AN INTERPRETATION OF WATER USE DATA FOR THE RIO GRANDE IN NEW MEXICO

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Introduction to the Rio Grande Project

For the past several years, three state universities have been involved in a water resources research project[1] centered on and around the Rio Grande River Basin. Within this study several academic disciplines are represented, thus making the analysis and evaluation one of the larger interdisciplinary projects currently being undertaken within the state.

Dr. Robert Lansford (Agricultural Economist) and Bobby Creel (Asst. to the Director, WRRI) from New Mexico State University are pursuing research into the agricultural uses of water. For this purpose land and water use information was collected and evaluated. Cropping patterns and acreage of each crop, CIR's (consumptive irrigation requirements), and diversion efficiencies are only a few of the items that have been collected and analyzed. Most of this effort has been pursued in conjunction with the State Engineer's Office.

Hydrology of the Basin, both in the surface and ground waters, has been tackled by Dr. Thomas Gebhard (Civil Engineer) at New Mexico State University and Dr. Willem Brutsaert (Hydrologist) at New Mexico Institute for Mining and Technology. Items such as the relationship between surface and ground water basins, the applicable transfer mechanisms and efficiencies between ground and surface water, and estimates of the availability and changes in these availability relationships through time have thus far been pursued by this arm of the project.

The economic evaluation has been our responsibility. Recreation demand and supply, production and its associated water use, economic relationships between transfers of surface and ground waters, and changes in future water demand with increased growth are only a few of the areas that have so far been pursued at UNM.

The study has proceeded under the auspices and leadership of all three state universities, NMSU, NMIMT, and UNM. No portion of this study is meant to stand alone, but rather to be complemented as well as to complement the other portions. A general model has been developed with all parties supplying basic data and then sharing in the interpretation and evaluation of the results.

One quick example should portray more vividly this interaction among the disciplines and the universities. A model of the economy of the Rio Grande

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[1] An Analytical Interdisciplinary Evaluation of the Utilization of the Water Resources of the Rio Grande in New Mexico.

River Basin has been developed. Economic data, constraints, and growth projections were developed at UNM. From NMSU and NMIMT came the agricultural and hydrological information needed to make the model operational. If now we economists project growth and changes in water demand such that agriculture decreases its portion of water use within the Basin, the agricultural economists will relate to us the basic feasibility of this, as well as the types of agriculture that could accordingly be expected to decrease their production. Additional information in the form of the marginal crops in terms of consumptive water use, the capital immobility factor (sales and transfers of unutilized resources), and the future agricultural demand in specific commodities will be derived from their evaluation of the economists' results.

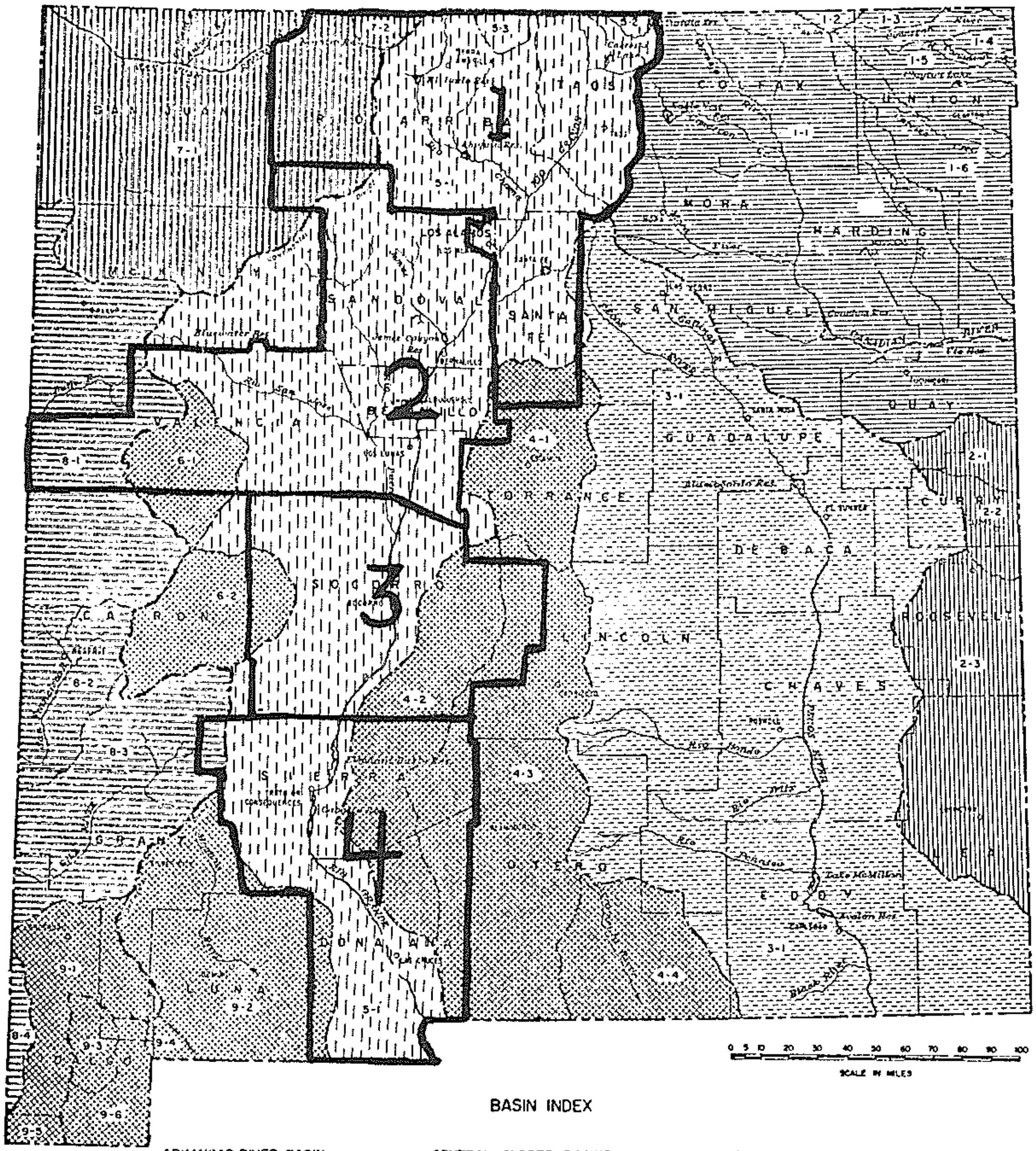
Purpose of the Paper

This paper will briefly present some of the economic interpretations thus far developed for the model, with some further evaluation concerned primarily with water use and its relationship to output, income, value-added, and employment in the Basin area itself. Some of the types of tools and methods currently in vogue will be used to evaluate and interpret the use of water and its associated data within the Rio Grande River Basin. Principally, the amount of new water intake (diversions) in the production processes will be examined. Much of the information presented in the paper is used directly as an input into the model and larger study, while the remaining evaluation presented will complement some of the results thus far derived. But first a brief view of the subject area, the Rio Grande River Basin itself.

Physical Description of the Rio Grande River Basin

The Rio Grande River enters New Mexico from Colorado near Labatos, flows southerly through the state for 430 miles to Texas and Mexico, where it then forms their border until it empties into the Gulf of Mexico. Within New Mexico the Rio Grande drains an area of 25,690 square miles or approximately 20% of the state's land area. Major tributaries include the Red River, Rio Chama, Embudo Creek, Jemez Creek, and the Rio Puerco. As can be seen from the placement of the main tributaries, the major portion of the water addition in New Mexico to the Rio Grande takes place in the northern part of the Basin.

The following map shows the major drainage areas (hydrologic definition) of the state. Outlined in black are the regions used in the present study. For this paper, the four regions were aggregated into one category, the Rio Grande River Basin (RGRB) whenever possible. As can be seen, the county definitions don't always conform to the hydrologic boundaries. Due to the methodology of reporting most types of economic data, the county definition had to be used. In almost all counties the concentrations of population and economic activity is within the hydrologic boundaries. The major user of water, agriculture, is certainly located within the confines of the hydrologic boundaries; except in Santa Fe county where a significant portion of the irrigated agriculture takes place in the Estancia Basin, part of the Central Closed Basin.



