HIGH PLAINS-OGALLALA AQUIFER STUDY, NEW MEXICO -- ECONOMIC IMPACTS

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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 groundwater resources in the region, primarily from the Ogallala Formation, has generated dramatic economic growth. This growth has exerted greater and greater demands on groundwater supplies, and water levels have declined and some irrigated areas have gone out of production. As a result, there is a threat to the economic activities in the area that are dependent on irrigated agriculture. 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 participated with five other states and the High Plains Associates (general contractor) in the Six-State High Plains-Ogallala Aquifer Area Study.

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

This article presents a brief summary of the on-farm and regional impacts for two sub-regions of the High Plains-Ogallala Aquifer region in New Mexico. The Southern High Plains sub-region included Lea County, Roosevelt County, Curry County, and the southwestern portion of Quay County. The Northern High Plains sub-region included the rest of Quay County, Union and Harding counties.

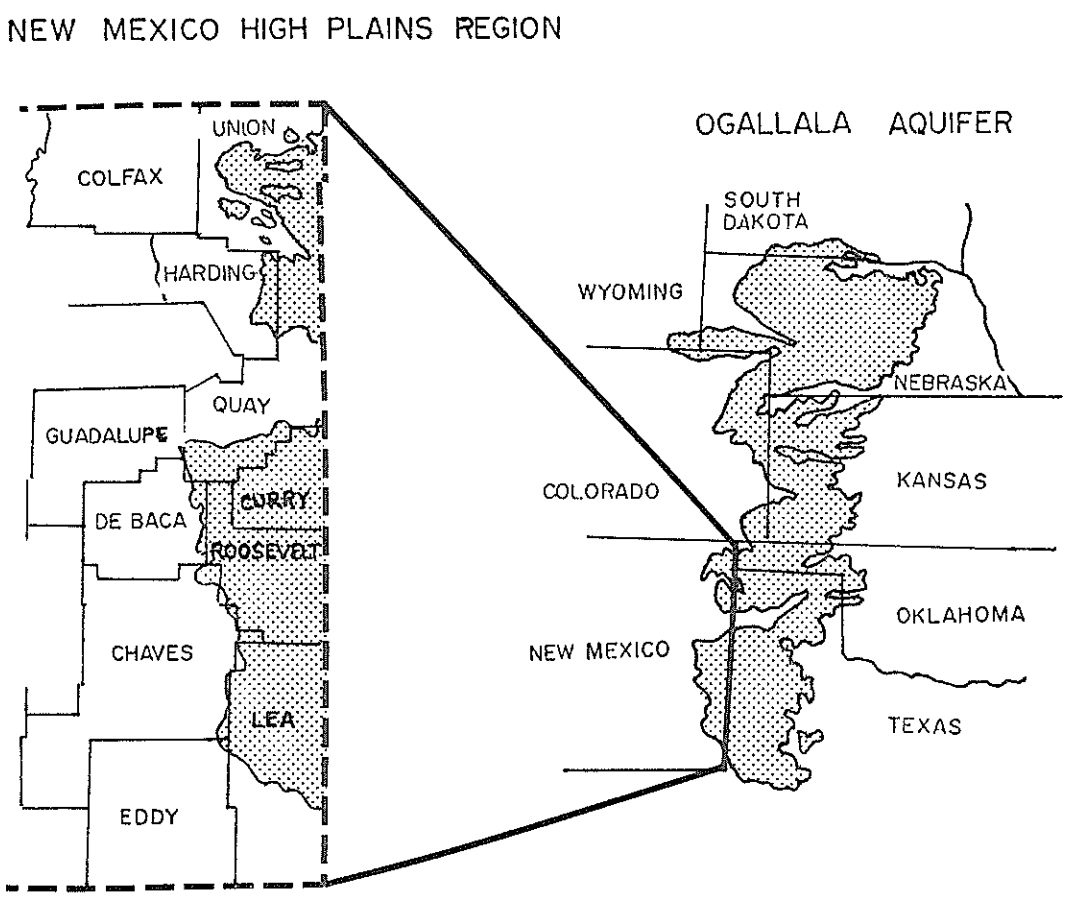

Figure 1. Ogallala Aquifer, Region and New Mexico.

METHODOLOGY

For the New Mexico agricultural production model, the methodology was to develop an aggregate linear programming (LP) model for the High Plains region of New Mexico. The LP model was designed to maximize returns to land and management from crop and livestock enterprises. The LP Model was structured in a diagonal cell framework which enables local conditions and resource requirements (cropping patterns, irrigation technology, etc.) to be met while the model maximized the regional returns. It included costs and returns budgets, a pumping cost model and hydrological data. The initial hydrologic data for 1977 were provided by the New Mexico State Engineer Office. The pumping costs model and hydrologic information also was designed to incorporate local conditions and resource utilization.

Assumptions concerning crop yields, commodity prices, energy prices and input prices were developed cooperatively between the six states and the general contractor. All states used basically the same assumptions for compatability.

An input/output (I/O) model was utilized to evaluate the regional economic impacts resulting from the alternative management strategies. A regional input-output table was developed for the High Plains region from a 1972 national I/O model (Young and Ritz, 1979). The 496-producing sectors national model was aggregated to 55-producing sectors using a location quotient technique. Information on the production functions for the agricultural sections were developed from the on-farm impact.

A second multi-regional socio-economic model developed by Shaul Ben-David and others (1980) generally referred to as the Southwest Water, Energy, Environment, and Population (SWEEP) model was used to project the regional gross total output, employment and population for the baseline and alternative management strategies.

RESULTS

Results are presented for the on-farm impacts by sub-region by management strategy for key resources, followed by regional economic impacts for selected years (1977, 1985, 1990, 2000 and 2020). Results are presented for the baseline and three alternative strategies -- voluntary water demand reduction, mandatory water supply reduction, and water supply augmentation for areas that physically exhaust its water supply.

Crop Acreages

Northern High Plains. Under all management strategies the total cropped acreage is expected to increase steadily over time by county (Figure 2) and strategy. The acreage irrigated in 2020 is expected to be the greatest under the voluntary strategy (127,740 acres) and lowest under the mandatory strategy (108,400 acres). The baseline strategy was estimated to have 155,854 acres irrigated in 2020. Under the baseline and the voluntary management strategy, no acreage is expected to transfer from irrigated to dryland. Under the mandatory strategy, transfers from irrigated acreage to dryland over the study period are expected to be about 19,400 acres, to meet the mandatory water reduction defined for this management strategy. There will be no imported water for the Northern High Plains because no irrigated areas are expected to go out of production due to aquifer exhaustion.

