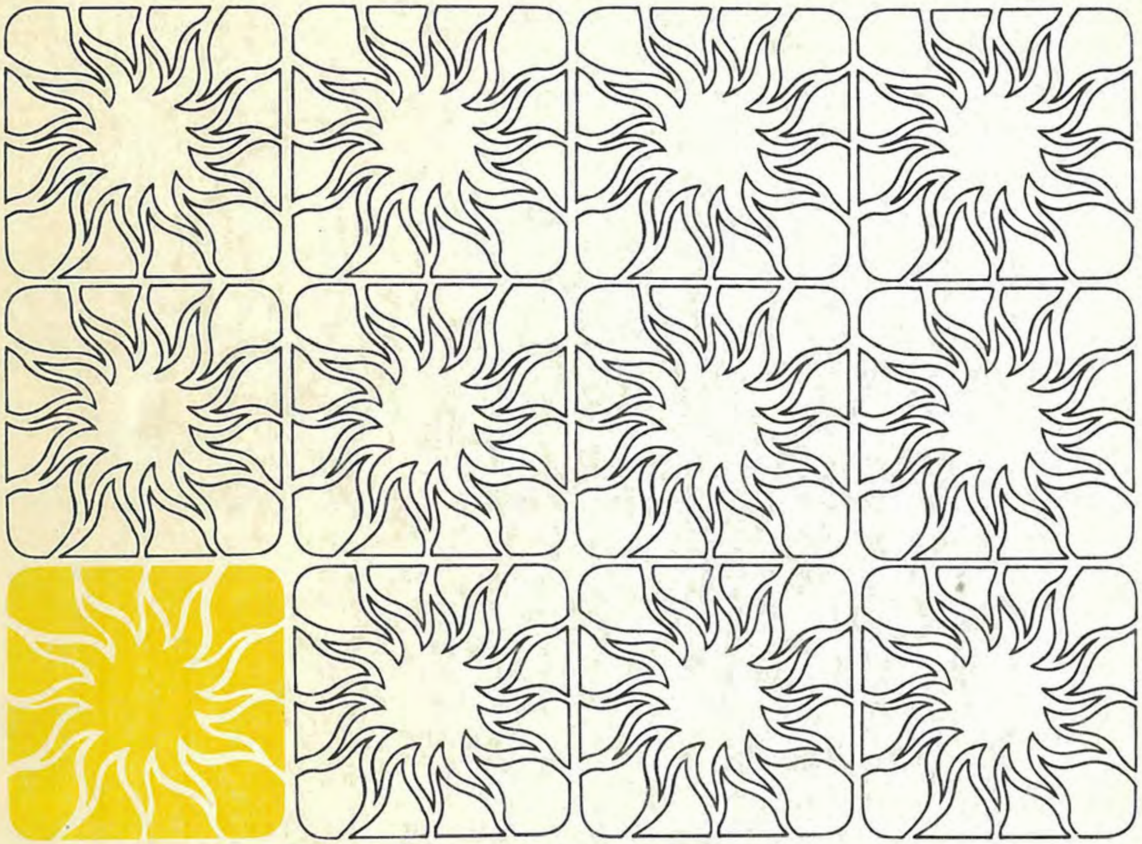

U.S. Energy Outlook

Nuclear Energy Availability

National Petroleum Council

U.S. Energy Outlook

Nuclear Energy Availability

A Report by the
Nuclear Task Group of the
Other Energy Resources Subcommittee
of the National Petroleum Council's Committee
on U. S. Energy Outlook

Chairman - George H. Cobb
Kerr-McGee Corporation

National Petroleum Council

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PREFACE

On January 20, 1970, the National Petroleum Council, an officially established industry advisory board to the Secretary of the Interior, was asked to undertake a comprehensive study of the Nation's energy outlook. This request came from the Assistant Secretary-Mineral Resources, Department of the Interior, who asked the Council to project the energy outlook in the Western Hemisphere into the future as near to the end of the century as feasible, with particular reference to the evaluation of future trends and their implications for the United States.

In response to this request, the National Petroleum Council's Committee on U.S. Energy Outlook was established, with a coordinating subcommittee, four supporting subcommittees for oil, gas, other energy forms and government policy, and 14 task groups. An organization chart appears as Appendix B. In July 1971, the Council issued an interim report entitled *U.S. Energy Outlook: An Initial Appraisal 1971-1985* which, along with associated task group reports, provided the groundwork for subsequent investigation of the U.S. energy situation.

Continuing investigation by the Committee and component subcommittees and task groups resulted in the publication in December 1972 of the NPC's summary report, *U.S. Energy Outlook*, as well as an expanded full report of the Committee. Individual task group reports have been prepared to include methodology, data, illustrations and computer program descriptions for the particular area studied by the task group. This report is one of ten such detailed studies. Other fuel task group reports are available as listed on the order form included at the back of this volume.

The findings and recommendations of this report represent the best judgment of the experts from the energy industries. However, it should be noted that the political, economic, social and technological factors bearing upon the long-term U.S. energy outlook are subject to substantial change with the passage of time. Thus future developments will undoubtedly provide additional insights and amend the conclusions to some degree.

INTRODUCTION

Nuclear power is expected to become increasingly important in meeting U.S. energy requirements. This development reflects (1) a shift of energy demand toward electrical usage and (2) the generally currently favorable economics of nuclear power plants for base-load generation of electricity over plants that utilize fossil fuels.

This report will examine--

- Various projected nuclear power growth rates and factors which influence these growth rates
- The adequacy of the domestic resource base of nuclear fuels--uranium and thorium
- Exploration, mining and milling activity required to supply U_3O_8 from the uranium resource base
- The calculated uranium (U_3O_8) prices corresponding to various supply assumptions
- The nuclear fuel processing requirements
- The cost of nuclear fuels in power generation
- The necessary capital expenditures for the nuclear fuel supply industry

SUMMARY AND CONCLUSIONS

The National Petroleum Council's Initial Appraisal assumed a continuation of the general government policies and economic climate in effect in 1971.* In this context, installed nuclear electric power generating capacity was projected to attain a level of 150,000 megawatts (MWe) in 1980 and 300,000 MWe in 1985. In order to assess the capability of the nuclear industry to provide more energy and to take into account possible changes in government policies and the economic climate, this study has developed projections for a maximum growth rate of nuclear electric power (Case I--450,000 MWe installed in 1985), a minimum growth rate (Case IV--240,000 MWe in 1985) and two intermediate growth rates (Case II--375,000 MWe in 1985 and Case III--300,000 MWe in 1985). The four different rates of growth were then further projected to the year 2000 in order to establish the requirements for the development of forward reserves of uranium and thorium in 1985 and to establish a basis for qualitative analysis of trends in supply of nuclear energy to the end of the century.

NUCLEAR POWER GROWTH

The Initial Appraisal projection and the four nuclear power growth cases developed for this study are given in 5-year increments in Table 1.

TABLE 1

PROJECTED GROWTH OF NUCLEAR POWER
(Thousand MWe of Installed Generating Capacity)

	Initial Appraisal	Case I	Case II	Case III	Case IV
1975	59	64	64	64	28
1980	150	188	188	150	107
1985	300	450	375	300	240

Case III corresponds very closely to the Initial Appraisal projection, and it is also very nearly equal to Atomic Energy Commission (AEC) and Federal Power Commission (FPC) official forecasts.†

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* NPC, *U.S. Energy Outlook: An Initial Appraisal 1971-1985*, Vols. I and II (1971).

† AEC, *Nuclear Power Growth 1971-1985*, WASH-1139--Rev. 1 (December 1971); FPC, *The 1970 National Power Survey Part I* (December 1971).

Since the AEC, in 1971, instituted procedures to evaluate all environmental factors related to nuclear power plants in compliance with the National Environmental Policy Act, the time necessary to obtain construction permits and operating licenses has increased significantly. The present legal and regulatory turmoil delaying nuclear plant licensing and operation will have to be substantially resolved in the near future, either through legislation or procedural improvement, to realize even the Case III projection.

Case IV projects a continuation or worsening in constraints on nuclear plant installation including: (1) technical problems of more than a routine nature; (2) delays in site acquisition and approval because of environmental considerations; and (3) delays in licensing plants because of legal and regulatory considerations.

Case II projects the converse of Case IV conditions, with streamlined licensing procedures, improved construction techniques and well-defined environmental standards. This should result in a 6- to 7-year order lead time, which will be sufficient for the reactor manufacturers, pressure vessel suppliers, turbine generator vendors and other nuclear plant component manufacturers as well as the design and construction industry to physically meet the increased nuclear growth rate suggested.

Case I projects that all central station base-load electric generating plants installed between 1980 and 1985 will be nuclear fueled. This level of nuclear power growth could be achieved with an immediate, concerted effort by both government and industry to make utilization of nuclear power a high priority national goal.

In order for nuclear energy to contribute its full potential, prompt development is needed of an effective government siting and licensing procedure that minimizes administrative processing and eliminates unwarranted delays in nuclear plant construction and operation.

- Radioactivity and the discharge of waste heat should be placed in a balanced perspective relative to the existence of these phenomena in nature and their environmental effects. Careful regulation of nuclear facilities--whether they may be power plants, processing facilities or storage areas-is necessary to ensure standards of design, construction and operation which will safeguard health and safety. However, objections to these facilities should be considered on the basis of fact, not emotion, and decided in light of the need for energy in order to control pollution of the environment and protect the health and safety of society generally.

- Regulatory and licensing procedures must be administered and, where necessary, changed so as to ensure a proper balance which will protect the individual citizen while, at the same time, permitting the construction and operation of nuclear plants in a timely manner so as to satisfy the growing requirements of that same citizen for energy supply.

All of the nuclear plants included in the projected nuclear power capacity through 1985 are assumed to be light water reactor (LWR) or high-temperature gas-cooled reactor (HTGR) plants. Fast breeder reactors, representing a new concept in nuclear technology, are not expected to be commercially available until after 1985, although they will probably become the major reactor type ordered during the 1990's. Because of the long lead time necessary for uranium exploration and the construction of new fuel cycle capacity, however, uranium discovery requirements and fuel cycle investments will tend to level out at a high rate prior to 1985 in anticipation of the introduction of breeder reactors in the late 1980's or early 1990's.

URANIUM DEMAND

The four nuclear power growth projections will require cumulative production of from 400,000 to 700,000 tons of U_3O_8 through 1985. These requirements are shown in detail in Table 2.

TABLE 2

ANNUAL U_3O_8 REQUIREMENTS FROM INDUSTRY*

(Thousand Tons U_3O_8)

	Initial Appraisal		Case I		Case II		Case III		Case IV	
	Annual	Cumul.	Annual	Cumul.	Annual	Cumul.	Annual	Cumul.	Annual	Cumul.
1975	18	66	19.1	58	19.1	58	19.1	58	11.5	30
1980	34	205	50.9	240	45.6	230	36.5	200	29.1	140
1985	59	450	108.5	700	89.2	600	70.7	500	60.4	400

* The requirements do not include uranium reserves needed in 1985 for future production. An additional 0.7 million to 1.3 million tons of U_3O_8 (corresponding closely to a 10-year "forward reserve", Case IV-Case I) is considered necessary for this purpose.

The Initial Appraisal estimates of U_3O_8 requirements from industry were based on an enrichment plant tails assay of 0.20 percent U_{235} with plutonium (Pu) recycle starting in 1974. Also, it was assumed that Government stockpiles of U_3O_8 would not be released for commercial use in electric power generation. The corresponding assumptions for Cases I-IV are: Enrichment plants will operate at a 0.20 percent U_{235} tails assay through 1981 and 0.275 percent tails thereafter; 60 percent of the plutonium produced in LWR's will be recycled beginning in 1978; the quantities of uranium required from industry exclude U_3O_8 supplies from the Government stockpile in accordance with the Government plan announced March 7, 1972.

NUCLEAR RESOURCES

No detailed assessment has been made of the full potential for discovery of uranium resources in the United States and such an undertaking was not possible in the time available for this study. However, the general extent of the relatively unexplored yet favorable areas has been taken into account in assessing the capability of U.S. industry to meet future uranium requirements.

As of January 1, 1972, the AEC estimated proved plus potential uranium resources minable at a forward cost of up to $15 per pound U_3O_8 to be 1.6 million tons. Also, the uranium resource base in the United States offers the prospect of locating significant additional deposits.

As defined by the AEC, potential resources refer to uranium surmised to occur in unexplored extensions of known deposits or in undiscovered deposits in known uranium districts and which is expected by the AEC to be minable in the given cost range. The AEC's estimate of resources can also be categorized as shown in Table 3.

TABLE 3

DOMESTIC RESOURCES OF URANIUM ESTIMATED BY THE AEC*
(Thousand Tons U_3O_8)

Maximum Forward Cost per Pound U_3O_8†	Reasonably Assured (Proved Reserves)	Estimated Additional (Potential Reserves)	Total
$ 8	273	460	733
10	423‡	650	1,073
15	625	1,000	1,625

* Estimates of the AEC as of January 1, 1972.

† The AEC cost levels cannot be directly compared with "prices" as calculated in this study because the AEC's values do not include a return on investment, interest, income tax or amortization of past investments in exploration and mine/mill construction.

‡ Includes 90,000 tons potentially recoverable as a by-product of copper and phosphate mining through the year 2000 if recovery facilities are provided. None of this material is being recovered today.

The AEC estimates of additional resources of U_3O_8 are not an attempt to measure the ultimate uranium resources of the country or the total recoverable resources at the costs indicated. The potential estimate is related to specific known mineralization and geological trends and, as such, is subject to change from time to time as new information is developed.

Substantially, all of the present proved reserves and approximately 85 percent of the potential reserves as determined by the AEC are located in the presently producing areas, yet these areas make up less than 10 percent of the total region in which uranium occurrences are found--and even the producing areas in many cases are not completely explored. Therefore, optimism is warranted regarding the ability of the uranium exploration industry to locate significant new domestic uranium resources, providing the necessary exploratory effort is mounted.

Policies concerning land use, economic incentives, regulatory standards and imports should encourage exploration efforts for uranium.

- The immediate need for increased exploration for uranium and the likelihood that more economically recoverable resources will be found in the United States lend an urgency to the prompt development of a general policy to encourage domestic exploration.

Access to public lands for development of uranium and thorium resources by private industry should be allowed on a basis that permits optimum planning and implementation of exploratory and development efforts.

- Approximately 50 percent of all proved and potential uranium resources are on federal or Indian lands; therefore, future land law changes and leasing policies could have a major impact on future uranium exploration activity.

- Federally controlled lands must be freely accessible for exploration if projected requirements for uranium from domestic reserves are to be met. All lands having uranium potential should remain available for exploration and development until exploration information allows assessment of the mineral values.

- Uranium land use regulations should allow the most efficient development of properties to take place without unnecessary restraints or increased cost and should consider the Nation's need for the immediate development of additional low cost uranium reserves. Any new time limits placed on federal claims and leases held for uranium should take into account the long lead times associated with uranium exploration and development as well as future market requirements. Reasonable restrictions to prevent misuse or unnecessary damage to the surface and surroundings should not unduly handicap the nuclear raw material industry.

In addition to uranium, thorium is a naturally occurring element which can be utilized in conjunction with highly enriched uranium as nuclear fuel in the HTGR. Thorium is known to be available in quantities significantly in excess of projected requirements

Federal sponsorship of research and development should be directed to the optimum utilization of our domestic natural resources of nuclear fuels.

- The orderly technical development of fast breeder reactors is a necessary national priority.

- Basic research leading to improved exploration techniques and advanced mineral (uranium) processing techniques would assist in determining the extent of U.S. uranium and thorium resources and in expanding their utilization.

URANIUM SUPPLY AND COSTS

While the uranium resource base is considered adequate, economic incentives must improve before exploration activity will be at the level necessary to locate required potential resources and to develop both proved and potential resources. Investments in uranium exploration must generally be made prior to nuclear power plant commitments because lead time for exploration and the addition of new capacity in mining and milling is normally as long or longer than reactor order lead time.

Exploration Activity

Reasonably assured, or "proved," uranium reserves are not sufficient to support the projected annual production requirements through 1985 for any of the four cases.* Therefore, new discoveries must be made. A rapid buildup in uranium exploration activity, beginning now and extending over the next 5 to 6 years, will be needed to meet uranium demand in the 1980-1985 period. Projections based on an assumed average discovery rate of 4 pounds of U_3O_8 per foot of surface drilling indicate that total surface drilling for uranium should increase from 15.5 million feet in 1971 to 45 million feet in 1977 to meet Case III demand and to 65 million feet in 1977 to meet Case I demand. A comparable rate of increase was attained in the past, though not over such an extended period of time.

Present market conditions have been less than satisfactory to provide the necessary incentives for uranium producers to explore extensively for additional uranium deposits or to develop many known properties, let alone to explore for and develop the higher cost ore bodies ($10 to $15 per pound U_3O_8). In fact, drilling rates have decreased in the last 2 years. Basic incentives are needed if a healthy domestic industry is to survive the period of transaction from supplying a government market to supplying a mature commercial market and achieve the required sharp increase in exploration activity.

Important incentives that could stimulate increased drilling activity by the domestic mining industry include--

- Long-range uranium purchase contracts between producers and utilities

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* Proved reserves are categorized by the AEC as having a maximum forward production cost of $8 per pound U_3O_8 or less.

- Uranium selling prices which cover the costs of discovery, development and production, and a reasonable return on investment
- Continued Government policy to restrict importation of uranium as required to maintain a viable industry.

Mining and Milling Capacity

Uranium mining and milling capacity now in operation or under construction plus the existing U_3O_8 inventory held by industry are adequate to meet projected U.S. requirements at least through 1975 under all demand cases considered. However, to meet each of the U_3O_8 demand cases through 1985, all presently discovered reserves and some potential reserves will need to be in production by 1980, and substantial production from new discoveries will be required in the 1980-1985 time period. Commitments to construct new mining and milling facilities needed after 1975 must begin within 1 or 2 years.

U_3O_8 "Prices"

In constant 1970 dollars, the calculated average "price" of U_3O_8 produced from new mines and mills that will come into production from 1979 to 1985 is approximately $10.50 per pound to provide a 15-percent discounted cash flow (DCF) rate of return on investment.

As used in this study, "price" does not mean a specific selling price between producer and purchaser and does not represent a future market value. Instead, the term "price" as used here refers to U_3O_8 values calculated to provide the specified DCF rate of return on investment in new production facilities based on estimated costs, lead times, ore reserves, production and deliveries.

For the purpose of estimating future costs of uranium, it was assumed that the average costs obtained from reserves yet to be discovered will be comparable to the estimated cost of mining uranium from presently known resources.

Average industry costs of uranium production, including both open-pit and underground properties, used in calculation of uranium supply economics are summarized in Table 4.

Further, it is estimated that exploration expenditures would start 9 years prior to production and that mine/mill construction would begin 4 to 5 years prior to production, with the average mine life being approximately 10 years.

Taking these cost and lead-time estimates into account, levelized U_3O_8 "prices" were calculated and are summarized in Table 5.

TABLE 4

COSTS OF URANIUM PRODUCTION*
(Constant 1970 Dollars)

	$ per Pound U_3O_8 Recovered
Exploration	0.95
Mine/Mill Capital	1.59
Operating	4.35
Total $/lb. U_3O_8	**6.89**

* Based on AEC data.

TABLE 5

LEVELIZED "PRICE" PER POUND U_3O_8*
(Constant 1970 Dollars)

DCF Return on Investment† (Percent)	$ per lb. U_3O_8
10	8.91
12.5	9.59
15	10.37
17.5	11.27
20	12.39

* The term "levelized price" as used here is the average "price" required over the assumed life of new U_3O_8 production centers starting production in 1979 and calculated to provide a given DCF rate of return on investment.

† All return on investment figures are after tax.

Uranium "prices" as computed in this study are particularly sensitive to uranium discovery rates. The discovery rate is projected to remain at the present level of 4 pounds of U_3O_8 per foot of surface drilling at least through 1985. A decrease of 1 pound per foot in the discovery rate increases the "price" of U_3O_8 required for a 15-percent return on investment by about $1.00 per pound.

Environmental, health and safety factors have already had significant impact on the economics of uranium mining and will undoubtedly continue to be a prime consideration. Cost increases in underground uranium mines to meet the 1971 radon exposure standards are estimated to range between $0.25 to $1.15 per pound

U_3O_8, depending upon ore grade and mining conditions. The cost of meeting 1971 radiation exposure standards has been taken into account in the production cost projections.

Health and safety standards and regulations for mining should be based on reliable evidence that such regulations will, in fact, achieve desirable goals.

- Reliable evidence that such standards and regulations are essential to human health and safety is particularly important in such areas as radiation control, sound abatement and dust control because the economic impact of unnecessarily restrictive regulations can curtail production of needed energy resources.

The cost of meeting land reclamation requirements in open-pit mining could also have a significant impact on uranium costs. Depending on the level of reclamation required, added costs could range from $0.10 to more than $1.00 per pound U_3O_8.

The Nation's needs for additional, economic, domestic energy supplies should be given full weight in establishing new federal land reclamation regulations.

- Overly restrictive reclamation requirements could impair the economic feasibility of uranium surface mining operations.

- Reclamation regulations should allow flexibility in the application of restoration methods to the highly varied ecological and land use conditions existing in different uranium mining areas and should be designed to encourage the optimum use of the land.

- Reclamation standards should not unnecessarily inhibit use of the most efficient mining methods. It should also be possible for operators to readily make improvements or changes in the reclamation plan as new methods are developed.

- Surface reclamation regulations should be coordinated by interested government agencies to prevent multiple inspection and reporting. They can best be administered on the state or local level.

Differential tax provisions which have historically been an incentive for production of domestic uranium should not only be continued but strengthened.

- In view of the immediate need for economic incentives to increase uranium exploration, the existing tax incentives provided the uranium mining industry should not be reduced, including intangible development costs and the depletion allowance.

To meet the range of projected domestic nuclear power plant demand and foreign requirements, sufficient enrichment plant capacity would be required to provide the amounts of separative work shown in Table 6.

TABLE 6

ANNUAL SEPARATIVE WORK DEMAND FOR ENRICHMENT
(Millions of Separative Work Units [SWU])*

		This Study			
Year	**Initial Appraisal**	**Case I**	**Case II**	**Case III**	**Case IV**
1975	16.5	11.6	11.6	11.6	8.9
1980	35.3	36.5	34.0	31.1	26.9
1985	70.7	63.6	56.7	48.7	43.4

* A measure of required work in uranium enrichment operations to increase the percentage of the isotope U_{235} above that found in natural uranium.

The Initial Appraisal estimate of demand for separative work assumed plutonium recycle beginning in 1974, a diffusion plant operating tails assay of 0.20-percent U_{235}, and a relatively high level of enrichment work for foreign customers. However, the corresponding assumptions for Cases I-IV of this study are (1) 60 percent of available plutonium recycled beginning in 1978, (2) an effective operating tails assay of 0.275-percent U_{235}, and (3) a significant reduction in enrichment work for foreign customers. The net effect of these new assumptions regarding the operation of the enrichment plants is a reduction in separative work requirements in Cases I-IV, as compared to the Initial Appraisal.

The optimum economic tails assay for operation of the enrichment plants is a complex determination which is dependent on both the cost of separative work and the cost of natural uranium The Government plan announced in March 1972 to increase enrichment plant tails assay from 0.200-percent to 0.275-percent U_{235} or higher and to use the Government's natural uranium stockpile to provide supplementary feed to offset the associated increased feed requirements extends the capability of the existing enrichment plants. It remains to be seen whether, in the long run, it will be more economical to operate at a high tails assay with the associated high U_3O_8 requirements or vice versa.

Overall economic balance between natural uranium requirements and enrichment costs should be used to establish the enrichment plant operating tails assay.

- The AEC should review the tails assay program on an annual basis and, if the U_3O_8 market growth falls significantly below that projected by the AEC as "most likely," comparable adjustments should be made in the rate at which stockpile material replaces domestically produced U_3O_8 in the commercial market. Furthermore, in the event that exploration policies or the lack of adequate incentives to the raw material producer react to postpone the immediate exploration necessary for increasing ore reserves, the AEC should reconsider its disposal policy and reserve the balance of its stockpile for future domestic use.

Considering the capacity of the three existing Government enrichment plants, the inventory of enriched uranium, plans for future production, the AEC's enrichment plant expansion program and its recently announced plan to increase the tails assay, a fourth enrichment facility will be needed by 1982 to meet the requirements of Case III. In order to meet the enrichment requirements of Case I, the enrichment plant would be needed by 1980. For Case IV, planned expansion of the existing enrichment facilities is adequate until 1985, provided the full enriched uranium inventory is produced.

The lead time required for planning and constructing a new enrichment facility will depend upon whether the plant is built by the Government or private enterprise. The lead time for industry is estimated at 9 years, and for the Government 6 to 7 years, depending on the availability of electric power. Even under Case III, a decision is needed in 1973 to implement plans for construction if private industry is to build the next plant. Under Case I, a new enrichment plant construction program would have to be part of the overall government/industry effort directed at emergency expansion of nuclear facilities.

The Government should move promptly to ensure that enrichment capacity in the United States will be sufficient to meet projected needs and to establish operating conditions that will encourage private industry to undertake the financing of the very large capital investments that new enrichment plants will require.

- Government policy in the next 1-2 years is very critical in determining the future actions that will be necessary to provide the needed expansion of enrichment capacity. Therefore, Government policy on enrichment should include the following:

  --Prompt, detailed, and timely actions to ensure implementation of plant expansion programs;

  --Acceleration of the transfer of separation technology to private industry;

  --Cooperation by the AEC and its contractors in providing all economic and financial data on alternate separation technologies to permit private industry to arrive at sound business decisions on how best to provide the expanded enrichment capacity needed;

--Readiness to move quickly to consider and resolve the complex environmental, antitrust and health and safety issues that licensing of a large, privately-owned enrichment facility might entail.

Excess capacity now exists in all other fuel processing sectors, including conversion (U_3O_8 to UF_6), fuel fabrication, transportation, spent fuel reprocessing and the storage of wastes. However, as with nuclear generation plants, orderly development of additional nuclear fuel processing capacity to meet future demand will be heavily dependent on reasonable and timely regulatory action, as well as on the necessary economic climate.

NUCLEAR FUEL COSTS

A significant increase in uranium costs would not materially affect the competitive position of nuclear generated electricity. For example, if the "price" of U_3O_8 doubled from $8.00 to $16.00 per pound, the fuel cycle cost would be increased by 0.66 mills per KWH, and this amount, carried through to the cost of nuclear generated electricity, would cause an increase of only about 10 percent.

Table 7 shows the components of fuel cycle cost for a typical 1,000 MWe pressurized water reactor (PWR), utilizing constant "prices" levelized over the first 10 years of plant operation at an 80-percent capacity factor and a 15-percent DCF rate of return.

TABLE 7

FUEL CYCLE COSTS FOR TYPICAL 1,000 MWe (BASE LOAD) PWR

Fuel Cycle Components	Cost (Mills/KWH)
Fabrication (@ $70/Kg U)	0.40
Uranium (@ $8/lb. U_3O_8)	0.66
Conversion (@ $2.52/Kg)	0.08
Enrichment (@ $32/SWU)	0.80
Reprocessing & Shipping (@ $45/Kg U)	0.14
Plutonium Credit (@ $7.50/Kg fissile)	(0.15)
Total Fuel Cycle Costs	**1.93**

The fuel cycle cost assumptions shown in Table 7 imply a total fuel cost of approximately $0.18 per million BTU's (constant 1970 dollars).

After allowing for the higher capital costs associated with building nuclear generating plants, the projected nuclear fuel cost places future nuclear power at a competitive break-even point with coal-fired plants utilizing fuels costing approximately $0.40 per million BTU's.*

CAPITAL EXPENDITURES

Total capital expenditures for the nuclear fuel supply industry over the 1971-1985 period are shown in Table 8.

TABLE 8

CAPITAL COSTS FOR NUCLEAR FUEL SUPPLY INDUSTRY
1971 to 1985
(Billions of 1970 Dollars)

Case I	Case II	Case III	Case IV
13.1	11.0	8.5	6.7

* This break-even value is based on a coal-fired plant with stack gas desulfurization.

Chapter One

NUCLEAR POWER GROWTH

BACKGROUND

The Initial Appraisal of the nuclear energy outlook for the 1971-1985 period was made under the basic assumption that Government policies and economic climate prevailing in 1971 would continue without major changes throughout the period. Installed nuclear power capacity was projected to reach 300,000 MWe in 1985.

This report examines the conditions under which an increased portion of U.S. energy requirements could be supported by domestic nuclear fuels, taking into consideration certain factors which might affect this capability. Four projections of nuclear power growth representing slow, medium, fast and maximum rates were prepared. These projections were then examined in light of the corresponding uranium resource availability, uranium exploration and production requirements, government policies and economic factors.

In projecting nuclear fuel demand, it was assumed that commercial use of nuclear fuel will be confined to the electric utility sector. While nuclear fuel may also be used to provide some process heat by 1985, this use was assumed to be negligible relative to the overall demand for nuclear fuel.

The assumptions were also made in assessing domestic nuclear power growth (as in the Initial Appraisal) that U.S. Government requirements for nuclear materials will be satisfied from government stocks, and that all requirements for nuclear fuels by domestic electric utilities will be furnished from U.S. sources. Further, it was assumed that uranium imported for enrichment in U.S. Government-owned facilities will be reexported for use in reactors abroad.

NUCLEAR FUEL CYCLE

Nuclear electric power today depends largely on fission of the uranium isotope, U_{235}, in a reactor to create the heat necessary to produce steam to drive the turbine. There are three types of commercial nuclear reactors available in the United States: (1) the pressurized water reactor, (2) the boiling water reactor (BWR), and (3) the high-temperature gas-cooled reactor. The PWR and BWR use uranium fuel with water serving as the primary coolant, and as such they are called light-water reactors. The HTGR is fueled with uranium and thorium, with helium serving as the primary coolant.

Commercial fast breeder reactors are projected to begin operation in the United States in the 1986-1990 period. The development of breeder reactors will allow an increase in the utilization of the energy content of natural uranium from between 1 and

2 percent, as is now achieved in non-breeder reactors, to about 60 to 70 percent.

The use of nuclear fuels differs substantially from fossil fuels in two important ways:

(1) Prior to use in an electric utility, uranium must undergo a complex series of processing and fabrication steps to produce fuel elements that are used within the nuclear reactors.

(2) Nuclear fuels are not completely expended when used for the first time in a reactor but are removed, purified, replenished and refabricated periodically.

These unique characteristics establish a "fuel cycle" which can be described broadly as consisting of the steps of exploration, mining, milling, conversion, enrichment, fuel fabrication, fuel recovery and reprocessing, transportation and waste disposal. The fuel cycle is illustrated in Figure 1. The economics of nuclear fuels are affected not only by the cost of the fuel itself but also by fuel design, reactor operating conditions and the amount of plutonium (Pu) recycle.

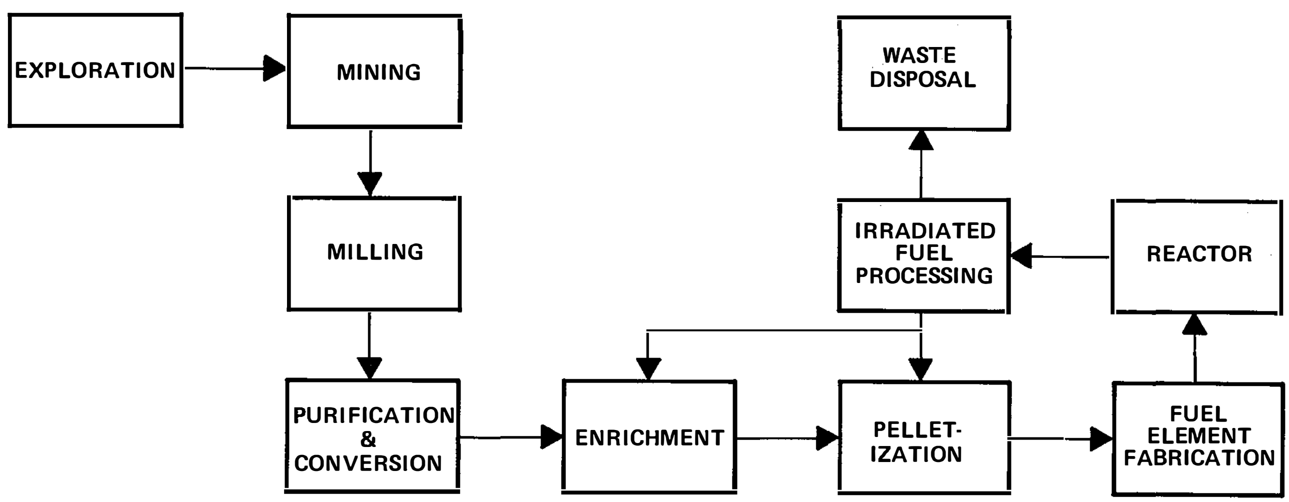

Figure 1. Nuclear Fuel Cycle.

Uranium as it is found in nature contains about 0.7 percent of the isotope U_{235} with the remainder being the isotope U_{238}. Through the process of "enrichment," which is accomplished in the AEC's gaseous diffusion plants, the percentage of U_{235} is increased to 2 to 3 percent, which is required in the LWR's. The isotope U_{238}, which comprises about 97 or 98 percent of the enriched uranium fuel, can contribute significantly to power production only after it is transformed into a fissionable isotope of plutonium within the reactor. This plutonium adds to the supply of heat.

HTGR's use highly enriched uranium (93-percent U_{235}) as the fissile fuel and thorium as the fertile fuel.* The thorium is used as a substitute for U_{238} in the HTGR, where it is converted to the fissionable isotope U_{233}. The U_{233} adds to the supply of heat.

At approximate annual intervals, 25 to 35 percent of the fuel assemblies are removed because a portion of the fuel is depleted in U_{235} content to the point that it no longer contributes to economic power production. The depleted fuel is then shipped to a reprocessing plant where it is treated chemically to recover plutonium and unutilized uranium.

Both uranium and plutonium have value and may be used as reactor fuel again, thus completing the fuel cycle. The recovered plutonium may be stored for future use as fuel in a breeder reactor or it may be recycled in fuel for LWR's as a substitute for U_{235}. The recovered U_{235} is recycled into fuel for LWR's and the recovered U_{233} from the HTGR fuel is recycled into HTGR fuel in place of U_{235}.

NUCLEAR POWER PROJECTIONS

The Initial Appraisal adopted the 1971 AEC estimates of nuclear electrical power growth and uranium requirements through 1985. In the present study, the nuclear power growth was reexamined with emphasis on variations in this growth as a function of alternative assumptions.

In evaluating the possibilities for greater domestic supply of nuclear energy, projections of nuclear electric power growth through the year 1978 were based on scheduled operation dates for electric utility plants under construction and on order as of October 1971.† From this base, three projections of electric load growth were developed through 1985: 450,000, 375,000 and 300,000 MWe of installed nuclear capacity for Cases I, II and III, respectively (see Table 9). A fourth projection was made to take into account the possibility of a very substantial slowing of nuclear plant additions through 1980, and a continuing lag through 1985 resulting in limiting installed capacity to 240,000 MWe in 1985 (Table 9, Case IV).

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* Fissile fuels such as U_{233}, U_{235} and Pu_{239} are those which undergo fission. Fertile fuels such as thorium and U_{238} absorb neutrons to produce a fissile fuel (U_{233} and Pu_{239} respectively).

† This projection was based on the Edison Electric Institute's (EEI) compilation of nuclear plant schedules. The AEC has subsequently published an estimate of expected nuclear power growth which shows a slightly lower rate of installation through 1978. However, the effect on nuclear fuel demand projections of using the more recent AEC data rather than the EEI data would be minor.

Installed capacity in each of the four cases was then projected to the year 2000 in order to establish the requirements for exploration and the development of forward reserves of natural uranium through 1985 and to analyze trends in demand for and supply of nuclear fuel to the end of the century. Levels of installed nuclear generating capacity utilized to develop U_3O_8 requirements beyond 1985 are also shown in Table 9. The generating capacity projections for the 1972-2000 period are converted to equivalent BTU's and KWH's in Table 10, utilizing the plant factor assumptions shown in Table 11.

Following is a general description of the four cases projected through 1985.

Case III assumes an orderly growth of nuclear power production. This is a "medium" nuclear energy demand case and closely approximates the AEC's "most likely" projection. In this case, nuclear plants come on line with gradually increasing frequency resulting

TABLE 9

PROJECTED NUCLEAR CAPACITY
(1,000 MWe)

	Initial Appraisal	Case I			Case II			Case III			Case IV		
	Thermal*	Total	Thermal	FBR†	Total	Thermal	FBR	Total	Thermal	FBR	Total	Thermal	FBR
1972	19	22	22		22	22		22	22		11	11	
1973	32	38	38		38	38		38	38		16	16	
1974	46	55	55		55	55		55	55		22	22	
1975	59	64	64		64	64		64	64		28	28	
1976	73	71	71		71	71		71	71		38	38	
1977	89	89	89		89	89		89	89		51	51	
1978	108	108	108		108	108		108	108		68	68	
1979	128	140	140		140	140		128	128		87	87	
1980	150	188	188		188	188		150	150		107	107	
1981	173	227	227		216	216		173	173		128	128	
1982	199	269	269		250	250		200	200		152	152	
1983	230	320	320		288	288		230	230		179	179	
1984	263	380	380		328	328		263	263		209	209	
1985	300	450	450		375	375		300	300		240	240	
1990		750	675	75	625	560	65	500	450	50	400	395	5
1995		1,065	795	270	890	665	225	710	530	180	568	463	105
2000		1,470	900	570	1,225	750	475	980	600	380	785	495	290

* Thermal includes light-water and high-termperature gas-cooled reactors.

† FBR means fast breeder reactor. For purposes of calculation of U_3O_8 requirements, the breeder reactor was assumed to be put in commercial use as follows: Cases I and II—5,000 MWe in 1986; Case III—4,000 MWe in 1986; Case IV—5,000 MWe in 1990. Breeders were assumed to be of 1,500 MWe size and to have a fuel doubling time of 8 to 10 years. A parametric study has also been prepared assuming that the breeder will enter into commercial use more slowly, beginning at a level of 1,000 MWe in 1987 and growing to only 5,000 MWe in 1990, 44,000 in 1995 and 254,000 in the year 2000 (see text).

TABLE 10

NUCLEAR ENERGY PROJECTIONS TO THE YEAR 2000

	Case I				Case II				Case III				Case IV			
	Thermal MWe (000)	FBR MWe (000)	KWH $\times 10^9$	BTU $\times 10^{12}$	Thermal MWe (000)	FBR MWe (000)	KWH $\times 10^9$	BTU $\times 10^{12}$	Thermal MWe (000)	FBR MWe (000)	KWH $\times 10^9$	BTU $\times 10^{12}$	Thermal MWe (000)	FBR MWe (000)	KWH $\times 10^9$	BTU $\times 10^{12}$
1972	22		96	983	22		96	983	22		96	983	11		72	736
1975	64		390	4,000	64		390	4,000	64		390	4,000	28		162	1,661
1980	188		1,107	11,349	188		1,107	11,349	150		955	9,787	107		662	6,788
1985	450		2,908	29,810	375		2,463	25,249	300 †		1,973	20,220	240		1,573	16,126
1990	675	75	4,981	49,348	560	65	4,147	41,059	450	50	3,323	32,902	395	5	2,674	26,726
1995	795	270	7,180	69,782	665	225	6,144	59,566	530	180	4,788	46,523	463	105	4,061	37,521
2000 *	900	570	9,986	95,356	750	475	8,322	79,461	600	380	6,657	63,569	495	290	5,330	51,046

* Case I includes the MWe equivalent of about 5-percent utilization of nuclear energy for process heat. If this is used as process heat, electrical output would have to be reduced accordingly.

† Converted from a fiscal year to a calendar year basis, the AEC's projection (WASH–1139, Rev. 1) of the "most likely" installed nuclear capacity is 300,000 MWe in 1985.

from improvements in both manufacturing techniques and regulatory procedures. The current licensing and legal problems are assumed to be resolved during the next 2 or 3 years. The lead time required from placing an order to plant operation drops to 6 or 7 years from the present 8 years or more. Because of their economics and general characteristics, nuclear plants comprise most of the large, base-load plant additions.

Case II assumes that, in addition to the situation described under Case III, a marked preference develops for nuclear plants over fossil-fueled plants because of increasingly stringent air pollution regulations and limited availability of clean fossil fuels. This results in licensing procedures being streamlined, improved construction techniques with engineering and manufacturing advances reducing associated lead times, and resolution of environmental problems without delays.

Case I assumes that both government and industry join in a maximum effort to increase U.S. nuclear power capacity. This could be the result of a national energy policy which makes nuclear power a first priority national goal or the existence of emergency conditions which require such an effort. Such a policy might be the result of both very stringent air pollution limits and a need to limit the use of oil and gas for electrical power production in order to minimize the U.S. dependence on imported fuels.

Case IV assumes a continuing chaotic situation with respect to licensing and siting. Environmental constraints, manufacturing and technical problems of more than a routine nature, and regulatory difficulties all continue to cause planning and construction delays such that only the plants already on order in 1971 will go into operation through 1980. Nuclear plant completions pick up after 1980, but the installed capacity by 1985 falls 20 percent short of Case III.

TABLE 11

PLANT FACTOR ASSUMPTIONS*

Capacity Factors

Thermal Reactors:

Year of Start-Up	Year After Starting Commercial Operation 1st	2nd	3rd
1975 and earlier	50%	70%	80%
1976-1980 inclusive	60%	80%	80%
1981 and thereafter	80%	80%	80%

FBR's

Year of Start-Up	Year After Starting Commercial Operation 1st	2nd	3rd
1986-1990	50%	70%	80%
1991-1995	60%	80%	80%
1996-2000	80%	80%	80%

Heat Rates†

LWR and HTGR (average):	
1970-1985	10,250 Btu/Kw-hr.
1986-2000	10,000 Btu/Kw-hr.
FBR:	
1986 and thereafter	8,800 Btu/Kw-hr.

* The Plant Factor Assumptions shown in this table above were utilized in computing the KWH and BTU's in Table 10. However, the 80-percent capacity factor is based on operational capacity of the plant rather than an estimate of its use in the overall electrical generation system. After 1990 the nuclear capacity is a sufficiently high fraction of the total that some of the plants will run at lower capacity factors. For example, in the year 2000 a 69-percent capacity factor is reasonable for LWR's in Case III, with breeder reactors running at 80 percent. This would drop the nuclear KWH and BTU's by about 10 percent in the year 2000 as compared to the data presented in Table 10. Cases I and II may show even lower plant capacity factors.

