala Aquifer Area Study. The purpose of the study was to estimate the economic impacts over a 40-year planning horizon resulting from rapidly rising energy costs and the declining Ogallala aquifer water tables in Lea County.

Four management strategies including a baseline, voluntary water conservation, mandatory irrigation water supply reduction, and interstate importation were evaluated.

For the baseline, the total gross output of all goods and services for Lea County was about $1,520 million in 1977. It is projected to be $2,835 million in 1985, $2,436 million in 1990, $1,427 million in 2000, and $1,170 million in 2020. The differences in gross output among the management strategies are due to changes in the agricultural sectors.

The most important sector is mining which contributed about 64 percent of the total output in 1977. By 1985, it is projected to account for about 55 percent. The expansion in the oil and gas extraction activities (mining sectors) is expected to be a driving force in the local economy with the construction, trade, and service sectors responding to the growth in mining. After 1985, the mining activity is expected to decrease, and by 2020 to contribute about 26 percent. The manufacturing sector is expected to expand faster than any of the other sectors, increasing from $73 million in 1977 to over $318 million in 2020. The agricultural sectors are projected to also increase from $88 million in 1977 to about $155 million in 2020.

The total employment in Lea County in 1977 was 17,234, and is expected to increase to 45,168 by 1985, then decrease to 9,954 by 2020. Trade was the largest employer in 1977 followed by mining. In 1985, construction was projected to be the largest employer. In 1990, trade was again larger, but in 2000 and 2020 the service sector was projected to be the most important.

The alternative management strategies basically had very little impact on the economy of Lea County. The voluntary strategy resulted in total output in 2020 of $8,000 more than the baseline. Mandatory resulted in $1.797 million more than the baseline and the importation strategy had $9.825 million more than the baseline. The impact on employment of the alternative management strategies in Lea County was also minor. The voluntary strategy resulted in 80 more jobs than the baseline in 2020. The mandatory had 77 more than the baseline and the importation had 295 more than the baseline. Population in the county is projected to follow a similar pattern as output and employment. Population under the different management strategies is projected to be slightly higher than the baseline throughout the period, but does not amount to enough to offset the general decline projected over time. Voluntary resulted in 185 more people than the baseline in 2020, mandatory had 239 more people than the baseline, and importation had 873 more people than the baseline in 2020.

KEYWORDS: *High Plains, *Ogallala Aquifer, *Lea County, *New Mexico, *management strategies, energy, water resources, on-farm impacts, regional impacts, gross output, employment, population, economic projections, resources, interdisciplinary.

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INTRODUCTION

A large part of eastern New Mexico is situated in the High Plains, a somewhat homogeneous region extending over large areas of Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas (Figure 1). Discovery and subsequent exploitation of extensive ground water resources in the region, primarily from the Ogallala Formation, have generated dramatic economic growth. This growth has exerted greater and greater demand on ground water supplies. Water levels have declined and some irrigated areas have gone out of production. As a result, the area's economic activities that depend on irrigated agriculture are threatened due to rapidly rising energy costs and declining water tables. If significant areas were to be forced out of irrigated production in the New Mexico High Plains, the economy of the entire state could be adversely affected. In response to these concerns, New Mexico, five other High Plains states, and the High Plains Associates (general contractor) participated in the Six-State High Plains-Ogallala Aquifer Area Study.

The general purpose of this study was to estimate the economic impacts over a 40-year planning horizon on regional income and employment, population, irrigated and dryland cropping patterns, agricultural output, and farm income. The impacts were measured under alternative sets of assumptions regarding public policy, water and energy costs and availability, and irrigation management practices.

The ground water irrigated acreage of the High Plains region represents about 35 percent of the irrigated acreage in New Mexico (Lansford, et al., November 1981) and accounts for about one-third of the cash receipts from crop sales in the state.

Irrigation has been a fairly recent development in Lea County. For example, in Lea County irrigated cropland increased from 1,970 to 119,240 acres from 1940 to 1980 (Lansford, et al., September 1982). However, parts of Lea County already have felt the effects of a declining water supply and rising energy costs. As a result, some irrigated cropland has been abandoned.

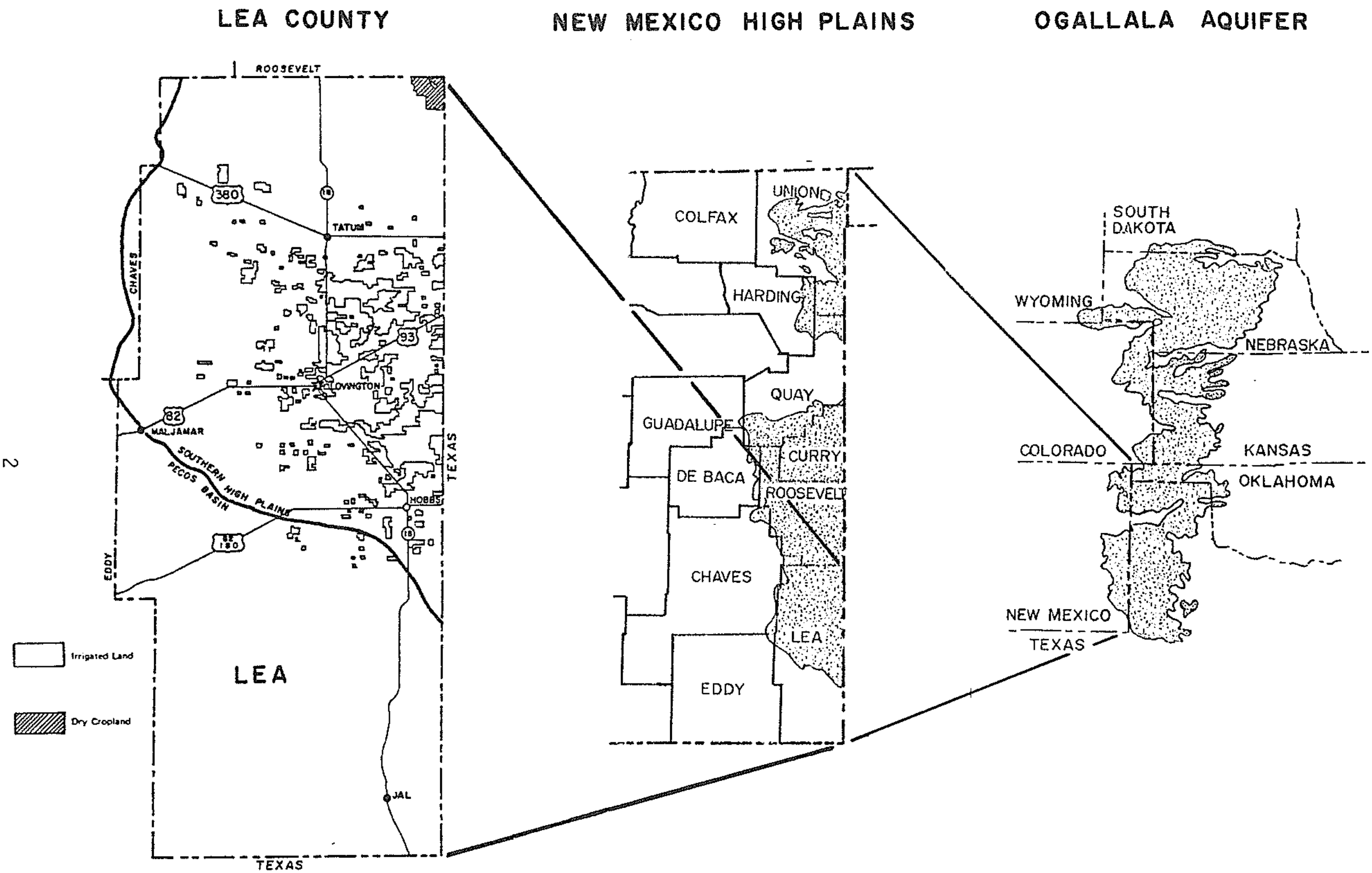

Figure 1. Ogallala Aquifer Region and New Mexico.

This report presents an in-depth look at the water, energy, and related resources in Lea County, New Mexico, which is a part of the High Plains-Ogallala Aquifer study region in New Mexico. Other reports have been prepared for Roosevelt County, Curry County, Quay County, Union and Harding counties, and for the New Mexico region (WRRI Reports 147 through 151).

MANAGEMENT STRATEGIES

Four management strategies, including a baseline, were evaluated: voluntary water conservation (Alternative Management Strategy 1); mandatory irrigation water supply reduction (Alternative Management Strategy 2); and importation, supply augmentation for those areas that physically exhaust their water supply under Alternative Strategy 1 (Alternative Management Strategy 5A). Management Strategy 3, local supply augmentation, and Management Strategy 4, intrastate transfers, were not evaluated for New Mexico.

Baseline

The baseline is defined as "no new public action or deliberate change--continuation of current trends in water and agricultural management in both public and private sectors." It has been consistently assumed that under the baseline neither states nor the federal government will initiate new policies or programs to reduce demands on the Ogallala aquifer or other resources. Neither would they augment the water supply during the study period. It is further assumed that current trends in public and private sector resource demand and supply management would continue throughout the study period. Only those changes in resource management already underway and anticipated to continue as rational economic behavior would be considered to influence long-term baseline projections. Under the baseline, the continuation of present trends in water conservation is expected to result in water savings of about 10 percent on sprinkler-irrigated lands over the study period. Furrow irrigation applications were assumed to be unaffected under baseline conditions.

Voluntary Irrigation Water Conservation

This alternative adds to the baseline by assuming incentives will be provided for technological change and improved water and agricultural management practices at the farm level. This alternative assumes an accelerated adoption rate of new and promising technologies. The changes in irrigation water and farm management practices are expected to occur through research and development, extension and education, and finally adoption of improved technology, improved farming practices, and improved plant varieties. The area of improved technology probably would include improved water conveyance and application systems. Improved farming practices would include techniques such as irrigation scheduling and evaporation reduction farming methods. Plant varieties might be adapted, through genetic research, to produce the same amount, only requiring less water. Operationally, this strategy is defined for two major irrigation systems: sprinkler and furrow.

Sprinkler water applications would be decreased by an additional 1.2 percent in 1985. There would be a 3 percent reduction in water applications in 1990, an additional 4 percent reduction in 2000, and an additional 5 percent reduction in 2020 for a total reduction of 12 percent from 1990 through 2020.

There would be a 4 percent reduction in water applications for furrow irrigation in 1985, an additional 5 percent reduction in 1990, an additional 6 percent reduction in 2000, and an additional 6 percent reduction in 2020 due to incentive programs and expanded research.

Mandatory Irrigation Water Supply Reduction

The mandatory strategy builds upon the voluntary strategy by adding mandatory water supply management. This strategy encompasses institutional/regulatory changes requiring water conservation, improved water and agricultural management practices at the farm level, and/or restrictions on new irrigated agricultural developments.

This strategy requires the supply of irrigation water to be reduced below what would be available under the voluntary strategy. Water supplies would be required to be reduced by 10 percent below the irrigation water applications in the voluntary strategy by 1985, by 20 percent by 1990, and by 30 percent by 2000.

Importation (Supply Augmentation)

Irrigation water would be imported to fully supply those lands that physically exhaust their natural water supply between 1977 and 2020. The irrigation water would be available in the year 2000 and be applied in a manner consistent with the voluntary strategy technology.

GENERAL DESCRIPTION

Lea County, New Mexico, lies in the extreme southeast corner of the state (Figure 1), with most of northern Lea County in New Mexico's Southern High Plains. The area slopes gently to the east and southeast and, with few exceptions, is remarkably smooth. Southern Lea County lies in an indefinite drainage area in the Pecos River Basin. This area is essentially a closed sub-basin with most surface flows directed toward the center of the basin to a series of intermittent playa lakes. There are no permanent streams in Lea County.

The plains, often referred to as the Llano Estacado or "staked plains," are bounded on the west by Mescalero Ridge (a short distance west in Chaves County) and continue north into Roosevelt County and east into Texas. The elevation varies from about 4,400 feet in the northwest to around 3,900 feet south of Hobbs. Elevations in the Pecos River drainage range from about 4,100 feet near Maljamar to approximately 2,900 feet in the southeast corner of the county.

Surface drainage is not well defined and, except for storm runoff, there are no surface flows. Numerous playas and "buffalo" wallows dot the plains. A few lakes intersect the ground water table and, except for some other small recreation lakes, these lakes provide the only surface water of a perennial nature in the county.

The area contains the Upper Sonoran and Lower Sonoran Life Zones. Oak shinnery is the predominant vegetative type near the edge of the

Caprock and in all of the area south of Mescalero Ridge. Most of the plains are undulating grasslands interspersed with some oak shinnery north of Hobbs (NMISC, 1975).

Climate

Lea County has a semi-arid climate characterized by clear, sunny days, large diurnal temperature ranges, low humidity, and moderately low rainfall. The mean annual precipitation is about 15 inches. The hot summer months are normally the wettest. Occasionally, thunderstorms are accompanied by hail which may damage crops and property. The average snowfall is light and the snows usually melt within a few days after occurrence. Moderate winds prevail most of the year and strong winds are common from January to May (NMISC, 1975).

Temperatures in the area average about 60 degrees Fahrenheit. Winters are usually mild and dry. Temperatures above 100 degrees Fahrenheit are not uncommon in the summer months. The growing season usually begins in early April and lasts from about 190 to 215 days, ending in late October or early November (NMISC, 1975).

Land

Lea County consists of approximately 2.8 million acres of land. About 17 percent of the land is under federal ownership, 31 percent under state ownership, and 52 percent is privately owned. Approximately 93 percent of the land in Lea County is rangeland used for grazing and 4 percent is cropland (3 percent is irrigated and 1 percent dryland). Urban and urban fringe areas comprise about 1 percent of the county land, and road systems also account for 1 percent. The remainder of the land includes 2,640 acres of inland water (NMISC, 1975).

Hydrology

The Ogallala Formation is the principal source of ground water in the Southern High Plains of Lea County. The extent of the Ogallala Formation in the southern High Plains is outlined on Figure 1. The

Ogallala is of Tertiary age and overlies older rocks of Cretaceous, Jurassic, Triassic, and Permian ages. The group of older formations yield comparatively small quantities of usable fresh water, but in places contain considerable saline water in storage (Ash, 1961).

The Ogallala is not present in southern Lea County (Figure 1). In this area, ground water is obtained from the older formations noted above. Yields from these formations are not sufficient for irrigation use and barely provide enough for rural domestic and livestock requirements.

As of January 1976, the depth-to-water in Lea County ranged from 30 to more than 260 feet with an average of 70 feet from the land surface. The saturated thickness of the Ogallala ranged from 25 to 200 feet, averaging approximately 135 feet. A typical irrigation well in this region will yield up to 1,000 gallons per minute with a specific well yield of 60 gallons per minute per foot of drawdown. The pumping head is comprised of the depth-to-water from the land surface, plus the drawdown, plus any head that is to be delivered to the irrigation system, such as a sprinkler. The pumping head for a typical gravity flow system is now about 80 feet (Akin and Jones, 1979).

Water level measurements have been maintained in this area by the U.S. Geological Survey since 1950 and reported by the State Engineer in the report series, "Water Levels in New Mexico." Irrigation well 15S 37E 31.132 was selected as representative of the ground water response in this general area. In 1950, the depth-to-water in this well was reported as 35.04 feet and in 1977 the depth-to-water was 66.07 feet, with a rather constant decline over the intervening years. The general rate of decline is approximately 1.0 foot per year.

The principal source of recharge to the Ogallala Formation is precipitation infiltrated into the aquifer. There is some discharge of ground water by natural means, such as through springs and seeps along the escarpments and by evaporation and transpiration. However, these are quite small in relation to the amount of water removed from the aquifer by pumping.

