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Mineral Extraction Taxes On The Uranium Industry In New Mexico

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MINERAL EXTRACTION TAXES ON THE URANIUM INDUSTRY IN NEW MEXICO

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MINERAL EXTRACTION TAXES ON THE URANIUM INDUSTRY IN NEW MEXICO

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THESIS

Submitted in Partial Fulfillment of the
Requirements for the Degree of
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ABSTRACT OF THESIS

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Chapter I of this report briefly examines the history of the uranium industry in New Mexico. Chapter II considers uranium supply parameters in New Mexico. This section examines techniques used in estimating potential uranium resources. In particular, the methodology of petroleum resource estimates as applied by M. A. Lieberman as well as ERDA's Subjective Probability Analysis for New Mexico uranium resources are considered. In Chapter III, the demand side of the uranium market situation is considered. Several factors which affect demand for U_3O_8 such as recycling and the level of U-235 remaining in enrichment tails is discussed. Estimates from numerous sources for the demand for U_3O_8 to the year 2000 are surveyed and high and low estimate series are selected. Additionally, price trends, costs and cost trends and projected employment levels are considered for purposes of anticipating future market conditions in the uranium industry.

The final chapter develops the historical treatment of uranium with respect to state mineral extraction taxes. This development notes the various changes in these taxes since their inception. A critique of the tax structure existing as of 1 January 1977 is made and is followed by a suggestion for altering the tax structure. The primary focus on existing problems is the statutory allowance of numerous deductions and the resulting erosion of the tax base as well as the preferential statutory allowance of deductions to underground miners, but not allowed to open pit miners. The suggestions for change include the establishment of a viable well-defined tax base and also an increase in the tax burden. The proposal for increasing the tax burden is based on the fact that New Mexico is presently possessed of more and lower cost reserves than any other state which has uranium reserves. Measuring this advantage against its closest domestic competitor, Wyoming yields a well-defined portion of the economic rent accruing to uranium mining and milling companies in New Mexico. This measurable advantage, translated into a percentage of gross value is the suggested amount of the tax burden to be imposed on the uranium industry. The rationale and impact of such a tax is then considered. The conclusion is that the uranium industry can

sustain a 36 percent tax burden on the gross value of production if the price of U_3O_8 continues to increase or if the suppliers of U_3O_8 can pass this increase in costs on to the buyers of U_3O_8.

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Chapter I

HISTORY OF THE URANIUM INDUSTRY

The uranium industry has experienced a period of rapid development in New Mexico during the past quarter century. From virtual nonexistence in 1950, the industry has made this state the nation's leading producer of yellowcake (U_3O_8), as the processed ore is called. The importance of uranium in the nation's search for energy resources and New Mexico's need for economic development cannot be overemphasized.

A brief history of the industry's development serves to underscore the possibilities of using New Mexico's uranium resources to accomplish these two goals. Uranium was known to be present in New Mexico as early as 1904.[1] In 1918, carnotite deposits containing uranium were discovered west of Shiprock, New Mexico.[2] Uraniferous materials were subsequently discovered in Grants County about 1920.[3] Small scale mining of some of these ores took place during that time. The primary use of uranium at that time was for pharmaceutical purposes.[4] By World War II, however, the United States found a revolutionary new use for uranium in nuclear bombs and, somewhat later, as a source of electrical

energy. It seems ironic that the development and initial explosion of the first nuclear device took place in the state soon to become the nation's leading producer of uranium, utilizing a raw material which, at that time, had to be imported. With the realization of the strategic importance of uranium and the knowledge of the possibilities of domestic supplies, the Atomic Energy Commission undertook a program of ore-buying and subsidization of the mining and milling of uranium.[5] Table I-1 reflects the purchases made by AEC nationally and in New Mexico as well as the price paid. In 1967, when domestic commercial purchases became significant, the then reduced AEC buying program declined further, until in 1971 the program was discontinued.

The AEC ore-buying program, coupled with the liberal provisions of the federal mining laws, assured the uranium mining and milling industry a lucrative beginning. The mining law provisions referred to are found in Title 30 § 26 of the United States Code which allows the locator of a valuable mineral on public lands a fee simple title to the land on or in which the mineral is found. There are other requirements which must also be met but they are minimal when compared to what is acquired by their fulfillment. (See Title 30 § 21 through § 54 USCA.) Table I-2 shows the importance of the locator device, utilized in acquiring title to public lands, to the uranium industry. Typically for the years for which data are available, as much as

TABLE I-1

COMMERCIAL DOMESTIC AND ATOMIC ENERGY COMMISSION
DOMESTIC PURCHASES OF U_3O_8

Calendar Year	Calendar Year Commercial Deliveries[3] Tons of U_3O_8	AEC Purchases Tons of U_3O_8[1] Total	New Mexico	AEC Concentrate Purchases $ thousands[1]	Average Price Paid in U.S. by AEC U_3O_8	Tons of U_3O_8 Produced in New Mexico[2]	New Mexico Prod. as a % of Total Domestic Production
1955		2,784	847	$ 19,878	$ 12.25		
1956		5,958	2,891	64,633	11.51		
1957		8,482	2,534	50,920	10.49		
1958		12,437	3,604	66,462	9.45		
1959		16,239	6,772	112,770	9.12		
1960		17,637	7,760	125,146	8.75		
1961		17,348	7,750	123,794	8.50		
1962		17,008	7,293	110,373	8.15		
1963		14,217	5,512	85,892	7.82		
1964		11,846	4,747	75,975	8.00		
1965		10,442	4,591	73,464	8.00		
1966		9,488	4,393	70,285	8.00	5,076/10,589	47.9%
1967	900	8,425	4,698	75,147	8.00	5,933/11,253	52.7%
1968	4,900	7,337	4,300	68,801	8.00	6,192/12,368	50.0%
1969	4,200	6,184	4,104	47,150	6.99	5,943/11,609	51.1%
1970	7,200	2,520	833	7,875	5.74	5,771/12,905	44.7%
1971	13,000	-	-	-	5.54	5,305/12,273	43.2%
1972	12,400	-	-	-	-	5,464/12,900	42.3%
1973	12,100	-	-	-	-	4,634/13,235	35.0%
1974	11,900	-	-	-	-	4,951/11,528	42.9%
1975	12,500	-	-	-	-	5,191/11,600	44.75%

[1]Statistical Data of the Uranium Industry GJO 100(76) p. 12, 13, published by ERDA, Grand Junction Office, Grand Junction, Colorado, 1975.

[2]Ibid., p. 83. [3]Ibid., p. 78.

TABLE I-2

THE BREAKDOWN OF LAND HELD FOR EXPLORATION BY OWNERSHIP FOR 1971-1975[1] (thousands of acres)

	1971	1972	1973	1974	1975	1976
State	5,835	3,995	1,859	1,945	2,968	3,385
Claim	11,471	8,755	9,679	10,290	11,634	12,605
Acquired	555	363	206	145	275	277
Indian	674	469	603	646	635	627
Fee	5,712	5,250	5,219	5,580	5,596	6,017
Railroad	159	175	111	168	168	-
Total	24,406	19,007	17,677	18,774	21,276	22,911
New Mexico	4,717	4,119	3,109	3,158	3,378	3,663
State	-	-	-	-	399,483[2]	-
Claim	-	-	-	-	1,364,975[2]	-
Federal Acquired	-	-	-	-	54,000[2]	-
Indian	-	-	-	-	424,609[2]	-
Fee	-	-	-	-	979,662[2]	-
Railroad	-	-	-	-	168,094[2]	-

[1] Statistical Data of the Uranium Industry, ERDA Grand Junction Office, GJO-100(75), and GJO-100(76).

[2] Lucius Pitkin Institute 75-8, The numbers reported are the numbers of acres held.

50 percent of the lands held are acquired for simply mining the ore.

The exploratory activity in the 1950s yielded results in New Mexico when a Navajo Indian named Paddy Martinez discovered uranium on land owned by the Santa Fe Railway Company. Well documented folklore has it that Mr. Martinez, having seen prospectors examining an ore specimen and discussing its nature, was familiar enough with the countryside to recall an area where rocks similar to the specimen were abundant. This turned out to be the outcrop of a valuable uranium deposit. Geologists for the railway noted that some of the vegetation in the area had a purplish cast which was associated with the chemical makeup of the earth's crust in areas where uranium was found. Paddy Martinez then proceeded to point out to the geologists other areas where the purplish vegetation grew in abundance. These areas also yielded recoverable uranium deposits.[6] The Santa Fe Railway Company brought in the Anaconda Company to develop its uranium deposits. Encouraged by the Martinez find, the Anaconda Company struck out on its own and discovered the now famous Jackpile mine. This activity stimulated further interest in uranium in New Mexico and other mining concerns entered the field. Anaconda built the first uranium processing mill in New Mexico during this time and launched New Mexico's uranium mining and milling industry on its present day course.

To this day, uranium prospecting has taken place in 27 counties in New Mexico with as many as 79 active mines operating in twelve different counties in 1956 alone.[7] Table I-3 represents a history of exploratory and developmental drilling from 1948 to 1974. The drilling data reflect a double peaked distribution typical of the distributions of the other parameters of the industry. The exploratory drilling peak preceded the developmental drilling peak as the resource was initially being developed as would be expected but the second peak in the distribution occurs simultaneously for exploratory and developmental drilling. This phenomenon is explainable when considered in conjunction with the distributions of other parameters in the industry.

Before presenting the remaining data, an explanation of certain problems arising with the collection and use of the data should be given. The first problem is the piecemeal nature of the data. This was initially attributed to the inherent secrecy of the early uses of uranium in The Manhattan Project. The second problem involves shifts in data collection techniques, such as shifts from calendar year to fiscal year, ore to ore concentrate, f.o.b. mine value to f.o.b. mill value. This presents a problem in perceiving the continuity of the data over the industry's history. Nevertheless, some of the data shifts have proved enlightening and in analyzing the data, certain inferences can be made.

TABLE I-3

HISTORY OF UNITED STATES URANIUM DRILLING

Year	Surface Drilling - Millions of Feet						Surface Drilling					
	Exploration		Development		Total Surface Drilling		Number of Holes			Average Depth - Feet		
	Annual	Cumulative	Annual	Cumulative	Annual	Cumulative	Exploration	Development	Total Surface	Exploration	Development	Total Surface
1948	.170	.170	.040	.040	.210	.210	-	-	-	-	-	-
1949	.360	.530	.053	.093	.413	.623	-	-	-	-	-	-
1950	.570	1.100	.208	.301	.778	1.401	-	-	-	-	-	-
1951	1.080	2.180	.348	.649	1.428	2.829	-	-	-	-	-	-
1952	1.362	3.542	.300	.949	1.662	4.491	-	-	-	-	-	-
1953	3.648	7.190	.367	1.316	4.015	8.506	-	-	-	-	-	-
1954	4.057	11.247	.553	1.869	4.610	13.116	-	-	-	-	-	-
1955	5.267	16.514	.762	2.631	6.029	19.145	-	-	-	-	-	-
1956	7.287	23.801	1.503	4.134	8.790	27.935	-	-	-	-	-	-
1957	7.352	31.153	1.848	5.982	9.200	37.135	-	-	-	-	-	-
1958	3.759	34.912	3.494	9.476	7.253	44.388	25,321	22,932	48,253	148	162	150
1959	2.368	37.280	3.282	12.758	5.650	50.038	16,253	19,585	35,838	146	168	158
1960	1.399	38.679	4.211	16.969	5.610	55.648	7,335	24,395	31,730	191	173	177
1961	1.319	39.998	3.190	20.159	4.509	60.157	8,256	19,314	27,570	160	165	164
1962	1.483	41.481	2.431	22.590	3.914	64.071	6,439	12,870	19,309	230	189	203
1963	.880	42.361	1.977	24.567	2.857	66.928	8,472	13,534	22,006	104	146	130
1964	.967	43.328	1.245	25.812	2.212	69.140	5,972	9,909	15,881	162	126	139
1965	1.164	44.492	.949	26.761	2.113	71.253	6,231	7,331	13,562	187	129	156
1966	1.800	46.292	2.400	29.161	4.200	75.453	5,751	13,179	18,930	313	182	222
1967	5.435	51.727	5.329	34.490	10.764	86.217	12,788	16,947	29,735	425	314	362
1968	16.227	67.954	7.527	42.017	23.754	109.971	38,470	19,531	58,001	422	385	410
1969	20.470	88.424	9.385	51.402	29.855	139.826	47,850	28,012	75,862	428	335	394
1970	17.981	106.405	5.547	56.949	23.528	163.354	43,980	14,874	58,854	409	373	400
1971	11.400	117.805	4.052	61.001	15.452	178.806	28,416	10,440	38,856	401	388	398
1972	11.815	129.620	3.609	64.610	15.424	194.230	26,909	9,706	36,615	439	371	421
1973	10.831	140.451	5.590	70.200	16.421	210.651	22,557	11,704	34,261	480	478	480
1974	16.000	156.451	6.000	76.200	22.000	232.651	27,400	12,300	39,700	580	490	550
1975	16.538	172.989	9.004	85.204	25.542	258.193	34,285	21,601	55,886	482	417	457

Table I-4 represents the value of uranium produced in New Mexico reported by various sources as noted. Ore grade figures as well as volume of production is also presented. Column 2 and column 3 represent the tonnage and value data as reported by the Minerals Yearbook. Column 4 represents information derived from the annual reports of the state mine inspector. In 1967 the data sources switch from f.o.b. mine value to f.o.b. mill value. The correspondence in the data in 1954 and 1955 for the value figures from the different sources is short-lived and not seen thereafter. This is explained by the method of data collection. The State Mine Inspector's Report depends upon the figures gleaned from the state's industry representatives. The Bureau of Mines obtains their data from the then Atomic Energy Commission and now Energy Research and Development Administration. The primary source to be used will be the Minerals Yearbook data since other data from AEC/ERDA will also be utilized, and collating all of the data from the same source will create the least bias in interpretation of the material. Column 5 represents data obtained from a report prepared by the United States Geological Survey. Its significance lies in its variance from 1950-1955 with the data in columns 3 and 4; this variation is explained by the fact that from 1950-1955, the column 5 data include all subsidies paid by the AEC as well as the value of the mined ore. Column 6 is the oregrade and simply reflects how many ten

TABLE I-4

A COMPARISON OF PRODUCTION DATA FOR NEW MEXICO FROM VARIOUS SOURCES

Column 1 Year	Column 2 Thou. of Lbs. of U_3O_8 Produced	Column 3[4] Value	Column 4[1] $ Value	Column 5[3,6] Value	Column 6 Ore Grade
1950	23.4		$ 61,273	$ 100,000	.0021
1951	8.6		8,768	61,000	.0024
1952	101		44,000	546,500	.0022
1953	425		529,048	2,067,000	.0025
1954	1,411	$3,019,463	3,019,463	6,303,000	.0036
1955	1,218	4,680,906	4,680,906	5,270,000	.0025
1956	6,344	24,086,000	15,349,376	24,086,234	.0026
1957	4,811	20,538,000	28,364,383	20,538,086	.0022
1958	9,820	32,264,000	30,509,345	32,264,000	.0026
1959	12,771	53,463,000	44,397,741	53,463,000	.0021
1960	14,817	61,827,000	59,086,797	61,827,000	.0021
1961	14,828	61,482,000	67,600,867	61,482,000	.0022
1962	15,526	63,504,000	68,534,131	63,504,000	.0023
1963	9,430	41,372,000	56,320,528[2]	41,372,000	.0022
1964	8,566	38,203,000	45,158,288	-	.0022
1965	8,615	38,311,000	39,814,857	-	.0023
1966	9,340	38,754,000/74,721,000	35,915,348	-	.0024
1967	11,202	89,615,000	87,796,000	-	.0021
1968	12,282	95,144,000	96,514,000	-	.0020
1969	11,811	69,877,000	77,449,000	-	.0020
1970	11,574	69,970,000	72,828,000	-	.0020
1971	10,567	65,517,000	66,767,000	-	.0020
1972	10,808	68,901,000	67,723,000	-	.0021
1973	9,286	60,356,000[7]	59,410,000	-	.0020
1974	9,971	86,069,672[7]	-	-	.0018
1975	9,900	110,612,700[7]	-	-	.0017

[1]Annual Reports of the State Inspector of Mines.

TABLE I-4 (continued)

[2] From 1963 on in this column, the reported data is by calendar year.

[3] The data in this column is derived from p. 210 of the source cited in footnote 1 of the text.

[4] The data reported in these columns are derived from annual publication of <u>The Minerals Yearbook</u> published annually by the Department of the Interior through 1972.

[5] Thousands of pounds.

[6] These values include all bonus payments, subsidies, etc. in addition to price f.o.b. mine value until year 1955 and thereafter f.o.b. mine value is the figure represented.

[7] Computed.

thousandths of a pound of yellowcake is found in a ton of ore. This nearly completes the picture of the history of the uranium industry. With this data, the inferences drawn from the drilling expenditure distribution may be continued. In the sixties, it was anticipated that commercial demand would prove to be an adequate substitute for the Atomic Energy Commission purchases. However, as the AEC buying program tapered off, the expansion of commercial demand did not occur as rapidly as had been anticipated. This explains the simultaneous dips in almost all parameters in the early seventies. This trend was dramatically reversed in 1973 when the spot price of uranium began a dramatic climb from $8.00/lb. to a price in excess of $40.00/lb. This phenomenon was triggered by numerous factors including the oil embargo as well as the realization of users that supply conditions were somewhat different from what had been theretofore anticipated. Since that time the prospects for the uranium industry have continued to brighten. Presently, the uranium industry in New Mexico is a vital part of the state's economy. The material which follows will examine some of the statistical data generated by the industry, and will contain recommendations of tax policy with respect to the uranium industry in New Mexico.

CHAPTER II

NEW MEXICO'S URANIUM SUPPLY

Uranium Supply Data: Limited Knowledge and Data Base

No realistic considerations of the impact of the uranium industry could be made without assessing the nature, quality, and amount of uranium and uranium deposits located in the state. Data of this nature are collected and processed by the Raw Materials Division of the Energy Research and Development Administration in Grand Junction, Colorado.[8] The data are collected from the industry on a voluntary basis and are, to a large extent, proprietary in nature. The data are used for purposes of computing and evaluating uranium resources supply and demand parameters on an aggregate basis. Initially, the concern for uranium resources arose from its strategic importance, but the critical need for energy planning has generated an even greater demand for accurate data regarding uranium natural resources. In fact, it is now becoming important to be able to generate and break down this information by county for purposes of state and local planning. The need for this type of data can be illustrated by considering the circumstances of the City of Grants which

will bear the brunt of supporting the growing uranium mining industry in New Mexico. Due to the uncertainties of the mining business and, in part, because of the lack of all but the most general data on the prospective future development of the industry, it has become difficult to provide the necessary support for this development. Housing and trained labor are scarce, yet the private sector is reluctant to invest in these areas because of uncertainty. These types of problems could be partly resolved by dissemination of data regarding anticipated development by ERDA and the industry to state and local agencies where the anticipated impact would be great.

ERDA Classification System and Corresponding Estimates

The data on uranium resources that are available are classified initially according to the likelihood of the occurrence of uranium. The first major classification is "reserves." Reserves are considered proven deposits. They are subdivided further according to forward costs of recovery. Forward costs are those costs incurred after geological investigation, land acquisition, and exploration. Forward costs are subdivided in \$8.00, \$10.00, \$15.00, and \$30.00 reserves. Some analysis with \$50.00 reserves is going on, but that has yet to find its way into the "Statistical Data of the Uranium Industry" as an official reserve classification.

Even classifications at $30/lb. would seem to be an incomplete picture of economic reserves since the current spot price of U_3O_8 in concentrate is in excess of $40/lb. Reserve classifications by cost are further subdivided by size of deposits, by geologic age, by resource region, by state, and by thickness of ore. These classifications are important for economic considerations of ore extraction as well as for locating future deposits. The data for New Mexico reserves are available only by forward cost and are shown in Table II-1.

Reserves are computed by ERDA using the following steps:[29]

1. Determination of the "cutoff" to define the lowest grade (in percent U_3O_8) of material that can be mined from a deposit at a minimum thickness where the total operating cost per pound of U_3O_8 in such material is equal to the chosen maximum forward cost per pound. The cutoff grade is determined by the following formula:

$$\text{Cutoff Grade} = \frac{\text{Cost of mining, hauling, royalty and milling/ton of ore}}{\text{Maximum forward cost/lb. } U_3O_8 \text{ X mill recovery X 20}}$$

2. Estimation of the quality of mineralized material in the deposit that meets or exceeds the cutoff grade and thickness criteria, expressed in tons of U_3O_8 and average grade.

Table II-1

ORE RESERVE DISTRIBUTION BY STATES

State	Tons Ore	% U_3O_8	Tons U_3O_8 in ore	% Total Tons U_3O_8	No. of Deposits
A. $8 Reserves (1 Jan. 75)					
New Mexico	47,905,000	.29	137,100	69	66
Wyoming	16,202,000	.17	28,300	14	14
Texas	8,044,000	.18	14,400	7	45
Colorado & Utah	3,654,000	.31	11,400	5	99
*Others	7,195,000	.12	8,800	5	60
Total	83,000,000	.24	200,000	100	284
B. $10 Reserves (1 Jan 75)					
New Mexico	74,730,000	.22	168,100	53	87
Wyoming	62,136,000	.16	102,100	32	102
Texas	14,315,000	.14	19,400	6	60
Colorado & Utah	5,656,000	.25	14,100	5	252
*Others	10,763,000	.10	11,300	4	95
Total	167,600,000	.19	315,000	100	596
C. $15 Reserves (1 Jan 76)					
New Mexico	115,900,000	.18	206,200	48	106
Wyoming	150,500,000	.10	158,000	37	157
Texas	30,900,000	.08	23,900	5	110
Colorado & Utah	13,000,000	.21	25,900	6	717
Others	18,700,000	.08	16,000	4	319
Total	329,000,000	.13	430,000	100	1409
D. $30 Reserves (1 Jan. 76)					
New Mexico	302,000,000	.10	302,700	47	173
Wyoming	352,000,000	.07	239,000	37	264
Texas	64,900,000	.07	43,900	7	130
Colorado & Utah	25,700,000	.13	34,200	5	849
Others	28,800,000	.07	20,200	4	403
Total	774,000,000	.08	640,000	100	1319

*Others may include Arizona, Montana, California, North Dakota, Washington, Oregon, South Dakota, Oklahoma, Nevada and Idaho.

Source: Statistical Data of the Uranium Industry GJO-100(75), ERDA, 1976 data is derived from the prospective edition for 1976.

3. Application of all forward costs, operating and capital, to the mineralized material derived in step 2.
4. If the cost/pound U_3O_8 derived in step 3 is less than the chosen maximum forward cost per pound, then the material is included in the estimate for the appropriate maximum forward cost category. An example will illustrate the formula's usage. Utilizing $50 as the maximum forward cost in the denominator and then varying actual costs from $25/ton to $300/ton, in the first column, the following cutoff grades are shown in the second column.

TABLE II-2

ILLUSTRATION OF USAGE OF CUTOFF GRADE FORMULA

Actual Costs/ton	Cutoff Grade
25	.026%
50	.053%
100	.106%
150	.159%
200	.21%
250	.26%
300	.31%

Similarly, it is possible to estimate the costs of production that may be incurred in developing an ore body by plugging in various grades and computing maximum allowable mining costs. These, then, can be aggregated for the ore body to determine its total production costs.

After reserves, the major classification is by resource. Resources are defined as a geologic judgment of the undiscovered tons of U_3O_8 present in mineable amounts in areas that are relatively unexplored in detail but about which enough is known of the uranium geology to predict the nature and extent of favorable environments or host rocks.[10] Potential resources are further subdivided into probable, possible, and speculative resources.

> Probable resources are those estimated to occur in known uranium districts and are further postulated to be in extensions of known deposits or in new deposits within trends or areas that have been mineralized as identified by exploration.[11]
>
> Possible resources are those estimated to occur in new deposits in formations or geologic settings productive elsewhere within the same geologic province or subprovince under similar geologic conditions or within the same geologic province or subprovince under different geologic conditions.[12]
>
> Speculative resources are those estimated to occur in new deposits in formations or geologic settings not previously productive, within a productive geologic province or subprovince or within a geologic province or subprovince not previously productive.[13]

Exploration is the primary conduit by which a resource classification finds its way into the reserve classification. Once the ore is discovered, a detailed analysis then takes place to determine if and where the deposit belongs in the reserve category.

Potential resources (includes probable, possible, and speculative) for the entire nation are reflected in Table II-3.

TABLE II-3[14]

POTENTIAL URANIUM RESOURCES AS OF 1 JANUARY 1975
Tons of U_3O_8

Class	\$8	\$10	\$15	\$30
Probable	300,000	460,000	680,000	1,140,000
Possible	200,000	390,000	640,000	1,340,000
Speculative	30,000	110,000	210,000	410,000
Totals	530,000	960,000	1,530,000	2,890,000

Validity of ERDA Estimates

The validity of ERDA data on potential resources has been questioned. The proponents of the data support their arguments with the following considerations.[15]

1. There is a high correlation between past drilling efforts and the amounts of uranium discovered.
2. The incompleteness of knowledge of uranium deposits implies the possibility of discovery of uranium in a different mode of occurrence than sandstone deposits.
3. Higher prices in the future will justify a search for lower grade ores than those mined at present.
4. There are mineralized areas already known that have not been fully explored, either because first results of drilling indicated marginal ore grades or below or because reserves in hand were adequate to sustain company production schedules.

5. The degree of exploration effort to date is not an adequate index of undiscovered resources that would be discovered if exploration efforts were greatly increased.

On the other hand, it is argued that ERDA estimates fail to take into account the following considerations:[16]

1. The most favorable areas have already been explored.
2. The amount of U_3O_8 found per foot of exploratory drilling has decreased from 14.7 pounds of U_3O_8 per foot in 1955 to 4.7 pounds per foot in 1971 (mostly because of increased drilling depths).
3. Drilling during 1971-1973 increased AEC "reserves" by only 7,000 tons of U_3O_8.
4. Drilling in certain areas that under the AEC system would have been estimated to certain potential resources has not been successful.
5. Evidence of the existence of large low-grade (.05-.1% U_3O_8) deposits of uranium in sandstone is lacking.
6. Exploration experience has contradicted projections involved in estimates of potential ore.
7. While known mineralization is widespread, a relatively few deposits contain the bulk of the reserves. About 95 percent of the reserves are in 150 of the 4,500 properties listed by the AEC.