Southern High Plains. The projected acreage of irrigated cropland by county for baseline is presented in Figure 3. By the year 2020, no irrigated cropland is expected in Curry County, nor in the southwestern portion of Quay County. The acreage in Roosevelt will be drastically reduced to about 38 percent of the 1977 acreage by 2020, and no irrigated cropland is expected to be farmed after 2021.

Under all management strategies the total cropped acreage in the Southern High Plains varied only slightly. However, significant shifts from irrigated to dryland production are expected. The baseline strategy

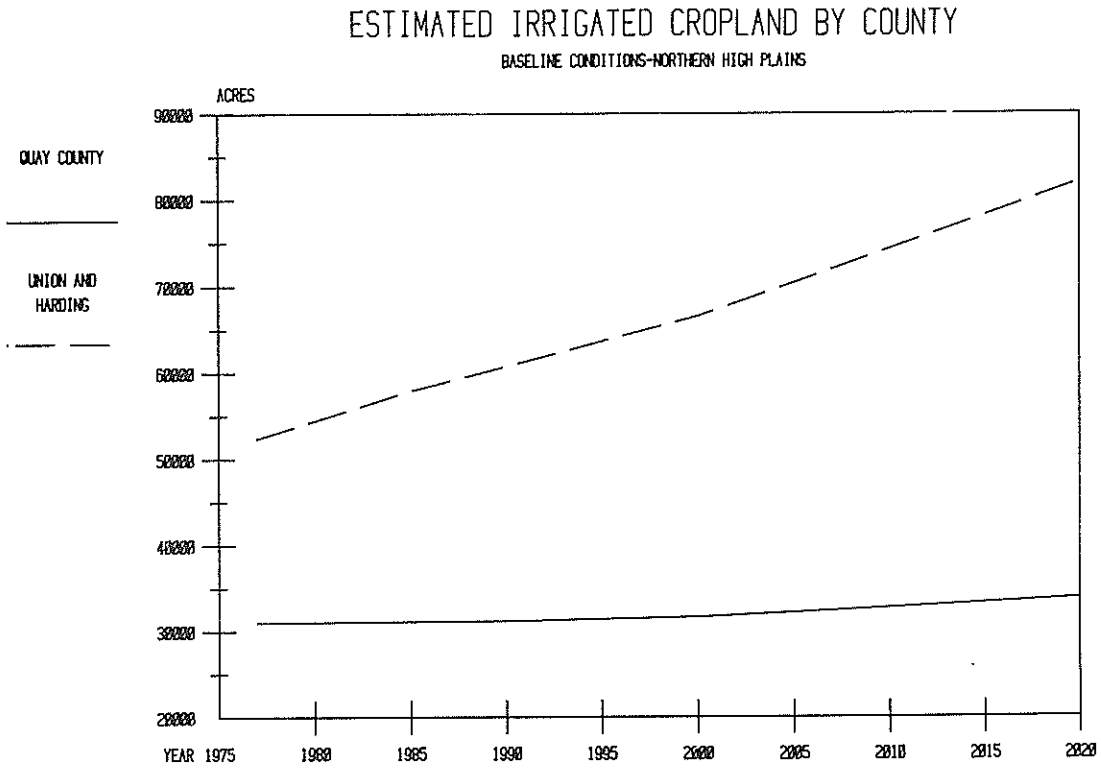

Figure 2

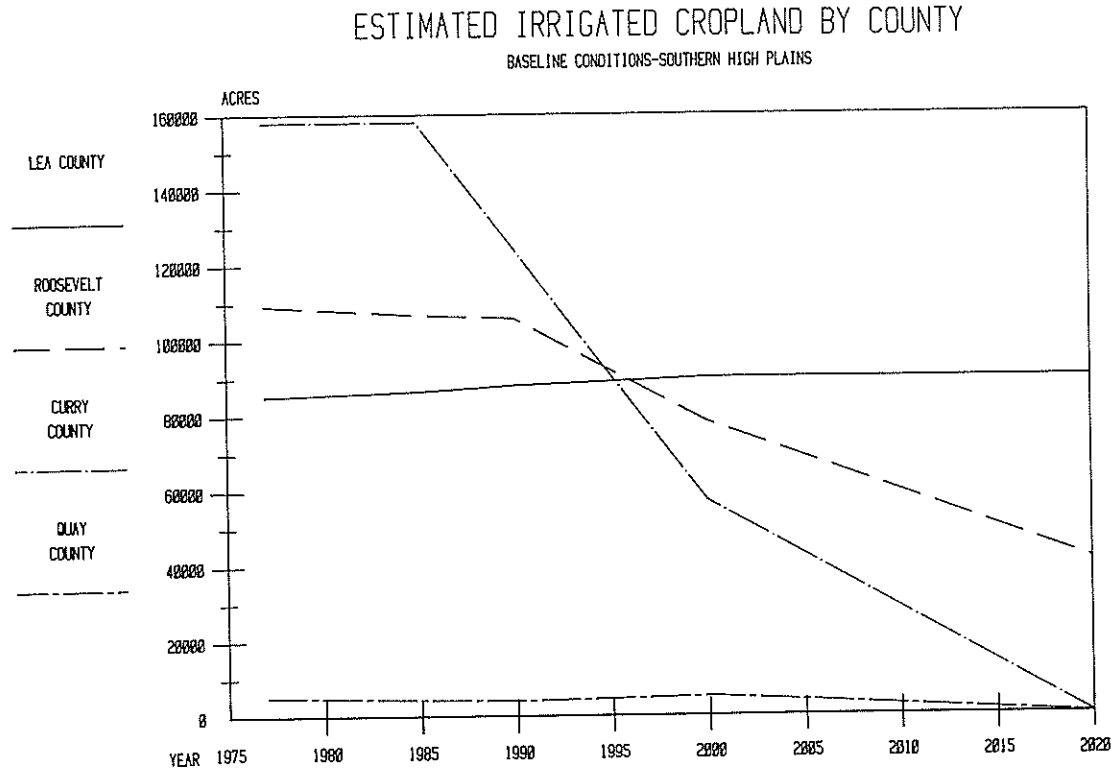

Figure 3

is expected to have the greatest acreage transfer from irrigated to dryland over the period 1977 through 2020. About 37,000 more acres are expected to remain in irrigation under the voluntary strategy than baseline in 2020 due to water conservation. Under the mandatory strategy about the same irrigated acreage as the baseline is expected through 2000, but by 2020 about 75,000 more irrigated acres are expected. The acreage irrigated is expected to be almost constant under the importation strategy, except for a decline in 1990 due to the exhaustion of the water supply in part of Curry County before the imported water becomes available in 2000 (Figure 4).