The amount and rate of recharge from precipitation depend on the amount, distribution, and intensity of the precipitation; the amount of moisture in the soil when rain or snowmelt begins; and the temperature, vegetative cover, and permeability of the materials at the site of infiltration. Because of the wide variations in these factors and lack of data, it is difficult to estimate the amount of recharge to the ground water reservoir. An unknown amount of water pumped from the Ogallala Formation for irrigation percolates back into the aquifer. This water does not constitute an addition to the supply water, but only a reduction in net discharge.

Havens (1966, p. F1) reports that the annual recharge on 1,400,000 acres in Lea County, New Mexico, during the period 1949-60 was about 95,000 acre-feet, or about 0.8 inch.

Water Quality

The water is typically hard and has an objectionably high concentration of fluoride in many areas. The hardness, in addition to a high concentration of silica, makes it somewhat objectionable for domestic and many industrial uses. Except possibly in the vicinity of the playa lakes and in local areas where the ground water may have been contaminated by seepage from brine disposal pits (Ash, 1961, 1963, sheet 2), the water is satisfactory for irrigation. Only the excessive fluoride content makes it objectionable for public supply.

Water Use

Ground water from the Ogallala Formation in Lea County is used for irrigation, public supply, industrial supply, and domestic and stock purposes.

Water Rights Administration

Most of the county is within the boundaries of the Lea County, Jal, and Capitan underground water basins as declared by the State Engineer. Permits from the State Engineer are necessary prior to drilling wells within the declared basin boundaries. No permit is required to drill wells in those portions of the county outside the declared basins (see Figure 2).

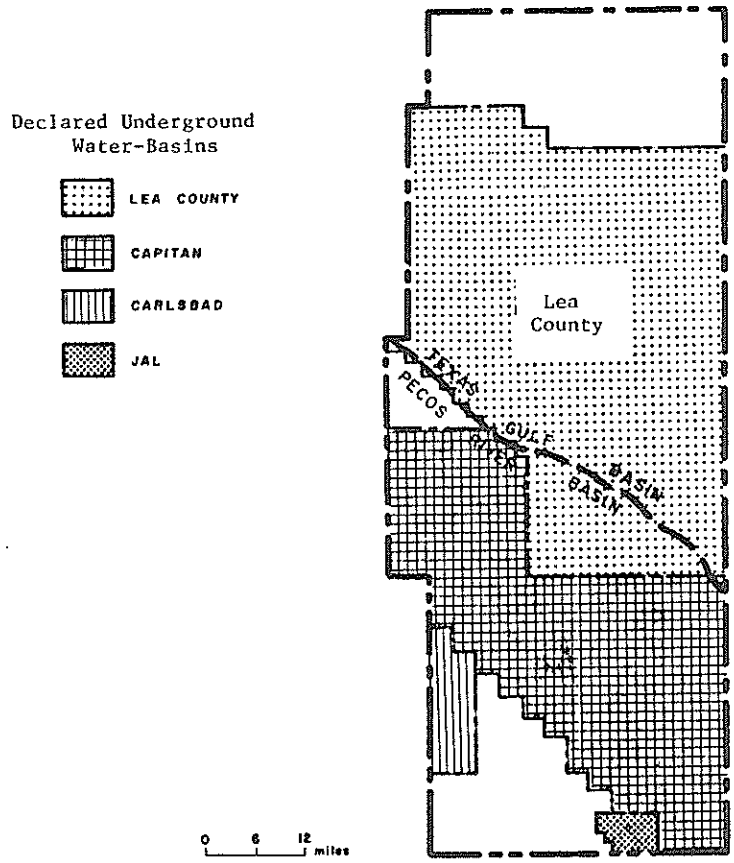

Figure 2. Declared Underground Water Basins, Lea County, New Mexico.

Energy

All of the energy production in the High Plains of New Mexico is located in Lea and Roosevelt counties. Lea County accounts for about 90 to 95 percent of all energy produced in New Mexico's High Plains.

Electricity

Most of the New Mexico High Plains region's electricity generation is in Lea County. The three generating plants in Lea County are the Maddox Station (New Mexico Electric Service Co.), the Cunningham Station (Southwestern Public Service), and the Lovington Station (Lea County Electric Cooperative) (Appendix Table A-1). As of December 1979, total generating capacity (nameplate rating) in the county was 522.2 megawatts (MW). In comparison, generating capacity was rated at 454.2 MW in 1969, or 20 percent below the existing level. The primary fuel for all generating units is natural gas. All units were built in the 1950s and 1960s and have an average projected life of 35 years.

Historical electric energy production for Lea County is presented in Table 1. In 1973, there was no reported data. In some years, there was no data reported for some of the plants, and estimates of production were made. The basis for all other years was the Electrical World Directory of Electric Utilities.

Oil Production

The Permian Basin of southeast New Mexico and west Texas has long been one of the major oil-producing provinces in the nation. There are four oil and gas producing counties (Chaves, Eddy, Lea, and Roosevelt) in southeastern New Mexico. Two of the four, Lea and Roosevelt counties, are in the High Plains study area. Since the Permian Basin has been producing oil and gas since the 1920s, the future discovery rate in both Lea and Roosevelt counties is expected to be more modest than in the past. However, the degree to which crude oil and casinghead gas production continues to decline also depends upon a number of exogenous factors ranging from technological to economic aspects of production. The uncertainty of such factors causes production projections beyond 10 years to be highly speculative.

Lea County is the most prolific oil-producing county in the state. It accounted for 65.8 percent of the state's crude oil and condensate production in 1980, and produced 97 percent of the oil and condensate in the New Mexico High Plains study area. The historical crude oil production and casinghead gas is shown in Table 1.

Dry Gas Production

Historically, Lea County has been primarily an oil-producing province. Only recently has there been a major effort in dry gas exploration. The main area of exploration has been in southern Lea County. The Atoka and Morrow formations are the main producing horizons and, as a general rule, produce a rather high daily rate of gas.

Table 1. Annual Historical Crude Oil, Casinghead Gas, Dry Gas Production, and Electric Energy Production in Lea County, New Mexico, 1969-1980.

Year	Crude Oil (millions of barrels)	Casinghead Gas (billions of cubic feet)	Dry Gas (billions of cubic feet)	Electricity Generation (gigawatt-hours)
1969	89.88	247.64	169.76	1,987.44*
1970	89.95	255.83	178.20	2,225.92
1971	82.52	249.31	176.64	1,896.10
1972	76.91	223.29	196.05	2,337.42
1973	70.78	218.47	201.68	2,573.88*
1974	65.12	258.26	178.67	2,808.44
1975	61.42	255.53	160.60	2,850.82
1976	58.19	245.73	167.48	2,955.83*
1977	54.09	230.26	171.34	3,075.31
1978	51.16	217.17	154.11	2,617.55
1979	48.42	207.23	145.37	n/a
1980	47.77	188.99	146.84	n/a

* Value was estimated or includes estimated value.

However, wells producing from these formations normally have relatively short production periods (seven-year average) compared to an average life of 35 years in northwest New Mexico's San Juan Basin.

During the 1970s, dry gas production fluctuated yearly, making it difficult to detect any general trends (Table 1). For example, the production levels in 1971, 1974, 1975, 1978, and 1979 were lower than the previous years' production levels. In all other years, production had shown an increase. Finally, the completion of several additional wells could have the effect of increasing total production 10 percent or more. Due to the characteristics of this type of gas production, projections are extremely difficult to make.

During the last 12 years, more than 99 percent of the dry gas production from the High Plains study area has come from Lea County, with less than 1 percent produced in Roosevelt County (Miller and Hill, 1979).

Agriculture

Lea County is an important agricultural area in New Mexico. In 1977, the value of production from the irrigated cropland was estimated to be about $19.6 million, from dry cropland to be about $745,000, and from range livestock to be about $27.9 million. Lea County accounted for about 21 percent of the total value of production from agriculture (irrigated, dry, and rangeland) in the High Plains region. In 1977, it accounted for about 7 percent of the total irrigated acreage and about 2 percent of the total dryland crop acreage in the state. The important irrigated crops in Lea County were corn, grain sorghum, cotton, alfalfa, and small grains. The important dryland crops in 1977 were grain sorghum, other sorghum, cotton, and wheat (Lansford, 1980).

OGALLALA HIGH PLAINS MODEL AND COMPONENTS

The purpose of this study was to estimate the economic impacts over a 40-year planning horizon on regional income, employment, population, irrigated and dryland cropping patterns, agricultural output, farm income, and energy production. The impacts were measured under alternative sets of assumptions regarding public policy, water and energy costs and availability, and irrigation management practices.

An interdisciplinary approach to the solution of the water resource problems of the High Plains region in New Mexico was made possible by integrating hydrology, geology, and engineering with economics. Research procedures developed to carry out this study were closely coordinated by the investigators to achieve the stated objectives. Inputs into the economic models were obtained from separate studies covering the hydrological, agricultural, and energy areas.

Assumptions concerning regional economic impacts, employment, population, crop yields, commodity prices, energy prices, input prices, and energy production were developed cooperatively among the six states and the general contractor. All states used basically the same assumptions for compatibility. A detailed description and discussion of the methodology for the separate area studies are presented in WRRI Report 151.

RESULTS

Results are presented for the Lea County economic impacts and key resources by management strategy for selected years (1977, 1985, 1990, 2000, and 2020).

Water Resources

Projected withdrawals for irrigation, urban, rural, manufacturing, minerals, power, livestock, and recreation uses are presented in Table 2. Table 2 also shows projections for depth-to-water (ground surface to water table), and the remaining saturated thickness of the Ogallala Formation and non-Ogallala water sources for the years 1977, 1985, 1990, and 2000 in Lea County. The base year for all projections is 1977. In Lea County, approximately 90 percent of the total water used in 1977 came from the Ogallala Formation.

Other than areas of future agricultural and urban uses, there is little possibility of reducing water demand in Lea County through voluntary or mandatory strategies. This does not mean conservation should be abandoned in all areas of water use. However, the use of water by irrigated agriculture (about 80 percent of the total ground water withdrawals) overshadows all other uses.

For these reasons, the only changes in the voluntary strategy projection and in the mandatory strategy projection (Table 2) from quantities shown in the baseline projection are for "irrigation" and "urban." Water requirements for other water-use categories are the same in all projections.

Other than irrigation and urban, the only significant increases in water demand are the amounts projected for "minerals." Most of this water is now used for secondary oil recovery and for potash mining and is expected to increase in the future. The projected amounts were reviewed and concurred with by personnel of the New Mexico Energy and Minerals Division.

Table 2. Estimated Withdrawals, Depth-to-Water, and Remaining Saturated Thickness of Ogallala Aquifer, Lea County, New Mexico, 1977-2020.

Strategy and Category	Year 1977	1985	1990	2000	2020
Baseline					
Withdrawals (1,000 ac. ft.)					
Irrigation	222.5	245.5	266.5	272.0	233.5
Urban	(10.0)	(12.0)	(15.0)	(18.0)	(28.5)
Ogallala Aquifer	8.5	10.2	12.8	15.3	24.2
Non-Ogallala Aquifer	1.5	1.8	2.2	2.7	4.3
Rural	(0.8)	(0.8)	(0.9)	(0.9)	(1.2)
Ogallala Aquifer	0.6	0.6	0.6	0.6	0.8
Non-Ogallala Aquifer	0.2	0.2	0.3	0.3	0.4
Manufacturing	(0.8)	(1.0)	(1.4)	(1.7)	(2.8)
Ogallala Aquifer	0.5	0.7	1.0	1.2	1.8
Non-Ogallala Aquifer	0.3	0.3	0.4	0.5	1.0
Minerals & Other Extractive Industries	(21.7)	(25.0)	(30.0)	(37.2)	(49.5)
Ogallala Aquifer	6.5	7.5	9.0	11.2	14.9
Non-Ogallala Aquifer	15.2	17.5	21.0	26.0	34.6
Power*	13.9	14.0	14.0	14.6	14.6
Livestock**	(1.1)	(1.4)	(1.6)	(1.8)	(1.9)
Ogallala Aquifer	0.4	0.5	0.7	0.8	0.8
Non-Ogallala Aquifer	0.7	0.9	0.9	1.0	1.1
Recreation, Fish & Wildlife**	(0.1)	(0.1)	(0.2)	(0.3)	(0.5)
Ogallala Aquifer	0.0	0.0	0.1	0.2	0.3
Non-Ogallala Aquifer	0.1	0.1	0.1	0.1	0.2
Total Withdrawals	(270.9)	(299.8)	(329.6)	(346.5)	(332.5)
Ogallala Aquifer	252.9	279.0	304.7	315.9	290.9
Non-Ogallala Aquifer	18.0	20.8	24.9	30.6	41.6
Depth-to-water (ft.)*	70.0	76.9	82.5	92.7	114.9
Remaining saturated thickness (ft.)*+	135.0	128.1	122.5	112.3	90.1
Voluntary Strategy					
Withdrawals (1,000 ac. ft.)					
Irrigation	222.5	234.9	239.1	229.4	210.2
Urban	(10.0)	(10.8)	(13.5)	(16.2)	(25.7)
Ogallala Aquifer	8.5	9.2	11.5	13.8	21.8
Non-Ogallala Aquifer	1.5	1.6	2.0	2.4	3.9
Rural	(0.8)	(0.8)	(0.9)	(0.9)	(1.2)
Ogallala Aquifer	0.6	0.6	0.6	0.6	0.8
Non-Ogallala Aquifer	0.2	0.2	0.3	0.3	0.4
Manufacturing	(0.8)	(1.0)	(1.4)	(1.7)	(2.8)
Ogallala Aquifer	0.5	0.7	1.0	1.2	1.8
Non-Ogallala Aquifer	0.3	0.3	0.4	0.5	1.0
Minerals & Other Extractive Industries	(21.7)	(25.0)	(30.0)	(37.2)	(49.5)
Ogallala Aquifer	6.5	7.5	9.0	11.2	14.9
Non-Ogallala Aquifer	15.2	17.5	21.0	26.0	34.6
Power*	13.9	14.0	14.0	14.6	14.6
Livestock*	(1.1)	(1.4)	(1.6)	(1.8)	(1.9)
Ogallala Aquifer	0.4	0.5	0.7	0.8	0.8
Non-Ogallala Aquifer	0.7	0.9	0.9	1.0	1.1
Recreation, Fish & Wildlife**	(0.1)	(0.1)	(0.2)	(0.3)	(0.5)
Ogallala Aquifer	0.0	0.0	0.1	0.2	0.3
Non-Ogallala Aquifer	0.1	0.1	0.1	0.1	0.2
Total Withdrawals	(270.9)	(288.0)	(300.7)	(302.1)	(306.4)
Ogallala Aquifer	252.9	267.4	276.0	271.8	265.2
Non-Ogallala Aquifer	18.0	20.6	24.7	30.3	41.2
Depth-to-water (ft.)*	70.0	76.9	81.5	91.8	111.3
Remaining saturated thickness (ft.)*+	135.0	128.1	123.5	113.2	93.7

* Ogallala Aquifer only.

** Includes surface water.

\+ Saturated thickness is defined as the thickness of a lens of saturated porous material existing below the water table, capable of yielding significant quantities of ground water to wells. The remaining saturated thickness reflects the impact of all ground water withdrawals on the quantity of water stored in the porous medium and, thus, the thickness of the lens.

Table 2 cont.