Quantitative Attempts to Evaluate the Resource

The Committee on Mineral Resources and the Environment (COMRATE) in compiling these considerations noted the difficulty in quantitatively evaluating these arguments.[17] Recently, however, attempts at quantitatively evaluating the resource have been made. These efforts will serve as a vehicle in analyzing the validity of the arguments supporting and challenging the ERDA estimates. The first analysis to be discussed will be a resource estimation made by M. A. Lieberman[18] utilizing techniques developed for petroleum estimation.[19] Two different methods are utilized to estimate the ultimately discoverable U_3O_8 in western sandstone deposits in which the greatest amount of uranium has, thus far, been discovered, and consequently, from which production has been highest.

The Lieberman Approach

The first approach utilizes historical exploratory drilling data, increments to reserves, and past production to compute a discovery rate of pounds of U_3O_8 per foot drilled. The time frame 1948-1974 is divided into eleven intervals, and the cumulative exploratory drilling for each interval is computed. The cumulative amount discovered and produced is divided by cumulative drilling yielding the discovery rate.[20] By plotting the discovery rate against

the cumulative footage drilled and by estimating the parameters of the resulting "best-fit" curve, the amount of U_3O_8 to be discovered can be derived. These estimations are done for the forward cost categories utilized by ERDA as well as the recoverable resource. Those forward cost categories are \$8, \$10, \$15, and \$30 or less per pound U_3O_8. The estimate of U_3O_8 resources available using Lieberman's analysis are shown in Table II-4.

TABLE II-4

ESTIMATES MADE BY M. A. LIEBERMAN OF RECOVERABLE U_3O_8 RESERVES[21]

Forward Cost Category	10^3 Short Tons
$<$ \$ 8/lb.	630
$<$ \$10/lb.	756
$<$ \$15/lb.	945
$<$ \$30/lb.	1136

The foregoing procedure was utilized to derive the total resource recoverable at a forward cost of \$8 per pound of U_3O_8. Estimates of higher cost categories of recoverable U_3O_8 were made by multiplying the \$8/lb. (forward cost) estimates by a multiple which represents the ratios of higher cost deposits to lower cost deposits. The multiples are based on ratios derived from published data.[22]

The second method of analysis will not be considered beyond noting that it is also dependent upon the rate of increase in the reserves which is contingent upon the discovery rate. This particular point will be returned to shortly.

ERDA's estimates of the total recoverable resource are shown in Table II-5.

TABLE II-5[23]

TOTAL OF POTENTIAL RESOURCES AND PROVEN RESERVES

Forward Cost Category	10^3 Short Tons
<$ 8/lb.	920
<$10/lb.	1285
<$15/lb.	1690
<$30/lb.	2470

The discrepancy between the Lieberman estimates and the ERDA estimates is glaring. Part of the explanation lies in the Lieberman assumptions as to the methodology utilized in computing ore reserves by forward costs. Lieberman states:

> Net additions to reserves in a given cost category are calculated by subtracting the yearly production from discoveries (gross additions) and shifting these resources which have become uneconomic to produce as a result of inflation into a higher cost category. For example, in 1974 for the $8 per pound U_3O_8 cost category, discoveries were 13,000 short tons of U_3O_8, production was 12,600 short tons and 77,000 tons were removed from this category because of inflation. Thus net reserves fell 77,000 short tons in 1974.

It has only been during the last few years that the inflationary correction has been of importance.[24]

Mr. Lieberman's mistaken assumption is that the inflationary correction is done annually and is historically unimportant. The correction in 1974 was a one-time correction "which is not done annually."[25] Table II-6 shows the impact of inflation over the period from 1955-1975. While the inflationary effect has been important, to some extent, it may have been offset by productivity. Advances in technology are considered proprietary data, insofar as they are developed and implemented by the individual firm and therefore data of that nature are not available to compute the offset between productivity and inflation. Furthermore, ERDA does not consider productivity changes in computing their reserve estimates because of the uneven nature in the adoption of new techniques as well as the proprietary nature of such information.[26]

Table II-6 shows equipment costs for mining and milling to have increased 134 percent from 1955-1975. Admittedly, equipment costs reflect only a portion of the picture but the other major component of cost that enters into cost calculations, labor, has risen 162 percent in the same period.[27] Therefore, for purposes of explaining the impact of inflation, it will suffice to use only the cost equipment index.

As noted earlier, the Lieberman article rests on the premise of a declining discovery rate of U_3O_8 per foot drilled.

TABLE II-6

THE MARSHALL & SWIFT MINING & MILLING EQUIPMENT COST INDEX
APPLIED TO VARIOUS FORWARD COST ORE GRADES
FROM 1955 TO 1975

Year	Marshall & Swift[1] Mining & Milling Cost Eqpt. Index	Percent Increase	1975 $8 Reserves Deflated to 1955 $	1955 $8 Reserves Inflated to 1975 $	1955 $10 Reserves Inflated to 1975 $	1955 $15 Reserves Inflated to 1975 $
1955	192.6	-	3.450	$ 8.000	$10.00	$15.00
1956	210.4	9.2	3.767	8.7360	10.92	16.38
1957	227.9	8.3	4.080	9.4600	11.83	17.74
1958	233.8	2.5	4.182	9.6900	12.12	18.18
1959	237.1	1.4	4.240	9.8300	12.29	18.44
1960	240.6	1.4	4.300	9.9700	12.46	18.69
1961	239.2	- .6	4.270	9.9100	12.39	18.58
1962	239.5	-	4.270	9.9100	12.39	18.58
1963	240.1	-	4.270	9.9100	12.39	18.58
1964	242.6	1.4	4.329	12.880	12.88	18.84
1965	245.3	1.1	4.377	10.160	13.02	19.05
1966	253.0	3.0	4.508	10.460	13.41	19.62
1967	263.5	4.1	4.693	10.890	13.96	20.42
1968	273.2	3.6	4.862	11.280	14.47	21.16
1969	284.5	4.1	5.061	11.740	15.06	22.03
1970	302.6	6.3	5.380	12.490	16.01	23.41
1971	321.1	6.1	5.709	13.250	16.98	24.85
1972	331.8	3.3	5.897	13.680	17.55	25.66
1973	342.9	3.3	6.092	14.130	18.13	26.51
1974	394.3	14.9	6.999	16.250	20.83	30.46
1975	451.2	14.4	8.000	18.550	23.83	34.85

[1] Ricci, Larry J., "C.E. Costs Indexes Accelerates 10-Year Climb," Chemical Engineering, 28 April 1975, p. 118.

By not taking proper account of inflation and taking into consideration the historical distribution of ore grade in reserve categories, it is virtually impossible to draw any other conclusion. For instance, in order to sustain a discovery rate of a certain amount of ore at a given forward cost category in current dollars, in an inflationary period, it would be necessary to discover ore of higher and higher grades each year to offset the inflationary impact of the reduction in the real value of the chosen forward cost. Eight dollar ore discovered in 1955 would be eighteen dollar and fifty-five cent ore in 1975 and eight dollar ore in 1975 would have been three dollar and forty-five cent ore in 1955. Carried to its logical end, assuming inflation to continue, at some point in the future, it would be necessary to find pure uranium nodules lying on the surface in order for the uranium to be recoverable at the reduced real value represented by a forward cost category in current dollars. Since this is not likely to be the case, the result of such analysis will be a declining discovery rate. This illustrates the problem of estimating ore reserves in forward cost categories. Not only is the conclusion drawn by the Lieberman article incorrect, but with the data available, the recoverable amount of the resource cannot be practically estimated. This is true because the ore estimates are classed into intervals and it is not known (except by the particular firm and ERDA) where, in the interval the ore deposit belongs. For

instance, ore bodies that in 1955 were recoverable at a forward cost of $4 per pound and ore bodies that were recoverable at $8 per pound were both classified as recoverable at $8 per pound or less. The $4 per pound deposit would have been picked up by the $10 reserves but the $8 per pound deposit would have slipped all the way down into the $30 reserves by 1975. Also the quantity of the reserve at a given cost level must be known as well as the actual forward cost per pound within the interval. The problem is further aggravated by the fact that Table II-6 values apply only to the ore which was estimated to be recoverable at some forward cost in that particular year. The computation must be made for every year. Presumably, when the cost of recovery of the ore inflates beyond the $30 forward cost category, it is no longer considered economically feasible to mine, and dropped from the reserve category since the present estimates of ore reserves are only estimated to a maximum cutoff value of $30 per pound.

One further problem with relating drilling data to discovery rates and hence quantifying the potential resource is that cumulative footage does not distinguish between the number of holes drilled and the depth of hole drilled. It has been posited that the rate of discovery has a higher correlation to the number of holes drilled than the depth of hole drilled, and that while in 1969, 29.9 million feet of drilling took place as compared to 9.2 million feet in

1957, only 25 percent more holes were drilled.[28] This, considered in conjunction with the inflationary problem, points out the distortion that is bound to occur in effects of relating drilling data discovery rates.

Not only are the estimates made by Lieberman incorrect, but as ERDA points out, its own estimates must be considered in light of their limiting factors. The most limiting consideration in evaluating the total stock of the resource is the quantification of the resource in terms of economic recoverability (forward cost) rather than a concept such as a stock of "pounds in the ground" of certain characteristics. The reason for utilizing this method has been that the data utilized has been primarily industry data, whose primary concern is the cost of recoverability. While drilling data is not the exclusive source of information, it makes up the greatest share and is the most reliable indicator. Table I-3 shows drilling data from 1948-1974. It should be noted that drilling data are divided into exploratory and developmental drilling. Exploratory drilling is associated with discovery while developmental drilling is used to define the ore body. As long as the price of U_3O_8 was depressed, lower grade ore bodies did not economically justify developmental drilling. Thus the data base for higher grade ores is quite substantial including exploratory and developmental drilling data, while lower grade ore data are largely exploratory only. Consequently, as long as uranium economics dictates that it is

uneconomical to produce lower grade ores, the knowledge of the potential resource will be sparse and estimates of the resource will remain educated surmise.

A second limiting factor is that as the years progressed and reserves were added, the reserves that were attributed to one ore deposit might have been accounted for at different forward costs as the grade in the deposit declined. If this particular deposit happened to be mined, only the economically justifiable ore would have been removed. Thus, some ore that may have been counted as a reserve at one time, but lost that status due to inflation, might become economical once again as the price of uranium rises. The problem becomes one of economic and technical feasibility of reopening an operation. To the extent that this is not feasible, some reserves are permanently lost.

In 1977, ERDA plans to publish a minerals inventory on uranium which will list over 2,100 properties with the amount of U_3O_8 recoverable from each property. Hopefully, ore body characteristics will also be part of the study so that economically recoverable U_3O_8 can be derived with current cost data from known physically existing ore bodies.

Returning to the considerations made supporting and discrediting the ERDA resource estimates, it seems clear that the impact of inflation on quantification and classification of reserves and the practice of classifying ore reserves by forward cost has the effect of underestimating the absolute amount of recoverable uranium reserve.

ERDA's Subjective Probability Analysis

ERDA supports its own estimates, at least in New Mexico in a recent report which estimates the uranium resources in the State of New Mexico.[29] This report, utilizing an innovative methodology, presents a statistically probable estimate and comprehensively breaks the estimate down by such characteristics as depth, grade, tonnage, etc. Since this is the most recent data available and treats New Mexico as an entity, it should find much use as a planning tool. Furthermore, this report attempts to correct the bias that arises from the inadequate knowledge of subeconomic resources by utilizing a "stock resource measure in absolute amounts." For these reasons, it becomes worthwhile to consider the contents of this report from three different perspectives:

a) Methodology used

b) Estimates of economic resources

c) Estimates of subeconomic resources.

a) Methodology

It is necessary to discuss the methodology only to that extent necessary to understand generally the procedural limitations. Questionnaires were sent to thirty-six individuals qualified as uranium geologists or explorationists. Twenty-six of the respondents were from the industrial sector, seven were from government and three were from universities.[30]

The questionnaires polled the respondents on their opinions regarding the uranium content of the earth in New Mexico and the characteristics of that uranium. The results of the questionnaires were then evaluated and the results were utilized to design a second questionnaire. The second questionnaire permitted previous estimates to be revised but if the revised response diverged significantly from the initial response, then justification of the revision was required.[31] Since, as the title of the report suggests, the responses were no more than the probability judgments of the respondents, the respondents were required to weight the self-assessed authority of their geological knowledge and their knowledge of uranium occurrence in each of 62 cells into which the state was partitioned.[32] (See Figure II-1.) The large size of the cells, roughly 1970 square miles apiece, was chosen to protect proprietary data of individual industry members.[33] The data received were then subjected to statistical analysis. Before discussing the results of this analysis, it should be noted that a great preponderance of the knowledge of the respondents is attributable to their work either done in or affiliated with in some way, the uranium industry. Since the industry's focus on uranium resources is primarily a function of economically recoverable ore, the response to the questionnaire would necessarily reflect an emphasis on higher grade ores. This point is well recognized in the study in that the second

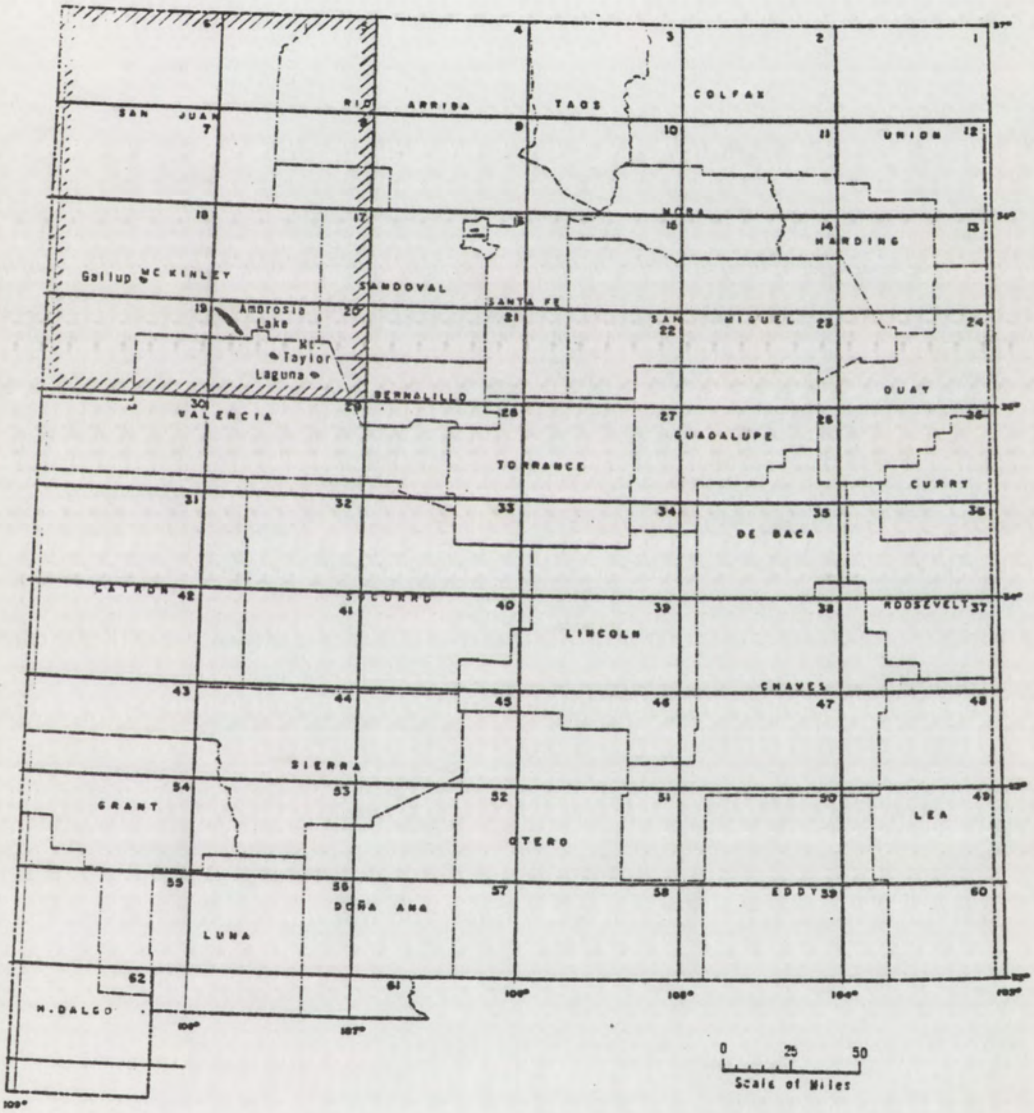


FIGURE II-1. Cell configuration, subjective probability study, State of New Mexico. Source: J. R. Ellis, D. P. Harris, R. H. Van Wie: A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico, ERDA-GJO-110(76).

questionnaire was designed to direct the attention of the respondents to this point.[34] The authors further acknowledge this problem in their evaluations of the strengths and weaknesses of the survey:

> It is most likely that the estimates in this study of uranium resources in economic deposits are conservative. And as indicated in the section on methods, it is even more likely that resources in subeconomic deposits of known modes of occurrence were underestimated by the panel of respondents.[35]

Because of this problem, subeconomic resources were estimated by extrapolating the relationship between the logarithm of cumulative tonnage of ore and decreasing average grade of the ore estimates made in the study plus production plus reserves.[36] The authors note that this procedure of extrapolation has limitations. One such limitation is the continuity of the occurrence of uranium with declining grade. This will be discussed shortly, but in consideration of the other limitations which are in the nature of faulting the procedure rather than the underlying assumptions, it will suffice to say that if the estimates by extrapolation are not extended too far beyond the probability distribution of the data produced by the study, their reliability will be suitable for ore estimation purposes.[37] Returning to the problem of geological continuity of occurrence of uranium ore with declining grade, the following considerations are relevant. The main basis for estimates of uranium ore is the geological knowledge of sandstone deposits.

Low grade ore is known to occur in a sandstone deposit either as a low grade deposit per se or as a halo around a deposit of higher grade. The evidence indicates that the reason for not having a substantial inventory of low grade ores is that the occurrence of low grade ore deposits in and of itself does not justify developmental drilling costs to block the deposit out rather than any factual basis for the nonexistence of such ore.[38] Furthermore, it is not unlikely that uranium ore of various grades will be discovered in other modes of occurrence. The existence of numerous low grade deposits in sandstone formations is well known.[39] It does not seem unreasonable, then, to assume that the geological basis for the extrapolative procedure used to estimate the state's total resource is sound.

b) Estimate of Economic Resources

Table II-7[40] gives the survey results in accordance with the revisions of the second questionnaire. The top of the table summarizes the results and the tabulation which follows breaks out ore distribution by tonnage and grade. U_3O_8 concentrate distribution by tonnage class and average grade is also given.

While this information is representative of only the most probable distribution of undiscovered uranium based on the opinions of the poll respondents, it does yield some interesting results. Table II-7 indicates that 80

TABLE II-7

CONSOLIDATED REPORT FOR 62 CELLS IN STATE OF NEW MEXICO (AFTER DELPHI).

Number of Deposits	526.7	(T)
Thou. Tons of Ore-		
Per Deposit	430.	(A)
Total	226601.	(T)
Ore-		
Grade, Pct.	0.225	(WA)
Avg. Depth	549.	(A)
Avg. Thickness	4.7	(A)
U_3O_8 Content, Tons/Sq. Mi.	4.17	(A)

Composite Estimates of Number of Deposits and U_3O_8 Content for Each Weight and Grade Class

Tonnage Class	Most Likely No. Deposits at Grade Range of (Pct.) .01-.04	.05-.14	.15-.25	.26-1.00	Total	Tonnage Class Midpoints	Most Likely U_3O_8 Content (Thou. Tons) ----- Grade Range Midpoints ----- 0.025	0.095	0.200	0.630	Total
0.0-1.0	16.636	29.252	16.501	2.455	64.845	0.5	0.002	0.014	0.017	0.008	0.040
1.0-3.0	20.634	34.430	21.945	3.444	80.453	2.0	0.010	0.065	0.088	0.043	0.207
3.0-10.0	26.944	41.337	29.527	4.707	102.516	6.5	0.044	0.255	0.384	0.193	0.876
10.0-30.0	24.109	41.676	30.445	5.442	101.672	20.0	0.121	0.792	1.218	0.686	2.816
30.0-100.0	16.248	28.662	20.677	5.125	70.711	65.0	0.264	1.770	2.688	2.009	6.821
100.0-300.0	5.072	13.482	14.020	5.327	37.900	200.0	0.254	2.562	5.608	6.712	15.135
300.0-1000.0	1.588	10.737	13.043	5.556	30.924	650.0	0.258	6.630	16.956	22.750	46.594
1000.0-3000.0	0.960	8.291	9.794	3.399	22.444	2000.0	0.480	15.753	39.178	42.824	98.235
3000.0-10000.0	0.560	4.512	4.630	1.945	11.647	6500.0	0.910	27.860	60.189	79.666	168.625
10000.0-30000.0	0.274	1.508	1.583	0.181	3.546	20000.0	1.371	28.650	63.316	22.798	116.135
Total	113.026	213.888	162.165	37.581	526.656	Total	3.712	84.351	189.640	177.778	455.479

Note: Differences between sums of column totals and row totals is due to internal machine rounding of last place digits.

Source: J. R. Ellis, D. P. Harris, R. H. Van Wie: A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico, ERDA-GJO-110 (76).

percent of New Mexico's U_3O_8 is of a grade greater than or equal to .15 percent. Eighty-four percent of the U_3O_8 is distributed in deposits of 1,000 tons or greater. Also, 25 percent of the estimated undiscovered resource will be found in fewer than 4 deposits; 62.5 percent will be found in approximately 15 deposits and 84 percent of the undiscovered resource will be found in fewer than 38 deposits. The total recoverable undiscovered resource will be 455,479 tons of U_3O_8. Only 10 percent of the recoverable resource is of a grade less than or equal to .095 percent. This information is significant in two respects. First, the high concentration of ore in high grade deposits, and the greater number of high grade deposits suggest a bias against lower grade ores. Secondly, the high percentage of concentration of high grade ores in relatively few deposits suggests a substantial saving in per pound mining and milling costs of New Mexico ore. The study reports that 80 percent of the U_3O_8 is available at a cost of less than \$15 per pound and as much as 98 percent of the undiscovered resource is recoverable at less than or equal to \$30 per pound.[41] Table II-8[42] shows the distribution of New Mexico's estimated 226,681,000 tons of ore by depth. It is significant to note from Table II-8 that by far the greatest portion of New Mexico's undiscovered uranium resource is at a depth of 1,000 feet or greater. Past production experience indicates that in a typical year 30 percent of the production in New Mexico has been from open pit mines.[43]

TABLE II-8

ORE TONNAGE AT GRADE FOR VARIOUS DEPTH CATEGORIES

Ore Tonnage (Thousands) at Grade for Depths LE 250 Ft.

Cell	- - - - - Grade Level (Pct. U308) - - - - -				Total
	0.01-0.04	0.05-0.14	0.15-0.25	0.26-1.00	
27	16.1	16.6	7.8	0.3	40.8
52	7.9	9.3	4.3	0.1	21.5
53	48.2	79.3	34.9	0.3	162.8
56	61.8	28.1	14.7	1.1	105.7
57	10.0	9.4	7.5	0.7	27.6
58	8.0	8.2	3.6	0.0	19.8
61	10.3	10.8	8.8	1.0	30.9
Total	162.3	161.6	81.7	3.5	409.1

Ore Tonnage (Thousands) at Grade for Depths GT 250 and LE 500 Ft.

Cell	- - - - - - - - Grade Level (Pct. U308) - - - - - - - -				Total
	0.01-0.04	0.05-0.14	0.15-0.25	0.26-1.00	
1	20.9	34.9	22.6	2.1	80.5
3	46.8	58.4	17.3	1.8	124.4
10	90.6	103.3	66.6	5.2	265.7
12	45.9	81.0	70.4	8.7	206.0
13	39.1	57.3	37.1	1.6	135.2
22	68.1	80.1	51.1	6.8	206.0
23	97.5	120.9	59.1	5.6	283.1
24	123.7	155.9	84.7	6.7	370.9
25	156.6	107.2	22.6	0.0	286.4
26	54.6	55.4	26.9	0.2	137.2
29	47.7	84.8	59.3	8.6	200.5
30	16.5	22.9	8.3	0.0	47.8
31	19.4	108.1	92.6	0.4	220.4
32	104.9	1195.2	915.2	17.3	2232.5
33	40.9	87.2	47.3	3.0	178.4
34	11.1	11.0	4.5	0.0	26.6
35	18.5	18.0	7.6	0.0	44.1
36	64.3	65.4	22.9	1.2	153.8
37	93.3	90.3	22.5	0.0	206.0
38	28.3	27.1	10.9	0.0	66.3
39	33.5	49.7	29.5	0.7	113.5
40	15.1	29.6	16.2	0.0	61.0
41	37.7	55.5	30.5	1.2	124.9
42	16.0	24.7	13.1	0.3	54.0
43	18.9	41.7	23.9	0.3	84.8
44	28.4	45.0	21.2	2.0	96.5
45	10.9	11.2	6.1	0.0	28.3
46	12.6	15.8	9.7	0.3	38.4
47	36.8	38.6	20.8	0.0	96.2
49	152.9	131.6	38.3	1.2	324.0
50	30.2	29.1	12.6	0.0	71.9
51	10.1	10.5	5.2	0.1	25.9
54	85.5	160.1	127.5	31.6	404.6
55	65.5	57.7	69.9	17.4	210.5
59	249.1	82.8	25.3	3.9	361.2
60	146.4	122.9	38.8	3.9	312.0
62	10.3	12.8	12.5	1.1	36.7
Total	2148.7	3483.8	2150.5	133.3	7916.2

Ore Tonnage (Thousands) at Grade for Depths GT 500 and LE 1000 Ft.