BASIN INDEX

ARKANSAS RIVER BASIN
1-1, CANADIAN RIVER
1-2, PURGATOIRE RIVER
1-3, CIMARRON RIVER
1-4, CARRIZOZO CREEK
1-5, NORTH CANADIAN RIVER
1-6, CARRIZO CREEK

SOUTHERN HIGH PLAINS
2-1, RED RIVER
2-2, BRAZOS RIVER
2-3, LEA PLATEAU

PECOS RIVER BASIN
3-1, PECOS RIVER

CENTRAL CLOSED BASINS
4-1, ESTANCIA BASIN
4-2, JORNADA DEL MUERTO BASIN
4-3, TULAROSA BASIN
4-4, SALT BASIN

RIO GRANDE BASIN
5-1, RIO GRANDE
5-2, COSTILLA CREEK
5-3, RIO SAN ANTONIO

WESTERN CLOSED BASINS
6-1, NORTH PLAINS
6-2, SAN AUGUSTIN PLAINS

SAN JUAN RIVER BASIN
7-1, SAN JUAN RIVER
7-2, NAVAJO RIVER

LOWER COLORADO RIVER BASIN
8-1, LITTLE COLORADO RIVER
8-2, SAN FRANCISCO RIVER
8-3, GILA RIVER
8-4, SAN SIMON CREEK

SOUTHWESTERN CLOSED BASINS
9-1, ANIMAS BASIN
9-2, MIMBRES BASIN
9-3, PLAYAS BASIN
9-4, WAMEL BASIN
9-5, SAN LUIS BASIN
9-6, HACHITA BASIN

Drainage basins of New Mexico

Following is a county definition of the regions and the associated names used within the major study and this paper:

Definition of Regions

Region	Sub-Basin Name	Counties
1	Upper Rio Grande	Taos Rio Arriba Santa Fe Los Alamos
2	Middle Rio Grande	Bernalillo Sandoval Valencia
3	Socorro	Socorro
4	Lower Rio Grande	Dona Ana Sierra
5	Rest of State	Remaining twenty-two counties

Economic Description of the Rio Grande River Basin

The basic importance of the Rio Grande and its associated ground water basin to the economy of New Mexico can be illustrated by looking at some basic economic data. Table 1 presents the census year population estimates for both the state as a whole and the Rio Grande River Basin.[2] Today the Basin area is approximately 75% urban in make-up. The urban group within the Basin comprises over 60% of the total urban population within the state. The greatest growth occurred in the 50's for the Basin as a whole, with an apparent slowing down of the growth rate in the 60's. However, several selected areas within the Basin (primarily Albuquerque) continued to show a marked increase in growth during the previous decade.

In 1967, with slightly over half of the state's population residing within the ten counties of the Basin (county definition), over 58% of the total state income was accounted for within the RGRB. In 1970 the percent of total income increased to over 59%.[3] The Basin had a per capita income average of over $2,500, approximately $100 above the state average.

Table 2 presents ESC employment data for the years 1960 and 1970. In all reported categories, except agriculture, the Basin has increased its portion of the total employment in the state; thus further pointing out the growing economic importance of this area in the preceding decade.

[2] County definition.

[3] Unpublished information from the Bureau of Business Research, UNM.

Table 1

Population for New Mexico and the Rio Grande Basin

	Urban	Percent of* Total	Rural	Percent of Total	Total	Percent Change from 1960 Census
1950						
New Mexico	341,889	50.2	339,298	49.8	681,187	28.1
Rio Grande Basin	175,230	53.5(51.3)	152,557	47.2(45.0)	327,787	(A)
Rest of State	166,659	47.2(48.7)	186,741	52.8(55.0)	353,400	(A)
1960						
New Mexico	626,479	65.9	324,544	34.1	951,023	39.6
Rio Grande Basin	318,553	57.2(50.8)	237,948	42.8(73.3)	556,501	70.0
Rest of State	307,926	78.0(49.2)	86,544	22.0(26.7)	394,522	11.6
1970						
New Mexico	708,775	69.8	307,225	30.2	1,016,000	6.8
Rio Grande Basin	427,440	74.7(60.3)	144,730	25.3(47.1)	572,170	2.8
Rest of State	281,335	63.4(39.7)	162,495	36.6(52.9)	443,830	12.5

* The percentsin parentheses represent the two regions' portion of urban and rural population respectively, on a state-wide basis.

(A) Los Alamos county did not exist in 1940; percentage change therefore not calculable.

Table 2

Employment[1] for New Mexico and the Rio Grande River Basin[2]

Classification	1960 Rio Grande River Basin	% of Total	Rest of State	% of Total	Total	1970 Rio Grande River Basin	% of Total	Rest of State	% of Total	Total
Total Civilian Work Force	170,391	52.26	155,609	47.73	326,000	214,608	57.39	159,292	42.60	373,900
Unemployment	9,650	53.02	8,550	45.16	18,200	12,907	54.45	10,793	45.54	23,700
Rate	5.7		5.5			6.0		6.7		
Non-Ag. Wage & Salary	131,691	55.73	104,609	44.26	236,300	175,053	60.36	114,947	39.63	290,000
Manufacturing	10,146	60.75	6,554	39.24	16,700	12,727	60.03	8,473	39.96	21,200
Mining	1,761	8.63	18,639	91.36	20,400	1,620	9.58	15,280	90.41	16,900
Contract Construction	10,521	55.96	8,279	44.03	18,800	10,870	68.36	5,030	31.63	15,900
Public Utilities, Transportation, & Communications	10,091	48.98	10,509	51.01	20,600	10,254	51.01	9,846	48.98	20,100
Wholesale & Retail Trade	26,750	54.14	22,650	45.85	49,400	37,829	62.01	23,171	37.98	61,000
Real Estate, Finance, & Insurance	6,391	66.57	3,209	33.42	9,600	8,639	69.66	3,761	30.33	12,400
Services & Misc.	25,437	68.19	11,863	31.80	37,300	37,236	69.60	16,264	30.40	53,500
Government	40,272	63.45	23,205	36.55	63,477	56,640	63.56	32,460	36.43	89,100
All Other Non-Ag.	21,121	46.62	24,179	53.37	45,300	19,952	50.13	19,848	49.86	39,800
Agriculture	7,897	43.19	10,384	56.80	18,281	6,126	30.32	14,074	69.67	20,200

[1] Based on ESC data.

[2] County definition.

Previous Studies

The states of Arizona, Utah, and California (as well as several others) have done some work in the area of relating water use to production. We have attempted to follow their lead and develop some relationships for the different sectors of the economy within New Mexico, and more specifically, for the Rio Grande River Basin and its related sub-basins or regions. Typically, intake use, consumptive use, and total water use (gross water use) have been examined by previous studies. For the purpose of this paper, however, water intake was the prime area of concern. There exists very little data on gross water use (although we suspect it is very close to water intake in most industries) in New Mexico; and little detailed information on the scale necessary for accurate consumptive use calculation. Therefore, the bulk of interpretation and the subsequent analysis deals primarily with new water intake and its relationships to the economy.

Definition of the Economic Sectors

The economy of New Mexico is made up of many processing or production sectors. From the 1960 I-O Table constructed by the Bureau of Business Research (BBR)[4], a total of twenty-four industries (after aggregation) was used for the study, with the result that not all of the sub-basins (regions) would be represented by each and every "industry." Cotton production is a good example. Regions 1 and 2 of course don't have any acreage devoted to cotton (for various reasons), and therefore no dollar production in this particular "industry." The sector definitions, SIC code classifications, and relationship to the 1960 I-O study are presented on the following page.

Diversion and Depletions

For the purpose of this paper an estimate was made of the major beneficial diversions and depletions for each region from initial results of the model. In Tables 3 and 4 these estimates are summarized for basic "sector" classifications. Of course, agriculture is by far the largest user of water within the Basin; but it should be noted that in Region 2, the middle valley area, other users do compose a significant percentage of the total. It should be kept in mind that both diversions and depletions within the RGRB in the agriculture sector are primarily from surface water supplies (with the remaining supplies of course being ground water). The remaining users are supplied almost entirely from ground water. For ground water sources, only a small portion of the difference between diversion (pumpage) and depletion is returned to the ground water aquifer in the immediate area; whereas the agricultural sectors return their unused portion (after non-beneficial depletions have been considered) of surface water diversions to the streams and drainage ditches. Thus for surface water users, the consumptive use (both beneficial and non-beneficial) is the more appropriate measure of water use within the Basin. For ground water users, the pumpage is probably the

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4 "A Preview of the Input-Output Study," BBR, October 1965, reprint from New Mexico Business.

Sector Definitions

No.	Classification	Description	1960 I-O Study[1]	Major SIC Codes
1	Ag1	Meat Animals, Farm, Dairy Products and Poultry	1,2	
2	Ag2	Food Grains and Feed Crops	3	
3	Ag3	Cotton and Cottonseed	4	
4	Ag4	Vegetables, Fruits and Nut Trees, Miscellaneous Farm Products	5	
5	Ag5	Agricultural Services	6	7
6	Min1	Metals and Non-Metals	7,8,11,12	10,12,14
7	Min2	Crude Petroleum and Natural Gas Oil and Gas Field Services	9,10	13
8	Man1	Meat Packing and Other Meat Products	13	201
9	Man2	Dairy Products	14	202
10	Man3	Grain Mill and Bakery	15	204,205
11	Man4	Miscellaneous Food Products	16	remainder of 20
12	Man5	Lumber and Wood Products, Concrete and Stone Products	17,21	24,25,32
13	Man6	Chemicals, and Petroleum Refining	19,20	28,29
14	Man7	Electrical Machinery and Equipment Fabricated Metal Products and Scientific Instruments	22,23	19,34,35 38 36,371-72-73
15	Man8	Printing and Publishing, Miscellaneous Manufacturing	18,24	22,23,27 31,39
16	TCU1	Railroads and all other Transportation	25,26	40,41,42,45,47
17	TCU2	Gas and Oil Pipelines	27	46,4924
18	TCU3	Communications,Electric and Gas Utilities	28,29,30	48,49
19	Tr1	Wholesale Trade and Most Retail Trade	31,34	56,57,59,50,52, 53,54
20	Tr2	Retail Auto Dealers and Gas Stations Eating and Drinking Places	32,33	55,58
21	FIRE1	Finance, Insurance, and Real Estate	35,36	65,66,67,60,61,62, 63,64
22	Ser1	Hotels, Motels, Personal Services, Business Services	37,38,39,40	70,72,73,75, 76,78,79
23	Ser2	Medical and Professional Services, Research Development	41,42	80,81,82,88, 89,37(P)
24	CON1	Contract Construction	47	15,16,17

[1] Refers to "A Preview of the Input-Output Study," Bureau of Business Research, 1965, a reprint from New Mexico Business.