Strategy and Category	Year 1977	1985	1990	2000	2020
Mandatory Strategy					
Withdrawals (1,000 ac. ft.)					
Irrigation	222.5	211.3	191.2	160.6	147.0
Urban	(10.0)	(9.0)	(11.2)	(13.5)	(21.4)
Ogallala Aquifer	8.5	7.6	9.6	11.5	18.2
Non-Ogallala Aquifer	1.5	1.4	1.6	2.0	3.2
Rural	(0.8)	(0.8)	(0.9)	(0.9)	(1.2)
Ogallala Aquifer	0.6	0.6	0.6	0.6	0.8
Non-Ogallala Aquifer	0.2	0.2	0.3	0.3	0.4
Manufacturing	(0.8)	(1.0)	(1.4)	(1.7)	(2.8)
Ogallala Aquifer	0.5	0.7	1.0	1.2	1.8
Non-Ogallala Aquifer	0.3	0.3	0.4	0.5	1.0
Minerals & Other Extractive Industries	(21.7)	(25.0)	(30.0)	(37.2)	(49.5)
Ogallala Aquifer	6.5	7.5	9.0	11.2	14.9
Non-Ogallala Aquifer	15.2	17.5	21.0	26.0	34.6
Power*	13.9	14.0	14.0	14.6	14.6
Livestock**	(1.1)	(1.4)	(1.6)	(1.8)	(1.9)
Ogallala Aquifer	0.4	0.5	0.7	0.8	0.8
Non-Ogallala Aquifer	0.7	0.9	0.9	1.0	1.1
Recreation, Fish & Wildlife**	(0.1)	(0.1)	(0.2)	(0.3)	(0.5)
Ogallala Aquifer	0.0	0.0	0.1	0.2	0.3
Non-Ogallala Aquifer	0.1	0.1	0.1	0.1	0.2
Total Withdrawals	(270.9)	(262.6)	(250.5)	(230.6)	(238.9)
Ogallala Aquifer	252.9	242.2	226.2	200.7	198.4
Non-Ogallala Aquifer	18.0	20.4	24.3	29.9	40.5
Depth-to-water (ft.)*	70.0	76.9	81.6	90.3	106.1
Remaining saturated thickness (ft.)*+	135.0	128.1	123.4	114.7	98.9

* Ogallala Aquifer only.

** Includes surface water.

\+ Saturated thickness is defined as the thickness of a lens of saturated porous material existing below the water table, capable of yielding significant quantities of ground water to wells. The remaining saturated thickness reflects the impact of all ground water withdrawals on the quantity of water stored in the porous medium and, thus, the thickness of the lens.

The voluntary projections for "urban" were estimated by reducing baseline projections by 10 percent. Mandatory projections were estimated by reducing voluntary projections by an additional 15 percent (a total of 25 percent with respect to the baseline quantities).

In the High Plains area of New Mexico, it was assumed that when the saturated thickness of the Ogallala aquifer in a given area becomes 25 feet or less, the water is no longer economically recoverable for irrigated agriculture and pumping for this purpose would cease. However, even though the water in the lower 25 feet of the aquifer is no longer economically extractable for irrigation use, many widely spaced wells producing small amounts of water could continue to produce sufficient supplies for urban and most other nonirrigation needs.

The estimated hydrologic conditions, well characteristics, irrigation system, and fuel for the 1977 baseline conditions for the Ogallala in Lea County are presented in Appendix Table B-1.

The estimated remaining saturated thickness resulting from irrigation are presented in Table 3. Except for 1977 conditions, the estimated remaining saturated thickness shown in these tables does not reflect the impact of withdrawals for uses other than irrigation.

To estimate the total effect of all uses upon the saturated thickness, the values shown in Table 3 were modified and are presented in Table 2. A linear analysis was used to determine the necessary adjustments for uses other than irrigation in Lea County. This was done on the basis of the 1975 Water-Use Inventory (Sorensen), and the location of uses as shown on Point Source Maps produced by the New Mexico Environmental Improvement Division (see selected references).

On-Farm Impacts

The on-farm impacts for Lea County include a discussion by management strategy of the on-farm economic impacts (irrigated and total value of production as well as returns to land and management); land resource, including cropland and cropping patterns (irrigated, dry cropland, and rangeland); and the utilization of ground water for irrigation (see Appendix Table C-1 for a summary of the baseline). Supporting tables, describing the land, water, and economic impacts by the selected years,

Table 3. The Projected Effect of Irrigation on Remaining Saturated Thickness, Lea County, New Mexico, 1977-2020.

Management Strategy	Year 1977	1985	1990	2000	2010	2020
	(feet of remaining saturated thickness)					
Baseline	135	129	124	115	105	96
Voluntary	135	129	125	116	108	100
Mandatory	135	129	125	118	113	107

can be found in WRRI Report 151. A sensitivity analysis of the on-farm impacts to demonstrate the effect of both higher and lower crop prices, crop yield, and energy costs on the irrigated agricultural economy of New Mexico is also presented in WRRI Report 151.

In Lea County, no aquifer exhaustion is expected, therefore, no water is expected to be imported by 2020. Thus, the only difference between the voluntary and the importation strategy will be slight changes in commodity prices due to a higher total six- state region production from imported water. These changes in commodity prices result in slightly lower values of production and returns to land and management.

Value of Production

The 1977 total agricultural value of production (TVP--irrigated crops, dryland crops, and rangeland) in Lea County was about $48.2 million (Figure 3). Under all the management strategies, the total value of production is expected to increase significantly over time, due to increasing crop yields and prices as well as expanded irrigated acreage. The largest increase, 77 percent ($28.7 million), is expected to occur under the baseline (Table 4). The voluntary strategy is projected to increase 73 percent and the mandatory strategy about 60 percent. The required changes in the cropping pattern and irrigation technologies necessary to meet the mandatory strategy are expected to cause a 10 percent ($8.1 million) reduction in the total value of production from the baseline in 2020. However, under the voluntary strategy, the value of production is expected to be reduced only $1.9 million, or 2 percent.

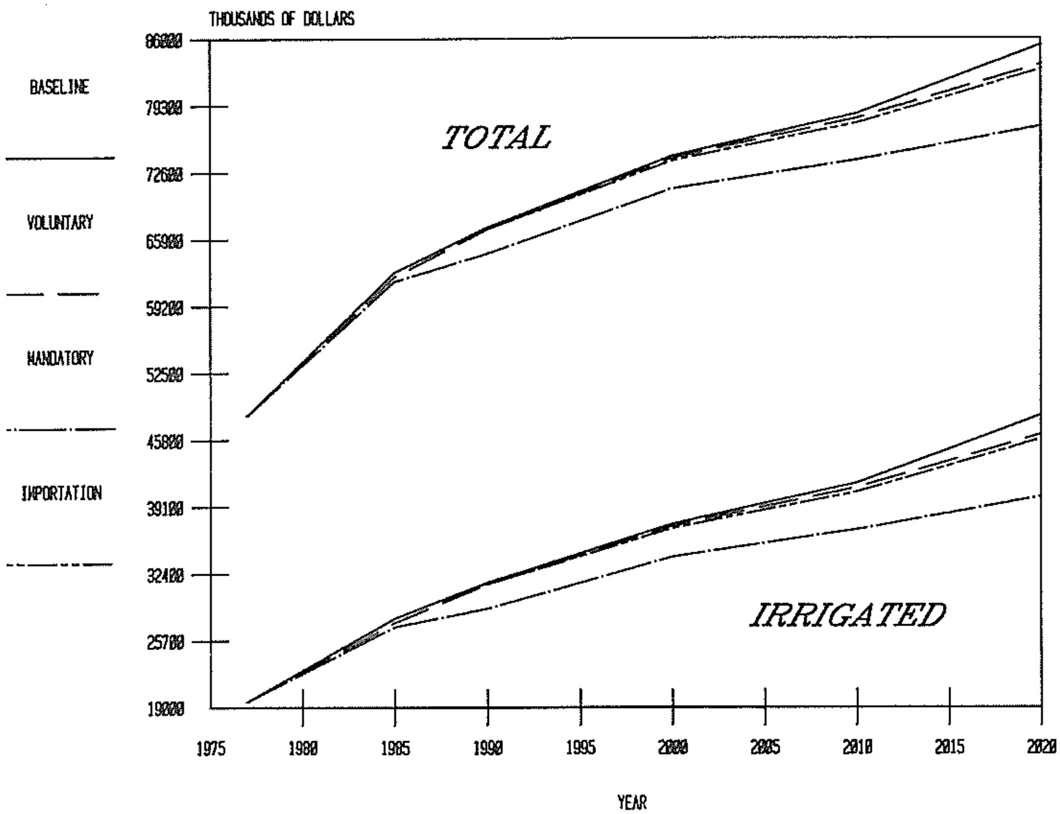

Figure 3. Total and Irrigated Value of Production for Lea County, New Mexico, 1977-2020.

The 1977 value of production for irrigated crops was about $19.6 million (41 percent of the total agricultural value of production) in Lea County (Figure 3). Under all the management strategies, the irrigated value of production is expected to follow the same general trend as TVP--increasing over time, due to increasing crop yields and prices, as well as expanding acreage. The largest increase of 146 percent ($28.7 million) is expected under the baseline. Increases for the voluntary and mandatory strategies are expected to be 137 and 105 percent, respectively. The required changes in the cropping pattern and irrigation technologies necessary to meet the mandatory water supply reduction strategy are expected to cause a 17 percent ($8.1 million) reduction from the baseline in 2020. However, the voluntary water conservation strategy reduces the expected 2020 value of production by only $1.9 million, or 4 percent from the baseline.

Table 4. Value of Production and Returns to Land and Management by Management Strategy for Selected Years, Lea County, 1977-2020.

Strategy and Item	1977	1985	1990	2000	2010	2020
	(1,000 dollars)					
			Value of Production			
Baseline	48,218	62,620	67,110	74,223	78,438	85,350
Irrigated Cropland	19,591	27,970	31,547	37,390	41,526	48,343
Dry Cropland	745	928	1,025	1,207	1,286	1,382
Rangeland	27,883	33,722	34,539	35,626	35,626	35,626
Voluntary	48,218	62,169	66,946	74,031	77,983	83,417
Irrigated Cropland	19,591	27,519	31,383	37,198	41,071	46,410
Dry Cropland	745	928	1,025	1,207	1,286	1,382
Rangeland	27,883	33,722	34,539	35,626	35,626	35,626
Mandatory	48,218	61,730	64,506	70,984	73,807	77,220
Irrigated Cropland	19,591	27,087	28,939	34,121	36,876	40,195
Dry Cropland	745	921	1,029	1,237	1,305	1,399
Rangeland	27,883	33,722	34,539	35,626	35,626	35,626
Importation	48,218	62,169	66,946	73,773	77,508	82,920
Irrigated Cropland	19,591	27,519	31,383	36,956	40,624	45,954
Dry Cropland	745	928	1,025	1,191	1,258	1,340
Rangeland	27,883	33,722	34,539	35,626	35,626	35,626
			Returns to Land and Management			
Baseline	10,757	16,754	18,108	22,813	26,256	30,486
Irrigated Cropland	4,698	8,513	9,435	13,634	17,098	21,358
Dry Cropland	148	234	299	460	529	615
Rangeland	5,911	8,008	8,374	8,718	8,629	8,514
Voluntary	10,757	16,643	18,154	23,127	26,538	30,829
Irrigated Cropland	4,698	8,401	9,481	13,948	17,380	21,700
Dry Cropland	148	234	299	460	529	615
Rangeland	5,911	8,008	8,374	8,718	8,629	8,514
Mandatory	10,757	16,060	17,199	21,948	23,971	26,784
Irrigated Cropland	4,698	7,826	8,522	12,740	14,794	17,638
Dry Cropland	148	227	303	490	548	632
Rangeland	5,911	8,008	8,374	8,718	8,629	8,514
Importation	10,757	16,643	18,154	22,868	26,063	30,331
Irrigated Cropland	4,698	8,401	9,481	13,706	16,933	21,244
Dry Cropland	148	234	299	444	501	573
Rangeland	5,911	8,008	8,374	8,718	8,629	8,514

Returns to Land and Management

The total 1977 returns to land and management (irrigated crops, dryland crops, and rangeland) in Lea County was about $10.8 million (Figure 4). The greatest expected increase of $20 million (185 percent) is expected to occur under the voluntary strategy (Table 4). Under the baseline, the total is expected to increase 182 percent, while the estimated increase under the mandatory strategy is 148 percent.

The 1977 returns to land and management for irrigated crops in Lea County were about $4.7 million (Figure 4). Significant increases in returns are expected for all strategies. The greatest increase, 362 percent ($17 million), is expected to occur under the voluntary strategy, with the baseline recording slightly less at 355 percent (Table 4). However, total returns under the mandatory strategy are expected to increase only 274 percent (Figure 4).

The projected increases of more than 185 percent in total returns to land and management, compared to the total value of production increases of about 77 percent, imply that returns to land and management capture a greater portion of the value of production in the future. However, of the projected $20 million increase in total returns, 85 percent ($17 million) is due to irrigated agriculture. Much of the increased returns to irrigated agriculture is directly attributable to projected increases in managerial ability and to increased capital improvements related to irrigated systems such as sprinklers and irrigation management scheduling and to other technological advancements.

The greatest increase in irrigated value of production occurs under the baseline strategy, while the greatest increase in irrigated returns occurs under the voluntary strategy. This implies incentives exist to accelerate the development of water savings measures. Technological improvements and changing cropping patterns more than pay for their costs. The results of an implementation of the mandatory strategy are to induce a severe reduction in both the irrigated value of production and returns.

Any future increase in land value above the inflation rate will result in reduction in the returns to land and management.

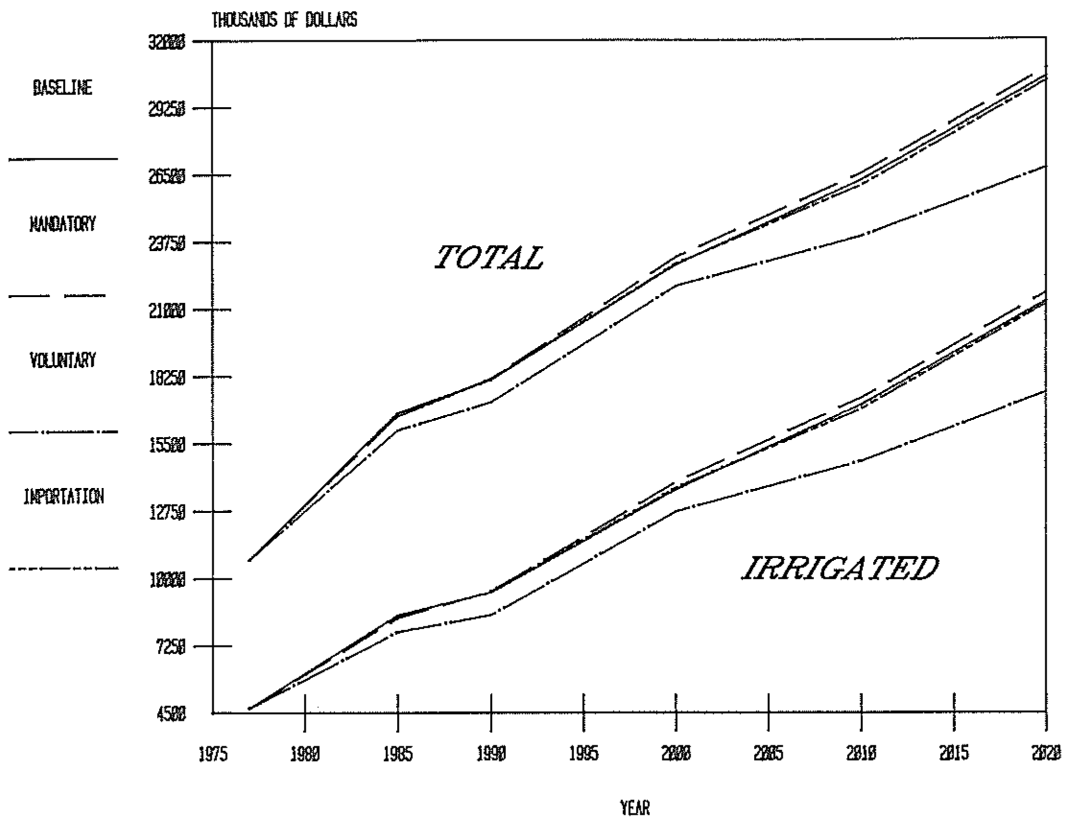

Figure 4. Total and Irrigated Returns to Land, Management, and Risk for Lea County, New Mexico, 1977-2020.