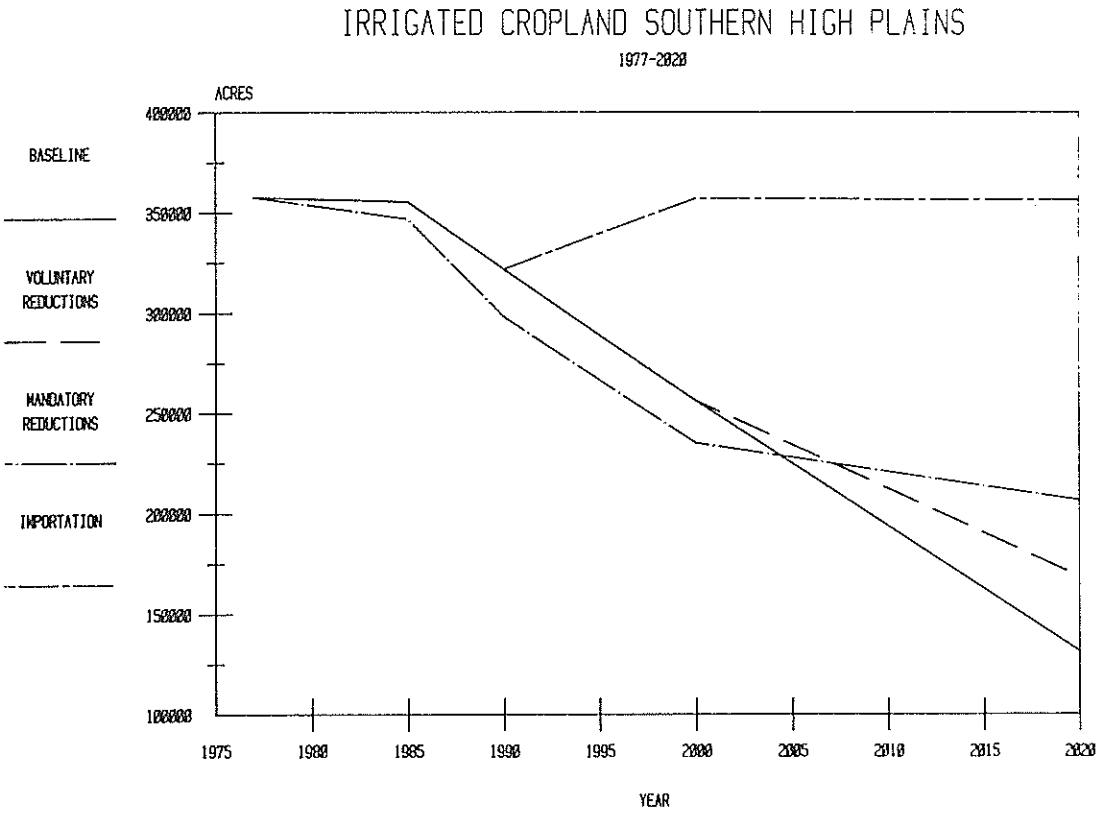

Figure 4

Cropping Pattern

Northern High Plains. Irrigated cropping patterns are affected less in the Northern High Plains than in the Southern High Plains because no area in the Northern High Plains is expected to run out of water. The acreages of corn and wheat are expected to be larger under the baseline, voluntary and importation strategies. Cotton acreage under all management strategies is expected to increase to 2000 then remain constant to 2020. Grain sorghum acreage basically is expected to decline and alfalfa acreage is expected to increase over the study period under all of the management strategies.

Of the dryland crops in the Northern High Plains, wheat and alfalfa follow a generally increasing trend while grain sorghum generally declines. However, there was a large shift from wheat to grain sorghum in 2000 and back to wheat in 2020. There was a slight decrease from baseline to the other management strategies in 2020 in range livestock. This was due to more land being converted from rangeland to irrigated cropland.

Southern High Plains. Generally, irrigated crops produced under the baseline and the voluntary strategy follow similar patterns -- irrigated feed grains and forage crops are expected to initially increase in acreage from 1977 to 1985 or 1990 before significant declines in acreage are expected to occur by 2020. Irrigated small grains and fiber crop acreages are expected generally to decline over time. The importation strategy follows similar patterns to the voluntary strategy until imported water becomes available. After importation, feed grains, forage crops and small grains tend to increase, while cotton tends to decline. Irrigated forage crops under the mandatory strategy are expected to initially increase in acreage in 1985, exhibit significant declines by 2000, then have a tremendous increase by 2020. The fiber crops acreage are expected to fluctuate a great deal, but in the end to be almost the same as they were in 1977. Feed grains and small grains are expected to follow a generally declining trend in acreage.

The dryland crops for all management strategies are expected to follow similar patterns. The dryland small grain acreage is expected to increase under all strategies, and significantly under some strategies. The dryland fiber crops are expected to increase in acreage slightly over time while the dryland feed grain crops are expected to have acreage declines over time. The acreage devoted to range livestock is not expected to change for the baseline, voluntary and importation strategies, but the acreage is expected to increase for the mandatory strategy.

Water Diversions

Northern High Plains. Under all management strategies except mandatory, significant increases in the quantity of irrigation water diversions are expected over the period of the study (Figure 5). Reductions are expected for the mandatory strategy because of the mandatory irrigation water application reductions.

The largest irrigation water diversions are expected to occur under baseline in 2020. They are expected to increase almost steadily from about 193,000 acre-feet in 1977 to 256,000 acre-feet in 2020. The diversions are expected to maintain about a 25/75 percent furrow/sprinkler relationship through 2000, but in 2020 they are expected to be more than 75 percent sprinkler.

Under the voluntary and importation strategies, decreases in water diversions are expected when compared to baseline. There is still an increasing trend in water applications from 1977 to 2020 similar to baseline. However, the flood/sprinkler relationship is expected to change (significantly less furrow irrigation).

The water applications per acre for all crops except pasture are expected to decline for all management strategies over time due to increasing field efficiency. The average water applications per acre are expected to decline 0.49 acre-foot per acre under the voluntary and importation strategies and 0.65 acre-foot per acre under the mandatory strategy due to mandatory supply controls. Despite the reduction in per

acre applications the total water applications are expected to increase under the baseline, voluntary and importation strategies due to greater irrigated acreage.