Table 3

Estimated Total Diversions[1] by Major Sectors in Each Region

Major Sector	Region 1	Region 2	Region 3	Region 4	R.G.R.B.[2]
1. Agriculture[3]	197,000	253,000	100,000	647,000	1,197,000
a. Surface	188,000	238,000	81,000	560,000	1,067,000
b. Ground	9,000	15,000	19,000	87,000	130,000
2. Mining, Oil and Gas	7,100	3,750	300	300	11,450
3. Industrial	2,250	14,850	300	875	18,275
4. Commercial Trade and Services	10,500	34,250	500	4,775	50,025
5. Municipal[4]	7,100	51,150	825	8,725	67,800
6. Rural	3,400	4,200	350	1,750	9,700
Total	227,350	361,200	102,275	663,425	1,354,250

Percentage of the Regional Total

Major Sector	Region 1	Region 2	Region 3	Region 4	R.G.R.B.[2]
1. Agriculture[3]	86.65	70.04	97.77	97.52	88.38
2. Mining, Oil and Gas	3.11	1.03	0.29	0.04	0.84
3. Industrial	1.00	4.11	0.29	0.13	1.34
4. Commercial Trade and Services	4.61	9.48	0.48	0.71	3.69
5. Municipal[4]	3.10	14.16	0.80	1.31	5.00
6. Rural	1.49	1.16	0.34	0.26	0.71
Total	100.00	100.00	100.00	100.00	100.00

[1] Diversions estimated by using information from NMSU, the State Engineer's Office, as well as from several other states. The diversions are in acre-feet.

[2] Total of the four regions.

[3] Includes stock pond evaporation and irrigated pasture - first number is total of ground and surface.

[4] Includes the public and governmental sectors.

Table 4

Estimated Total Depletions[1] by Major Sectors in Each Region

Major Sector	Region 1	Region 2	Region 3	Region 4	R.G.R.B.[2]
1. Agriculture[3]	80,000	105,000	43,000	278,000	506,000
a. Surface	75,000	95,000	32,000	225,000	427,000
b. Ground	5,000	10,000	11,000	53,000	79,000
2. Mining, Oil and Gas	3,030	1,500	150	150	4,730
3. Industrial	250	1,500	25	100	1,875
4. Commercial Trade and Services	4,200	13,700	200	1,900	20,000
5. Municipal[4]	3,550	28,600	400	5,250	37,800
6. Rural	2,050	2,550	200	1,050	5,650
Total	93,080	152,850	43,975	286,450	576,155

Percentage of the Regional Total

Major Sector	Region 1	Region 2	Region 3	Region 4	R.G.R.B.[2]
1. Agriculture[3]	85.94	68.69	97.78	97.05	87.82
2. Mining, Oil and Gas	3.25	0.97	0.34	0.05	0.83
3. Industrial	0.26	0.98	0.05	0.03	0.32
4. Commercial Trade and Services	4.51	8.96	0.45	0.66	3.47
5. Municipal[4]	3.81	18.71	0.90	1.83	6.56
6. Rural	2.20	1.66	0.45	0.36	0.98
Total	100.00	100.00	100.00	100.00	100.00

[1]Depletions estimated by utilizing depletion to diversion ratios and by using information from the State Engineer's Office, as well as from several other states in the Southwest. The depletions are in acre-feet.

[2]Total of the four regions.

[3]Includes stock pond evaporation and irrigated pasture - first number is total of ground and surface.

[4]Includes the public and governmental sectors.

better measure of use for the ground waters in the Basin. Part of pumpage from the ground water basin is drawn from the river. Therefore, in actuality, surface water use is somewhat more than the estimates presented in the tables. [Although the question of actual amounts of surface water flow into the ground water aquifer has been studied considerably by hydrologists and the State Engineer's Office, their findings (with their tendency to revise the surface and ground waters estimated relationships through time) were not considered in this paper. The larger study and model do however require these findings and estimates of the associated relationships. Again, this paper is concerned with primarily new water intake, whether it be surface or ground supplies.]

Agriculture accounts for approximately 88% of the consumptive uses of water within the Basin. Most of the remainder goes to the municipal and commercial sectors. Again, in Region 2 these sectors do account for a significant portion of consumptive water use. About 75% of the consumptive use is from surface supplies, while the remainder comes from the ground water basin. (This does not take into account equilibrium questions and the portion of ground water that is actually derived from surface water supplies. In the Albuquerque area, for example, approximately 70% of the ground water is in reality from the stream flow itself.)

Production and New Water Use by the Rio Grande River Basin

The next table presents water intake use by each of the twenty-four production sectors within the Basin. An estimate was first made of the dollar value of output in each of these "industries" for each region and then summed to arrive at an aggregate total for the RGRB. (Information from all four regions is used in the larger study.) This appears in column 2 of Table 5, along with their relative ranks in column 3. As can be seen, the trade and commercial sectors as a whole rank above the agricultural sectors. Figure 1 illustrates pictorially the magnitudes involved for all these sectors.

An estimate of a water-intake coefficient was derived next from various sources.[5] This coefficient tells us how much new water is needed to produce a million dollars of final product in a specific industry. These estimates appear in column 4 of Table 5 along with their relative rankings in column 5. Again, it should be remembered that presently the majority of agricultural water intake is from surface supplies, while the remaining sectors' intake is from ground waters. However, in the future it should be noted that any additional water intake by the agricultural sectors will have to come from the ground water basin due to the present full appropriation of surface water rights (once again ignoring the interdependent relationship of the two "water basins"). Figure 2 presents these estimates in graphical form. By way of comparison, agriculture uses water (intake) in quantities of ten to two-hundred times as great as that for all other users in the production of a million-dollar unit of final product. This points out even further the well recognized fact of the tremendous amount of water needed to keep agriculture production at the present level it enjoys today.

[5] Information and data was used from previous studies in the states of Arizona, California, and Utah; national manufacturing censuses and studies; and from published and unpublished material of the New Mexico State Engineer's Office.

Table 5

Production and New Water Use by New Mexico (Regional) Sectors

Rio Grande River Basin

Sectors	Output in Dollars[1]	Rank	Water Intake Coefficient[2]	Rank	Estimated Total Use[3]	Rank
Ag1	39.452511	13	3,782.34	4	149,223	3
Ag2	9.271483	22	56,459.90	1	523,467	1
Ag3	10.781332	21	39,770.23	2	428,776	2
Ag4	23.967717	16	5,238.92	3	125,565	4
Ag5	5.368773	24	6.00	24	31	24
Min1	81.784277	9	90.96	10	7,439	9
Min2	26.276066	14	151.62	7	3,984	13
Man1	20.651193	17	30.07	15	621	21
Man2	25.948143	15	42.66	12	1,107	19
Man3	14.197216	18	14.09	19	200	22
Man4	13.069654	20	144.46	8	1,888	15
Man5	56.157858	11	152.00	6	8,536	7
Man6	7.924270	23	374.04	5	2,964	14
Man7	70.344963	10	22.23	18	1,564	16
Man8	50.457791	12	27.21	16	1,373	17
TCU1	109.912530	6	6.23	22	685	20
TCU2	13.498663	19	6.22	23	84	23
TCU3	104.965017	7	106.86	9	11,217	6
Tr1	325.237252	2	12.28	21	3,993	12
Tr2	98.320701	8	13.62	20	1,339	18
FIRE1	177.372787	3	24.54	17	4,352	11
Ser1	151.552051	5	32.02	13	4,852	10
Ser2	517.959649	1	30.74	14	15,921	5
Con1	172.461980	4	44.04	11	7,596	8

[1] Estimated for 1967 in million-dollar units.

[2] The amount of new water in acre-foot units needed to produce one million dollars in final product.

[3] In acre-foot units.

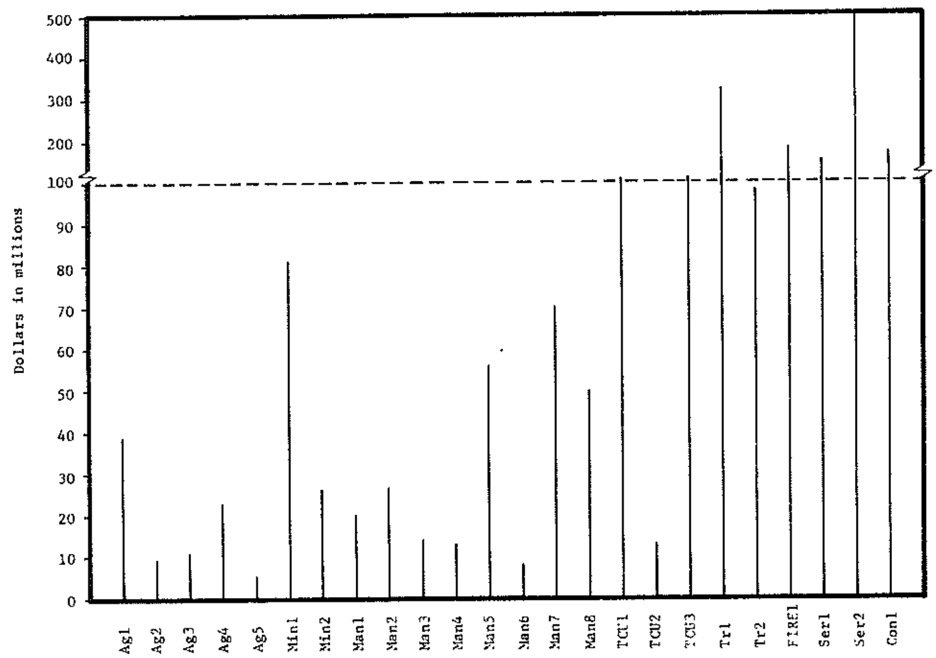

Figure 1. Output in million dollar units for the RGRB.