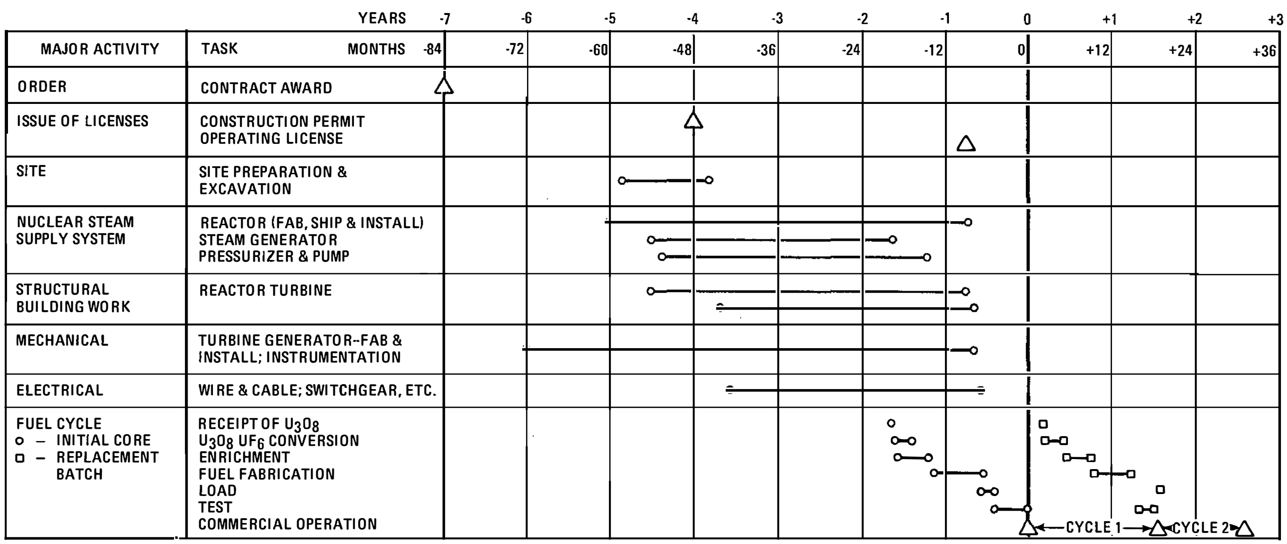
† Although the average heat rates shown in this table were assumed in order to calculate nuclear fuel requirements, the HTGR heat rate is projected to be 8,800 BTU/KWH, the LWR heat rate to be 10,250 BTU/KWH, and the heat rate for FBR's may range from 8,000 to 8,800 BTU/KWH.

The growth rate in nuclear generating capacity for each case in the 1986-2000 period generally reflects a continuation of the trend projected for the 1980-1985 period with the exception of Case I, which also takes into account the possibility that nuclear energy could be used for production of process heat in significant amounts in the year 2000.

FACTORS BEARING ON NUCLEAR POWER PLANT GROWTH

The installation of nuclear power plants is a complex operation which requires timely integration of a number of activities over a considerable period of time (see Figure 2). The actual rate at which nuclear power capacity will be added to the U.S. electric industry over the next 15 years depends upon a number of factors, many of which are common to all electric plants. However, there are several key factors which will bear uniquely on the growth of nuclear power generating capacity:

- Availability of plant sites
- Plant licensing considerations
- Environmental considerations
- Manufacturing industry's ability to supply necessary equipment
- Construction capability
- Capital cost of nuclear generating plants
- Nuclear fuel costs.



NOTE: MODIFICATION OF TABLE IV-16, IN THE AEC PUBLICATION "THE NUCLEAR INDUSTRY – 1971."
SYMBOLS (△, ○, □) INDICATE STARTING AND COMPLETION TIMES FOR THE ACTIVITY SHOWN.

Figure 2. Nuclear Electric Power Plant Construction and Operating Schedule.

Availability of Plant Sites

Guidelines have been issued by the Atomic Energy Commission which specify criteria for plant location and land requirements to be used in evaluating nuclear plant licensing requests. Natural characteristics important to the integrity of the plant are taken into consideration. Therefore, the seismology, geology, hydrology and meteorology of the site are evaluated by the AEC before it approves a proposed site. The maximum foreseeable site requirement for plants completed by 1985 would be 300. This assumes an average station size of only 1,500 MWe in conjunction with the

Case I projection of 450,000 installed MWe in 1985. The magnitude of this requirement is not to be minimized, but it should be considered in perspective by noting that the existing U.S. electric generating capacity of about 350,000 MWe for plants of all types (fossil and nuclear) is located on more than 3,000 separate sites. Some of these existing sites will be able to accommodate new nuclear units. Furthermore, the concept of preassembled, platform-mounted, large nuclear plants located on water, has been introduced by several manufacturers. This technique has promise of reducing the likelihood of problems of site availability.

Plant Licensing Considerations

AEC regulations require that a utility obtain a construction permit prior to starting construction of a nuclear plant and an operating license before beginning commercial operation. These regulations have recently been revised to require a full environmental review to meet the requirements of the National Environmental Policy Act of 1969. In addition, utilities must obtain as many as 60 clearances or permits from the local, state and national government agencies that have asserted jurisdiction over various aspects of siting, construction and operation of major electric power facilities.*

Regulatory delays in obtaining the necessary clearances and permits and court challenges involving the revised environmental requirements have recently become a major obstacle to the growth of nuclear power. Delays in commercial operation of 3 nuclear plants which had been scheduled to come on-stream in 1969, 3 in 1970, 2 in 1971, 10 in 1972, 8 in 1973, and 8 in 1974 (a total of 34 plants) were, in varying degrees, the result of regulatory delays and/or environmental challenges.

As of May 1972 no nuclear plant had been issued a construction permit or a full power operating license since early in 1971.†

Primarily as a result of such delays, the lead time from order to completion of a new nuclear plant has substantially increased to 8 years or more. However, given the growing awareness of the effect of these delays on the Nation's supply of electric power, there is reason to expect a serious effort to eliminate unwarranted delays in the future.

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* U.S. Congress, Senate Commerce Committee, Statement of Mr. Shearon Harris, President and Chairman of Carolina Power and Light Company and Chairman of the Edison Electric Institute, May 15, 1972.

†On June 2, 1972, the President signed a bill allowing issuance of temporary operating licenses for plants when the environmental review is not yet complete and the power supply situation is deemed to be critical. This action was too late to be judged as to its effectiveness in this study.

Many states, for example, have already taken action to expedite resolution of power plant siting questions. Fourteen states, in particular, have adopted special procedures for certification of power plant sites while other states are considering new procedures to resolve siting questions through use of existing agencies and authorities.

Much can and is being accomplished by the utilities themselves through discussion of their plans with governmental bodies and with interested citizen groups. In addition, all utilities are now filing long-range plans under Federal Power Commission Docket R362, and these plans are available to the public.

The degree to which nuclear growth rates might increase in the latter part of the 1972-1985 period will depend upon the ability of industry and government to develop effective plant siting and licensing procedures along with reasonable and definitive environmental standards. Long lead time and indefinite delay can discourage utilities from selecting nuclear power plants to meet their growing electrical demand. However, the degree of the restraining effect is relative to the delays encountered in building fossil fuel-fired plants and the availability of environmentally acceptable fossil fuel.

Environmental Considerations

While nuclear plants do not have particulate or gaseous pollutants from combustion, there are several potential environmental problems that are either unique or of particular concern to nuclear plants. These include--

- Radioactivity release to the environment in the form of radiation, airborne radioactivity and radioactive liquids: Potential exposure from these sources has been calculated to be well below exposure from the natural background and even below the normal medical and diagonostic x-ray exposures. While the amounts of radioactivity released are very small, special systems and procedures and continuous monitoring are required to limit environmental exposure.

- Heat dissipation from cooling water: The cooling process for nuclear plants is essentially the same as that for fossil-fueled plants. However, light-water type nuclear power plants in use today require larger amounts of cooling water and discharge greater amounts of waste heat to the water than comparably sized fossil-fueled plants because (1) they are less efficient in the conversion of thermal energy to electricity, and (2) they discharge all of their waste heat through the cooling water system, whereas about 25 percent of the waste heat from a fossil-fueled plant is discharged through the stack. However, thermal discharges are not necessarily harmful to the environment. The effects of thermal discharge are dependent upon the specific location, natural water body conditions and the natural temperature ranges. In areas where increased temperature of the natural waters is potentially harmful, cooling facilities such as cooling ponds or cooling towers can be installed to minimize or completely eliminate these heat effects.

- Potential release of radioactivity as a result of accident conditions such as a malfunction of the emergency core cooling system (ECCS): Rule-making hearings are presently being conducted by the AEC regarding the adequacy of present ECCS design criteria. Further, a loss of fluid test will be conducted in the near future by the AEC to gather experimental data on reactor conditions affecting ECCS design in order to ensure adequate regulatory requirements.

- Low-level radioactive waste products resulting from normal operation of a nuclear plant: These wastes, collected by a radioactive waste treatment system, are placed in protective containers at the power plant for shipment to an AEC approved facility, where the container is buried. High-level wastes are also created within the fuel elements as a result of fission of the nuclear fuel. However, these wastes remain sealed within the fuel elements until the spent fuel is reprocessed at a separate location (discussed more fully in Chapter Five, "Fuel Reprocessing" and "Waste Disposition").

Manufacturing Inudstry's Ability to Supply Equipment

A 6- to 7-year order lead time is adequate to adjust manufacturing capacity to meet demand in all areas of nuclear plant equipment supply. Generally, the items with the long lead times--requiring as much as 5 to 6 years each--are the turbine generator and the pressure vessel (see Figure 2).

On balance, the manufacturing industry's ability to supply the necessary equipment and services can be compatible with an expanded nuclear power program. There is intense competition among five domestic reactor suppliers, each seeking to increase his share of the commercial nuclear power plant market. This competitive situation suggests that the U.S. nuclear industry could respond very well to a substantial upsurge of nuclear plant orders. In addition, there is an appreciable foreign manufacturing capability, particularly for turbine generators and pressure vessels.

Construction Capability

For the long term, the construction industry's capability to build nuclear power plants is dependent upon its having highly qualified personnel to staff both design and field construction activities. Recent experience indicates that this will no longer be a major obstacle in the path of nuclear power growth. Design difficulties have diminished as the industry gains experience, and the quality of construction required by the exacting specifications has proved to be well within the skills of good craftsmen.

At the present time, the engineering and construction man-hours required to build a nuclear power plant are greater than those required to build a fossil-fueled plant of comparable size. However, with the improvement of nuclear technology and clarification of licensing requirements, it seems certain that design changes during construction will decrease with a consequent reduction in engineering and construction labor requirements. Furthermore, the technique of utilizing preassembled, barge-mounted nuclear plants holds promise of standardization and multiple construction under drydock conditions which could simplify field engineering and reduce field construction labor requirements.

As nuclear plants become more standard it is expected that the amount of engineering and construction labor required to build the present types of nuclear power plants will not be appreciably greater than the engineering and construction labor required to build fossil-fueled power plants of like size. Therefore, the problem of the availability of qualified construction labor can be considered in the broader context of the requirements for all power plants rather than solely of nuclear power plants. The electric power industry presently employs about 3 percent of the existing heavy industrial construction labor pool for its expansion requirements and this will increase to 5 percent by the year 2000. There may therefore be problems in providing sufficient labor for the construction of all electric generating plants unless adequate attention is given to better management, use of more efficient construction techniques and increased training programs--particularly for the skilled crafts. However, this increase in labor requirements, while significant, is still a relatively small percentage of the total labor force expected to be available.

Capital Costs of Nuclear Generating Plants

As long as licensing procedures are prolonged and safety and environmental requirements continually change and become more stringent, the capital cost of nuclear power plants will very likely increase, even on a constant dollar basis. When the influence of these factors and of basic engineering design stabilize, the major cause of future cost increases will be inflation and wage escalation. These same factors will, of course, cause increases in the capital cost of all electric power generation plants to some degree.

On a comparative basis, nuclear power plants are expected to be more expensive to build than comparable fossil-fueled plants during the time period under consideration in this study. In developing projections of electric utility investment requirements for the 1972-1985 period, the Electricity Task Group of the NPC utilized a capital cost factor for nuclear plants of $300 per KW for committed capacity and $400 per KW for uncommitted capacity.

Capital cost factors used by the Electricity Task Group for fossil-fueled plants ranged from $200 per KW to $300 per KW.

The higher capital cost of nuclear power can be more than offset, over the long term, by the relatively low cost of nuclear fuel (see "Nuclear Fuel Costs," below); and therefore, it is not expected to be a controlling factor in a decision to expand nuclear power. However, caution must be exercised in applying this general observation because conditions affecting both capital costs and fuel costs can vary considerably in different areas of the United States.

Nuclear Fuel Costs

Within reasonable ranges, increases in nuclear fuel costs will not retard the growth of nuclear power because nuclear fuel represents less than 25 percent of the cost of generating electricity in a nuclear power plant. As shown in Table 12, nuclear fuel costs for a typical base-load reactor amount to only about 1.9 mills per KWH out of a total electricity cost of 9 to 11 mills per KWH.

TABLE 12

COST OF ELECTRIC POWER FROM 1,000 MWe (BASE-LOAD) PWR

Fuel*	Power Costs (Mills/KWH)
Fabrication (@ $70/Kg U)	0.40
Uranium (@ $8/lb. U_3O_8)	0.66
Conversion (@ $2.52/Kg)	0.08
Enrichment (@ $32/SWU)	0.80
Reprocessing & Shipping (@ $45/Kg U)	0.14
Plutonium Credit (@ $7.50/Kg fissile)	(0.15)
Total Fuel Costs	**1.93**
All Other Costs	7.00 - 9.00
Total Power Cost	**9.00 - 11.00**

* This fuel cost calculation is for a typical 1,000 MWe PWR, uses constant prices and is levelized over the first ten years of operation at an 80-percent capacity factor with a 15-percent discount rate.

The total fuel cycle cost of about 1.9 mills per KWH shown in Table 12 is equivalent to about $0.18 per million BTU's. Assuming that other fuel-cycle costs remain the same, the projected increase in uranium raw material costs at 15-percent DCF rate of return would cause total fuel costs to approach $0.20 per million BTU's between 1980 and 1985.

The nuclear cost is not very sensitive to changes in the cost of one of the components and the cost of power even less so. For example, if uranium were to double in price from $8 to $16 per pound U_3O_8, the fuel cost would be increased by 0.66 mills per KWH, or about one-third; and, because of nuclear fuels' relatively small cost contribution, the resultant power cost increase would be less than 10 percent. A 20-percent increase in the price of enrichment services produces a 0.16 mills per KWH increase in fuel costs, and less than a 2-percent increase in power costs.

For large increases in any one of the cost components, the fuel cycle could be reoptimized to minimize the effect of the cost increase. For example, if fabrication costs decrease and uranium costs increase, then lower uranium enrichment would be used (hence less uranium) and the irradiation time would be shortened (hence more fabrication).

Chapter Two

NUCLEAR RESOURCES

Uranium ore reserves in the United States have been increased substantially in recent years and now stand at a higher level than any previous year even though the exploratory drilling effort to date has essentially been limited to a small portion of the total area in which uranium occurs. Since its beginning in 1948, the uranium industry in the United States has demonstrated the capability to discover uranium reserves in excess of the demand. The magnitude of the exploration effort for uranium which discovered the required new ore reserves has been directly related to the market for uranium concentrates.

In view of the long lead times required for exploration and production, converting domestic uranium resources to economically recoverable reserves will require that the recent decrease in uranium exploration activity be reversed in the near future. A growing, aggressive exploration program can be achieved only with sound government policy and improved economic incentives. The domestic uranium industry must be permitted access to nuclear natural resources. It must also have satisfactory evidence of a sufficient domestic market, with prices which will cover the costs of discovery, development and production, and a reasonable rate of return on investment.

The Initial Appraisal accepted the AEC estimate of (1) reasonably assured resources (proved uranium reserves) plus (2) estimated additional uranium resources (potential uranium reserves) as the basis for evaluating the adequacy of domestic uranium resources to supply a growth in domestic nuclear electric power which is projected to reach 300,000 installed MWe in 1985. Given appropriate economic incentives, the uranium resource position of the United States appears adequate with respect to low cost uranium to supply the related cumulative U.S. requirement of 450,000 tons of U_3O_8.

URANIUM RESOURCE REQUIREMENTS: 1971-1985

The current study evaluates the requirements for nuclear fuels needed to support growth rates of nuclear power over and above the rate projected in the Initial Appraisal. It also addresses the possibility of a reduced growth rate for nuclear power. Estimated ranges of nuclear growth indicate cumulative uranium production requirements from the domestic mining industry through 1985 ranging from approximately 400,000 tons of U_3O_8 in Case IV (low case) to approximately 700,000 tons in Case I (maximum case). The cumulative production requirement for Case II (high case) is estimated to be 600,000 tons, and for Case III (medium case) it is near 500,000 tons (see Table 13).

TABLE 13

REQUIREMENTS FROM INDUSTRY FOR URANIUM CONCENTRATE*
(1,000's Short Tons U_3O_8)

	Case I		Case II		Case III†		Case IV	
	Annual‡	Cumul.	Annual‡	Cumul.	Annual‡	Cumul.	Annual‡	Cumul.
1972	12.3	12.3	12.3	12.3	12.3	12.3	5.1	5.1
1973	12.6	24.9	12.6	24.9	12.6	24.9	5.9	11.0
1974	13.7	38.6	13.7	38.6	13.7	38.6	8.2	19.2
1975	19.1	57.7	19.1	57.7	19.1	57.7	11.5	30.7
1976	22.0	79.7	22.0	79.7	21.7	79.4	14.6	45.3
1977	28.0	107.7	28.0	107.7	23.5	102.9	18.1	63.4
1978	39.2	146.9	38.9	146.6	27.7	130.6	21.8	85.2
1979	44.4	191.3	40.9	187.5	31.6	162.2	24.9	110.1
1980	50.9	242.2	45.6	233.1	36.5	198.7	29.1	139.2
1981	71.7	313.9	62.9	296.0	48.4	247.1	39.3	178.5
1982	84.2	398.1	69.4	365.4	54.4	301.5	44.8	223.3
1983	96.3	494.4	76.7	442.1	61.2	362.7	50.2	273.5
1984	100.0	594.4	82.3	524.4	66.2	428.9	54.9	328.4
1985	108.5	702.9	89.2	613.6	70.7	499.6	60.4	388.8

* Demand was computed assuming (a) 0.20-percent U_{235} enrichment plant tails assay through 1981 and 0.275 percent thereafter and (b) 60 percent of the Pu produced in LWR's recycled beginning in 1978. An increase in enrichment plant tails assay of 0.050 percent U_{235} would increase U_3O_8 demand by 10 percent. Total elimination of plutonium recycle would increase annual U_3O_8 demand by about 10 percent by the year 1985.

† The Initial Appraisal estimate to supply the same installed nuclear power capacity in 1985 was based on a tails assay of 0.20-percent U_{235} and Pu recycle starting in 1974.

‡ U_3O_8 production for the year 1970 was 12.9 thousand tons.

The figures in Table 13 do not include reserves needed in 1985 for future production but do reflect requirements with enrichment plant operations consistent with the Government's stockpile disposal plan announced on March 7, 1972. Forward reserves in 1985 considered necessary for such production would amount to an additional 1.3 million tons of U_3O_8 for Case I, 1.1 million for Case II, 0.8 million for Case III, and 0.7 million for Case IV. This amounts to a forward reserve equal to approximately a 10-year demand for U_3O_8.

URANIUM RESOURCES AVAILABLE: 1971-1985

Estimates of domestic uranium resources (proved and potential reserves) at different cost levels made annually by the AEC have provided an established reference point against which to measure projections of required uranium production in the near future. The AEC estimates uranium resources in the United States, as of January 1, 1972, available at a cost of production not to exceed \$15 per pound of U_3O_8, to be 625,000 tons of reasonably assured plus 1 million tons of estimated additional resources (see Table 14). The resultant total of 1,625,000 tons of proved plus potential reserves are thus in excess of all the projected demands (maximum of 0.7 million tons in Case I) through 1985 and are sufficient to provide substantial forward reserves in all demand cases provided the necessary exploration and development is done.

TABLE 14

DOMESTIC RESOURCES OF URANIUM AS ESTIMATED BY AEC—JANUARY 1, 1972

	Tons of U_3O_8 (Cumulative)		
Cost of Production* ($ per Pound)	**Reasonably Assured † (Proved Reserves)**	**Estimated Additional ‡ (Potential Reserves)**	**Total**
$ 8 (or less)	273,000	460,000	733,000
$10 (or less)	423,000 §	650,000	1,073,000
$15 (or less)	625,000 §	1,000,000	1,625,000

* Costs are estimated by the AEC and are based on the forward cost of production, not including amortization of past investments, interest or income taxes. Does not necessarily represent the market price.

† Reasonably assured resources refer to uranium which occurs in known ore deposits or such grade, quantity, and configuration that it can, within the given cost range, be recovered with currently proven mining and processing technology. Estimates of the tonnage and grade are based on specific sample data and measurements of the deposits and on knowledge of ore-body habit.

‡ Estimated additional resources refer to uranium surmised to occur in unexplored extensions of known deposits or in undiscovered deposits in known uranium districts, and which is expected to be discoverable and exploitable in the given cost range. The tonnage and grade of estimated additional resources are based primarily on knowledge of the characteristics of deposits within the same districts.

§ Includes 90,000 tons potentially recoverable as a by-product of phosphate and copper mining at a cost of $10 per pound or less. through the year 2000 if recovery facilities are provided. None of this material is being recovered today.

However, it should be recognized that a precise comparison of AEC estimates of available uranium resources at various cost levels to the uranium requirements for power plants is misleading for several reasons:

- While the AEC's selection of cost levels at $8, $10 and $15 per pound of U_3O_8 brackets the range of average "prices" computed in this study to be necessary to produce uranium from various classes of ore reserves and production facilities, the AEC does not include in its values for cost of production either return on investment or certain other costs such as interest, income tax or amortization of past investment in exploration and mine/mill construction. The relationship of the AEC values to the "price" as calculated in this study is close enough only to provide a basis for judgement as to the general adequacy of resources to support domestic production.

- Present mining and milling facilities do not have the capacity to produce the uranium required, and it is therefore obvious that additional facilities must be constructed. Furthermore, at current prices of $8 per pound or less for U_3O_8, existing underground mining operations are not recovering the lower grade ores which have been adjudged to be capable of yielding U_3O_8 at prices in the range of $8 to $15 per pound. Bypassing these ores during the initial mining operation substantially reduces the possibility of recovering them in the future for comparable low cost.

- Extensive exploration and development drilling is necessary to bring the potential reserves into the proved category.

A sharp increase in exploration effort and hence surface drilling is necessary if the requirements from the industry for uranium concentrate are to be met. Due to the lead time (8 to 10 years) required from initiation of the exploration program until the first production of uranium, exploration for new deposits must be under way in the near future if it is to have any impact on uranium supply during the 1980-1985 period. With a prevailing market price of under \$8 per pound of U_3O_8, major efforts have not been made recently to do extensive exploration for or to develop low grade uranium deposits. "Price" projections shown in this report indicate that substantially higher "prices" in the range of roughly \$9.00 to \$12.50 per pound, based on average production costs, are necessary to provide a DCF rate of return of 10 to 20 percent on the investments required to discover and produce from new ore reserves. The risk inherent in exploration ventures makes the higher rate of return more likely in order to bring about the necessary drilling effort.

Historically, the success of exploration demonstrates the capability of the uranium industry to add new reserves through an increased exploration effort. Surface drilling, which historically has been a good measure of the level of uranium exploration activity, has varied in proportion to the anticipated market for uranium concentrates and financial incentives (see Figure 3). Drilling peaked in 1957 in response to the AEC's program to purchase uranium concentrates, only to fall sharply in 1958 with the announcement that the purchase programs would be curtailed. In response to an expanding private market, total footage drilled rose once again from a low of 2.1 million feet in 1965 to 24 million feet in 1968 and ultimately to 30 million feet in 1969. Following 1969, however, exploration effort declined sharply due to a significant decrease in the rate of placing new nuclear reactor orders.

The discovery rate, in pounds of uranium discovered for footage drilled, was the same for the 1966-1971 period as for the previous 6 years--3.8 pounds of U_3O_8 per foot. Statistics on historical uranium discovery rates as compiled by the AEC are shown in Table 15.

POTENTIAL RESERVES OF URANIUM

In the case of oil, quantative estimates of speculative potential reserves were made as a result of a comprehensive assessment of the potential of the entire United States, including its off-

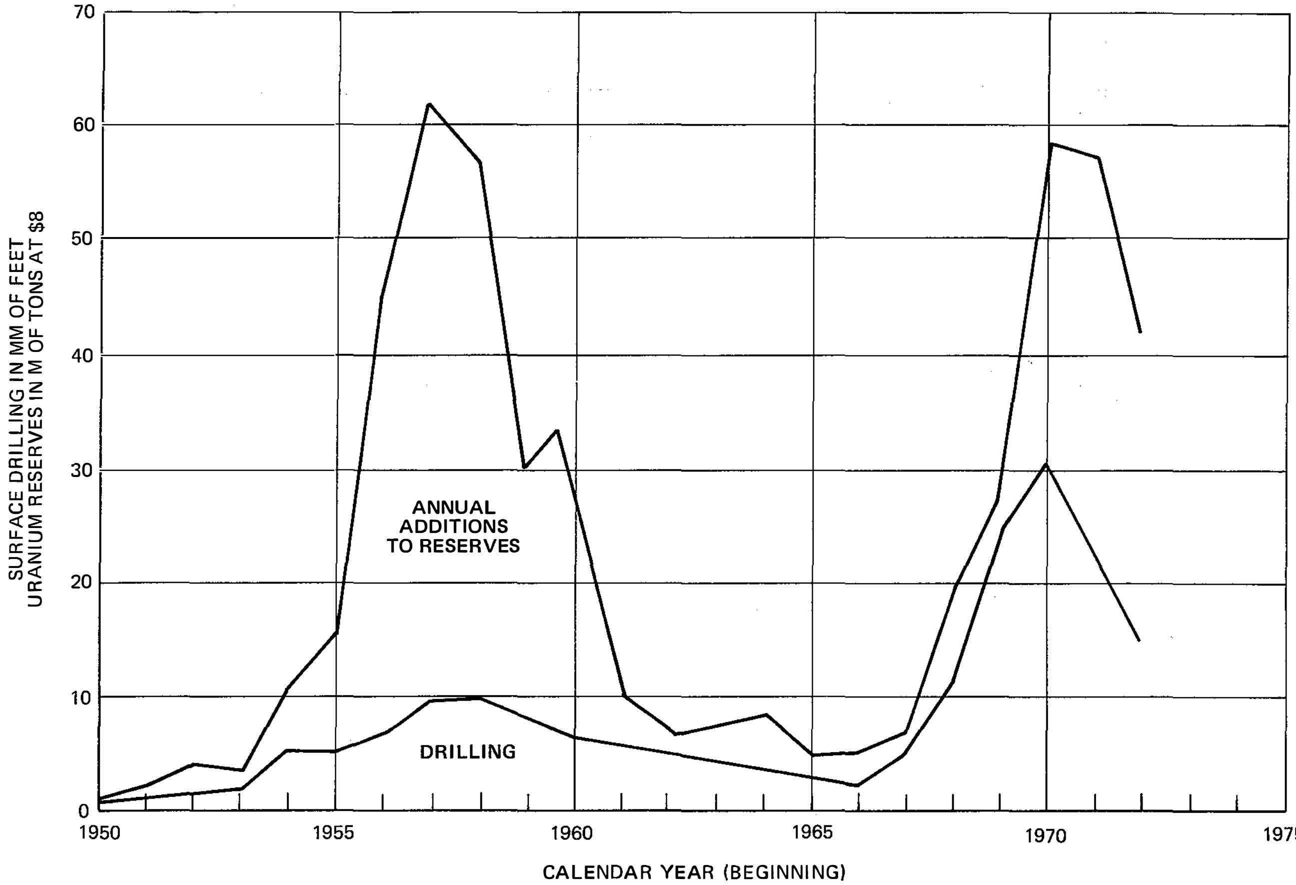

Figure 3. Annual Surface Drilling and Reserve Additions (Based on AEC Data).

TABLE 15

DRILLING EXPERIENCE FACTORS*
(Based on 3-Year Moving Averages)

3-Year Period	Pounds U_3O_8 Added to Reserves/Foot of Total Drilling†
1960-1962	3.2
1961-1963	3.6
1962-1964	4.0
1963-1965	4.6
1964-1966	3.5
1965-1967	3.5
1966-1968	2.6
1967-1969	3.1
1968-1970	3.5
1969-1971	4.4

* Compiled by the AEC.

† Reserve additions as defined by the AEC are those reserves mineable at costs of up to $8.00 per pound U_3O_8. The discovery rate over the 1969-1971 period including reserves mineable up to $10.00 per pound U_3O_8 is approximately 5.0 pounds U_3O_8/ft.

shore regions.* No such extensive assessment has yet been made of the potential for uranium, and such a study was considered beyond the scope of this report. However, the possibility of the existence of such speculative potential reserves must be taken into account in assessing the capability of U.S. industry to discover such reserves and to produce additional domestic uranium from them at costs of production of $15 per pound or less.

The AEC's published figure for "estimated additional resources" (potential reserves) of U_3O_8 (e.g., 1.0 million tons at $15 per pound or less) is not an attempt to measure either the ultimate uranium resources in this country or the total recoverable resources at the costs indicated. Rather, it is related only to specific known uranium mineralization and geological trends and, as such, is subject to change from time to time as new information is developed. The estimates of proved reserves are also subject to change with time and the development of new information.

Ninety-five percent of the uranium discovered in the United States is in sedimentary rocks, principally sandstone. While new types of deposits are expected to be found, the sandstone type will probably provide the basis for the U.S. uranium industry in the future, at least in the lower price range. Most of the uranium occurrences in sedimentary rocks in the United States have been found in a 450,000 square mile region of the western United States. Figure 4 indicates the areas of the western United States considered to be the most prospective for uranium exploration.

Opportunities exist for additional uranium discoveries not connected with known uranium mineralization and geological trends. Substantially, all of the proved reserves and approximately 85 percent of the potential reserves indicated in Table 14 are located in presently producing areas.† Eighty-five to 90 percent of recent drilling has been concentrated in and around these producing areas. These areas, which make up less than 10 percent of the total area in which uranium occurrences are found, are still incompletely explored. Exploration drilling outside of the producing areas has been limited only because there has been little incentive to undertake wildcat exploration while adequate opportunities for the discovery of new reserves still exist in the known districts. However, to meet projected demand, it will become necessary to explore outside the present producing areas.

The uranium industry is in a comparatively youthful stage of development when compared to the oil industry. Uranium, like oil, does not occur everywhere, however, there is little reason to think that uranium is restricted only to those areas that have been explored during these early years. Historical evidence for nearly

* NPC, *Future Petroleum Provinces of the United States* (1970).

† Rafford L. Faulkner "Outlook for Uranium Production to Meet Future Nuclear Fuel Needs in the United States," United Nations Fourth International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, September 6-16, 1971.

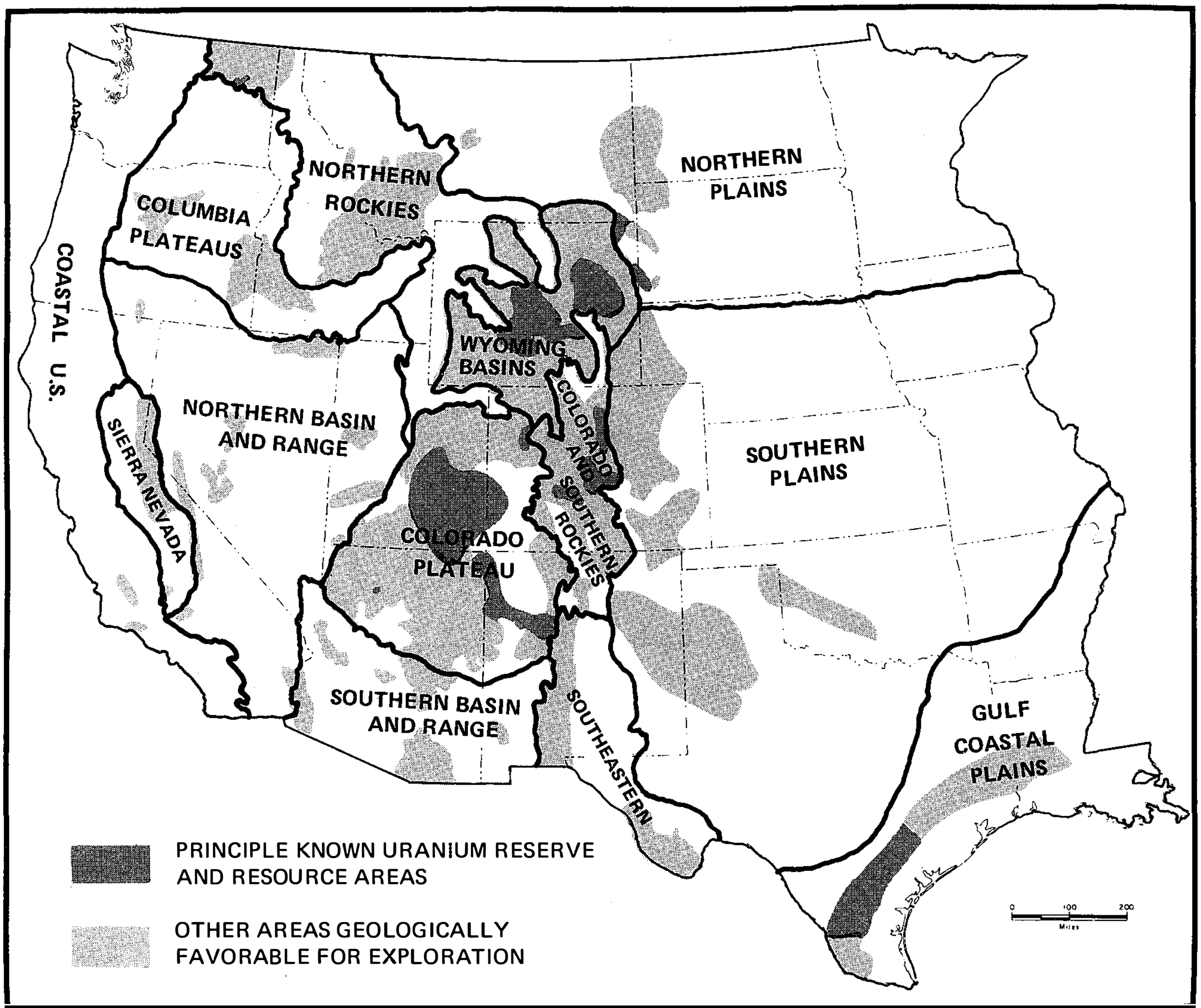

Figure 4. Uranium Resources--Western United States.

all minerals indicates resources, at any given period of time, in excess of earlier estimates. Furthermore, the amount of increase in these resources is directly related to the level of exploration activity. Given the large unexplored areas which may be favorable, there is every reason to believe that significant additional deposits of uranium will be discovered, depending upon the level of exploration.

THORIUM

Thorium is found in the United States in a number of different geologic environments. The major known low-cost reserves are in vein deposits located in Idaho and Montana. Thorium resources in the United States, as reported by the AEC, are estimated at 65,000 tons of indicated and inferred and 350,000 tons of potential additional resources, available under present economic conditions.

Projected requirements for nuclear grade thorium oxide through the year 2000 are not expected to exceed a few thousand tons annually. The available domestic resources are therefore more than adequate to meet projected demands for thorium oxide, and there is little incentive or need for exploration for new deposits.

Production capabilities for commercial and nuclear grade thorium oxide are more than adequate to meet current requirements. However, additional production capacity will be necessary to meet demand through the end of the century.

PUBLIC LANDS AND MINING LAWS

Nearly 50 percent of the estimated additional resources in both the $8 and $10 per pound U_3O_8 categories are located on the public domain (see Table 16). Exploration for uranium on the public domain, and production therefrom, is governed by the federal mining laws. These laws can, therefore, have a profound effect on domestic uranium supply.

TABLE 16

PERCENTAGE DISTRIBUTION OF DOMESTIC URANIUM ORE RESOURCES BY LAND CLASSIFICATION* JANUARY 1, 1972

	$ 8 Resources		$ 10 Resources	
Land Type	**Reasonably Assured**	**Estimated Additional**	**Reasonably Assured**	**Estimated Additional**
Fee Lands†	41%	23%	40%	21%
Public Domain	33	48	33	49
State Lands	3	3	3	3
Indian Lands	18	19	19	20
Federal Reacquired Lands	2	2	2	2
Railroad Lands	3	5	3	5
Total	**100%**	**100%**	**100%**	**100%**

* Information furnished by the U.S. Atomic Energy Commission. Distribution percentages are approximate.

† The significance of uranium in the public lands is greater than indicated by the category "Public Domain" in the above table, because uranium found on claims on public land which have since been patented has been included under "Fee Lands."

The Public Land Law Review Commission has recommended modifications of the present mining laws. These changes could increase land costs; however, they are not expected to affect the availability of land for uranium exploration.

Serious reduction in potential uranium reserves would result, however, if access to the public domain were to be substantially restricted as is being advocated in many quarters, including the legislative branch of Government. For example, a 50-percent reduction in the amount of public domain open to mineral exploration and production would reduce the current estimated additional resources by approximately 25 percent.

All lands having uranium potential should remain available for exploration and development until exploration information allows assessment of mineral values. Any new time limits placed on federal claims or leases held for uranium should take into account the long lead times associated with uranium exploration and development as well as future market requirements.

INCENTIVES FOR DISCOVERY

The uranium industry is faced with a tremendous challenge in the years ahead. Cumulative requirements for U_3O_8 production through the year 2000 range from roughly 1.5 million tons of U_3O_8 for Case IV to 2.7 million tons for Case I.* The mid-range growth rates (Cases II and III) will require approximately 2.3 and 1.9 million tons of uranium, respectively. Provision for a forward reserve beyond the year 2000 will require even larger amounts.

The growth rate in uranium production and hence exploration activity over the next 30 years will have to exceed the growth rates experienced in the past for most mineral commodities. Drilling rates have decreased in the last 2 years; and, if the necessary uranium to satisfy the demands through 1985 and beyond is to be provided, an immediate increase in drilling activity is necessary. Furthermore, since it may be impossible to sustain uranium discovery rates experienced over the past several years a proportionally greater drilling effort may be required.

In order to achieve the required sharp increase in drilling activity, and in view of the long lead times required from exploration to production, it is a necessity that uranium raw materials producers be provided immediately with incentives to undertake the task. Present market conditions have been less than satisfactory in providing the necessary incentives for uranium producers to develop even many known uranium properties, let alone explore extensively for new uranium reserves. Incentives that could stimulate increased drilling activity include:

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* Estimates are based on the assumption that the U_{235} assay of the tails from the enrichment plant will remain 0.275 percent in accordance with the plan outlined by AEC Chairman Schlesinger before the Joint Committee on Atomic Energy, March 7, 1972.

Utilization of thorium as a nuclear fuel in HTGR's could result in a lowering of demand for U_3O_8 by 5 to 10 percent after 1985. Also, because of the thermal efficiency (39 to 40 percent) of the HTGR and its improvised neutron economy with U_{233}, the economics of the thorium fuel cycle are relatively insensitive to the cost of uranium feed. Therefore, high cost uranium reserves can be utilized for the HTGR.

- Long-range uranium purchase contracts between producers and utilities

- Uranium selling prices which cover the cost of discovery, development and production, and a reasonable return on investment

- Assurance that Government policy will continue to restrict importation of uranium as required to maintain a viable domestic mining industry

- Timely access to public lands for uranium exploration and development

- Continuation of a favorable tax environment.

Given appropriate incentives to step up exploration activity on a timely basis, and considering the resources available, adequate uranium reserves can be developed to meet production requirements through 1985. Optimism is warranted on the adequacy of domestic uranium resources to meet production requirements for Cases II-IV through the year 2000. Although the magnitude of the exploration effort for Case I will require optimum success, reasonable optimism is warranted that the production requirements for this case could be supplied from domestic uranium reserves. It must be assumed, however, in order to meet demands through 1985 from these domestic resources in all cases except Case IV, that (1) the recent decline in uranium exploration activity be reversed in the near future and (2) economics and government policy be such so as to encourage the maintenance of a growing, aggressive exploration program by private industry. To meet the demands beyond 1985, additional geographic areas, currently unexplored, must yield uranium discoveries similar to those found in the past.

Chapter Three

URANIUM SUPPLY ANALYSIS--METHOD AND ASSUMPTIONS

To analyze the domestic uranium supply capability, the Nuclear Task Group adopted a demand oriented appraisal. Estimates of exploration and production activity levels, as well as the financial requirements placed on the uranium raw materials industry, were made with respect to the projected demand for nuclear power (rather than being based on some preestablished rate of growth in drilling levels, such as used in the oil and gas analysis). The nuclear energy supply analysis involved three fundamental steps:

(1) Establishing a range of nuclear power growth projections (Cases I-IV)

(2) Computing the resulting nuclear fuel demand

(3) Judging the ability of the uranium raw materials industry, the nuclear fuel processing industry and the nuclear plant manufacturing industry to supply the demand for each case.

Two computer models were used in projecting the activity in the key segments of the nuclear industry. The "uranium demand model," used in projecting demand for uranium and enrichment plant separative work, was provided by the Atomic Energy Commission's Office of Planning and Analysis. By utilizing this model, the Nuclear Task Group was able to project separative work demand and natural uranium requirements under a variety of nuclear generating capacity growth assumptions and a wide range of nuclear power plant and fuel cycle operating parameters. A simplified flow chart of the uranium demand model is illustrated in Figure 5.

A second model, the "uranium supply model," was constructed by the Nuclear Task Group to aid in data reduction and to facilitate study of the variables affecting uranium supply. This model was designed so that it could accept the computed output from the demand model.* Furthermore, it could utilize the detailed estimates of domestic uranium production capability as maintained by the AEC. The supply model provides three types of output data:

(1) Estimates of operating requirements for the uranium raw materials industry.

(2) Projections of capital expenditures and operating costs in the uranium raw materials industry.

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* The supply model is programmed in the Fortran IV code which accepts any set of annual U_3O_8 demand projections for the years 1971 through 2000.