Cell	- - - - - - - - Grade Level (Pct. U308) - - - - - - - -				Total
	0.01-0.04	0.05-0.14	0.15-0.25	0.26-1.00	
2	97.0	132.3	21.3	1.9	252.5
4	131.5	487.8	252.0	26.8	898.1
5	30.3	95.4	103.5	29.7	259.0
9	166.2	1985.9	2064.4	567.7	4784.1
11	15.8	31.5	21.9	1.8	71.0
14	336.2	327.6	127.0	8.0	798.8
15	50.5	80.7	46.4	6.3	183.8
16	71.2	218.2	183.4	41.2	514.0
19	52.9	2704.0	2272.3	839.7	5868.9
21	158.3	377.3	323.6	63.4	922.5
28	18.1	28.9	14.9	0.0	61.9
48	143.5	124.9	37.8	1.1	307.3
Total	1271.4	6594.5	5468.3	1587.7	14922.0

Ore Tonnage (Thousands) at Grade for Depths GT 1000 Ft.

Cell	- - - - - Grade Level (Pct. U308) - - - - -				Total
	0.01-0.04	0.05-0.14	0.15-0.25	0.26-1.00	
6	239.9	2729.1	2208.4	790.6	5968.0
7	280.8	6028.4	5462.9	2252.5	14024.7
8	45.7	764.6	1329.3	670.8	2810.4
17	257.3	6167.2	4280.3	908.0	11612.7
18	2598.9	20580.8	25021.9	5227.5	53429.2
20	7847.7	42280.8	48817.0	16644.9	115590.3
Total	11270.3	78550.9	87119.8	26494.3	203435.3

Source: J. R. Ellis, D. P. Harris, R. H. Van Wie: A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico, ERDA-GJO-110 (76).

Figure II-2 indicates the cellular distribution by average grade and tons per square mile. The spatial distribution of U_3O_8 is indicative of the relatively common occurrence of uranium even considering the systematic bias of the body of knowledge toward high grade ores. Table II-9 gives the data for the San Juan Basin which is cross hatched in Figure II-1.[44] When Table II-9 is compared to Table II-7, it can be seen that 95 percent of the undiscovered resource in U_3O_8 concentrate is expected to be found in the San Juan Basin. These data also indicate that 60 percent of the state's total undiscovered resource will most probably occur in fewer than 15 deposits of 3,000 tons or greater in the San Juan Basin. These figures, once again, must be digested together with the knowledge that industrial geologists and explorers make a great majority of the questionnaire respondents. It would seem that the data for the San Juan Basin are the most accurate since this area is the focal point of industrial geological knowledge and the remainder of the state has been grossly underestimated as to undiscovered resources. With this consideration in mind, it seems opportune to consider the report's evaluation of undiscovered subeconomic resources.

Estimates of Subeconomic Resources

Table II-10 reflects the data obtained by the extrapolation method described earlier.

When this Table (II-10) is compared to Table II-3 and if we assume that 50 percent of the uranium estimated

TABLE II-9

CONSOLIDATED REPORT FOR 8 SELECTED CELLS, SAN JUAN BASIN, NEW MEXICO (AFTER DELPHI).

Number of Deposits	161.7	(T)
Thou. Tons of Ore–		
Per Deposit	1296.	(A)
Total	209563.	(T)
Ore–		
Grade, PCT	0.232	(WA)
Avg. Depth	1587.	(A)
Avg. Thickness	7.4	(A)
U_3O_8 Content, Tons/Sq. Mi.	30.61	(A)

Composite Estimates of Number of Deposits and U_3O_8 Content for Each Weight and Grade Class

Tonnage Class	Most Likely No. Deposits at Grade Range of (Pct)					Tonnage Class	Most Likely U_3O_8 Content (Thou. Tons) ---- Grade Range Midpoints ----				
	.01-.04	.05-.14	.15-.25	.26-1.00	Total	Midpoint	0.025	0.095	0.200	0.630	Total
0.0-1.0	0.705	2.582	2.993	0.830	7.110	0.5	0.000	0.001	0.003	0.003	0.007
1.0-3.0	1.222	3.894	3.822	1.344	10.282	2.0	0.001	0.007	0.015	0.017	0.040
3.0-10.0	1.282	4.922	6.153	2.030	14.386	6.5	0.002	0.030	0.080	0.083	0.198
10.0-30.0	1.747	6.743	8.732	2.346	19.568	20.0	0.009	0.128	0.349	0.296	0.782
30.0-100.0	1.525	7.864	8.926	4.096	22.411	65.0	0.025	0.486	1.160	1.677	3.348
100.0-300.0	1.165	7.435	10.592	4.919	24.112	200.0	0.058	1.413	4.237	6.199	11.906
300.0-1000.0	1.148	9.441	12.118	5.408	28.116	650.0	0.187	5.830	15.754	22.148	43.918
1000.0-3000.0	0.781	7.691	9.439	3.359	21.269	2000.0	0.391	14.612	37.756	42.320	95.078
3000.0-10000.0	0.490	4.231	4.332	1.877	10.930	6500.0	0.796	26.126	56.321	76.852	160.055
10000.0-30000.0	0.274	1.508	1.583	0.181	3.546	20000.0	1.371	28.850	83.316	22.798	116.135
Total	10.339	56.311	68.691	26.390	161.730	Total	2.838	77.283	178.991	172.392	431.504

Note: Differences between sums of column totals and row totals is due to internal machine rounding of last place digits.

Source: J. R. Ellis, D. P. Harris, R. H. Van Wie: A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico, ERDA-GJO-110 (76).

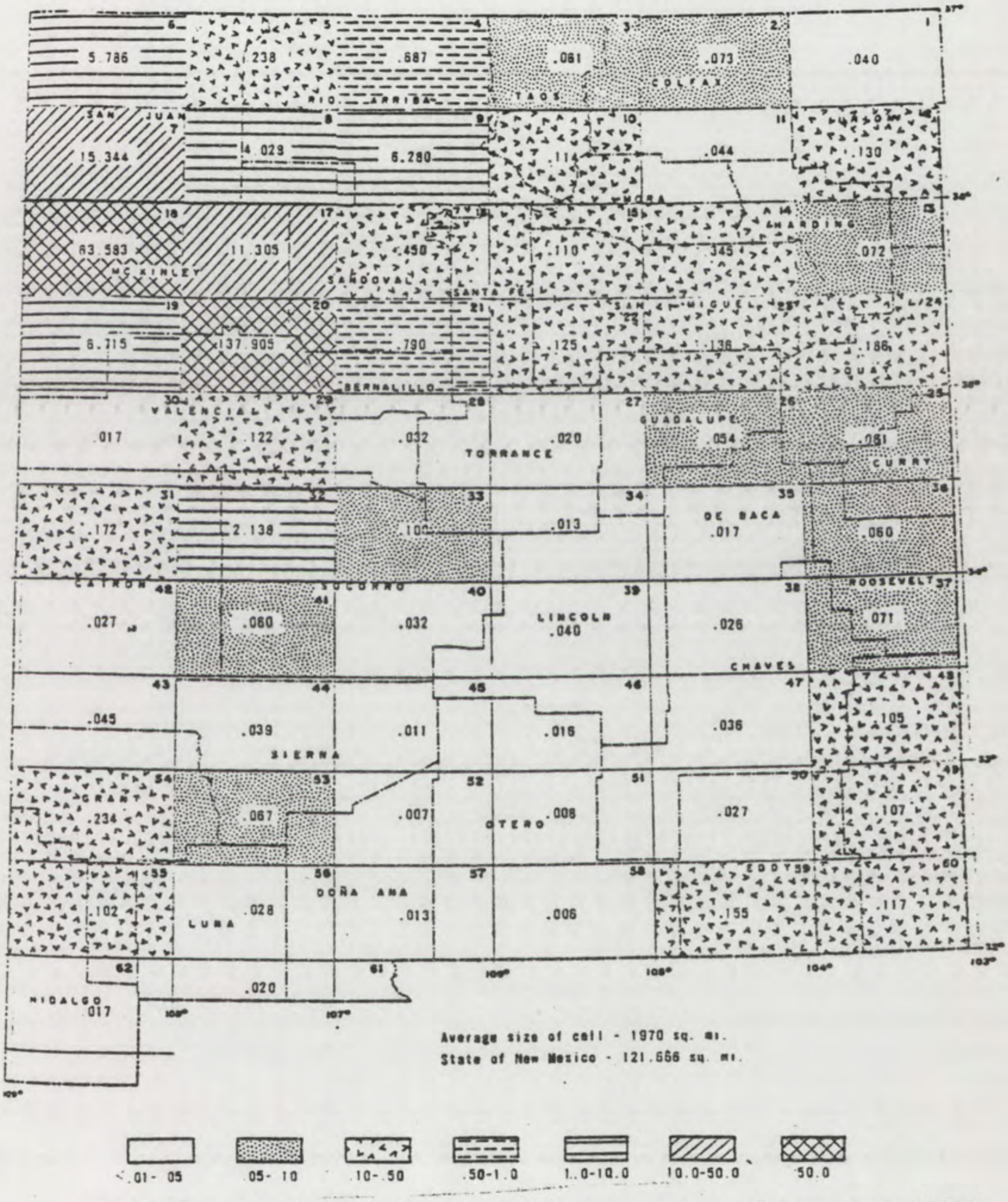


FIGURE II-2. Spatial distribution of U_3O_8 (tons per sq. mi.) after the Delphi reassessment. Source: J. R. Ellis, D. P. Harris, R. H. Van Wie: A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico, ERDA-GJO-110(76).

to exist in Table II-3 is in New Mexico (since roughly 50 percent of the ore reserves are found in New Mexico), then eliminating the speculative category of Table II-3 and accepting the extrapolative process only to the interval of .05-.10, then the estimates of the potential resource of Table II-3 and the extrapolated estimates of Table II-10 are within ten percent of one another. For future computations, the minimum figure for undiscovered resource will be considered to be 455,479 tons of U_3O_8 and the maximum undiscovered resource will be considered to be 1,050,508 tons of U_3O_8.

TABLE II-10

INFERRED UNDISCOVERED URANIUM RESOURCES OF NEW MEXICO[45]

Grade Interval %	Ore 10^6 Tons	Cumulative Ore 10^6 Tons	U_3O_8 Tons	Cumulative U_3O_8
.45+	.43	.43	2,106	2,106
.40 - .45	1.70	2.13	7,236	9,342
.35 - .40	3.77	5.90	14,131	23,473
.30 - .35	13.42	19.32	43,603	67,076
.25 - .30	33.92	53.30	93,454	160,530
.20 - .25	76.80	130.10	172,794	333,324
.15 - .20	78.55	208.65	137,455	470,779
.10 - .15	241.37	450.02	205,991	766,770
.05 - .10	385.43	835.45	283,738	1,050,508
.01 - .05	376.08	1,211.53	109,671	1,160,179

In summary, this chapter has attempted to survey and evaluate the data on uranium resources in New Mexico. The conclusion drawn was that ERDA's data, in their Subjective

Probability Analysis was the best gauge for measuring undiscovered resources in New Mexico, and that ERDA's reserve data was the best, although somewhat distorted, estimates of the state's proven reserves. The distortion in the reserve estimates arises because the method of computing reserves does not take inflationary forces into account. The total resource utilizing this data is:

Proven Reserves--302,700 tons U_3O_8 in ore recoverable at less than $30 per pound.[46]

Undiscovered Higher Grade Resources--455,479 tons U_3O_8 in ore, 98 percent of which is recoverable at less than $30 per pound.

Undiscovered Marginal Resources--595,029 tons of U_3O_8 of a grade of .05% or higher.

Total--1,353,208 tons.

CHAPTER III

URANIUM DEMAND AND ITS IMPACT IN NEW MEXICO

As difficult as it was to assess the potential uranium resources of New Mexico and as uncertain as these estimates are, it must be admitted that predicting a demand schedule for uranium will prove no less arduous and the results will be no less tenuous. The variables that determine demand for uranium as an energy source are many and changeable. Consequently, the estimates of future uranium requirements have varied considerably. Since the 1973 Arab oil embargo, the variance in these estimates has been particularly dramatic. Nevertheless, it is the purpose of this chapter to survey the recent predictions for requirements for uranium and to assess what the most likely demand schedule will be.

Demand Determinants

Initially, the estimates considered will be those of the Energy Research and Development Administration. Once again, ERDA's privity to industry data and its responsibility for actually coordinating energy policy places it in a unique position to make such predictions. Furthermore,

the variance of the predictions may shed light on the nature of the problems in making such predictions. Table III-1 gives ERDA predictions for uranium demand in recent years in columns 2 through 7 and actual production in column 8. Domestic requirements do not include exports, a fact which explains some of the discrepancies existing between predicted values and actual production. Table III-2 reflects projected sales to foreign countries.

Effect of Tailings Assay

A further problem which partially accounts for discrepancies between predicted values and production statistics is the value of the tails assay in the enrichment process. For instance, for the 1975 report the enrichments tails are estimated to be .20 percent to 7/1/76; .275 percent to 7/1/81; .30 percent thereafter.[47] This footnote is immediately followed by a note which states: "Current transaction tails planning (GJO News Release #12, 5/8/75; .20% to 10/1/77; .275% to 7/1/81; .30% uranium-235 thereafter."[48] The 1976 report notes that the enrichment tails will be: .20 percent tails to 10/1/78; .25 percent tails to 10/1/79; .275 percent tails to 10/1/81; .29 percent tails thereafter.[49] The interdependency of uranium demand and the value of tails assay is related to the fact that natural uranium consists of 99.3 percent U-238 and .7 percent U-235. U-235 is a uranium isotope whose atoms are fissionable. Enrichment is the process

TABLE III-1

AEC/ERDA FORECASTS OF U.S. URANIUM REQUIREMENTS
(tons of U_3O_8

Col. 1 Year	Col. 2 1970 Report	Col. 3 1972 Report	Col. 4 1973 Report	Col. 5 1974 Report	Col. 6 1975 Report	Col. 7 1976 Report	Col. 8 Actual Prod.
1970	7,500						12,905
1971	9,200						12,273
1972	12,500	9,200					12,900
1973	14,600	10,600	8,300				13,235
1974	15,600	14,400	11,500	9,300			11,528
1975	22,600	18,200	15,100	11,300	10,800		11,600
1976	26,200	20,500	17,600	12,700	14,100	10,700	
1977	29,100	23,800	19,800	15,400	17,500	17,400	
1978	33,500	28,400	24,500	17,900	20,500	21,100	
1979	37,700	32,600	28,500	24,200	23,200	25,200	
1980	42,500	37,000	31,600	28,900	25,800	31,400	
1981		42,100	36,400	30,900	30,800	35,200	
1982		47,400	40,800	36,100	37,700	35,800	
1983		53,200	55,900	49,700	41,800	34,100	
1984		59,700	63,200	57,000	46,100	34,900	
1985		66,600	71,500	64,200	50,900	31,700	
1990					87,600	1986 32,800	
1995					131,300	1987 34,400	
2000					172,800	1988 33,000	
						1989 31,900	
						1990 31,800	

SOURCE: Kerr McGee Corporation, 1975 Uranium Statistics and Industry Projections, August 1975, Oklahoma City; GJO-100 (76), p. 77.
These predictions have varying assumptions, which can be obtained by consulting the GJO-100 publication for the reporting year.

of refining part of the uranium with a higher percentage of U-235 at the expense of some other part of the uranium later discarded as tails. This is done by converting the uranium from a solid state to a gaseous compound known as uranium hexafluoride (UF_6). This gas is then fed through a porous membrane at high pressure. The U-235 atoms which are lighter attain a greater velocity and therefore pass through the membrane at a relatively higher rate than the heavier U-238. The foregoing is a description of a single stage of the enrichment process. Nuclear fuel is preferably a mix of uranium isotopes with as high a percentage of U-235 atoms as 4 percent.[50]

TABLE III-2

U_3O_8 SALES TO FOREIGN COUNTRIES

Year of Delivery	Tons U_3O_8	Tons U_3O_8 Cumulative
1966-1974	--	7,000
1975	500	7,500
1976	1,000	8,500
1977	1,400	9,900
1978	800	10,700
1979	300	11,000
1980 and later	0	

SOURCE: Statistical Data of the Uranium Industry, GJO-100 (76), p. 75.

To achieve a 4 percent U-235 mix, approximately 1,500 stages are required.[51] The enrichment process is, thus, a

complicated, drawn out affair, which presently takes place at one of three facilities in the United States: Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. The capacity of the enrichment plants is such that as the demand for nuclear fuel increases, the ability to enrich the uranium is increased by discarding a higher grade UF_6. Obviously, as the UF_6 passes through consecutive stages, the amount of U-235 that may be recovered from that uranium that has already sacrificed some of its U-235 is decreasing. At some point then a trade off between a higher percentage of U-235 recovery from the processed uranium in the latter stages and processing unprocessed uranium must be made. As the volume of uranium being processed increases, the higher will be the tails assay as the trade off is made. The impact of this trade off on uranium demand can be seen when it is considered that if the tails assay is .3 percent, 22 percent more uranium hexafluoride must be processed than if the tails assay was .2 percent.[52]

Effect of the Breeder Reactor

The next consideration which fundamentally affects calculations of uranium demand is the use of the breeder reactor. The breeder reactor is capable of utilizing the enrichment tailings as a fuel after processing; furthermore, the breeder creates its own fuel as a byproduct. Dr. Ralph Lapp demonstrates the uranium requirement differential

resulting from the use or non-use of the breeder reactor aptly with the following quotation:

> Consider, for example, the energy potential of the 3.5 million tons of uranium resources, assuming the success of the power breeder. Instead of being sufficient just to fuel about 300 reactors for their full forty year lifetimes, the resources become adequate to run the same number of power plants for 37 centuries.[53]

At present, the breeder reactor is not thought to be suitable for commercial use from an environmental and safety perspective. Nevertheless, most estimates of demand for uranium are presuming that the breeder reactor will become commercially usable in the next decade. Table III-3 reflects ERDA's estimates of uranium demand both utilizing the breeder and without the breeder and for varying tail assay scenarios. The impact of these two considerations (tail assay and breeder utilization) is dramatically shown.

Other Considerations Affecting Demand

Other problems which have plagued would-be forecasters are:

1. The recent recession has caused a pinch in the ability of utilities to undertake the implementation of costly nuclear power programs. This pinch has resulted in many postponements of nuclear power programs.
2. The recession has also had the effect of lowering projections of future power requirements. This will also reduce the need for nuclear power.

TABLE III-3

URANIUM REQUIREMENTS
ERDA DOMESTIC TOLL ENRICHMENT CONTRACTS
(208,000 MWe)

Calendar Year	Tons U_3O_8		
	0.37 Tails[1] No Pu Recycle	.29 Tails[2] Pu Recycle	.20 Tails Pu Recycle
1975	8,100	8,100	8,100
1976	10,700	10,700	10,700
1977	18,600	18,600	17,400
1978	22,400	22,400	20,600
1979	25,200	25,200	22,300
1980	31,400	31,400	27,500
1981	41,300	35,200	29,900
1982	45,200	35,800	30,100
1983	44,600	34,100	28,600
1984	46,900	34,900	28,900
1985	45,100	31,700	26,100
1986	47,500	32,800	26,900
1987	49,800	34,400	28,400
1988	49,900	33,000	27,200
1989	48,600	31,900	26,300
1990	48,200	31,800	26,100

[1] 0.20% Tails Through FY 77
0.25% Tails FY 78 & 79
0.275% Tails FY 80 & 81
0.37% Tails From FY 82

Assumes foreign conditional contracts will be serviced.

[2] 0.20% Tails Through FY 77
0.25% Tails FY 78 & 79
0.275% Tails FY 80 & 81
0.29% Tails From FY 82

Source: Patterson, John, Uranium Requirements and Supply Outlook, November 1975, p. 47, ERDA.

3. Many utilities have experienced difficulties in obtaining authorization and approval from regulatory bodies for commencing operations.

Survey of Demand Estimates

As a result of these problems, ERDA has changed its approach in making predictions. Instead of utilizing general demographic projections as a basis for predicting uranium demand, ERDA has based its forecasts on the amount of uranium for which enrichment feed contracts have been made. Further, these predictions were based on the 208,000 megawatt capacity of reactors operating, under construction or planned on 1 January 1976.[54] This approach is reflected in column 7 of Table III-1 (April '76 data[55]) and in the predictions of Table III-3 (November 1975 data[56]). The effect of this change on projected demand can be seen in the later years. This method of predicting demand will eliminate many of the vagaries inherent in earlier estimates but it seems that it must be viewed as a calculated underestimate or minimum estimate of future fuel requirements. For instance, as of 31 December 1975, the capacity of the nuclear power generating units operable, being built or ordered was 210,568,600 kilowatts, while the added capacity planned but, at that date, had no reactors ordered was 26,160,000 kilowatts for a total of 236,728,600 kilowatts.[57] This, already, envisions a ten percent increase in demand.

Nevertheless, recent experience has demonstrated the tenuous nature of planned but unordered reactors; therefore, the ERDA estimates in column 7 of Table III-1 can be viewed as a practical minimum demand schedule for uranium concentrate. This estimate follows ERDA's revision in its policy of feed delivery schedules. This revision provided an "open season" within bounds for varying individual consumer's feed delivery schedules.[58] The bounds placed on the "open season" were designed to assure a stable, sufficient, growing demand in uranium concentrate for the uranium industry.[59] The implication of this prediction, then, is that it is the minimum production requirements of the uranium industry.

There is no dearth of higher estimates; therefore, several estimates will be surveyed. These estimates are, in some cases, expressed in installed nuclear generating power and, in others, in tons of U_3O_8. Since New Mexico's interest in uranium is in the mining and milling of uranium, it will be necessary to translate electrical power demand into demand for tons of U_3O_8. In certain cases, this translation has been done by the authors of the particular sources cited; in other cases this conversion from electrical generating capacity to U_3O_8 would have to be computed. Table III-4, column 2 reflects the "Business as Usual" scenario of FEA as of 1974 in terms of installed nuclear powered generating capacity. The Federal Energy Administration revised their estimates in early 1976, but the revised figures did not

TABLE III-4

A SURVEY OF PROJECTED INSTALLED NUCLEAR POWER FROM VARIOUS SOURCES
[GWE]

Col. 1	Col. 2[1]	Col. 3[2]	Col. 4[3]	Col. 5[4]	Col. 6	Col. 7	Col. 8[5]	Col. 9	Col. 10
	FEA Nov. 74 Scenario	FEA Feb 76 Revision 30% Slower	OECD/	Edison Electric Institute Nuclear Fuels Supply Study 1976				ERDA Demographic Projections	
Year	I	Growth	IAEA	High	Med.	Low	Mod High	Mod Low	Low
1975	47	-	40.1	-	39.5	-	40	39	37
1976	54	54.0	47.5						
1977	61	58.9	54.6						
1978	71	65.9	61.8						
1979	93	81.3	68.2						
1980	120	100.2	82.2	85.3	77.3	72.9	82	76	70
1981	147	119.1	102.0						
1982	177	140.1	126.0						
1983	207	161.1	152.0						
1984	240	184.2	179.0						
1985	275	201.7	205.0	204.0	185.0	157.0	205	185	160
1986	312	227.6	234.0						
1987	352	255.6	266.0						
1988	396	286.4	301.0						
1989	445	320.7	341.0						
1990	500	359.2	385.0	389.0	340.0	213.0	385	340	285
1991			432.0						
1992			481.0						
2000			1,000.0	1,005.0	805.0	507.0	1,000	805	625

[1] Federal Energy Administration Project Independence Blueprint, Final Task Force Report, November 1974, p. 3.3-1.

TABLE III-4
(continued)

[2] This revision is computed on the basis of a 30 percent slower growth estimate than in column 2. National Energy Outlook, 1976, p. xxxii.

[3] Uranium, Resources, Production and Demand. A joint Report by the OECD Nuclear Agency and the International Atomic Energy Agency, December 1975, p. 28.

[4] Nuclear Fuels Policy, Fourth Draft, The Atlantic Council of the United States. App. A, Table I-4.

[5] Uranium Industry Seminar, October 7-8, 1975, GJO-108(75), p. 10.

appear in the 1976 FEA publication, The National Energy Outlook 1976. It was suggested, however, that the adjustment was approximately "a 30% slower growth rate" in nuclear power.[60] Column 3 approximates this revision by reducing the annual increments of column 3 to only 70 percent of the increments of column 2. National Energy Outlook 1976 made one further reference to the specific amounts of its revisions in that only 152,000 MWe would be on hand at the beginning of 1985.[61] This indicates that column 3 estimates are still too high. Column 4 represents the nuclear energy demand perspective for the United States of the "Organization for Economic Cooperation and Development" Nuclear Energy Agency and the International Atomic Energy Agency, as of December 1975. Columns 5, 6, and 7 represent the nuclear generating capacity of the United States as viewed by the Edison Electric Institute Nuclear Fuels Supply Study Program 1976.[62] Columns 8, 9, and 10 represent ERDA's projections for installed nuclear capacity.[63] The starting point for the ERDA projections was "on stream" capacity.[64] Plants planned or under construction provide direction until 1985,[65] and thereafter the scenario assumptions are the guiding factors.[66] The moderate/high view anticipates minimal construction problems and that the costs of nuclear fuel will remain relatively cheap.[67] The moderate/low growth case anticipates a lesser role for the electrical sector, rising capital costs for nuclear plants, and a

lessening of the advantages of nuclear fuel.[68] The low growth case anticipates no advantageous position in costs using nuclear fuels, industry inability to control capital costs, and project schedules requiring at least their full term for completion.[69]

The striking similarities of the data in columns 4, 5, and 8 of Table III-4 and the designation of the estimates in columns 5 and 8 as relatively high by the source authors make these projections favorable candidates for the upper end of the demand schedule for U_3O_8. Column 4 is converted into demand for U_3O_8 in Table III-5. Column 5 is converted into U_3O_8 demand by the source authors, and is reflected in Table III-5. The results in Table III-5 indicate substantial agreement between the OECD/IAEA and Edison Electrical Institute data when recycling and a tails assay of .3 percent is assured. The ERDA data for U_3O_8 was available for the moderate/low scenario reflected in column 9 of Table III-4 but not for column 8. Although the data derived from the OECD/IAEA data yields the highest cumulative U_3O_8 requirements by the year 2000, the Edison Electric Institute data provides a higher estimate for the near term (until 1990) and therefore for purposes of this study, this data will be utilized as the maximum anticipated demand for U_3O_8.