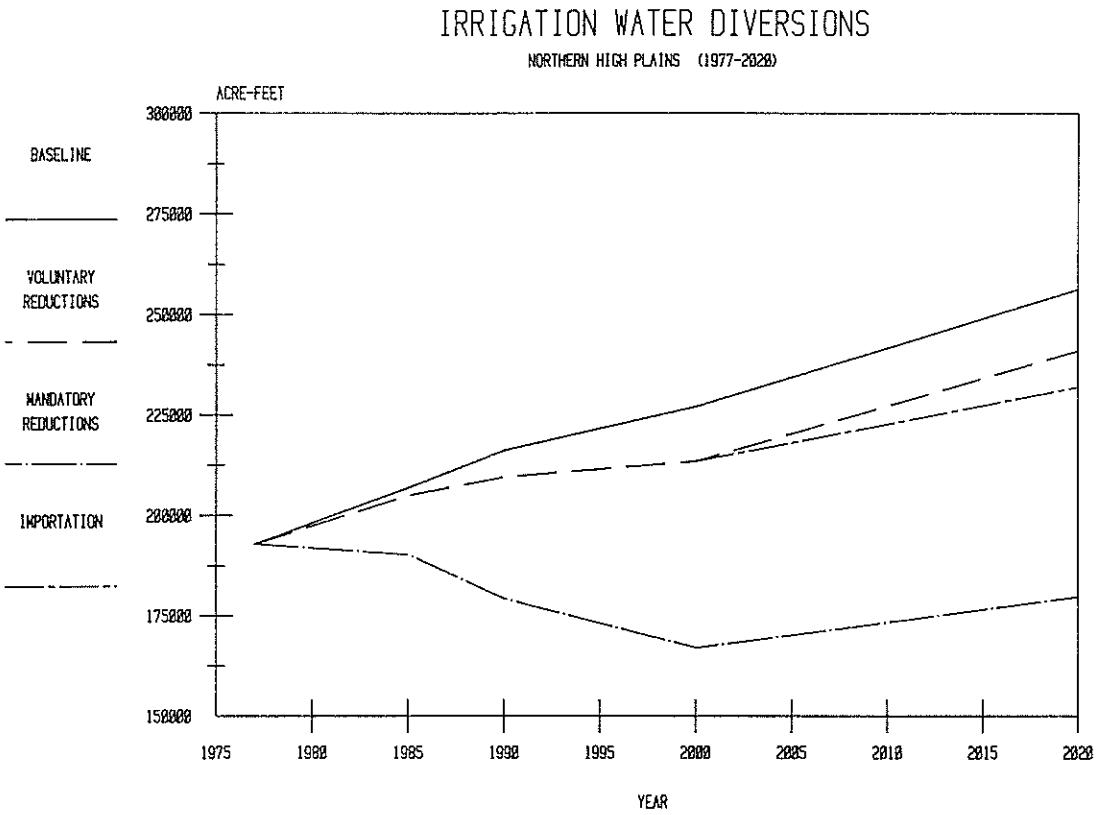

Figure 5

Southern High Plains. Significant reductions are expected in the quantity of irrigation water diversions over the period of the study due to aquifer exhaustion and increases in field irrigation efficiency for all management strategies (Figure 6). The greatest reductions are expected to occur in baseline, followed by the mandatory strategy. In 1985, diversions are expected to exceed 790,000 acre-feet under baseline and then decline to less than 300,000 acre-feet by 2020 due primarily to aquifer exhaustion. In addition to reduction in diversions, there are expected also to be significant changes in the furrow/sprinkler mix. The

baseline water diversions maintained about a 50/50 furrow/sprinkler relationship through 2000, but by 2020 the water diversions are expected to be 100 percent sprinkler.

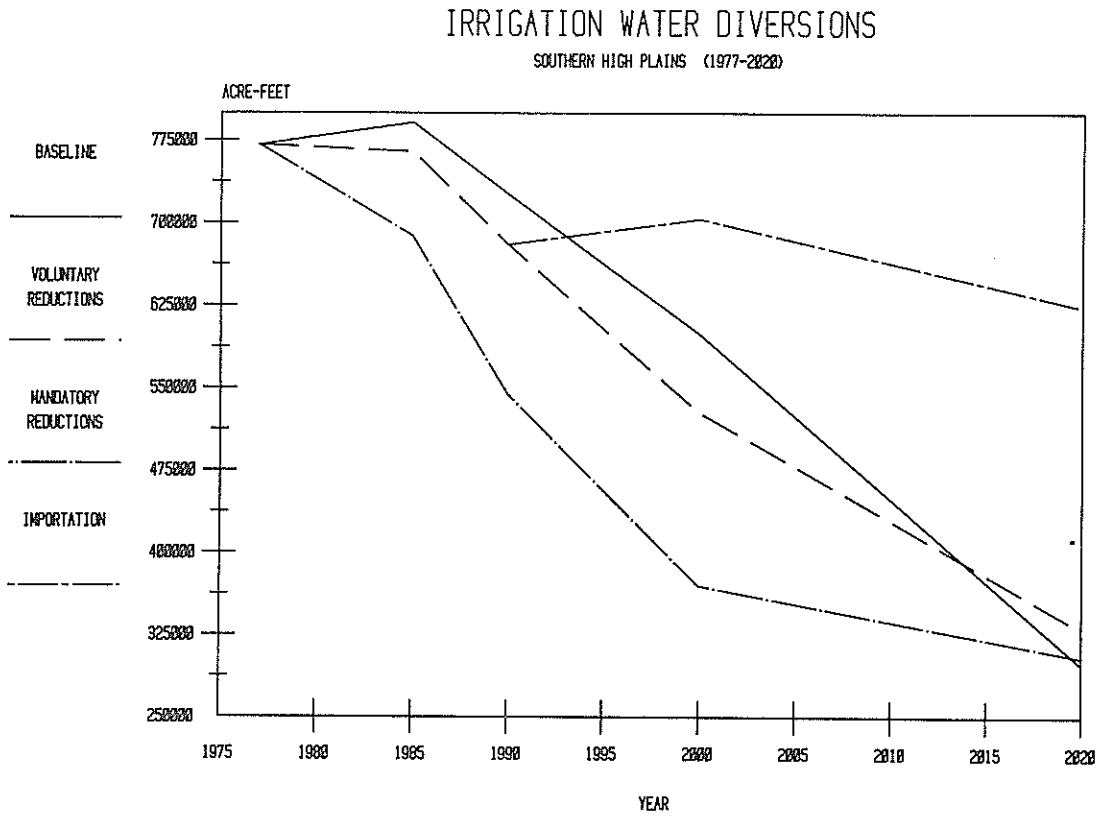

Figure 6

The annual water diversion for the voluntary strategy is expected to be lower than baseline except in 2020, where the diversions are expected to be about 32,000 acre-feet more than under baseline (Figure 6). This was also due to the availability of irrigation water in some areas where the aquifer is expected to be dewatered in baseline. In 2020, the voluntary strategy is expected to have more than 100,000 acre-feet of furrow irrigation due to the improved economic position of furrow relative to sprinkler irrigation.