Irrigation Water

The quantity of irrigation water diverted is expected to increase from 222,500 acre-feet in 1977 to 271,900 acre-feet in 2000 under the baseline with most of the increase occurring before 1990 (Table 5). After 2000, a slight decline is expected to 2010, then a 27,000 acre-feet decline to 2020 due to increased irrigation efficiency (Figure 5). Under the voluntary strategy, the quantity of irrigation water diverted is expected to be significantly less than under the baseline. By the year 2000, the annual diversion of irrigation water to irrigate the same acreage is expected to be 42,500 acre-feet less for the voluntary strategy than for the baseline. In 2020, under the voluntary strategy, 12,300 acre-feet less water is expected to be used than in 1977, while irrigating 4,750 more acres.

Table 5. Quantity of Irrigation Water Diverted by Management Strategy for Selected Years, Lea County, New Mexico, 1977-2020.

	1977	1985	1990	2000	2010	2020
	(acre-feet)					
Baseline	222,456	245,483	266,464	271,955	271,170	233,452
Voluntary	222,456	234,855	239,081	229,416	229,809	210,183
Mandatory	222,456	211,317	191,151	160,588	160,938	146,970
Importation	222,456	234,855	239,081	229,416	229,809	210,183

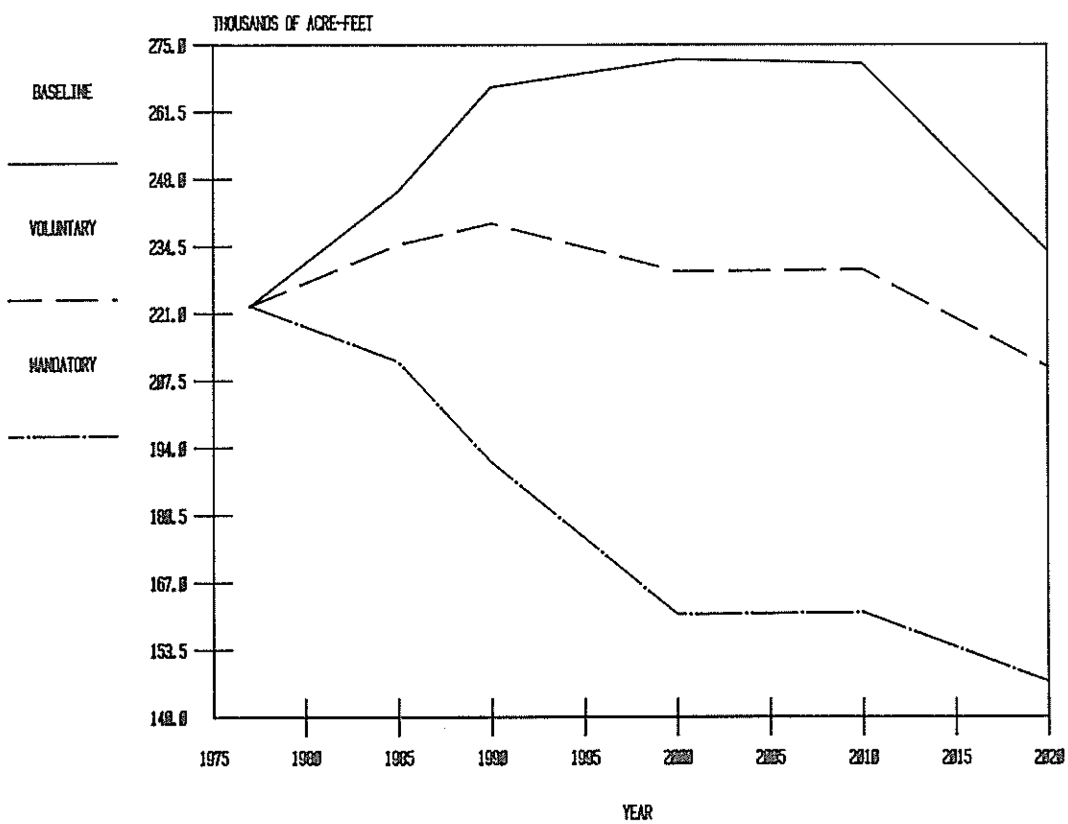

Figure 5. Quantity of Irrigation Applied, Lea County, 1977-2020.

Under the mandatory strategy, the water used for irrigation is a fixed percentage of that used under the voluntary and, as a result, the lowest water diversions are expected.

Cropland and Cropping Pattern

The irrigated cropland in Lea County is expected to increase from 85,250 acres in 1977 to 90,000 acres by 2000, then remain constant through 2020 for all four management strategies (Table 6). The dry cropland acreage is expected to remain constant under all management strategies at 8,500 acres. The rangeland acreage in Lea County is expected to remain at about 2.65 million acres for all the management strategies.

Under the baseline, a significant increase in the acreage of the more profitable heavy-water-using crops of corn and alfalfa is expected over time due to reductions in wheat and grain sorghum acreages (Table 6). Under the voluntary strategy, alfalfa, corn, and cotton are expected to increase in acreage while grain sorghum and wheat decline. However, the total changes are expected to be more gradual than under the baseline. Cotton is the most important crop under the voluntary strategy.

Under the mandatory strategy, significant shifts are expected in the cropping pattern over time (Table 6). Cotton and corn are expected to increase in acreage. Alfalfa and grain sorghum acreage is expected to move in inverse relationships. After 2010, advances in irrigation technology are expected to permit producers to increase the alfalfa acreage, thereby forcing a reduction in the grain sorghum acreage.

Sensitivity Analysis

Sensitivity analyses were performed for three key on-farm assumptions to determine the effect on returns of an increase or decrease of crop prices, crop yields, and energy costs. Under all six alternatives, no change is expected in the acreage irrigated and only minor changes in irrigation water applications. There are, however, expected changes in both the irrigated value of production and returns to land and management for each alternative (Table 7).

Table 6. Irrigated Cropland Acreages by Crop by Management Strategy for Selected Years, Lea County, New Mexico, 1977-2020.

Strategy and Crop	1977	1985	1990	2000	2010	2020
	(irrigated acres)					
Baseline	85,250	86,500	88,000	90,000	90,000	90,000
Alfalfa	18,755	24,220	29,040	29,700	29,700	29,700
Corn (grain)	19,608	25,085	29,040	29,700	29,700	29,700
Cotton	21,313	26,815	23,760	24,300	24,300	24,300
Grain Sorghum	12,788	4,325	0	0	0	0
Wheat	12,788	6,055	6,160	6,300	6,300	6,300
Voluntary	85,250	86,500	88,000	90,000	90,000	90,000
Alfalfa	18,755	22,866	26,574	27,178	27,513	29,700
Corn (grain)	19,608	23,731	26,849	27,458	27,756	29,700
Cotton	21,313	25,461	27,396	28,019	28,242	24,300
Grain Sorghum	12,788	8,387	1,021	1,044	189	0
Wheat	12,788	6,055	6,160	6,300	6,300	6,300
Mandatory	85,250	86,500	88,000	90,000	90,000	90,000
Alfalfa	18,755	18,824	11,570	3,420	4,476	26,382
Corn (grain)	19,608	24,039	25,731	27,267	26,975	26,751
Cotton	21,313	25,769	26,558	27,875	27,657	27,488
Grain Sorghum	12,788	11,814	17,980	25,138	24,592	3,080
Wheat	12,788	6,055	6,160	6,300	6,300	6,300
Importation	85,250	86,500	88,000	90,000	90,000	90,000
Alfalfa	18,755	22,866	26,574	27,178	27,513	29,700
Corn (grain)	19,608	23,731	26,849	27,458	27,756	29,700
Cotton	21,313	25,461	27,396	28,019	28,242	24,300
Grain Sorghum	12,788	8,387	1,021	1,044	189	0
Wheat	12,788	6,055	6,160	6,300	6,300	6,300

The sensitivity analysis indicates that changes in crop yields will have greatest impacts on both value of production and returns to land and management, and that changes in crop prices and energy costs will have slight impacts. The analysis also indicates that with decreased crop price and yield conditions, the percentage change in returns to land and management is less than the change in the value of production. This implies that farmers are able to implement cost-saving measures by changing cropping patterns or technologies. However, with increasing energy costs, the percentage change in returns are expected to be greater than the percentage change in the value of production.

Table 7. Effect of Sensitivity Analysis on Irrigated Value of Production and Returns to Land and Management.

Item	Changes From Baseline Irrigated Value of Production ($million)	(percent)	Changes From Baseline Irrigated Returns to Land and Management ($million)	(percent)
Crop Prices				
Increased	+ 2.0	+ 4.1	+2.0	+ 9.4
Decreased	- 2.6	- 5.5	-2.0	- 9.1
Crop Yields				
Increased	+ 9.6	+20.0	+9.6	+45.0
Decreased	-12.5	-26.0	-9.4	-44.0
Energy Costs				
Increased	- 3.1	- 6.5	-4.1	-19.0
Decreased	0.0	0.0	+1.5	+ 7.2

Regional Impacts

Baseline

The baseline assumes the continuation of current trends and no new public agricultural policies or programs. Under the baseline, the continuation of present trends in water conservation is expected to result in water savings of about 10 percent on sprinkler-irrigated lands over the study period. The on-farm impact results and the energy impact results were incorporated into the county impacts analysis.

Gross Output

The total gross output of all goods and services projected for the Lea County economy is reported in Table 8. It was about $1,520 million in 1977. It is projected to be $2,835 million in 1985, $2,436 million in 1990, $1,427 million in 2000, and $1,170 million in 2020.

Mining. The mining sectors (primarily oil and gas extraction) are projected to have a major impact on the local economy (Figure 6). In 1977, the mining sectors accounted for about $969 million, or about 64 percent of the total; however, by 1985 they are projected to account for

Table 8. Gross Output by Major Sector for Each of the Alternative Management Strategies, Lea County, New Mexico, 1977-2020.

Sector	Gross Output ($1977)				
	1977	1985	1990	2000	2020
	(millions of dollars)				
Baseline					
Agriculture	88.324	111.531	120.565	133.942	154.722
Mining	968.618	1,573.121	1,415.951	777.606	300.883
Manufacturing	73.017	123.261	99.003	121.376	318.049
TCU*	114.732	156.743	181.999	122.164	168.335
Construction	29.310	405.106	94.617	22.193	24.957
FIRE**	82.187	139.338	159.676	56.958	22.522
Trade	68.925	194.169	147.284	73.077	64.846
Services	95.161	132.077	217.333	120.115	115.385
Total	1,520.274	2,835.346	2,436.428	1,427.431	1,169.699
Voluntary					
Agriculture	88.324	111.530	120.777	133.775	154.744
Mining	968.618	1,573.121	1,415.951	777.606	300.883
Manufacturing	73.017	123.261	99.003	121.376	318.049
TCU*	114.732	156.743	181.999	122.164	168.335
Construction	29.310	405.106	94.617	22.193	24.943
FIRE**	82.187	139.338	159.676	56.958	22.522
Trade	68.925	194.169	147.284	73.077	64.846
Services	95.161	132.077	217.333	120.115	115.385
Total	1,520.274	2,835.345	2,436.640	1,427.264	1,169.707
Mandatory					
Agriculture	88.324	111.533	120.781	133.818	154.780
Mining	968.618	1,573.125	1,415.957	777.612	300.890
Manufacturing	73.017	123.262	99.007	121.385	318.133
TCU*	114.732	156.825	182.161	122.563	169.534
Construction	29.310	405.111	94.629	22.198	24.968
FIRE**	82.187	139.360	159.726	57.007	22.552
Trade	68.925	194.181	147.315	73.114	64.934
Services	95.161	132.090	217.384	120.207	115.705
Total	1,520.274	2,835.487	2,436.960	1,427.904	1,171.496
Importation					
Agriculture	88.324	111.530	120.777	134.008	154.886
Mining	968.618	1,573.121	1,415.951	777.673	300.927
Manufacturing	73.017	123.261	99.003	121.439	318.518
TCU*	114.732	156.743	181.999	123.308	172.527
Construction	29.310	405.106	94.617	22.335	25.395
FIRE**	82.187	139.338	159.676	57.330	23.129
Trade	68.925	194.169	147.284	73.486	66.178
Services	95.161	132.077	217.333	120.753	117.964
Total	1,520.274	2,835.345	2,436.640	1,430.332	1,179.524

* Transportation, Communication, and Utilities.

** Finance, Insurance, and Real Estate.

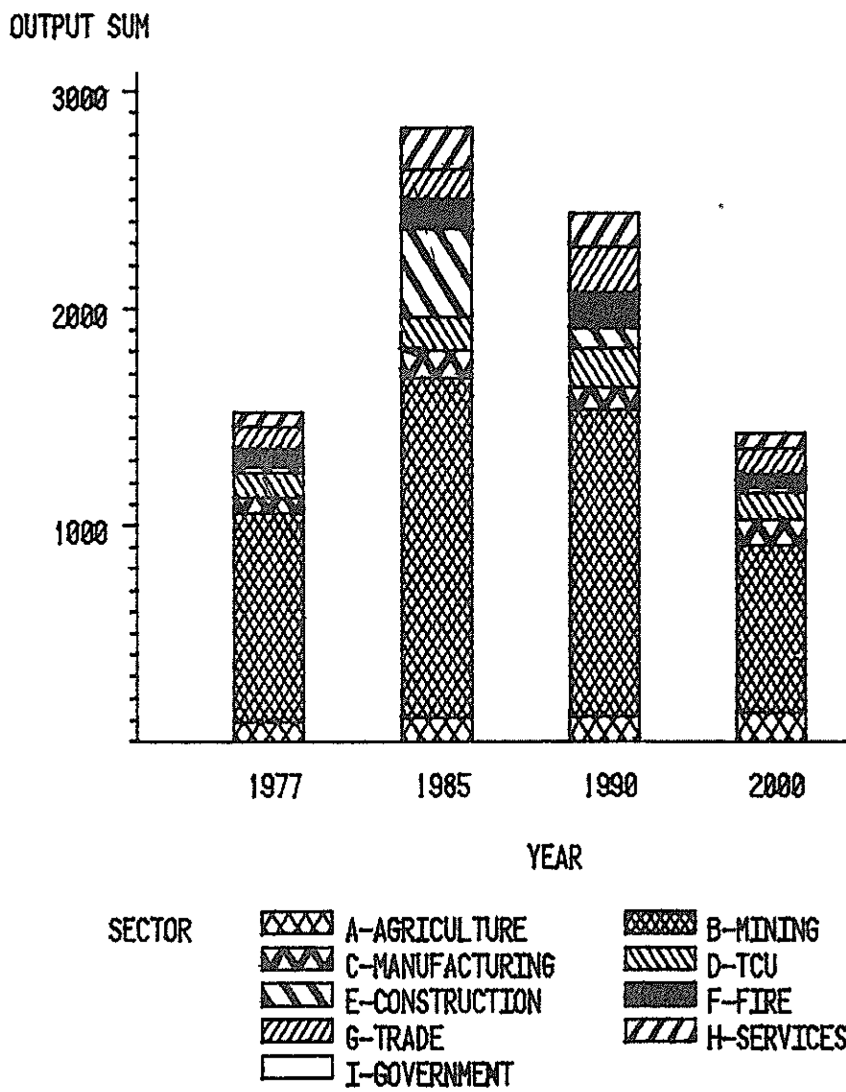

Figure 6. Projected Gross Output for Lea County, Baseline Conditions, 1977-2020.