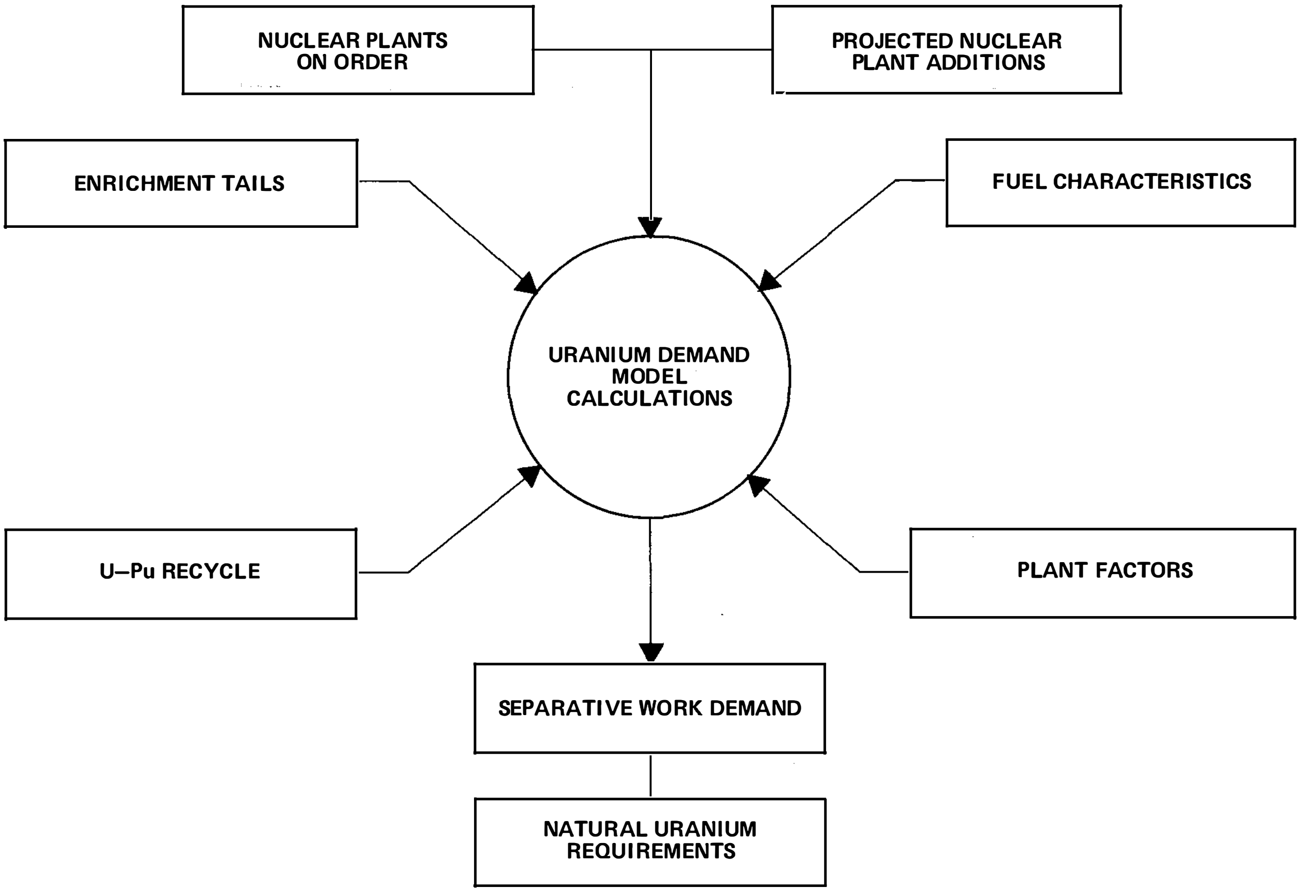

Figure 5. Conceptual Flow Chart--Uranium Demand Model.

(3) Uranium "prices" calculated to provide a specified DCF rate of return on projected investments. These U_3O_8 "prices" as calculated by the model are levelized "prices" which are based on average production costs. This implies, therefore, that the lower cost production centers will earn greater than average returns when selling at the levelized "price" while the higher cost production centers will be earning lower than average returns.

A simplified flow chart of the uranium supply model is illustrated in Figure 6.

DEMAND MODEL CALCULATIONS AND ASSUMPTIONS

The calculation of uranium demand was initiated with a projection of the annual additions to domestic nuclear capacity for each type of reactor through the year 2000. Initial fuel core characteristics of these reactors--such as enrichment level and core size--were combined with specified lead times for various fuel cycle services to project annual requirements for initial core fuel processing and supply. Operating characteristics were used with uranium and plutonium recycle projections and reprocessing lead times to calculate the various fuel cycle requirements for replace-

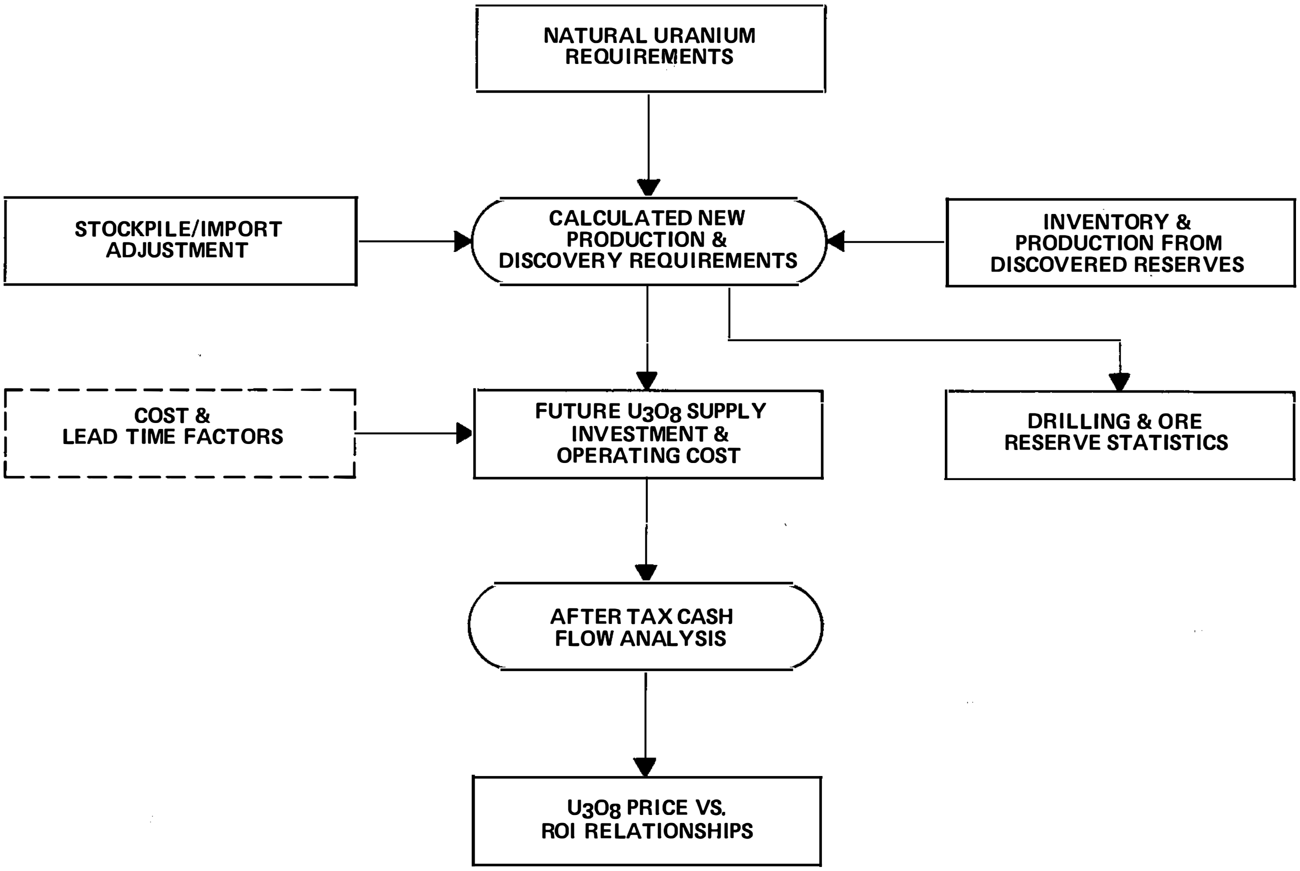

Figure 6. Conceptual Flow Chart--Uranium Supply Model.

ment fuel. These were then added to the projection of the initial core requirements to provide annual schedules of requirements for natural uranium and separative work. The calculations were repeated with various key parameters being assigned different values in order to test the sensitivity of the projected demand schedules to these parameters.

Assumptions regarding the basic reactor fuel characteristics as used in the uranium demand model are shown in Table 17 for LWR's and in Table 18 for the HTGR. The lead times assumed for fuel cycle processing (following exploration, mining and milling of natural uranium) as used in the uranium demand model, are shown in Table 19. Estimated separative work required for enrichment of foreign uranium subject to reexport and estimated U.S. Government requirements for separative work are shown in Table 20.*

SUPPLY MODEL CALCULATIONS

In evaluating the United States' uranium production capability, including both ore reserves and production facilities, five re-

* Assumptions shown in Table 20 were made to evaluate the adequacy of domestic enrichment capacity.

TABLE 17

CHARACTERISTICS OF LIGHT WATER REACTORS

	Plant Starting Commerical in Period			
	Boiling Water Reactor		**Pressurized Water Reactor**	
Characteristics*	**Through 1980**	**After 1980**	**Through 1980**	**After 1980**
Thermal Efficiency (Percent)	34	34	33	33
Specific Power (KWt/Kg H.M.)	22	24	38	41
Initial Core (Average)				
Irradiation Level (MWDt/MTU)	21,000	21,000	24,400	24,400
Fresh Fuel Assay (Wt. % U_{235})	2.20	2.20	2.63	2.63
Spent Fuel Assay (Wt. % U_{235})	0.77	0.77	0.76	0.76
Fissile Pu Recovered (Kg/MTU)†	5.0	5.0	5.84	5.84
Feed Required (Ton U_3O_8/MWe)‡	0.766	0.706	0.563	0.522
Separative Work Required (Kg/MWe)‡	287	264	236	218
Replacement Loadings (Steady State, at 80% Plant Factor and 60% Pu Recycle)§				
Irradiation Level (MWDt/MTU)	27,500	27,500	33,000	33,000
Fresh Fuel Assay (Wt. % U_{235})	2.56	2.56	3.19	3.19
Spent Fuel Assay (Wt. % U_{235})	0.75	0.75	0.84	0.84
Fissile Pu Recovered (Kg/MTU)†	5.4	5.4	6.84	6.84
Feed Required (Ton U_3O_8/MWe/yr.)‡	0.153	0.153	0.166	0.166
Separative Work Required (Kg/MWe/yr.)‡	78	77	88	99

* KWt is thermal kilowatts, H.M. is heavy metal (U-Th), MWDt is thermal megawatt days, MTU is metric ton (thousand kilograms) of uranium, "Ton U_3O_8" is short ton (2,000 pounds) of yellowcake from a mill, MWe is electrical megawatts.

† After losses.

‡ Based on operation of enriching facilities at a tails assay of 0.275 percent and 60-percent recycle of plutonium. Pu recycle starts in 1978. Therefore, U_3O_8 feed per year through 1977 is 0.186 tons U_3O_8/MWe for BWR's and 0.192 tons U_3O_8/MWe for PWR's; Similarly, annual separative work is 94 Kg/MWe for BWR's and 104 Kg/MWe for PWR's through 1977. The projected annual U_3O_8 requirements shown in this study do not include use of the Government stockpile and are based on an equivalent tails assay of 0.20 percent through 1981. For replacement loadings, the required feed and separative work are net in that they allow for the use of uranium recovered from spent fuel. Allowance is made for fabrication and reprocessing losses.

§ At steady state a portion of the reactor core (25 to 35 percent) is replaced with fresh fuel approximately on an annual basis.

serves-facility classifications of production (mining and milling) were utilized. The five classes are defined as follows:

Class 1: Existing production centers and associated reserves

Class 2: Production centers under construction and associated reserves

Class 3: Possible future production centers justified by defined reserves

Class 4: Possible future production centers justified by partially explored and potential reserves

TABLE 18

CHARACTERISTICS OF HIGH-TEMPERATURE GAS-COOLED REACTORS

Characteristics*	Plant Starting Commercial in Period (Typical 1,160 MWe) After 1980
Thermal Efficiency (%)	39
Specific Power (KWt/Kg H.M.)	82
Initial Core (Average)	
Irradiation Level (MWDt/MT H.M.)	54,500
Fresh Fuel (Kg U_{235})	1,600
Spent Fuel (Kg U_{235})	340
Fissile U_{233} recovered (Kg) †	750
Feed Required (ton U_3O_8/MWe) ‡	0.39
Separative Work Required (Kg/MWe) ‡	320
Replacement Loadings (Steady State at 80% Plant Factor) §	
Irradiation Level (MWDt/MT H.M.)	95,000
Fresh Fuel (Kg U_{235})	395
(Kg U_{235})	200
Spent Fuel (Kg U_{235})	26
Fissile U_{233} Recovered (Kg) †	200
Feed Required (ton U_3O_8/MWe/yr) ‡	0.091
Separative Work Required (Kg/MWe/yr) ‡	74

* KWt is thermal kilowatts, H.M. is heavy metal (U-Th), MWDt is thermal megawatt days, MT is metric tons (thousand kilograms), and "ton U_3O_8" is short ton (2,000 pounds) of yellowcake from a mill. MWe is electrical megawatts.

† After losses.

‡ Based on operation of enriching facilities at a tails assay of 0.275 percent. The projected annual U_3O_8 requirements shown in this study do not include use of the Government stockpile and are based on an equivalent tails assay of 0.20 percent through 1981. For replacement loadings, the required feed and separative work are net, in that they allow for the use of uranium recovered from spent fuel. Allowance is made for fabrication and reprocessing losses.

§ At steady state a portion of the reactor core (25 to 35 percent) is replaced with fresh fuel approximately on an annual basis.

Class 5: Production from future discoveries (no production center identified).

Classes 1-4 are based on AEC designations and definitions.* Class 5 was specifically created for the purpose of this study. A production center consists of a mill plus its supporting mines, ore reserves, and associated equipment, facilities and organization.

* See Appendix E.

TABLE 19

DOMESTIC FUEL CYCLE PROCESSING TIMES*

	Time in Months	
	Initial Core	Replacement Core
Decay After Discharge	–	6
Reprocessing	–	3
Conversion to UF_6	3	3
Enrichment	3	3
Fuel Fabrication	6	6
Finished Fuel Storage	3	3
Total	**15**	**24**

* The times shown are estimates for new reactors for which specific data are not available, generally those starting commercial operation in 1976 or later. When available, specific data was used in demand caluclations instead of the times shown here.

TABLE 20

ANNUAL FOREIGN AND U.S. GOVERNMENT REQUIREMENTS FOR SEPARATIVE WORK
(Thousands of Separative Work Units)

Year	Foreign Requirements	Government Requirements
1972	1,200	
1973	1,500	2,040
1974	2,400	800
1975	3,700	400
1976	5,100	1,020
1977	6,900	1,240
1978	8,900	1,290
1979	10,700	1,340
1980	12,100	1,310
1981	12,800	1,260
1982	13,600	1,240
1983	14,400	1,250
1984	14,900	1,250
1985	15,400	1,250

The following six steps outline the methodology employed in developing uranium raw material supply projections (see Figure 7 for flow chart):

(1) Projected natural uranium demand (from the demand model analysis) was adjusted for assumed feed from the Government-owned uranium stockpile and net uranium imports.* Stockpile usage was calculated to be the difference between U_3O_8 required when the enrichment plants are operated at 0.275-percent U_{235} tails assay (as announced by the AEC) and the lesser amount of U_3O_8 required if the enrichment plants were operated at 0.200-percent U_{235} tails assay (the actual basis for determining U_3O_8 feed from commercial sources). This stockpile disposal program was assumed to end in 1981 in each demand case regardless of the amount of U_3O_8 remaining in the stockpile at that time.

(2) As required by projected demand in Cases I-IV, sources of uranium supply were brought into production according to the following priorities: (a) production from Class 1 and 2 properties operating at capacity (for the first 5 years production is based on planned mine operating levels), (b) reduction in inventories (the model holds minimum U_3O_8 inventories at 10 percent of annual demand), (c) production from Class 3 properties, (d) production from Class 4 properties, and (e) production from new discoveries (Class 5 properties).

(3) Annual additions to uranium reserves required to sustain projected production levels were calculated based on assumed lead times and assumed reserve-to-production ratios.

(4) Annual drilling to support scheduled new reserve additions was computed.

(5) Schedules of exploration investment, mine/mill capital, primary development and operating expenses were computed for each year for each production class.

(6) As a model option, the U_3O_8 "price" required to provide a specified DCF return on investment is computed based on investments through 1985 for each class. This calculation takes into account all appropriate tax deductible expenditures including intangible development which is deducted in the year allowed under current tax regulations. Tax calculations include provisions for preference taxes and investment tax credits.

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* The uranium supply model was developed with the capability of considering uranium imports. Since imports do not constitute a source of supply for domestic purposes, a zero figure was utilized. (Refer to Appendix G, Schedule A).

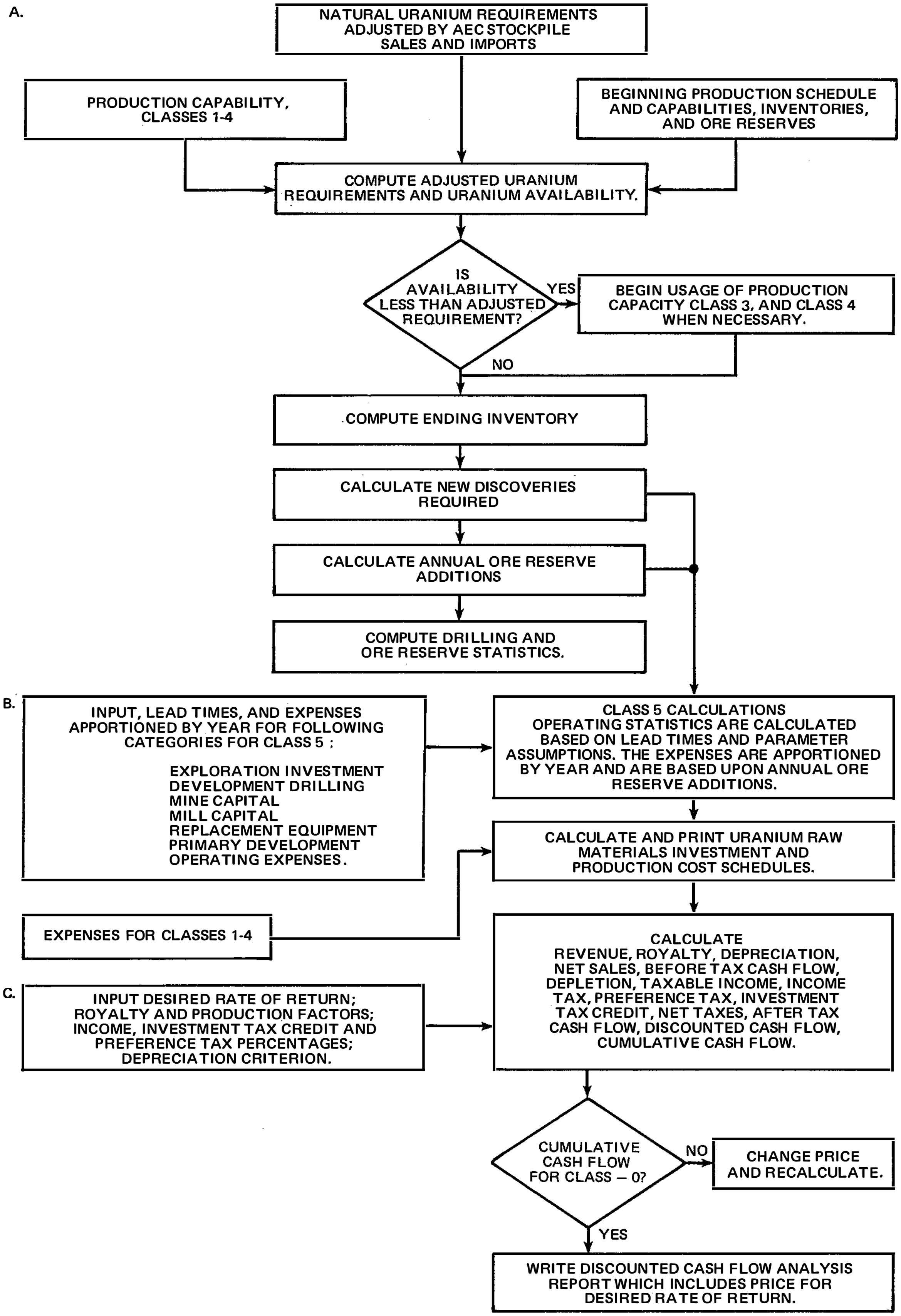

Figure 7. Uranium Supply Model Calculations.

SUPPLY MODEL ASSUMPTIONS

In order to compute both the required rate of uranium resource development and the associated industry investments and operating costs, it was necessary to make a number of assumptions regarding future development patterns, production rates and costs. With respect to production from properties in Classes 1 through 4, the general development patterns, production rates and associated investment and operating costs are taken directly from the published AEC estimates. For production from Class 5, development patterns and costs were assumed to be similar to those for known properties in Classes 3 and 4. The specific assumptions for Class 5 production which were used in developing the reference cases (Cases I-IV) and certain parametric studies are discussed in the following paragraphs. Cost assumptions with respect to Class 5 production also are summarized in Table 21.

Exploration

The principal elements of a modern uranium exploration program are depicted in Figure 8. The exploration phase is the initial stage in the development of new resources and is a period of extreme financial risk. The time and effort required to make a single new discovery cannot be predicted with accuracy.

The timing shown in Figure 8 indicates that, on the average, approximately 2 years are required from the inception of a specific project until discovery of uranium mineralization. (In this context, discovery does not mean a drilled-out ore body, but a "good show.") This 2-year period takes into account time spent in pursuing prospects that fail to result in discovery. Of course, the

TABLE 21

NEW URANIUM PROPERTY INVESTMENT AND OPERATING EXPENSE
(Constant 1970 Dollars)

Exploration	**Reserve Additions $/lb. U_3O_8 Indicated and Inferred Resources**	
Land Costs	0.10	
Exploration Drilling	0.60	
Development Drilling	0.20	
Total	**0.90**	
Capital	**$/lb. U_3O_8 Annual Production Capacity**	**$/lb. U_3O_8 Produced**
Mine Construction	1.10	0.110
Mill Construction	4.25	0.425
Mine Development	—	0.900
Operating Expense	**$/lb. U_3O_8 Produced**	
Equipment Replacement	0.15	
Total Direct and Indirect	4.35	

long-term exploration success of any uranium producer is influenced by the competence and experience of its exploration staff. Figure 8 illustrates that a given exploration project may fail at a number of decision stages. In uranium exploration, the risks are high and only a small percentage of the exploration drilling results in added ore reserves.

Once the initial discovery is made, a detailed drilling program is required to delineate the mineralized area and allow an engineering evaluation of the deposit. Overall, the exploration phase of a project (the time between initiation of an exploration project and the decision to proceed with mine development) is likely to encompass 4 or 5 years. The assumptions used in the uranium supply model regarding exploration lead times, costs and discovery rates are further specified below:

Exploration Costs

In the basic supply cases, total exploration costs are estimated at \$0.90 per pound U_3O_8 added to reserves, or approximately \$0.95 per pound U_3O_8 in concentrate. Unit exploration costs are a function of discovery rates and this cost factor is a key variable in the supply model.

A recent AEC report, *Uranium Exploration Activity*, published in August 1971, compiles data collected from an industry survey over the 5-year period 1966-1970.* Some selected results of this survey are summarized as follows:

- Surface exploration and development drilling reported for the 1966-1970 period--85.8 million feet
- Exploration investment reported for the 1966-1970 period: (1) Land--\$53.0 million; (2) Surface Drilling--\$100.5 million; (3) Other (Geological, etc.)--\$57.8 million; (4) Total--\$211.3 million.

Based on this data, it is possible to estimate exploration costs per pound of discovered reserves (Ec) as a function of the drilling success ratio (discovery factor) as follows:

$$Ec = \frac{\$211.3 \text{ million}}{85.8 \text{ million feet}} \quad X \quad \frac{\text{Surface feet drilled}}{\text{Pounds } U_3O_8 \text{ discovered}}$$

This formula is shown in graphical form in Figure 9.

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* A subsequent AEC survey made available in June 1972 indicates that during 1971 total exploration investment was approximately \$55.0 million in support of 15 million feet of surface drilling. This corresponds very closely with the task group estimates of 1970 costs shown in Figure 9.

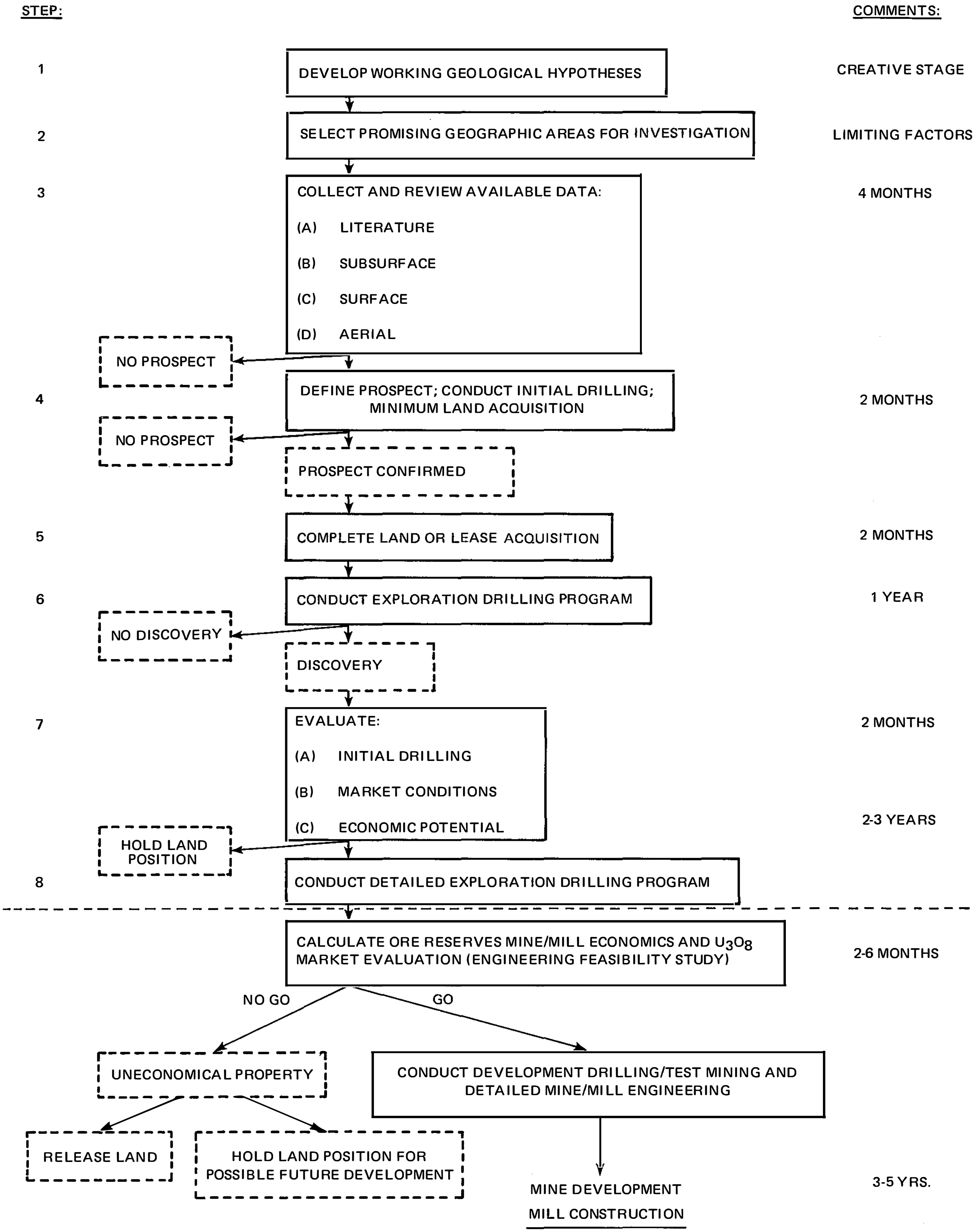


Figure 8. Decision Elements in Uranium Exploration.

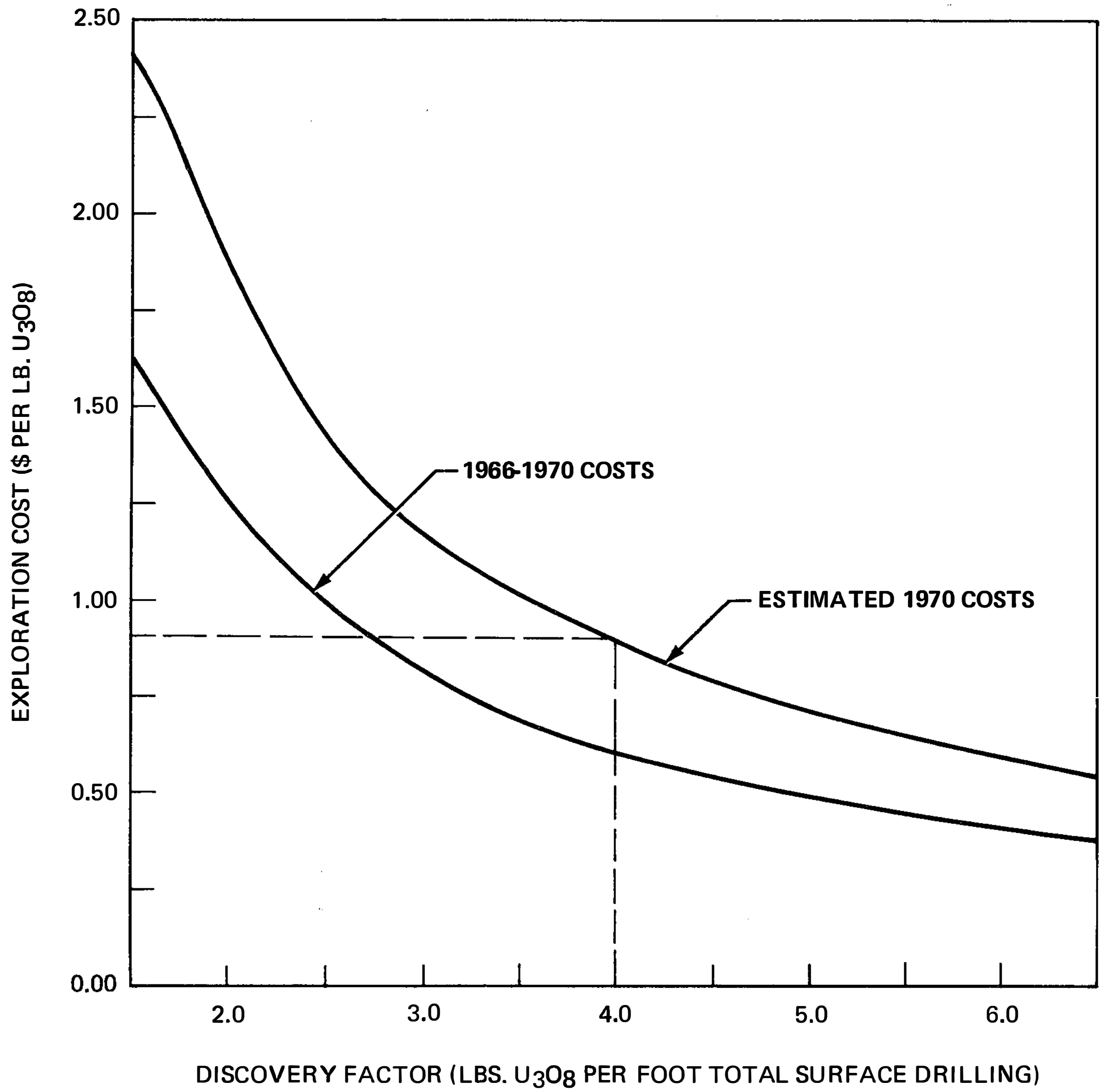


Figure 9. Uranium Exploration Costs vs. Finding Rate.

Discovery Rates

Uranium discovery rates are usually expressed as a function of total exploration drilling and development drilling since available industry statistics do not allow any clear breakdown between the two types of drilling. Statistical analyses of the discovery rate data were performed, however, no significant trends can be established from the historical data available.

A trend to deeper drilling and increased reliance in the future on underground uranium mining may have a bearing on future discovery rates. The average depth per surface exploration hole has increased substantially over the past several years (see Figure 10), and this trend is expected to continue. Remembering that Class 1 and 2 production centers are those mining and milling facilities now in operation or under construction and that Class 3 and 4 properties are defined as probable future production centers, a comparison of the percentage of open-pit *vs.* underground production capability is shown in the following tabulation:

Production Capability Through 1985

Class	Open-Pit	Underground
1 & 2	53%	47%
3 & 4	31%	69%

In Figure 10, historical average hole depths are plotted along with a projection of future drilling depths assuming that by 1980,

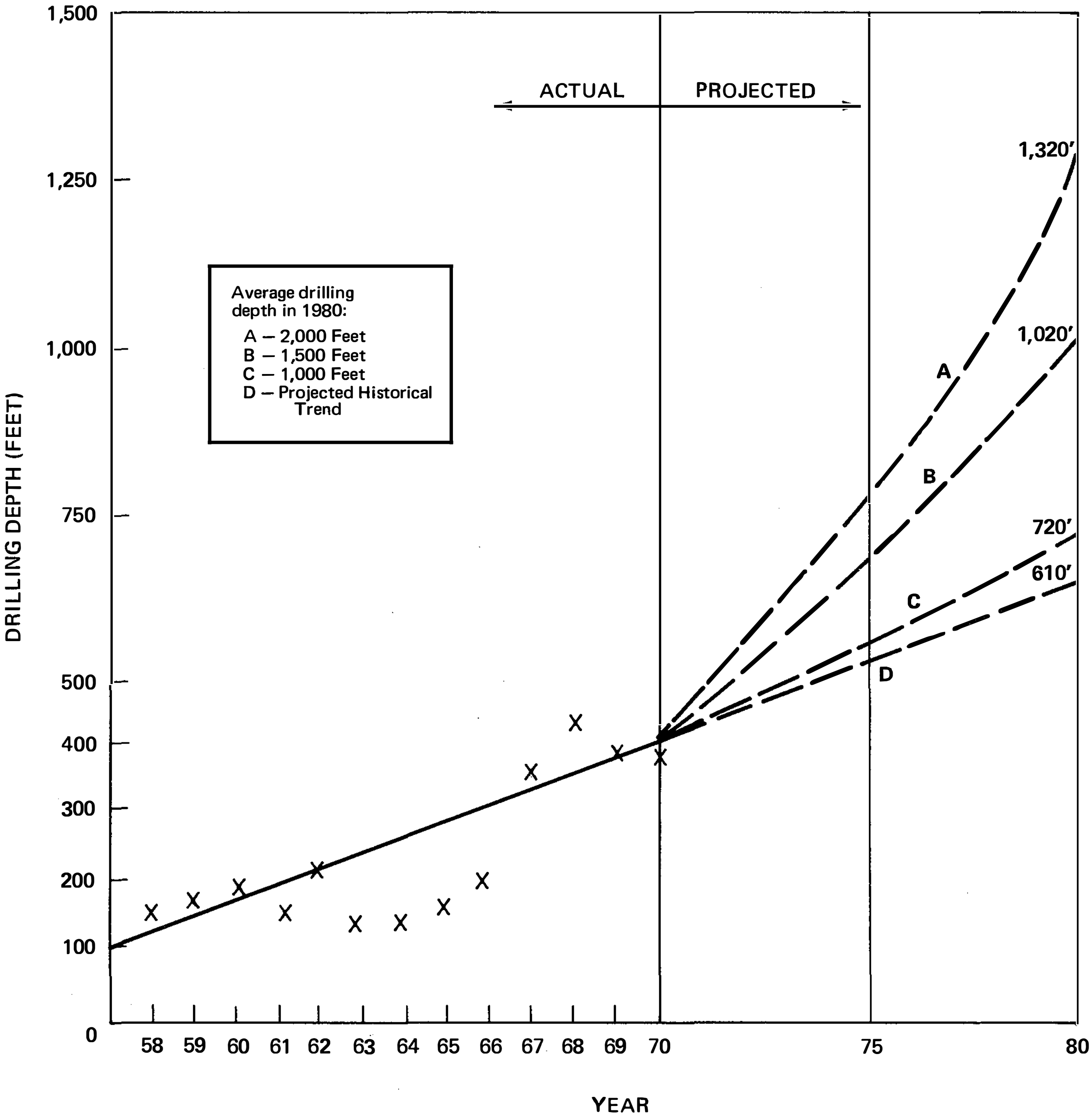


Figure 10. Trends in the Average Depth of Drilling.

60 percent of the drilling will be with an underground objective and 40 percent with an open-pit objective. The average depth of open-pit drilling is taken as 300 feet, and plots are shown for average underground depths of 1,000, 1,500 and 2,000 feet. (A linear least squares fit of the historical data indicates an average depth of approximately 600 feet in 1980.)

Three uranium discovery rates and corresponding exploration costs were considered in the supply model projections. An optimistic estimate which might result from improved technology and/or the discovery of large new uranium districts in frontier areas assumes a discovery rate of 5 pounds of U_3O_8 per foot at \$0.72 per pound. The median estimate is 4 pounds of U_3O_8 per foot at \$0.90 per pound, and the pessimistic estimate is 3 pounds of U_3O_8 per foot at \$1.20 per pound exploration costs.

Exploration Lead Times

The supply model assumptions regarding lead times for investments and drilling activity are summarized in Table 22 and illustrated in Figure 11.

Mine/Mill Investment

A typical mine/mill development schedule is diagrammed in Figure 12 for an underground mine and in Figure 13 for an open-pit

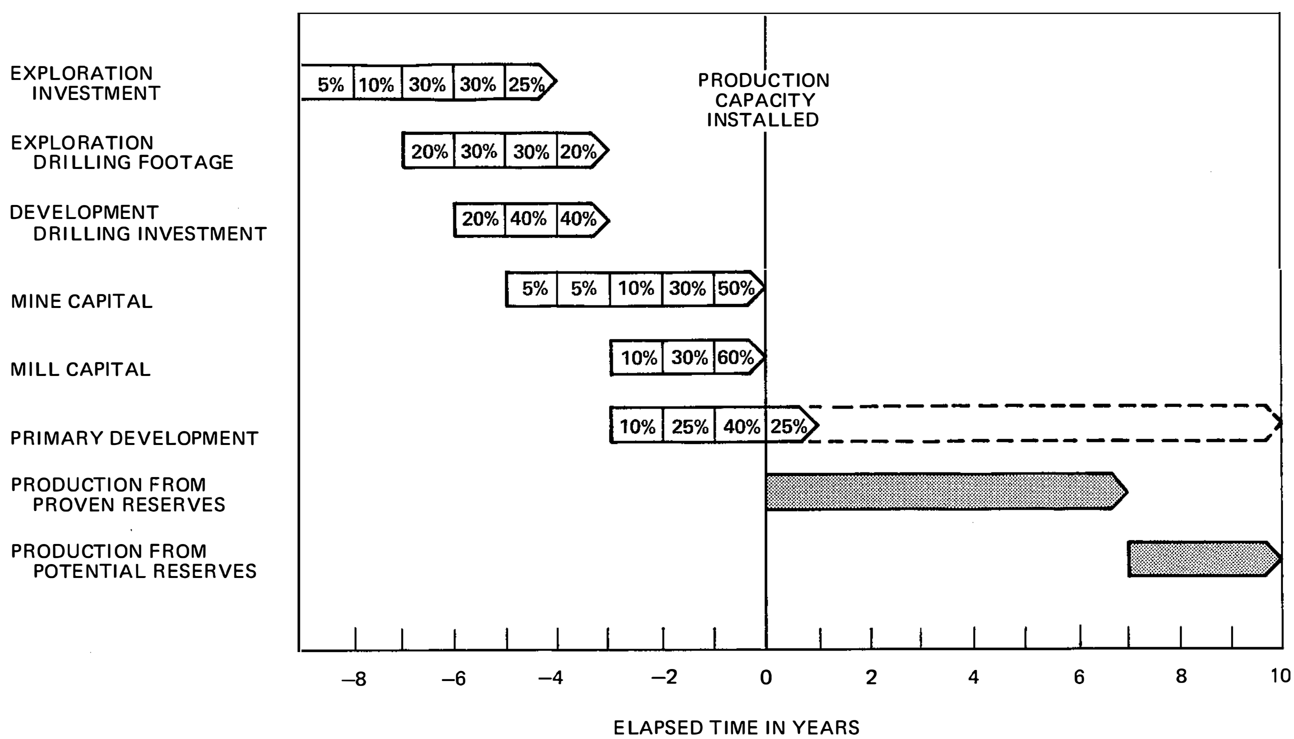


Figure 11. Uranium Exploration and Development Lead Times for Investments and Drilling Activity.

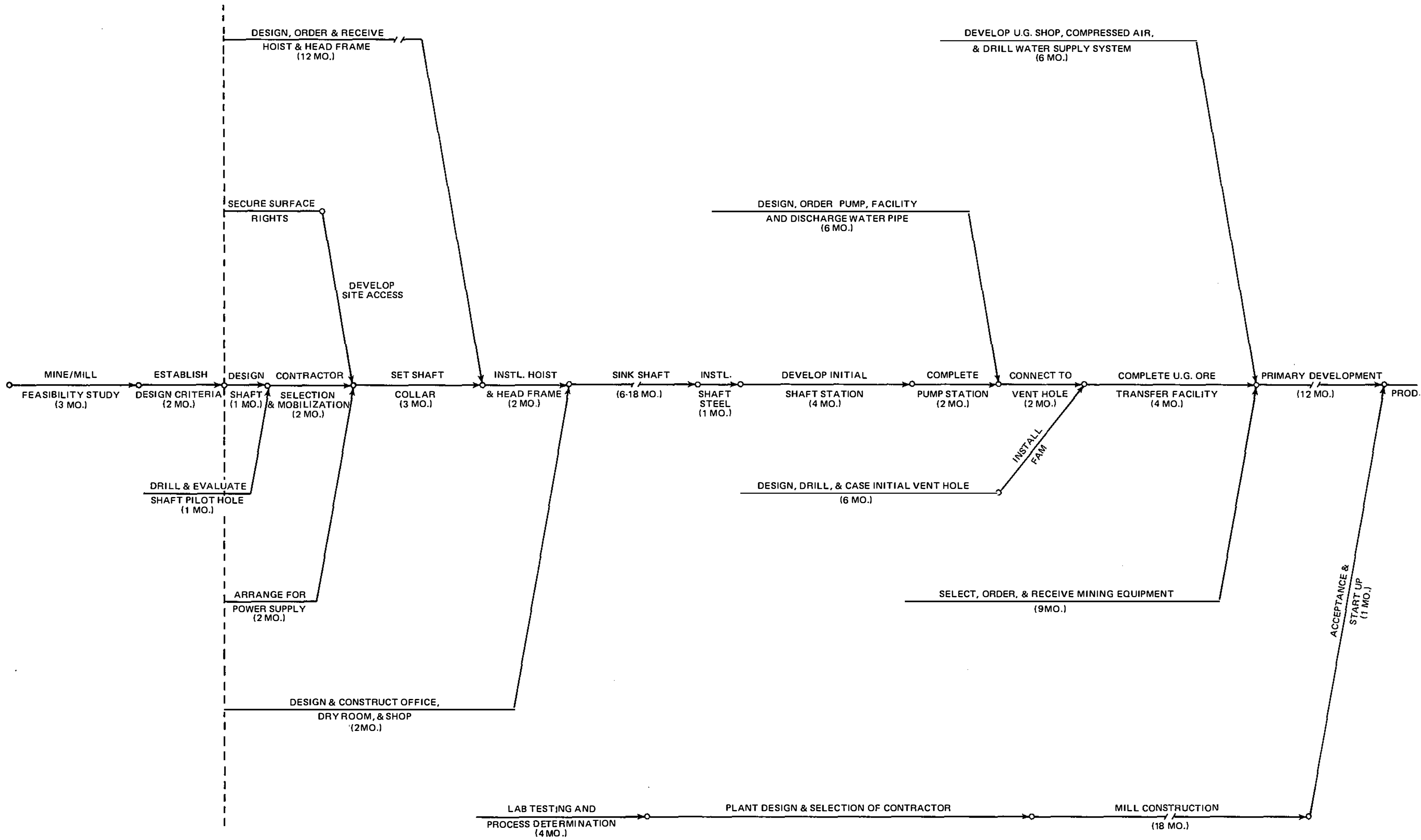


Figure 12. Typical Underground Mine/Mill Development Schedule.