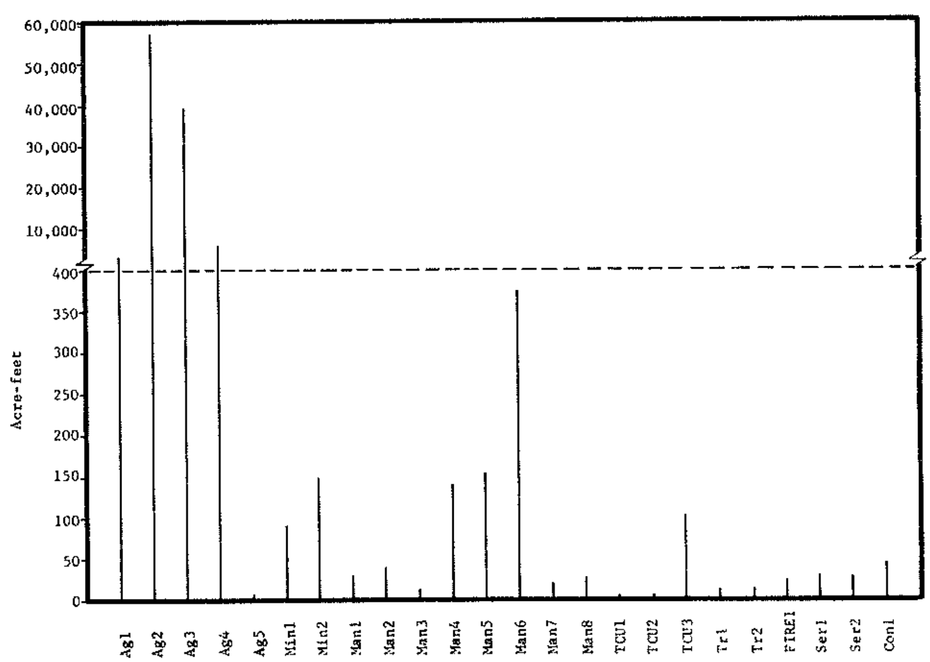

Figure 2. New water intake coefficient per million dollars of input for the RGRB.

By taking the output estimates (column 2) and multiplying by the estimated water intake coefficient (column 4), an estimate for total use was derived. These estimates appear in column 6 of Table 5 along with their relative rankings in column 7. Once again, a tremendous gap in magnitude exists between the agricultural sectors and the remaining production "industries." Figure 3 illustrates, by way of the line graph, these differences.

[It should be pointed out at this time that all of the information in this paper has been estimated from many primary and secondary sources. Even though many of the estimated numbers have several decimal places attached to them, they should not be construed as a presentation of the accuracy of any of these estimates themselves. But rather, they are used in order to point out the differences in magnitudes. These estimates of the coefficients and multipliers should serve as tools in the planning process of future water use and evaluation, as well as helping to point out the economic direction future water use should take.]

Output per Acre-Foot of New Water Intake

Table 6 presents the preceding material, as well as several other estimates, in a slightly different manner. Column 2 is the amount of final product per acre-foot of new water intake within the Rio Grande River Basin.[6] In column 3 appear the relative rankings of each of the sectors. Notice here that agriculture is of considerable magnitude below the other sectors. Care should be taken here in the interpretation of this information for policy formulation. According to this table, agricultural services (Ag5), transportation (TCU1), and oil and gas pipelines (TCU2) seem to be the logical choices for additional water allocation due to their high output to water ratios. It must always be kept in mind that many other factors play a role in the determination of the best economic use of additional water supplies. The demand for the final product here would dictate that unless production increased in certain other sectors at first, there would be no additional demand for agricultural services or transportation and pipeline industries. Figure 4 pictures the relative magnitudes of the estimates involved in column 2.

Income and Value-Added per Acre-Foot of New Water Intake

In addition to the output per acre-foot estimate, two more estimates were made in Table 6. The first, income per acre-foot of new water intake (column 4) was derived by calculating the household income to final product ratio for each sector and then using this ratio to calculate the income coefficient. The relative rankings (column 5) remain pretty much the same as for output to water, except in several cases. Thus, the estimates appearing in column 4 represent the amount of income (average) accruing to the population of the Basin from each acre-foot of new water intake in that particular sector. Columns 6 and 7 contain the dollar value-added per acre-foot of new water intake and their associated relative rankings. Value-added not only includes the income paid to households, but also taxes paid to all forms of government, plus depreciation and capital consumption. Figures 5 and 6 pictorially present both of the "coefficients." It should be noticed that

[6] Derived by using weighted averages from the four regions or sub-basins.

Table 6

Output, Income, and Value-Added per Acre-Foot of New Water Intake

Rio Grande River Basin[1]

Sector	Output in[2] Dollars	Rank	Income in[2] Dollars	Rank	Value Added[2] in Dollars	Rank
Ag1	380.41	21	120.19	22	130.51	22
Ag2	17.83	24	10.95	24	11.60	24
Ag3	25.16	23	14.66	23	15.44	23
Ag4	224.76	22	171.69	21	177.42	21
Ag5	173,341.07	1	103,192.76	1	107,439.27	1
Min1	11,686.29	15	6,069.38	14	7,473.69	13
Min2	6,595.62	19	3,663.67	17	4,782.24	17
Man1	33,256.11	10	5,338.42	15	5,891.58	16
Man2	23,440.57	13	6,073.22	13	6,139.52	15
Man3	72,890.73	6	19,994.20	6	21,386.47	7
Man4	7,095.99	17	2,570.01	19	2,663.78	19
Man5	7,041.83	18	3,062.43	18	3,354.61	18
Man6	2,673.51	20	540.96	20	590.44	20
Man7	45,297.58	7	17,390.35	8	19,064.94	9
Man8	38,652.83	9	18,825.69	7	20,440.49	8
TCU1	160,456.69	3	73,635.13	3	106,486.49	8
TCU2	160,700.27	2	92,152.68	2	110,813.71	2
TCU3	9,565.44	16	4,429.40	16	6,214.95	14
Tr1	81,443.99	4	48,725.91	4	53,710.21	4
Tr2	73,437.31	5	48,086.77	5	52,285.30	5
FIRE1	40,756.62	8	8,230.14	12	30,212.04	6
Ser1	31,321.14	12	16,724.22	10	18,267.85	10
Ser2	32,533.13	11	17,033.51	9	18,000.11	11
Con1	22,704.32	14	8,820.67	11	9,431.16	12

[1] Total of all ten counties within the county definition of the Rio Grande River Basin.

[2] These numbers represent weighted averages of all four regions within the county definition of the Basin.

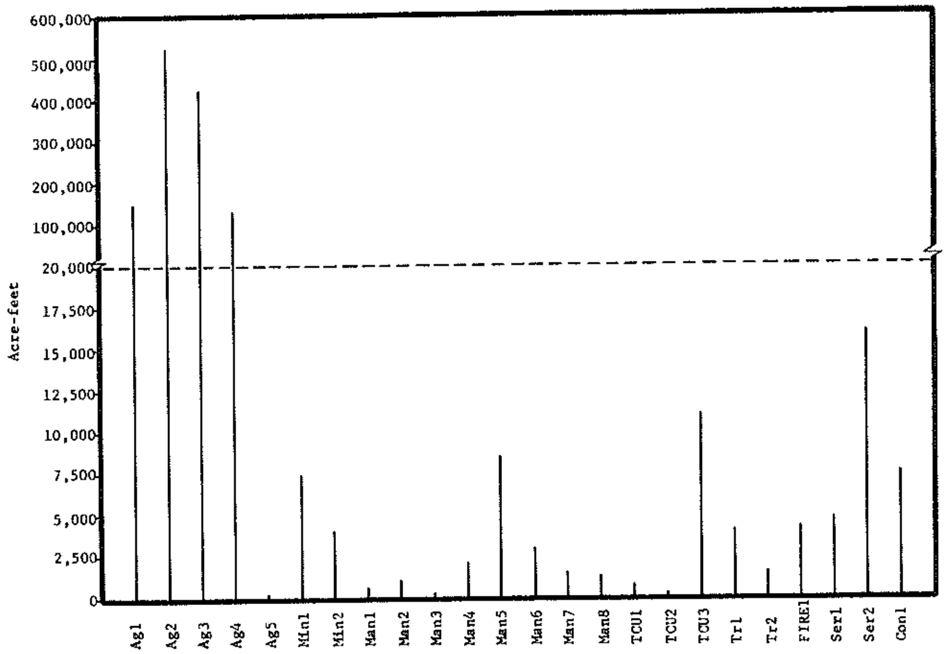

Figure 3. Total estimated new water intake for the RGRB.