Having selected minimum and maximum anticipated U_3O_8 demand schedules for domestic demand, some assumptions

TABLE III-5

SURVEY OF FUTURE DEMAND ESTIMATES OF U_3O_8
(thousands of short tons)

Col. 1	Col. 2[1]	Col. 3[2]	Col. 4[5]	Col. 5	Col. 6[3]	Col. 7	Col. 8	Col. 9
					U.S. U_3O_8 Req. Edison Electric Institute Study 1976			
Year	%[4]	U_3O_8 Demand Short Tons World	U.S. U_3O_8 Requirements Annual	U.S. U_3O_8 Requirements Cumulative	No Recycle	Recycle	No Recycle Cumulative Demand	Recycle Cumulative Demand
1975	-	-	13.600	13.600	12.7	12.7	12.7	12.7
1976	.546	24.7	13.500	27.100	15.2	15.2	27.9	27.9
1977	.520	31.2	16.224	43.224	17.0	17.0	44.9	44.9
1978	.506	39.0	19.734	63.058	21.4	21.1	66.3	65.9
1979	.467	50.7	23.676	86.734	26.8	25.9	93.1	91.8
1980	.459	62.4	28.641	115.375	30.7	29.6	123.8	121.4
1981	.449	66.3	29.768	145.143	35.4	33.5	159.1	154.9
1982	.442	80.6	35.625	180.768	42.3	38.6	201.4	193.6
1983	.444	87.1	38.672	219.440	49.1	43.6	250.5	237.2
1984	.437	94.9	41.471	260.911	54.0	47.6	304.5	284.8
1985	.427	106.6	45.518	306.429	61.5	54.5	366.0	339.3
1986	.431	117.0	50.427	356.856	69.4	60.7	435.4	400.0
1987	.432	131.3	56.721	413.577	76.4	65.7	511.8	465.7
1988	.434	144.3	62.626	476.203	83.5	70.4	595.3	536.1
1989	.438	156.0	68.328	544.531	91.6	74.8	686.9	610.9
1990	.440	169.0	74.360	618.891	100.8	78.1	787.7	689.0
1991	.449	184.6	82.885	701.776	109.6	82.0	897.2	771.0
1992	.445	197.6	89.908	791.684	117.6	86.4	1,014.9	857.4
2000	.498	306.8	152.786	1,780.005	163.8	127.3	2,194.8	1,740.0

[1] Uranium, Resources, Production and Demand, December 1975, OECD Nuclear Energy Agency and the IAEA, Table 8, p. 28. $\frac{\text{U.S. estimate}}{\text{World Total-low estimate}}$ is the source of this data.

[2] With Pu recycle, commencing in 1981, and .25 tails assay. The IACA/OECD figures were converted from metric tons of uranium metal to short tons of U_3O_8 using a conversion factor of 1.3 short tons $U_3O_8 \sim$ 1 metric ton of uranium metal.

TABLE III-5. (continued)

[3] Columns 6 through 9 are obtained from the Edison Electric Institute Nuclear Fuels Supply Study Program, 1976 and adopted by the Atlantic Council in their Nuclear Fuels Policy Fourth Draft, App. A, Table 6.1 and 6.2. Assumed is a tails assay of .3%.

[4] U.S. nuclear generating power as a percentage of world nuclear generating power.

[5] U.S. requirements are derived by multiplying column 2 X column 3 for the respective years.

must be made regarding New Mexico's role in providing U_3O_8 to meet these requirements. Typically, New Mexico has supplied close to 50 percent of the U_3O_8 that has been produced domestically.[70] New Mexico holds roughly 50 percent of the nation's proven reserves as well as nearly 50 percent of the nation's milling capacity.[71] The projections discussed in Chapter II of this report regarding the most probable amount of uranium ore existing in New Mexico and the fact that two additional mills are presently under construction in New Mexico[72] implies that New Mexico will continue to hold this position. Assuming that New Mexico will continue to supply around 50 percent of total domestic production, then Table III-6 would reflect the production requirements for New Mexico's uranium industry. Table III-6 reflects the minimum and maximum annual and cumulative demand schedules for U_3O_8 as indicated by the minimum and maximum nuclear power generating capacity selections discussed above. These figures are then divided by two to obtain the New Mexico schedule of expected production. Columns 10 and 11 of Table III-6 indicate the declining percentage of remaining $30 reserves at the minimum and maximum production rates. Recalling that the $30 reserves include all lesser forward cost categories, New Mexico's present day proven reserves, if no other uranium was produced during this time frame, would be exhausted by 1989 utilizing the maximum production rate and would be

TABLE III-6

U_3O_8 MINIMUM AND MAXIMUM PROJECTED DOMESTIC DEMAND SCHEDULES AND NEW MEXICO'S ROLE IN SUPPLY
(Short Tons U_3O_8)

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10[2]	Col. 11
Year[1]	Minimum Annual	Minimum Cumulative	Maximum Annual	Maximum Cumulative	New Mex. Supply Req. Minimum Annual	Col. 6 Cumulative	New Mex. Supply Req. Maximum Annual	Col. 8 Cumulative	Declining % of $ 30 Res. Minimum	Declining % of $ 30 Res. Maximum
1975	11,600	11,600	(12,700)	(12,700)	4,950	4,950	4,950	4,950	100.0%	100.0%
1976	10,700	22,300	15,200	27,900	5,350	10,300	7,600	12,550	98.3%	98.3%
1977	17,400	39,700	17,000	44,900	8,700	19,000	8,500	21,050	96.5%	95.8%
1978	21,100	60,800	21,100	65,900	10,550	29,550	10,550	31,600	93.7%	93.4%
1979	25,200	86,000	25,900	91,800	12,600	42,150	12,950	44,550	90.2%	89.5%
1980	31,400	117,400	29,600	121,400	15,700	57,850	14,800	59,350	86.0%	85.2%
1981	35,200	152,600	33,500	154,900	17,600	75,450	16,750	76,100	80.8%	80.0%
1982	35,800	188,400	38,600	193,600	17,900	93,350	19,300	95,400	75.0%	74.8%
1983	34,100	222,500	43,600	237,200	17,050	110,400	21,800	117,200	69.1%	88.4%
1984	34,900	257,400	47,600	284,800	17,450	127,850	23,800	141,000	63.5%	61.2%
1985	31,700	289,100	54,500	339,300	15,850	143,700	27,250	168,250	57.7%	53.4%
1986	32,800	321,900	60,700	400,000	16,400	160,100	30,350	198,600	52.5%	44.4%
1987	34,400	356,300	65,700	465,700	17,200	177,300	32,180	231,450	47.4%	34.3%
1988	33,000	409,300	70,400	536,100	16,500	193,800	35,200	266,650	41.4%	23.6%
1989	31,900	441,200	74,800	610,900	15,950	209,750	37,400	304,050	35.9%	11.9%
1990	31,800	473,000	78,100	689,000	15,900	225,650	39,050	343,100	30.7%	-
1991			82,000	771,000			41,000	384,100	25.4%	-
1992			86,400	857,000			43,200	427,300		
2000			127,300	1,740,000			63,650	868,870		

[1] The 1975 date in parentheses were an estimate as of the time of data preparation by the source authors cited elsewhere. All other data are actual production data.

[2] The reserve estimates for $30 forward cost reserves are found in Statistical Data of the Uranium Industry, GJO-100(76), p. 49.

reduced to 30.7 percent utilizing the minimum production rate time frame. (Note that the minimum demand schedule begins to decline after 1982; this is because this schedule reflects contracts with ERDA for enrichment for the present 208,000 MWe planned or operating capacity. This does not provide for expansion beyond the 208,000 MWe level nor does it include requirements for the 208,000 MWe that have not been contracted thus far.)

Although depletion of today's reserves by 1989 is not alarming in and of itself, when it is considered that there is a lag time of eight years between discovery and forward delivery,[73] it follows that there will be no production of U_3O_8 to be discovered in 1976 until 1984 and so on for ore discovered in 1977. During 1975, 40,000 tons of U_3O_8 were added to reserves.[74] This is most likely less than will be consumed in 1984. The thrust of these considerations is that if new discoveries continue at the 1975 rate or slower, 1976 reserves will continue to be depleted (at a slower rate) in spite of 1977 discoveries reaching the production stage. This will have a twofold effect; first, an intense effort at shortening development time, as 1976 reserves approach depletion, will occur. This will increase the cost of producing U_3O_8. Secondly, if conventional analysis is correct, this will create an inexorable upward pressure on the price of U_3O_8 as supply conditions tighten.

The Price of U_3O_8

Although almost everyone agrees that prices will increase for U_3O_8, there is little agreement on what they will be. One reason for this uncertainty is the fractured nature of the pricing structure in the industry. At one time, prices were dictated by the AEC. As the commercial demand for U_3O_8 grew, pricing policies were developed by the industry. Initially, bids were requested and submitted for yellowcake. This policy was discontinued, and pricing by "bargain and sale" bilateral contracts became the predominant mode of setting prices. At the same time, there developed a market for immediate delivery in which instead of bilateral contracting, buyers and sellers dealt in a market environment. The rapid rise in prices from 1973 to the present placed a great strain on the process of bilateral contracting for future delivery at a given price schedule. Some companies are seeking to disaffirm earlier contracts in the courts on the basis of economic impossibility of performance. Other companies are making new contracts based on the market price at the time of delivery. The net result is a good deal of uncertainty about what future prices will be. The problem is not aided by the confusion over present price. For purposes of paying New Mexico's Natural Resource Excise Tax,[75] the industry reported sales of 9,571,941.12 lbs. at a value of

77,135,833.95 with a weighted average price of $8.06, yet, the Bureau of Mines reported that New Mexico produced approximately 9.5 million lbs. of U_3O_8 in concentrate at a value of $215,800,000 with an average price of $21.80 per pound. This discrepancy remains unexplained. In its annual report to stockholders, Kerr-McGee reported prices of $9.31/lb. and $11.84/lb. for 1974 and 1975 respectively. United Nuclear, in its annual report, reported its average price to be just under $15.00/lb. The problem is muddled further by the dizzying climb of the "spot price" of U_3O_8 to $40.00 per pound.

As suggested earlier, prices are expected to increase as increasing demand pressures draw down available reserves. There are other problems in the industry structure in New Mexico which may pose supply problems. The first is an already existing shortage of labor and which will get worse as the industry expands. The second problem is mill capacity. At present, New Mexico has a mill capacity of 13,500 tons of ore per day.[76] By September 1976, a new mill with a capacity of 1,500 tons of ore per day will come on line.[77] This is the last anticipated addition to milling capacity until mid-1978 when United Nuclear will come on line with a new mill in Churchrock, New Mexico with an initial capacity of 2,000 tons per day for the first two years and 3,000 tons per day thereafter, with the ability to expand to 4,000 tons.[78]

As Table III-7 indicates, New Mexico's presently planned milling capacity is quickly outstripped by anticipated supply requirements even at a relatively high grade of ore (.20). A trend which makes this problem even more critical is that as prices rise, it becomes more economical to process lower grade ores. In fact, since the price of U_3O_8 began its rapid climb in 1973, the average ore grade has gone from .20 percent in 1973 to .18 percent in 1974, to .17 percent U_3O_8 in 1975.[79] As the prices rise, then, unless capacity is expanded, production will be artificially constrained resulting in even more upward pressure on price.

With these considerations in mind, the existing price data will be surveyed and a price schedule will be determined for purposes of valuing the U_3O_8 anticipated to be produced in New Mexico. There are two types of price structures which would be met in the industry by a potential buyer of uranium oxide concentrate. These are the spot price structure and the contract price structure. Spot prices are reflected by several small publications which publish commodity prices. One publication which deals exclusively with the uranium industry is the "Nuclear Exchange Corporation." Their predictions on the price of U_3O_8 as of 31 January 1976 and 31 May 1976 are reported in Table III-8. Obviously the price rise of U_3O_8 in concentrate is continuing as NUEXCO's later predictions are substantially higher than the earlier predictions. It

TABLE III - 7

NEW MEXICO MILLING CAPACITY

Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7
	Mill Capacity[1] Ore - Tons	U_3O_8 Producible at a Grade of:			New Mexico Annual Supply Requirement	
Year	Per Day	.1	.15	.2	Low	High
1975	13,500	4,927.5	7,391.25	9,855	-	-
1976	15,000	5,490.0	8,235.00	10,980	5,350	7,600
1977	15,000	5,475.0	8,212.50	10,950	8,700	8,500
1978	17,000	6,205.0	9,307.50	12,410	10,550	10,550
1979	17,000	6,205.0	9,307.50	12,410	12,600	12,950
1980	19,000	6,954.0	10,431.20	13,908	15,700	14,800

[1] See Footnotes 79, 80, and 81 of the Text.

is not uncommon to hear reference to a "spot price" of $100 per pound of U_3O_8 as occurring in the not too distant future from various individuals in or related to the uranium industry in their work.

TABLE III - 8

PROJECTED PRICE OF U_3O_8

Delivery Date	Exchange Value As of 1/31/76	Exchange Value As of 5/31/76
Immediate	$35.20	$40.00
July 1, 1976	36.20	40.20
July 1, 1977	38.75	42.80
July 1, 1978	41.45	45.60
July 1, 1979	44.35	48.55
July 1, 1980	47.45	51.75

SOURCE: The Nuclear Exchange Corporations Publication NUEXCO, on the dates referenced.

Contract price predictions are somewhat different, however, in that the predictions made are for a very limited amount of the uranium expected to be supplied at the time for which the prices are predicted. Table III-9 reflects contract prices as of 1 January 1976 and 1 July 1975. The data in this table must be scrutinized carefully in conjunction with the data of Table III-10 to see what it represents. Column 2, representing '76 survey prices are higher in the near term than '75 survey prices but lower in the more distant future. The higher price in the near term reflects "higher prices for additional near term deliveries

TABLE III-9

PRICE DATA REPORTED TO ERDA IN 1975 AND 1976

	January 1, 1976 Survey			July 1, 1975 Survey	
Year	Price Per Pound of U_3O_8	Percent of Commitments for Which Prices Were Reported[1]	Percent of Commitments in Market Price Contracts[2]	Price Per Pound of U_3O_8	Percent of Commitments For Which Prices Were Reported
1975	10.50	84	1	8.45	84
1976	10.70	86	3	10.20	86
1977	11.10	77	6	10.75	80
1978	12.20	88	4	12.05	85
1979	13.05	84	3	13.10	83
1980	14.35	79	3	13.80	86
1981	15.80	84	24	16.65	87
1982	16.35	87	32	19.20	89
1983	16.05	88	36	-	--
1984	15.45	85	16	-	--
1985	15.90	67	23	-	--

[1] $\frac{C}{T-M}$ Where: T = Total commitments
C = Commitments reported to have "contract" prices
M = Commitments reported to have "market" prices

[2] $\frac{M}{C+M}$

Source: *Survey of United States Uranium Marketing Activity*, ERDA 76-46, UC-51, p. 6.

TABLE III-10

URANIUM SUPPLY ARRANGEMENTS FOR REACTORS

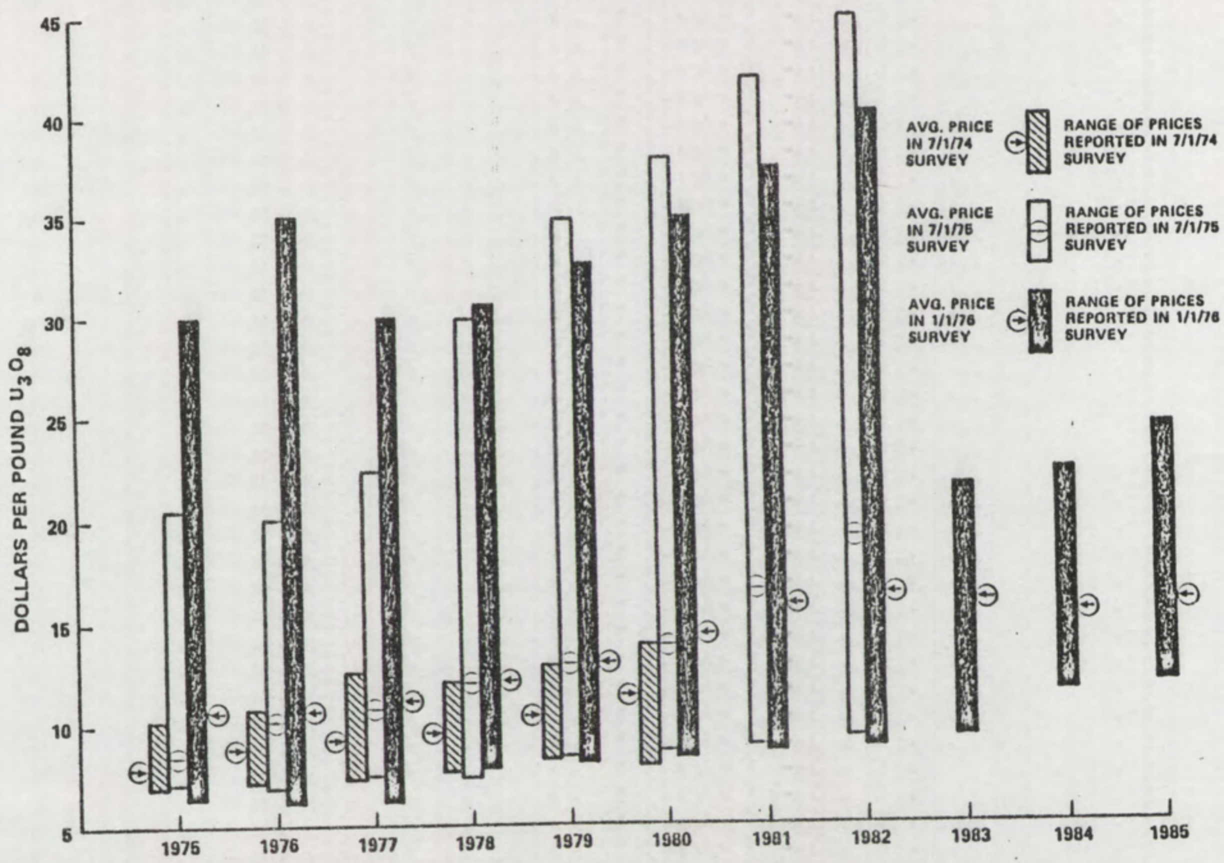
Col. 1 Year	Col. 2[1] Scheduled Nuclear Generating Capacity MWE	Col. 3[1] Capacity for Which Domestic Uranium is Committed for Fuel - MWE	Col. 4[1] Capacity For Which Foreign Uranium is Committed for Fuel - MWE	Col. 5[1] Capacity for Which No Fuel Arrangements Have Been Made - MWE	Col. 6 Col. 5 as a % of Col. 2	Col. 7 % of Commitments for Which Contract Prices Were Reported	Col. 8 % of Commitments For Which Market Price Contracts Were Reported	Col. 9 Col. 8 as a % of Col. 2	Col. 10 % of U_3O_8 Req. to which Table III-9 Prices Apply
1975	39,600	39,600							
1976	46,200	45,900		300	.6	77.6	2.4	2.4	77.00
1977	53,600	50,600		3,000	5.5	75.2	4.8	4.5	70.90
1978	60,200	48,900	1,300	10,000	16.6	76.8	3.2	2.6	62.30
1979	70,400	54,400	2,500	13,500	19.2	75.2	4.8	3.7	58.10
1980	79,700	59,800	2,800	17,000	21.3	75.2	4.8	3.6	56.40
1981	95,800	57,200	6,500	32,100	33.5	60.8	19.2	11.4	36.30
1982	123,100	59,100	12,200	51,800	42.0	54.0	26.0	12.4	25.90
1983	146,000	51,900	13,600	80,500	55.1	51.2	28.8	10.2	18.20
1984	166,000	43,600	6,000	116,400	70.1	67.2	12.8	3.3	17.65
1985	179,300	36,600	6,500	136,200	76.0	61.6	18.4	3.8	12.50
1986	189,900	27,500	5,800	156,600	82.5				
1987	196,500	20,900	6,500	169,100	86.0				

[1] Survey of United States Uranium Marketing Activity, ERDA 76-46 UC-51, p. 21

and renegotiation and upward adjustments to prices in old contracts."[80] The lower price in the later periods reflect the increase in percentages of commitments utilizing the market price concept discussed earlier (supra p. 60). Column 3 represents commitments for which prices were reported. These figures are artificially "high" in that, as footnote 1 of Table III-9 points out, market price contract commitments are excluded from the denominator before the computation is made. The result is a somewhat higher percentage of specific price contracts as a percentage of total commitments than is actually the case. Column 4 reflects the percent of commitments made using market price contracts. Similarly, Column 4 figures are deceptively large in that the denominator in footnote 2 of Table III-9 excludes those commitments which existed but were not reported to have contract prices or market prices (i.e., no prices were reported). Columns 5 and 6 of Table III-9 provide the price and percentage date for 1975 and differ from the 1976 methodology only in that market price does not enter into the computations. This price data appears very low in view of the spot price figures, the prices reported in annual reports to stockholders and the fact that the average value of a pound of U_3O_8 in concentrate was reported to be \$21.80 for 1975.[81] Although these are the only specific prices offered by ERDA in its marketing survey, Figure III-1, from the same source, shows the range

FIGURE III-1

RANGE OF REPORTED U_3O_8 PRICES, 7/1/74, 7/1/75, AND 1/1/76 SURVEYS



SOURCE: Survey of United States Uranium Marketing Activity, ERDA 76-46, UC51, p. 8.

of prices from which these prices were derived. It can be seen that in every year under consideration, some reported contract commitments have been made for prices equal to or in excess of $30 per pound. Furthermore, Figure III-1 price ranges apply only to those commitments for which price data was reported. Not reflected are commitments for which no prices were reported or prices for U_3O_8 for which requirements exist but for which no commitments have been made. As will be seen, the latter considerations will play a greater role in determining future prices than will commitments where prices have already been decided.

If: T = total commitments

C = commitments reported to have contract prices

M = commitments reported to have market prices

X = commitments for which no price was reported

T = X + C + M

and if X = .2T[82]

then it is possible to compute a percentage of total projected U_3O_8 demand for which the 1976 survey prices will be relevant. Initially, it is necessary to alter the figures arrived at in Table III-9 by ERDA whose formulated definitions in footnotes 1 and 2 do not correspond to the subjective definitions which are found at the head of the column. For instance, column 4 designated "Percent of Commitments in Market Price Contracts" is computed as

$\frac{M}{C + M}$. It seems that the percent of market price contracts would be defined more properly as $\frac{M}{T}$ or $\frac{M}{C + M + X}$. Table III-10 column 8 will reflect this modification. Similarly, column 7 of Table III-10 will reflect contract price commitments as a percentage of total commitments (i.e., $\% = \frac{C}{T}$). Column 10 will show what percentage of total U_3O_8 demand that will be subject to the contract prices of Table III-9.

Example of computations used to arrive at the results in columns 7, 8, and 9 in Table III-10 follows: If for 1982:

$$.32 = \frac{32}{100} = \frac{M}{C + M} \quad \text{(from Table III-9) then}$$

$$\frac{M}{T} = \frac{M}{C + M + X} = \frac{32}{125}$$

$$\text{because } C + M = T - X = T - .2T = .8T = 100$$
$$T = 125$$

thus the figure to be put in column 8 for 1982 will be $\frac{32}{125}$ or .26.

Similarly, if contract price commitments are $\frac{C}{T}$, then $\frac{C}{T - M} = \frac{87}{100}$ will not reflect contract commitments as a percentage of total commitments. If market price contracts are 26 percent of total commitments and 20 percent of total are assumed to go unreported, the contract price commitments as a percentage of total commitments must be 100 - [26 + 20] = 54% for column 7. Column 10 is derived by multiplying the figure in column 7 (.54) by the corresponding figure in column 3 to derive the capacity in megawatts

which when divided by the corresponding figure in column 2 will yield the percentage of nuclear generating capacity fueled by U_3O_8 sold under contract price commitments. Thus U_3O_8 requirements can be divided into four different types for pricing purposes:

1. U_3O_8 sold at "contract" price listed in Table III-9.
2. U_3O_8 sold at contract prices which were not reported.
3. U_3O_8 sold at market price contracts.
4. U_3O_8 sold at a yet to be bargained for price.

The amount and price of the first category have been determined. The amount of the second category has been approximated, but no price data is known. The amounts of the third and fourth categories are known and there is good reason to believe that this will be sold at prices which are very close to the spot price predictions of Table III-8. This information may be used to compute a weighted average for prices which will reflect a much higher percentage of U_3O_8 requirements than does the bowdlerized approach used by ERDA in Table III-9. Table III-11 assumed that the spot price of U_3O_8 will continue to rise at an average of $2.39 per pound. This was the average rise predicted from 1 July 1976 to 1 July 1980 in Table III-8.

This price schedule still seems unrealistically low when an average price per pound of U_3O_8 in 1975 is $13.00.[83] If it assumed that the average price reported in 1975 will be at least as high as 1975 levels in 1976, then the 20 percent

TABLE III-11

PREDICTED AVERAGE PRICE PER POUND OF U_3O_8 USING TABLES III-9 and III-10 DATA

Col. 1 Year	Col. 2 [% of U_3O_8 Req. Sold At Contract Prices	X Col. 3 1976 Contract Prices]	+ Col. 4 [% of U_3O_8 Sold by Market Price Contracts or by Future Commitments	X Col. 5 Predicted Spot Price]	÷ Col. 6 [Total % of Requirements Col.2 + Col.4 Considered in Computation]	= Col. 7 Average Weighted Price Per Lb. U_3O_8 For The Col. 6 Percentage Requirements for U_3O_8
1976	77.0	10.70	3.0	40.20	80.0	11.81
1977	70.9	11.10	10.0	42.80	80.9	15.01
1978	62.3	12.20	19.2	45.60	81.5	20.06
1979	58.0	13.05	22.7	48.55	80.7	23.03
1980	56.0	14.35	24.9	51.75	80.9	25.86
1981	36.0	15.80	44.9	54.64	80.9	37.35
1982	26.0	16.35	54.4	57.53	80.4	44.21
1983	18.0	16.05	65.2	60.42	83.2	50.82
1984	18.0	15.45	73.3	63.31	91.3	53.87
1985	12.0	15.90	78.8	60.20	90.8	59.55

factor which is not accounted for must be substantially higher than the average price computed in column 7 of Table III-11. This fact can be verified by a simple algebraic computation which follows:

$$.2X + .8\ (11.81) = \$13.00$$

$$X = \$17.76 \text{ per pound } U_3O_8.$$

The average price of the U_3O_8 which is the subject of the unreported commitments then must be around \$17.76/lb. U_3O_8. Even if the unreported commitments are ignored, the results of Table III-11 seem unrealistically low. Consequently, Table III-11 prices and the ERDA prices therein will not be used to evaluate the gross value of future production. Instead, the approximate average of the prices found in the Kerr-McGee and United Nuclear Annual Reports will be used. Thus, \$13.00 per pound is a starting point for such evaluation. As indicated earlier, it is anticipated that the price of U_3O_8 will continue to increase with tightening supplies; therefore, this paper will adopt an annual increment to average price of \$2.89 per pound. This is the average increment to price for the four year spot price prediction in column 3 of Table III-8.