TABLE 22

LEAD TIMES FOR INVESTMENTS AND DRILLING ACTIVITY

Years Prior to Start of Production	Exploration Expenditure (Percent)	Development Drilling Expenditure (Percent)	Drilling Footage (Percent)
10	—	—	—
9	5	0	—
8	10	0	—
7	30	0	20
6	30	20	30
5*	25	40	30
4	—	40	20
3	—	—	—
2	—	—	—
1	—	—	—
0	—	—	—

* Reserve established.

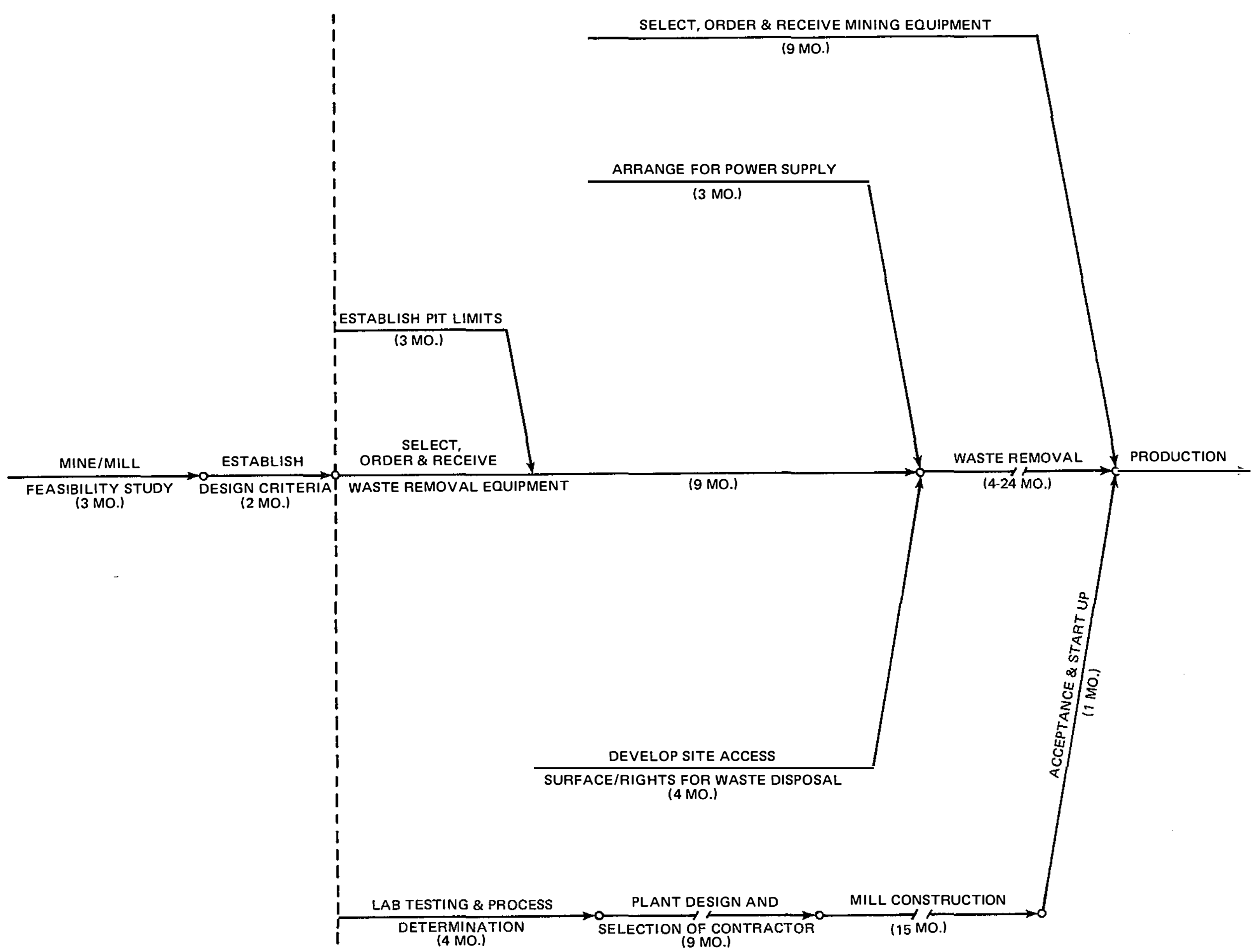


Figure 13. Typical Open-Pit Mine/Mill Development Schedule.

mine. The sequence of activities and timing shown on these figures will, of course, be modified to fit any specific circumstance. In general, however, one could expect a 2- to 3 1/2-year development and construction period for an open-pit mine/mill facility and a 4- to 5-year period for a major underground mine. The lead time requirements for uranium exploration and production are of prime importance since the timing of investments becomes a critical assumption in the DCF return on investment calculations.

The mine/mill capital costs used in the analyses for the sup ply model are--

- Mine construction: \$1.10 per pound of U_3O_8 production capacity
- Mill construction: \$4.25 per pound of U_3O_8 production capacity
- Total: \$5.35 per pound U_3O_8 production capacity.

These expenditures are based on the average future investment for all production centers, open-pit and underground, in the Class 3 and 4 categories (all known properties which could likely support a mine and mill, but for which no construction has been initiated). Further, these figures represent investments made prior to production; an additional assumption is that \$0.15 per pound of U_3O_8 produced will be invested over the producing life of the facilities for equipment replacement and capital additions.

Parametric studies investigate the effect of changes in mine/mill costs on uranium costs. There is a significant economy of scale associated with milling facilities. For example, with an average mill feed ore grade of 4 pounds of U_3O_8 per ton of ore, a 1,500 tons per day mill would cost about \$10 million, while a mill of twice that capacity would cost about \$15 million--an increase of only 50 percent in capital cost. The estimated investment factors are \$5.00 per pound of U_3O_8 capacity at 1,500 tons per day and \$3.75 per pound of U_3O_8 capacity at 3,000 tons per day. The mill investment per pound of U_3O_8 production capacity is, of course, also dependent on ore grade, recovery and the mill operating schedule.

Mine construction costs include all necessary mining equipment and real property. The costs of sinking shafts and station development and/or stripping are not included, but they are carried in a separate cost category termed primary development (discussed in the following section).

Assumptions used regarding lead times for calculation of mine/mill investment are shown in Figure 11.

Primary Development

An average primary development cost of \$0.90 per pound of U_3O_8 produced is used in all demand cases. As shown in Figure 11, some development work will precede production by as much as 4 years, including shaft sinking or stripping and primary underground development.

Operating Costs

The average operating cost used in the analysis for Class 5 production is \$4.35 per pound of U_3O_8. This figure includes royalty and ore hauling but excludes depreciation, amortization, and depletion.

Reserve-to-Production Ratio

The sizing of U_3O_8 production facilities to a proved ore reserve is very important to future discovery requirements and has substantial impact on economic evaluations. In some cases, milling facilities are designed so that they can be readily expanded beyond initial capacity limits based on the probability of developing potential ore reserves in addition to the proved reserve. In general, the basic mine/mill design decisions are based on surface drilling and related to ore reserve estimates that provide information on less than 100 percent of the controlled land. Therefore, additional information on the ore reserve is generated from underground drilling and further surface drilling during the early stages of mine development.

Production center Classes 2 and 3, as defined by the AEC, are based on sufficient proved ore reserves to support economical new production units. These two production capability categories are based on reserves of 92,000 tons of U_3O_8 and are projected to produce approximately 13,000 tons of U_3O_8 per year at what are considered optimum rates or announced production capabilities. This reduces to a reserve-to-production ratio (R/P) of 7.0 as an average of known economical ore bodies which had not been brought to production at the time of the AEC evaluations (January 1, 1971).

For the basic supply cases, it was assumed that, for production from Class 5 properties, (1) an R/P of 7.0 would be required before a new reserve could be placed into production and (2) additional reserves would be found during mine development through the first year of mine operation which would bring the overall R/P to 10.0 (or an average mine life of 10 years).

A parametric study investigates the effect on uranium reserve requirements and costs of changing the initial R/P from 7.0 to 5.0 and 9.0.

Taxes

Assumptions bearing on tax calculations for the four basic cases are:

- Unit-of-production depreciation was used for mine/mill equipment and surface structures.
- Intangible development costs were expensed as incurred.
- Equipment replacement costs were averaged over the production life and written off each year.
- Depletion was calculated each year for the industry as a whole. The 22-percent statutory rate with a 50-percent net income limitation was used.
- Income taxes were calculated at 50 percent of net taxable income.
- Preference taxes were calculated at an effective rate of 8 percent of depletion minus income tax.
- Investment tax credit was allowed at the rate of 7 percent on 80 percent of the mine/mill investment.

A number of tax parametric studies have been made, the results of which are discussed later in this report. A more detailed discussion of the tax assumptions and method of calculation used in the analysis is provided as Appendix F.

Rate of Return on Investment

The supply model was employed to calculate a levelized "price" corresponding to a specified DCF return on investment in each class of production center through 1985. Discount factors used in U_3O_8 "price" computations are: 10 percent, 12.5 percent, 15 percent, 17.5 percent and 20 percent.

LIMITATIONS OF THE SUPPLY MODEL

The supply model allows a fixed set of basic analytical projections to be made by simulation of the uranium raw material supply industry and provides for sensitivity testing of a wide range of influencing assumptions. It is not an econometric or price forecasting model.

The model does allow a "price" analysis of the uranium raw materials industry, treated as a single entity, in terms of the standard DCF rate of return on investment procedure. All significant variables of the internal rate of return on investment analysis are data input to the program and are therefore subject to sensitivity analysis or parameter variation. Further, the computer output provides separate annual schedules of industry operating statistics, investment and operating expenditures and financial data.

The model does not provide year-by-year prices for U_3O_8, but instead calculates a levelized "price" required over the assumed life of production centers in each class which are brought into production through 1985.

The uranium supply model is demand oriented. The model projects sequentially (1) requirements for additional production capacity, (2) reserve additions and (3) physical exploratory requirements. There are no built-in limits to the levels of activity projected except indirectly via the demand case considered. Therefore, the results of the supply model calculations require interpretation and analysis before being considered as valid and reasonable projections. Specifically, the rate of increase in new mining operations, the rate of increase in surface drilling, the rate of increase in ore reserve additions and the adequacy of natural uranium resources must be considered in light of the program output. Also, the demand orientation of the supply model creates some impractical peaks in exploration and production statistics which have been smoothed in presentation of results for improved analysis.

It is emphasized that the U_3O_8 "price" levels associated with a given return on investment calculated by the model are based on *average costs*. The lowest cost production center would, therefore, earn a return greater than 15 percent at the 15-percent return on investment "price" calculation by the model. Conversely, the most marginal production center would be operating at a much lower return than 15 percent at the same "price."

Chapter Four

URANIUM SUPPLY ANALYSIS--RESULTS

PRINCIPAL FINDINGS

In order for the domestic uranium industry to supply Case III requirements, production capability must double by 1980 and double again by 1985. Paradoxically, the present uranium production capacity of about 30 million pounds of U_3O_8 per year is considerably in excess of current demand, and the industry's inventories are expected to increase to about 32 million pounds of U_3O_8 by the end of 1974. Prior to 1980, new production requirements can be supplied from the proved and potential reserves (production classes 3 and 4) provided the necessary mines and mills are constructed. Assuming a continuation of present discovery rates, surface drilling must increase from the current level of about 15 million feet per year to about 45 million feet per year by 1977 in order to discover the reserves needed to assure domestic uranium supply in the 1980-1985 time period.

For Case I, substantial production from future discoveries (Class 5) will be needed in 1979 requiring surface drilling levels of over 60 million feet per year by 1976.

Supplying Case II requirements also requires production from future discoveries in 1979, with surface drilling approaching 50 million feet in 1976.

Case IV, on the other hand, will not require production from future discoveries until the assumed termination of the Government stockpile disposal program in 1982. For Case IV, surface drilling requirements lag approximately 1-1/2 years behind Case III.

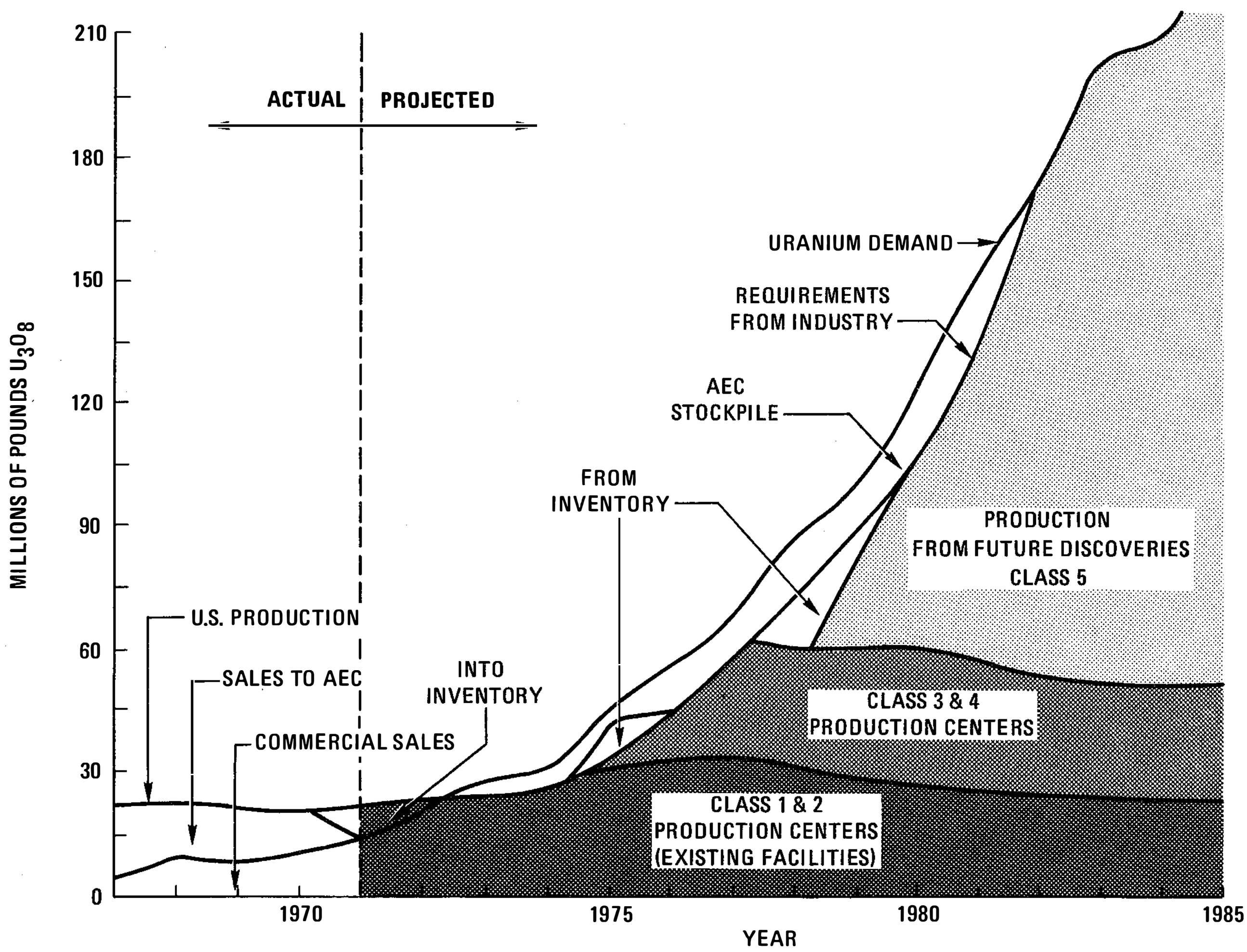
Information generated by the uranium supply model was compiled in three separate schedules: (1) Schedule A, which is a summary by year of U_3O_8 demand, plus associated exploration and production requirements; (2) Schedule B, which is a summary by year of uranium raw material investment requirements and operations costs; and (3) Schedule C, which is a pro forma income statement and cash flow projection by year. The supply model output for the four supply cases, reporting industry activity levels and capital investments (Schedules A and B), is included as Appendix G. A sample of the Schedule C report is also included in Appendix G. Data shown for Schedules A and B are for the years 1971 through 1985. Schedule C data are provided through the year 2000.

INTERPRETATION AND ILLUSTRATION OF RESULTS

The purpose of the supply model was to provide estimates of the various requirements needed to accommodate a previously calculated schedule of uranium demands. In constructing the model, however, certain assumptions were used--i.e., the sudden phaseout of the stockpile disposal program, the accommodation of current excess industry inventories and the inflexible rates of production for Class 1-4 production centers which have subsequently created minor variations in some of the supply model estimates. In particular, variations have appeared in the detailed annual projections of production requirements, reserve additions and drilling activity levels. In view of these variations, some of the supply model results shown graphically in this section have been purposely smoothed in order that a more reasonable pattern of industry requirements may be illustrated.

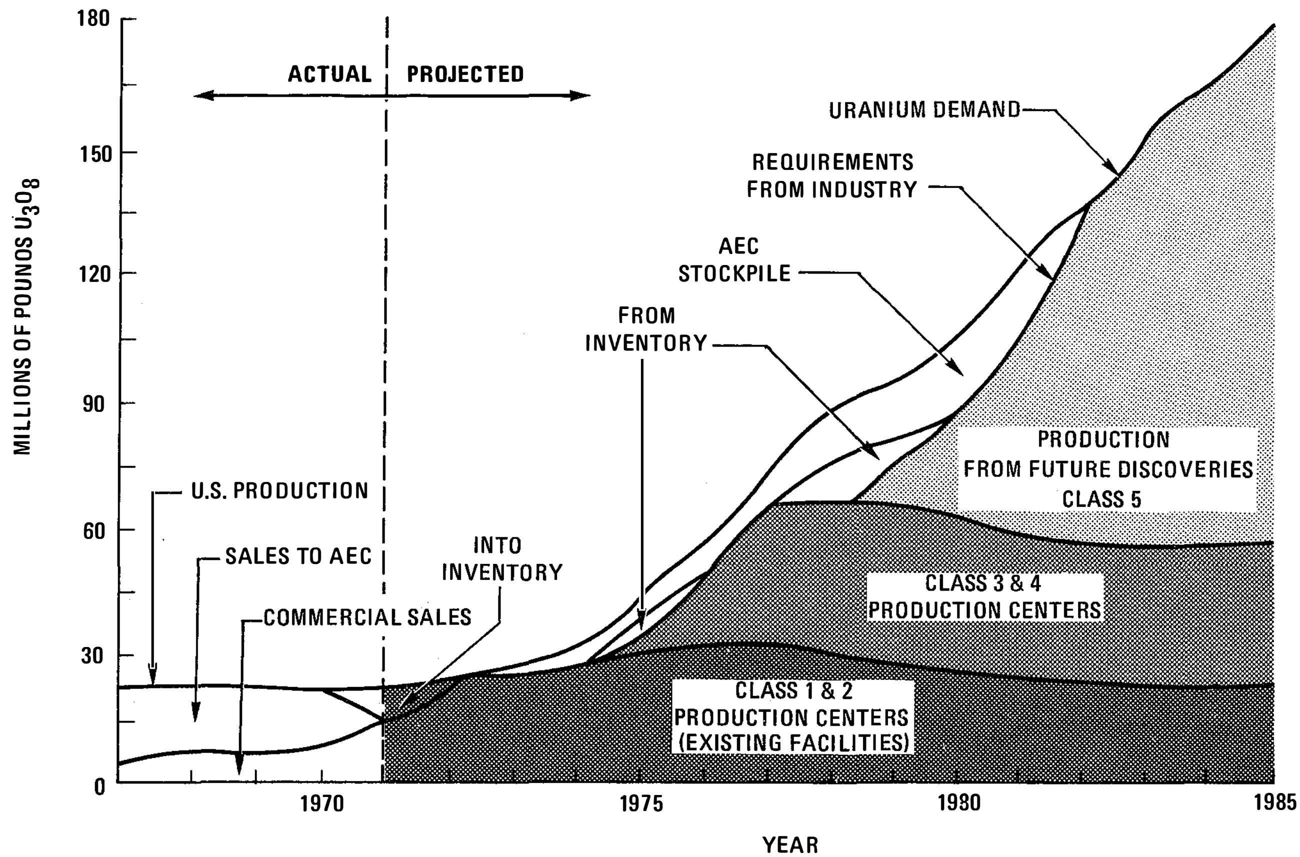
Production Requirements

For each of the four demand cases, estimates of annual U_3O_8 supply were calculated, as shown in Figures 14 through 17. Total



NOTE: "Uranium Demand" quantities reflect an enrichment plant tails assay of 0.275 percent. "Requirements from Industry" reflect an enrichment tails assay of 0.20 percent through 1981 and 0.275 percent thereafter. See Table 13. Variations in supply from inventory. are due to the utilization of a fixed pattern of future production from Class 3 and 4 production centers for all supply cases (I—IV).

Figure 14. Estimated Annual U_3O_8 Supply--Case I.



***NOTE:** "Uranium Demand" quantities reflect an enrichment plant tails assay of 0.275 percent. "Requirements from Industry" reflect an enrichment tails assay of 0.20 percent through 1981 and 0.275 percent thereafter. See Table 13. Variations in supply from inventory are due to the utilization of a fixed pattern of future production from Class 3 and 4 production centers for all supply cases (I—IV).*

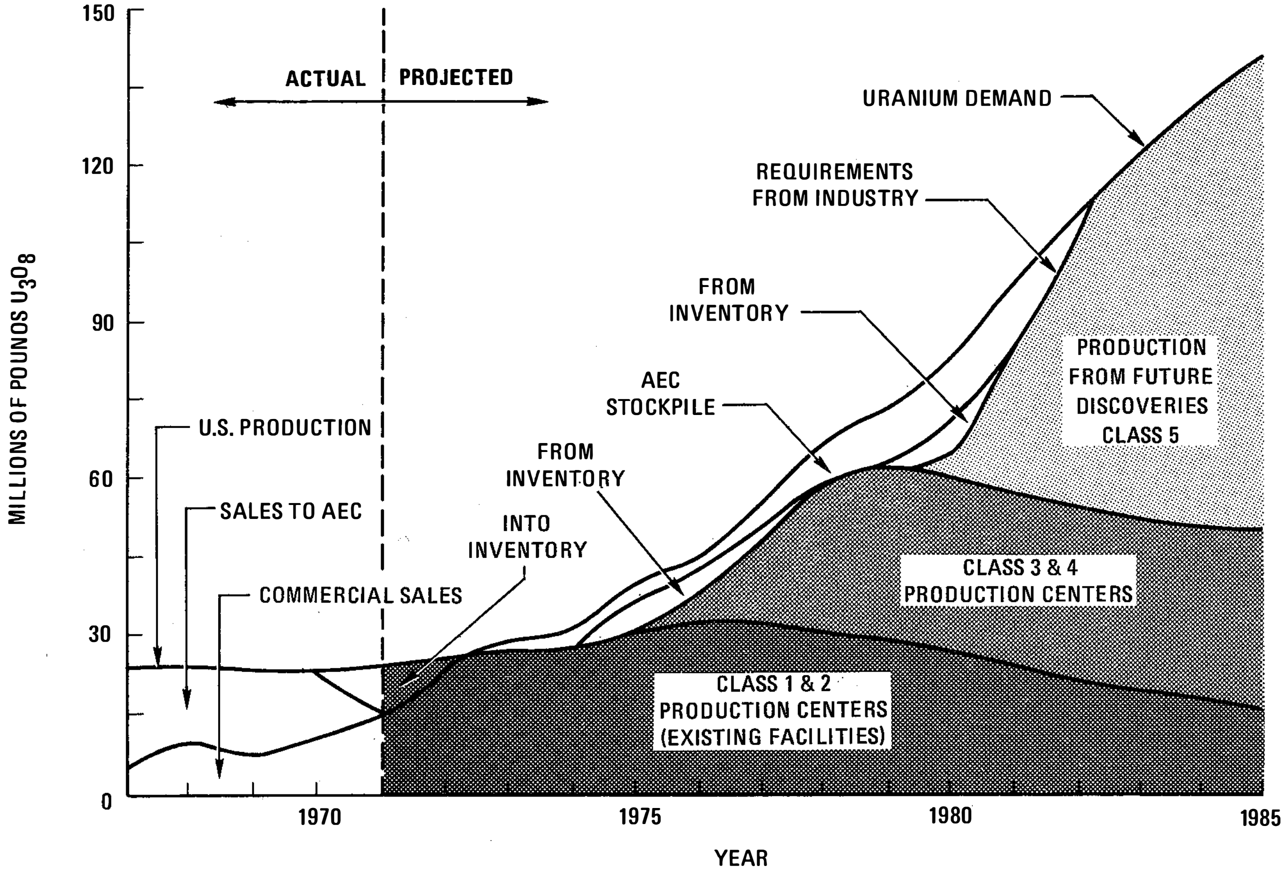
Figure 15. Estimated Annual U_3O_8 Supply--Case II.

U_3O_8 production from existing and new facilities through the year 1985 is summarized in the following schedule.*

	Million Pounds U_3O_8			
	Case I	Case II	Case III	Case IV
U_3O_8 Production (1971-1985)	1,400	1,200	1,000	800

In Cases I and II, production is required from Class 3 properties in 1975, from Class 4 properties in 1976 and from yet undiscovered properties (Class 5) as early as 1979. For Case III, which corresponds to the AEC's "most likely" nuclear growth forecast, production is required from Class 3 properties in 1976, from Class 4 properties in 1977, and from yet undiscovered reserves (Class 5 properties) in 1980. For Case IV (the low demand case), Class 3 production is not needed until 1979, Class 4 until 1980, and Class 5 until 1982.

* Adjusted for inventory and stockpile disposal.

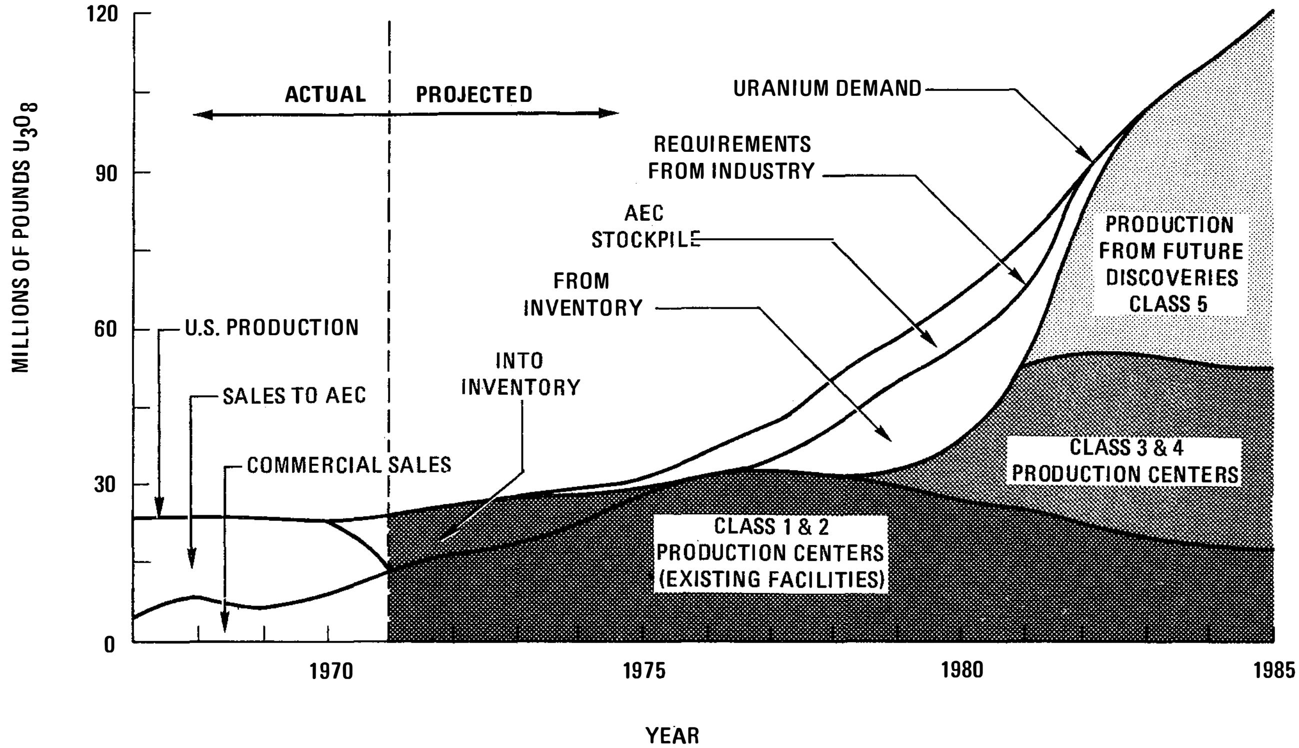


NOTE: "Uranium Demand" quantities reflect an enrichment plant tails assay of 0.275 percent. "Requirements from Industry" reflect an enrichment tails assay of 0.20 percent through 1981 and 0.275 percent thereafter. See Table 13. Variations in supply from inventory are due to the utilization of a fixed pattern of future production from Class 3 and 4 production centers for all supply cases (I—IV).

Figure 16. Estimated Annual U_3O_8 Supply--Case III.

Figures 14 through 17 also illustrate the use of industry inventories in meeting the projected U_3O_8 demands. It can be noted, however, in Cases I through III (Figures 14 through 16) that inventory is utilized in two separate time periods. This results from Class 3 and 4 production being introduced at a fixed rate as specified by the AEC's analysis of production from Class 3 and 4 properties. The supply model does not allow for an adjustment of the rate of bringing on Class 3 and 4 production since the investment and operating cost figures utilized in subsequent sections of the analysis are tied to the given production growth pattern. It should be remembered that the supply model is a theoretical model and that in practice the rates of production from new properties would likely be adjusted to accommodate the inventory in earlier years.

Figures 14 through 17 also show the contributions from the Government-owned uranium stockpile. The stockpile is utilized for each supply case on the basis of the recently announced AEC plan for disposal (the split-tails scheme). For each case, the disposal program has been projected to end in 1981; therefore, the quantity



NOTE: "Uranium Demand" quantities reflect an enrichment plant tails assay of 0.275 percent. "Requirements from Industry" reflect an enrichment tails assay of 0.20 percent through 1981 and 0.275 percent thereafter. See Table 13. Variations in supply from inventory are due to the utilization of a fixed pattern of future production from Class 3 and 4 production centers for all supply cases (I—IV).

Figure 17. Estimated Annual U_3O_8 Supply--Case IV.

of the stockpile disposed in the domestic market is greater for Case I than for Case II, and for Case II it is greater than for Case III, etc. The maximum quantity of Government uranium stockpile disposal projected is under the Case I assumption where approximately 86 million pounds of U_3O_8 is projected to be fed into the domestic market between 1973 and 1982. For Case IV the corresponding quantity is 49 million pounds of U_3O_8 from stockpile material.

Drilling and Discovery Requirements

Figure 18 shows the annual U_3O_8 reserve additions required in Case III. It is important to note that, in this case, new discoveries must account for only 30 percent of reserve additions in 1972 but that this proportion increases to 80 percent by 1985. In projecting new discovery requirements (ore reserve additions), two critical assumptions were made: (1) that the average R/P for new production centers is 7.0 and (2) that the lead time between establishing a proved reserve and first production will average 5 years. These assumptions allow for the calculation of future reserve requirements. This concept differs from present industry practice of analyzing forward reserve requirements in terms of an 8-year or 10-year forward supply. The supply model assumptions equate to ap-

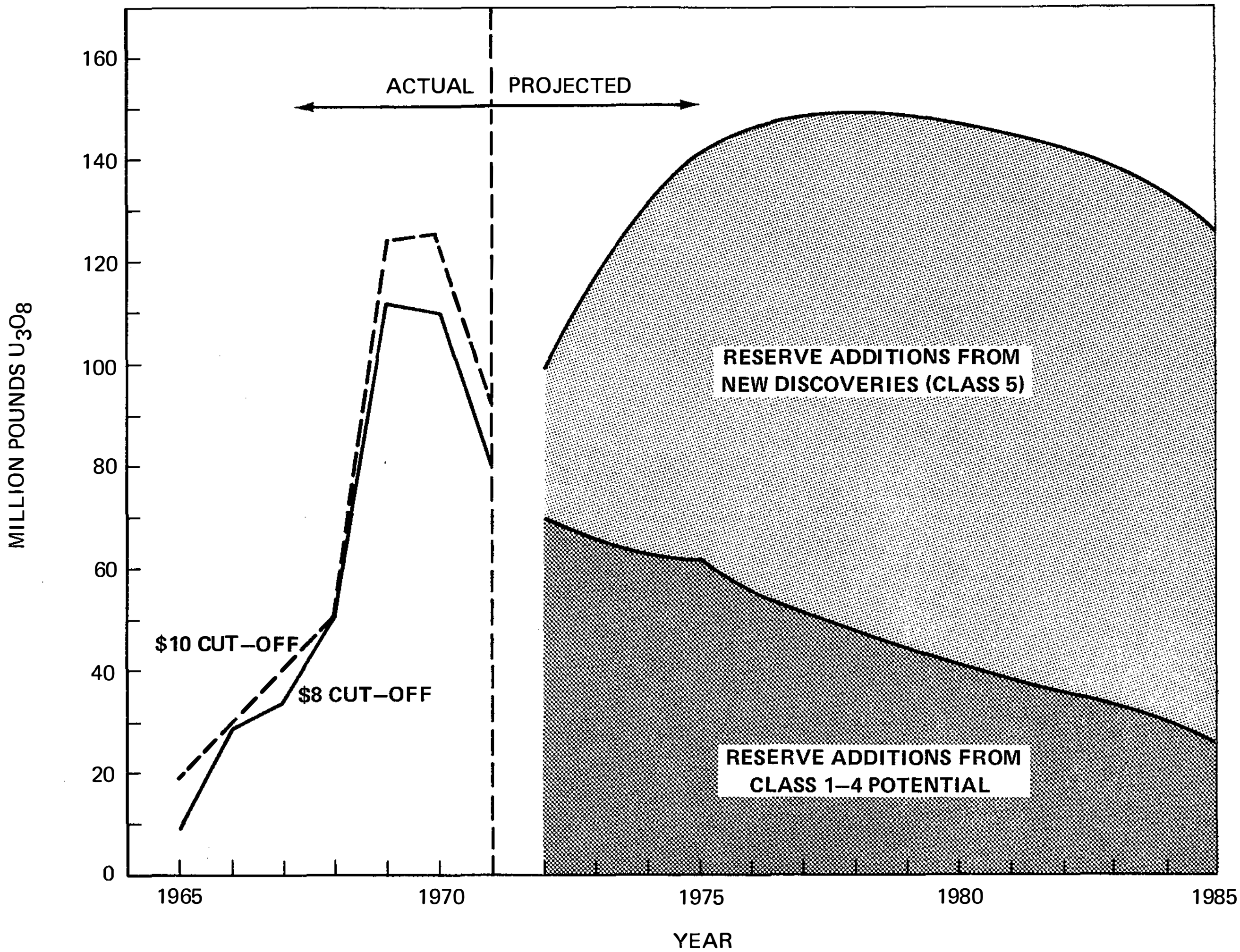
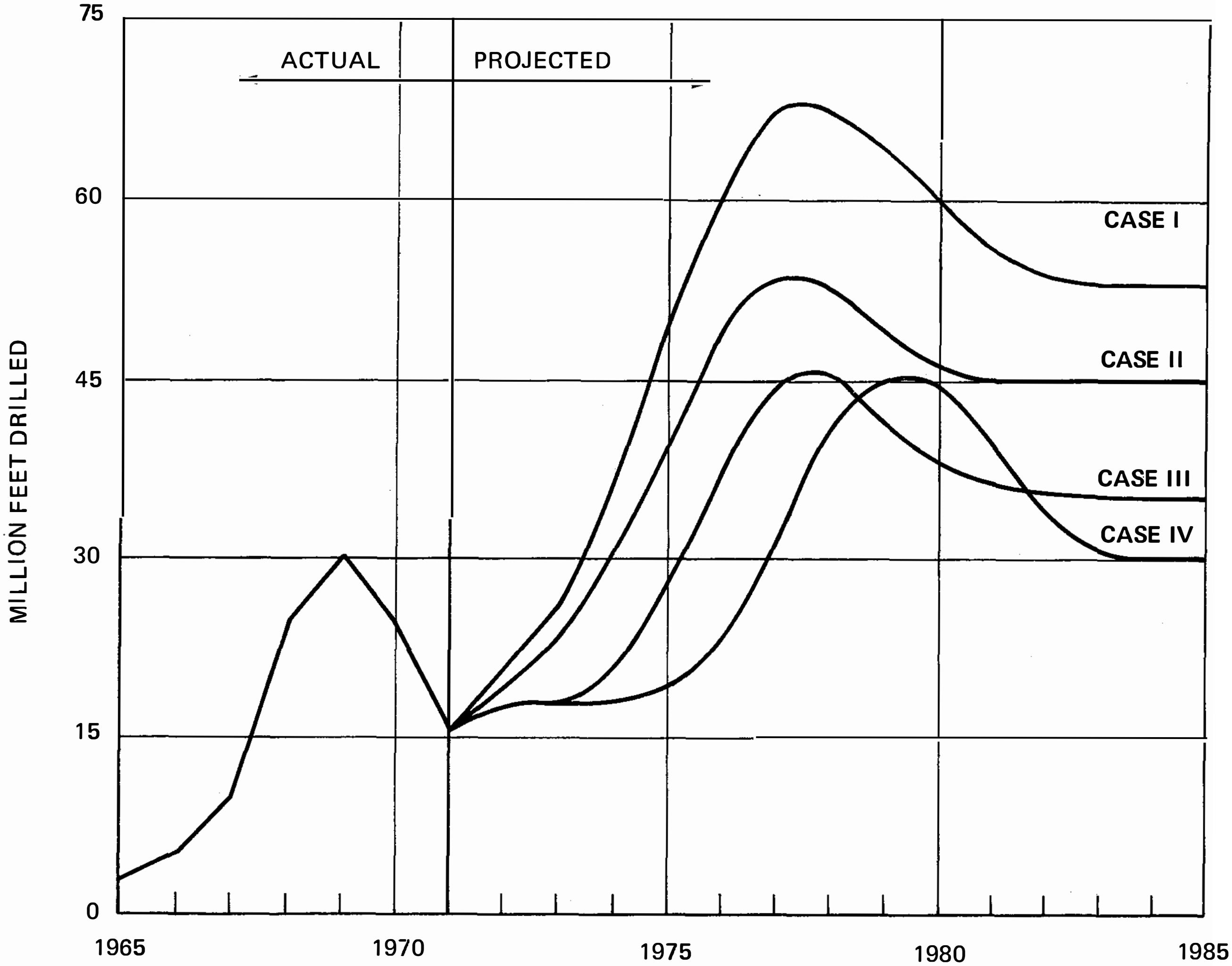


Figure 18. Annual U_3O_8 Discovery Requirements--Case III.

proximately a 10-year forward reserve for the low supply case studied. Some of the parametric studies, however, have assumed different forward reserve requirements.

Figure 19 shows the projected amount of surface drilling required per year for each supply case. It is obvious that a reversal of the recent downward trend in drilling activity is necessary even in the most pessimistic case. To achieve the Case I projection, the 1971 level of surface drilling must be doubled by 1973, while for Case II it must be doubled by 1974. The drilling footage required for Cases III and IV would not appear to press the industry.

The significant increase in surface drilling during the second half of the 1970's is needed to find uranium ore reserves for the new production centers that will be required to meet the substantial increases in U_3O_8 production projected for the 1980's. The peak in exploration and discovery requirements during the late 1970's is brought on by several factors affecting demand in the early 1980's:



Note: Levelized to drilling rate required to support a 10-year minimum forward reserve at the 1985 demand level.

Figure 19. Annual Surface Drilling Requirements--(Assumptions-Production Classes 1-5 Discovery Rate - 4 lb./ft. U_3O_8).

- The need to replace government stockpile deliveries, which are assumed to cease in 1981, with new production
- The retirement of existing production centers (Class 1) which must be replaced
- The rapid market growth projected for the 1980's.

The subsequent decline in annual drilling is due to the leveling out in demand for uranium during the late 1980's as a result of the introduction of fast breeder reactors.

Investment Requirements

Between 1972 and 1985, cumulative total uranium raw material investment is projected to range from $3.7 to $6.0 billion.