$1,573 million, or about 55 percent of the total. The expansion in the oil and gas extraction activities (mining sectors) is expected to be a driving force in the local economy with the construction, trade, and service sectors responding to the growth in mining (Figure 6). After 1985, the mining activity is expected to decrease to about $1,416 million in 1990, $778 million in 2000, and $301 million in 2020.

The annual rate of decline, under the most likely projection, differs slightly for crude oil and casinghead gas. Crude oil production is estimated to decline 7 percent annually through 2020 (Figure 7), while casinghead gas production is estimated to decline 8 percent from 1980

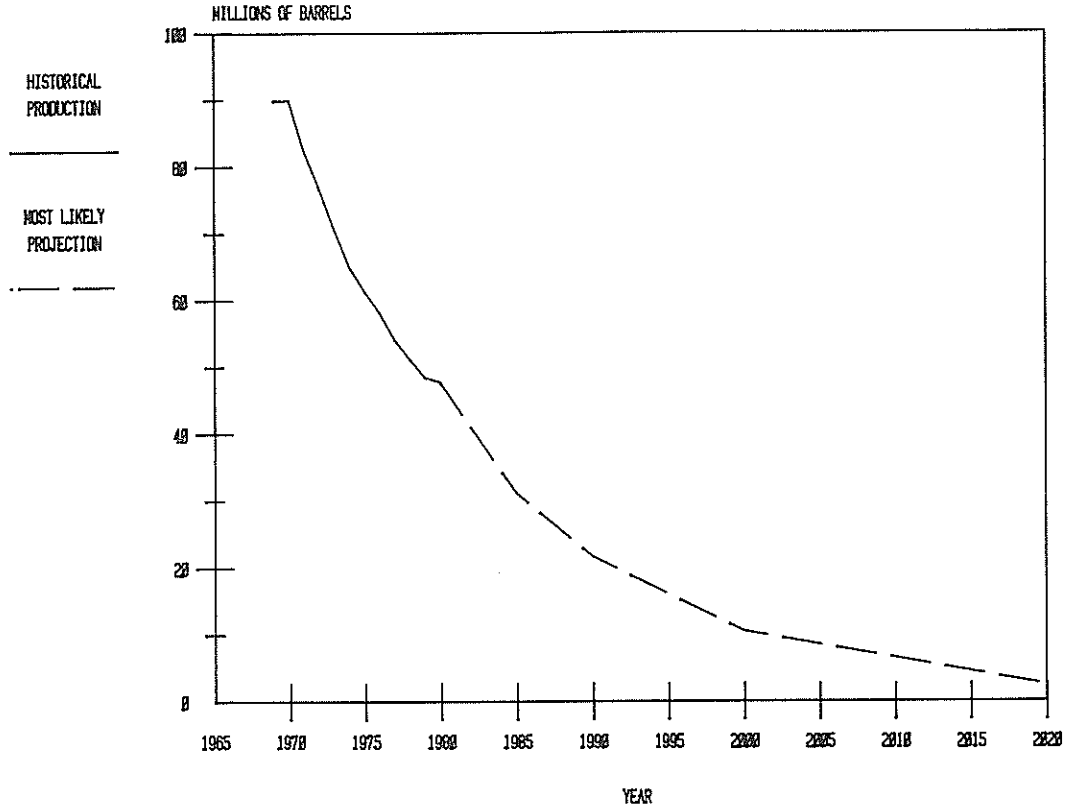

Figure 7. Crude Oil Production for Lea County, Historical and Most Likely Projection, 1965-2020.

through 1984, 9 percent from 1985 through 1989, and 10 percent from 1990 through 2020 (Figure 8). Dry gas production in the High Plains is expected to go from 146.8 billion cubic feet in 1980, to 113.3 billion cubic feet in 1985, and 7.1 billion cubic feet in 2020 (Figure 8).

Electrical Production. Most of the New Mexico High Plains region's electricity generation is located in the southern area. In 1979, total generating capacity in the region was 545.8 MW, of which 522.2 MW, or 95.7 percent, originated from Lea County. The primary fuel for all generating units is natural gas. The projection of electricity sales is expected to increase substantially and to reach 5597.09 million kWh in 2020 (Figure 9). Nearly all new electricity will come from outside the High Plains region.

Additional details on energy impacts are presented in Appendix A. Appendix A also contains a sensitivity analysis on three levels of production--high, expected, and low.

Agricultural. The agricultural sectors are expected to increase between 1977 and 2020 with about $88 million in 1977 and $155 million in 2020. This growth is projected to be relatively stable over the period

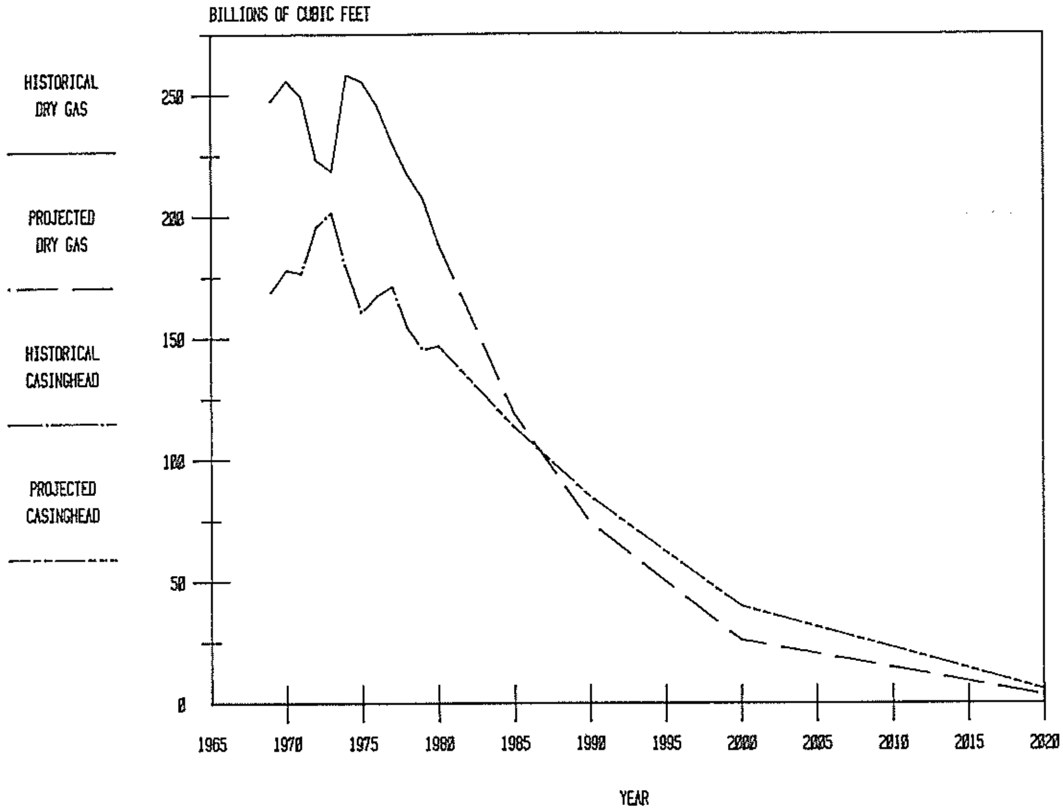

Figure 8. Casinghead and Dry Gas Production for Lea County, Historical and Most Likely Projection, 1967-2020.

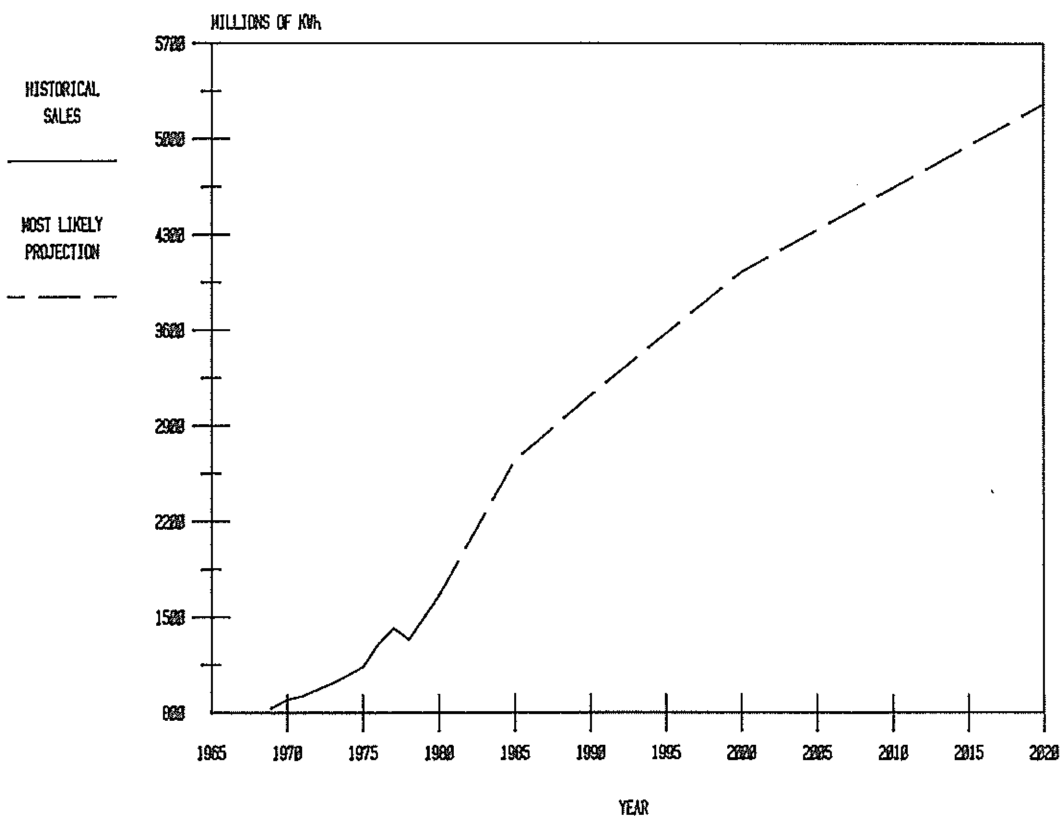

Figure 9. Electric Sales for Lea County, Historical and Most Likely Projection, 1967-2020.

(Figure 6). The agricultural sectors accounted for about 6 percent of the total output in 1977 and are projected to account for over 13 percent in 2020.

Manufacturing. The manufacturing sectors are projected to increase from $73 million in 1977 to about $318 million in 2020. The contribution of the manufacturing sectors to the total was about 5 percent in 1977, and is expected to be 4 percent in 1985 and 27 percent in 2020 (Table 8).

Transportation, Communication, and Utilities (TCU). The TCU sectors, taken together, generally show an increase over the period with a decrease occurring in 2000. These sectors are projected to increase from $115 million in 1977 to a peak of $182 million in 1990, then decline to $122 million in 2000 and then increase to $168 million in 2020 (Table 8). The contribution of these sectors to the total was about 8 percent in 1977, 6 percent in 1985, 7 percent in 1990, 9 percent in 2000, and is expected to reach 14 percent in 2020.

Construction. The construction sectors are projected to increase significantly between 1977 and 1985, then decline to 2020 (Figure 6). These sectors accounted for about $29 million in 1977. They are projected to reach $405 million in 1985, and then decline to $25 million in 2020. This is due to the close relationship that the construction sectors have to the mining activity in the area.

Finance, Insurance, and Real Estate (FIRE). The FIRE sectors are projected to increase between 1977 and 1990, then decrease to 2020 as the total economy begins slowing down in the area (Table 8).

Trade. The trade sector is expected to expand rapidly between 1977 and 1985, then decline through 2020 (Figure 6). It is expected to account for about 5 to 7 percent of the total output of the county through the period.

Services. The service sectors are projected to expand rapidly between 1977 and 1990, then decline to 2020 (Figure 6). In 1977, they accounted for about 6 percent of the total, peaked with 9 percent in 1990, and by 2020 they are projected to reach almost 10 percent.

In terms of output, the economy of Lea County is expected to change drastically from one heavily dependent on mining activities in the 1985-1990 period to one made up primarily of manufacturing. In 2020, the agricultural sectors are also expected to make a larger and larger contribution to the total as the mining activity declines. These shifts are expected to cause major adjustments not only in the type of industry present, but in the makeup of the labor force and population. As the mining and construction related activity declines, the labor force associated will also decline through migration, leaving the agricultural, manufacturing, and other trade and services.

Employment

Total employment in the form of jobs for each alternative for each sector by year is reported in Table 9. Employment projected for the baseline is summarized by major sector in Figure 10. The total jobs was 17,234 in 1977, and is expected to increase to 45,168 in 1985, then decrease to 33,162 in 1990, 15,285 in 2000, and 9,954 by 2020. Trade was the largest employer in 1977 accounting for about 25 percent. The percentage is expected to be about 26 percent in 1985, 24 percent in 1990, then decline to 19 percent in 2000 and 14 percent in 2020. The trade sector declined to third place in 2000, but was again second in 2020. Mining employed about 22 percent in 1977, and is expected to employ 17 percent in 1985, 21 percent in 1990 and 2000, and then decline to 6 percent in 2020. The service sector employed 17 percent in 1977 and is expected to employ 10 percent in 1985. It is expected to employ 21 percent in 1990, 25 percent in 2000, and 34 percent in 2020. The agricultural sectors accounted for less than 3 percent of the jobs in 1977, just over 1 percent in 1985 and 1990, over 3 percent in 2000, and are projected to reach over 4 percent in 2020. Construction provided about 5 percent of the jobs in 1977, but in 1985 is expected to contribute over 28 percent, then decrease to 9 percent in 1990, 4 percent in 2000, and then increase to 8 percent in 2020 (Table 9).

Population

The total population for Lea County for the baseline alternative and each of the management strategies is presented in Table 10. The county is projected to gain 67,875 people between 1977 and 1985, an in-

Table 9. Employment by Major Sector for Each of the Alternative Management Strategies, Lea County, New Mexico, 1977-2020.

Sector	Jobs 1977	1985	1990	2000	2020
	(number of jobs)				
Baseline					
Agriculture	464	466	446	463	438
Mining	3,723	7,698	6,860	3,286	612
Manufacturing	790	1,472	908	728	1,093
TCU*	1,776	2,702	2,861	1,421	1,057
Construction	825	12,893	2,973	684	747
FIRE**	1,364	2,335	2,606	875	311
Trade	4,290	11,826	7,970	2,915	1,419
Services	2,991	4,348	7,092	3,780	3,367
Government	1,011	1,428	1,446	1,133	910
Total	17,234	45,168	33,162	15,285	9,954
Voluntary					
Agriculture	464	487	469	474	478
Mining	3,723	7,699	6,860	3,286	612
Manufacturing	790	1,475	910	731	1,095
TCU*	1,776	2,732	2,874	1,439	1,062
Construction	825	12,909	2,991	690	750
FIRE**	1,364	2,347	2,616	883	313
Trade	4,290	11,863	8,038	2,944	1,426
Services	2,991	4,368	7,139	3,812	3,384
Government	1,011	1,436	1,453	1,141	914
Total	17,234	45,316	33,350	15,400	10,034
Mandatory					
Agriculture	464	470	452	448	451
Mining	3,723	7,699	6,860	3,286	613
Manufacturing	790	1,475	910	731	1,096
TCU*	1,776	2,734	2,876	1,445	1,070
Construction	825	12,909	2,991	690	751
FIRE**	1,364	2,347	2,618	884	313
Trade	4,290	11,864	8,040	2,945	1,428
Services	2,991	4,368	7,141	3,815	3,392
Government	1,011	1,436	1,453	1,142	917
Total	17,234	45,302	33,341	15,386	10,031
Importation					
Agriculture	464	487	468	507	521
Mining	3,723	7,699	6,860	3,287	614
Manufacturing	790	1,475	910	732	1,100
TCU*	1,776	2,732	2,874	1,453	1,090
Construction	825	12,909	2,991	694	764
FIRE**	1,364	2,347	2,616	889	321
Trade	4,290	11,863	8,038	2,960	1,457
Services	2,991	4,368	7,139	3,830	3,456
Government	1,011	1,436	1,453	1,146	926
Total	17,234	45,316	33,349	15,498	10,249

* Transportation, Communication, and Utilities.
** Finance, Insurance, and Real Estate.