Table III-12 reflects the anticipated high and low production schedules of U_3O_8 in New Mexico which, when multiplied by predicted price, will yield the value of annual U_3O_8 production. If ERDA's Subjective Probability

TABLE III-12

PRICE AND VALUE OF NEW MEXICO U_3O_8 PROJECTIONS

Col. 1 Year	Col. 2 U_3O_8 Requirements Low Estimates Short Tons	Col. 3 U_3O_8 Requirements High Estimates Short Tons	Col. 4 U_3O_8[1]	Col. 5 Price	Col. 6 Annual Value of U_3O_8 Low Estimate ($ billions)	Col. 7 Col. 6 Cumulated ($ billions)	Col. 8 Annual Value of U_3O_8 High Estimate ($ billions)	Col. 9 Col. 8 Cumulated ($ billions)	Col. 10 Annual Value of U_3O_8 Milling Capacity Estimates ($ billions)	Col. 11 Col. 10 Cumulated ($ billions)
1975	4,950	4,950	-	13.00	.128700	.128700	.128700	.128700	-	-
1976	5,350	7,600	7,391	15.89	.170023	.298723	.241528	.370228	.192 160 000	192 166 000
1977	8,700	8,500	8,235	18.78	.326772	.625495	.319260	.689488	.261 708 300	453 874 800
1978	10,550	10,550	8,212	21.67	.457237	1.082731	.457237	1.146725	.308 442 720	762 317 020
1979	12,600	12,950	9,307	24.56	.618912	1.701644	.636104	1.782829	.403 365 380	1.165 682 400
1980	15,700	14,800	9,307	27.45	.861930	2.563574	.812520	2.595349	.457 184 400	1,622 866 300
1981	17,600	16,750	10,431	30.34	1.067968	3.631542	1.016390	3.611739	.572 661 900	2.195 028 700
1982	17,900	19,300		33.23	1.189634	4.821176	1.282678	4.894417		
1983	17,050	21,800		36.12	1.231692	6.052868	1.574832	6.469249		
1984	14,450	23,800		39.01	1.127389	7.180257	1.856876	8.326125		
1985	15,850	27,250		41.90	1.328230	8.508487	2.283550	10.609675		
1986	16,400	30,350		44.79	1.469112	9.977599	2.718753	13.328428		
1987	17,200	32,850		47.68	1.640192	11.617791	3.132576	16.461004		
1988	16,500	35,200		50.57	1.668810	13.286601	3.560128	20.021132		
1989	15,950	37,400		53.46	1.705374	14.991975	3.998808	24.019940		
1990	15,900	39,050		56.35	1.791930	16.783905	4.400935	28.420875		
1991		41,000		59.24			4.857680	33.278555		
1992		43,200		62.13			5.368032	38.646587		

[1] These estimates are based on projected milling capacity utilizing an ore grade of .15%.

Analysis of uranium deposits in New Mexico is correct and New Mexico does have approximately 1,050,000 tons of recoverable U_3O_8 with an ore grade of .1 percent or higher. The value of this mineral resource at $50 per pound is $105 billion. As Table III-6 points out, by the year 2000, approximately 868,000 tons of U_3O_8 will have been mined and milled and, assuming no time lag will be created from lack of discovery, New Mexico's 1,050,000 tons of U_3O_8 will be exhausted by 2005, if predicted consumption rates existing in the year 2000 are reached and sustained.

Employment in the Uranium Industry

This gargantuan extraction process will have profound effects on the state's economy. Tables III-13 and III-14 reflect the jobs that will be created by the anticipated growth in the uranium industry. The methodology utilized in arriving at the labor requirements make several assumptions and therefore merit a full explanation. Initially, the U_3O_8 production requirements are those utilized in Table II-12. U_3O_8 in concentrate is translated into ore tonnage, assuming a 95 percent recovery rate by the mills[84] and a continued slow decline[85] of the average annual ore grade from .16 percent in 1976 to .12 percent in 1992. The decline in ore grade is attributable partly to the practice of low-grading as the price of U_3O_8 increases and partly to the depletion of higher grade ores as time goes

TABLE III-13[1]

EMPLOYMENT PARAMETERS IN THE URANIUM INDUSTRY IN NEW MEXICO

	Underground			Open Pit			Others			Mill Employees					
Year	Miners	Serv. and Supp.	Total Workers Per Mine[2]	Miners	Serv. and Supp.	Total Workers Per Mine[2]	All Others	Thous. Tons of Ore	Mill Employ-ees	Thous. Tons of Ore	Ave. Ore Grade Fed to Mills	Ave. Mill Re-covery	U_3O_8 Prod. in N.M.	Ore Mined and Fed to Mill tons	Total Employ-ment
1968	990	526	1.53	68	62	1.91	357	.11	558	.18	.00208	.945	6192	3,150,183	2,561
1969	995	573	1.57	107	58	1.54	227	.07	590	.19	.00202	.945	5943	3,113,311	2,702
1970	960	520	1.54	158	100	1.63	405	.13	609	.20	.00202	.948	5771	3,013,640	2,752
1971	821	371	1.45	105	190	2.80	373	.14	563	.20	.00206	.937	5305	2,748,391	2,423
1972	716	304	1.42	128	172	2.34	335	.12	543	.20	.00212	.932	5464	2,765,406	2,198
1973	647	353	1.54	142	147	2.03	349	.14	578	.24	.00202	.937	4634	2,448,302	2,216
1974	778	401	1.51	170	149	1.87	359	.12	621	.21	.00178	.933	4951	2,981,201	2,478
1975	1256	711	1.56	197	153	1.77	540	.16	852	.25	.00164	.935	5191	3,385,288	3,709
	Average (where applicable)		1.52			1.98		.12		.21					

[1]The employment data in this table was derived from the Statistical Data of the Uranium Industry, GJO-100 series, 1968 through 1975.

[2]The ratio is the total number of miners plus service and support workers divided by the number of miners for underground and open pit mining respectively.

TABLE III-14-1

EMPLOYMENT PROJECTIONS UTILIZING HIGH DEMAND ESTIMATES

Year	Ore Mined[1] And Milled Tons	Undergrd.[2] Mine Productivity	Undergrd.[3] Miner Man years Required	Open Pit[4] Miner Man years Required	Mill Employee Man years Required	Undergrd. Serv. & Support Employees Req. in Man years	Open Pit Serv. & Support Employees Req. in Man years	All Other Employees Req. in Man years	Total Employment Projected
1976	5,000,000	7.0	2,000	214	1,050	1,044	210	650	5,168
1977	5,591,875	7.2	2,175	240	1,174	1,131	235	671	5,626
1978	7,403,333	7.4	2,801	317	1,555	1,457	311	888	7,329
1979	9,088,000	7.6	3,348	389	1,908	1,741	381	1,091	8,858
1980	10,386,000	7.8	3,728	445	2,181	1,939	436	1,246	9,975
1981	11,754,657	8.0	4,114	504	2,469	2,139	494	1,411	11,131
1982	13,544,000	8.2	4,625	580	2,844	2,405	568	1,625	12,647
1983	15,298,000	8.4	5,099	656	3,213	2,651	643	1,836	14,098
1984	16,702,000	8.6	7,768		3,507	4,039		2,004	17,318
1985	20,488,571	8.8	9,313		4,303	4,843		2,459	20,918
1986	22,819,296	9.0	10,142		4,792	5,274		2,738	22,496
1987	24,699,286	9.2	10,739		4,187	5,584		2,964	24,474
1988	26,466,429	9.4	11,262		5,558	5,856		3,176	25,852
1989	30,283,077	9.6	12,618		6,359	6,561		3,634	29,172
1990	31,619,231	9.8	12,906		6,640	6,711		3,794	30,051
1991	35,965,000	10.0	14,386		7,553	7,481		4,316	33,736
1992	37,895,000	10.0	15,158		7,958	7,882		4,547	35,545

[1] Assumes mill recovery to be 95%.

[2] A manshift is an 8 hour day; a man year is 250 manshifts.

[3] Assumes 70% of future production will be underground through 1983 and all production thereafter will be from underground mines.

[4] Assumes open pit productivity to be 28 tons per manshift.

TABLE III-14-2

EMPLOYMENT PROJECTIONS UTILIZING LOW DEMAND ESTIMATES

Year	Tons of Ore Mined and Milled	Underground Mine Productivity Tons/ Manshift	Under-ground Man years Required	Open Pit Miner Man years Required	Mill Employees Man years Required	Undergrd. Service & Support Employees Man years Required	Open Pit Service & Support Employees Man years Required	All Other Employees Man years Required	Total Employment Projected
1976	3,520,000	7.0	1,449	151	739	753	148	422	3,662
1977	5,723,750	7.2	2,226	245	1,202	1,158	240	687	5,758
1978	7,403,333	7.4	2,801	317	1,555	1,457	311	888	7,329
1979	8,842,000	7.6	3,258	379	1,857	1,694	371	1,061	8,620
1980	10,328,750	7.8	3,708	443	2,169	1,928	434	1,239	9,921
1981	12,350,667	8.0	4,323	529	2,594	2,248	518	1,482	11,694
1982	12,561,334	8.2	4,289	538	2,638	2,230	527	1,507	11,729
1983	11,964,667	8.4	3,988	513	2,513	2,074	503	1,436	11,027
1984	12,245,333	8.6	5,696		2,571	2,961		1,469	12,697
1985	11,917,143	8.8	5,417		2,503	2,817		1,430	12,167
1986	12,330,714	9.0	5,480		2,590	2,850		1,480	12,400
1987	12,932,143	9.2	5,623		2,716	2,924		1,552	12,815
1988	12,405,714	9.4	5,279		2,605	2,745		1,489	12,118
1989	12,914,615	9.6	5,381		2,712	2,798		1,550	12,441
1990	12,874,615	9.8	5,255		2,704	2,733		1,545	12,237

on. Ore tonnage is tabulated by high and low estimates reflecting the high and low estimates for U_3O_8 demand. Mining technique is subdivided into underground mining and open pit mining. Underground mining is assumed to account for 70 percent of the ore mined[86] until 1983 and 100 percent thereafter. Productivity is estimated to be 7 tons per manshift for underground mining[87] in 1976 increasing by .2 of a ton per year until 1991. Open pit mine productivity is estimated to be 28 tons per manshift.[88] Productivity for open pit mills is assumed to remain at 28 tons for the short period of time (7 years) that open pit operations are expected to be carried on in New Mexico.

A manshift is estimated to be 8 hours per day with 250 manshifts in the work year. Data from the New Mexico Employment Security Commission[89] reflect that the average work week for uranium production workers from 1970 through 1975 was 37.5 hours and that the maximum average annual work week during this time frame was 38.6 hours per week in 1975. This fact validates the 250 manshift man-year assumption and implies that for each man-year of work required, one worker is required. Alternatively, overtime is not a significant factor in estimating the number of workers required to meet the industry's labor demand. If these relationships can be assumed to hold in the future, then the number of miners required to mine the ore in the amount predicted for a particular year can be projected. As Table III-13 reflects, miners are only one group of

several that go into making up the labor force. Service and support workers for underground and open pit mining are computed separately by projecting the ratio of service and support workers plus miners to miners for underground and open pit mining respectively. The ratio is an average ratio of the relationships that existed from 1968 through 1975. The relationship from 1968 to 1975 for underground service and support workers to miners was relatively stable. The relationship in the open pit case, however, was not as stable; nevertheless, service and support workers in the open pit mining segment of the industry do not make up a significant component of total employment. Milling employees were computed by projecting the average number of employees per thousand tons of ore fed to the mills from 1968 to 1975. "Others" included those categories of employees not involved in mining, service and support, or milling but were still included in employment in the mining and milling industries as listed by the Statistical Data of the Uranium Industry for the years 1968 through 1975. The "others" category was also computed on the basis of the average number of employees per thousand tons of ore produced for the years 1968 through 1975. Anticipated total employment to 1992 is predicted in the last two columns at the right hand columns of Table III-14-1 and 2. This does not include employment increases in the uranium exploration industry or in the construction industry due

to increases in future exploration and mine mill construction.

Costs of Production

Because of the various methods and conditions found in the mining and milling of uranium ore, as well as an absence of a reliable data base, it is difficult to assess costs of production except in the most general way. Table III-15 reflects cost estimates made and published by ERDA[90] for two dates: 1 January 1974 and 1 January 1976.

While these data have been used by industry members[91] to verify the rising costs of U_3O_8 production and to allegedly prove that costs of production in New Mexico are typically higher than in Wyoming, they are highly questionable for the first purpose and completely invalid for the second.

The first and least offensive problem reflected by the cost data in Table III-15 can be seen by adding the open pit capital costs per ton of ore to open pit operating costs per ton of ore. This adds to \$29.44 but is reported as \$29.88 for open pit total costs. Similarly, total underground mining costs add to \$49.79 per ton of ore while they are reported as \$49.47.

A second problem is the treatment of inflation and productivity changes in computing the impact of these factors on cost.

TABLE III-15

TYPICAL U. S. URANIUM COSTS

	U. S. Dollars per Ton of Ore		U. S. Dollars per lb. of U_3O_8	
	Jan 1976	Jan 1974	Jan 1976	Jan 1974
Capital				
Exploration	4.52	2.29	1.60	.81
Mining				
Open Pit	8.08	6.09	2.86	2.15
Underground	9.23	5.19	3.27	1.83
Mill	2.68	1.65	.95	.58
Total Capital Costs				
Open Pit	15.28	10.03	5.41	3.54
Underground	16.43	9.13	5.82	3.22
Operating				
Mining				
Open Pit	4.50	1.85	1.60	.66
Underground	23.00	8.15	8.16	2.84
Transportation	.94	.75	.33	.27
Milling	7.05	4.40	2.50	1.56
Royalty				
Open Pit	1.67	.94	.59	.33
Underground	2.37	1.34	.84	.47
Total Operating Costs				
Open Pit	14.16	7.94	5.02	2.82
Underground	33.36	14.64	11.83	5.14
Total Capital and Operating Costs				
Open Pit	29.88	17.97	10.43	6.36
Underground	49.47	23.77	17.65	8.36

Assumptions: .15% U_3O_8
Mill Recovery Rate 94%: Production Level 2,000 tons of ore/day
Open Pit Stripping Ration 24 to 1. Wyoming Conditions.
Underground Mine Depth 750'. New Mexico Conditions

Source: Patterson, John A. U. S. Uranium Production Outlook.

Productivity

ERDA data on productivity is conflicting. Table III-16 reflects the different views ERDA has on productivity changes from 1972 to 1976. Table III-15 cost data are based on the productivity figures of the U.S. Uranium Production Outlook. Since ERDA has a virtual monopoly on these data, it is impossible to know which are correct but with discrepancies as large as 88 percent, it is difficult to take the cost data of Table III-15 seriously. The Uranium Industry Seminar data reflect a drop in underground mining productivity of 14 percent and a drop in open pit mining productivity of 17 percent. The U.S. Uranium Production Outlook Data reflect a drop in underground mining productivity of about 20 percent and a drop in open pit mining productivity of 12 percent. The obvious effect of utilizing the U.S. Uranium Production Outlook data for cost computations is to flip-flop the conclusions that would be drawn (relative to comparative costs of underground and open pit mining) if the productivity data of the uranium industry seminar were utilized.

Inflation

It is not surprising to discover that inflation has had a significant impact on the costs of mining and

TABLE III-16

ERDA PRODUCTIVITY STATISTICS

		72	74 (1 Jan) (73 data)	76 (1 Jan) (75 data)
Uranium Industry Seminar data	Underground	8	7	6
	Open Pit	(20)*	30	25
U.S. Uranium Production Outlook Data	Underground	6	(5)*	4
	Open Pit	13	16	14

*The data in parentheses are interpolated from the source material.

Sources: Uranium Industry Seminar GJO-108(75) Oct. 75, p. 152.
Uranium Industry Seminar GJO-108(76) Oct. 76, pp. 191, 192.
U.S. Uranium Production Outlook Sept. 76, pp. 6, 7.

TABLE III-17

VARIATIONS IN COSTS OF U_3O_8 PRODUCTION
BY TWO YEAR INCREMENTS

	1972* (71 data)	1974 (73 data)	1976 (75 data)
Underground	8.37/lb.	8.36/lb.	17.65/lb.
Open Pit	6.04/lb.	6.36/lb.	10.43/lb.

Source: * J. Klemenic, Examples of Overall Economics in a Future Cycle of Uranium Concentrate Production for Assumed Open Pit and Underground Mining Operations. Oct. 1972, pp. 8, 14.

milling of uranium, but it is quite surprising to note the treatment of costs with respect to inflation in Table III-15. For instance, in 1974, the cost reported by ERDA[92] to produce a pound of U_3O_8 was \$8.36 and \$6.36, from underground and open pit mines respectively. By 1976, these costs are reported to have risen to \$17.65/lb. and \$10.43/lb. This is an increase of 111 percent and 64 percent. Table III-18 reflects the four most commonly used economic indicators for these computations and the percentage cost increase by two year increments from 1972 to 1976. Table III-18 also shows the increase in the average hourly wage paid to production workers. Since the increases in the economic indices are so much less than the percentage increases in the cost of producing U_3O_8, it must be assumed that the difference is made up by decreases in productivity. A simple calculation utilizing the 1974 cost data inflated by the labor and equipment indices and taking account of the productivity declines from 1974 to 1976 can test the validity of the 1976 cost figures reported by ERDA. The assumptions that must be made are that labor costs are 25 percent of the cost of open pit production and 50 percent of the costs of underground mine production, and that as productivity declines more labor will be hired to offset the productivity decrease. Assume also

TABLE III-18

VARIATIONS IN MAJOR PRICE AND COST INDICES BY TWO YEAR INCREMENTS

Indices	1972 (71 Data)	% Increase 1972-1974	1974 (73 Data)	% Increase 1974-1976	1976 (75 Data)
Bur. of Lab. Stat. Wholesale Price	116.5	26	146.5	23	179.5
Wholesale Price for Ind. Commodities	116.0	15	133.0	33	177.25
Chemical Engineering Plant Cost Index	124.0	11	137.5	24	171.0
Marshall & Swift Mining & Milling Equipment Cost	123.5	8	138.5	32	176.25
* Avg. hourly wage paid to production workers for 3 major New Mexico uranium mining companies	4.42/hr	6	4.70/hr	31	6.18/hr

* Source: Personal Correspondence with Employment Security Commission of New Mexico.

that a corresponding increase in other costs will occur with increased labor costs. Thus for underground mines:

Total Cost in 1974 = (8.36)

.5(T. C.) = Labor = .5(8.36) = 4.18 ~ cost of labor

.5(T. C.) = (TC - Labor) = 4.18 all other costs

Inflationary impact on Labor (1974 Labor Cost) · (1.31)[93]

= 1976 Labor Cost (4.18)(1.31) = 5.48

Productivity decrease impact on Labor (5.48) · (Increase in labor costs due to 20% decline in productivity)

(5.48)(1.25) = 6.84

Inflationary impact on Other Costs (1974 Other Costs) · (1.33) = 1976 Other Cost

(4.18) · (1.33) = 5.56

Productivity decrease impact on Other Costs (5.56) · (1.25) = 6.95 Total Costs = 6.84 + 6.95 = 13.79 ~ 65% increase in cost of underground mining

Similarly for open pit mines:

Total Cost in 1974 = (6.36)

.25)(T. C.) = Labor = (.25)(6.36) = 1.59 ~ cost of labor

(.75)(T. C.) = (T. C. - Labor) = (.75)(6.36) = 4.77 ~ all other costs

Inflationary impact on Labor: (1974 Labor Cost) (1.31) = 1976 cost of labor (1.59)(1.31) = 2.08

Productivity decrease impact on Labor (2.08)(Increase
in labor costs due to 17% decline in productivity)

(2.08)(1.14) = 2.37

Inflationary impact on Other Costs (1974 Other Costs
(1.33) = 1976 Other Costs

(4.77)1.33 = 6.34

Productivity decrease impact on Other Costs

(6.34)(1.14) = 7.23

Total Costs = 2.37 + 7.23 = 9.60

51% increase in the cost of open pit mining

Consequently, using the data supplied by U.S. Uranium Production Outlook, the conclusions reached reflect a much less dramatic increase in costs. If productivity data from the Uranium Industry Seminar are used, the increase takes on an even different perspective. The Uranium Industry Seminar data of Table III-16 reflect a 14 percent drop in underground mining productivity and a 17 percent drop in open pit mining. When these productivity changes are substituted in the computations for the U.S. Uranium Production Outlook figures, the 1 January 1976 costs come out to be 12.81/lb. from underground mining and 10.02/lb. for open pit production. This represents a 53 percent increase in the cost of production from underground mines and a 58 percent increase in the cost of production from open pit mines.

Another problem with the cost data of Table III-15 can be seen when the 1974 and 1976 costs are placed in juxtaposition with ERDA generated 1972 costs (Table III-17). If this is to be believed, costs for underground mines from 1972 to 1974 actually declined while costs for open pit mining increased by 5 percent. In view of the cost indicators of Table III-18, it is doubtful whether the decline in underground mining costs would withstand close scrutiny.

Finally, it must be noted that any valid comparison of costs of production must take into consideration the fact that in 1 January 1976 more than one-half of New Mexico's reserves are recoverable at less than or equal to $10/lb. while only 30 percent of Wyoming's reserves are recoverable at $10/lb. or less.[94] Also, the average unit cost of producing in New Mexico in spite of the preponderance of underground mines is less expensive than the cost of producing in Wyoming with its preponderance of open pit mines.[95]

CHAPTER IV

TAXATION OF THE URANIUM INDUSTRY: AN ECONOMIC PROPOSAL

In recent years, the uranium industry has been the benefactor of considerable special interest legislation. This legislation has had the effect of significantly reducing the industry's tax burden. More recently, however, the hue and cry has been raised not only to restore taxes to their former levels, but also to levy a substantially increased tax burden in order to provide New Mexico with its fair share of the revenues accruing from its uranium resource which is largely extracted by giant corporations for consumers in other states.

This chapter makes a recommendation for tax reform with respect to the mineral extraction taxes which fall on the uranium industry. The recommendation is based on considerations of existing problems in the tax structure and an economic comparison of New Mexico and its chief competition in the uranium industry in Wyoming. Considerations of the current tax structure are largely addressed to defining a sensible, viable tax base for

the different taxes in the mineral extraction tax structure. Economic considerations made are related to a determination of that tax burden levied by the state on the uranium industry which will maintain New Mexico's competitive advantage over Wyoming and yet maximize revenues to the state. By maintaining our competitive advantage, development will not be significantly impaired. If the tax base is defined, and the tax burden is determined, the tax burden can then be allocated among the various taxes to determine tax rates.

What should New Mexico's tax policy be with respect to the uranium extraction industry located within the state? The state is limited in its options insofar as general public policies and legal restraints manifest a preference for mineral extraction to be a function of private enterprise. Furthermore, it is recognized that private enterprise must be able to operate at a profit in order to operate at all. The latitude remaining to the state in the exercise of its tax power should be subject to rational economic and political considerations. The exercise of the taxing power or changes in its exercise should be preceded by a rigorous consideration of these economic and political considerations. As a framework upon which such an examination may be made soundly, the following questions should be answered:

A. What is the existing tax structure?

B. What are the policy objectives to be served by any changes in the tax structure?

C. What changes are proposed?

D. What benefits will accrue to New Mexico as a result of these changes?

E. What will be the impact of these changes on the uranium industry?

The first two questions can be answered without consideration of specific proposals but the latter three questions must be answered with respect to each change.

The Existing Tax Structure

The best expositions of New Mexico Taxation of the extractive industries have been put forward by Anne K. Bingaman[96] and Franklin Jones[97] in two separate articles. Since the appearance of these discussions, several developments in the mineral tax structure, particularly with regard to the uranium industry, have occurred, making the subject of these studies even more relevant today. The treatment in the cited articles applies to all hard mineral extraction, the consideration in this note is limited to uranium extraction thereby restricting the generalized principles considered in the cited articles to the unique situation of uranium.

The mineral extraction tax structure as it applies to the uranium industry consists of the severance tax,

the natural resources excise tax, and a tax on mineral property and mining equipment and improvements.

Those taxes have been subject to numerous revisions since their enactment. In some cases, legislative revision of the tax laws has resulted in confusing and arbitrary provisions being built into the tax structure. Consequently, at present, the mineral extraction tax structure as it applies to the uranium industry is difficult for the state to administer. Furthermore, while most of the tax revisions have been in the taxpayer's favor, these changes have increased the difficulty of compliance substantially.

The Severance Tax

The severance tax[98] is levied for the privilege of severing natural resources.[99] The underlying theory is that the extractive industry must pay a tax to the state for its removal of the mineral resources which, in part, constitute the natural heritage of the people of the State of New Mexico. The severance tax is designed to yield a tax due by applying a statutory rate to a statutory base. The severance tax was enacted in 1937,[100] but it was not until 1951 that uranium was specifically listed in the schedule of tax rates.[101] At that time it was taxed at a rate of 1/8 percent of its defined tax base. In 1957, the rate was increased to 1/2 percent of

the tax base.[102] In 1961 the rate of the severance tax on uranium was again increased from 1/2 to 1 percent of the tax base.[103] Today the rate still stands at 1 percent of the tax base valuation.