A capital investment summary for each of the four cases for the years 1972, 1975, 1980 and 1985 is shown in Figure 20, the an-

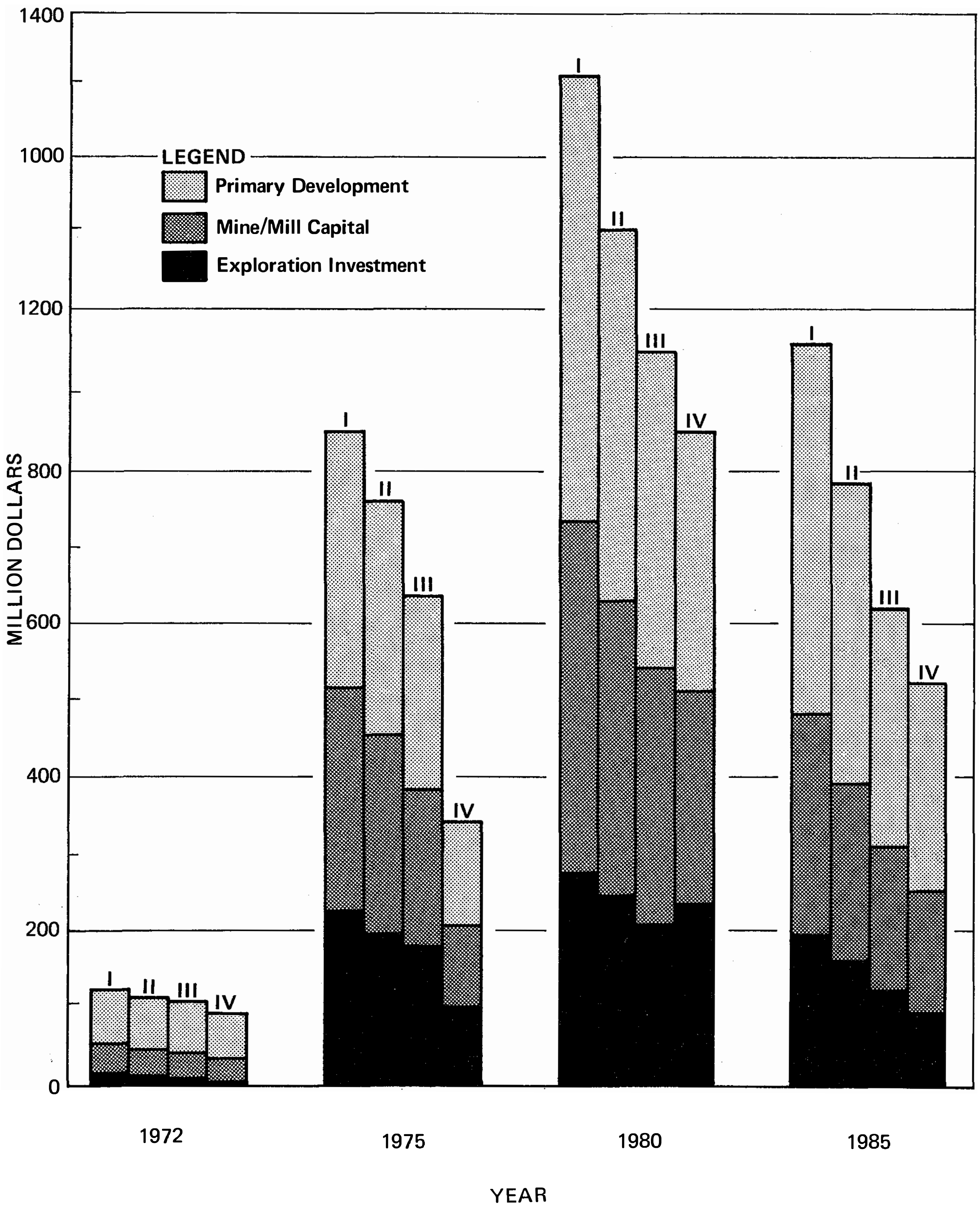


Figure 20. Uranium Raw Materials Capital Investment Summary.

nual investment peaks in 1980 in all cases. The pattern is cyclical with the emphasis being on exploration investment in the early period and mine/mill investment in the later period.

The decline in investment requirements after 1980 reflects (1) completion of the large buildup in production capacity which is needed to meet market requirements in the 1980-1985 period and (2) reduction in post-1985 uranium demand caused by the introduction of the breeder reactor.

Calculated Uranium "Price"

Using the detailed cost and lead time assumptions described earlier, a levelized uranium "price" required to yield a specified return on invested capital was calculated. These levelized "price" calculations (as a function of the DCF rate of return) are plotted in Figure 21 for Class 3, 4 and 5 production centers. The "prices" are the same for each of the four supply cases and were presented earlier in Table 5.

Production from Class 3 and Class 4 properties is expected to require a lower "price" for a given return than production from Class 5 properties because exploration costs required to delineate those reserves already determined to be associated with Class 3 and

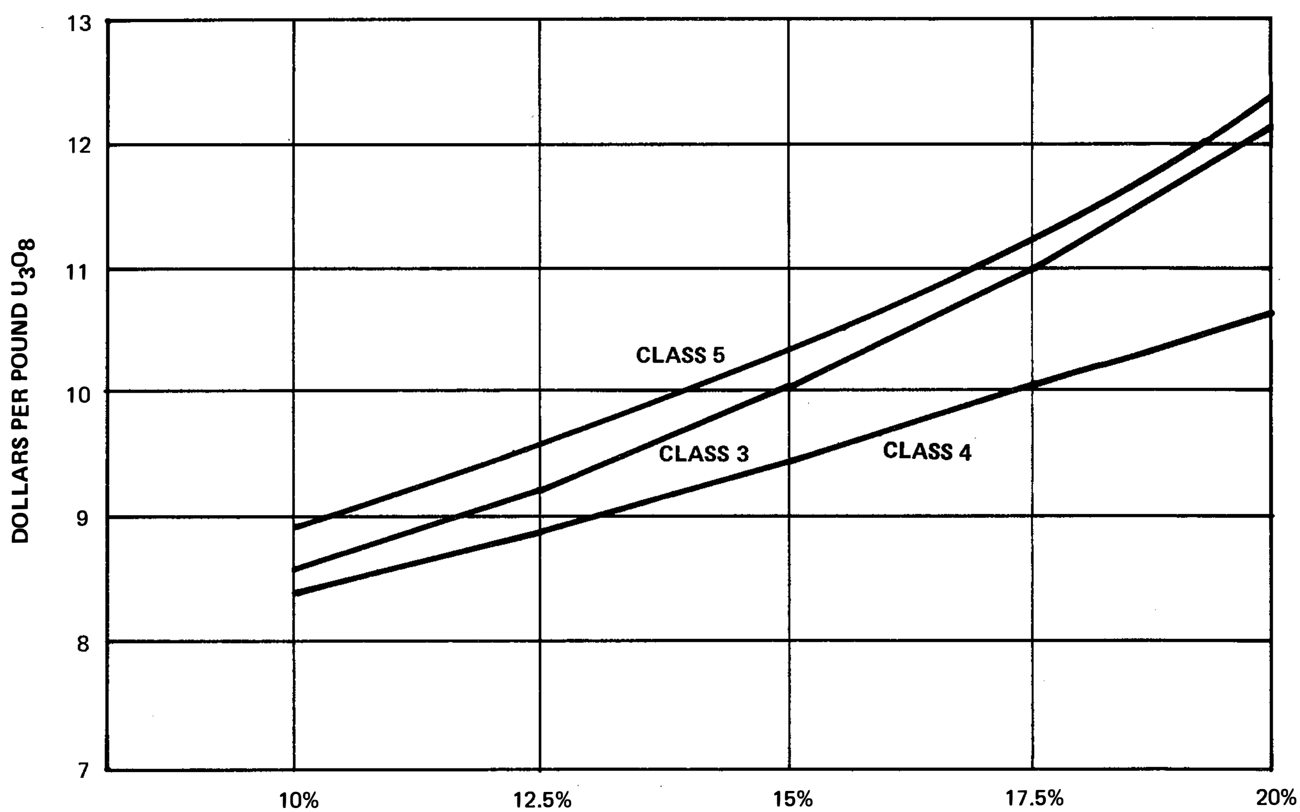


Figure 21. "Price"/Pound U_3O_8 vs. DCF Rate of Return for Production Classes 3,4 and 5.

4 properties can be expected to be less than the exploration cost associated with making new discoveries (Class 5 properties). Class 3 production, however, will require a higher "price" than Class 4 production because Class 3 production centers include primarily underground resources which result in higher mining costs, while Class 4 production centers include a larger percentage of surface resources, resulting in lower mining costs.

PARAMETRIC STUDIES

A number of parameter variations were studied with the aid of the uranium supply model in order to identify those variables which have the most significant effect on uranium supply and "price" calculations. The most significant of these variables are discussed in the following sections.

The magnitude of the exploration effort required to provide a given level of uranium supply is inversely proportional to the discovery rate. Figure 22 portrays this relationship. It should

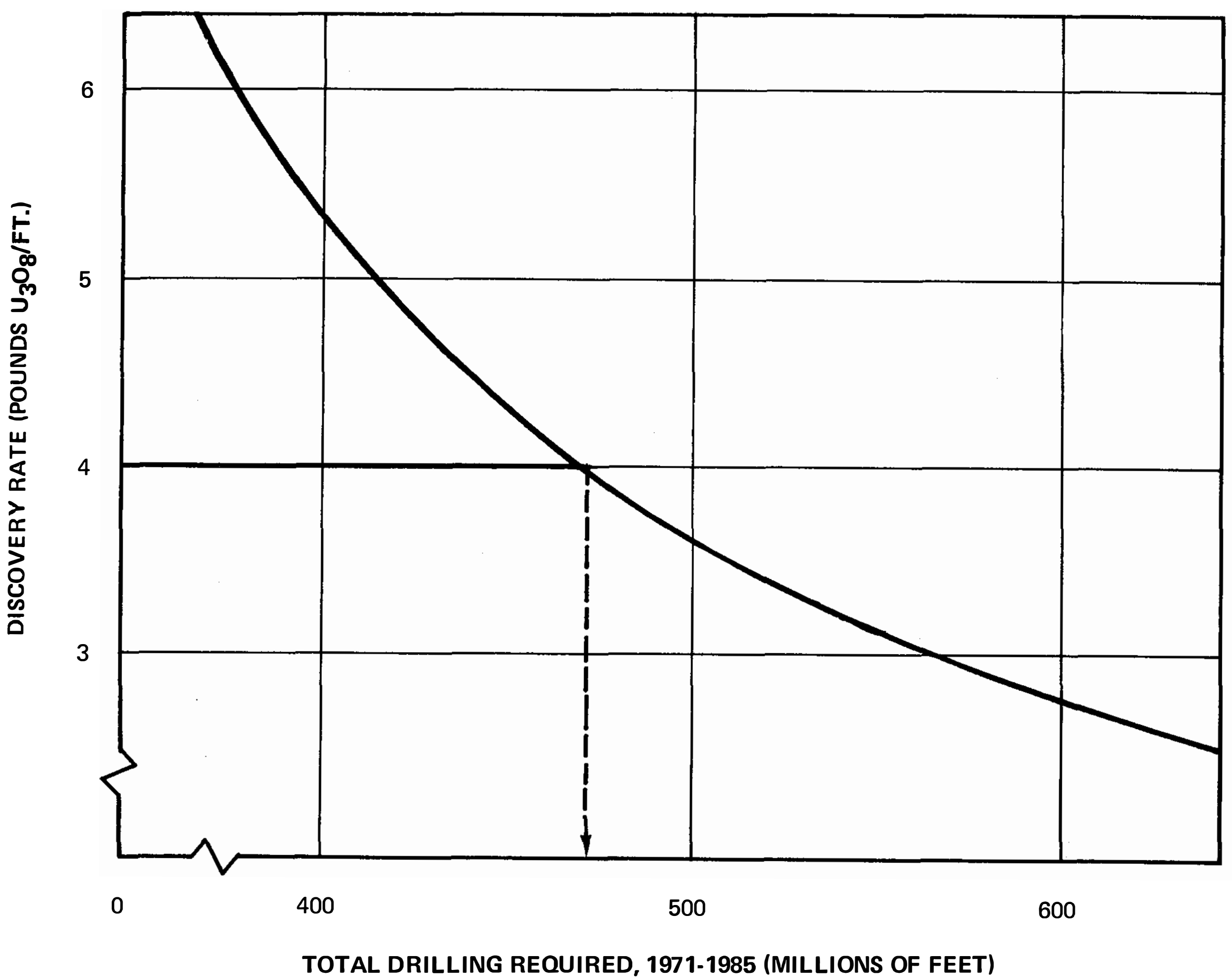


Figure 22. Parametric Study--Case III Drilling Footage vs. Discovery Rate.

also be noted that the effect of changes in the discovery rate on the calculated uranium "prices" is very significant. Figure 23 shows, over a range of discovery rates, the variation in calculated "prices" of U_3O_8 from Class 5 properties for DCF returns on investment between 10 percent and 20 percent. A reduction in the discovery rate from 4 pounds per foot, as used in the basic supply cases, to 2 pounds per foot increases the calculated "price" of U_3O_8 at a 15-percent return, from about $10.50 per pound to over $14.00 per pound. This represents a 40-percent increase.

Reserve-to-Production Ratio

The amount of exploration effort needed to support a given level of uranium supply is affected significantly by the quantity

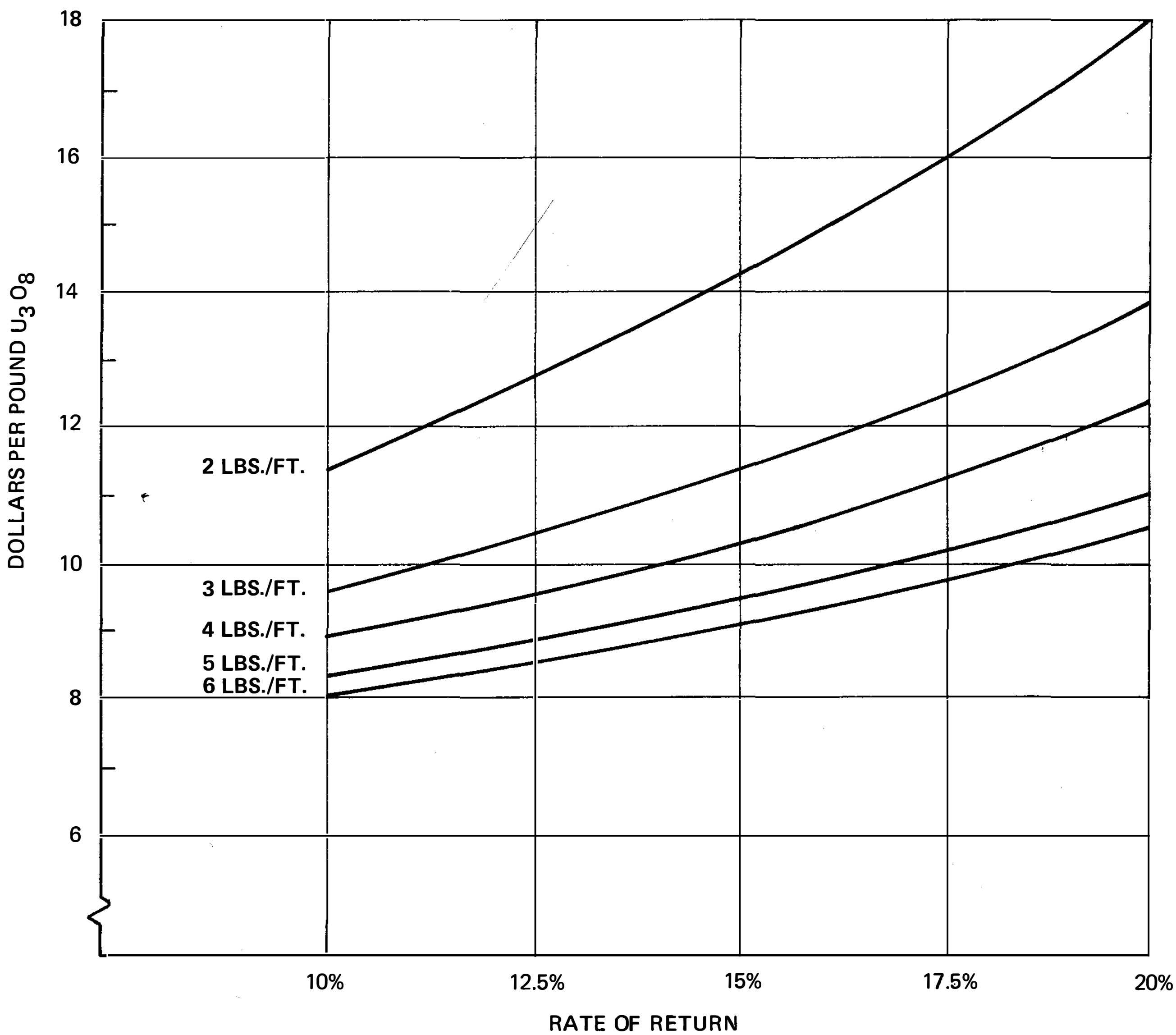


Figure 23. Parametric Study--Case III (Future Discoveries) Class 5 "Price"/Pound U_3O_8 vs. Discovery Rate.

of known reserves deemed necessary to be "in-hand" to sustain future production, i.e., the desired reserve-to-production ratio. The assumption in the basic supply cases was that an initial R/P of 7.0 would be representative of new uranium production operations.* Under the demand assumptions of Case III, an initial R/P of 9.0 for Class 5 properties would increase the need for new reserve additions by about 25 percent annually, while a ratio of 5.0 would decrease this need by about 25 percent (see Figure 24). Surface drilling requirements are affected by changes in the initial R/P in the same manner as reserve requirements are affected (see Figure 25).

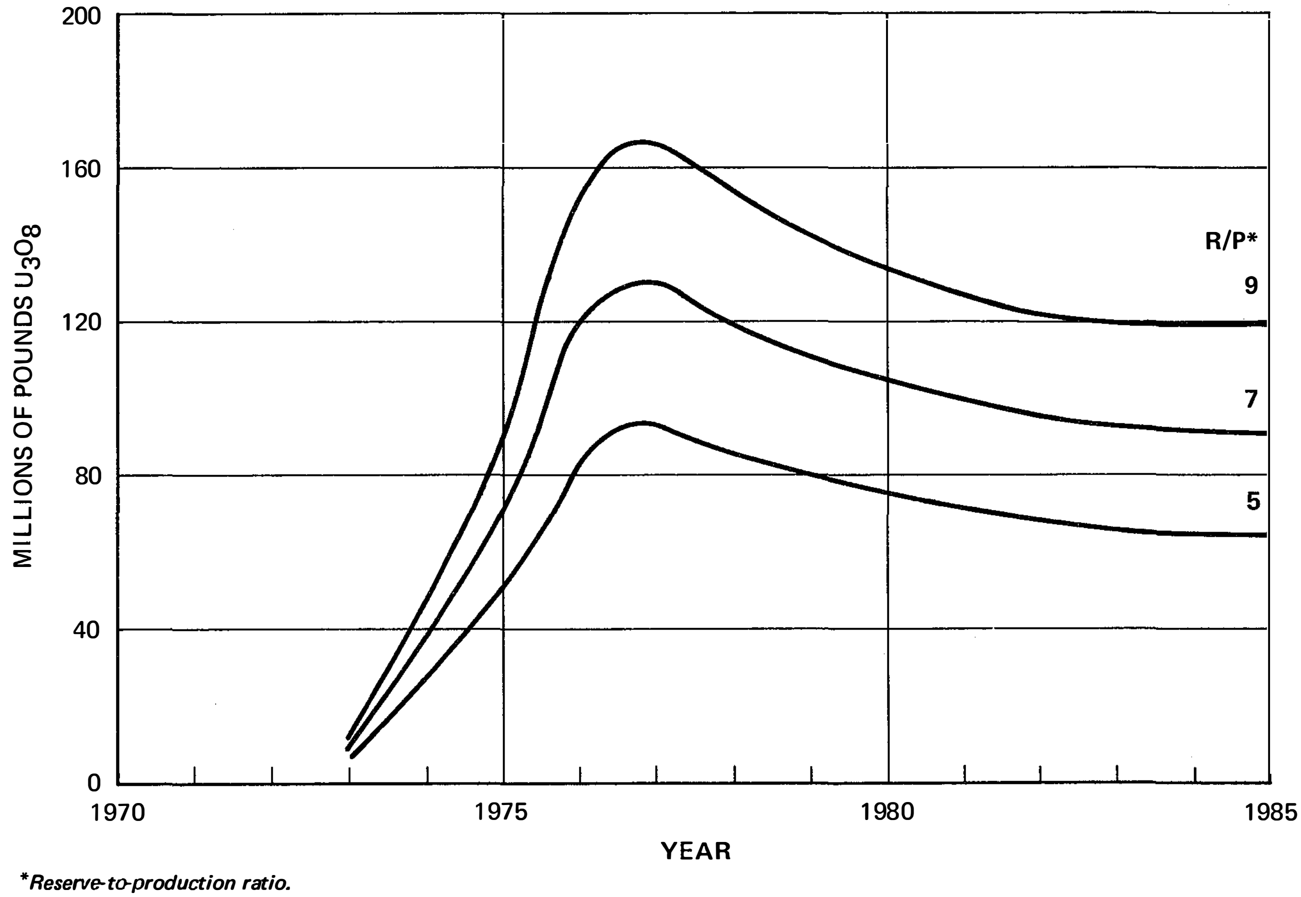


Figure 24. Parametric Study--Case III (Future Discoveries) Class 5 Reserve Additions vs. Reserve-to-Production Ratio.

The effect of variations in the R/P on calculated "prices" at various rates of return is illustrated in Figure 26. An increase in the R/P of 7.0 to 9.0 would cause an increase in the calculated "price" of U_3O_8 of about $0.50 per pound at a 15-percent DCF rate of return on investment.

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* Because of the lead time assumed for mine capital investment, this means that a reserve of seven times the expected annual rate of production must be proved approximately 5 years prior to the time production begins.

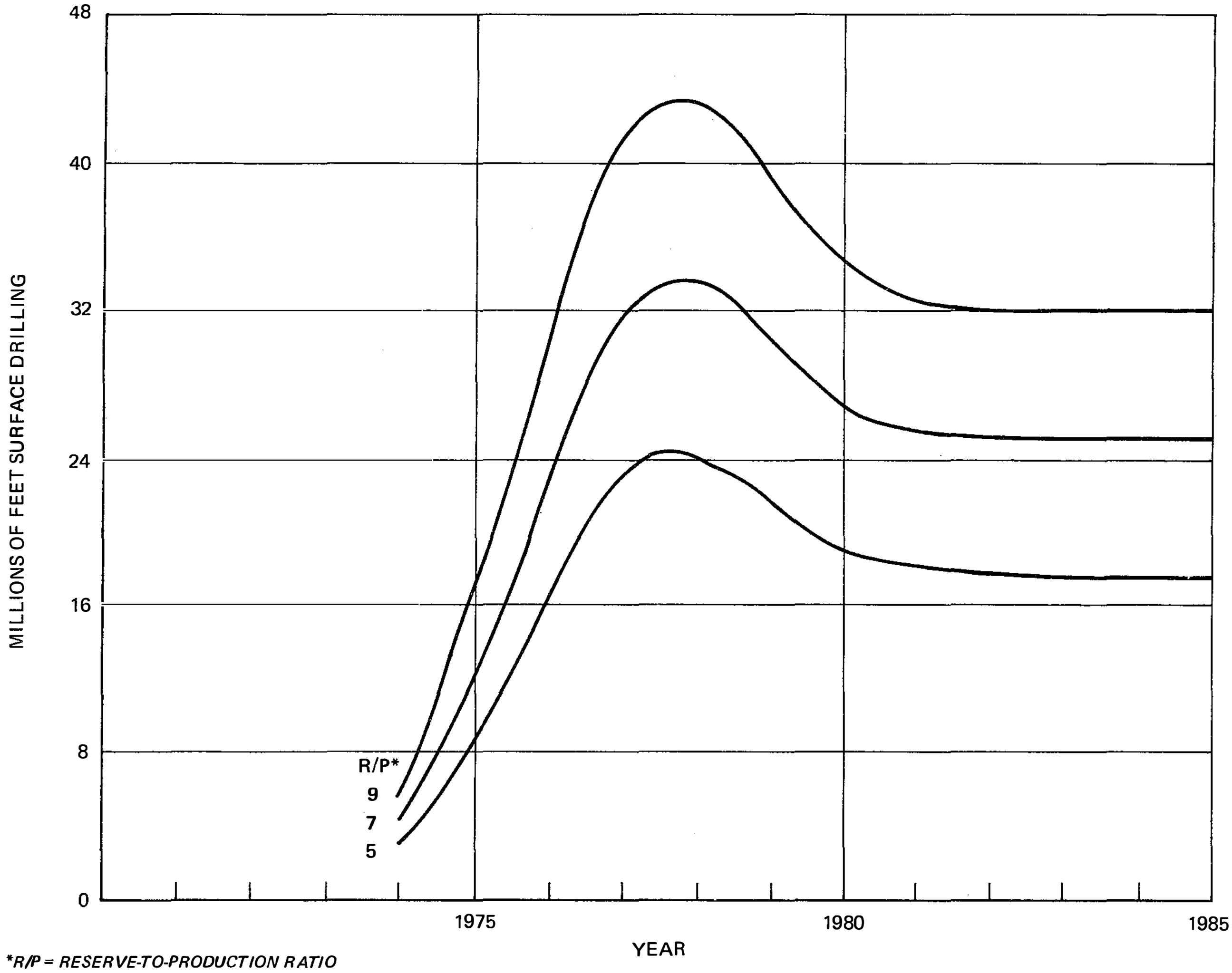
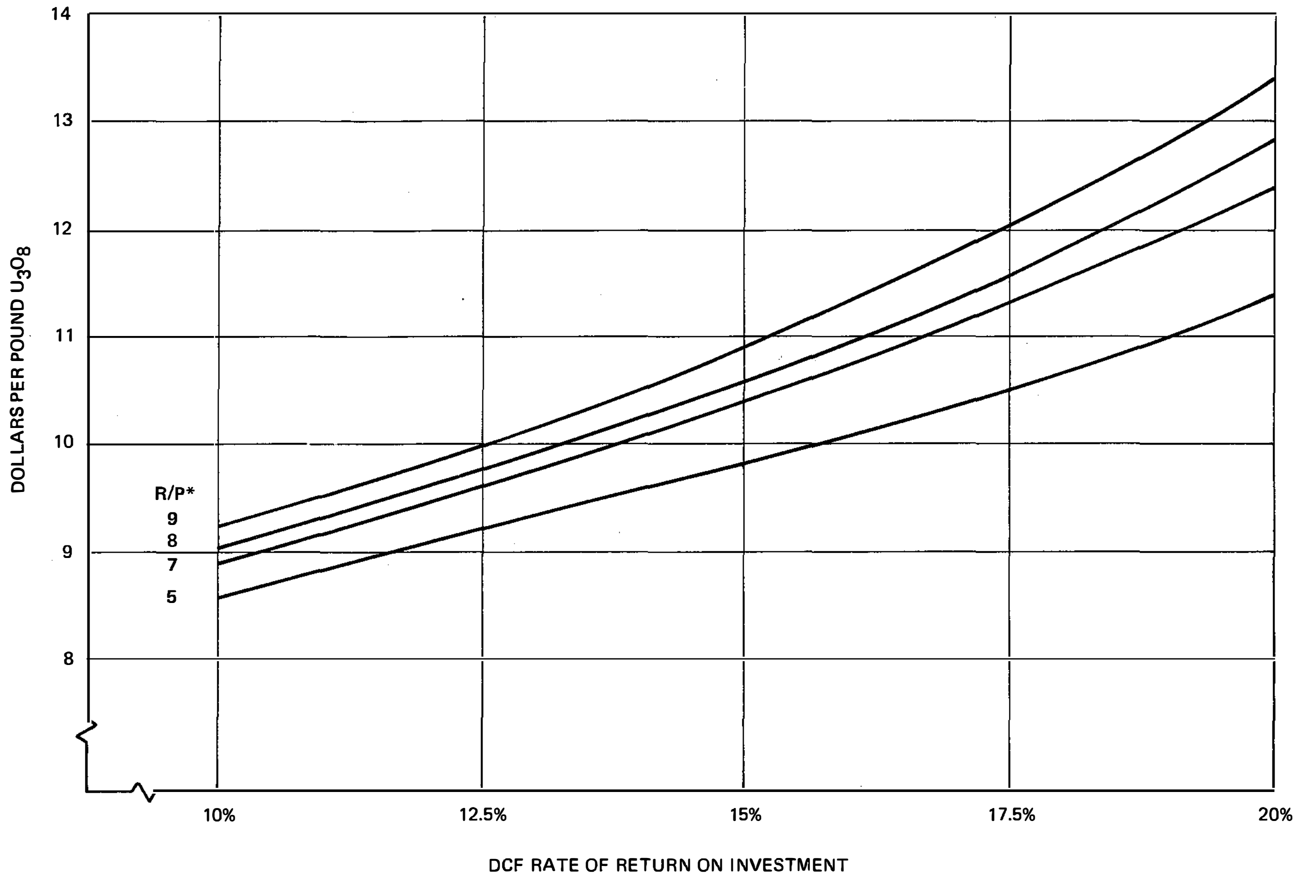


Figure 25. Parametric Study--Case III-- Drilling to Prove (Future Discoveries) Class 5 Reserves vs. Reserve-to-Production Ratio.

The initial R/P of 7.0 assumed for the basic supply cases does not provide sufficient reserves to sustain production over the assumed mine life of 10 years. Therefore, the required additional 3 years of potential reserves were assumed to have been proved during the first year of production from a new mining facility. Because of the long lead times between the years of exploration investment and first production, it is evident that there is an economic tradeoff between (1) expenditures in the early years to prove up reserves guaranteeing an increased mine life and (2) keeping the exploration investment to the minimum required for an economically viable production operation.

Mine/Mill Investment

Although the investment in mining and milling facilities is probably more certain for any specific project than are exploration costs, there may be a considerable range of capital costs because



*R/P = RESERVE-TO-PRODUCTION RATIO

Figure 26. Parametric Study--Case III (Future Discoveries) Class 5 "Price"/Pound U_3O_8 vs. Reserve-to-Production Ratio.

of differences in ore grade and in annual tonnage capability of mills associated with specific production centers. The effect of increased mine/mill investment on calculated uranium "prices" is, however, relatively small, as shown in Table 23.

TABLE 23

EFFECT OF INCREASED MINE/MILL INVESTMENT

DCF Rate of Return on Investment	"Price"/lb. U_3O_8 for Basic Cases I-IV (Class 5)	Effect on "Price" with Increased Investment				
		10%	20%	30%	40%	50%
10%	\$ 8.91	\$ 8.99	\$ 9.09	\$ 9.19	\$ 9.28	\$ 9.39
12.5%	9.59	9.67	9.79	9.91	10.03	10.13
15%	10.37	10.47	10.60	10.73	10.86	10.99
17.5%	11.27	11.39	11.55	11.71	11.87	12.01
20%	12.39	12.53	12.74	12.89	13.08	13.25

Note: Based on 1970 costs and on average costs.

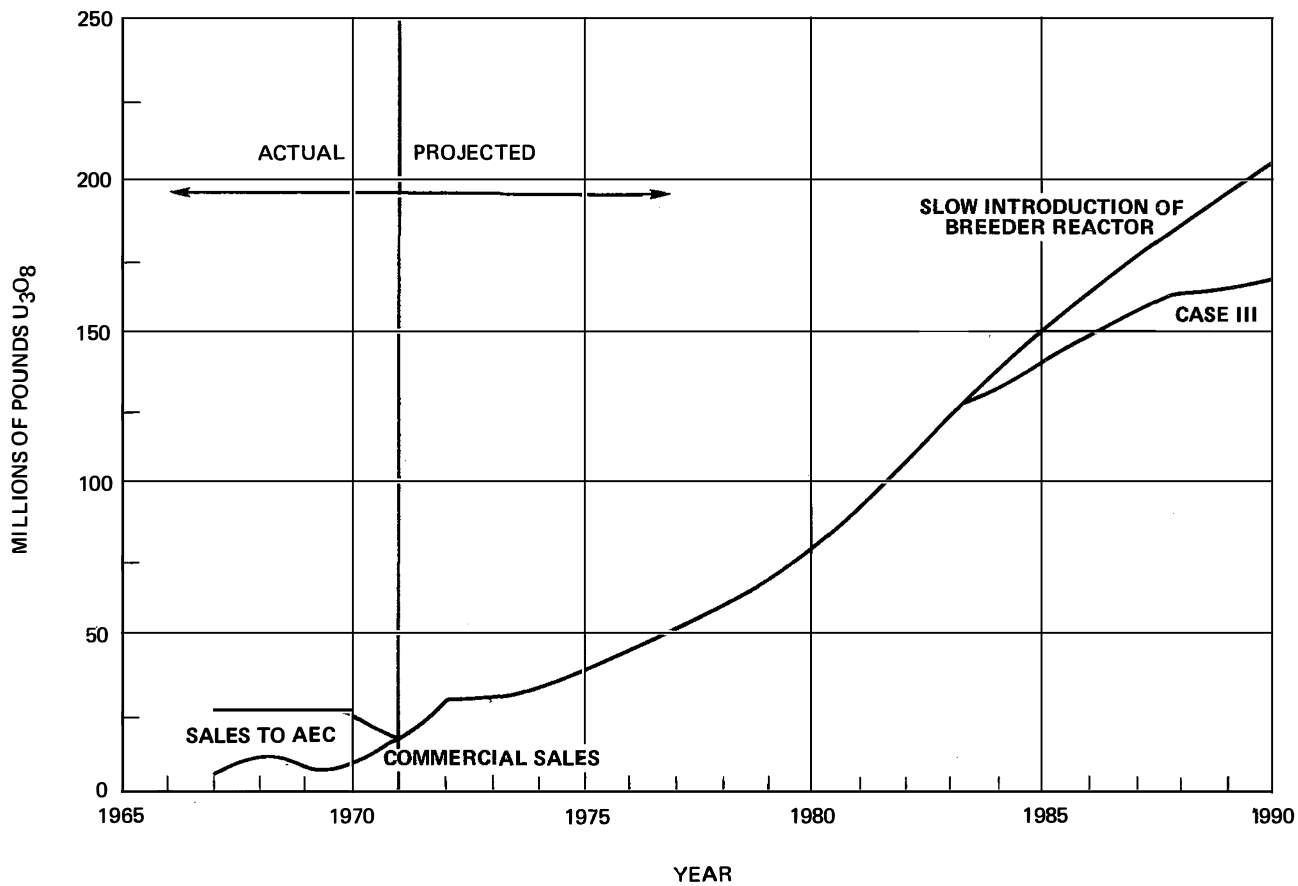


Figure 27. Parametric Study--Annual U_3O_8 Demand Assuming Slow Introduction of Breeder Reactors.

Tax Alternatives

Possible variations in the tax laws affecting uranium were studied. However, the range of tax alternatives studied should not be interpreted either as a recommendation for specific tax law changes or as evidence of special knowledge concerning pending tax proposals. What was attempted was to use the supply model to evaluate the importance of various tax parameters such as depletion allowance, investment tax credits and preference taxes.

Table 24 summarizes the results of an analysis of tax alternatives, utilizing the supply model. Of the cases considered, elimination of the depletion allowance would have the greatest impact on calculated uranium "prices," causing an increase of approximately $2.00 per pound of U_3O_8 or 20 percent at a 15-percent rate of return. On the other hand, a substantial increase in the 22-percent depletion allowance would, by itself, have a relatively small effect on the calculated uranium "price."

Even at the lower rates of return, the full statutory rate of 22 percent of product value is not received under current tax laws because the depletion allowance is limited to 50 percent of net income. Therefore, increased depletion allowances are not an advan-

TABLE 24

EFFECTS OF VARIOUS TAX POLICY ASSUMPTIONS
ON THE REQUIRED "PRICE" OF U_3O_8*
(Dollars per Pound)

		7 Parameters—"Prices" with Changes Shown in Tax Assumptions of Basic Supply Cases						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
DCF Rate of Return (Percent)	"Price" with Tax Policy Assumptions of Basic Supply Cases (I-- IV)†	Depletion = 0%	Depletion 27.5%	No % Net Income Limitation	Depletion = 27.5% No % Net Income Limitation	Primary Development Expense as Investment Tax Credit	Primary Development & Exploration Expense as Investment Tax Credit	No Preference Tax
10	8.91	10.19	8.91	8.57	8.05	8.81	8.61	8.81
12.5	9.59	11.13	9.59	9.33	9.03	9.45	9.23	9.45
15	10.37	12.23	10.37	10.23	9.89	10.23	9.95	10.21
17.5	11.27	13.45	11.21	11.27	10.85	11.11	10.77	11.09
20	12.39	14.89	12.19	12.39	11.97	12.23	11.81	12.23

* Values shown are the calculated levelized "prices" required for U_3O_8 produced from Class 5 properties (new discoveries) in order to obtain the DCF rates of return shown.

† Tax Assumptions of basic supply Cases I-IV are described in Chapter Three and are further detailed in Appendix F. The basic assumptions which were changed selectively in the parametric studies shown are: Depletion = 22 percent statutory rate with 50-percent net income limitation. Investment Tax Credit = 7 percent on 80 percent of the mine/mill investment.

tage to the domestic industry, except in a relatively small way at higher rates of return, unless the net income limitation is also removed. If the depletion rate for uranium were increased to 27.5 percent from the present level of 22 percent, no decrease in the calculated "price" at a 10-percent rate of return is evident. However, simultaneous removal of the 50 percent of net income limitation would reduce the calculated "price" at the same rate of return by almost $0.90 per pound of U_3O_8. At a 15-percent DCF rate of return, the "price" per pound of U_3O_8 decreases only 5 percent.

Rate of Fast Breeder Reactor Introduction

The timing and rate of breeder reactor introduction is an extremely important factor in projecting uranium requirements beyond 1985. Figure 27 illustrates the impact on uranium demand if breeder reactors enter into commercial operation at a somewhat slower rate than assumed in the basic Case III.* Even though there is no divergence until 1986 in the projected light water reactor *vs.* breeder reactor additions, the U_3O_8 demand curves begin to separate in 1984 due to the lead times involved. The annual U_3O_8 demand when breeder reactors are introduced slowly is approximately 20 percent greater than in the basic Case III by 1990, with the differential increasing thereafter.

This parameter variation substantially increases the uranium reserve discovery requirement and associated need for drilling projected for the the late 1970's and early 1980's. Projections from the supply model indicate that additional discoveries (over and above the basic Case III projection) will be needed by at least 1980 if the breeder reactors do not come in as rapidly as projected in Case III (see Figure 28).

* See footnote on Table 9, Chapter One, for buildup rate assumed.

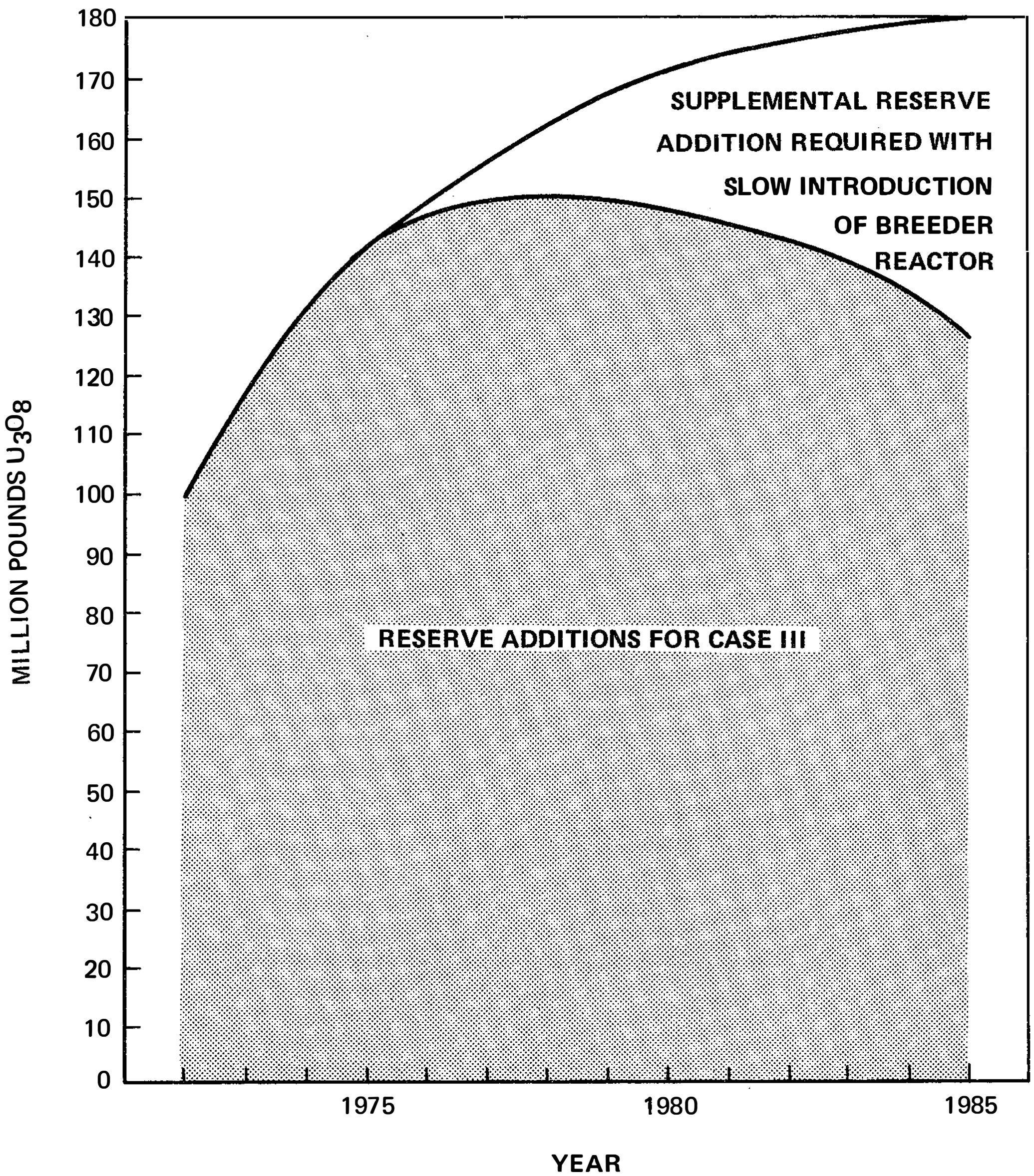
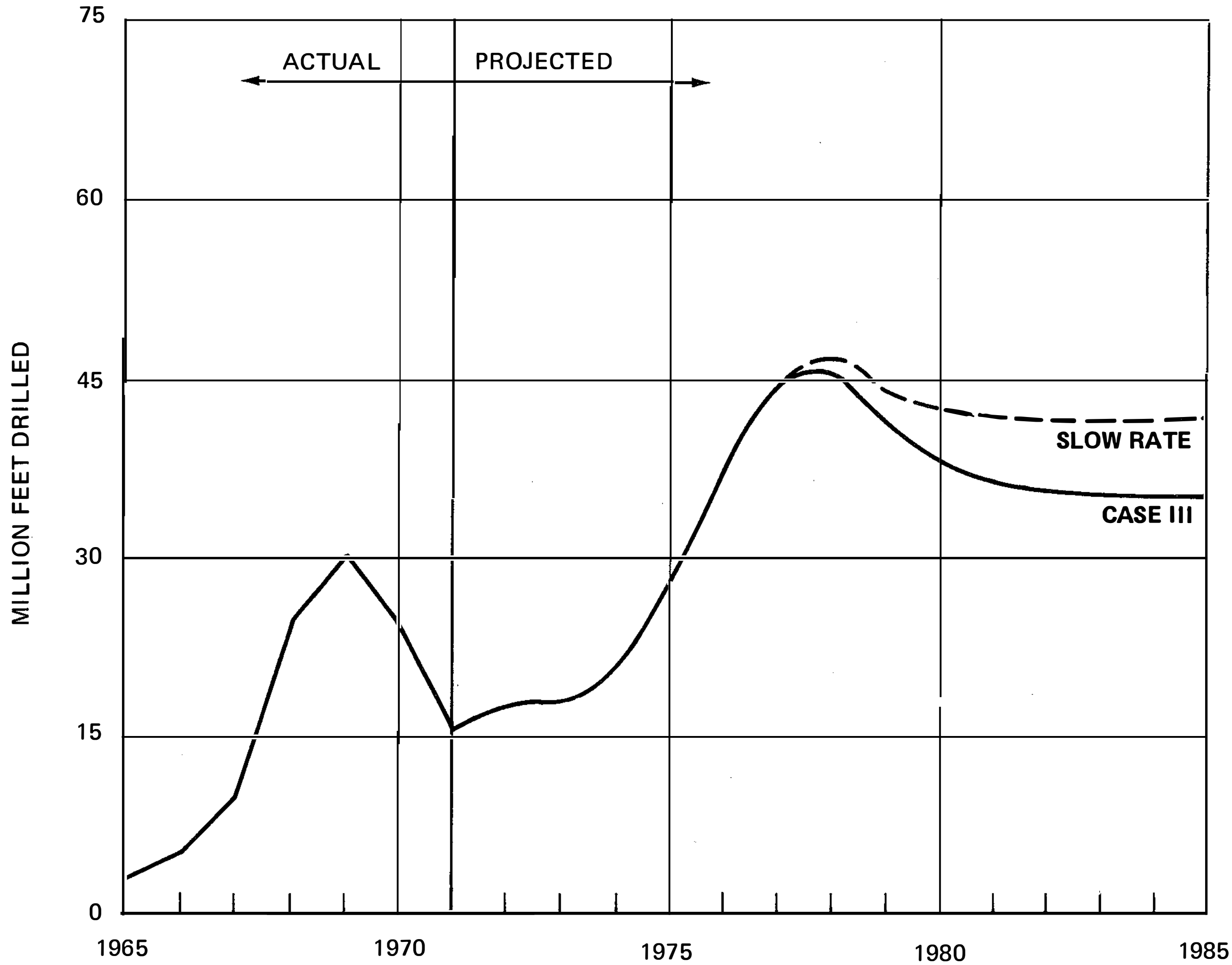


Figure 28. Parametric Study--Annual U_3O_8 Discovery Requirements Assuming Slow Introduction of Breeder Reactors.