The irrigation water diversions for the mandatory strategy are expected to be less than the voluntary strategy in all years.

Significant reductions in water diversions are expected under the mandatory strategy through 2000, but in 2020 the diversions are expected to be only about 26,000 acre-feet less than the voluntary strategy due to mandatory irrigation water diversion reductions. Furrow irrigation is also expected to be significantly reduced after 1977 to meet the mandatory water reductions.

The water applications per acre for all crops under all management strategies are expected to decline over the period from 1977 to 2020 due to increasing field efficiency. The greatest per acre water reduction over the study period is expected to occur under the mandatory strategy for all crops but wheat. Even though there was a constant decline in per acre water applications under baseline, the average per acre water applications are expected to increase due to a change in cropping pattern and increased irrigated acreage in some areas. Of the original nine irrigated areas, only three remain in production in 2020 under baseline. These three irrigated areas have a high percentage of alfalfa, corn and peanuts, all significant water-using crops. The average per acre water application for the alternative management strategies declines despite the influence of the high percentage of higher water-use crops. This was due to voluntary or mandatory conservation measures and the influence of some additional areas that remain in production. The average per acre water applications are expected to decline 9 percent under the voluntary, 32 percent under the mandatory, and 19 percent under the importation strategy.

As a part of the High Plains Study, the U.S. Army Corps of Engineers studied, at a reconnaisance level, four importation routes -- two from the Missouri River (routes A & B) and two from tributaries of the Mississippi River (routes C & D) (see William Pearson's presentation). The routes were sized to provide costs for a range of flows. Where possible, routes will be located to minimize environmental impacts.

Route D could provide water to New Mexico and parts of Texas and Oklahoma. Sources of water would be the White River at Clarendon, Ark.; the Arkansas River at Pine Bluff, Ark.; the Ouachita River at Camden, Ark.; the Red River at Fulton Ark.; the Sulphur River at Darden, Texas;

and the Sabine River at Tatum, Texas. These supplies then would route west and northwest across Texas into the panhandle of Texas to terminal storage west of Lubbock, Texas. This route would require a canal about 860 miles long and would have 30 pumping plants to lift the water 2,700 feet along the route.

The water diversions under the importation strategy are expected to be the same as those under the voluntary strategy through 1990. After imported water becomes available in 2000, the water diversions are expected to be significantly increased. The water diversions under the importation strategy in 2020 are expected to be about 300,000 acre-feet more than the voluntary strategy and over 330,000 acre-feet more than baseline. The diversions in 2000 are expected to be more than 50 percent furrow applied under the importation strategy, but by 2020 the diversions are expected to be more than 75 percent sprinkler applied.

Local water supply augmentation and intrastate water transfers will not furnish enough water to alter the time when irrigation goes out of production by more than a year or two.

Surplus water supplies available for interstate transport for the adjacent areas must be determined before any import scheme can be considered. If water supplies were available, a project of this magnitude would require many years to complete. Water from an interstate transport scheme probably would not be available to the High Plains until about 2020. Even if it is determined that surplus water could be brought to New Mexico's High Plains and that political, legal, environmental and other problems could be put to rest, it is unlikely that such a project could be completed in time to save much of the irrigated economy. As indicated below, much of the presently irrigated land in southern Quay, Curry and Roosevelt counties will have gone out of production by 2020.

County	Year Irrigation Ceases		
	Baseline	Voluntary	Mandatory
Union	2060	2060	2100
Harding	2063	2063	2108
Quay (House Area)	2010	2013	2016
Curry	2015	2017	2023
Roosevelt	2021	2027	2041
Lea	2085	2096	2114

Returns

Northern High Plains. The irrigated and total (irrigated, dryland and rangeland) value of production and returns to land and management for the Northern High Plains were calculated for each of the management strategies. The irrigated value of production for baseline is expected to maintain an increasing trend that continues through 2020 when the returns are 3.4 times the 1977 amount. The dryland value of production is expected to increase by 137 percent by 2020. The range livestock value of production is expected to increase by 28 percent. The irrigated returns to land and management are expected to increase from 1977 through 2020. The increase in returns from 1977 to 2020 are expected to be significant, about 835 percent. Dryland returns are expected also to show significant gains in returns over the study period. The dryland returns to land and management in 2020 are expected to be more than 6 times the returns in 1977. The rangeland returns are also expected to be up 44 percent. The total agricultural value of production and total agricultural returns to land and management follow almost identical trends as those for irrigation for all management strategies.

The voluntary strategy follows an almost identical pattern as the baseline except both the value of production and returns to land and management for irrigation are expected to be higher, and rangeland lower,

due to more land being in irrigated production in each time period (Figure 7). By more land being retained in irrigation, there is a decrease in rangeland acreage.