The history of the tax base has been more dynamic than the tax rate, with the trend being to reduce the tax base. At the time of enactment, the tax base of the severance tax for all taxed minerals was the

> . . . value of such products severed and saved from the soil of this state and shall be paid at the following rates: . . . The value of all such production shall be computed as of the time when and the place where the same have been severed or taken from the soil immediately after such severance.[104]

In 1949, the tax base became "gross value as hereinafter defined" and an allowable annual deduction of $200,000 per taxpayer was created.[105] In addition, gross value was defined as market value less costs of hoisting, crushing and loading necessary to place the severed product in marketable form for those severed materials which were not beneficiated before sale. Materials requiring beneficiation were valued at the proceeds of the first sale after beneficiation less freight charges subsequent to severance to the point of the first sale and the cost of processing or beneficiation.[106] In 1961, deductions for costs of hoisting, loading and crushing were limited to 50 percent of reported value.[107] This ended the

erosion of the tax base through explicit amendments to §72-18-2; the revisions in the severance tax base which were to follow took the form of new statutes. In 1971, a statute allowing deductions from gross value for rentals or royalty payments made to The United States or the State of New Mexico became law.[108] In 1972, the law was revised to allow deductions for rents or royalty "belonging" to the United States or the State of New Mexico as opposed to rents or royalties "made" to the United States or the State of New Mexico.[109] Also in 1972, a new statute was passed separately defining the gross value of uranium products. The new tax base for uranium products became:

> . . . the gross value to be reported for severed and saved uranium bearing material not disposed of as ore or solution but processed or beneficiated (other than by sizing and blending) regardless of the form in which the product is actually disposed of, shall be the value of U_3O_8 contained in ore or solution determined on the basis of the U_3O_8 ore or solution content at fifty percent (50%) of the taxpayers average unit sales price during the preceding calendar year U_3O_8 contained in the concentrate form commonly known as yellowcake, less 50% of the reported value as a deduction for expenses of hoisting, loading, crushing, processing and beneficiating uranium bearing material severed and saved from an underground mine.[110]

A recital of the severance tax changes does not reflect their full impact on the revenue producing power of the tax. A hypothetical example will illustrate this effect more clearly. The example is not meant to

reflect the actual tax paid by the industry in any given year but is simply meant to illustrate the effect of the tax changes on the revenue producing power of the severance tax.

For purposes of the hypothetical, the following assumptions will be made:

a. Annual production is 1,000,000 tons of ore with an average grade of .0025 (5 lbs. U_3O_8 per ton).

b. 80 percent of the ore is beneficiated and 20 percent is sold as raw ore.

c. 7 percent of production is from federally leased lands for which a royalty is paid amounting to 12 percent of true gross value of production from those lands.

d. 3 percent of production is from lands leased from Indians, for which a royalty is paid amounting to 12 percent of true gross value of production from those lands.

e. 10 percent of production is from lands leased from the state, for which a royalty is paid amounting to 12 percent of true gross value of production from those lands.

f. Costs of "hoisting, loading and crushing" are $8 per ton.

g. Costs of milling are $5 per ton.

h. The price of a pound of U_3O_8 "yellowcake" is hypothesized to be $8 per pound.

i. The price of a ton of unbeneficiated ore is $20.

j. For purposes of the $200,000 taxpayer exemption, there are three taxpayers who mill their own ore and there are twenty taxpayers who do not mill their ore but sell it outright.

k. U_3O_8 in ore is recovered at a rate of 100 percent in the milling process.

With these assumptions, several shorthand computations and definitions may be made for purposes of facilitating the tax computation.

a. True Gross Value is simply Price x Quantity

   1. True Gross Value for beneficiated material = [.8 x 5,000,000 pounds U_3O_8 in ore x $8 per pound] = $32,000,000.

   2. True Gross Value for unbeneficiated ore = [.2 x 1,000,000 tons of ore x $20 per ton] = $4,000,000.

b. Costs of milling annually = [800,000 tons of ore x $5 per ton] = $4,000,000.

c. Costs of hoisting, loading and crushing of ore sold as ore = [200,000 x $8 per ton] = $1,600,000.

d. Royalties made to Federal and State governments

(including royalties for the benefit of Indian tribes) are computed as follows:

1. for ore that has been milled [(.12)(.2) x 32,000,000] = $768,000.
2. for unprocessed ore [(.12) (.2) x 4,000,000] = $96,000.

e. Royalties belonging to Federal and/or State governments (excluding royalties paid for the benefit of Indian Tribes) are computed as follows:

1. for ore that has been milled [(.12)(.17) x 32,000.000] = $652,800.
2. for unprocessed ore [(.12)(.17) x 4,000,000] = $81,600.

f. Total of exemptions at rate of $200,000 per taxpayer:

1. for beneficiated material - $600,000.
2. for unbeneficiated ore - $4,000,000.

g. 50% of last year's price of U_3O_8 per pound x amount in ore processed less 50% for costs $= [\frac{(.5)(\$8)(4,000,000 \text{ lbs.})}{2}] = \$8,000,000.$

Computation of the tax on the basis of the foregoing assumptions and definitions during the years the legislature made changes, is set forth in Table IV-I. The table demonstrates the effect of legislation on the severance tax with all parameters but legislative action being held constant. Initially the rate of the tax was

TABLE IV-1

THE EFFECT ON TAX RECEIPTS OF LEGISLATIVE CHANGES
IN THE SEVERANCE TAX

Year		Rate	X	Tax Base [(True Gross Value - Deductions) - Exemptions]	=	Tax Due	Total Tax
1951	beneficiated material	.00125	X	[($32,000,000 - 4,000,000) - 600,000]	=	$ 34,250	
		.00125	X	(27,400,000)			
1951	unbeneficiated ore	.00125	X	[($4,000,000 - 1,600,000) - 4,000,000]	=	0	
						34,250	$ 34,250
1957	beneficiated material	.005	X	(27,400,000) ~ (same tax base)	=	137,000	
1957	unbeneficiated ore	.005	X	(0) ~ (same tax base)	=	0	
						137,000	~137,000
1961	beneficiated material	.01[16]	X	[32,000,000 - 4,000,000]	=	280,000	
		.01	X	(28,000,000)			
1961	unbeneficiated ore	.01	X	[4,000,000 - 1,600,000]			
		.01	X	(2,400,000)	=	24,000	
						304,000	304,000
1971	beneficiated material	.01[17]	X	[(32,000,000 - 4,000,000) - 768,000]	=	272,320	
		.01	X	(27,232,000)			
1971	unbeneficiated ore	.01	X	[(4,000,000 - 1,600,000) - 96,000]			
		.01	X	(2,304,000)		23,040	
						295,360	295,360
1972	beneficiated material	.01[18]	X	[8,000,000 - 652,800]			
		.01	X	[7,342,000]		73,472	
1972	unbeneficiated ore	(untaxed)				0	
						73,472	73,472

increased, thereby increasing the tax, but subsequent diminution of the tax base resulted in a net loss of revenues.

The approach used by the legislature in varying the severance tax reflects a lack of appreciation of sound tax policy. The impairment of the tax base by the various deductions and exemptions has had the effect of penalizing some and subsidizing others. For instance, to allow companies to deduct royalties paid to the federal or state governments results in these companies having a smaller tax base than would the company which produced on lands which it leased from private land owners and upon which royalties are paid. Furthermore, as requirements for revenue from the severance tax increase, and the rate is increased to provide this revenue, the burden of the tax increase falls on the limited base thereby increasing the disparity. A second problem in impairment of a tax base is lack of visibility. Visibility is that characteristic of a tax which reflects whether the tax level is what it appears to be. If the rate of the severance tax on uranium is 1 percent, and it is, it appears that the state retains 1 percent of the value of uranium production whereas in reality the effective rate of the severance tax on uranium production is actually less than one-quarter of 1 percent when the impairment of the

tax base is considered. A third problem is that by formulating the tax base in increasingly complicated terms, the cost of computing and administering the tax is increased as is the margin for error and duplicity in tax reporting. To be sure, an impairment of the tax base from gross value to something less is justifiable if the deduction is legislatively deemed worthwhile and a well defined tax base remains. However, distortion of the tax base to effect tax relief is questionable tax policy.

Additionally, the severance tax statutes present problems of interpretation. The first problem arises with § 72-18-4 entitled "Deductions from gross value" which states: "In computing the amount of tax due, rentals or royalty payments belonging to the United States or the State of New Mexico shall be deducted from gross value. . . ."[111] One is immediately led to ask whether rentals and royalties both are deductible or if the deductions are mutually exclusive. In New Mexico, lessees pay rentals and royalties.[112] A second, more troublesome problem pertains to the statute entitled "Gross value of uranium products defined" which allows the value of U_3O_8 contained in ore or solution for purposes of severance taxation to be assessed at 50 percent of the taxpayer's average unit sales price during the preceding year, less 50 percent of this value as a deduction for expenses of

hoisting, loading, crushing, processing and beneficiating uranium bearing material severed and saved from an underground mine.[113] No reference is made to open pit mines. The statute seems to lend itself to two possible interpretations.

The first interpretation is that uranium products from open pit and underground mines are valued at one-half of last year's price and then the base for uranium products from underground mines is reduced again by 50 percent to account for costs of hoisting, loading, crushing, processing, and beneficiating ore from underground mines. Presumably, open pit miners incur the same costs in beneficiation and processing ore as do underground miners. Furthermore, while open pit mines do not have to hoist their ore from the depths of the earth from which ore from underground mines is hoisted, it seems that crushing and loading costs are also incurred by the open pit miners. It appears that the cost deduction for underground miners then is arbitrary and unreasonable. This raises the question whether this statute under this interpretation is within the taxing power of the state government. If it is, we are left with absurd tax policy. A plain reading of Article VIII, Section 1 of The New Mexico Constitution implies that it is not. If it is not, and the law is challenged and declared void, uranium

valuation may be thrown back into the general definition of gross value.[114] for purposes of the severance tax on the basis of the "separability clause."[115]

The second interpretation would allow uranium products from underground mines only to be valued at 50 percent of last year's price less 50 percent of that figure for costs and uranium products from open pit mines would be valued in accordance with the general definition of gross value[116] which allows a deduction of up to 50 percent of gross value for expenses of hoisting, crushing, and loading but not for processing or beneficiating the ore. The differential tax treatment under this interpretation is twofold. Underground miners are allowed to value their products at one-half of last year's price and to deduct outright 50 percent for processing and beneficiating, etc. Open pit miners must value their products at current market value and must justify cost deductions up to 50 percent of reported value excluding costs for processing and beneficiation. This interpretation is just as arbitrary in its treatment of uranium miners as the first interpretation and the same problems, therefore, hold.

Natural Resources Excise Tax

The structure of the natural resources excise tax,[117] is considerably more straightforward than that

of the severance tax. This tax takes one of three forms, that of a resources tax,[118] or a processor's tax[119] or a service tax.[120] The resources tax is levied on any severer of natural resources at the rate of three-fourths of one percent for uranium, for the privilege of severing natural resources. The tax base is the value after severance less deductions for sales to the United States or any agency thereof, and the State of New Mexico or any political subdivisions thereof. The processor's tax is levied on any processor of natural resources at the rate of three-fourths of one percent for uranium for the privilege of processing natural resources. The tax base is the value of the beneficiated material less the same deductions as allowed for the resources tax. The service tax is levied on any person severing or processing natural resources that are owned by another person at a rate equivalent to that which would be levied upon the owners if they had severed or processed the material themselves. The tax base for the service tax is the service charge defined as "the total amount of money or the reasonable value of other consideration received for severing or processing any natural resources by any person who is not the owner of the natural resources."[121]

An owner of a uranium deposit mineral interest who severs uranium ore and sells it pays the resources

tax unless it is to be processed in New Mexico. An owner of a uranium deposit mineral interest who severs and processes the uranium ore pays the processor's tax. A lessee of a uranium deposit mineral interest who severs the uranium ore and sells it pays a service tax. A lesses of a uranium deposit mineral interest who severs and processes the uranium ore from a lessee pays the processor's tax on a tax base reduced by the lessee's service charge. A processor who purchases ore pays the processor's tax. Thus the resources excise tax reaches all combinations of the extraction process, as opposed to the severance tax which seems to allow severed uranium ore that is sold out of state to go untaxed.[122] Admittedly, the economics of the uranium mining-milling process dictate that the ore be processed relatively close to the mine mouth but at a high severance tax rate in New Mexico it may become economical to build and mill in Arizona and to shop ore from the Gallup-Churchrock area to Arizona for processing.

The only question raised by the Natural Resources Excise Tax Act arises in the definition of taxable value, where it is stated that:

> Amounts received from selling natural resources, other than metalliferous mineral ores, whether

> processed or unprocessed, to the United States or any agency or instrumentality thereof, the State of New Mexico or any political subdivision thereof, . . . may be deducted from taxable value.[123]

If the phrase, "whether processed or unprocessed" refers to the words "natural resources," then sales of U_3O_8 in concentrate to government agencies are deductible because U_3O_8 in concentrate is not a metalliferous mineral ore; it is a refined product. On the other hand, if the phrase "whether processed or unprocessed" refers to the words metalliferous mineral ores, then U_3O_8 sales to government agencies are not deductible because U_3O_8 in concentrate is a processed mineral ore. The significance of such a deduction is de minimis at the present time because the then Atomic Energy Commission (AEC) uranium buying program was terminated some time ago. From 1966 to 1970, however, deductions of sales to government agencies would have been a very substantial concession.

The Property Tax

The Property Tax on mineral property presents many of the same problems as the severance tax. The basic structure for the property tax on uranium producing property is set out in three statutory sections.

Section 72-29-11 defines the classes of mineral property for tax purposes.[124] Mineral properties are classified as:

Class 1 productive mineral property--lands used for uranium production which are held under private ownership in fee and all severed mineral products from such,
Class 1 non-productive mineral property--the same as Class 1 but not productive,
Class 2 mineral property--severed mineral products from mineral lands held by possessory title under the laws of the United States, and
Class 3 mineral property--severed products from leasehold or contract mineral rights in mineral lands, the fee of which is vested in the United States or the state.

Section 72-29-12[125] sets out the valuation procedure of mineral property and property used in connection with mineral property except for potash and uranium mineral property. Section 72-29-14[126] sets out the method of evaluation of mineral property and property used in connection with mineral property when the primary production from the mineral property is uranium. Under this section, equipment and improvements held or used in connection with uranium mineral property are valued under the methods of valuation required by the Property Tax Code.[127] Further, under this section, the Property Tax Code would be utilized to evaluate the surface interests for its value for agricultural purposes, etc., if such interests are held integrally with the mineral interest.

Class one productive, class two, and class three mineral property are taxed on the annual net production value of the uranium mineral property. Class one

nonproductive mineral property is taxed on a per acre value basis as defined by section 72-29-12E and Property Tax Department regulations.

Two significant problems with the property taxation of mineral lands held for uranium production are raised by the definition of "annual net production value." The definition is divided into two categories: that of the value of uranium bearing ore disposed of as such and that of U_3O_8 in concentrate. Ore valuation is simply the sales price less 50 percent for expenses incurred in production. U_3O_8 in concentrate is evaluated at 50 percent of the taxpayer's average unit sales price during the preceding calendar year, plus 50 percent of the representative sales price of all other minerals produced and saved from such uranium bearing material, less 50 percent of the value for the cost of producing and bringing the output to the surface and of milling, etc., uranium bearing material severed and saved from an underground mine.

The first problem with the property tax is that uranium properties receive preferential treatment. All other mineral properties except potash are valued for tax purposes at 300 percent of annual net production value while uranium properties are taxed on the value of annual net production value only. Furthermore, annual

net production value for other mineral properties is actual annual production value, less certain costs and royalties, while annual net production value of uranium is halved before cost deductions or royalty deductions are even considered.

The second problem is that the statute defining annual net production value for U_3O_8 in concentrate refers only to underground mines. This problem was discussed earlier in reference to the severance tax.[128] Article VIII, Section 1 of the New Mexico Constitution states that: "Taxes levied upon tangible property shall be in proportion to the value thereof and taxes shall be equal and uniform upon subjects of taxation of the same class."[129] Section 72-29-14 does not make clear the tax status of uranium open pit mining property. The first question that § 72-29-14 raises is whether or not the differential treatment of uranium mining property relative to all other mining property is in accord with Article VIII, Section 1 of the New Mexico Constitution. The second question is how open pit mining property and underground mining property are taxed under Section 72-29-14. It appears that there is different treatment. Is this in accord with Article VIII, Section 1?

In summary, the severance tax on uranium and the property tax on uranium mineral lands do not serve

well as revenue producers. The erosion of the tax base of both taxes limits their usefulness. Furthermore, if the tax rate were increased in order to derive the revenue that should and could be derived from these taxes, the already unequal burden on taxpayers within the industry would be increased. Even if these flaws were acceptable, surely the imprecise language, creating problems of constitutionality as well as problems of compliance with ill-defined statutory guidance is reason enough to legislate a more reasonable procedure in taxing the uranium industry.

The Objectives of Tax Policy

The objectives of a tax policy are:[130]

1. adequate revenues
2. stability
3. tax consciousness or visibility
4. facility in administration
5. optimal development of the state's resources, and
6. equity.

1. In 1968, the need for increased revenues was anticipated to forestall a deficit of some seven million dollars.[131] It was hoped that at least part of the needed revenue could be derived from increases in taxes on the extractive industries.[132] Instead, the

taxes levied on the uranium industry have been dramatically reduced since 1968. The reduced tax burden on the uranium industry may have been justified by the then existing business environment. The period was one of reduced buying of U_3O_8 by the Atomic Energy Commission and simultaneously there existed a milieu of stagnating prices. And, not unexpectedly, legislation hastily drawn up to provide immediate tax relief often overlooks incidental effects whose impacts outlive the original needs for which the legislation was drafted. The situation has changed dramatically for the uranium industry since the doldrums of the late sixties. Prices are now rising at a rapid rate and the anticipated demand will push the uranium industry to its production capacity. Consequently it is time to correct problems existing in the present tax structure and to determine how much of an increase in the tax rates will be necessary for New Mexico to obtain its fair share of revenues generated by uranium production.

2. The objective of stability in the extractive taxes requires consideration of the fundamental mechanism of the tax itself. The tax consists of a base which determines what will be taxed and a rate levied on the base which determines how much tax is paid. A very broadly based tax such as the gross receipts tax will generate

large amounts of revenue at relatively low rates. The tax burden is widely distributed over the base and the disparities of the impact of the tax burden in absolute terms are thereby reduced. Furthermore, to increase or decrease revenues substantially requires a relatively modest increase in the tax rate (assuming the same tax base). A tax of this nature is said to be stable in that important revisions in the law to accommodate changes in tax revenue requirements are unnecessary. On the other hand, if the tax base is substantially reduced by exemptions and deductions of various sorts (such as exists in the federal income tax structure), the tax rate on the tax base would necessarily have to be higher to produce the same revenues as would a broader based tax with a lower rate. Furthermore, this requires a larger burden to be shouldered by those taxpayers who do not qualify for the exemption and deductions that are allowed. (This is a common complaint with the federal income tax by the middle income taxpayer.) Also, to increase or decrease revenues by a given amount requires larger increases or decreases in the tax rate on such a reduced base than would be required on a more broadly based tax.

A further problem created by allowing exemptions and deductions which impair the tax base is that it violates

the equity principle as well as the stability principle of sound tax policy. For example, a deduction from the severance tax base for royalties payable to Indian Tribes would subsidize Anaconda and Exxon, the producers, who happen to lease tribal lands. Furthermore, the amount of this subsidy would have to be made up from producers on non-Indian lands if a specific revenue requirement existed for the severance tax. Naturally, there are situations where such subsidies are justified but the subsidy should be acknowledged and justifiable as opposed to incidental.

Stability of a state's tax structure is thought to be so vital to tax policy that it has been suggested[133] that in considering location or expansion in a certain taxing jurisdiction, the tax level is not as important as stability of the tax structure. The rationale of this suggestion is that the tax level reflects the level of services offered by the state government such as fire protection, police protection, transportation facilities, etc., whereas an unstable tax structure, where the tax burden is fluctuating with the annual needs of the state, adversely affects the firm in fiscal planning and results in liquidity costs or cash flow problems.

3. The visibility or tax consciousness objective requires that the tax be straightforward and well-defined.

It requires that subsidies and disparities in tax burdens be recognized, justified, and acknowledged rather than surreptitiously enjoyed by the recipients of such benefits. Visibility is best served by a broadly based tax with minimal exemptions and deductions. A tax with no deductions or exemptions by definition is more simple, straightforward and understandable. Nevertheless, equity may demand certain modifications to the tax base. On the other hand, the tax base for uranium under the present severance tax fits the now famous quotation of Senator Lowell Weicker of Connecticut: "This bill defies human understanding let alone senatorial understanding."

4. If a tax structure succeeds in achieving the objectives of stability and visibility, then it will be more easily administered than it would otherwise be. Stability implies longevity of life for the tax structure. With this longevity comes the solution of problems in disputed areas, as well as, the familiarity of taxpayers and administrative personnel with the tax procedures. Visibility also contributes to ease of administration in much the same fashion. A well defined tax reduces the areas of dispute available for taxpayers and tax collectors to exploit.

5. Optimal development of the state's resources as an objective of tax policy suggests a tax structure for the uranium industry which would foster the exploration and development of the uranium in New Mexico in an orderly fashion. A tax levied on an extractive industry such as the uranium industry may affect a firm's decision making process regarding the rate of recovery (how much ore is extracted from the mine per time period) and the level of recovery[134] (How low a grade of mineral will be extracted from a given deposit and the percentage recovery from the milling process.) The resource may be extracted at such a rapid rate as to induce boomtown development syndromes and then exhaust the mineral before the developed area had developed a sufficiently strong economic base to sustain itself. It may be that problems of this nature can be solved by retardation of the rate of extraction through tax policy. On the other hand, retardation of the rate of exploitation of a resource may cost the state more in lost collateral revenues such as income tax and gross receipt tax revenues.

6. Equity requires that tax differentiation among taxpayers be based on a reasonable classification. The reasons for differential taxation must be relevant to the rationale of the tax. For instance, the most relevant criterion for differentially taxing income

taxpayers would be income. Similarly, for the severance tax, the taxpayers would be differentiated by the amount of mineral that the taxpayer severed. The natural resources excise tax, which is levied for the privilege of doing business in New Mexico, differentiates between taxpayers on the volume of business. The property tax levied to provide local government revenues differentiates among taxpayers by the amount of property owned by the taxpayer.

Equity to the taxpayer has a dual nature, that of horizontal equity and that of vertical equity. Horizontal equity means that taxpayers in the same position will be treated similarly. For income tax purposes, individuals with equal income pay equal taxes; for natural resources excise tax purposes, firms with the same volume of business pay the same tax and so on. Vertical equity requires that taxpayers in different positions will be taxed in such a manner that the relative impact of the tax will be the same. For income tax purposes, if a taxpayer who has income of $10,000 pays ten percent of his income in income taxes, then a taxpayer with an income different from $10,000 also should pay ten percent of his income in income taxes.

In a broader context, equity considerations must go beyond the mere consideration of the taxpayer to

determine who actually bears the tax burden. This is referred to as the tax incidence. The tax burden is removed from the shoulders of one taxpayer to those of another by tax shifting. For instance, in the situation of a gross receipts tax, the vendor of goods and services is the taxpayer but the incidence of the tax burden is said to be shifted primarily forward to the vendee, but partially backward through reduced sales. The incidence of a tax is a very elusive concept, nevertheless, some account must be taken of it in attempting to forge a stable tax policy.

The Proposed Tax Changes

The proposed changes will be discussed in the following order: (1) changes in the tax base of the Severance Tax, Natural Resource Excise Tax, and Property Tax; (2) determination of the tax burden to be levied by the three taxes; and (3) allocation of the proposed tax burden among the several taxes in order to determine rates of each of these taxes.

Tax Base Changes

The Severance Tax: The severance tax is levied for the privilege of severing a mineral from the state and thus reducing the value of the state's tax base or the natural heritage of the people of the state. If

the resource were exploited by the state, the returns would be the profits obtained from exploitation, and such profits would be based upon the total ore the state chose to exploit. Similarly, if the state chooses instead the severance tax as the vehicle for deriving revenues from its natural resources, the maximum tax that could be levied would be that level which would tax away all profits. The simplest way to do this would be to tax away gross profits (revenues less costs). If the tax level were greater than the profit level, the firm would cease operating. The conclusion to be drawn from this, then, is that gross profit (revenue-costs) should be the tax base for the severance tax. The allowance of the deduction of costs from the tax base leaves a tax base which represents the value that could be derived by the state if the state exploited the resource itself. Further, this yields a modicum of horizontal equity in that were costs not allowed, those firms encountering marginal ore deposits (low grade of ore deposits located at great depth, etc.) would be forced to pay a greater percentage of gross profits than would firms exploiting more favorably situated ore bodies. By allowing costs to be deducted, this problem is eliminated and the value remaining in the tax base would be exactly what the state would earn if it fully exploited each deposit.

Nevertheless, there are arguments based on the theory of the firm for limiting cost deductions. A mining firm will attempt to maximize the present value of its future profit stream. Classical economic theory suggests that, other things being equal, a miner will maximize the present value of its profit stream by mining the richest ore bodies first. In an environment of rising prices and rising costs, the picture is altered. If the rate of increase in price is greater than the rate of increase in cost and the difference in the profits returned in one year and those returned in the preceding year represents a greater return than would be had by the same investment at the prevailing interest rate, then the present value of future profits streams will be maximized by extracting the poorest ores that are economical first.[135]

In actual practice an ore body is valued by determining that ore grade which will yield enough recoverable mineral to pay for its extraction and processing costs. All ores above this grade are considered minable. The ore that it considered minable is extracted from that deposit regardless of grade. This is done primarily because leaving a high grade or low grade ore in a deposit depending upon whether low grading or high grading conditions exist requires continued maintenance of the mine, a cost which otherwise might not

be incurred. Once, however, the ore leaves the mine, the choice as to grade utilized once again is made for processing. The average grade of ore fed to the mill will reflect the firm's belief in whether low grading or high grading conditions are in the offing.

In the case of uranium, it is anticipated that the price-cost differential will continue to increase in absolute terms. And it is anticipated that the annual increments to the price-cost differential would represent a higher return than would be obtained if invested at the prevailing interest rate. This means that the uranium industry will be mining the lowest grade ores first and, if full cost deductions are allowed, the full cost of mining, milling, etc., of low grade ores will be deducted. Since these costs make up a relatively higher percentage of the gross value of production than would the costs of higher grade ores, this would have the effect of reducing the tax base.