Similarly, a reduced rate of introduction of breeder reactors also increases drilling requirements. This effect on the basic Case III projection is shown in Figure 29.

Multiple Parametric Variations

The assignment of the same discovery rates, capital costs and operating costs to each of the four basic supply cases has implicit in it the assumption that the high level of activity required in Case I would be achieved with the same efficiency as the low level of activity required in Case IV. This may not be realistic. Therefore, parametric studies were made to examine the potential impact



Note: Levelized to drilling rate required to support a 10-year minimum forward reserve at the 1985 demand level.

Figure 29. Parametric Study--Effect of a Slow Rate of Breeder Introduction on Case III Surface Drilling Requirements.

of generally reduced efficiency as the level of activity increases (see Table 25).

Figure 30 indicates surface drilling requirements with the revised discovery rate assumptions. Figure 31 shows the required U_3O_8 "prices" under the assumptions of this parametric study. It should be noted that the combination of reduced discovery rates and increased capital and operating costs assumed for Case I increases the calculated U_3O_8 "price" to about $2.00 per pound more than the "price" for Case III at a 15-percent rate of return on investment.

MINING REGULATIONS

The health and safety standards set forth under the Federal Metal and Nonmetallic Mine Safety Act of 1966 and surface reclamation requirements established by state agencies have had in the

TABLE 25

CASE I - IV ASSUMPTIONS FOR MULTIPLE PARAMETER VARIATION CASES

Parameter	Case I	Case II	Case III	Case IV
Discovery Rate (lbs. of U_3O_8/ft. drilled)	3 lb./ft.	3 lb./ft.	4 lb./ft.	5 lb./ft.
Capital Cost	+20%	+10%	*	*
Operating Cost	+10%	+ 5%	*	*

* Standard Cost Assumptions. See Chapter 3.

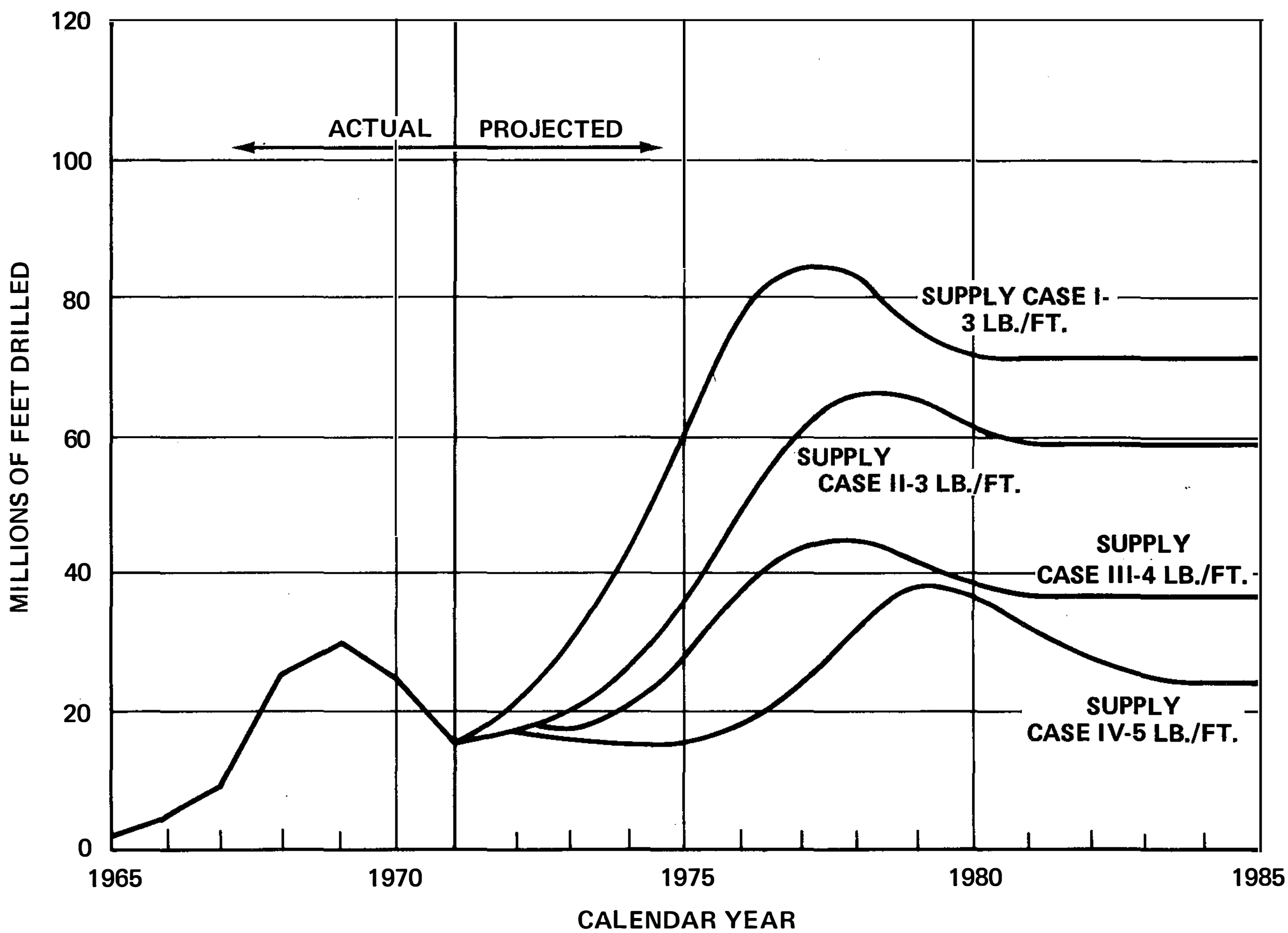


Figure 30. Parametric Study--Effect on Surface Drilling Requirements Assuming Increased Supply Activity Reduces Discovery Rate.

past, and will continue to have, major economic effects on mining operations. The impact has been particularly severe for the uranium mining industry where underground mines must comply with strict

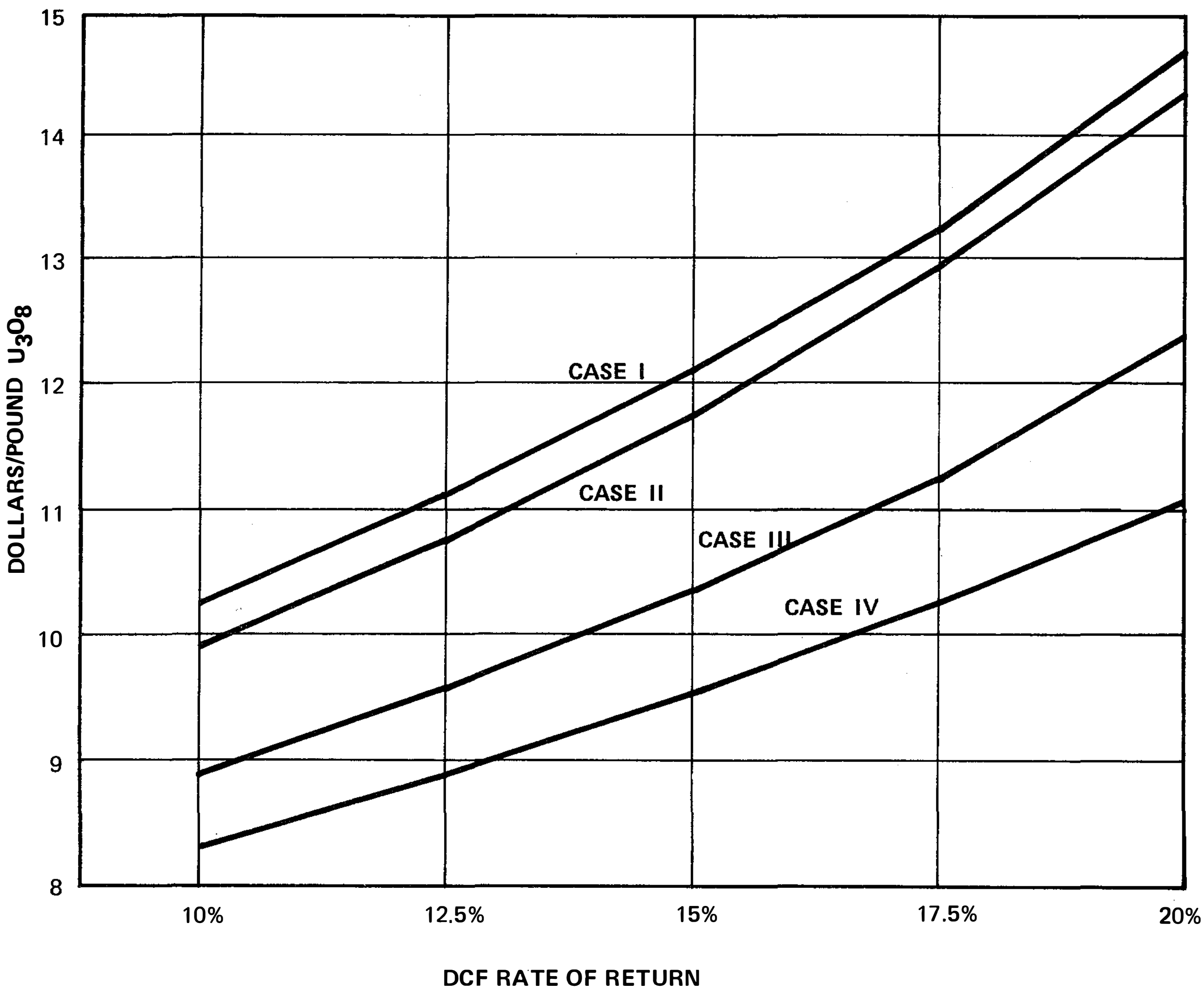


Figure 31. Parametric Study--Effect on (Future Discoveries) Class 5 "Price"/Pound U_3O_8 Assuming Increased Supply Activity Reduces Discovery Rate.

radiation exposure limits. The cost of complying with these standards will vary from mine to mine, and the limited experience under the new requirements does not provide sufficient data for firm determination of the incremental cost for meeting the new standards. However, reasonable estimates can be made. The relationship of U_3O_8 "prices" as calculated by the supply model to increased capital costs was discussed as a parametric study. However, increases in operating costs, unlike increases in capital costs, would require substantially an equivalent increase in "price" since the cash flows occur in the same year, and are therefore not subject to a discounting effect.

Underground Mines

The incremental costs of meeting the new radiation and safety standards have been estimated on the basis of current operating experience and the Arthur D. Little report.* Those incremental increases under differing conditions are shown in Table 26. All costs include the required additional capital expenditures and operating and indirect costs.

TABLE 26

ESTIMATED INCREMENTAL COSTS TO MEET NEW RADIATION AND SAFETY STANDARDS

	Mine Conditions		
	Favorable	Average	Severe
Cost/Ton Ore	$ 1,03	$ 1.64	$ 2.90
Cost/lb. U_3O_8			
@ 2.6 lb. Recovered	0.40	0.63	1.12
@ 3.0 lb. Recovered	0.34	0.55	0.97
@ 4.0 lb. Recovered	0.26	0.41	0.73

The majority of underground uranium mines now in operation (Classes 1 and 2) would be classified as having favorable or average mine conditions, while most new underground developments (Classes 3, 4 and 5) will be deeper and will produce more water. Conditions in the latter type mines would probably be considered to be severe.

Any further reduction in the radiation exposure standard would be costly and extremely difficult, if not impossible, to meet by further refinements of standard ventilation practices. A completely new approach to the problem would have to be developed, with the cost and results being speculative.

Open-Pit Mines

Open-pit mines are generally not affected by radiation limitations. However, other new health and safety standards will increase equipment cost. When related to cost per ton of ore, these requirements should not exceed $0.02 per ton. The major concern in open-pit mining is the land reclamation requirements enacted by the states. Requirements vary from state to state, and complete restoration of the land to its original condition may eventually be required in some areas.

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* Arthur D. Little, Inc., "The Economic Effects of Radiation Exposure Standards for Uranium Mines," prepared for the Federal Radiation Council, September 1970.

Based on cost estimates by the Stanford Research Institute (SRI) for coal mines, the cost of surface reclamation for a typical uranium open-pit mine will range from \$0.07 per ton of ore to \$2.90 per ton as indicated in Table 27.

TABLE 27

ESTIMATED INCREMENTAL COSTS TO MEET OPEN PIT RECLAMATION REQUIREMENTS

	Requirements*		
	Mild	Moderate	Severe
Cost/Ton Ore	7.0¢ - 11.5¢	11.0¢ - 17.0¢	\$2.10 - \$2.90
Cost/lb. U_3O_8			
@ 2.6 lb. Recovered	2.7¢ - 4.4¢	4.2¢ - 6.5¢	\$0.81 - \$1.12
@ 3.0 lb. Recovered	2.3¢ - 3.8¢	3.7¢ - 5.7¢	\$0.70 - \$0.97
@ 4.0 lb. Recovered	1.8¢ - 2.9¢	2.8¢ - 4.3¢	\$0.53 - \$0.73

* Reclamation requirements are as follows:
Mild requirements: Regrade dumps, cover with top soil and reseed.
Moderate requirements: Regrade dumps, slope pit walls, cover with top soil and reseed.
Severe requirements: Backfill all pits and return surface to near original.

Chapter Five

NUCLEAR FUEL PROCESSING

As illustrated earlier in this report (Figure 1, Chapter One) the nuclear fuel cycle includes many operations both before and after fuel usage. This chapter includes a discussion of the requirements and capabilities of the major segments of the uranium fuel cycle other than the raw material acquisition segments (exploration, mining and milling) which have already been discussed in detail.

URANIUM ENRICHMENT

The three Government-owned enrichment plants have a present total capacility of 17,230,000 units of separative work (SWU) per year. The plants are not now operating at full capacity, but they are processing more uranium than is required and are thereby providing a Government stockpile of enriched material that can be drawn upon in the future. With the completion of the AEC's expansion programs, namely Cascade Improvement Program and Cascade Uprating Program, the total capacity of the three plants will be increased by about 60 percent to 27.9 million SWU per year.

The annual separative work requirements for the four nuclear power supply cases to the year 2000 are shown in Figure 32. In 1980, these demands range from a low of 13.5 million units for Case IV to a high of 23.1 million units for Case I. The annual requirements in 1985 range from 26.7 million units for Case IV to 47 million units for Case I. During the period 1986 to 2000, thermal reactors will continue to be added as new capacity, although at a diminishing rate. Consequently, the requirements for separative work continue to grow. The enrichment requirements illustrated in Figure 32 and cited above are based on (1) 0.275-percent U_{235} tails assay,* (2) 60-percent plutonium recycle beginning in 1978 and (3) exclusion of foreign and U.S. Government requirements.

Cumulative separative work requirements are illustrated in Figure 33. Included in these projections, however, are the expected foreign and U.S. Government requirements for separative work. Figure 33 is therefore a representation of the total cumulative demand on the U.S. uranium enrichment plants. Also shown in Figure 33 is the cumulative separative work production as planned by the AEC.

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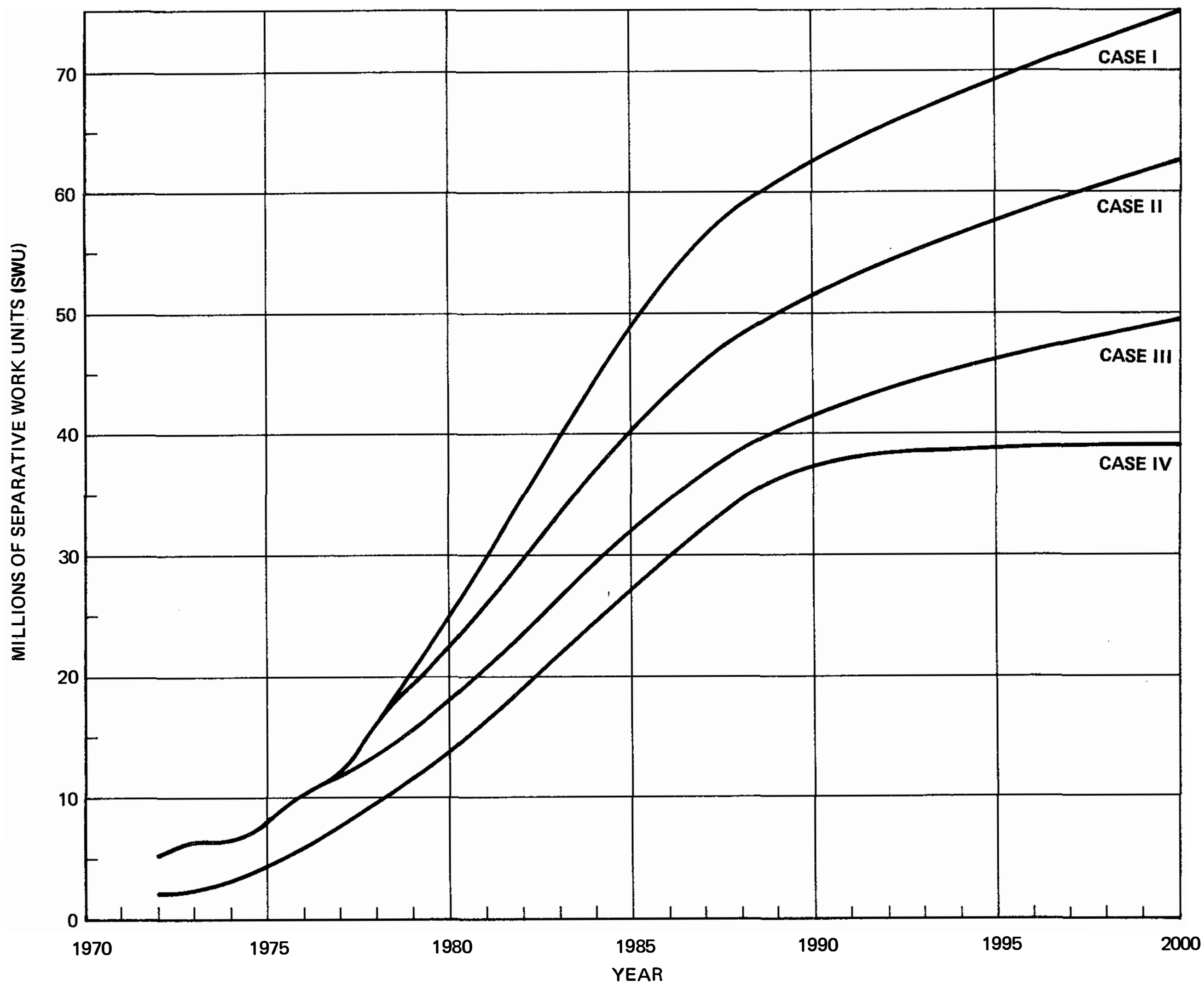
* This is not in conflict with previous statements that uranium demand was calculated based on 0.20-percent U_{235} tails assay through 1981.

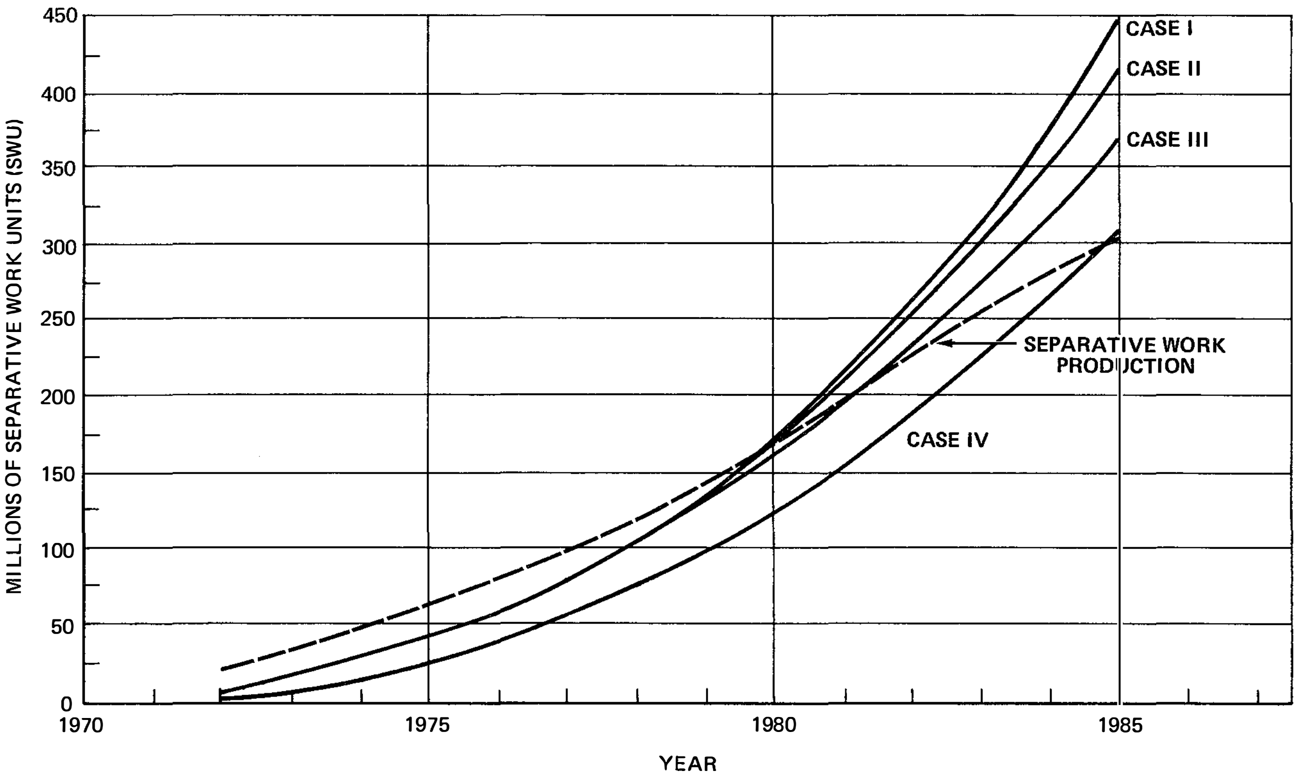


NOTE: Demand excludes foreign and U.S. Government requirements.

Figure 32. Annual U.S. Separative Work Requirements.

On the basis of these data, additional urnaium enrichment capacity beyond the expansion programs will be required for Case I by 1980, for Case II by 1981 and for Case III by 1982. Capacity is adequate for Case IV through 1985.

There is some flexibility in the capacity of an enrichment plant to supply enriched uranium, which is accomplished primarily by adjusting the assay of the plant tailings. By operating at a tails assay of 0.30-percent U_{235}, the production of enriched uranium can be increased by more than 20 percent above the capacity of the same plant operated at a tails assay of 0.20-percent U_{235}. However, this increase must be accompanied by an increase in the uranium feed requirements of about 20 percent. Thus, changes in uranium enrichment operations cannot be made without causing significant changes in uranium requirements.



NOTE: Demand includes foreign and U.S. Goverment requirements at 0.275 tails assay.

Figure 33. Cumulative Separative Work Requirements.

Government and industry must closely scrutinize enrichment requirements because of the long lead times associated with building new enrichment facilities. It is estimated that the lead time for industry to plan and construct new enrichment facilities will be 9 years, while for the Government it will be 6 to 7 years. Construction of additional capacity at an existing plant could reduce this lead time by 1 to 2 years and reduce capital costs by 25 percent. In any event, if additional power generating capacity is required, the limiting factor may be the 6 to 8 year lead time associated with building a new power plant.

Before additional enrichment capacity can be committed, several decisions will have to be made. They are--

- Will the new capacity be built by Government or by private industry?
- Who will own it?
- Where will it be located?
- Who will supply the power?

- What technology will be used?

- How much capacity will be added at one time?

If private industry is to provide new capacity by 1982, prompt action must be taken with respect to (1) acceleration of the transfer of technology to private industry, (2) energetic action by Government and industry to carry out the technology sharing program presently under way and (3) recognition by Government and industry that decision dates are near at hand on the many issues involving ownership, location, technology and size.

The cost of new enrichment capacity is about $125 to $150 per SWU capacity per year. Based on these costs, the capital requirements through 1985 for additional enrichment capacity could vary from about $2 billion in Case IV to over $6 billion in Case I. This estimate does not include the cost of the electric power plants needed to supply power to the enrichment plants. Capital requirements for the post-1985 period were not considered by the Task Group.

FUEL REPROCESSING

Three privately owned plants designed to reprocess irradiated fuel elements removed from power reactors are operating or are being built in the United States. Their combined capacity has been announced to be 2,700 metric tons uranium (MTU) per year. This is estimated to be sufficient to process the irradiated fuel discharged from power reactors through 1981 for Case I. Nonetheless, additional capacity will be required prior to 1985 in all four demand cases. In the post-1985 period even more reprocessing capacity will be needed in addition to a resolution of certain technological problems associated with the treatment of fast breeder and HTGR fuels. However, a reprocessing plant can be designed, or modified, to process fast breeder fuel as well as thermal reactor fuel.

Difficulties are being encountered in obtaining operating licenses for the plants now being built, and similar difficulties may be anticipated with any new plants. As reprocessing is a necessary step in the fuel cycle, licensing problems must be resolved. Because of this difficulty, a total lead time of about 8 years may be necessary. This includes 3 years for obtaining a license and 5 years for construction.

Estimates of the capital cost of reprocessing plants range between $50,000 and $100,000 per annual metric ton of throughput, depending upon the size of the plant and nature and extent of the facility. Additional facilities required by the AEC for the processing and recovery of solid, liquid and gaseous wastes may cause plants to have higher costs per annual metric ton. For the purpose of estimating total capital investment requirements, an average cost of $65,000 per annual metric ton of throughput capacity was assumed.

WASTE DISPOSITION

The fuel cycle generates radioactive wastes of various intensities. Low-level wastes are generally buried in storage tracts licensed by the AEC. High-level wastes are currently stored either in liquid form in large buried tanks or are converted to solid form such as glass or ceramic and stored on the surface at a reprocessing plant. The AEC is studying other storage possibilities for high-level wastes. These include storage in abandoned mines or in rooms excavated in salt beds. The quantity of high-level wastes is modest, estimated at 125,000 cubic feet (about 3,000 tons) for the period 1972 through 1985 and 770,000 cubic feet (about 20,000 tons) by the year 2000. Waste storage costs are expected to contribute only about 0.03 to 0.05 mills per KWH to the cost of power generation

An additional waste storage problem is the handling of gaseous radioactive wastes such as krypton 85 and tritium, which are released from the spent fuel during reprocessing. Technology is being developed for recovery and storage of this gaseous waste, and facilities will be built upon successful completion of the development program. At the present time, the cost of the recovery facilities is not known, so it is impossible to estimate a definitive cost per KWH for such disposal.

CONVERSION AND FABRICATION

The two remaining major steps in the fuel cycle are (1) conversion of uranium concentrates from U_3O_8 to UF_6 and (2) reduction of the enriched UF_6 to UO_2 and fabrication of the UO_2 into reactor cores.* The former is called conversion, the latter fabrication.

There is adequate capacity today in these fields, and lead time for plant construction is not considered a limiting factor for adding new capacity. For both types of plants, the lead time between start of design and operation is about 3 years.

The capital costs of conversion and fabrication plants are estimated to be respectively $4,000 and $25,000 per annual MTU capacity.

The availability of conversion and fabrication facilities to satisfy post-1985 demands does not appear to present any serious problems in terms of capital investment or technology. It should be recognized, however, that fuel fabrication will become increasingly more expensive with the advent of plutonium and U_{233} fabrication for recycle and fast breeder fuel elements.

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* Includes fabrication of tubing and fuel bundles.

PLUTONIUM SUPPLY

Plutonium is recovered from spent fuel removed from light-water reactors at a rate of approximately 6.4 kg per MTU in the reactor fuel.* It has two important uses in the nuclear power economy--as a fuel in non-breeder reactors to replace U_{235} and as the primary fuel in fast breeder reactors. The former use is known as plutonium recycle.

For the next few years, recycling is relatively unimportant because quantities are small. However, during the latter part of this decade and in the next, the use assigned to plutonium becomes increasingly significant. In this study it was judged that 60 percent of the recovered plutonium could be recycled starting in 1978 and that sufficient plutonium inventories would remain to support the projected breeder reactor program. If there is no plutonium recycle, the U_3O_8 demand for Case III of this study is increased by about 10 percent.†

The capital cost of a fabrication plant to produce mixed plutonium and uranium oxide fuel elements is estimated at $100,000 to $135,000 per annual metric ton of capacity.

TRANSPORTATION OF NUCLEAR MATERIALS

The transportation of nuclear fuel materials is regulated by the Department of Transportation and requires specific types of containers and shipment control. Until the nuclear fuel materials have been irradiated in a reactor, their transportation from point to point does not present any major problems.

Transport of recovered plutonium and U_{233} requires additional precautions, however. Shipment of irradiated fuel materials requires the use of containers which are heavily shielded and constructed so as to withstand damage in the event of accidents during transit. With the increasing volume of irradiated fuel elements from power reactors, a substantial number of containers will be required, and their transportation to and from reprocessing plants will present potential logistical problems. Adequate planning for the manufacture of the required containers as well as for the movement of these containers in interstate commerce is essential to avoid unnecessary economic penalties from the resulting delays.

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* This is the maximum rate of recovery and is attained when steady-state operation (fuel cycle equilibrium) is achieved.

† Recycle of a kilogram of fissile plutonium reduces enrichment capacity requirements about 125 kilogram units of separative work, based on a 0.275-percent U_{235} tails assay. Savings in natural uranium requirements and enrichment capacity requirements are also dependent on the specific fuel design.

FUEL CYCLE CAPITAL REQUIREMENTS

A summary of capital expenditures for the nuclear fuel cycle over the period 1972-1985 is shown in Table 28.

TABLE 28

CAPITAL EXPENDITURES FOR THE NUCLEAR FUEL CYCLE—1972 - 1985

	Billions of 1970 Dollars			
Fuel Cycle Sector	**Case I***	**Case II***	**Case III***	**Case IV***
Uranium Raw Materials†	$ 6.0	$ 5.1	$ 4.3	$ 3.7
Conversion	0.3	0.2	0.2	0.1
Enrichment‡	6.0	5.0	3.5	2.5
Fabrication	0.4	0.3	0.2	0.2
Transportation, Reprocessing and Waste Storage	0.4	0.4	0.3	0.2
Total Fuel Cycle	**$ 13.1**	**$ 11.0**	**$ 8.5**	**$ 6.7**

* Case I projects 450,000 installed MWe in 1985; Case II—375,000; Case III—300,000; Case IV—240,000.

† Includes primary development and overburden removal as capital items.

‡ Not including power plants required to supply power.

Appendices

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General Electric Company

Edward J. Hanrahan
Assistant Director
Energy and Environment
Office of Planning and Analysis
Atomic Energy Commission

Edward Kuhn
Edison Electric Institute

Robert P. Luke, Manager
Uranium Planning and Evaluation
Uranium Mining and Milling Division
Nuclear Division, Marketing
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A. R. Matheson, Manager
Industry and Government Activities
Uranium Supply and Distribution
Gulf Energy & Environmental Systems

John A. Patterson, Chief
Supply Evaluation Branch
Division of Production and
Materials Management
Atomic Energy Commission

A. V. Quine
Executive Consultant
Utah International Inc.

Donald K. Simpson
Operations Staff Assistant
National Petroleum Council

---

* Replaced John T. Sherman in May 1972.

† Replaced Albert Graff in January 1972.

‡ Replaced A. Eugene Schubert in January 1972.

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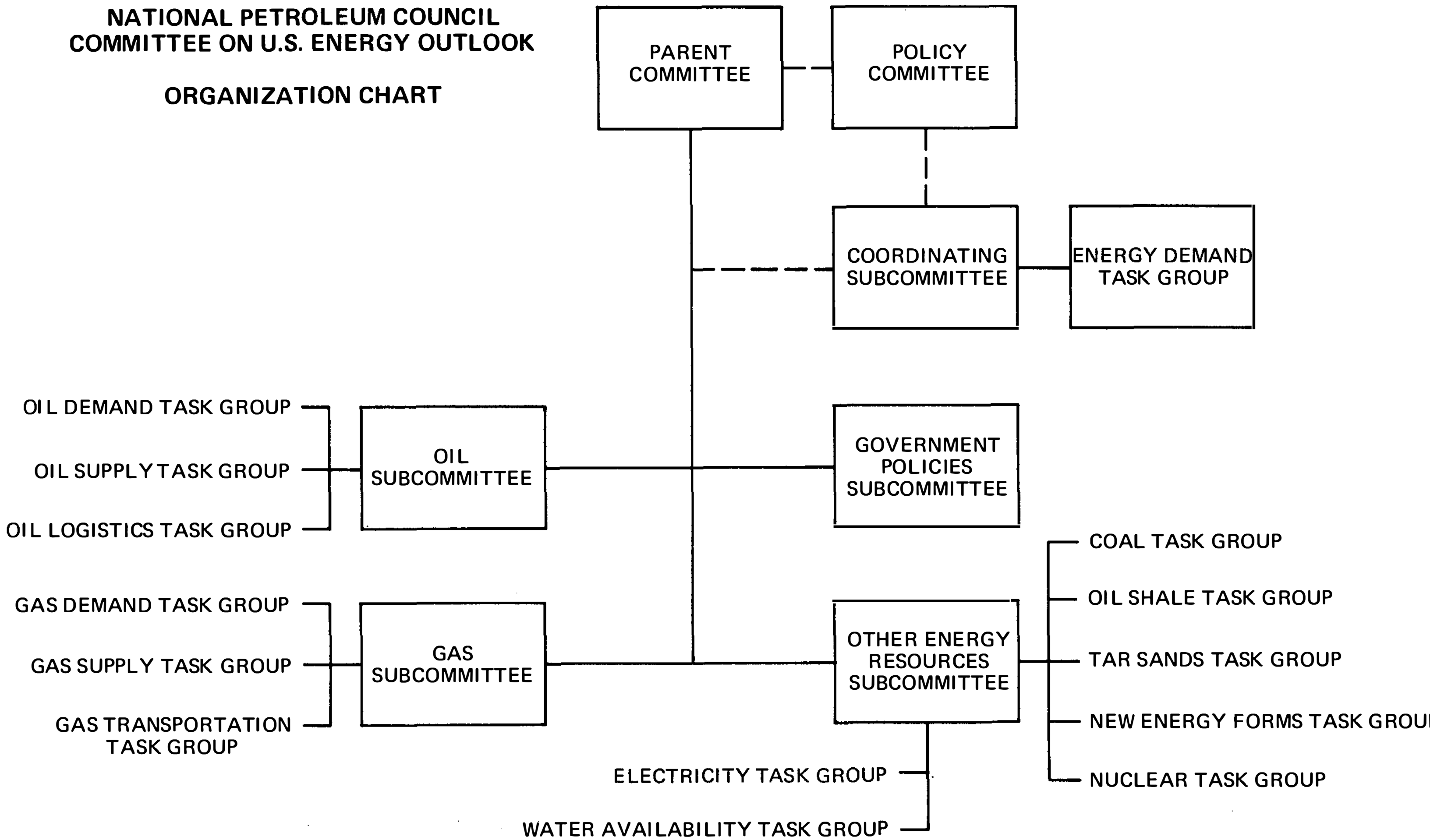

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Andrew Avramides Deputy Director National Petroleum Council	Energy Demand and Petroleum

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* Served until December 15, 1972; replaced by Duke R. Ligon

† Replaced Henry C. Rubin in June 1972.

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Office of Assistant Secretary-
Water & Power Resources
U.S. Department of the Interior

Donald Hunter, Director†
Uranium Supply Division
Gulf Energy and Environmental
Systems

V. M. Johnston, Manager
Economic Services
Island Creek Coal Sales Company

John J. Kearney, Vice President
Edison Electric Institute

Arnold E. Kelley, Associate
Director for Research Process
Engineering & Development
Union Oil Company of California

John E. Kilkenny
Senior Geologist
Union Oil Company of California

D. T. King, Director
Coal Preparation & Distribution
U.S. Steel Corporation

James N. Landis, Consultant
Bechtel Corporation

Olaf A. Larson, Staff Engineer
Process Research Department
Gulf Research & Development Co.

John E. Lawson, Director
Processing Group for Synthetic
Crude and Mineral Operations
North American Producing Division
Atlantic Richfield Company

Hugh J. Leach, Vice President
Research and Development
Cleveland-Cliffs Iron Company

Dwight L. Miller
Assistant Director, Northern
Regional Research Laboratory
Agriculture Research Service
U.S. Department of Agriculture

W. B. Oliver, Manager
Resources Acquisitions
Carter Oil Company

Harry Pforzheimer, Jr., Assistant
to the Senior Vice President
Natural Resources
The Standard Oil Company (Ohio)

Dr. C. J. Potter, Chairman
Rochester & Pittsburgh Coal Co.

E. H. Reichl
Vice President, Research
Consolidation Coal Company

W. H. Seaman, Vice President
Southern California Edison Co.

H. W. Sears, Vice President
Northeast Utilities Service Co.

John D. Selby‡
Deputy Division General Manager
Nuclear Energy Division
General Electric Company

Howard M. Siegel, Manager
Synthetic Fuels Research Dept.
Esso Research & Engineering Co.

---

* Replaced John T. Sherman--May 1972

† Replaced Albert Graff--January 1972.

‡ Replaced A. Eugene Schubert--January 1972.

Dr. George Skaperdas
Manager, Process Development
Research Department
The M. W. Kellogg Company

Donald E. Smith, Staff Economist
National Rural Electric
Cooperative Association

A. M. Wilson, President
Utah International Inc.

F. Leo Wright, Assistant to the
Executive Vice President
Nuclear Energy Systems
Westinghouse Electric Corporation

Dr. J. F. Wygant, Director
Products & Exploratory Research
American Oil Company

AEC'S URANIUM PRODUCTION DATA

As the structure of the supply model was determined to some degree by the data on U.S. uranium reserves and production capability as it is maintained by the Atomic Energy Commission (Raw Materials Office, Grand Junction, Colorado), this information is described below.

The AEC provides the official U.S. uranium ore reserve evaluations and maintains a compilation of uranium industry exploration and operating statistical information and projections of domestic production capability. The source data for these compilations and geological/engineering evaluations is provided voluntarily by the domestic uranium exploration and production industry. Since operating data is accumulated and reported only on a periodic basis, there is therefore some lag time built into the AEC's reporting capability. In spite of this, the Grand Junction data bank is generally considered by the industry to contain the most accurate and complete information available on domestic nuclear raw materials.

The source data is basic exploration and cost information. The Grand Junction staff performs an independent evaluation of each uranium ore body and of each existing or future potential uranium production center. These individual evaluations of each reported discovery are then summarized in a form that will not disclose individual company confidential information before release to the general public. It is this composite information that has been utilized as a key building element in the Nuclear Task Group's uranium supply model.

In order to analyze U.S. uranium production capability, the known ore bodies have been assigned by the AEC to a "production center," with production centers broken down into four classifications:*

- Class 1--Production centers based on existing mills and mines and resources available to support such mills
- Class 2--Production centers under construction for which the timing and rates of production can be reasonably predicted
- Class 3--Production centers which have, according to the evaluation of the Grand Junction staff, sufficient reserves to justify a production commitment

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* A production center consists of a mill and its supporting mines and available resources.

- Class 4--Production centers based on reserves which have not been fully explored but which have sufficient potential resources to warrant consideration of new production facilities.

Estimated ore reserves and production capabilities for each class, as well as associated investment and operating costs, are summarized in Tables A-1 through A-4. The data utilized in these tables are taken from AEC Grand Junction Workshop Papers, which were made available in September 1971, and were based on costs and resources as of January 1, 1971 (1970 constant dollars).

TABLE A–1

CLASS 1 PRODUCTION AND COST DATA

Year	Production Capability* (Thousand Tons of U_3O_8)	Operating Costs† (Millions of Dollars)	Capital Expenditures‡ (Millions of Dollars)
1971	14.4	$ 118	$ 30
1972	14.7	125	29
1973	15.0	123	29
1974	14.8	131	30
1975	14.5	122	31
1976	13.5	114	26
1977	13.5	112	25
1978	12.3	106	28
1979	12.4	106	29
1980	10.3	85	25
1981	9.8	82	21
1982	8.8	71	20
1983	8.0	57	19
1984	7.9	55	16
1985	7.0	50	12
Total	**176.9**	**$1,457**	**$370**

* Production capability through 1985 based on 141,000 tons U_3O_8 reserves (at costs up to $8/lb. U_3O_8) and 98,000 tons of potential.