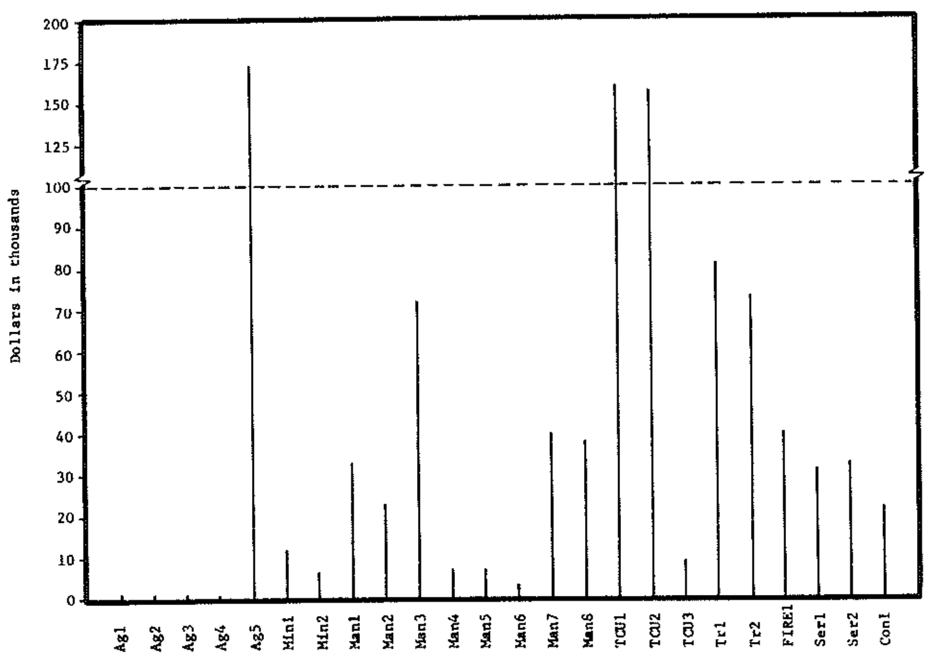

Figure 4. Output per acre-foot of new water intake in the RGRB.

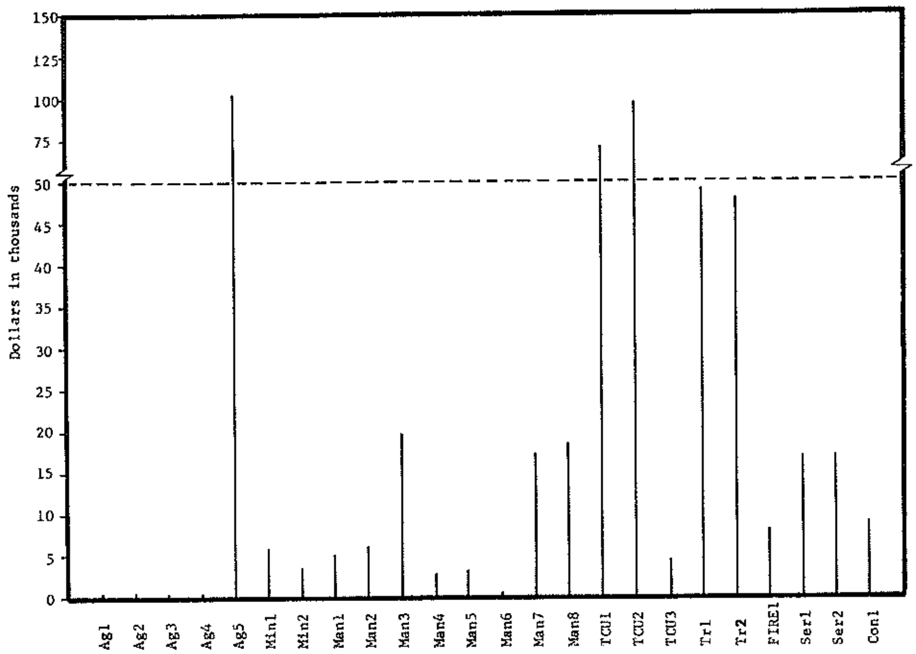

Figure 5. Income per acre-foot of new water intake in the RGRB.

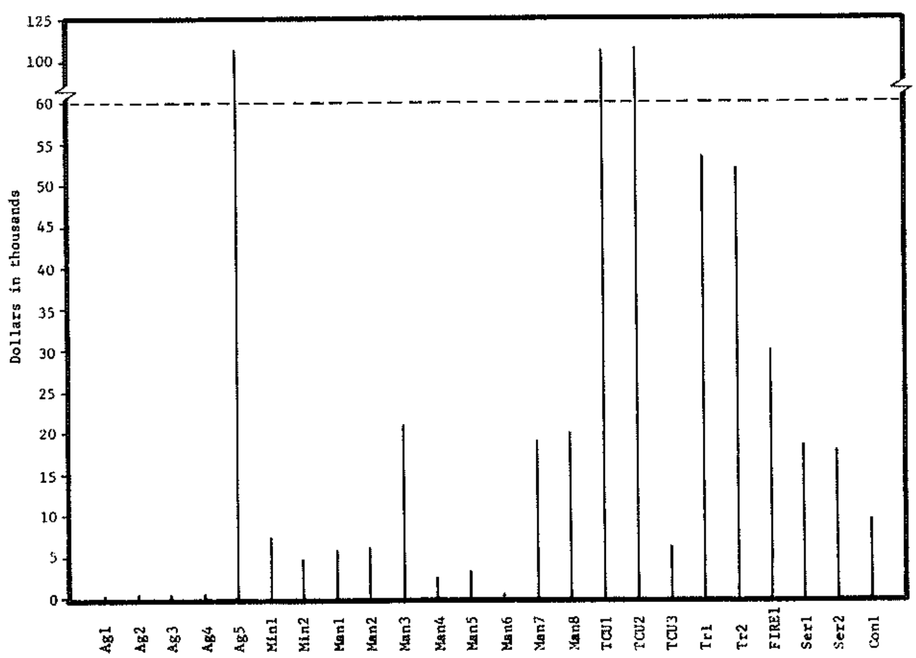

Figure 6. Value-added per acre-foot of new water intake in the RGRB.

the commercial and trade sectors are as a whole significantly above the manufacturing industries; and both of these major areas are substantially greater than the agricultural "sector."

Employment and Direct Employment per Acre-Foot of New Water Intake

Table 7 contains the estimated direct employment totals[7] and coefficients per acre-foot of new water intake for each sector within the RGRB. Columns 2 and 3 summarize the estimates on covered production employment, with column 3 containing the relative rankings. Here a different pattern is noticed. The commercial and trade sectors are employing considerably more people than the remaining sectors, but now the agricultural sectors rank above the manufacturing sectors. However, when looking at the employment per acre-foot of new water intake estimate (column 4), the familiar pattern re-emerges: the commercial and trade "sectors" are greater than manufacturing, which in turn is substantially greater than the agriculture "sector." Column 5 lists the relative rankings of the coefficient. Figures 7 and 8 again pictorially represent the two sets of estimates.

Direct and Indirect New Water Intake Requirements

The next table (Table 8 - a separate table was derived from information on the entire Basin for each region - only Region 2 is used in this paper) begins to throw a little more light on the total use of water within the production process. [Due to the set-up of the inter-dependences and the basin matrix of transactions, it is impossible to arrive at a representative average for the entire Rio Grande River Basin (RGRB), as was done in the previous tables.] Each industry buys from and sells to the other industries within the region. Not every sector needs to buy from and sell to each and every other sector, but it is enough just to have some of the interconnections within and between the regions to change the concept of total water requirements. Column 2 of Table 8, the direct and indirect requirement, gives us the total amount of new water intake required to produce one-million dollars of the product for final demand in that sector. This takes into account all of the water used by the industries it purchases its inputs from to produce one-million dollars. Figure 9 illustrates the relative differences among the sectors.

Perhaps an example may help to clarify this concept. The retail and wholesale sector purchases inputs from many firms in order to be able to sell commodities; such as from the serivce sector to package and merchandise the product, transportation sectors to deliver the inputs and final commodities, the manufacturing sectors from where the inputs are purchased in either finished or semi-finished form, and so on. Now these inputs required water for their production. These inputs in turn required raw materials as well as other semi-processed resources in their production process which required water for their initial production. In other words, the direct and indirect

[7] Estimated from ESC data on covered wage and salary employees. The total employment for all twenty-four production sectors represent only a portion of total estimated employment in all categories. The production sectors exclude government, self-employed, and non-covered workers.

Table 7

Total Employment[1] and Direct Employment per Acre-Foot of New Water Intake

Rio Grande River Basin

Sector	Employment[1]	Rank	Employment[2] per Acre-Foot	Rank
Ag1	2,055	13	0.0137	22
Ag2	1,223	14	0.0023	23
Ag3	542	16	0.0012	24
Ag4	3,366	10	0.0268	21
Ag5	503	20	16.2266	1
Min1	1,136	15	0.1542	18
Min2	302	21	0.0758	19
Man1	273	22	0.4397	14
Man2	505	19	0.4565	13
Man3	535	18	2.6772	7
Man4	539	17	0.2866	16
Man5	2,329	11	0.2728	17
Man6	109	24	0.0368	20
Man7	4,019	9	2.5697	8
Man8	2,139	12	1.5595	10
TCU1	5,007	7	7.3116	3
TCU2	267	23	3.2051	5
TCU3	4,520	8	0.4030	15
Tr1	22,070	1	5.5272	4
Tr2	11,301	4	8.4435	2
FIRE1	7,233	6	1.6634	9
Ser1	13,169	3	2.7141	6
Ser2	17,474	2	1.0975	12
Con1	9,558	5	1.2583	11

[1] As estimated from ESC data on covered wage and salary workers contained within each sector's SIC codes.