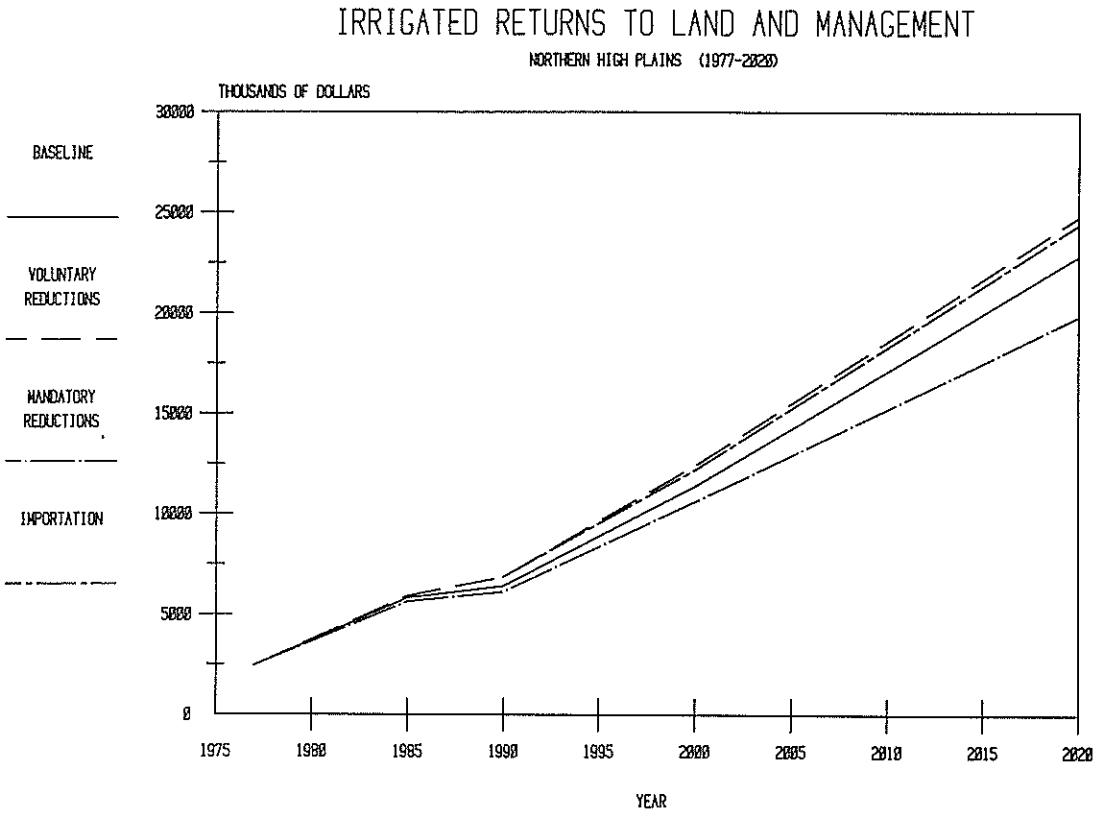

Figure 7

The irrigated value of production and returns to land and management under the mandatory strategy are expected to be less than the baseline or the voluntary strategy. This general reduction in both the value of production and returns is due to the changes in the cropping patterns, farm management techniques, and irrigation technology necessary to meet the mandatory water reductions.

Both the value of production and returns to land and management for dryland crop production were slightly greater under the mandatory strategy due to some areas converting to dryland from irrigation.

Southern High Plains. The irrigated and total value of production and returns to land and management for the Southern High Plains were calculated for each of the management strategies. The irrigated value of production for baseline is expected to peak in 1985, then begin a declining trend that continues through 2020, where it is expected to be only slightly less than the 1977 value. The dryland value of production is expected to increase by 268 percent by 2020. The range livestock value of production is expected to increase by a modest 28 percent over the study period. The total agricultural value of production is expected to increase to 2000, then decline slightly to 2020 due to irrigated cropland going out of production. Total agricultural returns to land and management are expected to increase over time. The irrigated returns to land and management are expected to increase from 1977 through 2000, but decrease in 2020 (Figure 8). The increase in returns from 1977 to 2020

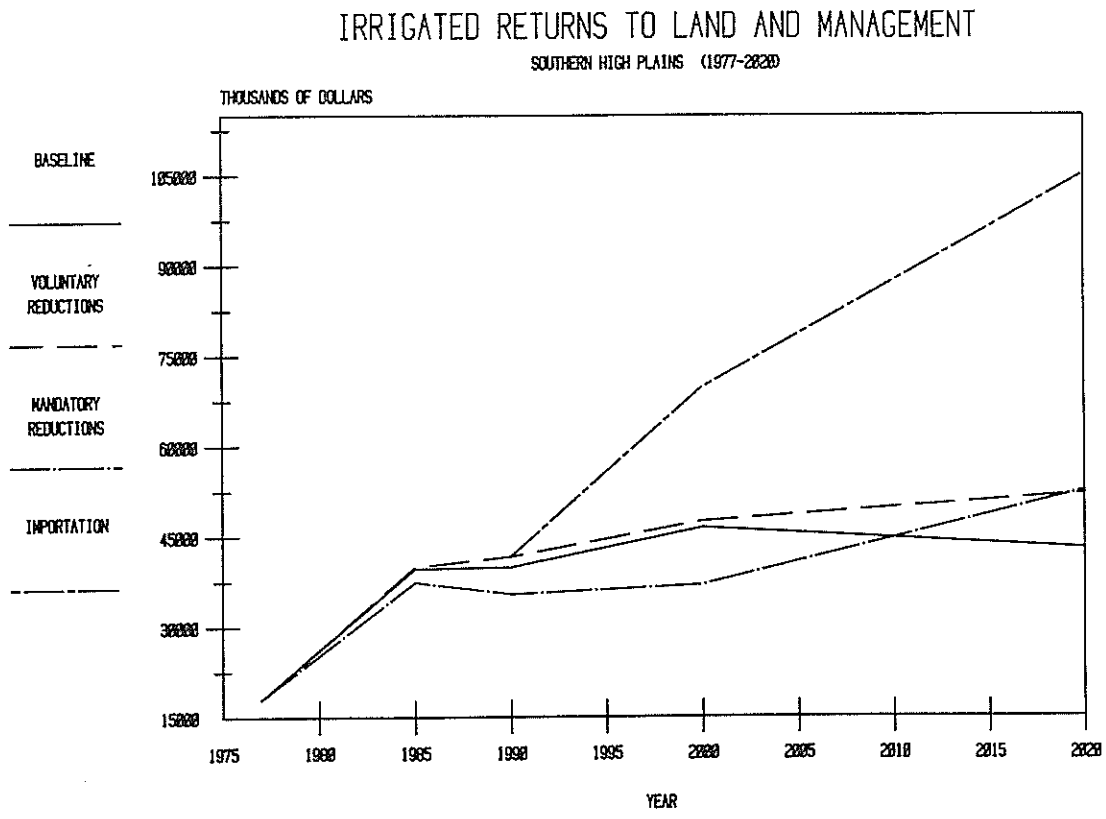

Figure 8

is expected to be about 140 percent, despite the decline from 2000 to 2020. Dryland returns are expected to show significant and increasing gains in net returns over the study period. The dryland returns to land and management in 2020 are expected to be more than 8 times the returns in 1977. The rangeland returns are expected to show a modest 44 percent gain over 1977.

The voluntary strategy follows an almost identical pattern as the baseline except in 2020 when both the value of production and returns to land and management for irrigation are expected to be higher, and dryland lower, due to more land being left in irrigated production.

The irrigated value of production under the mandatory strategy is expected to be less than baseline through 2000, but higher in 2020, since more irrigated land remains in production longer (about $24 million more than baseline and about $8 million more than the voluntary strategy). Even though the irrigated value of production is expected to be $8 million greater in 2020, the irrigated returns to land and management are expected to be about $275 million less than the voluntary strategy over the 40-year study period. This general reduction in both the value of production and returns in 1985, 1990 and 2000 under the mandatory strategy from baseline and the voluntary strategy is expected to be due to the changes in the cropping patterns, farm management techniques, and irrigation technology necessary to meet the mandatory water reduction. This indicates that it is expected to be more expensive to grow crops under the mandatory water reductions. Both the value of production and returns to land and management for dryland crop production were greater under the mandatory strategy. This was due to some areas converting to dryland from irrigation.