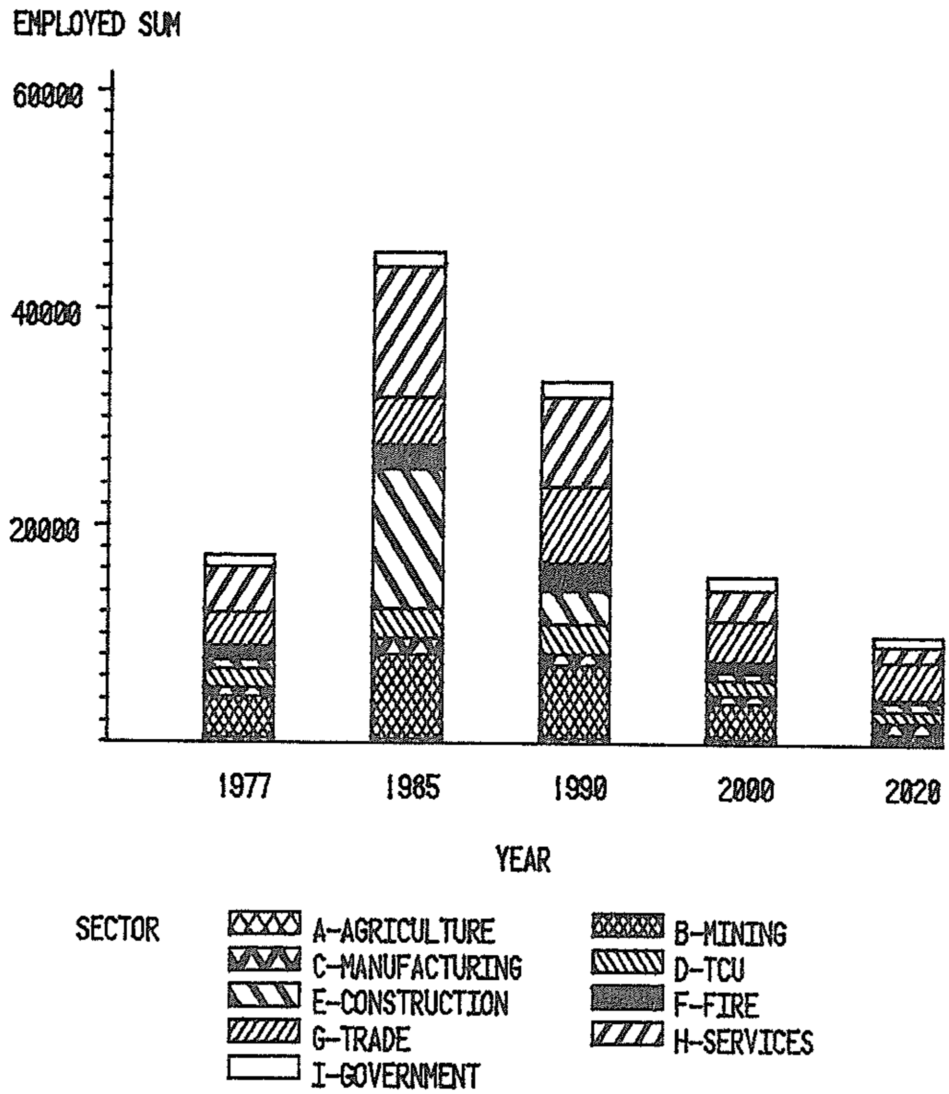

Figure 10. Projected Employment for Lea County.

Table 10. Summary of Population Projections for Lea County for Each of the Management Strategies, 1977-2020.

	Population Projection				
Strategy	1977	1985	1990	2000	2020
Baseline	63,055	130,930	100,917	51,893	33,519
Voluntary	63,055	131,200	101,455	52,181	33,804
Mandatory	63,055	131,161	101,445	52,109	33,758
Importation	63,055	131,200	101,465	52,417	34,392

crease of about 108 percent. This is an annual growth rate of about 13.5 percent. However, between 1985 and 1990, the population is projected to decrease by 30,013 or about 23 percent. By 2000, the population is projected to be below its 1977 level at 51,893 people. In 2020, the population is projected to decrease even further to 33,519. This is about 53 percent of the 1977 level.

Alternative Management Strategies

Gross Output

The gross output by major sector for each of the alternative management strategies is also summarized in Table 8. For 1977, all of the output estimates for the management strategies were the same as the baseline.

The differences in gross output between the baseline and management strategies came about because of changes in the agricultural and mining sectors. The voluntary and mandatory strategies both resulted in output levels slightly below baseline in 1985; however, in 1990-2020, they were projected to be slightly above the baseline. In 2020, they were estimated to be $8,000 more than the baseline. This difference was due to $22,000 more output in the agricultural sectors, and $14,000 less output in the construction sectors.

The importation strategy was the same as voluntary and mandatory in 1985 and 1990; however, in 2000 and 2020, it was projected to be somewhat higher. In 2000, the importation strategy resulted in $3.068 million more than the voluntary and mandatory strategies and $2.901 million more than the baseline. In 2020, it was $9.817 million more than voluntary and mandatory and $9.825 million more than the baseline. The importation strategy resulted in a higher level of output in all of the sectors. This was due to the availability of imported water for agriculture which resulted in more output sufficient to stimulate the rest of the economy.

Employment

Employment in the form of jobs for the baseline and each of the alternative management strategies is also summarized in Table 9 by major sector. The number of jobs was the same for all management strategies in 1977.

The voluntary strategy resulted in 148 more jobs than baseline in 1985 and 185 more in 1990, but was projected to have 115 more in 2000 and 80 more in 2020. The number of jobs in all of the sectors was projected to be greater for the voluntary strategy than for baseline; however, the strategy did not result in employment levels sufficient enough to overcome the general decline in employment in the economy after 1985 in baseline.

The mandatory strategy also resulted in higher levels of employment in all periods than baseline, but they were slightly less than the voluntary levels. The importation strategy resulted in the highest employment levels in 2000 and 2020 with 213 more jobs in 2000 and 295 more in 2020 than the baseline. All of the sectors responded with higher levels of employment as a result of the stimulant that the imported water had on the agricultural economy. However, between 1985 and 2020, the total employment was expected to decline by about 35,067 jobs, or to reach a level that was just over 22 percent of the peak in 1985 and about 60 percent of the 1977 level. Even though the agricultural sectors were able to increase their employment levels over the period, they were overwhelmed by the decline that was projected in the mining sectors. The decline in the mining sectors also had a major impact on the other sectors that resulted in the general decline in employment in the economy.

Population

The total population for the baseline and each of the management strategies is summarized in Table 10. For 1977, all of the projections for the management strategies were the same.

The voluntary strategy resulted in an increased population level over the baseline throughout the period 1985-1990; however, it still was projected to decline to about 54 percent of the 1977 level. The mandatory strategy was also higher than the baseline but lower than voluntary. The importation strategy resulted in the highest population levels of the strategies, but it was similarly not sufficient to overcome the decline, and by 2020 was projected to have about 54 percent of the 1977 level.

SUMMARY

The general purpose of this report was to estimate the economic impacts over a 40-year planning horizon on regional income and employment, population, irrigated and dryland cropping patterns, agricultural output, and farm income resulting from rapidly rising energy costs and the declining water tables. If significant areas were to be forced out of irrigated production in the New Mexico High Plains, the economy of the entire state could be adversely affected. In response to these concerns, New Mexico, five other High Plains states, and the High Plains Associates (general contractor) participated in the Six-State High Plains-Ogallala Aquifer Area Study. The impacts were measured under alternative sets of assumptions regarding public policy, water and energy costs and availability, and irrigation management practices.

Four management strategies, including a baseline, were evaluated: voluntary water conservation; mandatory irrigation water supply reduction; and importation, supply augmentation for those areas that physically exhaust their water supply.

The total gross output of all goods and services produced in Lea County was about $1,520 million in 1977. It is projected to be $2,835 million in 1985, $2,436 million in 1990, $1,427 million in 2000, and $1,170 million in 2020 for the baseline.

The differences in gross output among the management strategies are due to changes in the agricultural and mining sectors. Changes such as the increased output in agriculture and mining resulted in higher levels of output in the rest of the economy.

Under all strategies, the output levels are only slightly different from the baseline. By 2020, the voluntary strategy is only $8,000 greater than the baseline, mandatory is $1.797 million more than the

baseline, and the importation strategy is $9.825 million more than the baseline. The mining sectors account for the majority of the output through 2000 and then drop significantly to a level less than the output of the manufacturing sectors. The agricultural sectors generally increase throughout the period, but are not sufficient to overcome the decline caused by mining. The level of economic activity as measured by output in the county is estimated to be about 77 percent of the 1977 level for the baseline, voluntary, and mandatory strategies. The importation strategy is almost 78 percent of the 1977 level in 2020.

The employment levels projected for the baseline and each management strategy are summarized by major sector in Table 5. These levels follow a similar pattern as the output with essentially minor differences between the strategies and baseline. The voluntary strategy is estimated to have 80 more jobs than the baseline in 2020. The mandatory strategy is projected to have 77 more jobs than the baseline, and the importation strategy is projected to have 295 more jobs than the baseline. These levels are insignificant when compared to the change in employment over the period. The 1985 employment level of about 45,000 jobs is projected to decline to about 10,000 jobs.

The population of Lea County is projected to follow a similar pattern as output and employment, with about 63,000 in 1977, increasing to about 131,000 in 1985, 101,000 in 1990, dropping to about 52,000 in 2000, and to about 34,000 in 2020. Population under different management strategies is projected to be slightly higher than the baseline throughout the period, but does not amount to enough to offset the general decline projected over time. The importation strategy results in the highest level with about 890 more people than under the baseline in 2020.

In Lea County, a continuation of a "business as usual" (baseline) policy is estimated to result in the largest irrigated acreage, the least reduction in irrigation water diversions, the greatest increases in the value of production, and significant increases in returns to land and management of any of the management strategies examined. If voluntary water demand reduction policies are implemented, the same irrigated acreage, decreased water diversions, reductions in the value of production, and increases in returns over the study period are expected.

The implementation of a mandatory water supply reduction policy in Lea County is not expected to result in a change of the acreage irrigated. However, this would cause the greatest reduction in water diversions. There are also significant reductions in irrigated value of production ($8.1 million) and returns to land and management ($3.7 million) when compared to the baseline. This is due to changes in cropping patterns and lower levels of irrigation water applications which reduce crop yields.

If the natural water supply in the High Plains is augmented with imported water from adjacent areas during the last half of the study period, it is anticipated that this policy will have negative impacts on Lea County. Since exhaustion is not projected for the ground water supply in Lea County in the study period, no land is restored to irrigation and the acreage irrigated is the same as the other strategies. There is, however, a reduction in crop prices from increased six-state regional production from imported water. This has the effect of reducing both the value of production and returns in Lea County.

REFERENCES

Akin, P. D., and Jones, D. M. 1979. The Ogallala and Closely Associated Aquifers in the High Plains in New Mexico, (Study Elements A-3.1 and A-3.3): New Mexico Interstate Stream Commission.

Ash, S. R. 1961. Maps of Northern Lea County, New Mexico, showing (1) topography; (2) contour on the water table and the post-Mesozoic erosional surface; and (3) saturated thickness of the formation of Genozoic age, the approximate depths to water in 1952, and the chemical quality of the ground water: U.S. Geological Survey Open-File Maps; 6 sheets.

Black and Veatch. 1980. Energy Price Projections, Black and Veatch Consulting Engineers, Kansas City, MO, April.

Black and Veatch. 1980. Energy Price Projections Methodology, Black and Veatch Consulting Engineers, Kansas City, MO, April.

Black and Veatch. 1980. Energy Production Projections, Black and Veatch Consulting Engineers, Kansas City, MO, December.

Black and Veatch. 1981. Projections of Energy Production and Directly Associated Water Consumption, Black and Veatch Consulting Engineers, Kansas City, MO, January.

Brown, F. L., et al. 1980. An Energy Management System for the State of New Mexico, Bureau of Business and Economic Research, University of New Mexico, Albuquerque, NM.

Camp, Dresser and McKee. 1982. Agriculture and Water Use Management and Technology Assessments, Camp, Dresser and McKee, Austin, TX.

Creel, B. J., et al. 1982. New Mexico High Plains Ogallala Aquifer Study--Regional Impacts, New Mexico Water Resources Research Institute (NMWRRI) Work Task Report A-3.14 through A-3.17, Contract Number (DOC) CO-A01-78-00-2550 to High Plains Associates.

Havens, J. S. 1966. Recharge Studies on the High Plains in Northern Lea County, New Mexico, U.S. Geological Survey Water-Supply Paper 1819-F: U.S. Geological Survey Open-File Report, 82 pp.

High Plains Associates. 1982. Six-State High Plains Ogallala Aquifer Regional Resources Study, Camp, Dresser and McKee, Austin, TX.

Lansford, R. R., et al. 1979. Costs and Returns for Producing Selected Irrigated and Dryland Crops on Farms with Above-Average Management in Lea County, 1978, New Mexico Agricultural Experiment Station Research Report 388.

Lansford, R. R., et al. 1980. Sources of Irrigation Water and Irrigated and Dry Cropland Acreages in New Mexico by County, 1974-1979, New Mexico Agricultural Experiment Station Research Report 422.

Lansford, R. R., et al. 1981. Sources of Irrigation Water and Irrigated and Dry Cropland Acreages in New Mexico by County, 1975-1980, New Mexico Agricultural Experiment Station Research Report 454.

Lansford, R. R., and N. R. Gollehon. 1980. Model Assumptions and Information--Ogallala High Plains Study, NMWRRI Work Task Report Number A-1.3 through A-1.7, Contract Number (DOC) CO-A01-78-00-2550 to High Plains Associates.

Lansford, R. R., et al. 1981. High Plains-Ogallala Aquifer Study On-Farm Results, New Mexico, NMWRRI Work Task Report A-1.9 and A-1.10, Contract No. (DOC) CO-A01-78-00-2550 to High Plains Associates: Camp, Dresser and McKee, Inc.

Lansford, R. R., et al. 1982. High Plains-Ogallala Aquifer Study, Curry County, New Mexico, New Mexico Water Resources Research Institute Report No. 147, New Mexico State University.

Lansford, R. R., et al. 1982. High Plains-Ogallala Aquifer Study, Roosevelt County, New Mexico, New Mexico Water Resources Research Institute Report No. 148, New Mexico State University.

Lansford, R. R., et al. 1982. High Plains-Ogallala Aquifer Study, Quay County, New Mexico, New Mexico Water Resources Research Institute Report No. 149, New Mexico State University.

Lansford, R. R., et al. 1982. High Plains-Ogallala Aquifer Study, Union and Harding Counties, New Mexico, New Mexico Water Resources Research Institute Report No. 150, New Mexico State University.

Lansford, R. R., et al. 1982. High Plains-Ogallala Aquifer Study, New Mexico, New Mexico Water Resources Research Institute Report No. 151, New Mexico State University.

Miller, E., and J. M. Hill. 1981. Energy Production and Consumption Impacts, Work Task Report A-2, The New Mexico Energy and Minerals Department, Contract Number (DOC) CO-A01-78-00-2550 to High Plains Associates, Santa Fe, NM.

New Mexico Crop and Livestock Reporting Service. 1978. New Mexico Agricultural Statistics, 1977, Vol. VIII, New Mexico Department of Agriculture, New Mexico State University, Las Cruces.