† Includes mining, milling haulage, royalty, etc.

‡ Includes exploration, mine capital, mill capital, primary development and replacement equipment.

TABLE A–2

CLASS 2 PRODUCTION AND COST DATA

Year	Production Capability* (Thousand Tons of U_3O_8)	Operating Costs† (Millions of Dollars)	Capital Expenditures‡ (Millions of Dollars)
1971	1.3	$ 4	$ 29
1972	2.1	9	25
1973	3.3	19	12
1974	3.4	16	11
1975	3.4	19	11
1976	3.3	18	12
1977	3.4	19	10
1978	3.1	19	9
1979	2.9	18	8
1980	2.9	17	8
1981	2.9	17	6
1982	1.9	14	3
1983	1.9	14	4
1984	1.4	12	2
1985	1.3	10	1
Total	**38.5**	**$225**	**$151**

* Production capability through 1985 based on 38,500 tons U_3O_8 reserves (at costs up to $8/lb. U_3O_8) and 15,000 tons of potential.

† Includes mining, milling, haulage, royalty, etc.

‡ Includes exploration, mine capital, mill capital, primary development and replacement equipment.

TABLE A–3

CLASS 3 PRODUCTION AND COST DATA

Year	Production Capability† (Thousand Tons of U_3O_8)	Operating Costs‡ (Millions of Dollars)	Capital Expenditures§ (Millions of Dollars)
1971	–	$ –	$ 3
1972	–	–	3
1973	–	–	17
1974	–	–	34
1975*	0.9	10	49
1976	4.9	44	62
1977	9.2	77	44
1978	10.1	87	20
1979	10.2	88	17
1980	10.2	89	20
1981	10.0	90	20
1982	10.0	85	21
1983	10.0	84	15
1984	9.9	82	11
1985	9.6	82	9
Total	**95.6**	**$818**	**$345**

* 1975 is the earliest year of production allowed from Class 3.

† Production capability through 1985 based on 56,000 tons U_3O_8 reserves (at costs up to $8/lb. U_3O_8) and 173,000 tons of potential.

‡ Includes mining, milling, haulage, royalty, etc.

§ Includes exploration, mine capital, mill capital, primary development and replacement equipment.

TABLE A–4

CLASS 4 PRODUCTION AND COST DATA

Year	Production Capability† (Thousand Tons of U_3O_8)	Operating Costs‡ (Millions of Dollars)	Capital Expenditures§ (Millions of Dollars)
1971	–	$ –	$ –
1972	–	–	3
1973	–	–	6
1974	–	–	1
1975	–	–	3
1976	–	–	26
1977*	0.2	3	57
1978	5.2	48	27
1979	6.3	57	20
1980	6.4	57	19
1981	6.5	56	20
1982	6.6	56	17
1983	6.6	61	14
1984	6.7	59	13
1985	6.7	59	10
Total	**51.2**	**$456**	**$236**

* 1977 is the earliest year of production allowed from Class 4.

† Production capability through 1985 based on 12,600 tons U_3O_8 reserves (at costs up to $8/lb. U_3O_8) and 80,000 tons of potential.

‡ Includes mining, milling, haulage, royalty, etc.

§ Includes exploration, mine capital, mill capital, primary development and replacement equipment.

APPENDIX F

TAX CALCULATIONS

For each class of production center the following procedures and assumptions are used in the uranium supply model's tax calculations:

- The revenue schedule corresponding to a given return on investment is calculated.
- Royalties, operating costs and primary development expenditures are deducted from revenue to give before tax cash flow.
- In order to calculate taxable income, certain items are deducted from before tax cash flow. They are (1) mine/mill depreciation, (2) equipment replacement expense, (3) development drilling and (4) depletion.

(1) Mine/Mill Depreciation--Unit of production depreciation is assumed for mine/mill equipment and buildings. These calculations are of course dependent on the reserve-to-production ratio and mine-life assumptions. It is likely that some facilities will be on an accelerated depreciation schedule. However, the industry average costs indicate that most mines will be under the net profits limitation on depletion. Further, reserve-to-production ratios are expected to average 10 or less. For these reasons, unit-of-production depreciation is considered reasonable. Sensitivity tests indicate that there is no significant impact on the "price" calculations from the expected effects of accelerated depreciation.

(2) Development Drilling--Development drilling expense is an allowed intangible development expense under current tax laws and is deducted for tax purposes in the year incurred.

(3) Equipment Replacement--Mine/mill equipment replacement @ $0.15 per pound of U_3O_8 produced per year is assumed to be short-lived equipment, and for the tax calcuation is expensed as incurred.

(4) Depletion--The depletion calculation is made each year for the industry as a whole. The 22 percent statutory rate applies except when there is a 50 percent net income limitation. At lower returns on investment (ROI's), the 50 percent limitation is generally in effect, and effective depletion rates can be as low as 12 percent. When prices limit the average property to 50 percent of net income for

depletion, the total industry depletion is overstated to the degree that the best properties are on 22 percent of revenue. Conversely, at the higher ROI's, depletion is understated to the extent that marginal properties are subject to the 50 percent limitation. As the "effective depletion rate" for the industry is a function of the selling price (ROI), this appears to be a reasonable model for the industry, and any bias is somewhat compensated in the preference tax calculation.

- Preference taxes are calculated at an effective rate of 8 percent (depletion minus income tax). There is no significant effect on the calculated "price" from minor variations in the effective preference tax rate.

Any number of alternative tax policy assumptions could be made using the uranium supply model.

SUPPLY MODEL PRINTOUT

The example printout enclosed in this appendix is provided to show the format of data generated by the Uranium Supply Model and utilized by the Nuclear Task Group.

The following schedules are included for Supply Cases I, II, III and IV:

- Schedule A -- "U.S. U_3O_8 Supply Availability, Statistical Summary"
- Schedule B -- "Uranium Raw Materials Production and Investment Costs."

As an example of the financial analyses made, a parametric case in which the discovery rate was held to 3 pounds U_3O_8 per foot of exploration drilling is shown for various ROI's in the enclosed Schedule C ("Discounted Cash Flow Analysis").

CASE I -- MAXIMUM

SCHEDULES A AND B

UNITED STATES U3O8 SUPPLY AVAILABILITY
STATISTICAL SUMMARY

SCHEDULE A

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF POUNDS U3O8															
TOTAL REQUIREMENTS	13.8	28.1	28.7	31.1	43.5	50.0	65.4	90.4	102.4	117.5	143.5	168.3	192.7	199.9	217.0	1492.3
AEC STOCKPILE SALES	0.0	0.0	1.8	3.7	5.4	6.2	9.3	11.9	13.5	15.5	19.1	0.0	0.0	0.0	0.0	86.4
NET IMPORTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ADJUSTED REQUIREMENTS (DOMESTIC IND. DEMAND)	13.8	28.1	26.9	27.4	38.1	43.8	56.1	78.5	88.9	102.0	124.4	168.3	192.7	199.9	217.0	1405.9
YELLOWCAKE PRODUCTION	24.7	26.0	28.0	28.4	28.4	43.8	62.6	63.6	84.7	103.5	127.0	170.8	195.1	200.6	218.7	1406.0
U3O8 INVENTORIES (1/1/71=21.6MM LBS.)	32.5	30.4	31.5	32.5	22.8	22.8	29.3	14.4	10.2	11.8	14.3	16.8	19.3	20.0	21.7	
PRODUCTION CAPABILITY																
CLASS I	28.8	29.4	30.0	29.6	29.0	27.0	27.0	24.6	24.4	20.6	19.6	17.6	16.0	15.8	14.0	353.4
CLASS II	2.6	4.2	6.6	6.8	6.8	6.6	6.8	6.2	5.8	5.8	5.8	3.8	3.8	2.8	2.6	77.0
CLASS III	0.0	0.0	0.0	0.0	1.8	9.8	18.4	20.2	20.4	20.4	20.0	20.0	20.0	20.0	20.0	191.0
CLASS IV	0.0	0.0	0.0	0.0	0.0	0.4	10.4	12.6	12.8	13.0	13.2	13.2	13.4	13.4	13.4	115.8
SUB TOTAL	31.4	33.6	36.6	36.4	37.6	43.8	62.6	63.6	63.4	59.8	58.6	54.6	53.2	52.0	50.0	737.2
CLASS V(NEW DISCOVERY)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3	43.7	68.4	116.2	141.9	148.6	168.7	
ANNUAL ADDITIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3	22.4	24.7	47.8	25.8	6.7	20.1	168.7
I+I RESERVE ADDITIONS	0.0	0.0	0.0	157.2	164.8	181.9	352.1	189.8	100.4	201.7	172.3	153.5	118.9	186.3	298.7	2277.7
LEVELIZED I+I REQ.	0.0	0.0	52.4	107.4	168.0	232.9	241.3	214.1	164.0	158.1	175.8	148.2	152.9	201.3	256.7	2273.2
ORE RESERVES	529.3	572.9	663.7	805.5	1004.3	1249.4	1480.5	1679.8	1868.3	2032.0	2193.3	2351.7	2421.1	2472.6	2598.1	
YEARS FORWARD RESERVES	9.3	8.8	8.5	8.4	8.5	8.8	9.0	9.1	9.2	9.2	9.3	9.5	9.5	9.5	9.7	
	MILLIONS OF FEET SURFACE DRILLING															
DRILLING TO PROVE CLASS I-IV POTENTIAL RESERVES	15.5	17.4	16.6	15.7	14.8	14.0	13.1	12.2	11.3	10.5	9.6	9.4	8.6	7.7	6.8	183.2
DRILLING TO PROVE CLASS V RESERVES	0.0	2.6	9.3	20.4	34.9	47.5	54.7	54.0	48.3	43.7	40.7	39.9	41.4	46.8	58.0	542.2
ESTIMATED TOTAL DRILLING REQUIREMENTS	15.5	20.0	25.9	36.1	49.7	61.5	67.8	66.2	59.6	54.2	50.3	49.3	50.0	54.5	64.8	725.4

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS I																
EXPLORATION INVESTMENT	1.5	2.3	3.0	2.6	51.4	51.2	51.2	51.0	51.5	50.2	49.5	49.8	49.8	47.8	0.0	512.8
DEVELOPMENT DRILLING	0.5	0.7	1.0	1.4	14.9	15.1	15.1	15.3	14.8	15.1	14.8	14.5	14.5	13.5	0.0	151.2
SUB TOTAL	2.0	3.0	4.0	4.0	66.3	66.3	66.3	66.3	66.3	65.3	64.3	64.3	64.3	61.3	0.0	664.0
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REPLACEMENT EQUIPMENT	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
SUB TOTAL	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
PRIMARY DEVELOPMENT	22.0	22.0	21.0	22.0	22.0	17.0	17.0	19.0	19.0	15.0	15.0	15.0	15.0	15.0	11.0	267.0
OPERATING EXPENSES	118.0	125.0	123.0	131.0	122.0	114.0	112.0	106.0	106.0	85.0	82.0	71.0	57.0	55.0	50.0	1457.0
TOTAL	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS II																
EXPLORATION INVESTMENT	0.0	0.0	0.0	0.0	10.8	11.6	10.8	11.7	10.8	11.7	11.6	10.8	10.8	10.8	0.0	111.4
DEVELOPMENT DRILLING	0.0	0.0	0.0	0.0	3.1	3.3	3.1	3.2	3.1	3.2	3.3	3.1	3.1	3.1	0.0	31.6
SUB TOTAL	0.0	0.0	0.0	0.0	13.9	14.9	13.9	14.9	13.9	14.9	14.9	13.9	13.9	13.9	0.0	143.0
MINE CAPITAL	6.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
MILL CAPITAL	13.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0
REPLACEMENT EQUIPMENT	0.0	0.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	8.0
SUB TOTAL	19.0	15.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	42.0
PRIMARY DEVELOPMENT	10.0	10.0	10.0	10.0	10.0	10.0	9.0	8.0	8.0	7.0	4.0	3.0	3.0	2.0	1.0	105.0
OPERATING EXPENSES	4.0	9.0	19.0	16.0	19.0	18.0	19.0	19.0	18.0	17.0	17.0	14.0	14.0	12.0	10.0	225.0
TOTAL	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS III																
EXPLORATION INVESTMENT	1.6	1.6	1.5	2.3	23.0	19.1	20.6	18.6	20.6	20.5	21.5	18.3	17.2	16.8	1.0	204.2
DEVELOPMENT DRILLING	0.4	0.4	0.5	0.7	6.5	6.4	6.9	6.9	6.9	7.0	7.0	7.2	5.3	4.7	0.0	66.8
SUB TOTAL	2.0	2.0	2.0	3.0	29.5	25.5	27.5	25.5	27.5	27.5	28.5	25.5	22.5	21.5	1.0	271.0
MINE CAPITAL	0.0	0.0	3.0	3.0	6.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0
MILL CAPITAL	0.0	0.0	2.0	15.0	30.0	22.0	9.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	1.0	1.0	3.0	2.0	3.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	18.0
SUB TOTAL	0.0	0.0	5.0	19.0	37.0	35.0	21.0	5.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	130.0
PRIMARY DEVELOPMENT	1.0	1.0	10.0	13.0	5.0	26.0	19.0	13.0	10.0	11.0	11.0	14.0	12.0	10.0	7.0	163.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	10.0	44.0	77.0	87.0	88.0	89.0	90.0	85.0	84.0	82.0	82.0	818.0
TOTAL	3.0	3.0	17.0	35.0	81.5	130.5	144.5	130.5	127.5	128.5	130.5	125.5	119.5	114.5	91.0	1382.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS IV																
EXPLORATION INVESTMENT	2.3	4.7	0.8	5.3	6.1	5.7	5.8	6.8	6.2	6.1	5.0	4.0	3.0	0.0	0.0	61.8
DEVELOPMENT DRILLING	0.7	1.3	0.2	1.6	1.8	2.2	2.1	2.1	2.7	2.8	2.9	0.0	0.0	0.0	0.0	20.4
SUB TOTAL	3.0	6.0	1.0	6.9	7.9	7.9	7.9	8.9	8.9	8.9	7.9	4.0	3.0	0.0	0.0	82.2
MINE CAPITAL	0.0	0.0	0.0	0.0	1.0	7.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0
MILL CAPITAL	0.0	0.0	0.0	0.0	17.0	33.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	20.0
SUB TOTAL	0.0	0.0	0.0	0.0	19.0	42.0	11.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	89.0
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	4.0	13.0	14.0	13.0	13.0	13.0	11.0	12.0	11.0	11.0	11.0	126.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	3.0	48.0	57.0	57.0	56.0	56.0	61.0	59.0	59.0	59.0	515.0
TOTAL	3.0	6.0	1.0	6.9	30.9	65.9	80.9	81.9	80.9	79.9	76.9	79.0	75.0	72.0	72.0	812.2

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS V																
EXPLORATION INVESTMENT	1.8	7.4	24.4	53.5	91.7	127.4	149.7	153.4	138.8	122.6	114.6	113.5	117.1	129.5	157.0	1502.4
DEVELOPMENT DRILLING	0.0	0.0	2.1	8.5	19.5	31.3	41.7	46.5	43.0	36.6	32.8	32.6	32.0	32.1	38.6	397.5
SUB TOTAL	1.8	7.4	26.5	62.0	111.2	158.7	191.4	199.9	181.8	159.2	147.4	146.1	149.1	161.6	195.6	1899.9
MINE CAPITAL	0.0	0.0	0.0	1.2	2.4	4.9	13.5	25.9	27.5	33.7	37.5	19.7	12.7	18.4	14.2	211.5
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	9.1	36.7	93.4	108.8	134.8	157.5	82.7	49.2	73.0	49.1	794.5
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	6.6	10.3	17.4	21.3	22.3	25.3	106.3
SUB TOTAL	0.0	0.0	0.0	1.2	2.4	14.0	50.2	119.3	139.5	175.0	205.2	119.9	83.2	113.7	88.6	1112.3
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	1.9	8.7	23.7	46.4	73.4	102.5	125.9	140.0	152.6	164.6	839.6
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.8	190.1	297.5	505.4	617.4	646.5	733.9	3083.7
TOTAL	1.8	7.4	26.5	63.1	113.7	174.6	250.4	342.9	460.6	597.7	752.7	897.3	989.7	1074.5	1182.6	6935.5

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
TOTALS BY CLASS																
CLASS I	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0
CLASS II	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0
CLASS III	3.0	3.0	17.0	35.0	81.5	130.5	144.5	130.5	127.5	128.5	130.5	125.5	119.5	114.5	91.0	1382.0
CLASS IV	3.0	6.0	1.0	6.9	30.9	65.9	80.9	81.9	80.9	79.9	76.9	79.0	75.0	72.0	72.0	812.2
CLASS V	1.8	7.4	26.5	63.1	113.7	174.6	250.4	342.9	460.6	597.7	752.7	897.3	989.7	1074.5	1182.6	6935.5
TOTAL	188.8	204.4	227.5	293.0	484.3	616.2	717.0	792.5	905.2	1016.3	1161.3	1285.0	1353.4	1421.2	1418.6	12084.7

CASE II -- HIGH

SCHEDULES A AND B

UNITED STATES U3O8 SUPPLY AVAILABILITY
STATISTICAL SUMMARY

SCHEDULE A

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF POUNDS U3O8															
TOTAL REQUIREMENTS	13.8	28.1	28.7	31.1	43.5	50.0	65.4	89.8	94.6	105.4	125.7	138.9	153.5	164.5	178.3	1311.3
AEC STOCKPILE SALES	0.0	0.0	1.8	3.7	5.4	6.2	9.3	11.9	12.7	14.1	16.9	0.0	0.0	0.0	0.0	82.0
NET IMPORTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ADJUSTED REQUIREMENTS (DOMESTIC IND. DEMAND)	13.8	28.1	26.9	27.4	38.1	43.8	56.1	77.9	81.9	91.3	108.8	138.9	153.5	164.5	178.3	1229.3
YELLOWCAKE PRODUCTION	24.7	26.0	28.0	28.4	28.4	43.8	62.6	63.6	76.4	92.4	110.8	140.2	155.0	165.6	179.7	1225.5
U3O8 INVENTORIES (1/1/71=21.6MM LBS.)	32.5	30.4	31.5	32.5	22.8	22.8	29.3	15.0	9.5	10.5	12.6	13.9	15.4	16.5	17.8	
PRODUCTION CAPABILITY																
CLASS I	28.8	29.4	30.0	29.6	29.0	27.0	27.0	24.6	24.4	20.6	19.6	17.6	16.0	15.8	14.0	353.4
CLASS II	2.6	4.2	6.6	6.8	6.8	6.6	6.8	6.2	5.8	5.8	5.8	3.8	3.8	2.8	2.6	77.0
CLASS III	0.0	0.0	0.0	0.0	1.8	9.8	18.4	20.2	20.4	20.4	20.0	20.0	20.0	20.0	20.0	191.0
CLASS IV	0.0	0.0	0.0	0.0	0.0	0.4	10.4	12.6	12.8	13.0	13.2	13.2	13.4	13.4	13.4	115.8
SUB TOTAL	31.4	33.6	36.6	36.4	37.6	43.8	62.6	63.6	63.4	59.8	58.6	54.6	53.2	52.0	50.0	737.2
CLASS V(NEW DISCOVERY)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	32.6	52.2	85.6	101.8	113.6	129.7	
ANNUAL ADDITIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.0	19.6	19.7	33.4	16.1	11.8	16.1	129.7
I+I RESERVE ADDITIONS	0.0	0.0	0.0	95.5	144.6	144.8	246.0	118.9	118.3	165.6	130.2	117.9	105.9	144.2	245.3	1777.2
LEVELIZED I+I REQ.	0.0	0.0	31.8	80.0	128.3	178.5	169.9	161.1	134.3	138.0	137.9	118.0	122.6	165.1	209.4	1775.0
ORE RESERVES	529.3	572.9	643.1	757.6	916.6	1107.3	1267.0	1413.3	1555.3	1701.8	1826.2	1941.8	1992.3	2058.1	2163.3	
YEARS FORWARD RESERVES	9.5	9.1	8.7	8.7	8.8	9.0	9.1	9.2	9.2	9.3	9.4	9.6	9.5	9.5	9.8	
	MILLIONS OF FEET SURFACE DRILLING															
DRILLING TO PROVE CLASS I-IV POTENTIAL RESERVES	15.5	17.4	16.6	15.7	14.8	14.0	13.1	12.2	11.3	10.5	9.6	9.4	8.6	7.7	6.8	183.2
DRILLING TO PROVE CLASS V RESERVES	0.0	1.6	6.4	14.8	26.1	35.5	40.6	40.5	37.6	35.4	33.3	32.2	33.2	38.0	47.1	422.2
ESTIMATED TOTAL DRILLING REQUIREMENTS	15.5	19.0	23.0	30.5	40.9	49.5	53.7	52.7	48.9	45.9	42.9	41.6	41.8	45.7	53.9	605.4

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS I																
EXPLORATION INVESTMENT	1.5	2.3	3.0	2.6	51.4	51.2	51.2	51.0	51.5	50.2	49.5	49.8	49.8	47.8	0.0	512.8
DEVELOPMENT DRILLING	0.5	0.7	1.0	1.4	14.9	15.1	15.1	15.3	14.8	15.1	14.8	14.5	14.5	13.5	0.0	151.2
SUB TOTAL	2.0	3.0	4.0	4.0	66.3	66.3	66.3	66.3	66.3	65.3	64.3	64.3	64.3	61.3	0.0	664.0
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REPLACEMENT EQUIPMENT	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
SUB TOTAL	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
PRIMARY DEVELOPMENT	22.0	22.0	21.0	22.0	22.0	17.0	17.0	19.0	19.0	15.0	15.0	15.0	15.0	15.0	11.0	267.0
OPERATING EXPENSES	118.0	125.0	123.0	131.0	122.0	114.0	112.0	106.0	106.0	85.0	82.0	71.0	57.0	55.0	50.0	1457.0
TOTAL	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS II																
EXPLORATION INVESTMENT	0.0	0.0	0.0	0.0	10.8	11.6	10.8	11.7	10.8	11.7	11.6	10.8	10.8	10.8	0.0	111.4
DEVELOPMENT DRILLING	0.0	0.0	0.0	0.0	3.1	3.3	3.1	3.2	3.1	3.2	3.3	3.1	3.1	3.1	0.0	31.6
SUB TOTAL	0.0	0.0	0.0	0.0	13.9	14.9	13.9	14.9	13.9	14.9	14.9	13.9	13.9	13.9	0.0	143.0
MINE CAPITAL	6.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
MILL CAPITAL	13.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0
REPLACEMENT EQUIPMENT	0.0	0.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	8.0
SUB TOTAL	19.0	15.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	42.0
PRIMARY DEVELOPMENT	10.0	10.0	10.0	10.0	10.0	10.0	9.0	8.0	8.0	7.0	4.0	3.0	3.0	2.0	1.0	105.0
OPERATING EXPENSES	4.0	9.0	19.0	16.0	19.0	18.0	19.0	19.0	18.0	17.0	17.0	14.0	14.0	12.0	10.0	225.0
TOTAL	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS III																
EXPLORATION INVESTMENT	1.6	1.6	1.5	2.3	23.0	19.1	20.6	18.6	20.6	20.5	21.5	18.3	17.2	16.8	1.0	204.2
DEVELOPMENT DRILLING	0.4	0.4	0.5	0.7	6.5	6.4	6.9	6.9	6.9	7.0	7.0	7.2	5.3	4.7	0.0	66.8
SUB TOTAL	2.0	2.0	2.0	3.0	29.5	25.5	27.5	25.5	27.5	27.5	28.5	25.5	22.5	21.5	1.0	271.0
MINE CAPITAL	0.0	0.0	3.0	3.0	6.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0
MILL CAPITAL	0.0	0.0	2.0	15.0	30.0	22.0	9.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	1.0	1.0	3.0	2.0	3.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	18.0
SUB TOTAL	0.0	0.0	5.0	19.0	37.0	35.0	21.0	5.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0	130.0
PRIMARY DEVELOPMENT	1.0	1.0	10.0	13.0	5.0	26.0	19.0	13.0	10.0	11.0	11.0	14.0	12.0	10.0	7.0	163.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	10.0	44.0	77.0	87.0	88.0	89.0	90.0	85.0	84.0	82.0	82.0	818.0
TOTAL	3.0	3.0	17.0	35.0	81.5	130.5	144.5	130.5	127.5	128.5	130.5	125.5	119.5	114.5	91.0	1382.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS IV																
EXPLORATION INVESTMENT	2.3	4.7	0.8	5.3	6.1	5.7	5.8	6.8	6.2	6.1	5.0	4.0	3.0	0.0	0.0	61.8
DEVELOPMENT DRILLING	0.7	1.3	0.2	1.6	1.8	2.2	2.1	2.1	2.7	2.8	2.9	0.0	0.0	0.0	0.0	20.4
SUB TOTAL	3.0	6.0	1.0	6.9	7.9	7.9	7.9	8.9	8.9	8.9	7.9	4.0	3.0	0.0	0.0	82.2
MINE CAPITAL	0.0	0.0	0.0	0.0	1.0	7.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0
MILL CAPITAL	0.0	0.0	0.0	0.0	17.0	33.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	20.0
SUB TOTAL	0.0	0.0	0.0	0.0	19.0	42.0	11.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	89.0
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	4.0	13.0	14.0	13.0	13.0	13.0	11.0	12.0	11.0	11.0	11.0	126.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	3.0	48.0	57.0	57.0	56.0	56.0	61.0	59.0	59.0	59.0	515.0
TOTAL	3.0	6.0	1.0	6.9	30.9	65.9	80.9	81.9	80.9	79.9	76.9	79.0	75.0	72.0	72.0	812.2

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS V																
EXPLORATION INVESTMENT	1.1	5.0	16.8	38.7	67.8	96.0	111.6	115.0	106.3	99.2	94.0	92.3	93.5	104.8	127.5	1169.4
DEVELOPMENT DRILLING	0.0	0.0	1.3	5.7	14.1	23.8	31.3	34.3	31.9	29.2	27.3	26.8	25.4	25.9	31.4	308.3
SUB TOTAL	1.1	5.0	18.0	44.5	81.8	119.8	142.9	149.3	138.1	128.3	121.3	119.0	118.9	130.6	158.9	1477.7
MINE CAPITAL	0.0	0.0	0.0	0.7	1.8	3.6	9.4	18.5	22.5	25.1	26.5	15.5	13.8	14.5	11.3	163.1
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	5.5	24.9	66.4	89.3	99.5	110.8	63.1	55.5	57.5	39.1	611.6
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	4.9	7.8	12.8	15.3	17.0	19.5	79.3
SUB TOTAL	0.0	0.0	0.0	0.7	1.8	9.1	34.2	84.9	113.7	129.6	145.1	91.4	84.6	89.1	69.9	854.0
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	1.2	5.8	16.7	34.1	54.6	75.7	93.1	105.7	117.1	126.8	630.7
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.4	141.7	227.2	372.4	442.7	494.2	564.1	2298.7
TOTAL	1.1	5.0	18.0	45.2	83.6	130.0	183.0	250.9	342.3	454.2	569.3	676.0	751.8	831.0	919.7	5261.1

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
TOTALS BY CLASS																
CLASS I	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0
CLASS II	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0
CLASS III	3.0	3.0	17.0	35.0	81.5	130.5	144.5	130.5	127.5	128.5	130.5	125.5	119.5	114.5	91.0	1382.0
CLASS IV	3.0	6.0	1.0	6.9	30.9	65.9	80.9	81.9	80.9	79.9	76.9	79.0	75.0	72.0	72.0	812.2
CLASS V	1.1	5.0	18.0	45.2	83.6	130.0	183.0	250.9	342.3	454.2	569.3	676.0	751.8	831.0	919.7	5261.1
TOTAL	188.1	202.0	219.0	275.1	454.2	571.6	649.6	700.5	786.9	872.8	977.9	1063.7	1115.5	1177.7	1155.7	10410.3

CASE III -- REFERENCE

SCHEDULES A AND B

SCHEDULE A

UNITED STATES U308 SUPPLY AVAILABILITY
STATISTICAL SUMMARY

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF POUNDS U308															
TOTAL REQUIREMENTS	13.8	28.1	28.7	31.1	43.5	49.2	55.2	64.3	73.4	84.8	96.9	108.8	122.5	132.4	141.3	1074.0
AEC STOCKPILE SALES	0.0	0.0	1.8	3.7	5.4	6.0	8.0	9.0	10.1	11.6	13.4	0.0	0.0	0.0	0.0	69.0
NET IMPORTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ADJUSTED REQUIREMENTS (DOMESTIC IND. DEMAND)	13.8	28.1	26.9	27.4	38.1	43.2	47.2	55.3	63.3	73.2	83.5	108.8	122.5	132.4	141.3	1005.0
YELLOWCAKE PRODUCTION	24.7	26.0	28.0	28.4	28.4	35.4	44.0	59.6	63.0	65.9	84.7	110.0	123.9	133.4	142.2	997.5
U308 INVENTORIES (1/1/71=21.6MM LBS.)	32.5	30.4	31.5	32.5	22.8	15.0	11.8	16.1	15.8	8.5	9.7	10.9	12.3	13.2	14.1	
PRODUCTION CAPABILITY																
CLASS I	28.8	29.4	30.0	29.6	29.0	27.0	27.0	24.6	24.4	20.6	19.6	17.6	16.0	15.8	14.0	353.4
CLASS II	2.6	4.2	6.6	6.8	6.8	6.6	6.8	6.2	5.8	5.8	5.6	3.8	3.8	2.8	2.6	77.0
CLASS III	0.0	0.0	0.0	0.0	0.0	1.8	9.8	18.4	20.2	20.4	20.4	20.0	20.0	20.0	20.0	171.0
CLASS IV	0.0	0.0	0.0	0.0	0.0	0.0	0.4	10.4	12.6	12.8	13.0	13.2	13.2	13.4	13.4	102.4
SUB TOTAL	31.4	33.6	36.6	36.4	35.8	35.4	44.0	59.6	63.0	59.6	58.8	54.6	53.0	52.0	50.0	703.8
CLASS V(NEW DISCOVERY)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	25.9	55.4	70.9	81.4	92.2	
ANNUAL ADDITIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	19.6	29.5	15.5	10.5	10.8	92.2
I+I RESERVE ADDITIONS	0.0	0.0	0.0	0.0	46.3	144.6	217.2	114.1	77.5	94.7	114.3	121.6	83.0	27.1	95.9	1136.3
LEVELIZED I+I REQ.	0.0	0.0	0.0	15.4	63.6	136.0	158.6	136.3	95.4	95.5	110.2	106.3	77.2	68.7	120.6	1183.8
ORE RESERVES	529.3	572.9	611.3	661.1	755.6	912.2	1079.3	1204.7	1282.3	1372.8	1495.5	1617.9	1652.1	1649.7	1687.7	
YEARS FORWARD RESERVES	10.4	10.0	9.5	9.1	9.0	9.3	9.6	9.7	9.5	9.4	9.6	9.9	9.8	9.6	9.6	
	MILLIONS OF FEET SURFACE DRILLING															
DRILLING TO PROVE CLASS I-IV POTENTIAL RESERVES	15.5	17.4	16.6	15.7	14.8	14.0	13.1	12.2	11.3	10.5	9.6	9.4	8.6	7.7	6.8	183.2
DRILLING TO PROVE CLASS V RESERVES	0.0	0.0	0.8	4.3	12.7	23.7	32.1	33.7	30.1	26.6	25.5	24.9	22.7	22.3	28.5	287.9
ESTIMATED TOTAL DRILLING REQUIREMENTS	15.5	17.4	17.4	20.0	27.5	37.7	45.2	45.9	41.4	37.1	35.1	34.3	31.3	30.0	35.3	471.1

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS I																
EXPLORATION INVESTMENT	1.5	2.3	3.0	2.6	51.4	51.2	51.2	51.0	51.5	50.2	49.5	49.8	49.8	47.8	0.0	512.8
DEVELOPMENT DRILLING	0.5	0.7	1.0	1.4	14.9	15.1	15.1	15.3	14.8	15.1	14.8	14.5	14.5	13.5	0.0	151.2
SUB TOTAL	2.0	3.0	4.0	4.0	66.3	66.3	66.3	66.3	66.3	65.3	64.3	64.3	64.3	61.3	0.0	664.0
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REPLACEMENT EQUIPMENT	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
SUB TOTAL	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
PRIMARY DEVELOPMENT	22.0	22.0	21.0	22.0	22.0	17.0	17.0	19.0	19.0	15.0	15.0	15.0	15.0	15.0	11.0	267.0
OPERATING EXPENSES	118.0	125.0	123.0	131.0	122.0	114.0	112.0	106.0	106.0	85.0	82.0	71.0	57.0	55.0	50.0	1457.0
TOTAL	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS II																
EXPLORATION INVESTMENT	0.0	0.0	0.0	0.0	10.8	11.6	10.8	11.7	10.8	11.7	11.6	10.8	10.8	10.8	0.0	111.4
DEVELOPMENT DRILLING	0.0	0.0	0.0	0.0	3.1	3.3	3.1	3.2	3.1	3.2	3.3	3.1	3.1	3.1	0.0	31.6
SUB TOTAL	0.0	0.0	0.0	0.0	13.9	14.9	13.9	14.9	13.9	14.9	14.9	13.9	13.9	13.9	0.0	143.0
MINE CAPITAL	6.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
MILL CAPITAL	13.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0
REPLACEMENT EQUIPMENT	0.0	0.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	8.0
SUB TOTAL	19.0	15.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	42.0
PRIMARY DEVELOPMENT	10.0	10.0	10.0	10.0	10.0	10.0	9.0	8.0	8.0	7.0	4.0	3.0	3.0	2.0	1.0	105.0
OPERATING EXPENSES	4.0	9.0	19.0	16.0	19.0	18.0	19.0	19.0	18.0	17.0	17.0	14.0	14.0	12.0	10.0	225.0
TOTAL	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS III																
EXPLORATION INVESTMENT	1.6	1.6	1.5	2.3	23.0	19.1	20.6	18.6	20.6	20.5	21.5	18.3	17.2	16.8	1.0	204.2
DEVELOPMENT DRILLING	0.4	0.4	0.5	0.7	6.5	6.4	6.9	6.9	6.9	7.0	7.0	7.2	5.3	4.7	0.0	66.8
SUB TOTAL	2.0	2.0	2.0	3.0	29.5	25.5	27.5	25.5	27.5	27.5	28.5	25.5	22.5	21.5	1.0	271.0
MINE CAPITAL	0.0	0.0	0.0	3.0	3.0	6.0	10.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.0
MILL CAPITAL	0.0	0.0	0.0	2.0	15.0	30.0	22.0	9.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	80.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	1.0	1.0	3.0	2.0	3.0	2.0	1.0	1.0	1.0	1.0	1.0	17.0
SUB TOTAL	0.0	0.0	0.0	5.0	19.0	37.0	35.0	21.0	5.0	2.0	1.0	1.0	1.0	1.0	1.0	129.0
PRIMARY DEVELOPMENT	0.0	1.0	1.0	10.0	13.0	5.0	26.0	19.0	13.0	10.0	11.0	11.0	14.0	12.0	10.0	156.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	10.0	44.0	77.0	87.0	88.0	89.0	90.0	85.0	84.0	82.0	736.0
TOTAL	2.0	3.0	3.0	18.0	61.5	77.5	132.5	142.5	132.5	127.5	129.5	127.5	122.5	118.5	94.0	1292.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS IV																
EXPLORATION INVESTMENT	2.3	4.7	0.8	5.3	6.1	5.7	5.8	6.8	6.2	6.1	5.0	4.0	3.0	0.0	0.0	61.8
DEVELOPMENT DRILLING	0.7	1.3	0.2	1.6	1.8	2.2	2.1	2.1	2.7	2.8	2.9	0.0	0.0	0.0	0.0	20.4
SUB TOTAL	3.0	6.0	1.0	6.9	7.9	7.9	7.9	8.9	8.9	8.9	7.9	4.0	3.0	0.0	0.0	82.2
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	1.0	7.0	4.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	17.0	33.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	55.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	2.0	2.0	2.0	2.0	2.0	2.0	18.0
SUB TOTAL	0.0	0.0	0.0	0.0	0.0	19.0	42.0	11.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	87.0
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	4.0	13.0	14.0	13.0	13.0	13.0	11.0	12.0	11.0	11.0	115.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	0.0	3.0	48.0	57.0	57.0	56.0	56.0	61.0	59.0	59.0	456.0
TOTAL	3.0	6.0	1.0	6.9	7.9	30.9	65.9	81.9	81.9	80.9	78.9	73.0	78.0	72.0	72.0	740.2

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
CLASS V	MILLIONS OF DOLLARS															
EXPLORATION INVESTMENT	0.5	3.3	12.5	31.7	60.5	85.9	95.8	87.0	75.4	70.0	70.0	66.8	65.0	76.8	106.8	907.9
DEVELOPMENT DRILLING	0.0	0.0	0.0	0.6	3.8	11.8	22.3	29.0	27.4	22.4	19.7	20.7	20.4	17.4	16.5	212.0
SUB TOTAL	0.5	3.3	12.5	32.3	64.3	97.7	118.1	116.0	102.8	92.4	89.7	87.6	85.4	94.2	123.3	1119.9
MINE CAPITAL	0.0	0.0	0.0	0.0	0.3	1.4	3.4	6.7	14.6	23.4	23.6	14.1	11.1	10.1	8.5	117.2
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	2.7	16.3	53.6	94.2	99.4	57.5	44.5	42.1	34.7	444.9
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.9	8.3	10.6	12.2	13.8	49.8
SUB TOTAL	0.0	0.0	0.0	0.0	0.3	1.4	6.1	23.1	68.2	118.6	126.8	79.8	66.2	64.4	57.0	611.9
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.7	13.1	29.6	49.0	64.6	75.1	84.0	91.9	411.6
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3	112.7	240.9	308.3	354.0	401.0	1444.3
TOTAL	0.5	3.3	12.5	32.3	64.6	99.1	124.7	142.8	184.0	267.9	378.3	472.9	535.0	596.7	673.2	3587.7

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
TOTALS BY CLASS																
CLASS I	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0
CLASS II	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0
CLASS III	2.0	3.0	3.0	18.0	61.5	77.5	132.5	142.5	132.5	127.5	129.5	127.5	122.5	118.5	94.0	1292.0
CLASS IV	3.0	6.0	1.0	6.9	7.9	30.9	65.9	81.9	81.9	80.9	78.9	73.0	78.0	72.0	72.0	740.2
CLASS V	0.5	3.3	12.5	32.3	64.6	99.1	124.7	142.8	184.0	267.9	378.3	472.9	535.0	596.7	673.2	3587.7
TOTAL	186.5	200.3	199.5	245.2	392.2	452.7	564.3	604.4	634.6	686.5	787.9	856.6	904.7	947.4	912.2	8574.9

CASE IV -- LOW

SCHEDULES A & B

UNITED STATES U3O8 SUPPLY AVAILABILITY
STATISTICAL SUMMARY

SCHEDULE A

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF POUNDS U3O8															
TOTAL REQUIREMENTS	13.8	11.9	13.4	18.7	26.2	32.8	42.2	50.1	57.3	67.1	78.7	89.7	100.4	109.8	120.7	832.8
AEC STOCKPILE SALES	0.0	0.0	0.8	2.3	3.2	3.7	5.8	6.5	7.4	8.9	10.5	0.0	0.0	0.0	0.0	49.1
NET IMPORTS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ADJUSTED REQUIREMENTS (DOMESTIC IND. DEMAND)	13.8	11.9	12.6	16.4	23.0	29.1	36.4	43.6	49.9	58.2	68.2	89.7	100.4	109.8	120.7	783.7
YELLOWCAKE PRODUCTION	24.7	26.0	28.0	28.4	28.4	33.6	33.8	30.8	32.0	36.6	54.2	83.7	101.5	110.7	121.8	774.2
U3O8 INVENTORIES (1/1/71=21.6MM LBS.)	32.5	46.6	62.0	74.0	79.4	83.9	81.3	68.5	50.6	29.0	15.0	9.0	10.0	11.0	12.1	
PRODUCTION CAPABILITY																
CLASS I	28.8	29.4	30.0	29.6	29.0	27.0	27.0	24.6	24.4	20.6	19.6	17.6	16.0	15.8	14.0	353.4
CLASS II	2.6	4.2	6.6	6.8	6.8	6.6	6.8	6.2	5.8	5.8	5.8	3.8	3.8	2.8	2.6	77.0
CLASS III	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	9.8	18.4	20.2	20.4	20.4	20.0	111.0
CLASS IV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	10.4	12.6	12.8	13.0	13.2	62.4
SUB TOTAL	31.4	33.6	36.6	36.4	35.8	33.6	33.8	30.8	32.0	36.6	54.2	54.2	53.0	52.0	49.8	603.8
CLASS V(NEW DISCOVERY)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.5	48.5	58.7	72.0	
ANNUAL ADDITIONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.5	19.0	10.3	13.2	72.0
I+I RESERVE ADDITIONS	0.0	0.0	0.0	0.0	0.0	0.0	217.1	140.0	75.7	97.6	81.1	139.0	98.5	35.4	43.3	927.7
LEVELIZED I.I REQ.	0.0	0.0	0.0	0.0	0.0	72.4	119.0	144.3	104.4	84.8	105.9	106.2	91.0	59.1	38.2	925.2
ORE RESERVES	529.3	572.9	611.3	645.7	678.5	771.3	908.9	1071.2	1188.8	1279.1	1369.2	1517.7	1598.6	1608.5	1591.8	
YEARS FORWARD RESERVES	11.9	11.5	11.1	10.6	10.0	10.0	10.1	10.3	10.3	10.1	10.0	10.5	10.7	10.5	10.2	
	MILLIONS OF FEET SURFACE DRILLING															
DRILLING TO PROVE CLASS I-IV POTENTIAL RESERVES	15.5	17.4	16.6	15.7	14.8	14.0	13.1	12.2	11.3	10.5	9.6	9.4	8.6	7.7	6.8	183.2
DRILLING TO PROVE CLASS V RESERVES	0.0	0.0	0.0	0.0	3.6	11.4	21.6	28.6	28.8	26.7	24.8	24.7	23.0	18.5	17.0	228.8
ESTIMATED TOTAL DRILLING REQUIREMENTS	15.5	17.4	16.6	15.7	18.4	25.4	34.7	40.8	40.1	37.2	34.4	34.1	31.6	26.2	23.8	412.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS I																
EXPLORATION INVESTMENT	1.5	2.3	3.0	2.6	51.4	51.2	51.2	51.0	51.5	50.2	49.5	49.8	49.8	47.8	0.0	512.8
DEVELOPMENT DRILLING	0.5	0.7	1.0	1.4	14.9	15.1	15.1	15.3	14.8	15.1	14.8	14.5	14.5	13.5	0.0	151.2
SUB TOTAL	2.0	3.0	4.0	4.0	60.3	66.3	66.3	66.3	66.3	65.3	64.3	64.3	64.3	61.3	0.0	664.0
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REPLACEMENT EQUIPMENT	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
SUB TOTAL	6.0	4.0	4.0	4.0	4.0	4.0	3.0	4.0	5.0	6.0	3.0	2.0	1.0	1.0	1.0	52.0
PRIMARY DEVELOPMENT	22.0	22.0	21.0	22.0	22.0	17.0	17.0	19.0	19.0	15.0	15.0	15.0	15.0	15.0	11.0	267.0
OPERATING EXPENSES	118.0	125.0	123.0	131.0	122.0	114.0	112.0	106.0	106.0	85.0	82.0	71.0	57.0	55.0	50.0	1457.0
TOTAL	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS II																
EXPLORATION INVESTMENT	0.0	0.0	0.0	0.0	10.8	11.6	10.8	11.7	10.8	11.7	11.6	10.8	10.8	10.8	0.0	111.4
DEVELOPMENT DRILLING	0.0	0.0	0.0	0.0	3.1	3.3	3.1	3.2	3.1	3.2	3.3	3.1	3.1	3.1	0.0	31.6
SUB TOTAL	0.0	0.0	0.0	0.0	13.9	14.9	13.9	14.9	13.9	14.9	14.9	13.9	13.9	13.9	0.0	143.0
MINE CAPITAL	6.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
MILL CAPITAL	13.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.0
REPLACEMENT EQUIPMENT	0.0	0.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	8.0
SUB TOTAL	19.0	15.0	2.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	42.0
PRIMARY DEVELOPMENT	10.0	10.0	10.0	10.0	10.0	10.0	9.0	8.0	8.0	7.0	4.0	3.0	3.0	2.0	1.0	105.0
OPERATING EXPENSES	4.0	9.0	19.0	16.0	19.0	18.0	19.0	19.0	18.0	17.0	17.0	14.0	14.0	12.0	10.0	225.0
TOTAL	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS III																
EXPLORATION INVESTMENT	0.0	0.0	1.6	1.6	1.5	2.3	23.0	19.1	20.6	18.6	20.6	20.5	21.5	18.3	17.2	186.4
DEVELOPMENT DRILLING	0.0	0.0	0.4	0.4	0.5	0.7	6.5	6.4	6.9	6.9	6.9	7.0	7.0	7.2	5.3	62.1
SUB TOTAL	0.0	0.0	2.0	2.0	2.0	3.0	29.5	25.5	27.5	25.5	27.5	27.5	28.5	25.5	22.5	248.5
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	6.0	10.0	10.0	0.0	0.0	0.0	0.0	32.0
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	2.0	15.0	30.0	22.0	9.0	2.0	0.0	0.0	0.0	80.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	3.0	2.0	3.0	2.0	1.0	1.0	14.0
SUB TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	5.0	19.0	37.0	35.0	21.0	5.0	2.0	1.0	1.0	126.0
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	1.0	1.0	10.0	13.0	5.0	26.0	19.0	13.0	10.0	11.0	11.0	120.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	44.0	77.0	87.0	88.0	89.0	90.0	485.0
TOTAL	0.0	0.0	2.0	2.0	3.0	4.0	44.5	57.5	79.5	130.5	144.5	132.5	128.5	126.5	124.5	979.5