[2] A weighted average of the four regions.

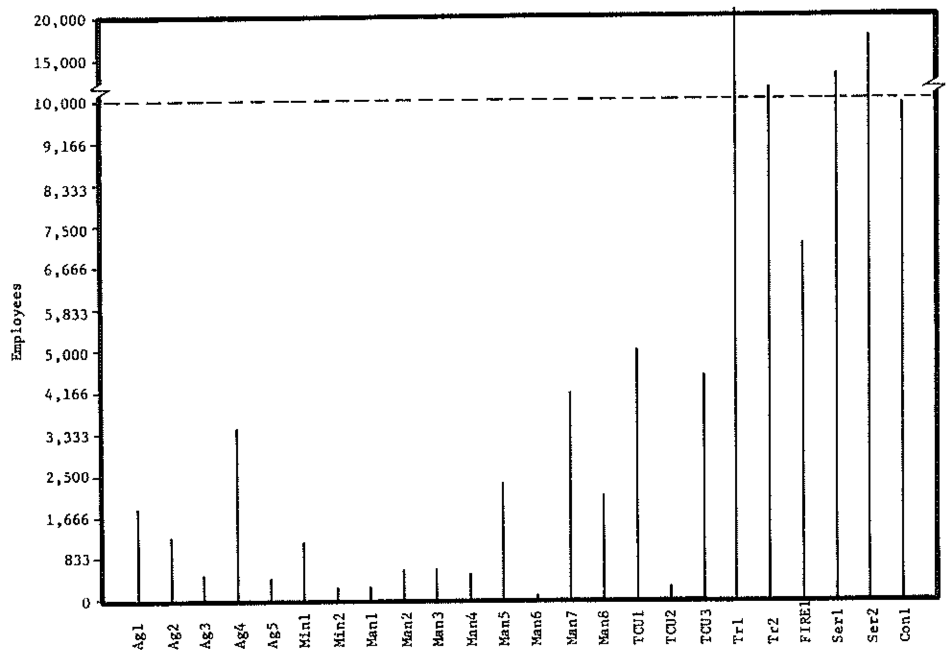

Figure 7. Total employment[1] by sector in the RGRB.

[1] ESC covered 2-digit SIC codes.

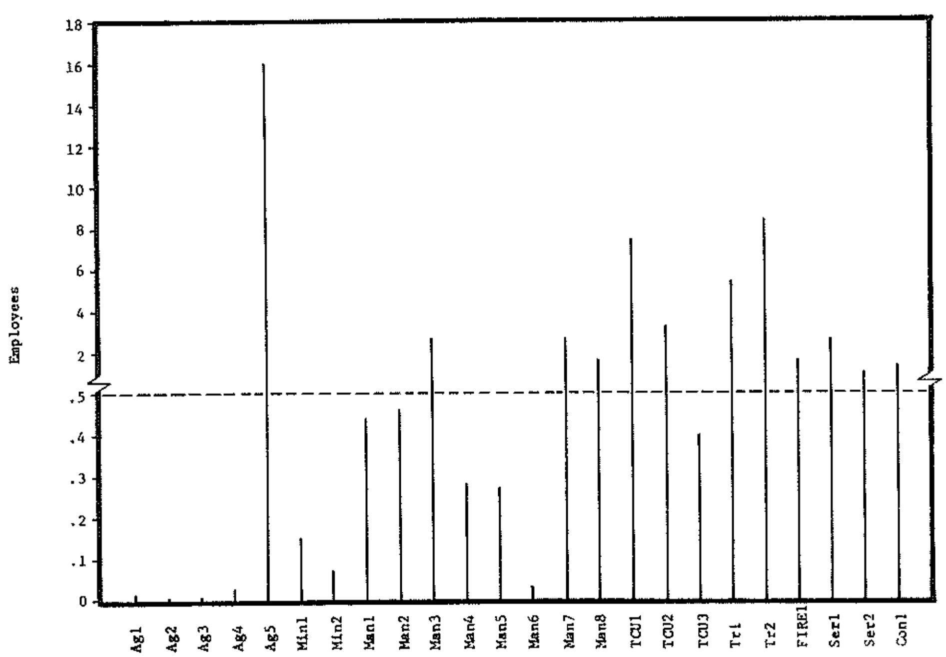

Figure 8. Employment[1] per acre-foot of new water intake in the RGRB.

[1] Estimated from ESC data.

Table 8

Direct and Indirect New Water Intake Requirements,* Water Multiplier and Weighted Water Multiplier*

Region 2

Sector	Direct and Indirect Req.[1]	Rank	Multiplier[2]	Rank	Weighted Multiplier[3]	Rank
Ag1	2,751.92	7	1.0181	21	872.60	13
Ag2	60,057.51	1	1.0119	22	2,763.01	9
Ag3	0.0		0.0		0.0	
Ag4	22,748.19	2	1.0005	23	1,382.09	10
Ag5	19,581.15	3	3,263.5300	1	2,920.65	8
Min1	83.09	21	1.1591	19	298.61	18
Min2	213.84	17	1.4251	17	117.03	21
Man1	43.82	23	1.4568	16	87.29	23
Man2	56.79	22	1.3306	18	116.78	22
Man3	722.23	11	53.2618	6	885.41	11
Man4	163.91	18	1.1436	20	137.94	20
Man5	603.99	12	3.9537	14	785.76	15
Man6	1,094.98	10	2.9270	15	566.58	17
Man7	147.75	20	6.4917	13	797.07	16
Man8	357.65	14	15.3104	11	874.16	12
TCU1	155.98	19	25.0771	8	866.92	14
TCU2	328.92	15	52.8810	7	207.60	19
TCU3	2,388.78	9	24.7337	9	10,681.05	6
Tr1	6,809.77	5	554.5651	2	154,909.89	1
Tr2	2,444.84	8	179.6356	4	15,141.43	5
FIRE1	9,579.92	4	390.3798	3	79,394.15	2
Ser1	4,256.24	6	135.3766	5	29,266.13	3
Ser2	609.77	13	19.8364	10	19,969.92	4
Con1	295.27	16	6.7046	12	3,469.38	7

* In acre-foot units.

1 The amount of new water intake, both indirect and indirect, per million-dollar unit increase in final demand output by this particular sector.

2 The direct and indirect new water intake requirement divided by the direct new water intake.

3 Based upon a 10% change in final demand multiplied by the direct and indirect new water intake requirement.

Table 5

Production and New Water Use by New Mexico (Regional) Sectors

Region 2

Sectors	Output in[1] Dollars	Rank	Water Intake[2] Coefficient	Rank	Estimated[3] Total Use	Rank
Ag1	13.973370	16	2,720.91	3	38,020	2
Ag2	3.433238	22	59,348.92	1	203,759	1
Ag3	0.0		0.0		0	
Ag4	0.684840	23	22,736.26	2	15,571	3
Ag5	3.580411	21	6.00	23	21	23
Min1	38.522670	11	71.77	9	2,764	12
Min2	6.569016	20	150.05	6	986	15
Man1	20.370050	14	30.08	14	613	19
Man2	22.287410	13	42.68	11	951	16
Man3	14.011440	15	13.56	19	190	21
Man4	9.547336	17	142.70	7	1,362	14
Man5	41.793230	10	156.08	5	6,523	6
Man6	7.924270	19	374.10	4	2,964	11
Man7	63.856710	8	22.76	17	1,453	13
Man8	34.139190	12	23.36	16	797	18
TCU1	62.469580	9	6.22	21	389	20
TCU2	8.979109	18	6.22	22	56	22
TCU3	73.617620	6	96.58	8	7,110	5
Tr1	260.460500	2	12.28	20	3,198	9
Tr2	68.974120	7	13.61	18	939	17
FIRE1	138.893800	3	24.54	15	3,408	8
Ser1	98.213680	5	31.44	12	3,088	10
Ser2	345.814600	1	30.74	13	10,630	4
Con1	123.627500	4	44.04	10	5,445	7

[1] Estimated for 1967 in million-dollar units.

[2] The amount of new water in acre-foot units needed to produce one million dollars of final product.

[3] In acre-foot units.