New Mexico Environmental Improvement Division. 1976. Point Source Map - Southern High Plains, New Mexico Environmental Improvement Division, Santa Fe, NM.

New Mexico Interstate Stream Commission. 1979. Plan of Work for New Mexico State Level Research on the Six-State High Plains-Ogallala Aquifer Study, Santa Fe, NM.

New Mexico Interstate Stream Commission (NMISC) and the New Mexico State Engineer Office. 1975. County Profiles - Water Resources Assessment for Planning Purposes - Lea County, New Mexico Interstate Stream Commission and New Mexico State Engineer, Santa Fe, NM.

New Mexico Interstate Stream Commission and the New Mexico State Engineer Office. 1981. Demands and Available Supplies for Alternative Development Strategies in the Southern and Northern Subregions in New Mexico, New Mexico Interstate Stream Commission, Santa Fe, NM.

New Mexico Interstate Stream Commission and the New Mexico State Engineer Office. 1981. Response of the Ogallala Aquifer to Projected Water Demands for Alternative Development Strategies in the Southern and Northern Subregions in New Mexico, New Mexico Interstate Stream Commission.

Quance, L. 1980. The National/Inter-Regional Agricultural Projections (NIRAP) System: An Executive Briefing, International Economics Division, ESCS, USDA, Washington, DC.

Sorensen, E. F. 1977. Water Use by Categories in New Mexico Counties and River Basins and Irrigated and Dry Cropland Acreage in 1975, New Mexico State Engineer Technical Report 44, Santa Fe, NM.

U.S. Army Corps of Engineers. 1982. Water Transfer Elements of High Plains-Ogallala Aquifer Study, Southwest Regional Office, Dallas, TX.

Young, P. C., and P. M. Ritz. 1980. Updated Input-Output Table of the U.S. Economy: 1972, Bureau of Economic Analysis, Interindustry Economics Division, BE-51, U.S. Department of Commerce, Washington, DC.

APPENDIX A

ENERGY IMPACTS

This section contains a summary of the electrical energy impacts and the oil and casinghead gas energy impacts on the High Plains region of New Mexico (extracted from Miller and Hill, 1981). All of the energy production in the High Plains is located in Lea and Roosevelt counties. Lea County accounts for about 90 to 95 percent of all energy produced on the High Plains.

ELECTRICAL ENERGY IMPACTS

Electric Generating Capacity

Generating capacity projections were made on a region-wide basis and gave considerable weight to assessments made by the utilities and cooperatives serving the High Plains region. It could reasonably be argued, however, that additional capacity will most likely continue to be concentrated in the Southern High Plains region, given the more diverse structure of the local economy and its proximity to fuel sources.

Electric Energy Production

The projected unit performance for 1980 and 1990 is summarized in Table A-1. New combustion turbine capacity would be for peakload generation with an annual output of 1,500 full load hours; new combined cycle capacity would be for intermediate operation with an annual output of 3,500 full load hours.

The low, expected, and high band projections of electric energy production by power plants in the New Mexico High Plains are presented in Table A-2 and generating capacity in Table A-3 (Figure A-1). In these projections, the 1985 values are linear interpolations between the 1980 and 1990 values.

Under all scenarios, production within the study region is projected to diminish as existing units are retired or put on standby. The cost and availability of water and fuel (i.e., coal) were considered in the analysis.

Table A-1. Projected Performance in 1980 and 1990 for Power Plants in the New Mexico High Plains.

Station (Units)	Capacity	1980 Performance	1990 Performance
North Lovington Diesel (Lea County)	19	Average of 1977 and 1978 capacity factors	Retired
North Lovington S-1 & 2 (Lea County)	49	Average of 1977 and 1978 capacity factors	Peakload: 1,500 full-load hours
Maddox 1 (Lea County)	118	Average of 1977 and 1978 capacity factors	Intermediate: 3,500 full-load hours
Maddox 2 (Lea County)	66	Average of 1977 and 1978 capacity factors	Peakload: 1,500 full-load hours
Cunningham 1 (Lea County)	75	Average of 1977 and 1978 capacity factors	Retired
Cunningham 2 (Lea County)	190.4	Average of 1977 and 1978 capacity factors	Peakload: 1,500 full-load hours

Table A-2. Projected Annual Electric Energy Production for the High Plains, New Mexico, 1985-2020.

Year	Electricity Production Low Band	Expected Band	High Band
	(gigawatt-hours)		
1985	1,886	1,886	2,074
1990	887	887	1,262
2000	0	375	1,250
2020	0	375	1,250

Table A-3. Projected Annual Electric Energy Generating Capacity for the High Plains Region, New Mexico, 1985-2020.

Year	Electric Energy Production Low	Most Likely	High
	(gigawatt-hours)		
1985	522	522	522
1990	447	447	697
2000	0	250	500
2020	0	250	500

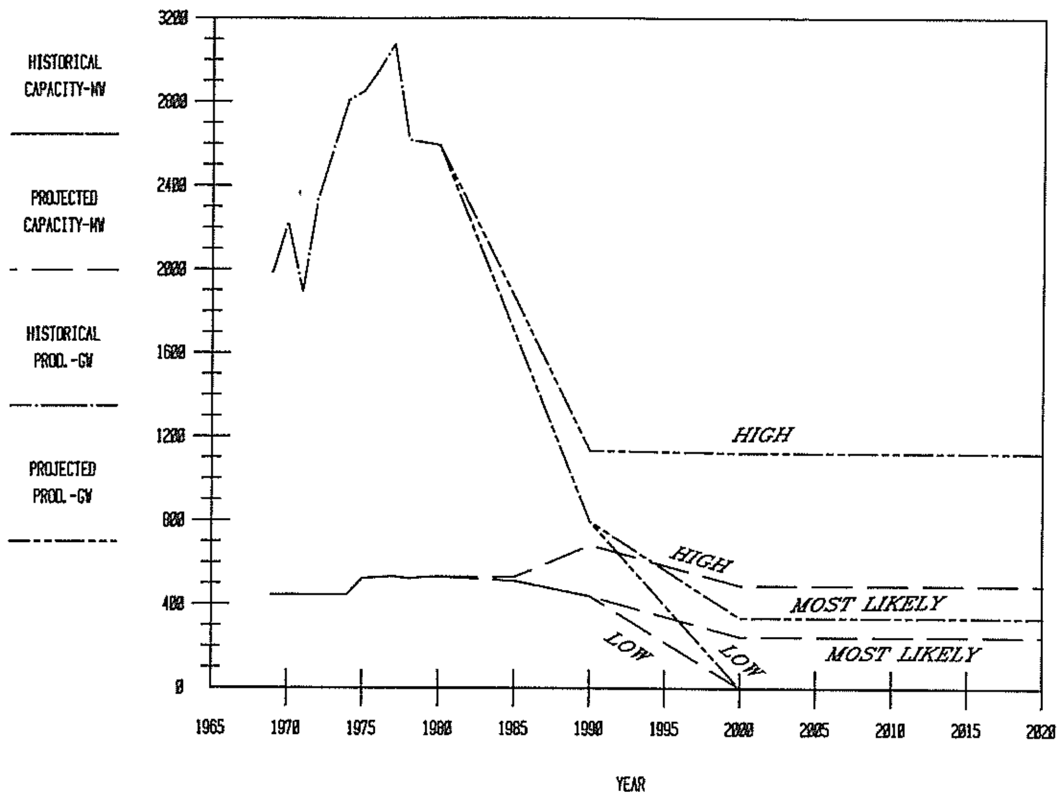

Figure A-1. Electricity Generation and Production, Historical and Most Likely Projected Levels, Lea County.

Electricity Sales

Historical and projected electricity sales for the High Plains region are presented in Table A-4 and Figure A-2. Electricity sales for 1969-78, on a county-level basis, are included in Appendix B of the final New Mexico energy report by Miller and Hill (1981).

Under the low projections, electricity sales in the study area are projected to increase from 1,768.87 million KWh in 1980 to 5,053.97 million KWh in 2020, an overall increase of 186 percent. The underlying assumption of this scenario is that regional electricity sales will continue to increase, but at a decreasing rate. For example, electricity sales increased 59 percent from 1969 through 1978 (Table A-5), while sales are projected to increase only 57 percent for the 1980-1990 time frame. Higher electricity price is the primary factor expected to reduce the growth rate. Population, conservation, and previous patterns

Table A-4. Projected Annual Electricity Energy Sales for the High Plains Region, New Mexico, 1985-2020.

Year	Electricity Sales	
	Low	Most Likely
	----------(million kilowatt hours)---------	
1985	2,277.82	2,820.93
1990	2,781.77	3,324.89
2000	3,745.66	4,288.78
2020	5,053.97	5,597.09

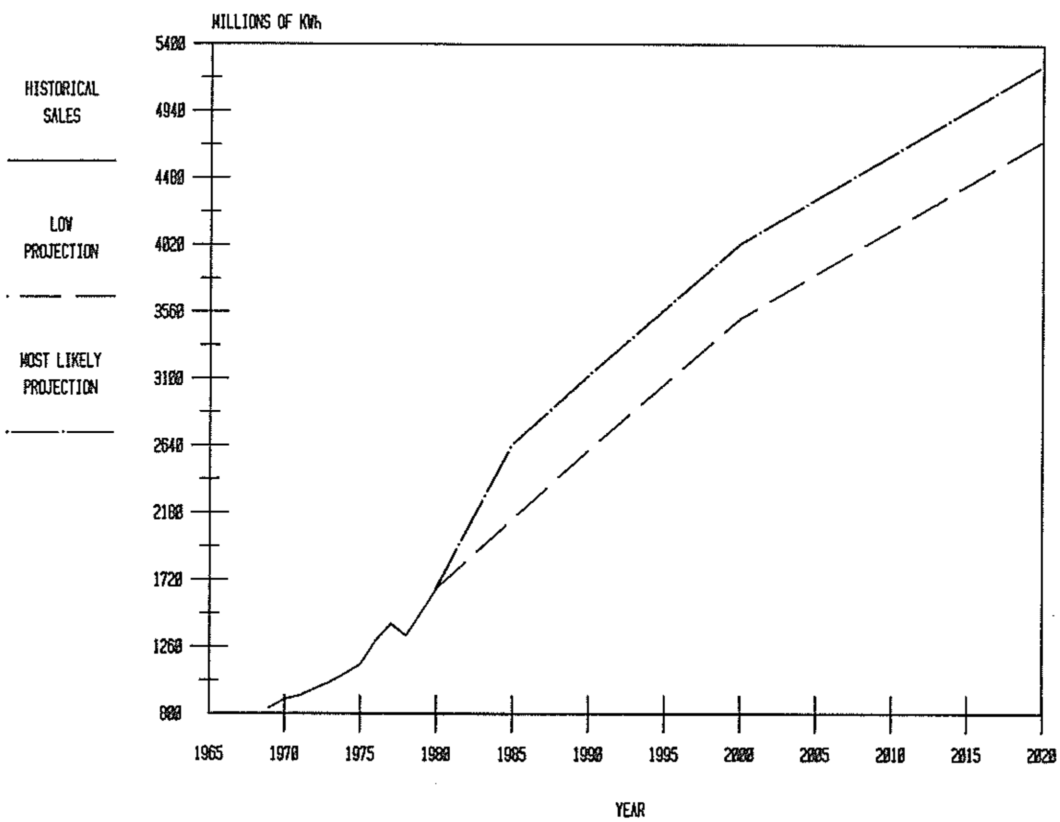

Figure A-2. Historical and Projected Electric Sales for Lea County, New Mexico, 1969-2020.

Table A-5. Historical Electric Energy Production in Lea County, New Mexico, 1969-1978.

	Utility and Plant				
	Lea County Elec. Coop.	New Mexico Electric Service		Southwestern Public Service	
Year	(N. Lovington)	(Hobbs)	(Maddox)	(Cunningham)	Total
	(gigawatt-hours)				
	Annual Electricity Generation				
1969	252.996*	560.384	--	1,174.060	1,987.44*
1970	265.140	617.163	--	1,343.615	2,225.92
1971	278.077	0.007	478.174	1,139.842	1,896.10
1972	278.880	0.007	559.531	1,499.003	2,337.42
1973	--	--	--	--	2,573.88*
1974	281.451	0.007	591.484	1,935.500	2,808.44
1975	295.236	0.006	585.179	1,970.399	2,850.82
1976	341.506*	0.004*	669.919*	1,944.399*	2,955.83*
1977	387.775	0.002	759.659	1,927.876	3,075.31
1978	294.078	--	689.063	1,634.405	2,617.55

* Value is estimated or includes estimated value.

Source: Data from Electrical World, Directory of Electric Utilities, various years, as compiled by Black & Veatch, Kansas City, Missouri.

were also considered to be contributing factors by Southwestern Public Service Company.

The most likely projection shows electricity sales increasing substantially by 1985. During the 1980-85 time frame, sales are expected to increase 59 percent under this scenario compared to a 29 percent increase under the low projection. Carbon dioxide development in the Bravo Dome area (Union, Harding, and Quay counties) accounts for this larger increase. By the year 2020, electricity sales are projected to reach 5,597.09 million KWh, which is about 10 percent greater than the sales level under the low scenario. The overall impact of these projections is increased electricity sales at a decreasing rate. This corresponds with most other electricity demand projections which were reviewed in the course of the study.

OIL AND CASINGHEAD GAS IMPACTS

Lea County Crude Oil and Casinghead Gas Production

A 5 percent annual decline through 2020 in the production of both crude oil and casinghead gas is expected under the high projection assumption (Figure A-3). Annual crude oil production in 1985 is estimated to be 36.16 million barrels and is expected to decline to 6.0 million barrels in 2020, or a decrease of 83 percent from the 1985 level of production (Table A-6). Casinghead gas production also is expected to drop off 83 percent during this time frame, from 148.7 billion cubic feet in 1985 to 24.7 billion cubic feet in 2020 (Figure A-4). Under the low projection, both crude oil and casinghead gas production are expected to decline 97.5 percent by 2020 from the 1985 production levels (i.e., 24.76 million barrels of oil and 101.9 billion cubic feet of casinghead gas) (Table A-6).

The most likely projections of crude oil production are expected to drop off to 2.45 million barrels in 2020, which is a 92 percent reduction from the 1985 production level of 31.16 million barrels. Casinghead gas production is estimated to be 118.7 billion cubic feet in 1985 and is expected to decrease 97 percent by 2020 to 3.1 billion cubic feet (Figure A-4).

Dry Gas Production

The Lea County dry gas production projection under the high projection production levels of dry gas in Lea County by 2020 is estimated to amount to 7.1 billion cubic feet, or a 94 percent reduction from the 1985 level of 123.1 billion cubic feet (Table A-7).