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
CLASS IV																
EXPLORATION INVESTMENT	0.0	0.0	0.0	2.3	4.7	0.8	5.3	6.1	5.7	5.8	6.8	6.2	6.1	5.0	4.0	58.8
DEVELOPMENT DRILLING	0.0	0.0	0.0	0.7	1.3	0.2	1.6	1.8	2.2	2.1	2.1	2.7	2.8	2.9	0.0	20.4
SUB TOTAL	0.0	0.0	0.0	3.0	0.0	1.0	6.9	7.9	7.9	7.9	8.9	8.9	8.9	7.9	4.0	79.2
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	7.0	4.0	2.0	0.0	0.0	0.0	14.0
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	33.0	5.0	0.0	0.0	0.0	0.0	55.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	1.0	2.0	2.0	2.0	12.0
SUB TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	42.0	11.0	3.0	2.0	2.0	2.0	81.0
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	13.0	14.0	13.0	13.0	13.0	11.0	81.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	48.0	57.0	57.0	56.0	56.0	277.0
TOTAL	0.0	0.0	0.0	3.0	0.0	1.0	6.9	7.9	30.9	65.9	81.9	81.9	80.9	78.9	73.0	518.2

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

CLASS V

	1971	1972	1973	1974	1975	1976	1977	1978
	MILLIONS OF DOLLARS							
EXPLORATION INVESTMENT	0.0	0.0	2.5	9.2	28.6	54.0	78.2	82.7
DEVELOPMENT DRILLING	0.0	0.0	0.0	0.0	0.0	2.9	10.6	21.1
SUB TOTAL	0.0	0.0	2.5	9.2	28.6	56.9	88.8	103.8
MINE CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.7
MILL CAPITAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SUB TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	1.6	2.7
PRIMARY DEVELOPMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPERATING EXPENSES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	2.5	9.2	28.6	56.9	90.4	106.5

	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS							
EXPLORATION INVESTMENT	76.1	68.9	67.8	65.4	56.4	49.4	59.0	698.3
DEVELOPMENT DRILLING	25.2	23.3	19.4	19.5	20.6	18.1	13.5	174.2
SUB TOTAL	101.4	92.2	87.2	84.9	77.0	67.5	72.5	872.5
MINE CAPITAL	4.9	13.1	24.9	16.4	12.1	12.4	10.1	98.2
MILL CAPITAL	12.5	45.6	103.7	67.2	47.8	51.8	42.9	371.5
REPLACEMENT EQUIPMENT	0.0	0.0	0.0	4.4	7.3	8.8	10.8	31.3
SUB TOTAL	17.4	58.8	128.7	88.0	67.2	73.0	63.8	501.1
PRIMARY DEVELOPMENT	2.7	11.0	26.8	43.8	55.7	66.1	75.8	281.8
OPERATING EXPENSES	0.0	0.0	0.0	128.2	210.8	255.5	313.2	907.7
TOTAL	121.4	162.0	242.7	344.9	410.7	462.1	525.3	2563.1

URANIUM RAW MATERIALS INVESTMENT AND PRODUCTION COST SCHEDULES

SCHEDULE B

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
TOTALS BY CLASS																
CLASS I	148.0	154.0	152.0	161.0	214.3	201.3	198.3	195.3	196.3	171.3	164.3	152.3	137.3	132.3	62.0	2440.0
CLASS II	33.0	34.0	31.0	27.0	43.9	43.9	42.9	41.9	39.9	38.9	36.9	30.9	31.9	27.9	11.0	515.0
CLASS III	0.0	0.0	2.0	2.0	3.0	4.0	44.5	57.5	79.5	130.5	144.5	132.5	128.5	126.5	124.5	979.5
CLASS IV	0.0	0.0	0.0	3.0	6.0	1.0	6.9	7.9	30.9	65.9	81.9	81.9	80.9	78.9	73.0	518.2
CLASS V	0.0	0.0	2.5	9.2	28.6	56.9	90.4	106.5	121.4	162.0	242.7	344.9	410.7	462.1	525.3	2563.1
TOTAL	181.0	188.0	187.5	202.2	295.8	307.1	383.0	409.1	468.0	568.6	670.3	742.5	789.3	827.7	795.8	7015.8

PARAMETRIC STUDY -- BASIC ASSUMPTIONS
EXCEPT DISCOVERY RATE AT 3 POUNDS OF
U_3O_8 PER FOOT OF SURFACE DRILLING

SCHEDULE C

CLASS V
SALES PRICE $ 9.61/LB.
RATE OF RETURN 10.0 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
REVENUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.4	249.0	532.3	681.1	782.2	887.9	3192.7
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.4	249.0	532.3	681.1	782.2	887.9	3192.7
OPER.COSTS.PRIM.DEV.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.7	13.1	56.9	161.7	305.6	382.6	434.7	485.0	1844.0
BEFORE TAX CASH FLOW	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-3.7	-13.1	3.5	87.2	226.7	298.4	347.4	402.8	1348.7
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	13.9	29.6	37.9	43.5	49.4	177.7
2. EQUIPMENT REPLAC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.9	8.3	10.6	12.2	13.9	49.8
3. DEVELOPMENT DRILL.	0.0	0.0	0.0	1.0	6.4	20.0	37.9	49.3	46.6	36.6	27.9	23.2	19.7	15.1	11.2	295.2
4. DEPLETION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.8	82.8	115.1	138.3	164.2	521.1
TAXABLE INCOME	0.0	0.0	0.0	-1.0	-6.4	-20.0	-38.5	-53.1	-59.7	-37.4	20.8	82.8	115.1	138.3	164.2	304.9
TAXES AT 50 PERCENT	0.0	0.0	0.0	-0.5	-3.2	-10.0	-19.3	-26.5	-29.9	-18.7	10.4	41.4	57.5	69.2	82.1	152.5
PREFERENCE TAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.7	5.2	6.2	7.4	23.5
INVESTMENT TAX CREDIT	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.3	3.8	6.6	7.1	4.4	3.4	2.6	0.8	30.5
NET TAXES	0.0	0.0	0.0	-0.5	-3.2	-10.1	-19.6	-27.8	-33.7	-25.4	4.3	40.7	59.3	72.8	88.7	145.4
AFTER TAX CASH FLOW	0.0	0.0	0.0	0.5	3.2	10.1	19.0	24.1	20.6	28.8	83.0	186.1	239.1	274.7	314.1	1203.3
LESS INVESTMENT																
1. EXPLORATION	0.7	4.1	15.3	40.0	80.8	125.6	154.7	152.7	128.0	100.9	80.5	66.6	51.8	37.5	24.3	1063.4
2. MINE/MILL	0.0	0.0	0.0	0.0	0.3	1.4	6.1	23.1	68.2	118.6	126.4	79.1	60.9	46.3	13.9	544.1
TOTAL INVESTMENT	0.7	4.1	15.3	40.0	81.1	127.0	160.8	175.8	196.2	219.5	206.9	145.7	112.7	83.8	38.2	1607.6
NET CASH FLOW	-0.7	-4.1	-15.3	-39.4	-77.9	-116.9	-141.7	-151.7	-175.6	-190.7	-123.9	40.4	126.4	190.9	276.0	-404.3
DISCOUNT FACTORS	0.9535	0.8668	0.7880	0.7164	0.6512	0.5920	0.5382	0.4893	0.4448	0.4044	0.3676	0.3342	0.3038	0.2762	0.2511	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	-0.6	-3.5	-12.1	-28.3	-50.7	-69.2	-76.3	-74.2	-78.1	-77.1	-45.6	13.5	38.4	52.7	69.3	-341.8
CUMULATIVE CASH FLOW	-0.6	-4.2	-16.2	-44.5	-95.2	-164.4	-240.7	-314.9	-393.0	-470.1	-515.7	-502.2	-463.8	-411.1	-341.8	

CLASS V
SALES PRICE $ 9.61/LB.
RATE OF RETURN 10.0 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
	MILLIONS OF DOLLARS															
REVENUE	887.9	887.9	887.9	887.9	827.5	638.9	355.6	206.8	105.7	0.0	0.0	0.0	0.0	0.0	0.0	8878.7
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	887.9	887.9	887.9	887.9	827.5	638.9	355.6	206.8	105.7	0.0	0.0	0.0	0.0	0.0	0.0	8878.7
OPER.COSTS.PRIM.DEV.	485.0	484.5	481.3	472.0	428.1	323.3	179.5	102.4	50.3	0.0	0.0	0.0	0.0	0.0	0.0	4850.5
BEFORE TAX CASH FLOW	402.8	403.4	406.6	415.9	399.4	315.6	176.1	104.4	55.4	0.0	0.0	0.0	0.0	0.0	0.0	4028.2
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	49.4	49.4	49.4	49.4	46.1	35.6	19.8	11.5	5.9	0.0	0.0	0.0	0.0	0.0	0.0	494.3
2. EQUIPMENT REPLAC.	13.9	13.9	13.9	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	138.6
3. DEVELOPMENT DRILL.	7.0	3.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	306.9
4. DEPLETION	166.3	168.3	171.0	176.3	170.2	135.0	75.4	44.8	23.3	0.0	0.0	0.0	0.0	0.0	0.0	1651.7
TAXABLE INCOME	166.3	168.3	171.0	176.3	170.2	135.0	75.4	44.8	24.6	0.0	0.0	0.0	0.0	0.0	0.0	1436.8
TAXES AT 50 PERCENT	83.1	84.1	85.5	88.2	85.1	67.5	37.7	22.4	12.3	0.0	0.0	0.0	0.0	0.0	0.0	718.4
PREFERENCE TAX	7.5	7.6	7.7	7.9	7.7	6.1	3.4	2.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	74.3
INVESTMENT TAX CREDIT	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	35.4
NET TAXES	89.8	90.9	92.4	95.3	92.0	73.0	40.8	24.2	13.2	0.0	0.0	0.0	0.0	0.0	0.0	757.2
AFTER TAX CASH FLOW	313.0	312.4	314.1	320.6	307.3	242.5	135.3	80.1	42.2	0.0	0.0	0.0	0.0	0.0	0.0	3271.0
LESS INVESTMENT																
1. EXPLORATION	12.9	5.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1083.0
2. MINE/MILL	13.9	13.9	13.9	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	632.9
TOTAL INVESTMENT	26.8	19.3	15.1	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1715.9
NET CASH FLOW	286.2	293.2	299.1	306.7	294.4	232.6	129.8	76.9	40.5	0.0	0.0	0.0	0.0	0.0	0.0	1555.1
DISCOUNT FACTORS	0.2283	0.2075	0.1886	0.1715	0.1559	0.1417	0.1288	0.1171	0.1065	0.0968	0.0880	0.0800	0.0727	0.0661	0.0601	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	65.3	60.8	56.4	52.6	45.9	33.0	16.7	9.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	2.3
CUMULATIVE CASH FLOW	-276.4	-215.6	-159.2	-106.6	-60.7	-27.7	-11.0	-2.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	

CLASS V
SALES PRICE $ 10.41/LB.
RATE OF RETURN 12.5 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
REVENUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.4	269.7	576.6	737.8	847.3	961.8	3458.5
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.4	269.7	576.6	737.8	847.3	961.8	3458.5
OPER.COSTS.PRIM.DEV.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.7	13.1	56.9	161.7	305.6	382.6	434.7	485.0	1844.0
BEFORE TAX CASH FLOW	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-3.7	-13.1	8.5	108.0	271.1	355.1	412.5	476.7	1614.5
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	13.9	29.6	37.9	43.5	49.4	177.7
2. EQUIPMENT REPLAC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.9	8.3	10.6	12.2	13.9	49.8
3. DEVELOPMENT DRILL.	0.0	0.0	0.0	1.0	6.4	20.0	37.9	49.3	46.6	36.6	27.9	23.2	19.7	15.1	11.2	295.2
4. DEPLETION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.2	104.9	143.4	170.9	201.1	651.5
TAXABLE INCOME	0.0	0.0	0.0	-1.0	-6.4	-20.0	-38.5	-53.1	-59.7	-32.4	31.2	104.9	143.4	170.9	201.1	440.3
TAXES AT 50 PERCENT	0.0	0.0	0.0	-0.5	-3.2	-10.0	-19.3	-26.5	-29.9	-16.2	15.6	52.5	71.7	85.4	100.6	220.2
PREFERENCE TAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	4.7	6.5	7.7	9.0	29.3
INVESTMENT TAX CREDIT	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.3	3.8	6.6	7.1	4.4	3.4	2.6	0.8	30.5
NET TAXES	0.0	0.0	0.0	-0.5	-3.2	-10.1	-19.6	-27.8	-33.7	-22.8	9.9	52.8	74.8	90.5	108.8	219.0
AFTER TAX CASH FLOW	0.0	0.0	0.0	0.5	3.2	10.1	19.0	24.1	20.6	31.3	98.1	218.3	280.4	322.0	367.9	1395.5
LESS INVESTMENT																
1. EXPLORATION	0.7	4.1	15.3	40.0	80.8	125.6	154.7	152.7	128.0	100.9	80.5	66.6	51.8	37.5	24.3	1063.4
2. MINE/MILL	0.0	0.0	0.0	0.0	0.3	1.4	6.1	23.1	68.2	118.6	126.4	79.1	60.9	46.3	13.9	544.1
TOTAL INVESTMENT	0.7	4.1	15.3	40.0	81.1	127.0	160.8	175.8	196.2	219.5	206.9	145.7	112.7	83.8	38.2	1607.6
NET CASH FLOW	-0.7	-4.1	-15.3	-39.4	-77.9	-116.9	-141.7	-151.7	-175.6	-188.2	-108.8	72.6	167.7	238.3	329.7	-212.0
DISCOUNT FACTORS	0.9430	0.8380	0.7450	0.6620	0.5890	0.5230	0.4650	0.4140	0.3680	0.3270	0.2960	0.2580	0.2300	0.2040	0.1820	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	-0.6	-3.4	-11.4	-26.1	-45.9	-61.1	-65.9	-62.8	-64.6	-61.5	-32.2	18.7	38.6	48.6	60.0	-269.7
CUMULATIVE CASH FLOW	-0.6	-4.0	-15.4	-41.5	-87.4	-148.6	-214.5	-277.3	-341.9	-403.4	-435.6	-416.9	-378.3	-329.7	-269.7	

CLASS V
SALES PRICE $ 10,41/LB,
RATE OF RETURN 12,5 PCT,

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
	-------	-------	-------	-------	-------	-------	-MILLIONS	OF DOLLARS-	-------	-------	-------	-------	-------	-------	-------	-------
REVENUE	961,8	961,8	961,8	961,8	896,4	692,1	385,2	224,0	114,5	0,0	0,0	0,0	0,0	0,0	0,0	9617,8
ROYALTY	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
NET SALES	961,8	961,8	961,8	961,8	896,4	692,1	385,2	224,0	114,5	0,0	0,0	0,0	0,0	0,0	0,0	9617,8
OPER.COSTS,PRIM.DEV.	485,0	484,5	481,3	472,0	428,1	323,3	179,5	102,4	50,3	0,0	0,0	0,0	0,0	0,0	0,0	4850,5
BEFORE TAX CASH FLOW	476,7	477,3	480,5	489,8	468,3	368,8	205,7	121,6	64,2	0,0	0,0	0,0	0,0	0,0	0,0	4767,3
LESS DEDUCTIBLE ITEMS																
1, DEPRECIATION	49,4	49,4	49,4	49,4	46,1	35,6	19,8	11,5	5,9	0,0	0,0	0,0	0,0	0,0	0,0	494,3
2, EQUIPMENT REPLAC,	13,9	13,9	13,9	13,9	12,9	10,0	5,5	3,2	1,7	0,0	0,0	0,0	0,0	0,0	0,0	138,6
3, DEVELOPMENT DRILL,	7,0	3,5	1,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	306,9
4, DEPLETION	203,2	205,2	208,0	211,6	197,2	152,3	84,7	49,3	25,2	0,0	0,0	0,0	0,0	0,0	0,0	1988,2
TAXABLE INCOME	203,2	205,2	208,0	214,9	212,1	171,0	95,6	57,6	31,5	0,0	0,0	0,0	0,0	0,0	0,0	1839,4
TAXES AT 50 PERCENT	101,6	102,6	104,0	107,5	106,0	85,5	47,8	28,8	15,7	0,0	0,0	0,0	0,0	0,0	0,0	919,7
PREFERENCE TAX	9,1	9,2	9,4	9,4	8,2	6,0	3,3	1,8	0,9	0,0	0,0	0,0	0,0	0,0	0,0	86,7
INVESTMENT TAX CREDIT	0,8	0,8	0,8	0,8	0,7	0,6	0,3	0,2	0,1	0,0	0,0	0,0	0,0	0,0	0,0	35,4
NET TAXES	110,0	111,1	112,6	116,1	113,5	90,9	50,8	30,5	16,5	0,0	0,0	0,0	0,0	0,0	0,0	970,9
AFTER TAX CASH FLOW	366,7	366,2	367,9	373,7	354,7	277,8	154,9	91,2	47,7	0,0	0,0	0,0	0,0	0,0	0,0	3796,4
LESS INVESTMENT																
1, EXPLORATION	12,9	5,4	1,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1083,0
2, MINE/MILL	13,9	13,9	13,9	13,9	12,9	10,0	5,5	3,2	1,7	0,0	0,0	0,0	0,0	0,0	0,0	632,9
TOTAL INVESTMENT	26,8	19,3	15,1	13,9	12,9	10,0	5,5	3,2	1,7	0,0	0,0	0,0	0,0	0,0	0,0	1715,9
NET CASH FLOW	339,9	346,9	352,8	359,9	341,8	267,9	149,3	87,9	46,0	0,0	0,0	0,0	0,0	0,0	0,0	2080,5
DISCOUNT FACTORS	0,1620	0,1440	0,1280	0,1140	0,1010	0,0900	0,0800	0,0710	0,0630	0,0560	0,0500	0,0440	0,0400	0,0350	0,0310	
PRESENT VALUE OF INVESTMENT = 0,0																
DISCOUNTED CASH FLOW	55,1	50,0	45,2	41,0	34,5	24,1	11,9	6,2	2,9	0,0	0,0	0,0	0,0	0,0	0,0	1,2
CUMULATIVE CASH FLOW	-214,6	-164,7	-119,5	-78,5	-44,0	-19,9	-7,9	-1,7	1,2	0,0	0,0	0,0	0,0	0,0	0,0	

CLASS V
SALES PRICE $ 11.41/LB.
RATE OF RETURN 15.0 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
								MILLIONS OF DOLLARS								
REVENUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.7	295.6	632.0	808.6	928.7	1054.2	3790.7
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.7	295.6	632.0	808.6	928.7	1054.2	3790.7
OPER.COSTS.PRIM.DEV.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.7	13.1	56.9	161.7	305.6	382.6	434.7	485.0	1844.0
BEFORE TAX CASH FLOW	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-3.7	-13.1	14.8	133.9	326.4	426.0	493.9	569.1	1946.8
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	13.9	29.6	37.9	43.5	49.4	177.7
2. EQUIPMENT REPLAC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.9	8.3	10.6	12.2	13.9	49.8
3. DEVELOPMENT DRILL.	0.0	0.0	0.0	1.0	6.4	20.0	37.9	49.3	46.6	36.6	27.9	23.2	19.7	15.1	11.2	295.2
4. DEPLETION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.1	132.6	177.9	204.3	231.9	790.9
TAXABLE INCOME	0.0	0.0	0.0	-1.0	-6.4	-20.0	-38.5	-53.1	-59.7	-26.1	44.1	132.6	179.8	218.8	262.7	633.1
TAXES AT 50 PERCENT	0.0	0.0	0.0	-0.5	-3.2	-10.0	-19.3	-26.5	-29.9	-13.1	22.1	66.3	89.9	109.4	131.3	316.6
PREFERENCE TAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	6.0	7.9	8.5	9.1	33.5
INVESTMENT TAX CREDIT	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.3	3.8	6.6	7.1	4.4	3.4	2.6	0.8	30.5
NET TAXES	0.0	0.0	0.0	-0.5	-3.2	-10.1	-19.6	-27.8	-33.7	-19.7	17.0	67.9	94.4	115.3	139.6	319.6
AFTER TAX CASH FLOW	0.0	0.0	0.0	0.5	3.2	10.1	19.0	24.1	20.6	34.5	116.9	258.6	331.6	378.6	429.5	1627.2
LESS INVESTMENT																
1. EXPLORATION	0.7	4.1	15.3	40.0	80.8	125.6	154.7	152.7	128.0	100.9	80.5	66.6	51.8	37.5	24.3	1063.4
2. MINE/MILL	0.0	0.0	0.0	0.0	0.3	1.4	6.1	23.1	68.2	118.6	126.4	79.1	60.9	46.3	13.9	544.1
TOTAL INVESTMENT	0.7	4.1	15.3	40.0	81.1	127.0	160.8	175.8	196.2	219.5	206.9	145.7	112.7	83.8	38.2	1607.6
NET CASH FLOW	-0.7	-4.1	-15.3	-39.4	-77.9	-116.9	-141.7	-151.7	-175.6	-185.1	-90.0	112.9	218.9	294.8	391.3	19.6
DISCOUNT FACTORS	0.9325	0.8109	0.7051	0.6131	0.5332	0.4636	0.4031	0.3506	0.3048	0.2651	0.2305	0.2004	0.1743	0.1516	0.1318	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	-0.6	-3.3	-10.8	-24.2	-41.5	-54.2	-57.1	-53.2	-53.5	-49.1	-20.7	22.6	38.2	44.7	51.6	-211.2
CUMULATIVE CASH FLOW	-0.6	-3.9	-14.7	-38.9	-80.4	-134.6	-191.7	-244.9	-298.4	-347.5	-368.2	-345.6	-307.5	-262.8	-211.2	

CLASS V
SALES PRICE $ 11.41/LB.
RATE OF RETURN 15.0 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
	-----	-----	-----	-----	-----	-----	-----MILLIONS	OF	DOLLARS-----	-----	-----	-----	-----	-----	-----	-----
REVENUE	1054.2	1054.2	1054.2	1054.2	982.5	758.5	422.2	245.5	125.5	0.0	0.0	0.0	0.0	0.0	0.0	10541.7
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	1054.2	1054.2	1054.2	1054.2	982.5	758.5	422.2	245.5	125.5	0.0	0.0	0.0	0.0	0.0	0.0	10541.7
OPER.COSTS,PRIM.DEV.	485.0	484.5	481.3	472.0	428.1	323.3	179.5	102.4	50.3	0.0	0.0	0.0	0.0	0.0	0.0	4850.5
BEFORE TAX CASH FLOW	569.1	569.7	572.9	582.2	554.4	435.2	242.7	143.1	75.2	0.0	0.0	0.0	0.0	0.0	0.0	5691.2
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	49.4	49.4	49.4	49.4	46.1	35.6	19.8	11.5	5.9	0.0	0.0	0.0	0.0	0.0	0.0	494.3
2. EQUIPMENT REPLAC.	13.9	13.9	13.9	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	138.6
3. DEVELOPMENT DRILL.	7.0	3.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	306.9
4. DEPLETION	231.9	231.9	231.9	231.9	216.2	166.9	92.9	54.0	27.6	0.0	0.0	0.0	0.0	0.0	0.0	2276.1
TAXABLE INCOME	267.0	270.9	276.5	287.0	279.2	222.8	124.5	74.4	40.0	0.0	0.0	0.0	0.0	0.0	0.0	2475.4
TAXES AT 50 PERCENT	133.5	135.5	138.2	143.5	139.6	111.4	62.2	37.2	20.0	0.0	0.0	0.0	0.0	0.0	0.0	1237.7
PREFERENCE TAX	8.9	8.7	8.4	8.0	6.9	5.0	2.8	1.5	0.7	0.0	0.0	0.0	0.0	0.0	0.0	84.2
INVESTMENT TAX CREDIT	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	35.4
NET TAXES	141.6	143.4	145.9	150.7	145.8	115.8	64.7	38.5	20.6	0.0	0.0	0.0	0.0	0.0	0.0	1286.5
AFTER TAX CASH FLOW	427.6	426.3	427.0	431.5	408.6	319.4	178.0	104.6	54.6	0.0	0.0	0.0	0.0	0.0	0.0	4404.7
LESS INVESTMENT																
1. EXPLORATION	12.9	5.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1083.0
2. MINE/MILL	13.9	13.9	13.9	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	632.9
TOTAL INVESTMENT	26.8	19.3	15.1	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1715.9
NET CASH FLOW	400.8	407.0	411.9	417.7	395.7	309.4	172.4	101.4	52.9	0.0	0.0	0.0	0.0	0.0	0.0	2688.8
DISCOUNT FACTORS	0.1146	0.0997	0.0867	0.0754	0.0655	0.0570	0.0495	0.0431	0.0375	0.0326	0.0283	0.0246	0.0214	0.0186	0.0162	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	45.9	40.6	35.7	31.5	25.9	17.6	8.5	4.4	2.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
CUMULATIVE CASH FLOW	-165.3	-124.7	-89.0	-57.5	-31.6	-13.9	-5.4	-1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	

CLASS V
SALES PRICE $ 12.57/LB.
RATE OF RETURN 17.5 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
REVENUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.9	325.7	696.3	890.8	1023.1	1161.3	4176.1
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.9	325.7	696.3	890.8	1023.1	1161.3	4176.1
OPER.COSTS.PRIM.DEV.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.7	13.1	56.9	161.7	305.6	382.6	434.7	485.0	1844.0
BEFORE TAX CASH FLOW	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-3.7	-13.1	22.0	163.9	390.7	508.2	588.3	676.3	2332.1
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	13.9	29.6	37.9	43.5	49.4	177.7
2. EQUIPMENT REPLAC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.9	8.3	10.6	12.2	13.9	49.8
3. DEVELOPMENT DRILL.	0.0	0.0	0.0	1.0	6.4	20.0	37.9	49.3	46.6	36.6	27.9	23.2	19.7	15.1	11.2	295.2
4. DEPLETION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.1	153.2	196.0	225.1	255.5	888.9
TAXABLE INCOME	0.0	0.0	0.0	-1.0	-6.4	-20.0	-38.5	-53.1	-59.7	-18.8	59.1	176.4	243.9	292.4	346.3	920.5
TAXES AT 50 PERCENT	0.0	0.0	0.0	-0.5	-3.2	-10.0	-19.3	-26.5	-29.9	-9.4	29.6	88.2	122.0	146.2	173.1	460.3
PREFERENCE TAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	5.8	6.7	7.1	7.4	29.7
INVESTMENT TAX CREDIT	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.3	3.8	6.6	7.1	4.4	3.4	2.6	0.8	30.5
NET TAXES	0.0	0.0	0.0	-0.5	-3.2	-10.1	-19.6	-27.8	-33.7	-16.1	25.2	89.6	125.2	150.7	179.8	459.5
AFTER TAX CASH FLOW	0.0	0.0	0.0	0.5	3.2	10.1	19.0	24.1	20.6	38.1	138.8	301.1	383.0	437.6	496.5	1872.7
LESS INVESTMENT																
1. EXPLORATION	0.7	4.1	15.3	40.0	80.8	125.6	154.7	152.7	128.0	100.9	80.5	66.6	51.8	37.5	24.3	1063.4
2. MINE/MILL	0.0	0.0	0.0	0.0	0.3	1.4	6.1	23.1	68.2	118.6	126.4	79.1	60.9	46.3	13.9	544.1
TOTAL INVESTMENT	0.7	4.1	15.3	40.0	81.1	127.0	160.8	175.8	196.2	219.5	206.9	145.7	112.7	83.8	38.2	1607.6
NET CASH FLOW	-0.7	-4.1	-15.3	-39.4	-77.9	-116.9	-141.7	-151.7	-175.6	-181.4	-68.1	155.4	270.3	353.9	458.4	265.1
DISCOUNT FACTORS	0.9230	0.7850	0.6680	0.5690	0.4840	0.4120	0.3510	0.2990	0.2540	0.2160	0.1840	0.1570	0.1330	0.1140	0.0970	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	-0.6	-3.2	-10.2	-22.4	-37.7	-48.2	-49.7	-45.4	-44.6	-39.2	-12.5	24.4	35.9	40.3	44.5	-168.6
CUMULATIVE CASH FLOW	-0.6	-3.8	-14.0	-36.5	-76.2	-122.3	-172.1	-217.4	-262.0	-301.2	-313.7	-289.3	-258.4	-213.1	-168.6	

CLASS V
SALES PRICE $ 12,57/LB,
RATE OF RETURN 17,5 PCT,

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
	MILLIONS OF DOLLARS															
REVENUE	1161,3	1161,3	1161,3	1161,3	1082,4	835,7	465,1	270,5	138,3	0,0	0,0	0,0	0,0	0,0	0,0	11613,4
ROYALTY	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
NET SALES	1161,3	1161,3	1161,3	1161,3	1082,4	835,7	465,1	270,5	138,3	0,0	0,0	0,0	0,0	0,0	0,0	11613,4
OPER,COSTS,PRIM,DEV,	485,0	484,5	481,3	472,0	428,1	323,3	179,5	102,4	50,3	0,0	0,0	0,0	0,0	0,0	0,0	4850,5
BEFORE TAX CASH FLOW	676,3	676,9	680,0	689,4	654,3	512,4	285,6	168,1	87,9	0,0	0,0	0,0	0,0	0,0	0,0	6762,9
LESS DEDUCTIBLE ITEMS																
1, DEPRECIATION	49,4	49,4	49,4	49,4	46,1	35,6	19,8	11,5	5,9	0,0	0,0	0,0	0,0	0,0	0,0	494,3
2, EQUIPMENT REPLAC,	13,9	13,9	13,9	13,9	12,9	10,0	5,5	3,2	1,7	0,0	0,0	0,0	0,0	0,0	0,0	138,6
3, DEVELOPMENT DRILL,	7,0	3,5	1,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	306,9
4, DEPLETION	255,5	255,5	255,5	255,5	238,1	183,8	102,3	59,5	30,4	0,0	0,0	0,0	0,0	0,0	0,0	2525,1
TAXABLE INCOME	350,5	354,5	360,1	370,6	357,1	283,0	157,9	93,8	50,0	0,0	0,0	0,0	0,0	0,0	0,0	3298,1
TAXES AT 50 PERCENT	175,3	177,3	180,0	185,3	178,6	141,5	79,0	46,9	25,0	0,0	0,0	0,0	0,0	0,0	0,0	1649,1
PREFERENCE TAX	7,2	7,0	6,8	6,3	5,4	3,8	2,1	1,1	0,5	0,0	0,0	0,0	0,0	0,0	0,0	69,9
INVESTMENT TAX CREDIT	0,8	0,8	0,8	0,8	0,7	0,6	0,3	0,2	0,1	0,0	0,0	0,0	0,0	0,0	0,0	35,4
NET TAXES	181,7	183,5	186,0	190,8	183,2	144,7	80,8	47,9	25,4	0,0	0,0	0,0	0,0	0,0	0,0	1683,6
AFTER TAX CASH FLOW	494,6	493,3	494,0	498,5	471,0	367,6	204,8	120,2	62,6	0,0	0,0	0,0	0,0	0,0	0,0	5079,4
LESS INVESTMENT																
1, EXPLORATION	12,9	5,4	1,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1083,0
2, MINE/MILL	13,9	13,9	13,9	13,9	12,9	10,0	5,5	3,2	1,7	0,0	0,0	0,0	0,0	0,0	0,0	632,9
TOTAL INVESTMENT	26,8	19,3	15,1	13,9	12,9	10,0	5,5	3,2	1,7	0,0	0,0	0,0	0,0	0,0	0,0	1715,9
NET CASH FLOW	467,8	474,0	478,9	484,7	458,1	357,6	199,3	117,0	60,9	0,0	0,0	0,0	0,0	0,0	0,0	3363,5
DISCOUNT FACTORS	0,0820	0,0700	0,0600	0,0510	0,0430	0,0370	0,0310	0,0270	0,0230	0,0190	0,0160	0,0140	0,0120	0,0100	0,0090	
PRESENT VALUE OF INVESTMENT = 0,0																
DISCOUNTED CASH FLOW	38,4	33,2	28,7	24,7	19,7	13,2	6,2	3,2	1,4	0,0	0,0	0,0	0,0	0,0	0,0	0,1
CUMULATIVE CASH FLOW	-130,2	-97,1	-68,3	-43,6	-23,9	-10,7	-4,5	-1,3	0,1	0,0	0,0	0,0	0,0	0,0	0,0	

CLASS V
SALES PRICE $ 13.95/LB.
RATE OF RETURN 20.0 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
	MILLIONS OF DOLLARS															
REVENUE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.6	361.4	772.7	988.6	1135.4	1288.8	4634.6
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.6	361.4	772.7	988.6	1135.4	1288.8	4634.6
OPER.COSTS.PRIM.DEV.	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.7	13.1	56.9	161.7	305.6	382.6	434.7	485.0	1844.0
BEFORE TAX CASH FLOW	0.0	0.0	0.0	0.0	0.0	0.0	-0.6	-3.7	-13.1	30.7	199.7	467.1	606.0	700.7	803.8	2790.6
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	13.9	29.6	37.9	43.5	49.4	177.7
2. EQUIPMENT REPLAC.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	3.9	8.3	10.6	12.2	13.9	49.8
3. DEVELOPMENT DRILL.	0.0	0.0	0.0	1.0	6.4	20.0	37.9	49.3	46.6	36.6	27.9	23.2	19.7	15.1	11.2	295.2
4. DEPLETION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	77.0	170.0	217.5	249.8	283.5	997.8
TAXABLE INCOME	0.0	0.0	0.0	-1.0	-6.4	-20.0	-38.5	-53.1	-59.7	-10.2	77.0	236.0	320.2	380.1	445.7	1270.0
TAXES AT 50 PERCENT	0.0	0.0	0.0	-0.5	-3.2	-10.0	-19.3	-26.5	-29.9	-5.1	38.5	118.0	160.1	190.0	222.9	635.0
PREFERENCE TAX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	4.7	5.2	5.4	5.5	24.2
INVESTMENT TAX CREDIT	0.0	0.0	0.0	0.0	0.0	0.1	0.3	1.3	3.8	6.6	7.1	4.4	3.4	2.6	0.8	30.5
NET TAXES	0.0	0.0	0.0	-0.5	-3.2	-10.1	-19.6	-27.8	-33.7	-11.7	34.9	118.2	161.9	192.8	227.5	628.7
AFTER TAX CASH FLOW	0.0	0.0	0.0	0.5	3.2	10.1	19.0	24.1	20.6	42.4	164.8	348.9	444.1	507.9	576.2	2161.9
LESS INVESTMENT																
1. EXPLORATION	0.7	4.1	15.3	40.0	80.8	125.6	154.7	152.7	128.0	100.9	80.5	66.6	51.8	37.5	24.3	1063.4
2. MINE/MILL	0.0	0.0	0.0	0.0	0.3	1.4	6.1	23.1	68.2	118.6	126.4	79.1	60.9	46.3	13.9	544.1
TOTAL INVESTMENT	0.7	4.1	15.3	40.0	81.1	127.0	160.8	175.8	196.2	219.5	206.9	145.7	112.7	83.8	38.2	1607.6
NET CASH FLOW	-0.7	-4.1	-15.3	-39.4	-77.9	-116.9	-141.7	-151.7	-175.6	-177.1	-42.1	203.2	331.4	424.1	538.1	554.4
DISCOUNT FACTORS	0.9129	0.7607	0.6339	0.5283	0.4402	0.3669	0.3057	0.2548	0.2123	0.1769	0.1474	0.1229	0.1024	0.0853	0.0711	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	-0.6	-3.1	-9.7	-20.8	-34.3	-42.9	-43.3	-38.7	-37.3	-31.3	-6.2	25.0	33.9	36.2	38.3	-134.9
CUMULATIVE CASH FLOW	-0.6	-3.7	-13.4	-34.2	-68.5	-111.4	-154.7	-193.4	-230.7	-262.0	-268.2	-243.2	-209.3	-173.1	-134.9	

CLASS V
SALES PRICE $ 13.95/LB.
RATE OF RETURN 20.0 PCT.

DISCOUNTED CASH FLOW ANALYSIS

SCHEDULE C

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	TOTAL
	MILLIONS OF DOLLARS															
REVENUE	1288.8	1288.8	1288.8	1288.8	1201.2	927.4	516.1	300.2	153.4	0.0	0.0	0.0	0.0	0.0	0.0	12888.4
ROYALTY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NET SALES	1288.8	1288.8	1288.8	1288.8	1201.2	927.4	516.1	300.2	153.4	0.0	0.0	0.0	0.0	0.0	0.0	12888.4
OPER.COSTS.PRIM.DEV.	485.0	484.5	481.3	472.0	428.1	323.3	179.5	102.4	50.3	0.0	0.0	0.0	0.0	0.0	0.0	4850.5
BEFORE TAX CASH FLOW	803.8	804.4	807.5	816.9	773.1	604.1	336.7	197.8	103.1	0.0	0.0	0.0	0.0	0.0	0.0	8037.9
LESS DEDUCTIBLE ITEMS																
1. DEPRECIATION	49.4	49.4	49.4	49.4	46.1	35.6	19.8	11.5	5.9	0.0	0.0	0.0	0.0	0.0	0.0	494.3
2. EQUIPMENT REPLAC.	13.9	13.9	13.9	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	138.6
3. DEVELOPMENT DRILL.	7.0	3.5	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	306.9
4. DEPLETION	283.5	283.5	283.5	283.5	264.3	204.0	113.6	66.0	33.8	0.0	0.0	0.0	0.0	0.0	0.0	2813.7
TAXABLE INCOME	450.0	454.0	459.5	470.0	449.8	354.5	197.8	117.0	61.8	0.0	0.0	0.0	0.0	0.0	0.0	4284.5
TAXES AT 50 PERCENT	225.0	227.0	229.8	235.0	224.9	177.3	98.9	58.5	30.9	0.0	0.0	0.0	0.0	0.0	0.0	2142.3
PREFERENCE TAX	5.3	5.1	4.8	4.4	3.5	2.4	1.3	0.7	0.3	0.0	0.0	0.0	0.0	0.0	0.0	51.9
INVESTMENT TAX CREDIT	0.8	0.8	0.8	0.8	0.7	0.6	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	35.4
NET TAXES	229.5	231.3	233.8	238.6	227.7	179.1	99.9	59.0	31.1	0.0	0.0	0.0	0.0	0.0	0.0	2158.7
AFTER TAX CASH FLOW	574.3	573.1	573.7	578.3	545.4	425.0	236.8	138.8	72.0	0.0	0.0	0.0	0.0	0.0	0.0	5879.2
LESS INVESTMENT																
1. EXPLORATION	12.9	5.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1083.0
2. MINE/MILL	13.9	13.9	13.9	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	632.9
TOTAL INVESTMENT	26.8	19.3	15.1	13.9	12.9	10.0	5.5	3.2	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1715.9
NET CASH FLOW	547.5	553.8	558.7	564.4	532.4	415.0	231.2	135.6	70.4	0.0	0.0	0.0	0.0	0.0	0.0	4163.3
DISCOUNT FACTORS	0.0593	0.0494	0.0411	0.0343	0.0286	0.0238	0.0198	0.0165	0.0138	0.0115	0.0096	0.0080	0.0066	0.0055	0.0046	
PRESENT VALUE OF INVESTMENT = 0.0																
DISCOUNTED CASH FLOW	32.5	27.4	23.0	19.4	15.2	9.9	4.6	2.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
CUMULATIVE CASH FLOW	-102.4	-75.0	-52.1	-32.7	-17.5	-7.6	-3.0	-0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0	

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