In order to limit the effect of this reduction in the tax base, a limit of 50 percent of the value of yellowcake produced should be the limit allowed for cost deductions. This has the effect of guaranteeing the state a viable tax base and source of revenue, whereas allowing inlimited cost deductions introduces the possibility of a zero price-cost differential and thereby dissolving the tax base. The cost limitation

has the further impact of rewarding efficient producers and penalizing inefficient producers. It does introduce a degree of horizontal inequity by taxing producers of uranium who encounter favorably situated ore less heavily than those who encounter ore that is more expensive to mine or mill. However, by only allowing deduction of costs up to 50 percent of the gross value of production, the horizontal inequity problem is reduced substantially more than would be the case if no cost deductions were allowed. In the balance, it must be concluded that the state's need for a secure viable tax base outweighs the minimal horizontal inequity of limiting cost deductions.

A further argument against allowing cost deductions from the tax base for the severance tax is that assuming that the tax is fully shifted forward, implying an increase in price exactly equal to the per unit tax, the high cost producers are in effect receiving price subsidies. They not only are passing the tax on but also are deriving the benefit of the cost deductions. By having higher costs the tax paid per pound of U_3O_8 is less than the tax paid per pound of lower cost U_3O_8. Consequently, when the price of U_3O_8 is increased to shift the tax, the high cost producer is not required to increase his price as much as the low cost producer, making his product a more attractive bargain. If the

high cost producer does increase his price to equal the increased price of the low cost producer, the difference in this price and the lower price which would just pay for the high cost producer's tax represents a price subsidy. Alternatively, to disallow cost deductions would be to allocate the tax burden through the discovery process. The firm which discovers the most favorable ore bodies, already occupying an advantaged position, would have their advantage reinforced through the tax policy. Thus, limiting cost deductions to 50 percent of gross value strikes a balance between creating price subsidies for the inefficient producer by allowing such deductions and penalizing the developers of marginal resources by disallowing such deductions.

Producers are currently allowed a deduction for royalty payments belonging to the state or federal government.[136] The exact rationale for such a deduction is not clear, but there are three possibilities. The deductions may be allowed in order to subsidize certain producers, or to encourage development of government (both state and federal) lands, or to avoid problems of intergovernmental immunity from taxation. None of these possibilities is adequate justification. The primary uranium firms producing in 1975 were Kerr McGee, United Nuclear, Anaconda, and Rancher's Exploration and Development. The firms entering the market are Phillips,

Sohio, Gulf, and Exxon. It is difficult to see any rationale for subsidizing firms of this size. The returns that are awaiting the uranium entrepreneur must be handsome indeed to attract such development attention. If the returns are that good, then it would not be necessary to encourage development of uranium laden lands; the profit motive will suffice. Intergovernmental immunity from taxation is simply not a problem. It is well settled that state excise taxes and ad valorem taxes on gross production, which fall upon the product derived from land leased from the government is a tax on the lessee's interest and is not a tax upon the lessor's interest.[137]

Thus, there is no justification for continuing such deductions. Sound tax policy requires that unreasonable deductions from the tax base be eliminated. Consequently, a second recommendation for revising the Severance Tax Act is to repeal the statutory deductions allowed for royalty payments to the state and federal governments.

One further consideration regarding the tax base is that the taxable event for purposes of the severance tax is the beneficiation process. Thus, the tax base may not include unmilled ore. As suggested earlier, a question presently exists as to the taxability of unmilled ore that might be milled out of state. If the taxable

event were the actual severing of the ore from the earth, and U_3O_8 was valued at the average sales price of the firm during the calendar year for which the tax is being paid, then the taxability of unmilled ore problem would be resolved. It is recommended, therefore, that severance of the ore be the taxable event rather than the beneficiation process.

Summarizing the tax base recommendations, the tax base should be the gross value of U_3O_8 in ore valued at the taxpayer's average unit sales price during the period for which the tax is applicable. This should include all ore whether milled or not, thus making the extraction itself the taxable event. The only deductions from the tax base that should be allowed are costs, and they should be limited to 50 percent of gross value.

The Natural Resources Excise Tax: New Mexico resource excise tax act does not present nearly as many problems as the severance tax. The two problems that do exist with its tax base are: first, the allowance of deductions for royalties paid to the United States, its agencies or instrumentalities (including Indian tribes and pueblos), and the state; and, second, the allowance of a deduction for sales to government. Presumably, the allowance of deductions for royalties once again involves the question of intergovernmental tax immunity. Since the natural resource excise tax is levied for the privilege

of severing or processing, etc., it is levied on the firms in the industry and payable by them. The incidence of the tax may be partly borne, because of industry shifting of the burden, by the government or the Indians or the state, but it would be difficult to find a tax whose incidence ultimately did not, in some way, fall on one of these entities. It is logical, however, to distinguish those taxes which fall directly upon one of these entities and those taxes which fall indirectly by shifting of the tax burden. Only the former should be considered for purposes of intergovernmental immunity. Consequently, for these reasons, as well as those discussed earlier with reference to the same deduction to the severance tax, the sales and royalty deductions should be disallowed.

This leaves the proposed tax bases for the severance tax and the natural resources excise tax with one difference, the allowance of deductions for costs. Since the severance tax is levied on the privilege of severing natural resources and serves the purposes of compensating (though nominally) the state for this severance, it stands to reason that at least some part of costs should be allowed to be deducted from the tax base since the value that the U_3O_8 would represent if the state were the severer would be its value in excess of costs. On the other hand, the natural resources

excise tax is levied for the privilege of severing or processing, etc., and therefore amounts to a tax on doing business and the tax base should be made up of the gross receipts of the business. The natural resources excise tax is analogous to the gross receipts tax.

The Property Tax: The current property tax base on mineral properties provides properties held for uranium production with special treatment as discussed earlier. The proposed change in the tax base for the property tax would change the valuation from its current definition to one of 300 percent of gross value less costs of production thereby eliminating the special treatment. If it is assumed that costs of production are approximately 50 percent, this would effectively increase the property tax burden on annual production by a factor of six.

Determination of the Total Tax Burden

Assuming that the problems existing with the tax bases are resolved, it remains to determine what the total tax burden of the mineral extractions tax with respect to uranium should be and to allocate the burden among the severance tax, natural resources excise tax and the property taxes respectively.

The only state that has uranium resources which are comparable to those of New Mexico is Wyoming. New

Mexico has a distinct advantage over its chief domestic competitor, however, in terms of amount of U_3O_8 as well as the cost of producing U_3O_8. This advantage is indicated by Table IV-2. This advantage constitutes a portion of the economic rent that is returned to the uranium producer. To explain why this advantage makes up only a portion of the economic rent accruing to uranium producers requires a brief divergence to discuss economic rent in the uranium industry before attempting to quantify the advantageous nature of New Mexico's uranium resource.

The concept of economic rent has suffered from an acute case of schizophrenia in economics literature. Economic rent is defined by the subscribers of the Marshall-Mill-Ricardo definition as the excess amount earned by a factor over the sum necessary to induce it to do its work.[138] The Paretian rent concept is the excess of earnings over the amount necessary to keep the factor in its present occupation.[139] The first consideration is relevant to whether or not the factor is supplied at all and the Paretian definition relates to whether or not the factor's opportunity cost is being met.[140] These concepts both find use in analyzing the uranium industry. Presumably, economic rent in the Marshall-Mill-Ricardo sense has existed since the 1950s when production of uranium was characterized by few large producers and many

TABLE IV-2

RESERVE COMPARISONS OF NEW MEXICO AND WYOMING ORES

		New Mexico	Wyoming
$30 Reserves	Tons of Ore	302,000,000	352,600,000
	% U_3O_8	0.10	.07
	Tons U_3O_8	302,700	239,000
$15 Reserves	Tons of Ore	115,900,000	105,500,000
	% U_3O_8	.18	.10
	Tons U_3O_8	206,200	158,000
$10 Reserves	Tons of Ore	57,100,000	62,500,000
	% U_3O_8	.26	.12
	Tons U_3O_8	151,000	73,000
$8 Reserves	Tons of Ore	44,920,000	19,187,000
	%U_3O_8	.29	.17
	Tons U_3O_8	131,600	33,800

Source: A. $30, $15, and $10 reserves can be found in The Statistical Data of the Uranium Industry, GJO 100 (76).

B. $8 reserve data for 1 January 1976 was only published in the aggregate at 200,000 tons of U_3O_8 [p. 21, GJO-100 (76)]. To approximate $8 reserves for New Mexico and Wyoming, the 1975 data were used [GJO-100 (75)] with a slight adjustment. The adjustment was to delete from New Mexico's 1976 $8 reserves that amount of U_3O_8 which was mined in New Mexico in 1975. An identical amount was then added to Wyoming's $8 reserves to restore the aggregate to 200,000 tons. These adjustments are made to account for any change in $8 reserves due to depletion and/or discovery in 1975.

small producers. However, not until 1973 and later has the level of economic rent become so attractive that returns to uranium producers have been able to cover certain opportunity costs in the Paretian sense of economic rent. This is manifested by the recent entries into the industry that have been made by firms such as Exxon, Sohio, Gulf, and Phillips. It is well known that these firms, whose long histories have been inextricably entwined with the petroleum industry, receive substantial economic rents from petroleum production. Consequently, if these firms are entering the uranium industry in New Mexico, then apparently the rents that are anticipated in uranium production exceed those that would be anticipated in other ventures including those in the petroleum industry. At least one of these firms also operates in Wyoming, so it must also be reasoned that this high level of economic rent typifies the returns to uranium producers in Wyoming as well as New Mexico.

If this is the case, and it certainly appears to be, then the natural advantage of New Mexico's uranium resources provides a substantial amount of economic rent over that received in Wyoming. This could provide the basis for New Mexico's extraction tax.

Since firms, such as Exxon, require higher returns to justify their entry into an industry, only the rent differential existing as a result of New Mexico's naturally

enhanced resource can be taxed away without incurring the risk of impinging on the rent required by such firms to continue operating. If the tax burden reduces profits to the level of not meeting opportunity costs for such firms, these firms will be operating at a theoretical loss. If, for instance, Exxon's money was invested in an industry where the percentage return was lower than could be had elsewhere, the stockholders might have justification to replace the company's current management. Consequently, opportunity is a very real consideration.

On the other hand, the State of New Mexico is not bound to provide a guaranteed return to those who exploit its resources. Yet, as suggested earlier, the state must be conscious of developmental considerations. The state's tax policy should not be a great deal more burdensome than states with similar resources. Nor should the tax burden on one mineral extraction process be such that potential developers of other minerals question the wisdom of operating in New Mexico and suffering a similar fate when their operations reach their zenith.

A question remains and that is what would be the consequences of taxing the "Exxons" out of the business and then allowing development to take place by smaller firms which have not institutionalized an excessive profit margin. If smaller firms were able to afford

the high cost of entry (exploration, development, mining and milling) without a return for nearly ten years, this would be an attractive alternative. The more likely result of high taxation would not be the development of the resource by smaller firms but rather the large firms would hold their reserves and would wait for the price of U_3O_8 to rise enough to make production worthwhile.

Before the tax level which would precipitate this type of problem is ever reached, there is an untaxed surplus in the resource itself which could provide substantial sums in the tax revenues. This brings the natural resource differential between Wyoming and New Mexico back into sharp focus. As Table IV-2 indicates, New Mexico has 63,700 more tons of U_3O_8 in 50,000 fewer tons of ore and 91 fewer deposits than Wyoming. The fact that there is more mineral in fewer tons of ore as well as fewer deposits implies that New Mexico has a higher grade of uranium in fewer deposits.

These facts imply that New Mexico nas a lower cost per pound of U_3O_8 than does Wyoming. It is this cost advantage that New Mexico has relative to Wyoming which should constitute a measure of the taxability of the uranium industry in New Mexico. This cost advantage can be calculated utilizing data from various ERDA publications. The derivation of this cost advantage must be

carried through several steps. Each step will be discussed separately and the data derived will be arranged in a table to be used in ensuing steps.

Step 1. The first step requires the construction of a table correlating ore grade to mill recovery. This has been done by ERDA for a limited range of grades[150] but must be inferred for other grades from ERDA publications.[142]

Step 2. Since Table IV-2 represents only the amount of U_3O_8 present in the ore, it is necessary to calculate the amount of U_3O_8 that can be recovered from the ore. Before this can be done, however, the reserve data of Table IV-2 which reflect total known reserves in New Mexico and Wyoming by forward cost must be separated into increments of ore reserves which when added to a lower forward cost category of ore reserves, will yield the next higher forward cost category. These data are presented in Table IV-4.

Step 3. This step will utilize the data of Table IV-3 (interpolating where necessary) and the data of Table IV-4 to compute the amount of U_3O_8 that can be practically recovered for New Mexico and Wyoming (see Table IV-5).

Step 4. Now that it is known how much U_3O_8 is practically recoverable from known $30 reserves in New Mexico and Wyoming, the cost of production per pound

TABLE IV-3

RECOVERY RATE OF VARIOUS ORE GRADES

Ore Grade % U_3O_8	.25	.20	.10	.05	.025	.01
Mill Recovery %	95	95	92.5	87.5	77.5	47.5

TABLE IV-4

NEW MEXICO AND WYOMING ORE RESERVES BY COST INCREMENTS

	Fwd. Cost	Tons of Ore	Grade	Tons of U308 in Ore
New Mexico	$8 Reserves	44,920,000	.29	131,600
	$10 Reserves less $8 Reserves	12,180,000	.16	19,400
	$15 Reserves less $10 Reserves	58,800,000	.09	55,200
	$30 Reserves less $15 Reserves	186,100,000	.05	96,500
	Total	302,000,000		302,700
Wyoming	$8 Reserves	19,187,000	.18	33,800
	$10 Reserves less $8 Reserves	43,313,000	.09	39,200
	$15 Reserves less $10 Reserves	88,000,000	.09	85,000
	$30 Reserves less $15 Reserves	202,100,000	.04	81,000
	Total	352,600,000		239,000

TABLE IV-5

U_3O_8 RECOVERABLE FROM ORE RESERVES

	Reserve Category	Grade	Tons of U_3O_8 in Ore	x	Recovery Rate	=	Recoverable U_3O_8 (Tons)
New Mexico	$8	.29%	131,600		.95		125,020
	[$10-$8]	.16	19,400		.94		18,236
	[$15-$10]	.09	55,200		.915		50,508
	[$30-$15]	.05	96,500		.875		84,437
Total			302,700				278,201
Wyoming	$8	.18	33,800		94.5		31,941
	[$10-$8]	.09	39,200		91.5		35,868
	[$15-$10]	.09	85,000		92.0		78,200
	[$30-$15]	.04	81,000		83.5		67,635
Total			239,000				213,644

of U_3O_8 can be computed. Table IV-6 demonstrates the calculation of the average cost per pound of mining and milling U_3O_8 in New Mexico and Wyoming.

Forward Costs do not include exploration, land acquisition and primary development costs, but if the $1.60/lb. figures are adopted from the Uranium Production Outlook data,[143] these costs can be taken into consideration.

Step 5. The differential between the Wyoming and New Mexico unit costs divided by the average cost of producing a pound of U_3O_8 in New Mexico will yield the average cost advantage of producing U_3O_8 in New Mexico as opposed to Wyoming.

New Mexico	11.87		Wyoming	17.68	
	1.60	(Exploration Costs/lb.)		1.60	(Exploration Costs/lb.)
	13.47			19.46	

$$\frac{\text{Wyoming Costs-New Mexico Costs}}{\text{New Mexico Costs}}$$

$$\frac{19.46 - 13.47}{13.47} = \frac{5.99}{13.47} = 44.4\%$$

Assuming cost to be 80 percent of market value, the market advantage will be 35.6% - 36%.

The high grading analysis compares the cost of production of Wyoming's recoverable $30 reserves with a commensurate amount of New Mexico's lowest cost reserves. This comparison shows that New Mexico's lowest cost reserves could bear a 36 percent tax before the costs

TABLE IV-6

TOTAL FORWARD COSTS OF MINING AND MILLING OF U_3O_8
RESERVES IN NEW MEXICO AND WYOMING
USING A HIGH GRADING ANALYSIS

Forward Cost per lb.	Pounds U_3O_8 Recovered (millions)	Total Forward Cost (billions)	
New Mexico			
8	250.0	2.00	
10	36.5	.365	Average Cost/lb = $\frac{5.074 \text{ billion}}{427.3 \text{ million}}$ = $11.87
15	101.9	1.515	
30	39.8	1.194	
TOTAL........	427.3	5.074	
Wyoming			
8	63.9	.511	
10	71.7	.717	Average Cost/lb = $\frac{7.633 \text{ billion}}{427.3 \text{ million}}$ = $17.86
15	156.4	2.346	
30	135.3	4.059	
TOTAL........	427.3	7.633	

of mining and milling these reserves would equal the cost of mining and milling Wyoming's $30 reserves. As Table IV-5 reflects, cost and ore grade have an inverse relationship insofar as proven reserves are concerned; therefore, the choice of mining the lowest cost reserves will have the effect of mining the highest grade reserves. The validity of this analysis, however, follows from the fact that if, for some hypothetical reason such as a 36 percent tax, costs were to increase in New Mexico, the uranium firms, if acting rationally would be forced to mine lower cost and usually a higher grade of ore in order to make the break even point. If, on the other hand, costs were to drop, or equivalently, prices increased, a lower grade (higher cost) ore would become economical to mine.

The industry has objected to this reasoning on three grounds. First, if forced to high grade, the ores that were left in the ground as not being economical may never be recovered. Second, some lower cost deposits are only economical in conjunction with a higher cost deposit. Consequently, if higher cost deposits were eliminated, certain lower cost deposits would also be forfeited. Thirdly, Table IV-5 assumed that all reserves are recoverable at exactly the forward cost category in which they are classified.

These objections reflect a narrow, self-interested, static view of the underlying considerations of the analysis. The first objection may be met by noting that if the uranium producers were able to pass the increased costs on to their consumers, then they would be in the same position as they would have been before any cost increase, and the necessity of high grading will have disappeared. The same reasoning applies if prices were to increase. Since New Mexico has 50 percent of the nation's domestic reserves, it is likely that the industry could pass on the costs and, in an energy-dear environment, get higher prices. Further, the first objection assumed all parameters constant until all mining is completed. This is roughly a period of thiry years. Such an assumption is contraindicated by all forecasters in the uranium market. All forecasters predict markedly increasing prices from now forward. This means that in a relatively short period of time, the increased cost will be more than made up for by increases in price. The second objection must fall with the first.

The third objection is trivial. Utilizing midpoints of \$6, \$9, \$12.50, and \$22.50 yields an almost identical cost advantage. The third objection would be valid only if there were uneven distributions of U_3O_8 over the entire cost range for one state but not for the

other (i.e., all of New Mexico's $8 reserves were exactly $8 and all of Wyoming's $10 reserves were $8.01). This is simply not the case.

Consequently, it follows that the New Mexico uranium industry's average reserves could stand a 36 percent tax and remain competitive with Wyoming's $30 reserves. Inflation has taxed the industry at a substantially higher rate over the past three years but prices have more than kept pace with inflation and it is anticipated that price will also keep pace with other cost increases such as taxes.

Allocation of the Tax Burden

Table IV-7 reflects the 1975 tax burden of the severance tax and the natural resource excise tax to be .8 percent of the value of gross production. Dr. Gerald Boyle of the Department of Economics of the University of New Mexico estimates the property tax burden to be approximately 1 percent of the gross value of production. Of the 1 percent of value of gross production, .3 percent is collected from the ad valorem property tax on production and .7 percent is derived from the property tax on equipment. As noted earlier the proposed change to the property tax base (on production) would have the effect of increasing the tax by a factor of six. Thus the .3 percent would be increased to become

TABLE IV–7

NATURAL RESOURCES EXCISE TAX RECEIPTS AND SEVERANCE TAX RECEIPTS AS A PERCENTAGE OF THE VALUE OF GROSS PRODUCTION -1975

Total Production	x	Price	=	Gross Value of Production
10,826,593.58 lbs.		$8.06		$87,262,344.25
Severance Tax Paid	÷	Gross Value of Production	=	Severance Tax Paid as a Percentage of Gross Value of Production
$179,946.56		$87,262,344.25		.2%
Natural Resources Excise Tax Paid	÷	Gross Value of Production	=	Net Resource Excise Tax Paid as a Percentage of Gross Value of Production
$564,002.61		$87,262,344.25		.6%
		Total Tax Burden		.8%

Source: The figures utilized were obtained from a presentation by Mr. Fred O'Cheskey to the Legislative Energy Committee in an open hearings session in April 1976.

1.8 percent. Adding this to the .7 percent collected through the property tax on equipment would yield a total property tax burden of 2.5 percent of the gross value of production.

The proceeds from the Severance Tax are paid to the Severance Tax Bonding Fund and when the obligations from the Severance Tax Bonding Fund are met, the surplus is paid into the Severance Tax Permanent Fund. The proceeds from the Natural Resources excise tax go to the general fund and the property tax proceeds provide local governments with a share of the revenues.

Presently, the Severance Tax Bonding Fund and the Severance Tax Permanent Fund are adequately funded, therefore it is not necessary to alter the rate for the severance tax; it will suffice simply to alter the tax base from the present eviscerated definition of the "Gross Value of Uranium Products" to a true gross value of production [lbs. of U_3O_8 in ore severed x average price in the year for which tax is paid] with a 50 percent deduction allowance for costs. This would raise the burden of the severance tax to one-half of 1 percent of the value of gross production.

The tax rate for the natural resources excise tax on uranium would then be raised to 33 percent. A 33 percent natural resource excise tax rate on a tax base of the value of gross sales without deductions would

equate to a tax burden of 33 percent. Added to the proposed severance tax (1/2 percent) and the property tax 2 1/2 percent) burdens, the total tax levied as a percentage of gross production would be approximately 36 percent. The figure is approximate because of differences which might occur between production and sales.

The foregoing represents the basic tenets of a suggestion for revision of the extracted mineral tax structure with particular reference to uranium. Significantly, the recommendations made by the Jones and Bingaman articles[145] regarding utilization of the federal tax structure of the percentage depletion allowance were omitted. While it is true that § 613 of the Internal Revenue Code[146] offers a well established and easily administered vehicle for state mineral extraction taxes, it does create some problems. The first problem that arises is that by adopting a federal statute as a basis for a state statute, the state, in effect, becomes stuck with subsequent changes in the federal statute. A recent problem of this nature was experienced by the state when § 151 of the Internal Revenue Code was revised, increasing the deduction for personal exemption from $600.00 to $750.00. This revision was a de facto reduction in the New Mexico Income Tax since the tax base for the New Mexico Income Tax is the federal definition

of taxable income. Although this problem could be avoided by adopting the words of § 613 rather than the statute itself or the statutory definitions of "gross income from mining" and "taxable income," avoidance of the other problems is somewhat more difficult.

The second problem arises in the definition of gross income from the property. While the statutory definition in § 613(c) of the Internal Revenue Code[147] defines gross income from mining in detail and seemingly is in conformity with the definition of gross income in the sense that gross income equals price x quantity, the income tax regulations, in particular § 1.613-2(C)(5)(i) states:

> In all cases there shall be excluded in determining the "gross income from the property" an amount equal to any rents or royalties (which are depletable income to the payee) which are paid or incurred by the taxpayer in respect of the property and as not otherwise excluded from "gross income from property."[148]

This definition of gross income would once again yield a tax which has a discriminatory tax base. Royalty deductions from the tax base would discriminate against producers who operate on lands whose mineral interests were owned by the producers. Furthermore, this would reduce the tax base and therefore the revenue producing power of the tax. Consequently, the firm's motivation to maximize "gross income from property" for percentage depletion allowance is constrained by royalty deductions.

Royalties may amount to between 15 and 20 percent of the value of gross production; if the tax base is reduced by this amount, given a fixed tax rate, tax revenues would be similarly diminished. Furthermore, this would have the effect of subsidizing those firms which produce from leased property. For many of the reasons stated earlier these are undesirable features to incorporate into our mineral extraction tax policy.

Benefits of the Proposed Tax Changes

The most obvious benefit that will occur is that New Mexico will share in the uranium boom through increased revenues. Column 2 of Table IV-8 represents the estimates of revenues that would be derived if high U_3O_8 production projections based on present growth trends in nuclear power consumption are realized and a 30 percent tax burden were levied. Column 3 represents the estimates of revenues that would be derived, if low U_3O_8 production projections based on minimal usage of nuclear power are realized. Column 4 represents revenues that are most likely to be derived given New Mexico's presently planned milling capacity and if it is assumed that the average grade of ore milled is .15 percent.

An additional benefit that immediately follows from the first consideration is tax relief. It is estimated

TABLE IV-8

PROJECTED REVENUE IN MILLIONS FOR EXTRACTION TAXES ON THE URANIUM INDUSTRY ASSUMING A TAX BURDEN OF 30 PERCENT*

Column 1	Column 2	Column 3	Column 4
Year	High	Low	Limited Milling Capacity
1977	95.8	98.0	78.5
1978	137.2	137.2	92.5
1979	190.8	185.7	121.0
1980	243.8	258.6	137.2
1981	304.9	320.4	171.8
1982	384.8	356.9	
1983	472.4	369.5	
1984	557.1	338.2	
1985	685.1	398.5	
1986	815.6	440.8	
1987	993.8	492.0	
1988	1,068.0	500.6	
1989	1,199.2	511.6	
1990	1,320.2	537.6	
1991	1,457.3		
1992	1,610.4		

*These figures were computed by taking 30 percent of the value of production from the data in Table III-12 of this report.

that if the gross receipts tax on food was removed, the state general fund would lose 30 million dollars. This would be more than made up by the increase in the extractive industry taxation.

Impact of Tax Proposals on the Uranium Industry

The increased tax burden must either be absorbed by the industry or by someone else. If it is absorbed by someone else, it may be passed forward resulting in reduced costs for the factors of production or it may be passed on to the product consumers resulting in a higher price to consumers. To the extent that the tax burden is passed forward or absorbed by the industry, the state will feel some of the impact of the tax. To the extent that the tax burden is passed on to the consumers of U_3O_8, the tax burden will be exported and therefore is of no great concern to the State of New Mexico.

An exact determination of the ultimate incidence of the tax burden is virtually impossible, nevertheless, some insight in this regard can be gained from consideration of the costs of the entire process of the uranium fuel cycle from the mine to power consumption by the ultimate consumer.