If the natural water supply in the Southern High Plains is augmented with imported water under the conditions of voluntary water demand reductions during the last half of the study period, it is expected there would be the least impacts on irrigated acreage, water diversions and on-farm employment. In addition, it is anticipated that this policy would result in by far the greatest increase in both total and irrigated returns in the latter part of the study period.

Under the importation strategy irrigated value of production and returns to land, management and water are expected to increase significantly in 2000 and 2020. This is expected to be due primarily to the importation of water that enabled previously irrigated areas that had been dewatered to restore irrigation. In addition to the acreage restored to irrigation, there is expected to be no water cost associated with the imported water which will further increase net returns. The irrigated value of production and returns to land, management and water are expected to be highest of any management strategy in 2000 and 2020 under the importation strategy. The importation strategy, therefore, provides for the greatest economic recovery.

Costs for Route D, as proposed by the U.S. Army Corps of Engineers, are expected to range from $320 to $370 per acre-foot. In addition to these costs, $200 to $400 per acre-foot would be needed to construct local distribution systems to deliver water from terminal storage to farm headgates. Farmers can only afford to pay about $150 per acre-foot.

	Ability to pay in 2020		
	(Acres)	($/Acre)	($/Ac-Ft)
Portales East	25,500	251.43	164.33
Curry County	157,900	231.78	151.49
Quay County (House Area)	5,000	43.68	21.31
TOTAL	188,400		
Weighted Average		$229.45	$149.77

The dryland value of production and net returns to land and management for the importation strategy for 2000 and 2020 were less than the other management strategies. This was due to the restoration of previously irrigated, presently dryland, acreage back into irrigation with imported water. The value of production and returns to range for the importation strategy were the same as the voluntary strategy.

REGIONAL ECONOMIC IMPACTS

Gross Output

The gross output for baseline by major sector and year is presented in Figure 9. The total gross output was about $2,384 million in 1977; and is expected to be $3,852 million in 1985 (an increase of about 62 percent); $3,674 million in 1990 (5 percent decrease); $2,817 million in 2000 (23 percent decrease); and $2,704 million in 2020 (4 percent decrease).

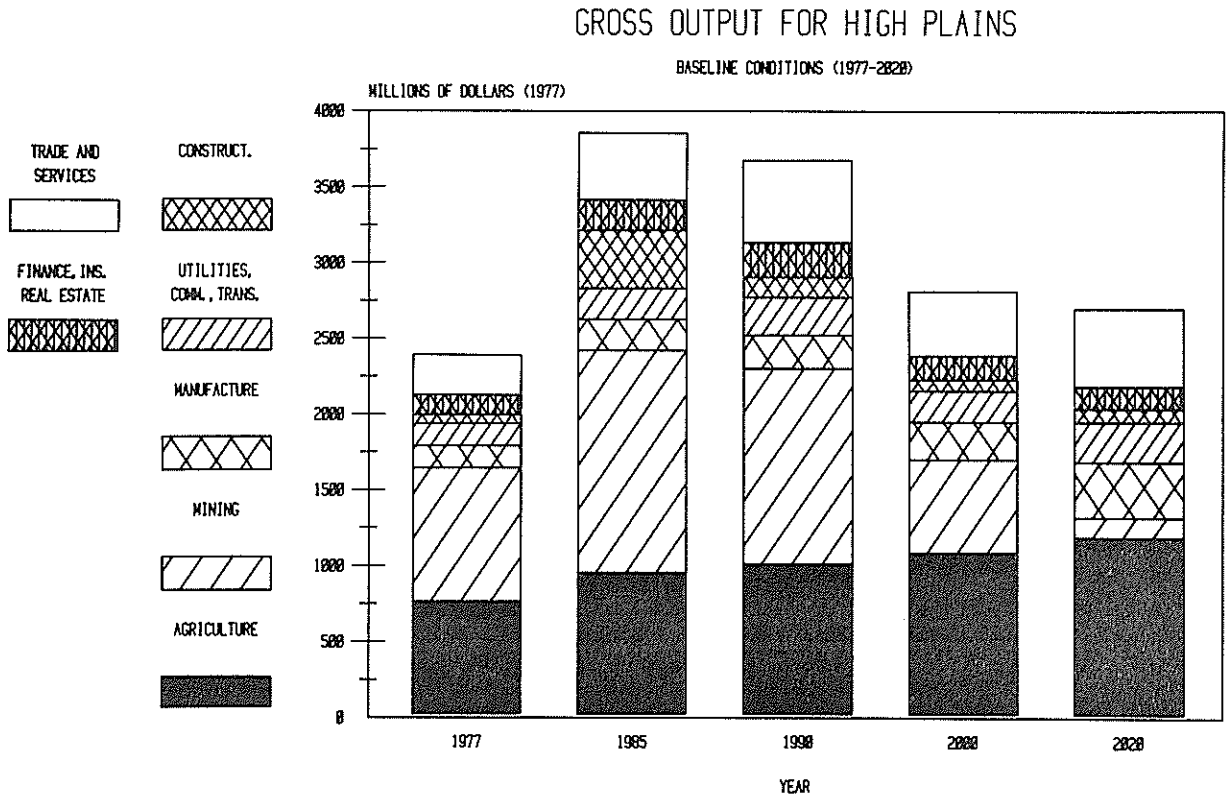

Figure 9

The mining sectors were expected to have substantial growth between 1977 and 1985, but then begin a decline that would result in very little

mining activity remaining in the area in 2020. In 1977 the mining sectors accounted for about $883 million or 37 percent of the total. At their peak in 1985 they accounted for $1,467 million or about 38 percent of the total. By 2020 they were projected only to account for $132 million or about 5 percent of the total.

The agricultural sectors are expected to increase between 1977 and 2020 from about $759 million in 1977 to $1,195 million in 2020. This growth was projected to be relatively stable over the period. In 1977 the agricultural sectors accounted for about 32 percent of the total and by 2020 were projected to account for more than 44 percent. Most of the individual agricultural sectors were projected to increase in a similar pattern with the exception of irrigated grain sorghum which was projected to decline in importance in the area.

The manufacturing sectors were projected to increase between 1977 and 2020 from $148 million in 1977 to about $364 million in 2020, or a growth of about 146 percent. The contribution of the manufacturing sectors to the total was about 5 percent in 1985, 6 percent in 1990, 9 percent in 2000 and 13 percent in 2020.