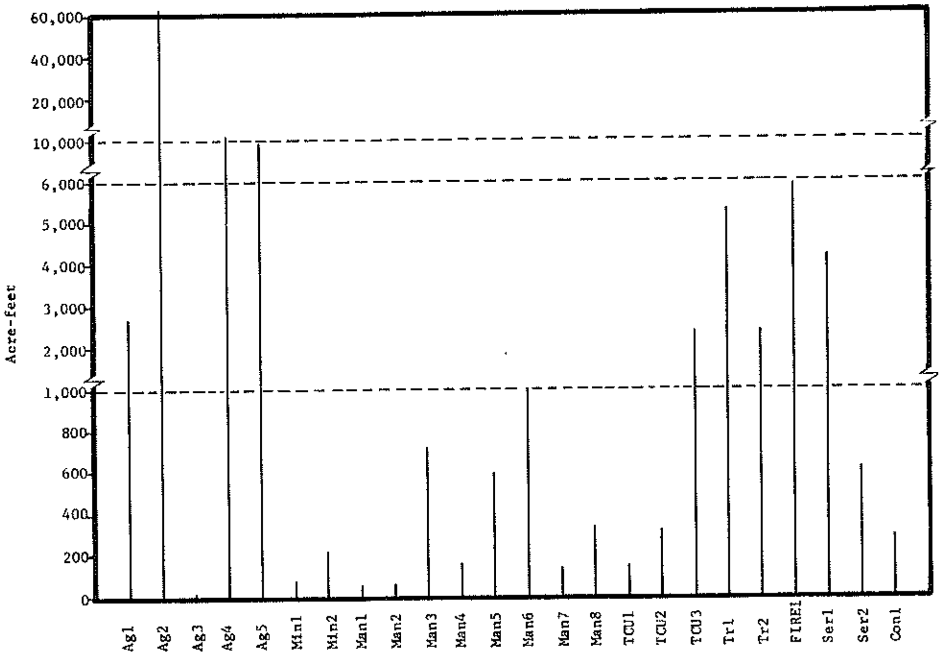

Figure 9. The direct and indirect new water intake per million dollars of output for final demand - Region 2, RGRB.

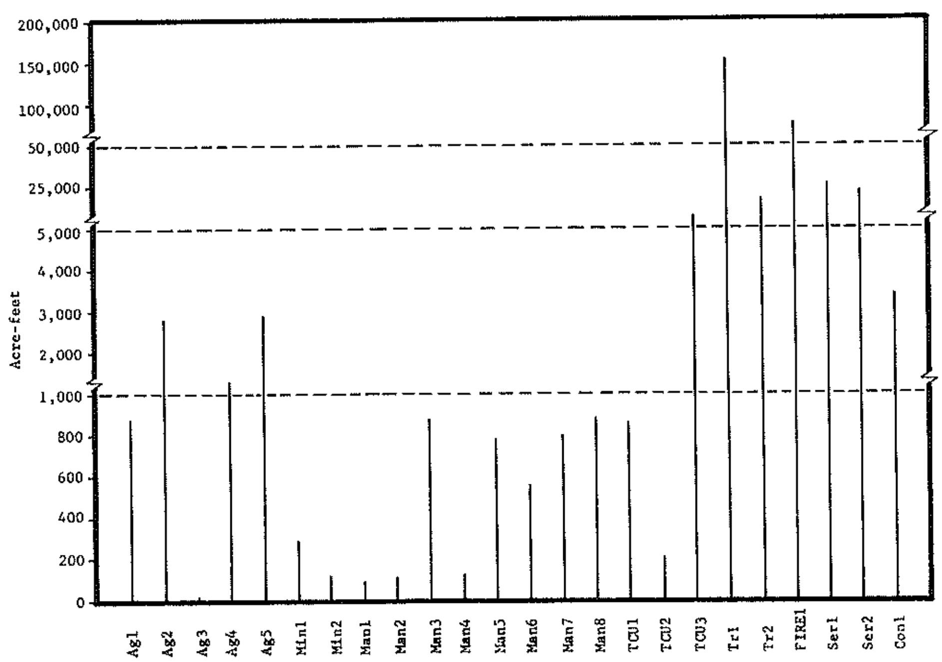

Figure 10. Weighted Multiplier: Based on 10% change in final demand - Region 2, RGRB.

water requirement tells us how much water was used by all the input and raw materials sectors, plus the amount of water needed to do a million dollars worth of business for final demand in that sector.

The relative rankings of the coefficients of direct and indirect water use are listed in column 3 of Table 8. A comparison can be made with the direct water requirements from Table 5 for Region 2 (this follows Table 8 so that a comparison can be made). By subtracting column 4 of Table 5 - the direct new water intake coefficient - from Column 2 of Table 8 - the direct and indirect new water intake requirement - the amount of indirect water use by all the required inputs can be calculated.

Multiplier

Another method of comparison is shown in column 4 of Table 8, the multiplier. This number is actually a ratio, derived by dividing the total direct and indirect requirements by just the direct coefficient. The name multiplier means that if one wanted to increase production in a particular sector, the total required additional water to the system (in this case Region 2) could be calculated by taking the product of the multiplier and the direct new water intake coefficient. The higher the multiplier, the more new water will be needed by the entire system to produce a given increase in a specific sector in comparison to just the water needed by the initiating sector. The relative rankings are presented in column 5 of Table 8.

Weighted Multiplier

Column 6 of Table 8 lists the amount of total water (both direct and indirect) required to meet a ten percent (10%) increase in final demand for that particular sector. Final demand is in many cases substantially less than output in any sector, and represents household and government consumption plus exports of the final product. Of the total output, only a portion is supplied to final demand, the remainder goes to supply the production processes of other industries as inputs; i.e., the metal sector delivers much of its product to other industries as input into their production. Thus when we are speaking of final demand this implies final consumption and export.

A ten percent increase in final demand is probably a better test of changes in future demand. In this case, by using a ten percent change to weight the change in water demand, we present a more reasonable picture of what might take place. Generally speaking, a percent change in exports or consumption is used when measuring future growth possibilities. For example the "weighted multiplier" of column 6 tells us what happens to water intake for a given 10% change in exports of that product. The "weighted multiplier" represents the total new water intake needed by the system (region here) to meet this increase in exports. Column 7 gives the relative rankings of this "weighted multiplier."

[The "weighted multiplier" gives a more realistic picture of possible future new water intake than the direct and indirect water requirements do. As remembered, this later requirement was calculated for a change in total final demand - a million dollars worth. Certain sectors have more potential than others for growth. Certainly in the short run, not all sectors could be expected to increase its final demand output by a million dollars, but at the same time other sectors could be expected to increase their final demand output by substantially more (a much larger production base). In addition, with percentage decreases in final demand for various sectors, the "weighted water multipliers" will tell us the amount of additional water that would then be made available to the system (region) from the decrease in production.]

Two different effects are inherent in the calculations of the "weighted multiplier." First, the amount of direct and indirect water intake per unit of final demand output shows up in the agricultural sectors very vividly (looking at the direct and indirect requirements). However, this effect is dampened considerably because a ten percent change in final demand is much less than the other sectors in these cases. On the other hand, by viewing the commercial and trade "sector," we get the opposite result, a low (relatively) direct and indirect effect, but a substantial effect from the ten percent change in final demand output. Figure 10 illustrates the major magnitudes involved for Region 2.

Direct and Indirect a) Income and b) Employment per Direct and Indirect Acre-Foot of New Water Intake

Table 9 presents possibly the most comprehensive method of analyzing water from an economic point of view. Every production sector generates income payments to households in terms of wages, salaries, profits, etc. Of course, each "industry" or sector doesn't produce the same percent of income per unit of production. At the same time, with each sector purchasing inputs from other sectors, it is responsible for generating some indirect income - income paid to households by the input sectors from their sales to the purchasing sector. Column 2 presents the estimates of generated income from allowing an increased acre-foot water intake to the initiating sector. This water is actually water to the system, with the initiating sector taking a portion of it to increase its production, while the remainder is used by the other "inputting" sectors to supply the initiating sector. Column 3 lists the relative rankings.

[Only Region 2's table is presented for this paper. Again, as in Table 8, due to the construction of the model and analysis, it is impossible to form an aggregate table for the RGRB as a whole, or, to use any efficient weighting mechanism to arrive at an average. Due to the interdependencies implicit in an input-output table, the whole table must be used as a unique unit in this type of evaluation and interpretation of the information. The four regions formed only a portion of the total I-O matrix developed for the state of New Mexico. The forthcoming interdisciplinary study will give a much fuller explanation.]

In addition to income generated to the households, the production process also generates employment. Table 7 presented estimates of employment for each sector. By taking these estimates and dividing them into total output, an employee coefficient per unit of output is derived. The coefficient

Table 9

Direct and Indirect a) Income and b) Employment Effects per Acre-Foot of Direct and Indirect Water Intake by the Initiating Sector

Region 2

Sector	Income Change[1]	Rank	Employment Change[2]	Rank[3]	Adjusted Employment Change[4]
Ag1	153.78	20	0.0342	15	0.0420
Ag2	11.48	23	0.0009	23	0.0011
Ag3	0.0		0.0		0.0
Ag4	33.68	22	0.0048	22	0.0059
Ag5	47.07	21	0.0061	21	0.0075
Min1	6,700.46	1	0.2060	6	0.2533
Min2	2,698109	6	0.0284	16	0.0349
Man1	3,681.50	4	0.3133	4	0.3853
Man2	5,113.70	2	0.3825	3	0.4704
Man3	474.94	13	0.0640	12	0.0787
Man4	2,313.93	7	0.2604	5	0.3202
Man5	1.077.73	12	0.1155	9	0.1420
Man6	219.36	16	0.0164	20	0.0201
Man7	3,318.36	5	0.4404	2	0.5416
Man8	1,596.35	9	0.1450	8	0.1783
TCU1	3,971.11	3	0.4714	1	0.5798
TCU2	1,964.36	8	0.0642	11	0.0789
TCU3	327.51	14	0.0342	14	0.0420
Tr1	166.43	19	0.0203	18	0.0249
Tr2	312.75	15	0.0523	13	0.0643
FIRE1	167.49	18	0.0170	19	0.0209
Ser1	209.41	17	0.0276	17	0.0339
Ser2	1,244.99	11	0.0981	10	0.1206
Con1	1,512.55	10	0.2044	7	0.2514

[1]In dollars.