The annual rate of decline under the low projection scenario indicates a level of production in Lea County in 2020 to be 3.2 billion

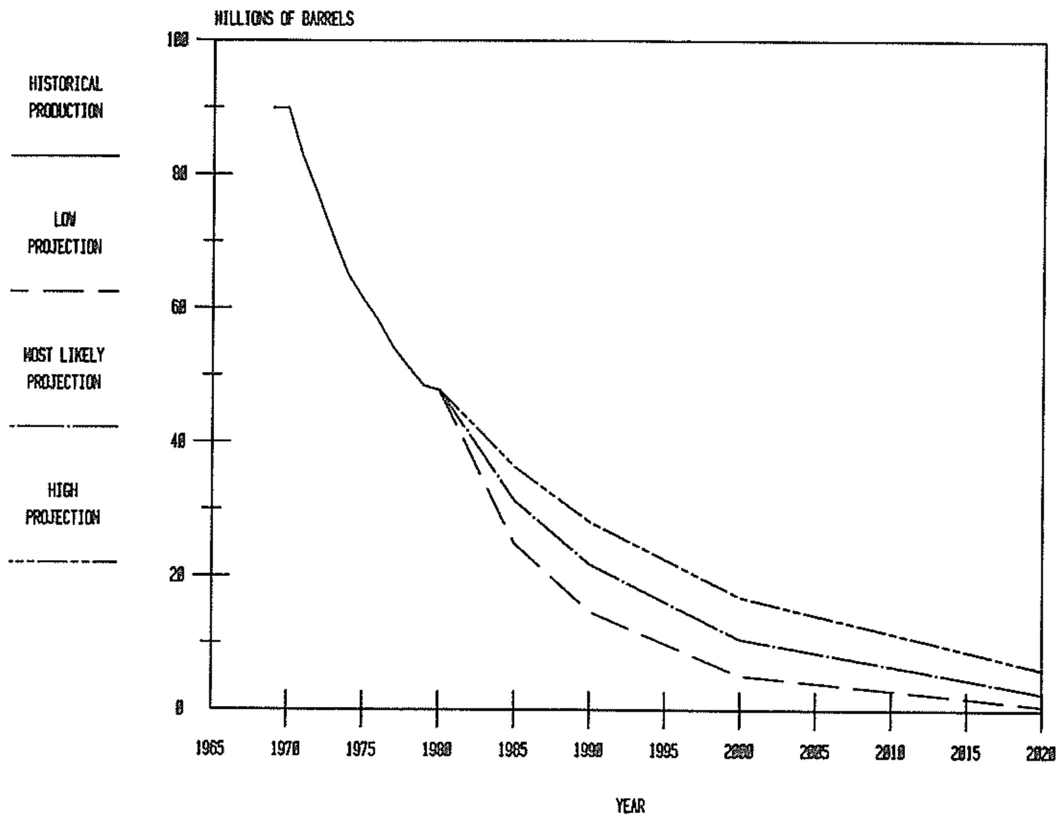

Figure A-3. Crude Oil Production for Lea County, Historical and Projected Amounts, 1965-2020.

Table A-6. Projected Annual Oil Production and Casinghead Gas for Lea County, 1985-2020.

Year	Oil Production			Casinghead Gas Production		
	Low	Most Likely	High	Low	Most Likely	High
	----(millions of barrels)----			---(billions of cubic feet)--		
1985	24.76	31.16	36.16	101.9	118.7	148.7
1990	14.63	21.67	27.97	60.1	74.1	115.0
2000	5.10	10.49	16.75	21.0	25.8	68.9
2020	.62	2.45	6.00	2.5	3.1	24.7

cubic feet, or 97 percent lower than the estimated 1985 production level of 101.9 billion cubic feet (Figure A-5).

Under the most likely projection, dry gas production in Lea County in 1985 is estimated to be 113.3 billion cubic feet. By the year 2020, production in Lea County is projected to have dropped to 5.7 billion cubic feet.

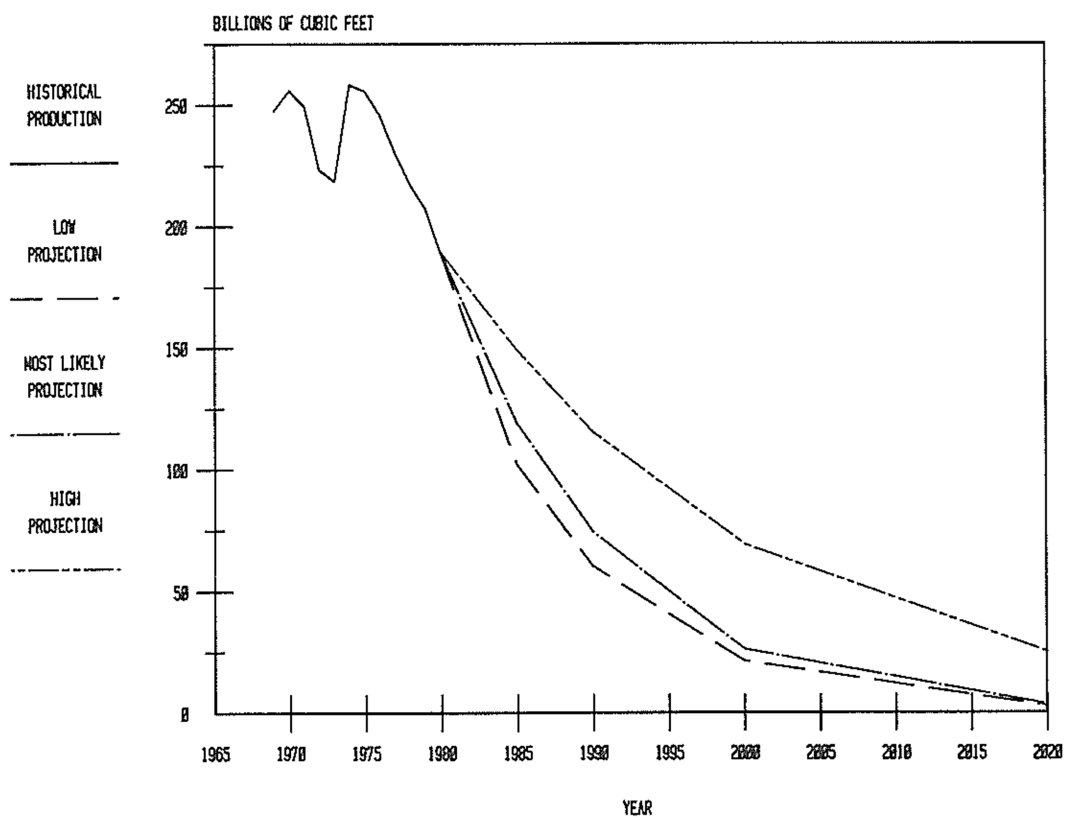

Figure A-4. Casinghead Gas Production for Lea County, Historical and Projected Amounts, 1965-2020.

Table A-7. Projected Dry Gas Production for Lea County, 1985-2020.

Year	Dry Gas Production Low	Most Likely	High
	(billions of cubic feet)		
1985	101.9	113.3	123.1
1990	67.8	84.9	97.2
2000	26.9	39.9	49.6
2020	3.2	5.7	7.1

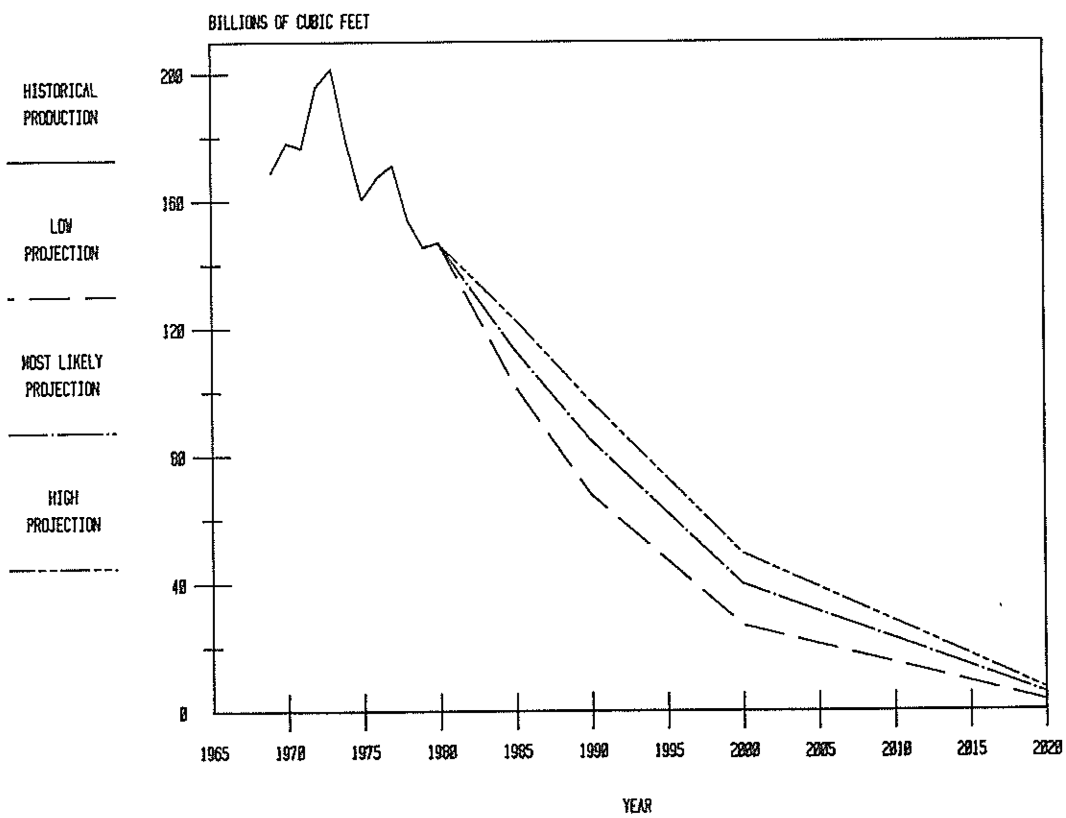

Figure A-5. Dry Gas Production for Lea County, Historical and Projected Amounts, 1965-2020.

APPENDIX B

HYDROLOGIC AND IRRIGATION SYSTEMS ASSUMPTIONS

Table B-1. Baseline Conditions--Hydrologic and Irrigation Systems Information, Lea County, New Mexico, 1977.

Item	Unit of Measure	1977 Estimate
Hydrologic Information		
Saturated thickness	feet	135
Maximum irrigated acreage	acres	82,600
Depth-to-water	feet	70
Average water withdrawals (1977 base)	acre-feet	227,100
Average water decline	ft./yr.	0.8
Gallons per minute		
flood	gpm	820
sprinkler	gpm	580
Specific capacity	gpm/ft. drawdown	60
Irrigation Systems		
Type		
flood	percent	40
sprinkler	percent	60
Pumping plant fuels		
natural gas	percent	65
electricity	percent	35
diesel	percent	--
LPG	percent	--
Average pumping plant efficiencies*		
natural gas	percent	10.0
electricity	percent	47.9
diesel	percent	--
LPG	percent	--

* Good efficiencies were considered to be 13.9 percent for natural gas; 66.1 percent for electricity; 19.9 percent for diesel; and 18.6 percent for LPG.

APPENDIX C
SUMMARY OF ON-FARM IMPACTS

Table C-1. Summary of On-Farm Impacts, Lea County, New Mexico, 1977-2020--Baseline.

Item	Unit	1977	1985	1990	2000	2010	2020
Value of Production	$1,000	48,218	62,620	67,110	74,223	78,438	85,350
Irrigated Cropland	$1,000	19,591	27,970	31,547	37,390	41,526	48,343
Dry Cropland	$1,000	745	928	1,025	1,207	1,286	1,382
Rangeland	$1,000	27,883	33,722	34,539	35,626	35,626	35,626
Returns to Land & Management	$1,000	10,757	16,754	18,108	22,813	26,256	30,486
Irrigated Cropland	$1,000	4,698	8,513	9,435	13,634	17,098	21,358
Dry Cropland	$1,000	148	234	299	460	529	615
Rangeland	$1,000	5,911	8,008	8,374	8,718	8,629	8,514
Irrigation Water							
Quantity	acre-ft	222,456	245,483	266,464	271,955	271,170	233,452
Cost	$1,000	2,035	2,744	3,546	4,083	4,467	4,950
Land Use							
Irrigated Cropland	acres	85,250	86,500	88,000	90,000	90,000	90,000
Dry Cropland	acres	8,500	8,500	8,500	8,500	8,500	8,500
Rangeland	acres	2,657,400	2,656,150	2,654,650	2,652,650	2,652,650	2,652,650
Irrigation Energy							
Natural Gas	mcf	950,081	298,876	239,333	62,808	66,942	74,430
Electricity	1000 kwh	20,546	37,462	43,691	54,888	56,652	59,407
Irrigated Crops							
Alfalfa							
Acreage	acres	18,755	24,220	29,040	29,700	29,700	29,700
Production	ton	97,526	137,178	169,959	190,643	213,070	255,123
Irrigation Water	acre-ft	84,257	121,191	145,309	148,611	148,611	119,690
Irrigation Water Cost	dollars	746,516	1,079,108	1,701,251	2,057,614	2,322,230	2,537,998
Value of Production	$1,000	6,047	8,715	11,030	13,063	15,420	19,448
Returns to Land & Mgt.	$1,000	2,438	3,557	4,152	5,552	7,600	10,251
Corn for Grain							
Acreage	acres	19,608	25,085	29,040	29,700	29,700	29,700
Production	bu	1,862,712	2,990,061	3,724,795	4,124,892	4,354,033	4,845,046
Irrigation Water	acre-ft	49,019	62,248	71,583	73,855	74,250	66,605
Irrigation Water Cost	dollars	471,348	685,089	990,394	1,058,747	1,160,245	1,412,353
Value of Production	$1,000	4,029	8,347	10,575	12,489	13,531	15,336
Returns to Land & Mgt.	$1,000	290	2,474	2,906	4,472	5,274	6,013
Cotton							
Acreage	acres	21,313	26,815	23,760	24,300	24,300	24,300
Production	cwt	90,578	130,269	124,289	144,094	150,137	156,180
Irrigation Water	acre-ft	33,674	41,357	36,205	36,145	35,283	34,441
Irrigation Water Cost	dollars	298,349	653,027	623,820	706,273	719,415	730,315
Value of Production	$1,000	6,159	8,848	8,622	10,236	10,787	11,577
Returns to Land & Mgt.	$1,000	1,725	2,060	2,125	3,198	3,656	4,359
Grain Sorghum							
Acreage	acres	12,788	4,325	0	0	0	0
Production	cwt	533,665	220,755	0	0	0	0
Irrigation Water	acre-ft	22,514	7,388	0	0	0	0
Irrigation Water Cost	dollars	201,836	116,660	0	0	0	0
Value of Production	$1,000	1,903	974	0	0	0	0
Returns to Land & Mgt.	$1,000	310	273	0	0	0	0
Wheat							
Acreage	acres	12,788	6,055	6,160	6,300	6,300	6,300
Production	bu	485,925	294,199	365,811	442,143	476,156	510,168
Irrigation Water	acre-ft	32,992	13,299	13,367	13,345	13,026	12,716
Irrigation Water Cost	dollars	317,238	209,987	230,313	260,755	265,607	269,631
Value of Production	$1,000	1,453	1,086	1,320	1,602	1,787	1,982
Returns to Land & Mgt.	$1,000	-66	149	252	413	569	735
Dryland Crops							
Cotton							
Acreage	acres	3,825	3,825	3,825	3,825	3,825	3,825
Production	cwt	7,650	8,745	9,416	10,674	11,121	11,569
Value of Production	$1,000	520	594	653	758	799	858
Returns to Land & Mgt.	$1,000	128	145	182	270	305	359
Grain Sorghum							
Acreage	acres	4,675	4,675	4,675	4,675	4,675	4,675
Production	cwt	60,775	73,858	81,244	92,323	98,232	103,401
Value of Production	$1,000	225	334	371	449	487	524
Returns to Land & Mgt.	$1,000	20	89	117	190	223	256
Rangeland							
Steers							
Acreage	acres	1,275,552	1,274,952	1,274,232	1,273,272	1,273,272	1,273,272
Production	1977 $	20,766	20,756	20,744	20,729	20,729	20,729
Value of Production	$1,000	20,766	25,115	25,723	26,533	26,533	26,533
Returns to Land & Mgt.	$1,000	2,857	3,925	4,105	4,277	4,238	4,173
Cows							
Acreage	acres	1,381,848	1,381,198	1,380,418	1,379,378	1,379,378	1,379,378
Production	1977 $	7,116,517	7,113,170	7,109,153	7,103,797	7,103,797	7,103,797
Value of Production	$1,000	7,117	8,607	8,815	9,093	9,093	9,093
Returns to Land & Mgt.	$1,000	3,054	4,083	4,269	4,442	4,391	4,340