The utilities, communication and transportation sectors taken together generally were expected to increase over the period with a decrease occurring in 2000. These sectors were projected to be about $146 million in 1977, $196 million in 1985, $243 million in 1990, $202 million in 2000, and $266 million in 2020. The contribution of these sectors to the total was about 6 percent in 1977, and is expected to be 5 percent in 1985, 7 percent in 1990, and 10 percent in 2020.

The construction sectors were projected to increase significantly between 1977 and 1985 then begin a decline following fairly closely the output pattern of the mining sectors. These sectors accounted for about $53 million in 1977; and are expected to account for $383 million in 1985 (a six-fold increase); $126 million in 1990 (a 67 percent decrease); $76 million in 2000 (a 40 percent decrease); and $88 million in 2020 (a 16 percent increase).

The finance, insurance and real estate (FIRE) sectors were projected to increase between 1977 and 1990, then decrease to 2020 as the total

economy began slowing down in the area. In 1977 they were expected to produce about $138 million, increase to $202 million in 1985, $236 million in 1990, then decrease to $159 million in 2000, and $148 million in 2020.

The trade and services sectors are expected to expand rapidly between 1977 and 1990, then decline in 2000, followed by a recovery in 2020. In 1977 they accounted for about 11 percent of the total and by 2020 were projected to reach almost 19 percent.

There were only minor differences in the alternative management strategies over the period. These differences were stimulated by the agricultural sectors, and their impact was evaluated in the on-farm impacts results.

Jobs

The total employment in the form of jobs for each of the alternative management strategies for the major sectors is presented in Figure 10.

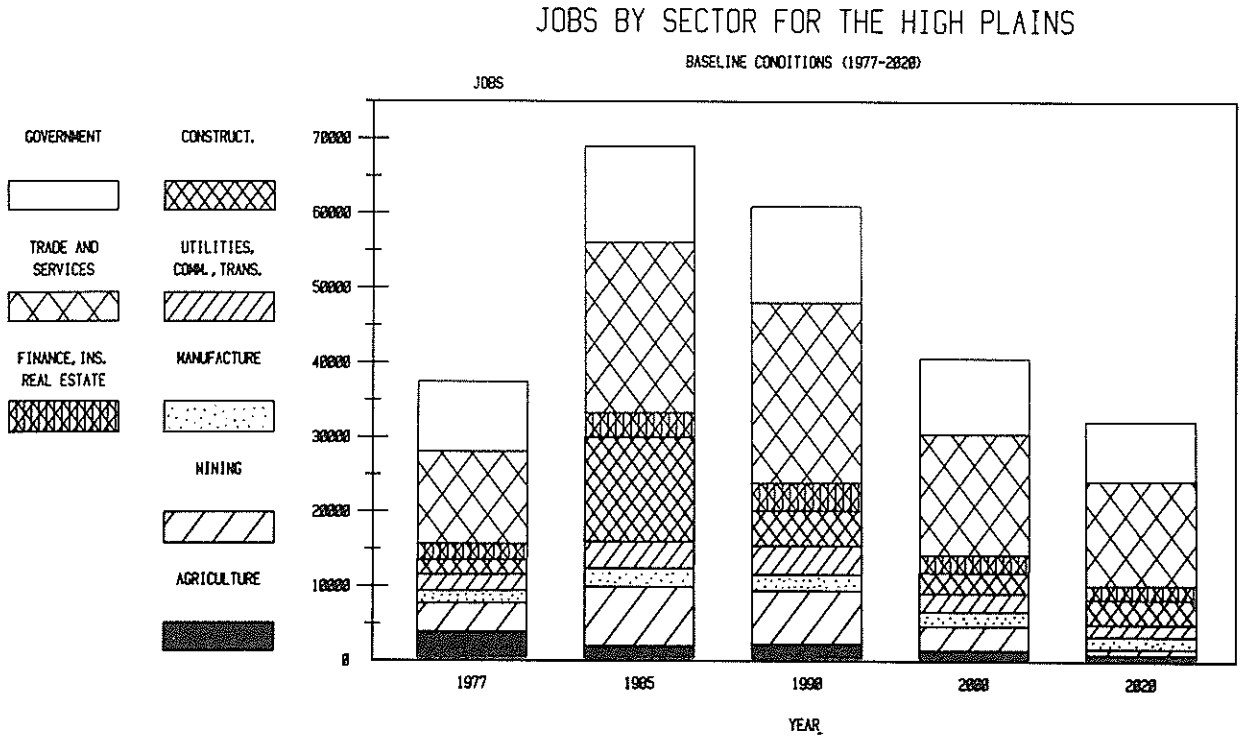

Figure 10

The total number of jobs was projected to be about 37,248 in 1977, increasing to 69,646 in 1985, then decreasing to 32,211 by 2020. The trade and service sectors were the largest employers accounting for about 33 percent in 1977. The percentage is expected to remain the same in 1985, then increase to 39 percent in 1990, 40 percent in 2000, and 43 percent in 2020. Government employed about 24 percent in 1977, and is expected to employ 19 percent in 1985, 21 percent in 1990, and 25 percent in 2000 and 2020. Agricultural employment was about 11 percent in 1977, but was expected to decline to about 2 percent in 2020. Mining employment accounted for 10 percent in 1977, but was expected to increase to 11 percent in 1985, 12 percent in 1990, then decline to about 9 percent in 2000, and 3 percent in 2020. Construction was estimated to provide only about 5 percent of the jobs in 1977, but in 1985 would contribute more than 20 percent, then decrease to 8 percent in 1990, 7 percent in 2000, and increase to 10 percent in 2020.

Population

The region's population was projected to increase significantly between 1977 and 1985 with an increase of about 63,900, or about 47 percent. This is an annual growth rate of 5.9 percent. Between 1985 and 1990 the population was projected to decrease by about 14,000, or about 7 percent. By 2000 the population was projected to decrease even further to 108,481. This is about 80 percent of the 1977 level.

	Population				
	1977	1985	1990	2000	2020
Baseline	136,284	200,142	185,838	137,947	108,481
Voluntary	136,284	201,641	186,725	139,066	109,007
Mandatory	136,284	201,684	186,803	139,252	109,529
Importation	136,284	201,641	186,725	139,846	110,841

CONCLUDING REMARKS

Research results and recommendations from the $6 million, six-state study will be presented to Congress in the fall of 1982. In New Mexico, county-level reports are being prepared for Lea, Roosevelt, Curry, Quay, Union, and Harding counties. They will be published by the New Mexico Water Resources Research Institute at New Mexico State University and should be available in late summer. These reports will provide additional detail for each county.