[2]This column only presents the changes based upon ESC 2-digit covered wage and salary employment for each sector.

[3]Ranks remain the same for both employment changes.

[4]This column presents the total expected change in employment - which includes those in 2 plus those categories not covered by ESC 202 data, such as individual proprietors, partnerships, etc., (excluding government) but estimated as total employment.

then is used to develop the next water related concept, total employment[8] change per acre-foot of direct and indirect water intake. The explanation of direct and indirect employment per total delivered acre-foot of water intake to the system (region) paralells the above discussion on income. Column 4 presents the estimated total change in ESC (2 digit SIC code) covered wage and salaried employment per acre-foot of direct and indirect water intake. This means that if one-hundred acre-feet of water is added to the system and the mining sector (Min1) initiated the production increase (and thus increasing its inputs), that over twenty additional persons would be employed, some in the mining sector, and the remainder in the sectors that supply the inputs.

This employment change doesn't take into account any change in government employment, self-employed persons, and all of the remaining non-covered employment estimated by the ESC. Column 6 lists the estimated total direct and indirect employment from an acre-foot increase in water intake, given the assumption that government employment doesn't change, but that other non-covered employment increases for all sectors at a constant percentage. This assumption is, of course, fairly unrealistic (agriculture doesn't generate the same amount of secondary or spin-off employment as does manufacturing, thus the percentage changes will be different when referring to this category for anticipated increases or decreases); but due to the method of reporting ESC data, and the numerous disclosure rules, it is impossible at this time to develop an efficient method for calculating the different increases that would be appropriate for secondary employment. This estimate does, however, present a little better picture of the actual amount of employment that could be expected per acre-foot in direct and indirect water to a particular sector initiating an increase in production. Column 5 presents the relative rankings of column 4 and 6.

Figures 11 and 12 illustrate the above estimates of the direct and indirect income and employment effects in a little different manner. The horizontal axis of both figures represents the change in acre-feet (in thousands) of new water intake. The vertical axis of Figure 11 is the increase in income that could be expected given the change in new water intake to Region 2, while the vertical axis of Figure 12 is the increase in employment[9] that could be expected. With the increase in income and employment in Region 2, both the direct to the initiating sector and indirect to the remaining interdependent sectors are incorporated into the vertical axis presentation.

An example may help to illustrate the use of Figures 11 and 12. By looking at the sector Man2 in Figure 11, we can see that if an additional 50,000 acre-feet of water was in some form added to the available supplies in Region 2 for the increased production in Man2, that an additional 260 million dollars of income would be generated within Region 2. This income comes not only from the increased sales of Man2, but also from the increased sales of the suppliers of inputs to Man2.

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[8] ESC covered 2 digit SIC data for column 4 of Table 9: column 6 represents this amount plus the estimated non-covered employment less the government sector.

[9] Only ESC 2 digit SIC covered wage and salaried employment.

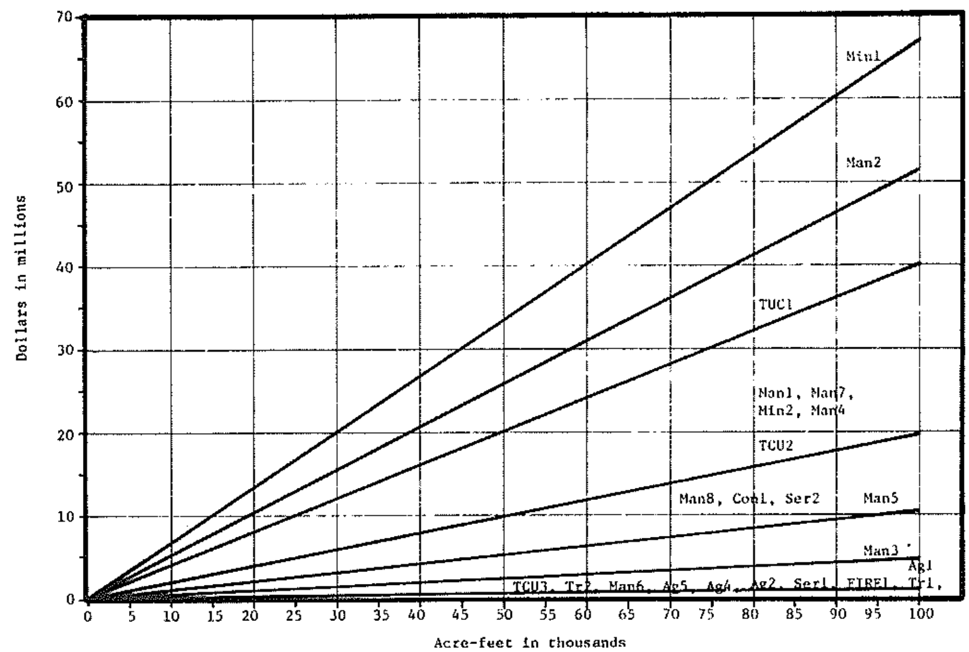

Figure 11. Total direct and indirect income per acre-foot of direct and indirect new water intake - Region 2, RGRB.

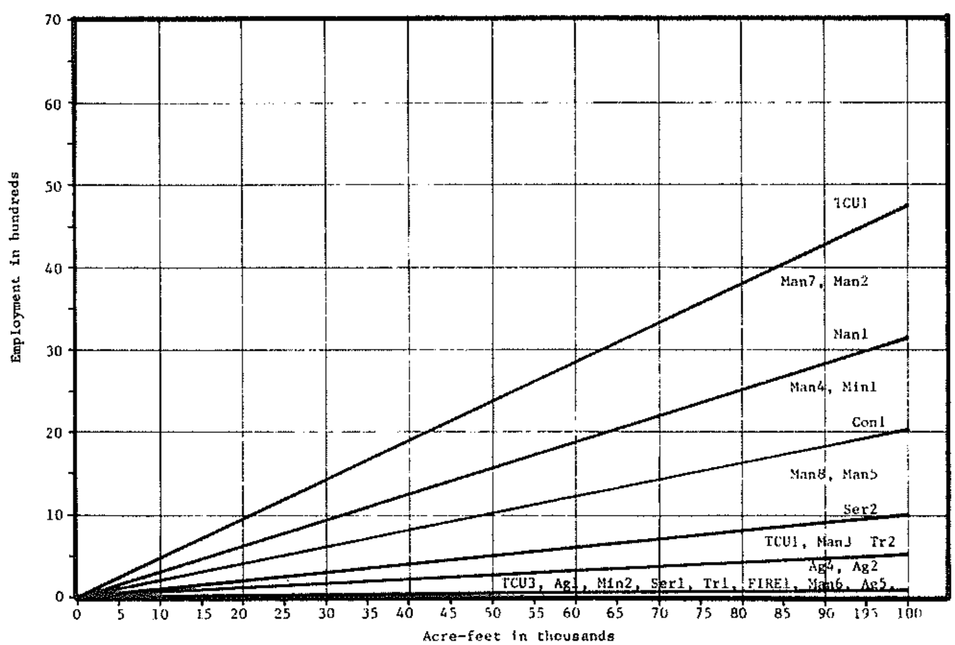

Figure 12. Total direct and indirect employment[1] per acre-foot of direct and indirect new water intake - Region 2, RGRB.

Or, if one wanted to generate a specific employment increase (limited definition), Figure 12 could be used. If one-thousand additional employees were desired, by reading across to the initiating sector one could determine the amount of new water needed in Region 2. Given that TCU1 was initiating an increase in its production to account for the 1,000 increase in employment (both direct in TCU1 and indirect in the remaining sectors), an additional 21,000 of new water would be required (a portion of which goes to TCU1 and the remainder to its suppliers). However, if Ser2 was initiating the increase, an additional 100,000 acre-feet would be needed.

The two preceding figures should be used with care. Some of the higher ranked sectors (in regards to increasing income and employment to the region when they are initiating the process) are also the same sectors that economic information tells us are the least likely to increase their production (primarily from increased export demand) autonomously. In other words, any increase in these sectors will come from increased demands for their products and services by other production sectors. TCU1 is an excellent example of this. It is the sector with the third highest income potential and the highest employment potential, but being that TCU1 is primarily the transportation industry it is highly unlikely that this sector will or could increase its production without first an increase in the business activities of Region 2. Tr2, however, is a good counter-example. Trade is influenced by a variety of economic variables and conditions and could very easily be expected to increase its production autonomously (an example would be the eating and drinking places from increased tourist trade). It ranks much lower in income and employment generation capabilities, but appears on the surface to be much more plausible when looking at future growth possibilities.

Conclusion

This paper has been an attempt at an economic analysis of water use (new water intake) within the Rio Grande River Basin. It is hoped that in the near future the same type of methodology can be applied to the consumptive use of water by the production sectors of the RGRB. By proper and careful use of the various estimates arrived at in this paper, one may begin to formulate future growth criteria based upon the premise that the water supplies will become increasingly scarcer through time.

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