Table IV-9 reflects that the mining and milling of uranium is 28 percent of the costs incurred in

TABLE IV-9

BREAKDOWN OF COSTS OF NUCLEAR POWER GENERATION

Column 1		Column 2	
Generation Costs		Fuel Cycle Costs/Dollar	
Capital Investment	69%	Mining and Milling	35¢
Operation and Maintenance	6%	Conversion to UF6	3¢
Fuel Cycle	25%	Transportation and Waste Management	4¢
		Reprocessing	18¢
		Fuel Fabrication	13¢
		UF6 Enrichment	50¢
			$1.23
		Less Plutonium Cost	-.23
		If Breeders are Utilized	$1.00

Source: Uranium, Bureau of Mines Bulletin 667, p. 17, Fig. 3.

producing fuel if plutonium is not recycled and 35 percent of the costs if plutonium generated by the reactors is recycled. Furthermore, as Column 1 suggests, the cost of the fuel cycle is 25 percent of the total costs of generation, and if mining and milling is only 28 percent of the cost of the fuel cycle, then mining and milling cost can only represent 7 percent of the total cost of power generation. The tax proposal of increasing

the tax burden from 2 percent to 36 percent is an increase of 34 percent of the cost of U_3O_8 to the immediate consumer of U_3O_8. A 34 percent increase would represent an increase of about 2 percent in the total cost of nuclear power generation. If 20 percent of all generated power is nuclear, then the cost increase is less than one-half of one percent. While an exact determination of the impact this would have on the demand for nuclear power would depend on the elasticity of demand for nuclear power, it can be surmised, in circumstances of 6 percent plus inflation annually (with growth in demand for electrical power uncurtailed) that a cost increase as small as one-half percent will have virtually no effect on the demand for electrical power. Furthermore, Table IV-10 indicates that the cost increase being discussed would have no effect on the competitive position of nuclear power generation relative to other modes of power generation. Consequently, the entire cost of the tax increase can be passed on through each stage of the fuel cycle to the final consumer of electrical power. This would permit distribution of the tax burden to be spread over a much larger group thereby minimizing its impact. To the extent that the ultimate consumers of electrical power are commercial entities, their cost increases may be passed on even further.

TABLE IV-10

COMPARATIVE FUEL COSTS FOR ELECTRICAL GENERATION

SALES PRICE	COST IN CENTS PER MILLION BTU	
	COAL (DELIVERED)	
DOLLARS/TON	8,000 BTU/LB	13,000 BTU/LB
5.00	31.3	19.2
10.00	62.5	38.5
15.00	93.8	57.7
20.00	125.0	76.9
25.00	156.3	96.2
30.00	187.5	115.4
35.00	218.8	134.6
40.00	250.0	153.8
	FUEL OIL	
DOLLARS/BARREL	130,000 BTU/GAL.	152,000 BTU/GAL.
5.00	91.6	78.4
7.00	128.2	109.7
9.00	164.8	141.1
11.00	201.5	172.4
13.00	238.1	203.8
15.00	274.7	235.1
17.00	311.4	266.5
	NATURAL GAS	
DOLLARS/MF^3	900 BTU/CF	1,030 BTU/CF
.20	22.2	19.4
.40	44.4	38.8
.60	66.6	58.3
.80	88.8	77.7
1.00	111.1	97.1
1.20	133.3	116.5
	FABRICATED URANIUM* FUEL	
DOLLARS/LB U_3O_8		
10.00	24.2	
15.00	27.8	
20.00	31.4	
25.00	34.8	
30.00	38.4	
35.00	41.8	
40.00	45.3	

*ASSUMPTIONS: URANIUM FUEL COSTS INCLUDE:
25,000 M_t DAYS/TON
$3.75 PER Kg CONVERSION
$55.00 PER Kg SWU
$100.00 PER Kg FABRICATION
3.0% ENRICHMENT
.200 TAILS ASSAY
} ESTIMATED 1975-1976 COSTS AT EQUILIBRIUM

CALCULATIONS DO NOT INCLUDE COST OF REPROCESSING OR CREDIT FOR REPROCESSED FUEL.

Source: Kerr-McGee Corporation, 1975 Uranium Statistics and Industry Projections, August 1975, Oklahoma City. p. 76.

It appears, then, insofar as economic considerations are concerned, that the tax increase can be passed on to consumers. In fact, this was the position taken by the uranium industry in Colorado when increases in mineral extraction taxes were being considered.[149] A question remains as to how soon the tax could be passed on. It has been argued that present contract terms are so inflexible that a tax increase could not be passed on until new contracts are formed.[150] This is a novel argument when members of the industry are currently disavowing contractual obligations on the basis of economic impossibility of performance. In the face of this consideration, little remains of this type of argument. Typical contracting practices allow for escalation of costs, and if such provisions are not part of a contract, then force majeure considerations may provide another means to shift the tax burden.[151]

It is more likely, when one considers the monopolistic position of the uranium industry in the western states, that the resistance to increased taxes, is not because the consequent price increases cannot be passed on but rather that the industry has already anticipated raising the price of U_3O_8 to the highest level that the market will bear and that the tax increase will cut into the profit derived from this powerful pricing position. If this is the case, and the tax burden is absorbed by the industry, it must be noted that the tax was designed to equalize the average returns to uranium

producers in New Mexico to the average return of the producers in Wyoming. It can hardly be complained that the tax is unduly burdensome when it puts New Mexico producers on an equal footing with Wyoming producers. Table IV-11 reflects that the uranium industry is taking advantage of the dividend accruing from New Mexico's superior quality uranium resource. In 1974, the average content of U_3O_8 in ore produced was 12.5 percent higher in New Mexico than in Wyoming and in 1975 the average content of U_3O_8 in ore produced was 28 percent higher in New Mexico than in Wyoming.

TABLE IV-11

COMPARISON OF ORE GRADE FOR THE TWO MOST RECENT YEARS' PRODUCTION IN NEW MEXICO AND WYOMING

State	Year	Tons of Ore	Tons U_3O_8	% of Total U_3O_8	Avg. Grade
New Mexico	1974	2,997,000	5,400	43%	.18%
Wyoming	1974	2,458,000	4,000	32%	.16%
New Mexico	1975	2,985,000	5,500	45%	.18%
Wyoming	1975	2,589,000	3,700	30%	.14%

Source: <u>Statistical Data of the Uranium Industry</u> 1975 and 1976, GJO-200 Series, p.29 and p. 25 respectively.

In summary, it appears that an increase in the tax burden on the uranium industry will be passed on to the consumers of U_3O_8. Mining and milling costs make up less than 10 percent of the cost of nuclear power generation so it is not expected that the tax increase will affect the demand for nuclear power or, therefore, the demand for U_3O_8.

To the extent that the tax cannot be passed on, it will represent an increase in costs to the uranium industry. Nevertheless, the windfall profits accruing to the industry from the naturally enhanced position of New Mexico uranium resources and the dramatic increase in U_3O_8 prices are expected to offset any undue economic burden to the industry.

ENDNOTES

[1] <u>Mineral and Water Resources of New Mexico</u>, Report prepared by the U.S. Geological Survey, requested by Senator Clinton Anderson for the Senate Committee on Interior and Insular Affairs (Washington, D.C.: Government Printing Office, 1965.

[2] Ibid.

[3] Ibid.

[4] Ibid.

[5] Victor L. Devers, "A History and Economic Analysis of the Uranium Industry in New Mexico (Master's thesis, The University of New Mexico, 1962) pp. 17-21.

[6] Merle Armitage, <u>Stella Dysart of Ambrosia Lake</u> (New York: Dull, Sloan and Pierce, 1959), pp. 125-127.

[7] New Mexico Mine Inspector's Annual Report 1956, <u>passim</u>.

[8] <u>Mineral Resources and the Environment Supplementary Report: Reserves and Resources of Uranium in the United States</u>, prepared by the Committee on Mineral Resources and the Environment (COMRATE), p. 11.

[9] <u>Statistical Data of the Uranium Industry</u>, GJO 100(75), ERDA, pp. 16-17.

10 Mineral Resources and the Environment, p. 15.

11 Ibid.

12 Ibid.

13 Ibid.

14 Ibid., p. 17.

15 Ibid., p. 19.

16 Ibid., p. 18.

17 Ibid., p. 20.

18 M. A. Lieberman, "United States Uranium Resources--An Analysis of Historical Data," Science Magazine, 30 April 1976, 431.

19 Ibid.

20 Ibid., p. 434.

21 Ibid., p. 432.

22 Ibid., p. 435. The ratios are: r (10/8) = 1.2; r (15/8) = 1.5 and r (30/8) - 1.8.

23 These figures are obtained by adding potential resource and reserves and cumulative production. GJO 100(75), pp. 18, 28. The estimates of potential resource are for 1973 only.

24 Lieberman, p. 432.

25
Telephone conversation with Mr. Carl Applin, ERDA Grand Junction Office, on 27 May 1976.

26
Ibid.

27
Current Wage Development, Vol. 28 (No. 1, January 1976.

28
R. T. Zittung,"Estimation of Potential Uranium Resources," Mineral Resources and the Environment, App. B of the Supplementary Report entitled, Reserves and Resources of Uranium in the United States, p. 148.

29
J. R. Ellis, D. P. Harris, and N. H. VanWie, A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico, GJO 110(76), December 1976.

30
Ibid., p. 2

31
Ibid., p. 5

32
Ibid., p. 35.

33
Ibid., pp. 4-5.

34
Ibid., pp. 4, 5.

35
Ibid., p. 74.

36
Ibid.

37
Ibid., pp. 54-56.

38
M. Paul Mathews Phoncon, vice president in charge of Mining Engineering, Rancher's Exploration and Development Corporation, 7 June 1976.

39
Mineral and Water Resources of New Mexico, 1965, report prepared by U.S.G.S., p. 225.

40
Ellis et al., p. 7.

41
Ibid., p. 1.

42
Ibid., p. 9.

43
State of the Art, Uranium Mining, Milling, and Refining Industry, EPA-660/2-74-038, June 1974, p. 26

44
Ellis et al., p. 13.

45
Ibid., p. 23.

46
Statistical Data of the Uranium Industry, GJO 100(76), p. 49.

47
Statistical Data of the Uranium Industry, GJO 100 100 (70), p. 75.

48
Ibid.

49
Statistical Data of the Uranium Industry, GJO 100(76), p. 77.

50
Ralph E. Lapp, "It's a Long Haul from Mine to Reactor," Fortune, October 1975, p. 156.

51
Energy Alternatives: A Comparative Analysis by the Science and Public Policy Program (Norman: University of Oklahoma), pp. 6-21.

52
Lapp, p. 156.

53
Ralph E. Lapp, "We May Find Ourselves Short of Uranium Too," Fortune, October 1975.

54
Survey of United States Uranium Marketing Activity, ERDA 76-46, p. 1.

55
Ibid., p. 12. Also this estimate presumes the breeder reactor to be in operation in 1981.

[56] John Patterson, Uranium Requirements and Supply Outlook, November 1975, p. 47.

[57] ERDA GJO News Release #76-6, 26 January 1976.

[58] ERDA GJO News Release #76-46, p. 11.

[59] Patterson, p. 42.

[60] National Energy Outlook, February 1976, p. xxxii.

[61] Ibid., p. 36.

[62] And as adopted by The Atlantic Council of The United States in their Nuclear Fuels Supply, Fourth Draft, 19 February 1976.

[63] Uranium Industry Seminar, 7-8 October 1975, GJO 108(75), p. 10.

[64] Ibid., p. 9.

[65] Ibid.

[66] Ibid.

[67] Ibid.

[68] Ibid.

[69] Ibid.

[70] These considerations were developed in Chapter I of this report.

[71] Statistical Data of the Uranium Industry, GJO 100(76).

[72] Uranium Requirements and Supply Outlook, John Patterson, p. 43.

73 Lieberman, p. 436.

74 Statistical Data of the Uranium Industry, p. 22.

75 §72-16A-20 to 72-16A-29 NMSA (1953).

76 Statistical Data of the Uranium Industry, GJO 100(76), p. 82.

77 Phoncon, 1 July 1976 with Mr. Al Topp, New Mexico Environmental Protection Agency.

78 Ibid.

79 Uranium Industry Seminar, 7-8 October 1975, GJO 100(75), p. 157.

80 Survey of United States Uranium Marketing Activity, April 1976, ERDA 76-46, UC-51, p. 3.

81 Mineral Industry Surveys: The Mineral Industry of New Mexico in 1975.

82 Survey of United States Uranium Marketing Activity, April 1976, ERDA 76-46 UC-51, p. 3. In discussing the source author's Table II (Table III-9 in this report) the author states: "The price data reported for most years cover over 80% of domestic uranium commitments, providing a good sample of prices." From this it follows that about 20 percent of domestic uranium commitments are unreported.

83 $13.00 is a rough average of the prices reported by Kerr-McGee in their annual report (p. 2) and by the United Nuclear in their annual report (p. 4).

[84] Uranium Industry Seminar, GJO 108(75), October 7-8, 1975; J. Fred Facer, Jr., Production Statistics, p. 156.

[85] Ibid. Although Mr. Facer suggests that a short term rise in millfeed grade will occur, the data for 1975 reflect otherwise. The average ore grade for 1975 was less than .17 percent rather than greater. Therefore, for the reasons given, the assumption of a slowly declining ore grade will be maintained.

[86] State of the Art Uranium Mining, Milling and Refining Industry, p. 22.

[87] Uranium Industry Seminar, p. 152.

[88] Ibid.

[89] By correspondence, 2 July 1976.

[90] J. Patterson, U.S. Uranium Production Outlook, September 1976, pp. 22, 23.

[91] These data were introduced in hearing by the Revenue Stabilitzation Committee on 29 November 1976 by Mr. Leland Erdahl of Rancher's Exploration and Development Co.

[92] See Table III-17.

[93] See Table III-18

[94] Statistical Data of the Uranium Industry GJO 100(76), passim.

[95] This can be observed by computing the average cost of producing a pound of U_3O_8 in New Mexico and in Wyoming utilizing the Statistical Data of the Uranium Industry data.

96
Bingaman, New Mexico's Effort at Rational Taxation of Hard Mineral Extraction, 10 Nat. Res. J. 415 (1970).

97
Jones, The Struggle for Equitable Taxation of Mines--the New Mexico Example, 16 Rocky Mountain Min. L. Inst. 463 (1971).

98
N.M. Stat. Ann. § § 72-18-1 et seq. (Repl. 1961, Supp. 1975).

99
N.M. Stat. Ann. § 72-18-1.2 (Supp. 1975).

100
See History notes to N.M. Stat. Ann. § 72-18-1 (Supp. 1975).

101
See Amendment notes to N.M. Stat. Ann. § 72-18-2 (Repl. 1961).

102
Id.

103
Id.

104
Id.

105
Id.

106
Id.

107
Id.

108
N.M. Stat. Ann. § 72-18-4 (Supp. 1975); see Amendments notes.

109
Id.

110 N.M. Stat. Ann. § 72-18-2.2 (Supp. 1975).

111 N.M. Stat. Ann. § 72-18-4 (Supp. 1975).

112 N.M. Stat. Ann. § 7-9-22 & 7-9-23 (Repl. 1974).

113 N.M. Stat. Ann. § 72-18-2.2 (Supp. 1975).

114 N.M. Stat. Ann. § 72-18-2 (Repl. 1961, Supp. 1975).

115 1961 N.M. Laws, ch. 98, §3.

116 N.M. Stat. Ann. § 72-18-2 (Repl. 1961), Supp. 1975).

117 N.M. Stat. Ann. § § 72-16A-20 to 72-16A-29 (supp. 1975).

118 Id. § 72-16A-23.

119 Id. § 72-16A-24.

120 Id. § 72-16A-25.

121 Id. § 72-16A-22F.

122 N.M. Stat. Ann. § 72-18-2.2 (Supp. 1975) requires that the taxable event for this section is the feeding of uranium bearing material to process whereby yellowcake is recovered. Further, the same statute requires that "gross value to be reported for severed and saved uranium bearing material not disposed of as ore or solution but processed or beneficiated . . . , regardless of the form in which the product is disposed of, . . ." The words "not disposed of as ore . . . but processed or beneficiated . . . regardless of the form

in which the product is actually disposed of . . . , " together with the denoting of milling as the taxable event seems to imply that the severance and sales of raw ore incurs no tax liability.

123 N.M. Stat. Ann. § 72-16A-22.1 (Supp. 1975).

124 N.M. Stat. Ann. § 72-29-11 (Supp. 1975).

125 *Id.* § 72-29-12.

126 *Id.* § 72-29-14.

127 N.M. Stat. Ann. § 72-28-1 *et seq.* (Supp. 1975).

128 *See* text at notes 21 to 24 *supra*.

129 N.M. Const. art. VIII, § 1.

130 Temporary Commission on the Fiscal Affairs of State Government, State of New York, 1 A Program for Continued Progress in Fiscal Management 32 (Feb. 1955).

131 Jones, *supra* at 463.

132 *Id.*

133 Jones, *Taxation and Industrial Location*, 23 N.M. Business, No. 6, 1 (1970); *see* Muir, *Ad Valorem Tax Status of a Private Lessee's Interest in Publicly Owned Property: Taxability of Possessory Interests in Industrial Projects under the New Mexico Industrial Revenue Bond*, Act, 3 N.M. L. Rev. 136, 165 (1973).

134 Jones, *Equitable Taxation of Mines*, *supra* at 468.

135
See Appendix 1.

136
N.M. Stat. Ann. § 72-18-4 (Supp. 1975).

137
Oklahoma Tax Commission v. Texas Co., 336 U.S. 342 (1949).

138
Wessel, A Note on Economic Rent, in Readings in Price Theory, 427 (1973).

139
Id.

140
Id.

141
J. Klemenic, An Estimate of the Economics of the Uranium Concentrate Production from Low Grade Sources 4 (1974). This provides the recovery rate for ores from .01 to .10 percent U_3O_8. Mr. Klemenic is the Assistant Director of the Planning and Analysis Division of ERDA's Grand Junction Office.

142
J. Klemenic, Examples of Overall Economics in a Future Cycle of Uranium Concentrate Production for Assumed Open Pit and Underground Mining Operations (1972). The recovery rate for ores of .25% and .20% are inferred from pages 2 and 7 utilizing the following calculations:

$$.25 : \frac{34.70 \text{ \$/ton}}{7.303 \text{ \$/lb recovered}} = 4.75$$

$$.20 : \frac{22.75 \text{ \$/ton}}{5.987 \text{ \$/lb recovered}} = 3.7999$$

$$\frac{4.75 \text{ lbs recovered}}{5.0 \text{ lbs in ore}} = 95\% \text{ mill recovery rate}$$

$$\frac{3.799 \text{ lbs recovered}}{4.0 \text{ \$/lb recovered}} = 94.9 \quad 95\% \text{ mill recovery rate}$$

143
J. Patterson, U.S. Uranium Production Outlook (1976). Mr. John A. Patterson is the Chief of the Supply

Evaluation Branch, Division of Nuclear Fuel Cycle and Production, U.S. Energy and Development Administration. The reference is to the last two pages of a paper delivered at the Atomic Industrial Forum, International Conference on Uranium, in Geneva, Switzerland (September 14, 1976).

144
These figures were obtained from a presentation by Mr. Fred O'Chesky to the Legislative Energy Committee in an open hearing in April 1976.

145
See notes 1 and 2, *supra*.

146
I.R.C. § 613.

147
I.R.C. § 613(c).

148
Treas. Reg. § 1.613-2(c)(5)(i).

149
Colorado Legislative Council Research Publication No. 214, Mineral Taxation 93 (Nov. 1975).

150
Id.

151
The Anaconda Company exercised a force majeure clause in one of its contracts in 1975 to accommodate a problem in the supply of U_3O_8. Anaconda, Annual Report 17 (1975).

APPENDIX I

In an environment of rising prices and rising costs and where the increment to the price-cost differential from one year to the next is less than the interest that would accumulate on a similar investment at the prevailing interest rate, then it would behoove the firm to mine its best ores first in order to maximize its future stream of profits. If on the other hand, the increment to the price-cost differential from one year to the next is greater than the interest that would accumulate on a similar investment at the prevailing interest rate, then it would behoove the firm to mine its poorest ores (that are economical to mine) first. By "economical to mine" is meant that ore which will yield enough mineral to pay for its extraction and processing. These points are illustrated in the example by the fact that in Case 1, of the hypothetical below, the present value of the future stream of profits is maximized in the first combination where the highest grade ore is mined first. And in Case 2, the present value of the future stream of profits is maximized in the fifth combination where the most marginal ores are mined first.

APPENDIX I

EXAMPLE

Assumptions:

3,000 ton ore body:	1,000 tons of 3 lb. metal/ton of ore	Interest/discount
	1,000 tons of 2 lb. metal/ton of ore	rate = 10%
	1,000 tons of 1 lb. metal/ton of ore	1,000 ton/year
		mining capacity

CASE 1

			Profits from ore bodies		
Year	Price	Cost	1 lb./ton	2 lb./ton	3 lb./ton
1	$10/lb.	$10.00/ton	0	$10.00/ton	$20.00/ton
2	$11/lb.	$10.50/ton	$.5/ton	$11.50/ton	$22.50/ton
3	$12/lb.	$11.00/ton	$1/ton	$13.00/ton	$25.00/ton

Combinations

	Profit Yrs. 1 +	Profit Yr. 2 (PV)* +	Profit Yr. 3 (PV) =	Present Value of Profit Stream
1*	$20	$11.50 ($10.41)	1 (.82)	$31.23
2	20	.50 (.45)	13.00 ($10.64)	31.09
3	10	22.50 (20.36)	1 (.82)	31.18
4	10	.50 (.45)	25.00 ($20.47)	30.92
5	0	11.50 (10.41)	25.00 ($20.47)	30.88
6	0	22.50 (20.36)	13 (10.64)	31.00

CASE 2

			Profits from ore bodies		
Year	Price	Cost	1 lb./ton	2 lb./ton	3 lb./ton
1	$10	$10.00/ton	0	$10.00/ton	$20.00/ton
2	12	$10.50/ton	$1.50/ton	$13.50/ton	$25.50/ton
3	14	$11.00/ton	3/ton	17/ton	31/ton

Combinations

	Profit Year 1 +	Profit Year 2 (PV) +	Profit Yr. 3 (PV) =	PV of Profit Stream
1	20	$13.50 ($12.21)	$3 (2.46)	$34.67
2	20	1.50 (1.36)	17 (13.91)	35.27
3	10	25.50 (23.07)	3 (2.46)	35.53
4	10	1.50 (1.36)	31 (25.38)	36.74
5*	0	13.56 (12.21)	31 (25.38)	37.59
6	0	25.50 (23.07)	17 (13.91)	36.98

*Present Value of profit stream is maximized.

BIBLIOGRAPHY

Anaconda Company. Annual Report 17 (1975).

Armitage, Merle. Stella Dysart of Ambrosia Lake. New York: Dull, Sloan and Pierce, 1959.

Bingaman, Anne. New Mexico's Effort at Rational Taxation of Hard Mineral Extraction, 10 Natural Resources Journal 415 (1970).

Colorado Legislative Council Research Publication No. 214, Mineral Taxation 93 (Nov. 1975).

Committee on Mineral Resources and the Environment (COMRATE). Mineral Resources and the Environment Supplementary Report: Reserves and Resources of Uranium in the United States, 1965.

Devers, Victor L. "A History and Economic Analysis of the Uranium Industry in New Mexico." Master's thesis, The University of New Mexico, 1962.

Ellis, J. R., Harris, D. P., and VanWie, N. H. A Subjective Probability Appraisal of Uranium Resources in the State of New Mexico. GJO 110(76), December 1976.

Jones, F. The Struggle for Equitable Taxation of Mines--the New Mexico Example, 16 Rocky Mountain Min. L. Inst. 463 (1971).

Jones, F. Taxation and Industrial Location, 23 N.M. Business, No. 6, 1 (1970).

Klemenic, J. An Estimate of the Economics of the Uranium Concentrate Production from Low Grade Sources (1974).

Klemenic, J. Examples of Overall Economics in a Future Cycle of Uranium Concentrate Production for Assumed Open Pit and Underground Mining Operations (1972).

Lapp, Ralph E. "It's a Long Haul from Mine to Reactor." Fortune, October 1975, p. 156.

Lapp, Ralph E. "We May Find Ourselves Short of Uranium Too." Fortune, October 1975.

Lieberman, M. A. "United States Uranium Resources--An Analysis of Historical Data." Science Magazine, 30 April 1976, 431

Muir, F. Ad Valorem Tax Status of a Private Lessee's Interest in Publicly Owned Property: Taxability of Possessory Interests in Industrial Projects under the New Mexico Industrial Revenue Bond, Act, 3 N.M. L. Rev. 136, 165 (1973).

New Mexico Mine Inspector's Annual Report. 1956.

O'Chesky, Fred. Report to Legislative Energy Committee. April 1976.

Oklahoma Tax Commission v. Texas Co., 336 U.S. 342 (1949).

Patterson, J. U.S. Uranium Production Outlook (1976). Paper delivered to Atomic Industrial Forum, International Conference on Uranium, in Geneva, Switzerland, September 14, 1976.

Science and Public Policy Program. Energy Alternatives: A Comparative Analysis. Norman: University of Oklahoma.

Temporary Commission on the Fiscal Affairs of State Government. State of New York, 1 A Program for Continued Progress in Fiscal Management 32 February 1955.

U.S. Congress. Senate. Committee on Interior and Insular Affairs. Mineral and Water Resources of New Mexico. Report prepared by the U.S. Geological Survey for Senator Clinton Anderson. Washington, D.C.: Government Printing Office, 1965.

U.S. Department of Interior. Bureau of Mines. Mineral Industry Surveys: The Mineral Industry of New Mexico in 1975. Washington, D.C.: Government Printing Office, 1975.

U.S. Environmental Protection Agency. State of the Art, Uranium Mining, Milling, and Refining Industry. EPA-660/2-74-038. Washington, D.C.: Government Printing Office, 1974.

U.S. Energy Research and Development Agency. Statistical Data of the Uranium Industry. GJO 100 (75). Washington, D.C.: Government Printing Office.

U.S. Energy Research and Development Agency. Survey of United States Uranium Marketing Activity. ERDA 76-46, UC-51. Washington, D.C.: Government Printing Office, April 1976.

U.S. Energy Research and Development Agency. Grand Junction Office. Uranium Industry Seminar, GJO 108 (75), October 7-8, 1975.

Wessel, S. A Note on Economic Rent. In Readings in Price Theory, 427 (1973).